MARROW ED8

Anatomy

Comprehensive Question Bank

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Gametogenesis

Question 1:

What are the site and the timing of the origin of the primordial germ cells?

a) Gonads, 4th week of embryonic development

b) Epiblast, 2nd week of embryonic development

c) Gonads, 2nd month of embryonic development

d) Yolk sac, 4th week of embryonic development

Question 2:

What is the correct sequence of stem cell potency based on their ability to differentiate?

a) Pluripotent >Totipotent > Multipotent > Oligopotent > Unipotent

b) Totipotent > Pluripotent > Multipotent > Oligopotent > Unipotent

c) Totipotent > Pluripotent > Oligopotent > Multipotent >Unipotent

d) Pluripotent >Totipotent > Oligopotent > Multipotent > Unipotent

Question 3:

What is a part of the embryo that exerts morphogenetic stimulus on its adjacent part called?

a) Differentiator

b) Organizer

c) Stem cell

d) Inducer

Question 4:

During which phase of meiotic division are leptotene and zygotene stages seen?

a) Metaphase 1

b) Prophase 1

c) Metaphase 2

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d) Prophase 2

Question 5:

Which of the following represents the embryonic period of development?

a) 0-2 weeks

b) 3-8 weeks

c) 8-10 weeks

d) 10-12 weeks

Question 6:

During which stage of prenatal development does gastrulation occur?

a) Embryonic period

b) Pre-embryonic period

c) Gametogenesis

d) Fetal period

Question 7:

When does spermatogenesis begin?

a) Fetal life

b) Birth

c) Puberty

d) After 18 years

Question 8:

Which of the following cells remain dormant in the testis until puberty?

a) Primordial germ cells

b) Primary spermatocytes

c) Secondary spermatocytes

d) Spermatids

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Question 9:

Which of the following cells have haploid number of chromosomes?

a) Type A spermatogonia

b) Type B spermatogonia

c) Primary spermatocyte

d) Secondary spermatocyte

Question 10:

Which stage of spermatogenesis is characterized by an independent assortment of maternal and paternal chromosomes?

a) Spermatogonia to primary spermatocyte

b) Primary spermatocyte to secondary spermatocyte

c) Secondary spermatocyte to spermatid

d) Spermatid to spermatozoa

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Question 11:

Which of the following transformations is seen in spermiogenesis?

a) Primordial germ cells to spermatogonia

b) Spermatogonia to primary spermatocytes

c) Primary spermatocytes to secondary spermatocytes

d) Spermatids to spermatozoa

Question 12:

Spermatogenesis is completed in approximately how many days?

a) 54

b) 94

c) 24

d) 74

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Question 13:

Which organelle gives rise to the acrosomal cap of the sperm?

a) Nucleus

b) Golgi apparatus

c) Centrosome

d) Mitochondria

Question 14:

Spermatozoa attain motility in _____

a) Seminiferous tubules

b) Vas deferens

c) Epididymis

d) Ejaculatory duct

Question 15:

You reassured the parents after you noted cryptorchidism in a premature baby. Which of the following cells are responsible for secreting the hormone responsible for its normal descent?

a) Primordial germ cells

b) Spermatogenic cells

c) Sertoli cells

d) Leydig cells

Question 16:

Which of the following cells remain dormant in the ovary until puberty?

a) Primordial germ cell

b) Primary oocyte

c) Secondary oocyte

d) First polar body

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Question 17:

A 30-year-old woman came to the obstetrician for in-vitro fertilization. FSH analogs were injected to induce follicular growth and hCG was injected to induce final oocyte maturation. The oocyte was then retrieved transvaginally. The oocyte thus retrieved■ is arrested at which of the following stages?

a) Prophase of meiosis I

b) Prophase of meiosis II

c) Metaphase of meiosis I

d) Metaphase of meiosis II

Question 18:

If the ovum is not fertilized, the corpus luteum may persist for about _____

a) 48 hours

b) 1 week

c) 2 weeks

d) 3 weeks

Question 19:

Meiosis occurs in:

a) Adrenal

b) Adult ovary

c) Prepubertal testis

d) Hypothalamus

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Answer Key

Question No.	Correct Option
1	b

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2	b
3	b
4	b
5	b
6	a
7	c
8	a
9	d
10	b
11	d
12	d
13	b
14	c
15	d
16	b
17	d
18	c
19	b

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Detailed Explanations

Solution to Question 1:

Primordial germ cells originate in the epiblast, during the 2nd week of development.

Primordial germ cells (PGCs) are also known as primitive sex cells. During the 2nd week of development, they originate in the epiblast at the caudal end of the primitive streak.

They are the precursors of gametes in both genders. They pass through the primitive streak during gastrulation and reach the wall of the yolk sac. They migrate from the yolk sac in the 4th week and reach the developing gonads by the end of the 5th week.

Solution to Question 2:

The correct order of arrangement of stem cells, based on their potency to differentiate into different cells (highest to lowest) is totipotent > pluripotent > multipotent > oligopotent > unipotent.

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Solution to Question 3:

Any part of the embryo that exerts a morphogenetic stimulus on adjacent parts is known as the organizer.

First level is the primary organizer that induces the development of new tissues. This newly developed tissue can then induce another tissue in turn to become the secondary organizer. Therefore, there is a sequence or chain of organizers called primary, secondary, and tertiary organizers.

Examples of the three levels of organizers:

• Primary organizer: e.g., Blastopore induces differentiation of notochord

• Secondary organizer: e.g., Notochord induces the development of the neural tube (that forms the brain and spinal cord)

• Tertiary organizer. e.g., Neural tube induces segmentation of paraxial mesoderm into somites

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Solution to Question 4:

Leptotene and zygotene are stages of prophase 1 of meiosis I.

Meiosis is a special type of cell division that reduces the chromosome number by half. It creates 4 daughter cells, each with haploid chromosomes distinct from the parent cell. Meiosis consists of two successive divisions called the first and second meiotic divisions. The various stages of meiosis are as follows:

First meiotic division (meiosis I)

• Prophase 1 (Leptotene, Zygotene, Pachytene, Diplotene, Diakinesis)

• Metaphase 1

• Anaphase 1

• Telophase 1

Second meiotic division (meiosis II)

• Prophase 2

• Metaphase 2

• Anaphase 2

• Telophase 2

Solution to Question 5:

The embryonic period extends from the 3rd week of intrauterine life to the 8th week of intrauterine life.

The prenatal period is divided into 3 different stages:

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Stages of prenatal development	Important events of each stage
Pre-embryonic period(First 2 weeks)	FertilizationCleavage and blastocyst formationImplantationFormation of embryoblast and trophoblastDifferentiation of embryoblast totwo-layered (bilaminar) germ discDifferentiation of trophoblast into cytotrophoblast and syncytiotrophoblast
Embryonic period(3-8 weeks)	Trilaminar germ discformation with the formation of 3 germ layersEarly organogenesis Formation of extraembryonic supportive organs and membranes such as placenta, umbilical cord, amnion, and allantois
Fetal period(9 weeks to birth)	Growth and specialization of body structures

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Solution to Question 6:

Gastrulation occurs during the embryonic period at the 3rd week of gestation.

During the 3rd week of intra-uterine life, three definitive germ layers are formed, namely ectoderm, mesoderm, and endoderm. The three germ layers develop from the epiblast by a process of cell proliferation and migration known as gastrulation. This transforms the bilaminar germ disc into a trilaminar structure.

Solution to Question 7:

Spermatogenesis starts at puberty.

The spermatozoa are produced in seminiferous tubules by a process known as spermatogenesis. In this process, spermatogonia are transformed into spermatozoa.

Shortly before puberty, the sex cords acquire a lumen and become seminiferous tubules, and primordial germ cells differentiate into spermatogonial stem cells. These spermatogonial stem cells then give rise to type A spermatogonia. This marks the beginning of spermatogenesis.

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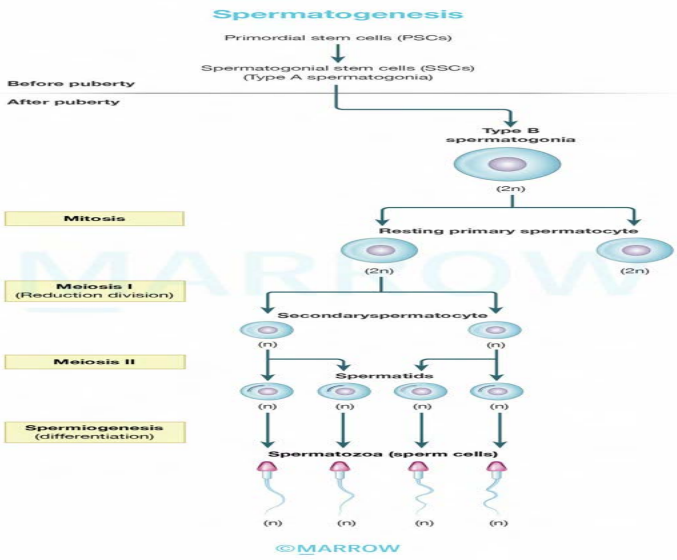

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Solution to Question 8:

Primordial germ cells (PGCs) remain dormant in the testis until puberty.

At puberty, PGCs differentiate into spermatogonial stem cells. These spermatogonial stem cells then give rise to type A spermatogonia. This marks the beginning of spermatogenesis.

Solution to Question 9:

Secondary spermatocytes have haploid number of chromosomes.

During the process of spermatogenesis, each primary spermatocyte gives rise to 4 sperm cells (in contrast, each primary oocyte gives rise to only 1 ovum). The haploid cells formed during this process are secondary spermatocytes, spermatids, and spermatozoa.

The flowchart below shows the steps of spermatogenesis:

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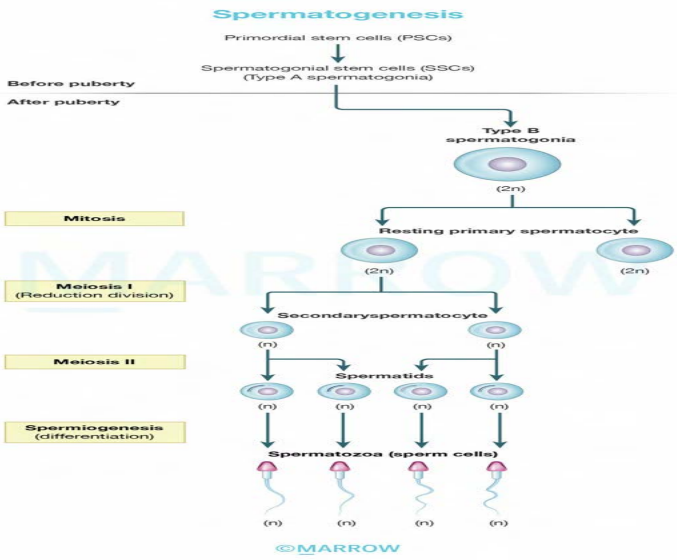

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Solution to Question 10:

Independent assortment is the random distribution of chromosomes. It takes place during meiosis I where there is division from primary spermatocyte to secondary spermatocyte.

The law of independent assortment states that alleles for separate traits are passed independently of one another into the gametes.

During the first meiotic division, paternal and maternal chromosomes are distributed between the daughter cells entirely at random. This prevents all chromosomes from the same source (mother or father) from ending up in the same gamete. After meiosis, each haploid daughter cell contains a mixture of genes from the mother and father.

Solution to Question 11:

Spermiogenesis or spermateleosis is the process of maturation of spermatids to spermatozoa. It is the final stage of spermatogenesis.

The major events occurring during spermiogenesis include:

- Nuclear morphogenesis and condensation
- Formation of tail
- Formation of acrosome
- Rearrangement of organelles (mitochondria, centrioles, etc.)
- Shedding off excess cytoplasm

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Solution to Question 12:

Spermatogenesis is completed in approximately 74 days. Spermatogenesis covers the entire process of sperm formation from spermatogonia into spermatozoa.

Spermiogenesis covers the process of transformation from spermatid into spermatozoa.

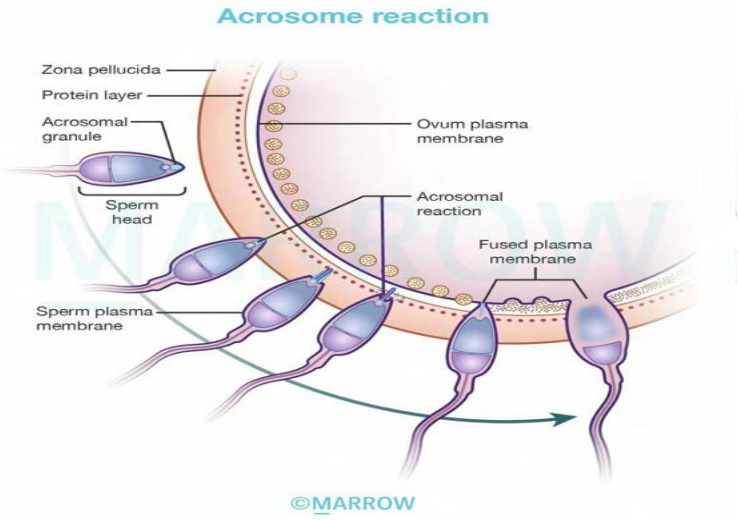
Solution to Question 13:

The acrosomal cap of the sperm is derived from the Golgi apparatus.

Parts of the sperm and their derivatives:

The image given below shows the acrosome reaction.

Cell organelle	Part of the sperm
Nucleus	Head of sperm
Golgi apparatus	Acrosomal cap
Mitochondria	Spiral sheath around the middle piece
Centrosome	Proximal centriole: spherical structure in sperm neckDistal centriole: the distal end of the middle piece (annulus)
Cytoplasm	Shed as residual bodies of Regaud
Cell membrane	Covering of spermatozoa



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Solution to Question 14:

Spermatozoa attain full motility during their passage through the epididymis.

Initially, spermatozoa are only slightly motile, but they obtain full progressive motility in the epididymis. This involves the activation of a unique set of cation channel proteins from the CatSper family located in the principal piece of the sperm tail.

Solution to Question 15:

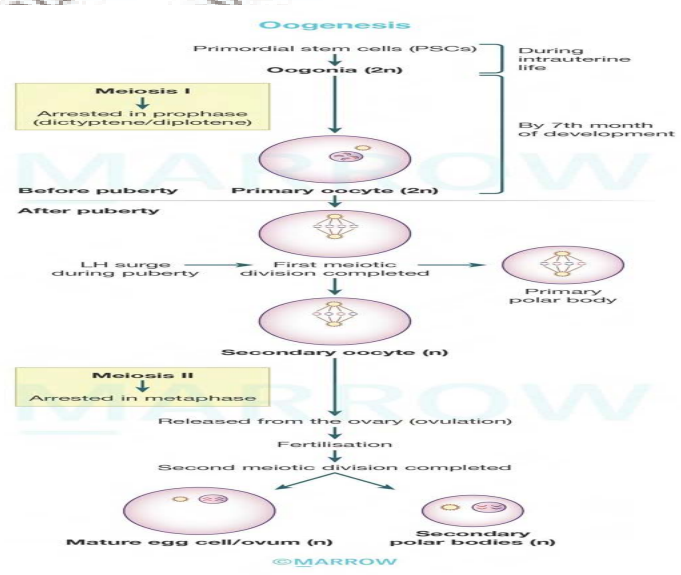
Testosterone is involved in testicular descent. They are secreted by the Leydig cells.

Leydig cells are large polyhedral cells present in the connective tissue between the seminiferous tubules. Testosterone is synthesized from cholesterol in Leydig cells. The secretion of testosterone from Leydig cells is under the control of the luteinizing hormone (LH).

Solution to Question 16:

Primary oocytes remain dormant in the ovary until puberty. They are arrested in prophase (dicytotene/diplotene) of meiosis I and surrounded by flat epithelial cells (primordial follicles) in the ovary before puberty.

Steps of oogenesis before puberty are shown in the image below:



Solution to Question 17:

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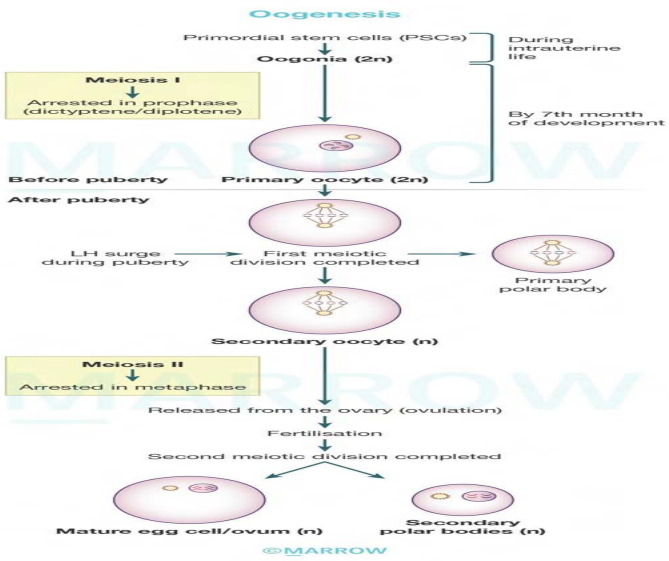
The oocyte retrieved after final maturation is the secondary oocyte that is arrested in metaphase of meiosis II.

Steps of oogenesis after puberty are shown in the image below:



If there is no fertilization, the secondary oocyte fails to complete the second meiotic division and degenerates about 24 hours after ovulation.

In in-vitro fertilization, initially, FSH analogs are administered to induce follicular growth. At this stage, the oocyte is arrested in the prophase stage of meiosis I. The final maturation of the oocyte is induced by the administration of hCG. This causes the oocyte to resume the meiotic division, complete meiosis I, and enter meiosis II. However, the oocyte is arrested in the metaphase of meiosis II until fertilization.

Solution to Question 18:

If the ovum is not fertilized, the corpus luteum persists for about 14 days i.e., 2 weeks.

The fate of the corpus luteum depends on the fertilization of the ovum:

• No fertilization:

• Corpus luteum of menstruation remains small and secretes progesterone.

• This progesterone prepares the uterine endometrium to enter the progestational or secretory phase.

• It persists for about 14 days.

• It reaches maximum size by about 9 days after ovulation and starts to shrink 3–4 days before the next menses.

• It undergoes fibrosis to become a white scar tissue called corpus albicans.

• Ovum fertilized:

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• Corpus luteum of pregnancy is formed.

• Regression of the corpus luteum is prevented by hCG secreted by the syncytiotrophoblast of the developing embryo.

• It continues to grow and secrete progesterone that helps maintain the pregnancy.

• It persists for 3-4 months until the placenta takes over.

Solution to Question 19:

Meiosis occurs in the adult ovary.

Meiosis takes place only in germ cells and results in the formation of haploid gametes. Meiosis requires two cell divisions, meiosis I and meiosis II, to reduce the number of chromosomes to the haploid number of 23.

Option C: Spermatogenesis begins at puberty. Primordial germ cells (PGCs) remain dormant in the testis until puberty. At puberty, PGCs differentiate into spermatogonial stem cells. These spermatogonial stem cells then give rise to spermatogonia which marks the beginning of spermatogenesis.

Options A and D: These are somatic cells that only undergo mitosis and not meiosis.

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Pre-Embryonic Phase of Development

Question 1:

Which of the following is included in pre-embryonic phase of development?

a) First 2 weeks of intrauterine development

b) First 3 weeks of intrauterine development

c) First 4 weeks of intrauterine development

d) First 8 weeks of intrauterine development

Question 2:

Where does fertilization of the ovum commonly occur?

a) Fimbriae

b) Ampulla

c) Infundibulum

d) Isthmus

Question 3:

What is the final step of maturation of spermatozoon before fertilization known as?

a) Spermiogenesis

b) Capacitation

c) Acrosome reaction

d) Cortical reaction

Question 4:

During fertilization, all of the following barriers in the ovum are penetrated by the sperm except:

a) Corona radiata

b) Zona pellucida

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c) Oocyte cell membrane

d) Nuclear membrane

Question 5:

Which of the following is not an acrosomal enzyme?

a) Acrosin

b) Hyaluronidase

c) Acid phosphatase

d) Alkaline phosphatase

Question 6:

Which of the following events is referred to as zona reaction?

a) Penetration of sperm through the zona pellucida

b) Complete dissolution of the zona pellucida

c) Alteration of zona pellucida to prevent polyspermy

d) Binding of sperm to zona proteins

Question 7:

A 26-year-old man presented with sudden onset of visual loss. After evaluation, he was diagnosed with a mitochondrial disorder called Leber's hereditary optic neuropathy. What is the origin of the affected DNA in this condition?

a) Paternal only

b) Maternal only

c) 50% paternal and 50% maternal

d) Either paternal or maternal

Question 8:

What is the normal site of implantation of the blastocyst?

a) Endometrium and myometrium

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b) Functional layer of the endometrium

c) Basal layer of the endometrium

d) Myometrium

Question 9:

What does the inner cell mass form during blastocyst formation?

a) Cytotrophoblast

b) Syncytiotrophoblast

c) Embryoblast

d) Blastocele

Question 10:

Arrange the following events of pre-embryonic development in order, from the earlier stage to the later stage.

a) 2 – 4 – 1 – 3

b) 3 – 1 – 2 – 4

c) 4 – 2 – 3 – 1

d) 4 – 2 – 1 – 3

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Question 11:

The bilaminar embryonic disc is made up of which of the following cells?

a) Cuboidal cells of hypoblast layer near amniotic cavity

b) Cuboidal cells of epiblast layer near blastocyst cavity

c) Columnar cells of epiblast layer near amniotic cavity

d) Columnar cells of hypoblast layer near blastocyst cavity

Question 12:

Where does the Heuser's membrane develop from?

a) Columnar cells derived from epiblast

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b) Flattened cells derived from epiblast

c) Columnar cells derived from hypoblast

d) Flattened cells derived from hypoblast

Question 13:

What is the part of extraembryonic mesoderm lining the amniotic cavity called?

a) Parietal or splanchnopleuric extraembryonic mesoderm

b) Visceral or splanchnopleuric extraembryonic mesoderm

c) Parietal or somatopleuric extraembryonic mesoderm

d) Visceral or somatopleuric extraembryonic mesoderm

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Answer Key

Question No.	Correct Option
1	a
2	b
3	b
4	d
5	d
6	c
7	b
8	b
9	c
10	d
11	c
12	d
13	c

Detailed Explanations

Solution to Question 1:

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The pre-embryonic phase includes the first 2 weeks of intrauterine development, from fertilization to the formation of bilaminar germ disc.

Major morphogenetic events that occur in the pre-embryonic phase include:

• Fertilization

• Cleavage

• Transportation of cleaving zygote

• Formation of blastocyst

• Implantation

• Specialization of primordial embryonic tissue

• Differentiation of embryoblast to bilaminar germ disc

• Differentiation of trophoblast to cytotrophoblast and syncytiotrophoblast

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Solution to Question 2:

Fertilization of the ovum commonly occurs in the ampulla of the uterine tube.

The ovulated egg enters the infundibulum of the uterine tube and then passes into the ampulla. The sperms released into the female genital tract swim to the ampulla and fertilize the ovum there.

Timeline of fertilization:

• The ovum released after ovulation is capable of being fertilized for 12-24 hours.

• The spermatozoa after ejaculation are capable of fertilization for 24-48 hours.

• Fertilization occurs within 1–2 days after ovulation.

Solution to Question 3:

The final step of maturation of spermatozoon before fertilization is known as capacitation.

Capacitation involves a period of conditioning of the sperm in the female reproductive tract, predominantly in the uterine tube. It provides the sperms with the ability to penetrate the outer layer of the ovum. Chemical changes in the tail provide them with greater mobility. It lasts approximately 7 hours.

Solution to Question 4:

The sperm does not penetrate the nuclear membrane of the oocyte.

The three barriers for sperm penetration in the ovum include:

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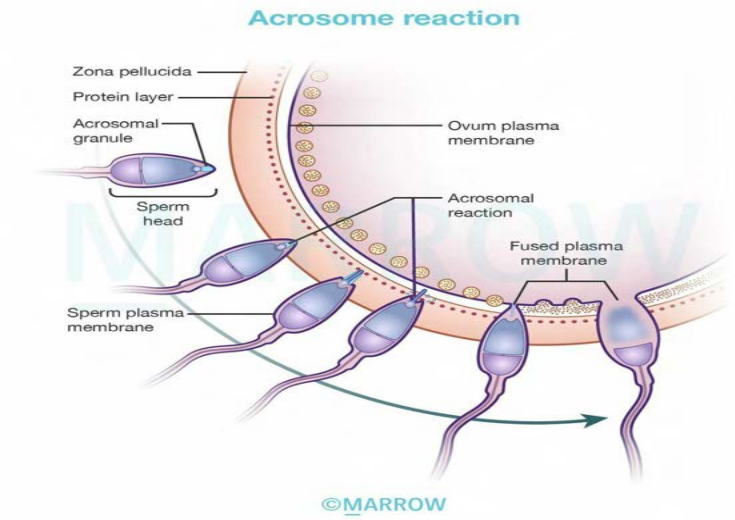
• Corona radiata

• Zona pellucida

• Oocyte cell membrane

After the fusion of the sperm and oocyte cell membranes, the nucleus of the ovum is converted to the female pronucleus. The nucleus of the sperm becomes the male pronucleus.



Solution to Question 5:

Alkaline phosphatase is not an acrosomal enzyme.

The three main acrosomal enzymes include:

• Acrosin

• Hyaluronidase

• Acid phosphatase

The sperm binds to the zona pellucida through the glycoprotein ligands ZP3 and ZP2 (zona proteins). This binding causes the release of the acrosomal enzymes that allow the sperm to penetrate the zona pellucida. This is called acrosomal reaction.

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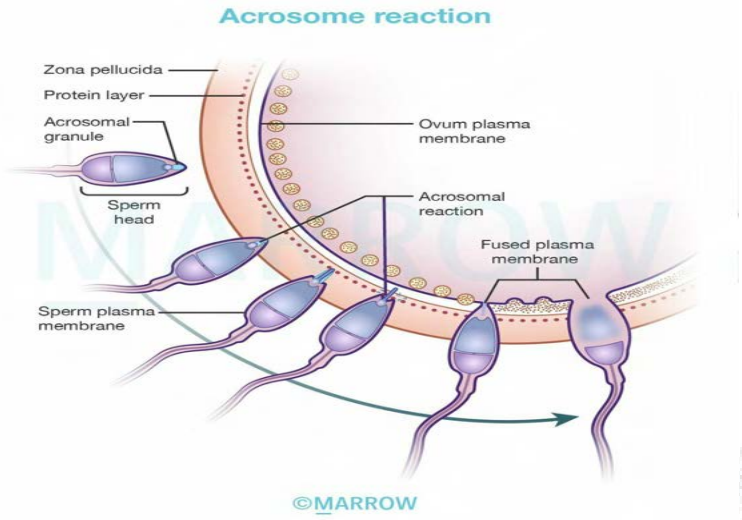

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Solution to Question 6:

Alteration of the properties of the zona pellucida to prevent the entry of other sperms is zona reaction.

After penetrating the zona, the sperm comes in contact with the oolemma (the plasma membrane of the oocyte). This contact results in weak membrane depolarization and a calcium wave.

The calcium wave triggers the release of lysosomal enzymes from the cortical granules lining the oolemma (cortical reaction). These enzymes hydrolyze the ZP3 receptor on the zona pellucida. Digestion of ZP3 and alteration of zona pellucida (zona reaction) prevents other sperms from binding, thus creating a block to polyspermy.

Solution to Question 7:

Mitochondrial disorders (e.g., Leber's hereditary optic neuropathy) have mutations in the mitochondrial DNA. Mitochondria and mitochondrial DNA of all human adult cells are of maternal origin.

During fertilization, the sperm's midpiece (with mitochondria) and tail are discarded. The sperm nucleus becomes the male pronucleus. Therefore, only the mitochondria present within the secondary oocyte (maternal mitochondria) remain in the fertilized zygote. Mitochondria, mitochondrial genetic variations, and mutations are passed only through the female line.

Solution to Question 8:

The blastocyst normally implants in the functional layer of the uterine endometrium.

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In the secretory phase, three layers can be recognized in the endometrium: stratum compactum, stratum spongiosum, and stratum basale. The first two layers (stratum compactum and spongiosum) are together known as stratum functionale or the functional layer.

If implantation does not occur, the functional layer is shed off during menstruation. If implantation occurs, the functional layer is retained as the decidua.

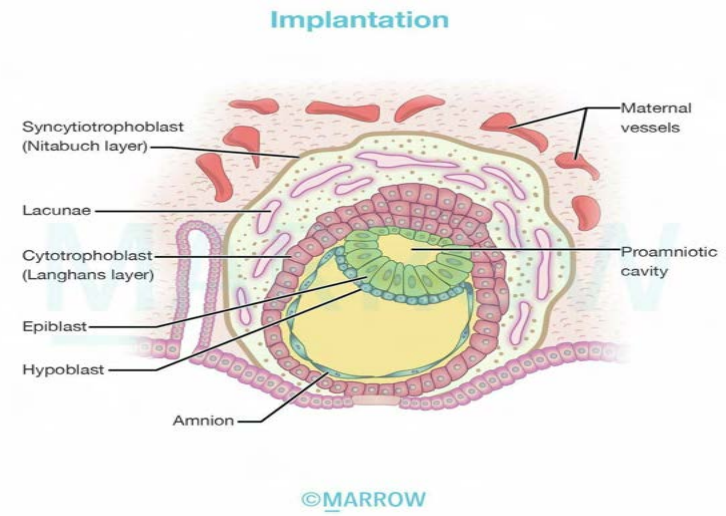
Timeline of implantation:

• 3-4 days after fertilization: The morula (12-16 cells) enters the uterus.

• 4th day after fertilization: The advanced morula reaches the uterine lumen.

• 4-5 days after fertilization: The early blastocyst stage is seen.

• 6-7 days after fertilization: The blastocyst implants in the uterus. Implantation corresponds to 20-22 days of the menstrual cycle.



Solution to Question 9:

The inner cell mass gives rise to the embryoblast, which forms the embryo proper.

Around the 4th-5th day of development, the morula becomes the blastocyst. Fluid passes into the morula from the uterine cavity and converts it to a blastocyst with a fluid-filled cavity called blastocoele. This fluid partially separates the cells of the inner cell mass from the outer cell mass.

Cell masses in the blastocyst:

• The outer cell mass is called the trophoblast and forms a major part of the placenta

• The inner cell mass is called the embryoblast and forms the embryo proper

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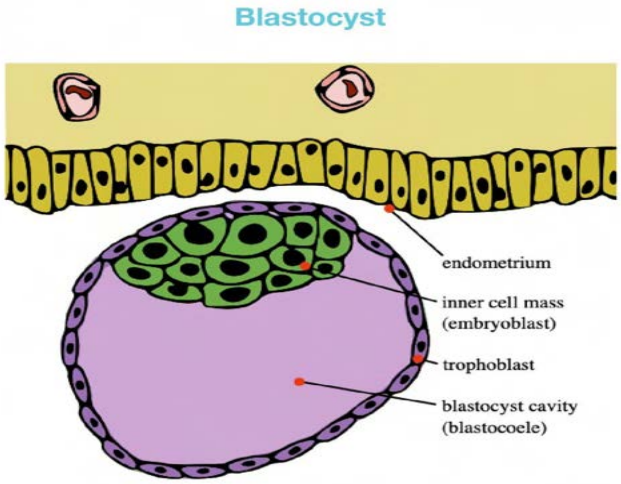

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Solution to Question 10:

The correct order of the listed events of the pre-embryonic period is cleavage - compaction - cavitation - implantation.

Events of the pre-embryonic phase of development:

• Fertilization

• Cleavage - Formation of blastomeres; the cells are loosely arranged until the 8-cell stage.

• Compaction - After 3 cleavages, the blastomeres are held together by tight junctions.

• Differentiation - The compacted 8-cell stage divides to form a 16-cell morula.

• Cavitation - Formation of the blastocyst with inner cell and outer cell mass.

• Hatching of the blastocyst - Release of the blastocyst from the zona pellucida.

• Implantation - Attachment of developing embryo to the uterine endometrium.

• Cell mass differentiation - Differentiation of the embryoblast (inner cell mass) into columnar epiblast cells and cuboidal hypoblast cells.

• Bilaminar disc formation - Formation of the bilaminar disc suspended by the connecting stalk. It has two layers (epiblast and hypoblast) and two cavities (amniotic and yolk sac).

Solution to Question 11:

The bilaminar embryonic disc is made up of the epiblast layer (columnar cells) near the amniotic cavity and the hypoblast layer (cuboidal cells) near the blastocyst cavity.

On the 8th day of development, the embryoblast differentiates into two layers, hypoblast and epiblast, to form the bilaminar disc. Around the same time, a small amniotic cavity appears within

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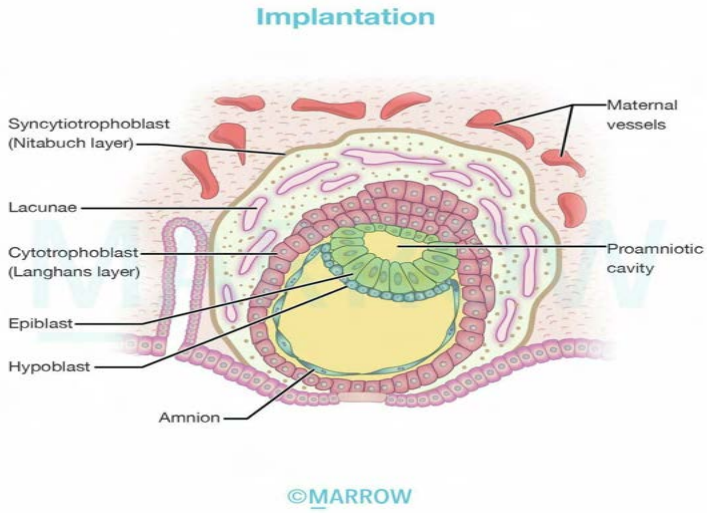
the epiblast. At this stage, the two layers of embryoblast are arranged as follows:

• One layer of high columnar cells known as the epiblast layer, adjacent to the amniotic cavity

• One layer of small cuboidal cells known as the hypoblast layer, adjacent to the blastocyst cavity

The image given below shows the embryonic disc with the epiblast and hypoblast layers.



Solution to Question 12:

Heuser's membrane or exocoelomic membrane develops from flattened cells derived from the hypoblast.

On day 9-10 of pre-embryonic development, flattened cells from the hypoblast begin to migrate to the abembryonic pole. They form a layer of cells just beneath the cytotrophoblast. This layer is called the Heuser's membrane. Once the blastocyst cavity is fully lined with Heuser's membrane, it is called the exocoelomic cavity.

The image below shows the formation of Heusner's membrane.

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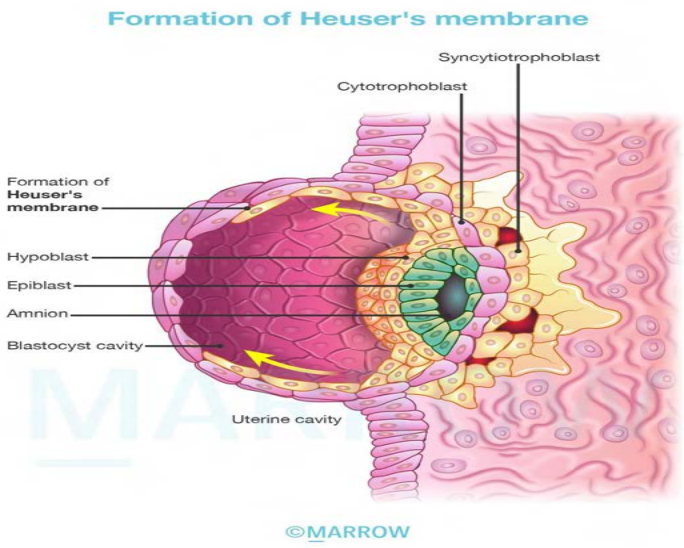

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Solution to Question 13:

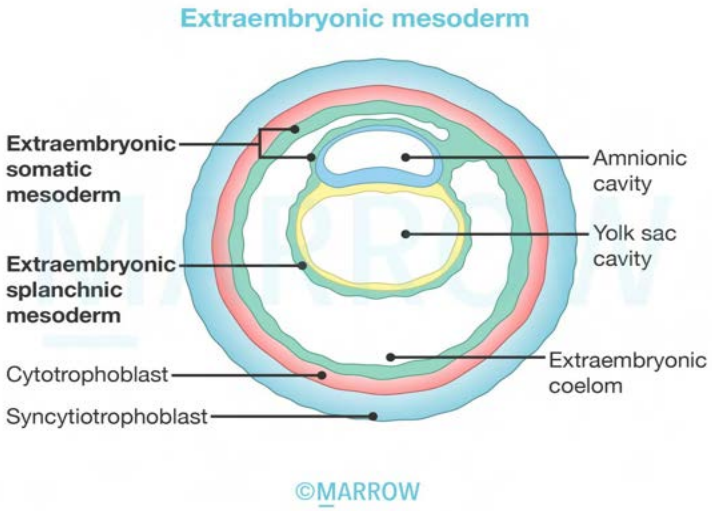
The parietal or somatopleuric extraembryonic mesoderm lines the amniotic cavity.

The extraembryonic mesoderm is derived from yolk sac cells. Large cavities develop in extraembryonic mesoderm, and they join to form the extraembryonic cavity (or chorionic cavity). Formation of the extraembryonic cavity splits the extraembryonic mesoderm into two layers:

• Parietal or somatopleuric extraembryonic mesoderm lining the trophoblast and outside of the amniotic cavity

• Visceral or splanchnopleuric extraembryonic mesoderm lining the outside of yolk sac

The image given below shows the extraembryonic mesoderm.



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Embryonic Phase of Development

Question 1:

Formation of which of the following indicates the beginning of gastrulation?

a) Notochord

b) Neural groove

c) Neural pit

d) Primitive streak

Question 2:

Which of the following germ layer(s) are formed from the epiblast?

a) Ectoderm

b) Endoderm, Mesoderm, and Ectoderm

c) Ectoderm and Mesoderm

d) Endoderm and Mesoderm

Question 3:

Which of the following statements regarding intraembryonic mesoderm is false?

a) It is also known as secondary mesoderm

b) It Is formed from the epiblast cells

c) It spreads throughout the embryonic disc

d) Most of the body tissues are formed from mesoderm

Question 4:

Arrange the following structures formed during the development of the definitive notochord, from the earlier stage to the later stage.

a) 3 – 4 – 2 – 1

b) 1 – 4 – 2 – 3

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c) 3 – 2 – 4 – 1

d) 1 – 2 – 4 – 3

Question 5:

Which of the following statements regarding the notochord is false?

a) It induces neural plate formation

b) It persists as apical ligament of the dens

c) It persists as nucleus pulposus

d) It develops from hypoblast cells

Question 6:

Neurulation refers to the process of the formation of:

a) Primitive streak

b) Neural plate

c) Notochord

d) Neural tube

Question 7:

A 45-year-old woman presented with an itchy elevated lesion on her face as shown in the image. On dermoscopy, there is an atypical pigmented network. From which structure is the cell responsible for this lesion derived?

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a) Lateral plate mesoderm

b) Intermediate mesoderm

c) Neural crest cell

d) Paraxial mesoderm

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Question 8:

Anomaly scan in a pregnant woman revealed renal agenesis in the fetus. Which of the following mesodermal layers is involved?

a) Extra-embryonic mesoderm

b) Paraxial mesoderm

c) Intermediate mesoderm

d) Lateral plate mesoderm

Question 9:

A 26-year-old man with congenital scoliosis is found to have hemivertebrae. The affected structures are derivatives of which layer of the mesoderm?

a) Lateral mesoderm

b) Paraxial mesoderm

c) Intermediate mesoderm

d) Extraembryonic mesoderm

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Question 10:

Which of the following gives rise to the pericardial cavity?

a) Paraxial mesoderm

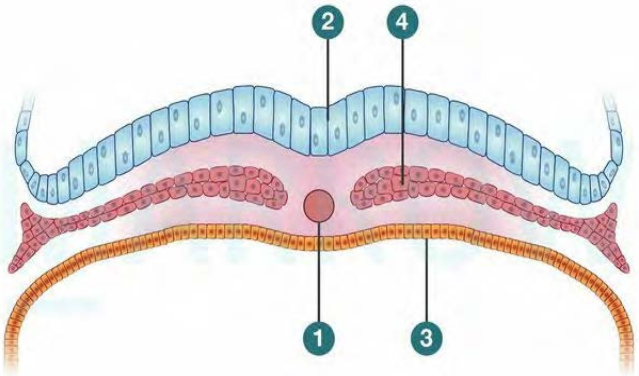
b) Intermediate mesoderm

c) Lateral plate mesoderm

d) Extraembryonic mesoderm

Question 11:

Nucleus pulposus is derived from _____



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a) 1

b) 2

c) 3

d) 4

Question 12:

Which of following structures becomes the primitive gut?

a) Part of amniotic cavity lined by the mesoderm

b) Part of amniotic cavity lined by the endoderm

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c) Part of yolk sac lined by the endoderm

d) Part of yolk sac lined by the mesoderm

Question 13:

A newborn presented to the NICU with respiratory distress and meconium discharge from the umbilicus. The condition occurs due to the patency of the duct that connects the primitive gut to the _____.

a) Embryonic body cavity

b) Chorionic cavity

c) Amniotic cavity

d) Yolk sac

Question 14:

A 32-year-old primigravida who is a known diabetic, had a spontaneous miscarriage. The baby had the deformity as shown in the image below. Which of the following defects during embryonal development is likely to cause the given condition?

a) Insufficient formation of mesoderm

b) Persistence of pluripotent cells in primitive streak

c) Defect in the development of notochord

d) Loss of cells in the anterior midline of the germ disc

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Question 15:

Which of the following blood vessels in the connecting stalk disappears during development?

a) Right artery

b) Left artery

c) Right vein

d) Left vein

Question 16:

Which of the following structures develops into Wharton's jelly?

a) Somatopleuric mesoderm

b) Splanchnopleuric mesoderm

c) Extraembryonic mesoderm

d) Paraxial mesoderm

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Answer Key

Question No.	Correct Option
1	d
2	b
3	c
4	c
5	d
6	d
7	c
8	c
9	b
10	c
11	a
12	c
13	d
14	a
15	c

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16	c

Detailed Explanations

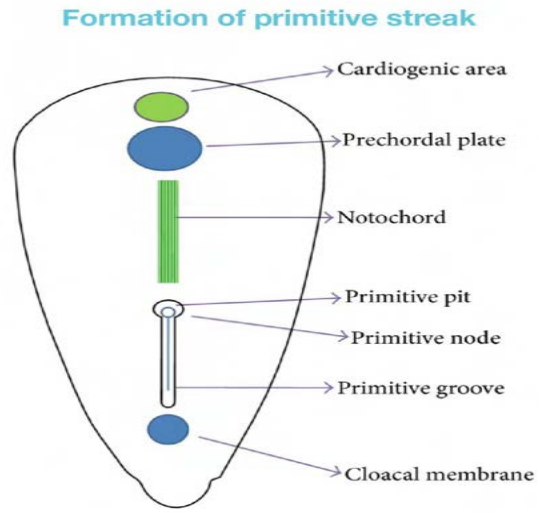
Solution to Question 1:

The formation of the primitive streak from the epiblast is an indicator of the beginning of gastrulation.

By the 15th day of development, some epiblast cells lying along the central axis, near the tail end of the embryonic disc, begin to proliferate. These proliferated cells form an elevation called primitive streak that bulges into the amniotic cavity.

Gastrulation is the process that forms all the 3 germ layers namely, ectoderm, mesoderm, and endoderm in the embryo. It occurs during the 3rd week of gestation.

The image given below shows the formation of primitive streak.



Solution to Question 2:

Epiblast gives rise to all the 3 germ layers through the process of gastrulation.

After the formation of the primitive streak, the epiblast cells migrate toward the primitive streak. When they arrive at the primitive streak, these cells become flask-shaped, detach from the epiblast, and slip beneath the primitive streak. This inward movement is known as invagination.

Some of the invaginated epiblast cells displace the hypoblast to create the embryonic endoderm. Endoderm is the first germ layer to form.

Some of the invaginated cells then start occupying the space between the epiblast and newly created endoderm to form mesoderm. Cells remaining in the epiblast then form the ectoderm.

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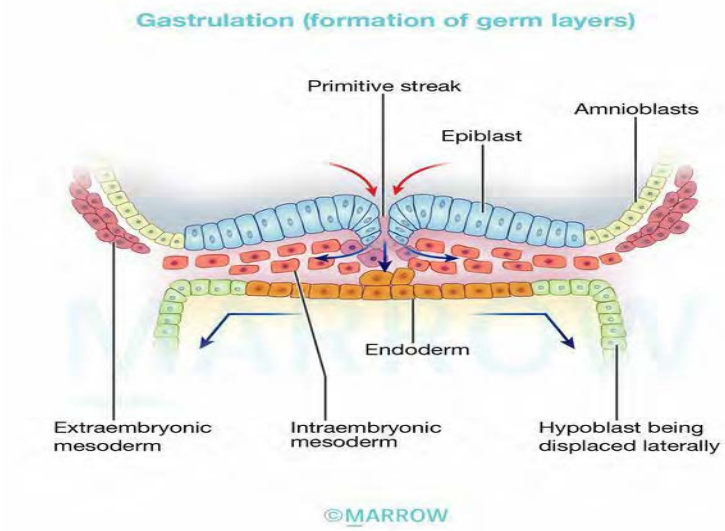
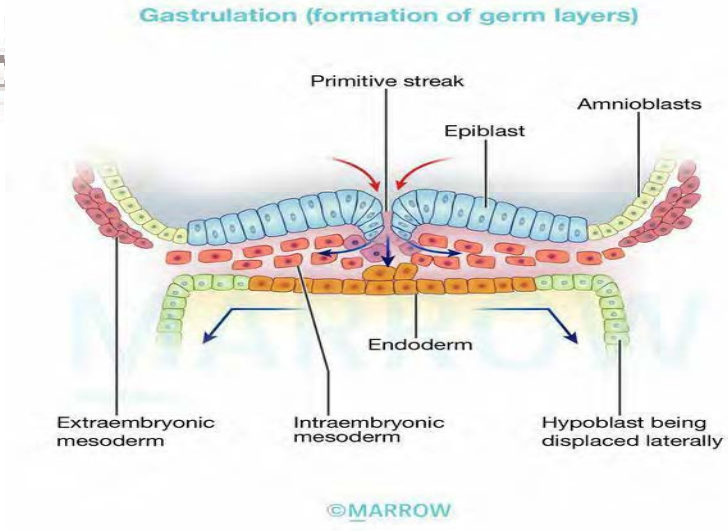
The image given below shows the formation of germ layers.



Solution to Question 3:

The intraembryonic mesoderm spreads throughout the embryonic disc, except in the region of the prechordal plate and cloacal membrane. In these two regions, the ectoderm is in direct contact with the endoderm.

The image given below shows the direct contact of intraembryonic mesoderm with the endoderm.



The intraembryonic mesoderm or secondary mesoderm is formed by the invagination and movement of epiblast cells between the newly formed endoderm and the epiblast.

In the later stages of development, the ectoderm and endoderm mostly persist as lining epithelium. Mesoderm forms most of the tissues of the body, including bone, cartilage, connective

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tissue, muscles (skeletal, smooth, cardiac), blood, lymph, and cardiovascular organs.

Solution to Question 4:

The correct order is blastopore - notochordal process - notochordal canal - notochordal plate - definitive notochord.

Notochord formation steps:

• Primitive knot - The cranial end of the primitive streak thickens to form the primitive knot (primitive node or Hensen's node).

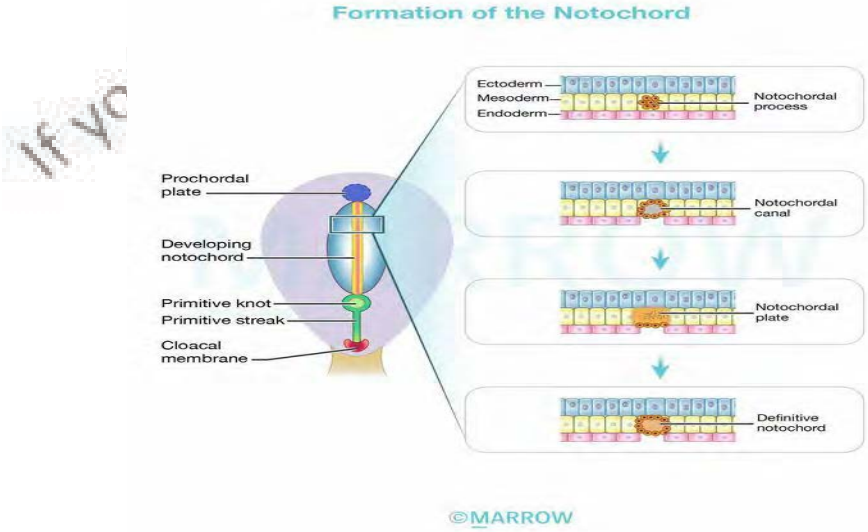
• Primitive pit (Blastopore) - A depression appears in the center of the knot known as the primitive pit (or blastopore).

• Notochordal process - The cells in the primitive knot multiply and pass cranially in the midline between the ectoderm and endoderm. They reach up to the caudal margin of the prechordal plate. These cells form a solid chord known as the notochordal process or head process.

• Notochordal canal - The cavity of the blastopore then extends into the notochordal process to form a tube-like structure called the notochordal canal.

• Notochordal plate - The floor of the notochordal canal gets intercalated (mixed up) with the endoderm and gradually breaks down. This eventually leads to the formation of a flat plate-like structure notochordal plate.

• Definitive notochord - The cells from the notochordal plate proliferate to form a solid rod-like structure called a definitive notochord.



Solution to Question 5:

The notochord is derived from the epiblast and not from the hypoblast cells.

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Epiblast cells from the primitive knot region of the primitive streak multiply and pass cranially in the midline between the ectoderm and endoderm. They undergo several stages of rearrangement to form the notochord.

During the initial stages of neurulation, the notochord plays a role in the induction of overlying ectoderm to thicken and form the neural plate.

Although the notochord regresses, it has 2 important remnants:

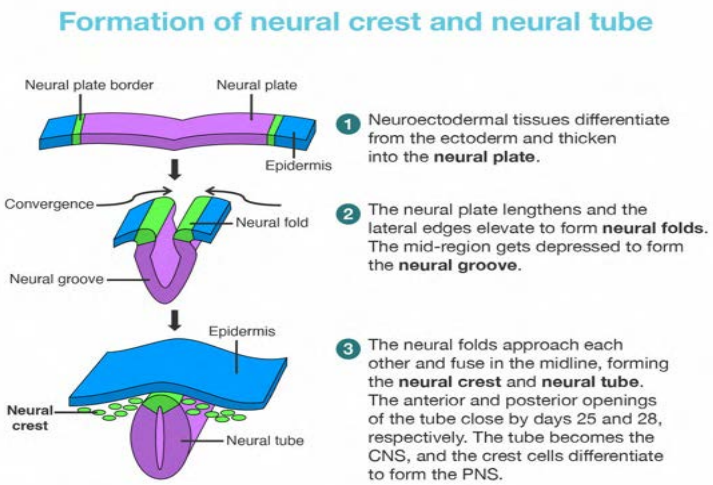
• Nucleus pulposus in the region of the intervertebral disc

• Apical ligament of the dens of axis vertebra

Solution to Question 6:

Neurulation refers to the process of the formation of the neural tube from the neural plate. The neural tube gives rise to the central nervous system.

The image given below shows the steps of neurulation:



Solution to Question 7:

The given image shows asymmetrical pigmented lesion on the face with an irregular border. This is suggestive of malignant melanoma arising from the melanocytes. Melanocytes are derived from neural crest cells (NCC).

During neurulation, when the neural folds elevate and fuse, the cells at the lateral border (the neural crest) of the neuroectoderm dissociate from their neighboring cells. These neural crest cells undergo an epithelial-to-mesenchymal transition while leaving the neuroectoderm and then migrate to the underlying mesoderm.

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NCCs contribute to many organs and tissues and are sometimes referred to as the fourth germ layer:

• In the trunk region, they form:

• Melanocytes

• Sensory ganglia

• Sympathetic and enteric neurons

• Schwann cells

• Adrenal medulla cells

• In the cranial region, they contribute to the:

• Craniofacial skeleton

• Neurons for cranial ganglia

• Satellite glial cells

• Melanocytes

• Some of the other neural crest derivatives are:

• C cells of the thyroid gland

• Conotruncal septum in the heart

• Odontoblasts

• Smooth muscle cells to blood vessels to face and forebrain.

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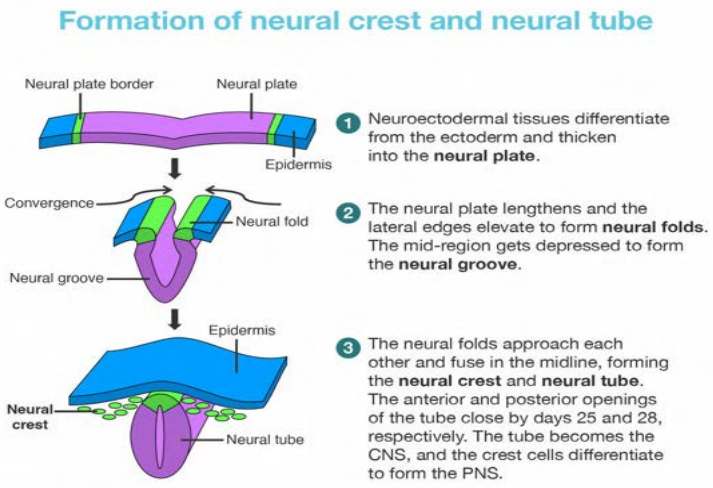

Option A: Lateral plate mesoderm is the lateral layer of the intraembryonic mesoderm. This is a thin layer. This layer develops a large cavity called the intraembryonic cavity and gives rise to a somatic or parietal mesodermal layer and a splanchnic or visceral mesodermal layer. The intraembryonic cavity gives rise to pericardial, pleural, and peritoneal cavities.

Option B: Intermediate mesoderm is a longitudinal strip of intraembryonic mesoderm that connects paraxial with the lateral plate mesoderm. The urinary and genital systems are derived

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from the intermediate mesoderm.

Option D: Paraxial mesoderm is the thickened plate of the intraembryonic mesoderm close to the midline, on either side of the notochord. This forms the somitomeres and somites.

Solution to Question 8:

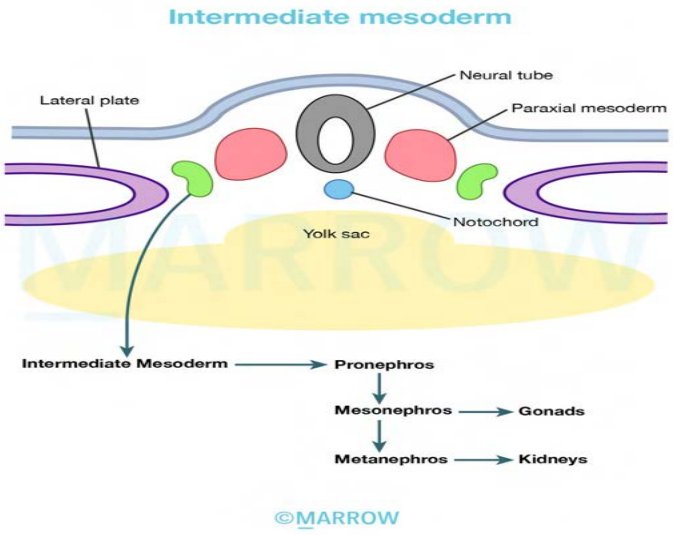
Kidneys are developed from the intermediate mesoderm.

After the notochord is formed, the intraembryonic mesoderm on either side can be seen organized into 3 layers:

• Paraxial mesoderm - Thickened plate of the mesoderm close to the midline, on either side of the notochord. This forms the somitomeres and somites.

• Intermediate mesoderm - Longitudinal strip of mesoderm that connects paraxial with the lateral plate mesoderm. The urinary and genital systems are derived from the intermediate mesoderm.

• Lateral plate mesoderm - A thinner layer of mesoderm that lies laterally. This layer develops a large cavity called the intraembryonic coelom that gives rise to pericardial, pleural, and peritoneal cavities.



Solution to Question 9:

The vertebrae are derived from somites which are derivatives of paraxial mesoderm. The paraxial mesoderm during development gets organized into segments called somitomeres and somites.

Somitomeres appear in the head region of the embryo. They are rounded structures and 7 in number. They form the mesoderm and muscles of the head and jaw.

From the occipital region downwards, somitomeres organize into somites. The first pair of somites arise in the occipital region of the embryo at approximately the 20th day of development.

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From here, new somites appear in craniocaudal sequence at a rate of approximately 3 pairs per day.

By the end of the 5th week, 42-44 pairs of somites are present. There are 4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 8 to 10 coccygeal pairs. The first occipital and the last five to seven coccygeal somites later disappear. The remaining somites form the axial skeleton.

Solution to Question 10:

The pericardial cavity is formed by the intraembryonic celom in the lateral plate mesoderm.

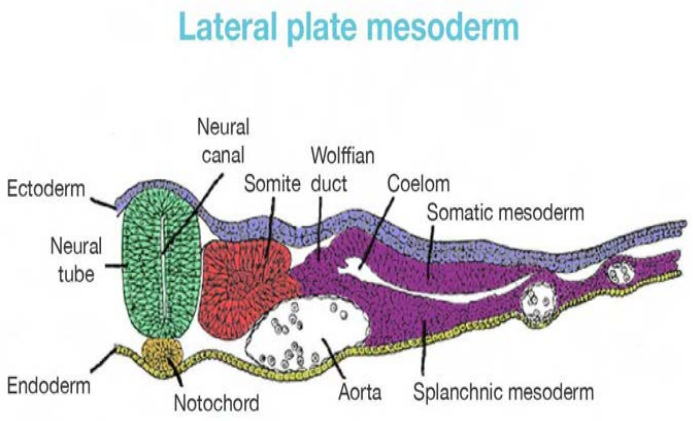
Within the lateral plate mesoderm, a large cavity known as intraembryonic celom is formed. The intraembryonic celom forms the pericardial, pleural, and peritoneal cavities.

The lateral plate mesoderm is divided by the intraembryonic celom to form:

• Somatopleuric or parietal layer of intraembryonic mesoderm that is in contact with the ectoderm. This forms the parietal layer of peritoneal, pleural, and pericardial membranes.

• Splanchnopleuric or visceral layer of intraembryonic mesoderm that is in contact with endoderm. This forms the visceral layer of the peritoneal, pleural, and pericardial membranes.

The image given below shows the somatopleuric and splanchnopleuric layers and the intraembryonic celom.



Solution to Question 11:

Nucleus pulposus is derived from the notochord (marked as 1).

The other labelled structures are

2 - Ectoderm

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3 - Endoderm

4 - Intraembryonic mesoderm

Solution to Question 12:

The primitive gut is derived from the part of the yolk sac lined by the endoderm.

With the development of the lateral folds of the embryo, a part of the yolk sac gets enclosed within the embryo, to form a tube-like structure. This structure is lined by the endoderm and is called the primitive gut.

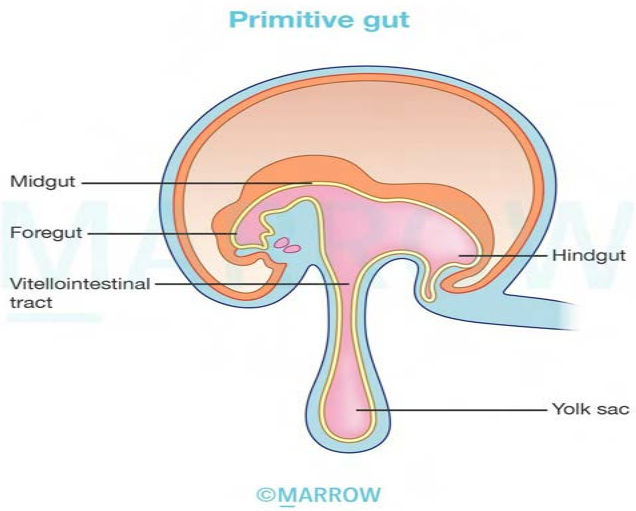
Initially, the primitive gut has a wide communication with the yolk sac. Later, three different sections of the primitive gut can be recognized:

• Foregut - Part of the primitive gut cranial to the communication with the yolk sac

• Midgut - Middle part of the primitive gut in communication with the yolk sac

• Hindgut - Part of the primitive gut caudal to the communication with the yolk sac

The image given below shows the sections of primitive gut.



Solution to Question 13:

The presence of meconium discharge at the umbilicus is suggestive of vitelline fistula. It occurs due to patent vitelline duct, which connects the primitive gut to the yolk sac.

The primitive gut is connected to the definitive yolk sac through a narrow stalk-like communication known as the vitellointestinal duct. It is also known as vitelline duct or yolk stalk or omphalomesenteric duct.

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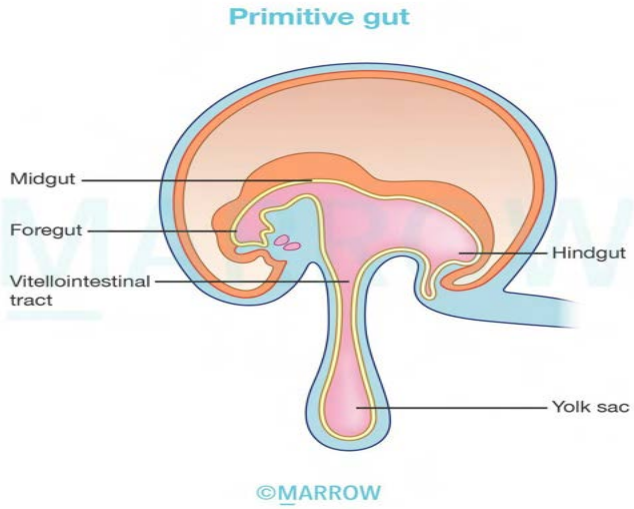
Due to the folding of the embryo in the cephalocaudal and lateral directions, the embryo gets enclosed all around by ectoderm, except in the region through which the vitellointestinal duct passes. In this region, there is a circular aperture, which is now called the umbilical opening. The vitellointestinal duct completely obliterates by the 7th week of development.



Vitelline duct abnormalities:

• Meckel's diverticulum: In about 2% o the individuals, a portion of the vitelline duct persists an outpouching of the ileum called, Meckel diverticulum. The diverticulum is usually asymptomatic unless it contains heterotopic pancreatic or gastric mucosa, which may lead to bleeding, ulceration, or perforation.

• Vitelline cyst: In some individuals, both the ends of the vitelline duct transforms into fibrous cords. However, the middle portion of the duct forms a large cyst called, enterocystoma, or vitelline cyst. As the fibrous cords run across the peritoneal cavity, it may lead to intestinal obstruction, strangulation, or volvulus.

Solution to Question 14:

The condition shown in the above image is sirenomelia. It is caused due to insufficient formation of mesoderm in the caudal most region of the embryo.

The mesoderm in the caudal region is involved in the formation of lower limbs, urogenital system, and lumbosacral vertebrae. Therefore, the defects seen in this condition include hypoplasia and fusion of the lower limbs, vertebral abnormalities, renal agenesis, imperforate anus, and anomalies of the genital organs.

During the third week of development, a process called gastrulation occurs which leads to the formation of all three germ layers. The process begins with the formation of the primitive streak, which develops into the primitive node and primitive pit. The primitive pit further invaginates and organizes itself into cells arranged in three layers, which eventually develop into ectoderm, mesoderm, and endoderm.

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Gastrulation related abnormalities:

Sacrococcygeal teratomas occur due to remnants of pluripotent cells from the primitive streak. They are the most common tumor in newborns, occurring at a frequency of 1 in 37,000 births. Sacrococcygeal teratomas contain tissues derived from all three germ layers. When pluripotent cells from the primitive streak remain in the sacrococcygeal region, they proliferate to form sacrococcygeal teratomas.

Holoprosencephaly is a deficiency in the midline craniofacial structures. It occurs due to teratogenic exposure (such as high alcohol dose) during gastrulation which kills the cells in the anterior midline of the embryonic disc. In holoprosencephaly, the forebrain is small, the two lateral ventricles are often merged into a single ventricle, and the eyes are close together (hypotelorism).

Solution to Question 15:

The right vein in the connecting stalk disappears during development.

At first, the connecting stalk is at the caudal end of the embryonic disc. With the formation of the tail fold, the connecting stalk moves to the ventral part of the embryo, near the area of the umbilical opening.

The blood vessels connecting the placenta to the embryo pass through the connecting stalk. Initially, there are 2 arteries and 2 veins. Later the right vein disappears (the left vein is left behind). The connecting stalk then consists of 2 arteries and 1 vein.

Solution to Question 16:

The extraembryonic mesoderm of the connecting stalk develops into a gelatinous substance known as Wharton's jelly.

When the tail fold of the embryo is formed, the connecting stalk moves towards the ventral aspect of the embryo. The connecting stalk is now attached only in the region of the umbilical opening. The extraembryonic mesoderm of the connecting stalk becomes Wharton's jelly in the umbilical cord. Wharton's jelly protects the blood vessels in the umbilical cord.

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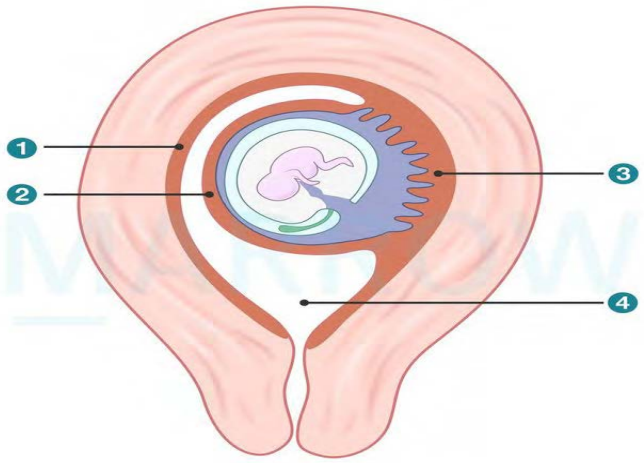
Placenta, Fetal Membranes and Twinning

Question 1:

Identify the structures labeled in the image from 1 to 4.



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a) Decidua basalis, Decidua capsularis, Decidua parietalis, Amniotic cavity

b) Decidua parietalis, Decidua capsularis, Decidua basalis, Amniotic cavity

c) Decidua basalis, Decidua capsularis, Decidua parietalis, Uterine cavity

d) Decidua parietalis, Decidua capsularis, Decidua basalis, Uterine cavity

Question 2:

Which of the following contributes to the maternal and fetal components of the structure shown below, respectively?

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a) Decidua basalis and chorion laeve

b) Decidua capsularis and chorion frondosum

c) Decidua capsularis and chorion laeve

d) Decidua basalis and chorion frondosum

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Question 3:

Which of the following statements regarding chorionic villi is false?

a) Primary villi contain cytotrophoblast and syncytiotrophoblast

b) Secondary villi contain extraembryonic mesoderm

c) Tertiary villi contain extraembryonic mesoderm

d) Secondary villi contain fetal capillaries

Question 4:

Which of the following are components of the definitive chorion?

a) Cytotrophoblast and syncytiotrophoblast

b) Extraembryonic somatic mesoderm and cytotrophoblast

c) Extraembryonic somatic mesoderm and syncytiotrophoblast

d) Extraembryonic somatic mesoderm, cytotrophoblast, and syncytiotrophoblast

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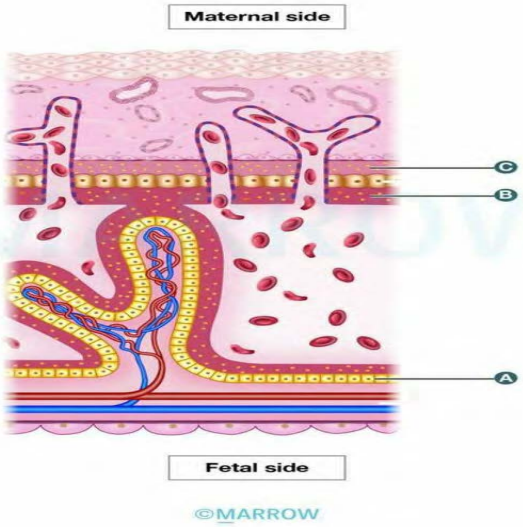
Question 5:

Identify the layers marked as A, B, and C, respectively, in the image of the definitive placenta.



a) Rohr's layer, Langhan's layer, Nitabuch's layer

b) Langhan's layer, Rohr's layer, Nitabuch's layer

c) Langhan's layer, Nitabuch's layer, Rohr's layer

d) Nitabuch's layer, Langhan's layer, Rohr's layer

Question 6:

Identify the structures marked as 1 to 4, respectively, in the chorionic plate of the placental tissue as depicted below.

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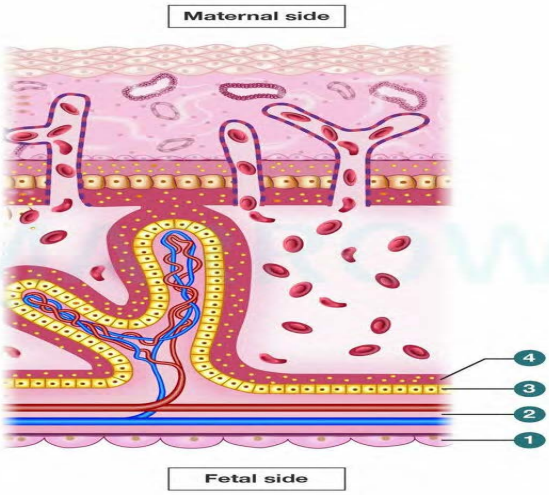

a) Amnion, extraembryonic mesoderm, syncytiotrophoblast, cytotrophoblast

b) Extraembryonic mesoderm, amnion, syncytiotrophoblast, cytotrophoblast

c) Amnion, extraembryonic mesoderm, cytotrophoblast, syncytiotrophoblast

d) Extraembryonic mesoderm, amnion, cytotrophoblast, syncytiotrophoblast

Question 7:

Which of the following is present in the intervillous space of placenta?

a) Maternal blood

b) Fetal blood

c) Maternal and fetal blood

d) Amniotic fluid

Question 8:

Which of the following are macrophages present in the mesoderm of the chorionic villus?

a) Langhans cells

b) Nitabuch's cells

c) Hofbauer cells

d) Rohr's cells

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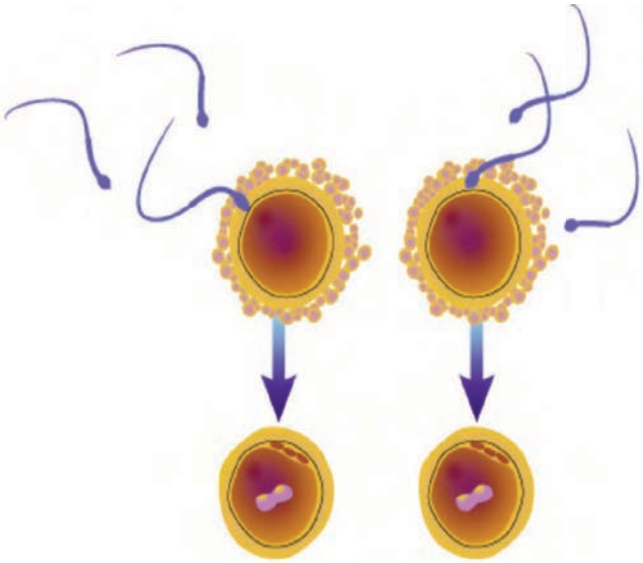
Question 9:

Fertilization, as shown in the image, will result in twins that are _____



a) Dizygotic, Bichorial, Biamniotic

b) Dizygotic, Monochorial, Biamniotic

c) Monozygotic, Monochorial, Biamniotic

d) Monozygotic, Monochorial, Monoamniotic

Question 10:

On USG examination of a pregnant woman at 15 weeks gestation, the following finding was noted. Which of the following events will result in the development of this condition?

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a) Early blastomere separation

b) Duplication of inner cell mass before amniotic sac formation

c) Duplication of embryonic disc between 4 -7 days after fertilization

d) Duplication of embryonic disc between 8 - 12 days after fertilization

Question 11:

The following finding was noted in the twins that were delivered a couple of hours ago. Identify the condition.

a) Heteropagous

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b) Xiphipagous

c) Omphalopagous

d) Pygopagus

Question 12:

A pregnant lady comes for a routine antenatal checkup during the first trimester. USG examination reveals the following finding. Identify the type of twins in this patient.

a) Dichorionic, monoamniotic

b) Dichorionic, Diamniotic

c) Monochorionic, Diamniotic

d) Monochorionic, Monoamniotic

Question 13:

A 37-year-old man is diagnosed with renal failure and is advised to undergo renal transplantation. The patient has a twin brother who is willing to donate his kidney. Which of the following types of twins are HLA identical, hence the recepient twin does not require immunosuppression?

a) 1 only

b) 2 and 3

c) 3 only

d) 1, 2, and 3

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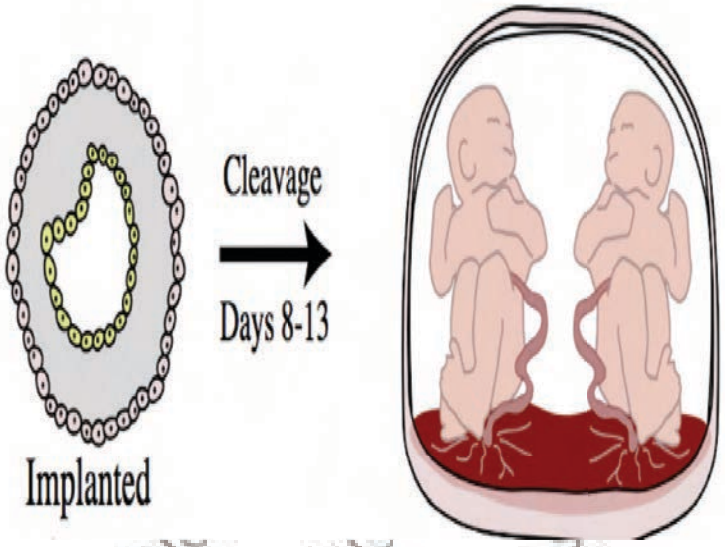
Question 14:

Identify the type of twin babies shown in the image below.



a) Dizygotic

b) Monozygotic, Bichorial, Biamniotic

c) Monozygotic, Monochorial, Biamniotic

d) Monozygotic, Monochorial, Monoamniotic

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Answer Key

Question No.	Correct Option
1	d
2	d
3	d
4	d
5	b
6	c
7	a
8	c
9	a

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10	d
11	d
12	b
13	d
14	d

Detailed Explanations

Solution to Question 1:

The structures labeled in the above image are (1) Decidua parietalis, (2) Decidua capsularis, (3) Decidua basalis, and (4) Uterine cavity.

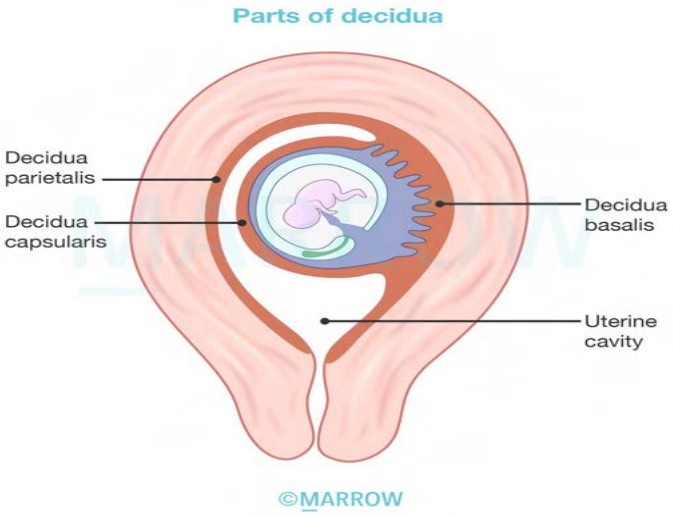
The decidua is the modified endometrium formed under the influence of progesterone and human chorionic gonadotropin (hCG) secreted by the cells of syncytiotrophoblast. After the implantation of the blastocyst, the decidua gets divided into 3 parts as follows:

• Decidua capsularis: part surrounding the embryo and separating it from the uterine cavity

• Decidua basalis: part deeper to the developing blastocyst that contributes to the maternal component of the placenta

• Decidua parietalis: part lining the rest of the uterine cavity

The image given below shows the parts of decidua.



Solution to Question 2:

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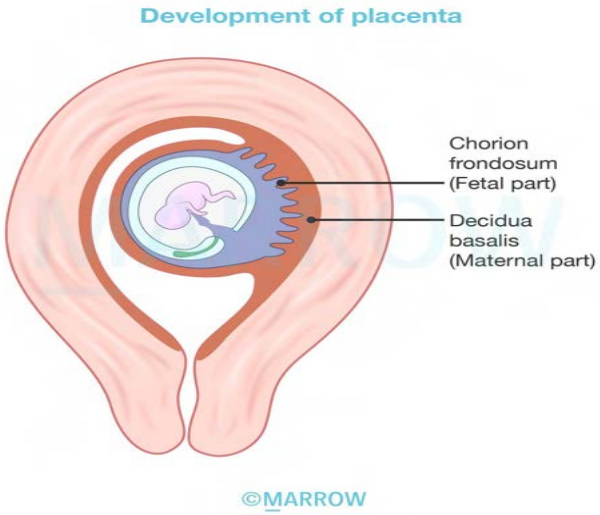
The image shown is of a placenta. The maternal component of the placenta is from the decidua basalis and the fetal component is from the chorion frondosum.

The placenta is a fetomaternal organ containing tissues from two different sources as follows:

• Maternal component - contributed by the decidua basalis. The decidua basalis is also referred to as the decidua serotina or decidual plate.

• Fetal component - contributed by chorion frondosum. The chorionic villi adjacent to the decidua basalis undergo significant development and branching to form a bushy region called chorion frondosum.



Solution to Question 3:

Secondary villi do not contain fetal capillaries. Fetal capillaries are present in tertiary villi.

Chorionic villi pass through the following stages during development:

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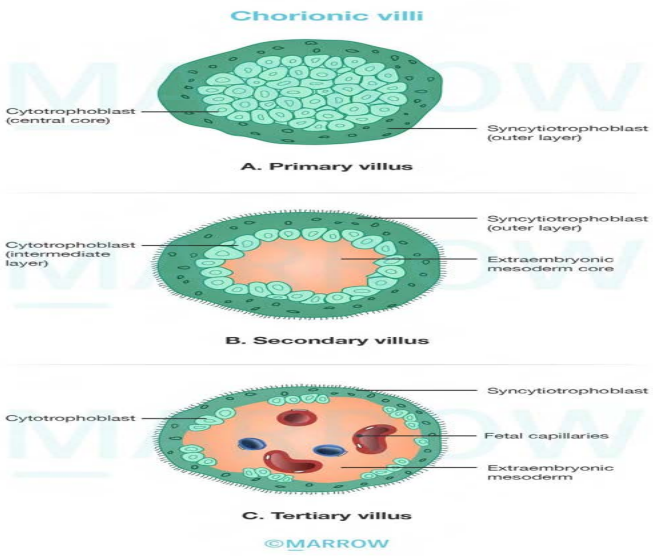
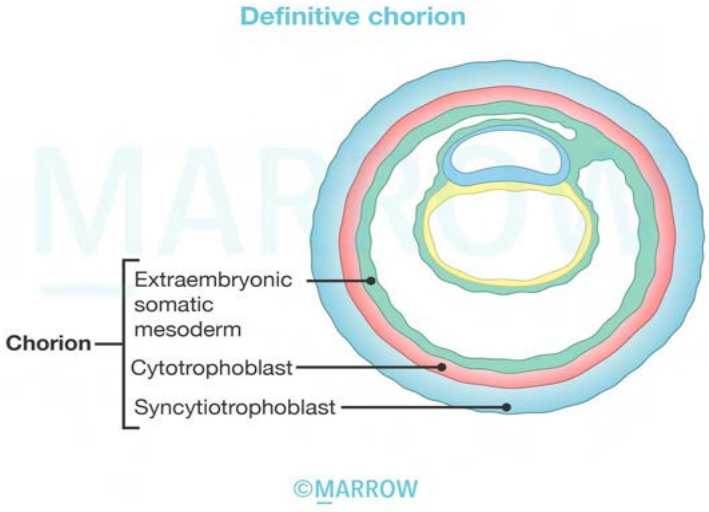


Solution to Question 4:

The definitive chorion is an extraembryonic membrane composed of three components:

- Extraembryonic somatic mesoderm
- Cytotrophoblast
- Syncytiotrophoblast

It contributes to the fetal portion of the placenta, including the villi and villus lakes.



Solution to Question 5:

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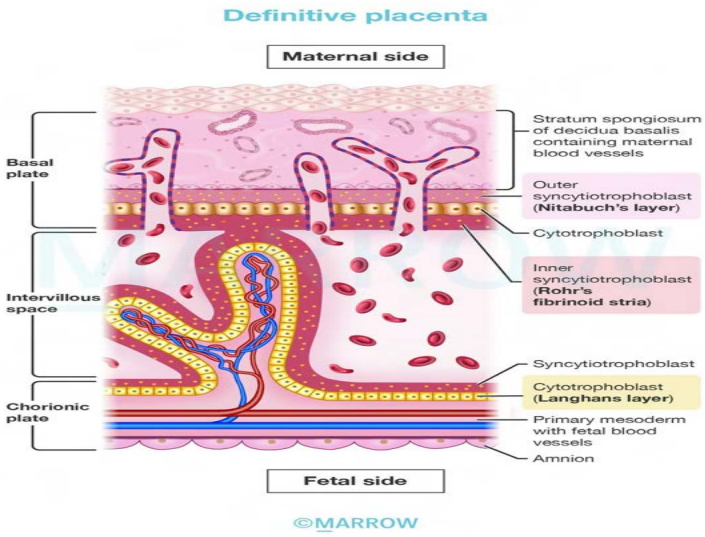
The structures marked in the above image are (A) Langhan's layer, (B) Rohr's layer, and (C) Nitabuch's layer.

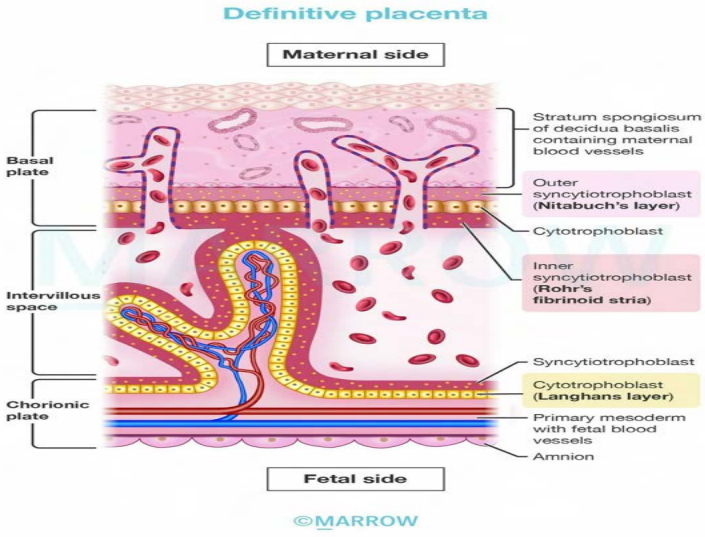
The definitive placenta consists of the chorionic plate on the fetal aspect and a basal plate on the maternal aspect with the intervillous space between them.

The structures of the definitive placenta are shown in the image below:



Solution to Question 6:

The structures labeled in the above image of the chorionic plate (fetal component) are (1) amnion, (2) extraembryonic mesoderm, (3) cytotrophoblast, and (4) syncytiotrophoblast.



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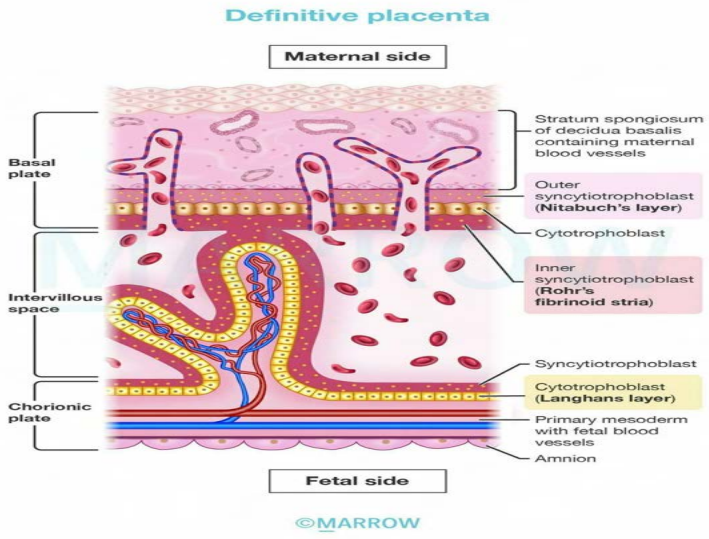
Solution to Question 7:

The intervillous space between the chorionic plate and the basal plate of the placenta contains only maternal blood. Fetal blood circulates in the blood vessels in the villi.

Maternal blood flows into the lacunar spaces of the syncytiotrophoblast as early as the 9th day of pregnancy. After the formation of chorionic villi, the lacunar space is known as the intervillous space.

Eroded uterine spiral arteries empty into the intervillous space and immerse the chorionic villi in maternal blood. In the fully formed placenta, the intervillous spaces contain about 150 mL of blood that is replaced every 15–20 seconds (i.e. three to four times per minute).



Solution to Question 8:

Hofbauer cells are fetal-derived macrophages present in the placenta.

Hofbauer cells are large (10–30 μm), pleomorphic cells, with highly vacuolated and granular cytoplasm. They are seen in the fetal villi of the placenta from the first trimester of pregnancy until birth.

The role of Hofbauer cells is not established yet, but they are thought to play a gate-keeper role in preventing the transmission of pathogens from the mother to the fetus.

Solution to Question 9:

The above image shows the fertilization of two different ova by two different sperms that will result in dizygotic twins, each with its own chorion and amnion (bichorial, biamnionic).

Dizygotic twins arise from two oocytes that mature during the same menstrual cycle and are fertilized by two different sperm cells. Thus, dizygotic twins can be of the same or opposite sex.

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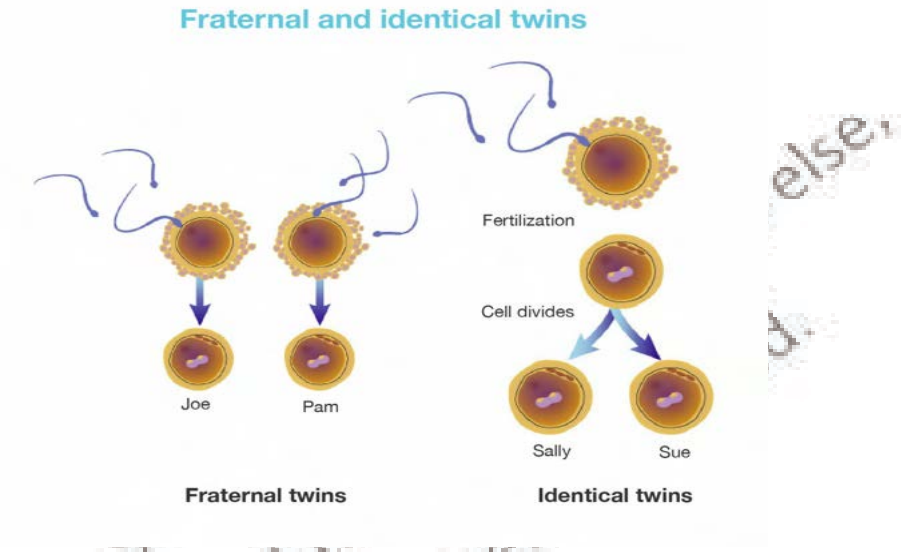
Dizygotic embryos implant separately and develop membranes that are independent of each other. Each twin has its own placenta, its own chorion, and its own amniotic cavity.

Dizygotic twins are more common than monozygotic twins. They are also known as fraternal twins, sibling twins, or false twins because genetically they are as different as two separately born siblings of the same biological parents.

The image given below shows how fertilization occurs in fraternal and identical twins.



Solution to Question 10:

The USG examination is suggestive of monozygotic, monochorionic, monoamniotic twins. Duplication of the embryonic disc between the 8-12 days after fertilization will result in the development of this condition.

At this stage, the amniotic sac is already formed. In this case, the two fetuses share a common chorion and common amniotic cavity.

The image given below shows a diagrammatic representation of the placentation.

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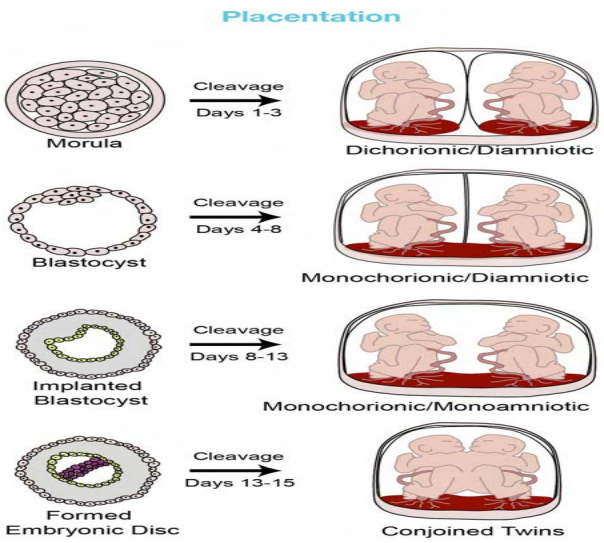

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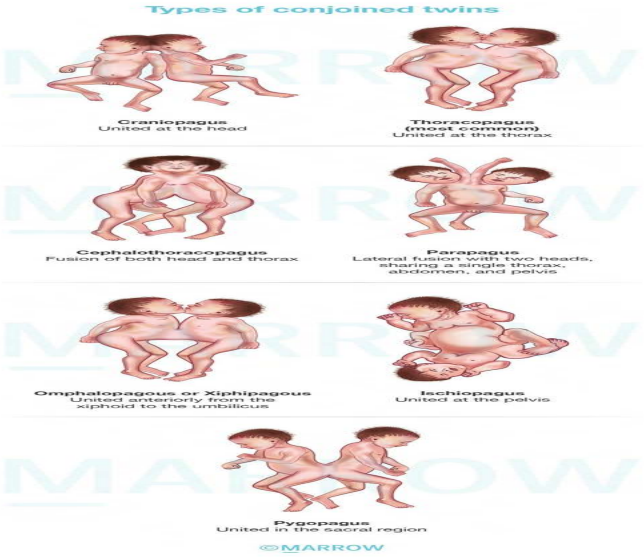
Solution to Question 11:

The image shows conjoined twins with fusion in the sacral region, which is known as the pygopagus.

In monochorionic monoamniotic twinning, incomplete duplication of the embryonic disc can occur. Incomplete separation of the monozygotic twins results in the birth of two infants that are joined or fused together at some part of the body. These twins are known as conjoined twins or Siamese twins.

Depending on the degree of incomplete separation, different types of conjoined twins can form:



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Solution to Question 12:

The given scenario is suggestive of dichorionic, diamniotic twins. The image shows two separate amniotic cavities (diamniotic) and lambda sign (dichorionic).

In dichorionic twins, there is a thick triangular projection of placental tissue between the two gestational sacs. This is known as the lambda sign or twin peak sign. The following image shows the lambda/twin peak.

Dichorial, diamniotic twins can occur in 2 instances:

• Dizygotic twins: The two fertilized ova get implanted at two separate sites and develop separate chorion and two separate amniotic cavities

• Monozygotic twins: With early blastomere separation (up to 3rd day after fertilization), the two embryos formed will have separate chorionic and amniotic sacs, similar to dizygotic twins.

Solution to Question 13:

All monozygotic twins are of the same gender, genetically identical, have identical HLA genes, regardless of the stage of separation of the cell mass.

All monozygotic twins develop from a single zygote that is formed as a result of the fertilization of a single oocyte with a single sperm. At a later stage, there is a separation of the blastomeres, inner cell mass, or embryonic disc to give rise to twins. Since they are formed from a single zygote, the twins have similar genetic composition.

Solution to Question 14:

The image shows monozygotic, monochorial, monoamniotic twins. It depicts that a single zygote has separated between 8-13 days and therefore resulted in twins implanted at one site,

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having the same chorion and having a single amniotic cavity.

The monozygotic, monochorionic, monoamniotic twins develop due to the duplication of the embryonic disc after the amniotic sac is already formed, i.e., between the 8th and 12th day after fertilization.

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Pharyngeal arches, Skeletal & Muscular Systems

Question 1:

The core of the branchial arch is derived from which of the following?

a) Ectoderm and mesoderm

b) Endoderm and neural crest cells

c) Mesoderm and neural crest cells

d) Ectoderm and endoderm

Question 2:

Which of the following pharyngeal arches disappear soon after formation?

a) 3rd Arch

b) 4th Arch

c) 5th Arch

d) 6th Arch

Question 3:

The site in the pharyngeal arch where the ectodermal cleft meets the endodermal pouch is known as:

a) Pharyngeal cleft

b) Pharyngeal pouch

c) Pharyngeal membrane

d) Cervical sinus

Question 4:

A 4-day-old infant who was delivered at home is brought to the pediatrician for a routine checkup. The infant has a noticeable small mandible and cleft palate. A CT scan reveals hypoplasia of the mandible and a defect in the ■middle ear cavity and tympanic membrane. A developmental defect of which of the following pharyngeal arches is most likely?

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a) 1st pharyngeal arch

b) 2nd pharyngeal arch

c) 3rd pharyngeal arch

d) 6th pharyngeal arch

Question 5:

A newborn had hypoplasia of the mandibles and zygomatic bones, malformed external ears, and slanted palpebral fissures. Abnormality in the development of which of the following pharyngeal arches will most likely■ lead to the given condition?

a) Pharyngeal arch 1

b) Pharyngeal arch 2

c) Pharyngeal arch 3

d) Pharyngeal arch 6

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Question 6:

Which of the following structures is not derived from Meckel's cartilage?

a) Anterior ligament of malleus

b) Spine of sphenoid

c) Stapes

d) Sphenomandibular ligament

Question 7:

A 49-year-old woman came with complaints of dull aching pain in the throat and right side of the face. She also frequently gets pain while swallowing associated with earache and headaches. On CT scan, a calcified stylohyoid ligament was seen. This ligament is derived from:

a) First pharyngeal arch

b) Second pharyngeal arch

c) Third pharyngeal arch

d) Fourth pharyngeal arch

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Question 8:

Which structure is derived from the 3rd pharyngeal arch?

a) Lesser cornu of hyoid bone

b) Greater cornu of hyoid bone

c) Upper part of the body of hyoid bone

d) Full body of the hyoid bone

Question 9:

Which of the following muscles is affected in patients with mandibular nerve injury?

a) Stylopharyngeus

b) Tensor tympani

c) Posterior belly of digastric

d) Levator veli palitini

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Question 10:

During thyroidectomy, the surgeon accidentally damages a nerve. Post-op, the patient is not able to raise the pitch of his voice. Which arch is the affected structure derived from?

a) 4th pharyngeal arch

b) 2nd pharyngeal arch

c) 3rd pharyngeal arch

d) 1st pharyngeal arch

Question 11:

Which of the following is the nerve of 6th pharyngeal arch?

a) Mandibular nerve

b) Superior laryngeal nerve of vagus

c) Glossopharyngeal nerve

d) Recurrent laryngeal nerve of vagus

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Question 12:

The nerve of the second branchial arch is:

a) Glossopharyngeal nerve

b) Trigeminal nerve

c) Facial nerve

d) Vagal nerve

Question 13:

Which of the following arteries develops from the hyoid arch?

a) Maxillary artery

b) Stapedial artery

c) Subclavian artery

d) Common carotid artery

Question 14:

A 5-month-old infant was brought to the pediatric OPD for a routine checkup. The child had congenital hypoparathyroidism. CT scan revealed thyroid hypoplasia and absent thymus. Abnormality in the development of which of the following pharyngeal pouches will most likely cause the given features?

a) Fourth and fifth pharyngeal pouch

b) First and second pharyngeal pouch

c) Second and third pharyngeal pouch

d) Third and fourth pharyngeal pouch

Question 15:

A 46-year-old woman presented with thyroid swelling. After evaluation, it was diagnosed as medullary thyroid cancer. Calcitonin produced from parafollicular C cells was used as a prognostic marker. These cells are derived from which structure?

a) 3rd pharyngeal cleft

b) 3rd pharyngeal pouch

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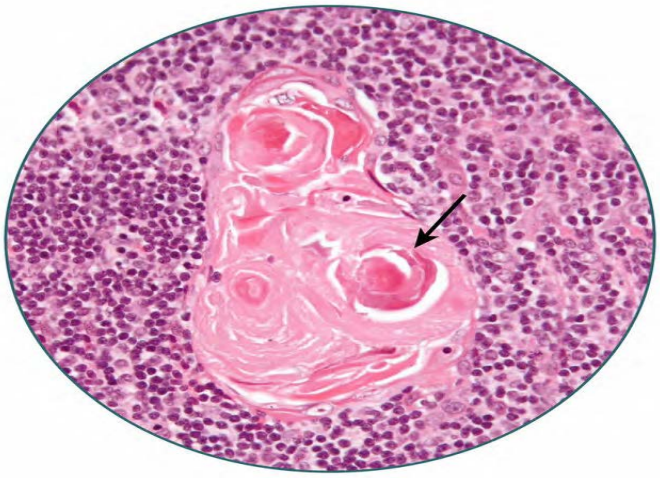
c) 4th pharyngeal cleft

d) Ultimobranchial body

Question 16:

A patient diagnosed with thymoma underwent thymectomy. The histological section of the the organ is given below. The structure marked is derived from which pharyngeal pouch?



a) Fourth pharyngeal pouch

b) Third pharyngeal pouch

c) Second pharyngeal pouch

d) First pharyngeal pouch

Question 17:

An 8-year-old girl was brought to the OPD with fever and throat pain for 3 days. On examination congestion and inflammation of the palatine tonsils were noticed. The affected structure is derived from which of the following?

a) 1st pharyngeal pouch

b) 2nd pharyngeal pouch

c) 3rd pharyngeal pouch

d) Ultimobranchial body

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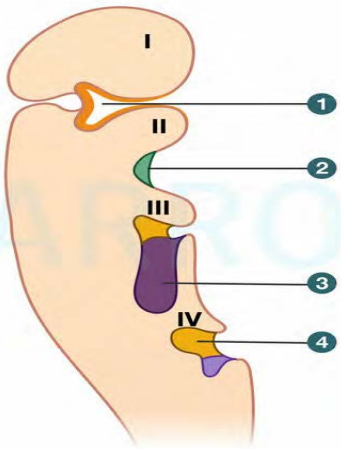
Question 18:

A young patient presented with hypoparathyroidism, absent thymus and tetany. Which of the following marked areas in the picture is defective in this condition?



a) 1

b) 2

c) 3

d) 4

Question 19:

The foramen cecum indicates the site of development of _____.

a) Thyroid

b) Parathyroid

c) Thymus

d) Pituitary

Question 20:

The tongue muscles are derived from _____

a) Preoccipital myotomes

b) Occipital myotomes

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c) Ectoderm derived

d) Splanchnic mesoderm

Question 21:

A 19-year-old girl presented with a painless swelling on the right side of the neck. CT-scan revealed a well-defined cystic mass at the angle of the mandible just in front of the anterior border of the sternocleidomastoid muscle. Persistence of which of the following structures during the development will most likely cause the given condition?

a) First branchial cleft

b) Ultimobranchial body

c) Cervical sinus

d) Fourth branchial pouch

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Question 22:

The cardiac and smooth muscles are derived from:

a) Ectoderm

b) Somatic mesoderm

c) Branchial mesoderm

d) Splanchnic mesoderm

Question 23:

The structures marked as “1” and “2” in the image below are developmentally derived from _____ and _____, respectively.

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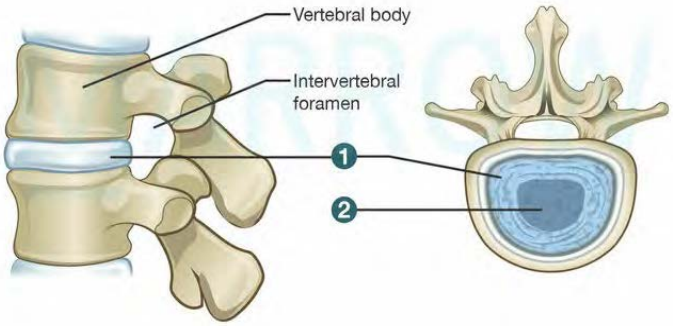

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a) Notochord and sclerotome

b) Sclerotome and dermatome

c) Dermatome and notochord

d) Sclerotome and notochord

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Question 24:

The long left recurrent laryngeal nerve is due to the persistence of which arch artery?

a) 3rd arch

b) 4th arch

c) 5th arch

d) 6th arch

Answer Key

Question No.	Correct Option
1	c
2	c
3	c
4	a
5	a

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6	c
7	b
8	b
9	b
10	a
11	d
12	c
13	b
14	d
15	d
16	b
17	b
18	c
19	a
20	b
21	c
22	d
23	d
24	d

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Detailed Explanations

Solution to Question 1:

The core of each pharyngeal arch (branchial arch) is derived from mesoderm and neural crest cells.

Pharyngeal arches initially have identical structures:

• Surface ectoderm on the outside

• A mesenchymal core derived from mesoderm

• Endoderm derived epithelium on the inside

The mesoderm in the arches is derived from paraxial mesoderm and lateral plate mesoderm. This is invaded by the neural crest cells that contribute to the formation of skeletal elements and connective tissue of the head and neck region.

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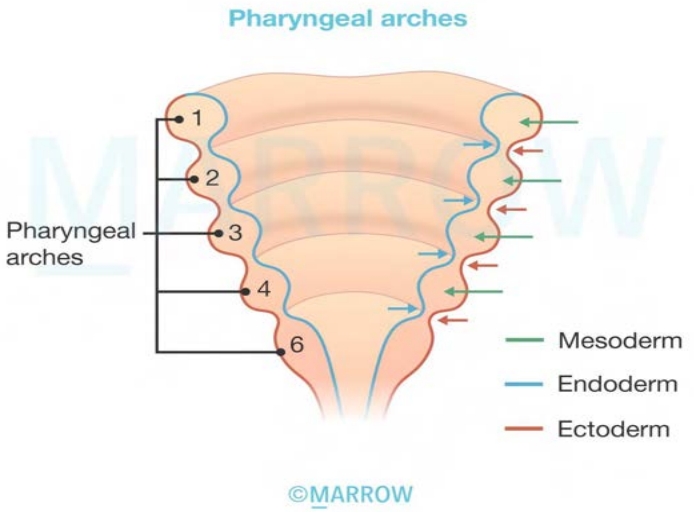

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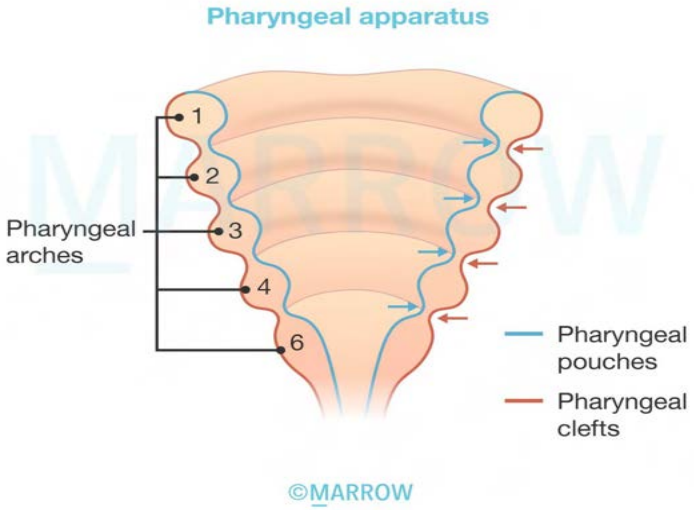
Solution to Question 2:

The 5th pharyngeal arch disappears soon after its formation, so only 5 arches remain.

Pharyngeal arches appear in the 4th or 5th week of development and contribute to the formation of the head and neck region. They are formed as a series of 6 thickenings in the cranial most part of the foregut (the future pharynx). They are craniocaudally numbered from I to VI. The 5th pharyngeal arch disappears, so only 5 arches remain.

- The first pharyngeal arch is also known as the mandibular arch
- The second pharyngeal arch is also known as the hyoid arch
- The 3rd, 4th, and 6th pharyngeal arches have no special names



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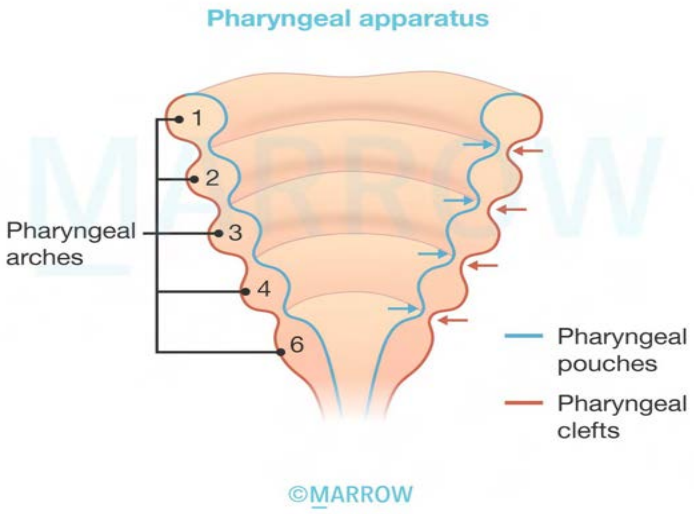
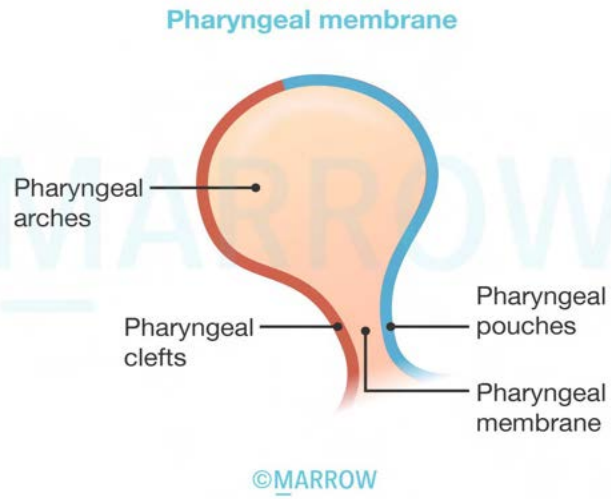
Solution to Question 3:

The pharyngeal membrane is the location where the ectoderm of the pharyngeal cleft meets the endoderm of the pharyngeal pouch.

In the interval between any two adjoining pharyngeal arches, the endoderm extends outward in the form of a pouch (pharyngeal pouch) to meet the ectoderm, which dips into this interval as a pharyngeal cleft. The membrane formed where the pharyngeal cleft comes in contact with the pouch is called the pharyngeal membrane.

Initially, there are four pharyngeal membranes between the five arches. Only the first pharyngeal membrane develops and contributes to the formation of the tympanic membrane. The 2nd, 3th, and 4th pharyngeal membranes do not develop further into any structure. They get obliterated when the mesoderm from the 2nd arch overgrows and fills the succeeding clefts.





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Solution to Question 4:

The clinical features are suggestive of first arch syndrome due to the defect in the development of the first pharyngeal arch.

The derivatives of the first pharyngeal arch are:

Skeletal derivatives: It has 2 prominences -

• Mandibular prominence (ventral)

• Meckel's cartilage: Malleus, incus, anterior malleolar ligament, the spine of the sphenoid, and the sphenomandibular ligament.

• Mesenchyme: In the jaw region, it surrounds the Meckel's cartilage and undergoes membranous ossification to form the mandible

• Maxillary prominence (dorsal)

• Mesenchyme: Maxilla, zygomatic bone, and part of the temporal bone are formed by membranous ossification

Pharyngeal pouch derivatives:

• Auditory tube

• Middle ear cavity

Muscular derivatives:

• Tensor tympani

• Tensor veli palaitini

• Muscles of mastication

• Anterior belly of digastric

• Mylohyoid

Vascular derivatives:

• Maxillary artery

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Solution to Question 5:

The given scenario is suggestive of Treacher Collins syndrome that results from abnormal development of the 1st pharyngeal arch (mandibular arch).

First arch syndromes are congenital defects caused due to the failure of the neural crest cells to migrate into the 1st pharyngeal arch. They are:

• Treacher-Collins syndrome (mandibulofacial dysostosis) - Autosomal dominant genetic disorder characterized by:

• Craniofacial bone defects - Involves mandible (causing micrognathia), maxilla, and zygomatic arches

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• Ear defects - Involves the external ear, atresia of auditory canals, and abnormalities of the middle ear ossicles leading to bilateral conductive hearing loss

• Eye defects - Down-slanting palpebral fissures and lower eyelid colobomas

• Pierre Robin sequence (or Robin sequence) - Caused due to genetic defects or due to environmental factors. It can also be seen in oligohydramnios when the chin gets compressed against the chest in utero.

• It is characterized by a triad of micrognathia, glossoptosis (posteriorly placed tongue), and cleft palate

• The primary defect is poor growth of the mandible (micrognathia)

• As a consequence of this, the tongue is posteriorly placed (glossoptosis)

• Additionally, the tongue remains in between the palatal shelves and they fail to fuse (cleft palate)

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Solution to Question 6:

The stapes is not derived from the Meckel's cartilage.

The cartilage of the first arch is Meckel's cartilage. Structures derived from it include:

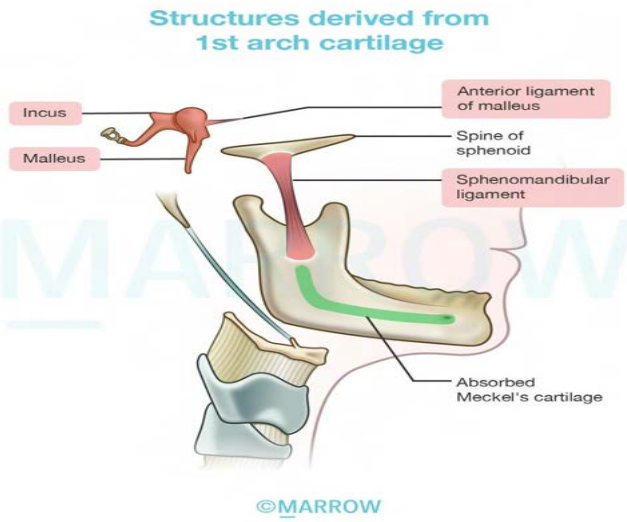
• Malleus

• Incus

• Anterior ligament of malleus

• Spine of sphenoid

• Sphenomandibular ligament



Note:

• The mandible, maxilla, zygomatic bone, and part of the temporal bone are formed from the mesenchyme of the first arch and not from Meckel's cartilage.

• The portion of Meckel's cartilage that extends from the mandibular symphysis to mental foramen is probably incorporated into the intramembranous mandibular bone.

Solution to Question 7:

The stylohyoid ligament is derived from the cartilage of the second pharyngeal arch which is Reichert's cartilage.

Reichert's cartilage contributes to the development of the following structures:

The dorsal portion forms:

• Stapes

• Styloid process of the temporal bone

• Stylohyoid ligament

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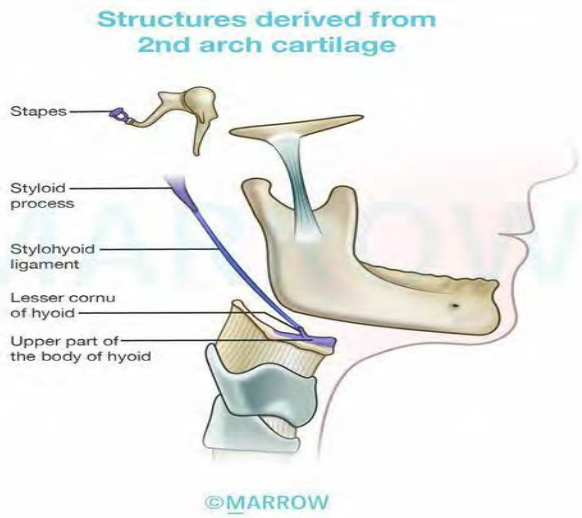
The ventral portion forms:

• The upper part of the body and the lesser cornu of the hyoid bone.

Note: This condition is called Eagle syndrome. It is a condition associated with the elongation of the styloid process or calcification of the stylohyoid ligament.



These structures can be remembered as 5S's:

• Stapes

• Styloid process of the temporal bone

• Stylohyoid ligament

• Smaller (lesser) cornu of the hyoid bone

• Superior part of the body of the hyoid bone

Solution to Question 8:

Greater cornu (greater horn) is derived from the 3rd pharyngeal arch.

The lower part of the body of the hyoid bone is also formed from 3rd pharyngeal arch.

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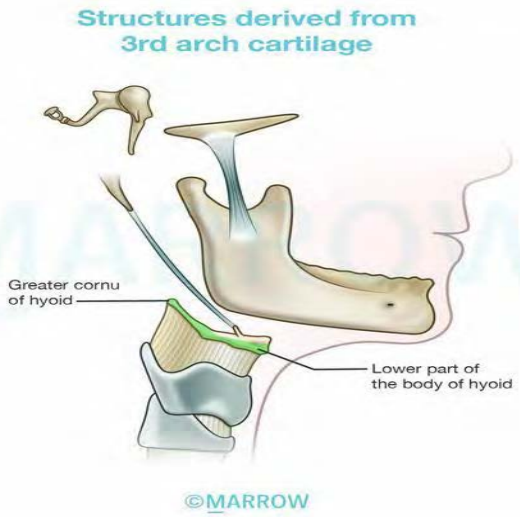

Solution to Question 9:

The tensor tympani muscle is affected in the mandibular nerve injury. The mandibular nerve supplies the muscle since it is derived from the first pharyngeal arch (mandibular arch).

Pharyngeal Arch	Muscle derivatives
I	Muscles of mastication, mylohyoid, anterior belly of digastric, tensor tympani, and tensor veli palatini
II	Muscles of facial expression, stapedius, stylohyoid, platysma, and posterior belly of digastric
III	Stylopharyngeus
IV	Larynx - cricothyroid; soft palate - levator veli palatini; pharyngeal constrictors
VI	Larynx - All intrinsic muscles (except cricothyroid)

Solution to Question 10:

In the above scenario, the cricothyroid muscle is affected since it is responsible for high pitch phonation. It is derived from the 4th pharyngeal arch.

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All the other intrinsic muscles of the larynx arise from the 6th pharyngeal arch.

Pharyngeal Arch	Muscle derivatives
I	Muscles of mastication, mylohyoid, anterior belly of digastric, tensor tympani, and tensor veli palatini
II	Muscles of facial expression, stapedius, stylohyoid, platysma, and posterior belly of digastric
III	Stylopharyngeus
IV	Larynx - cricothyroid; soft palate - levator veli palatini; pharyngeal constrictors
VI	Larynx - All intrinsic muscles (except cricothyroid)

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Solution to Question 11:

The recurrent laryngeal nerve of the vagus is the nerve of the 6th pharyngeal arch.

The vagus nerve is distributed to the 4th and 6th arches as follows:

• Superior laryngeal nerve for 4th arch

• Recurrent laryngeal nerve for 6th arch

Solution to Question 12:

The facial nerve is the nerve of the 2nd pharyngeal arch.

Each pharyngeal arch is characterized by its own muscular components. The muscular components of each arch have their own cranial nerve. Wherever the muscle cells migrate, they carry their nerve component with them.

The neurons of the 5th, 7th, 9th, and 10th cranial sensory ganglia that supply the pharyngeal arch structures are derived from ectodermal placodes (epipharyngeal placodes) and from the neural crest cells.

Solution to Question 13:

The stapedial artery develops in the second pharyngeal arch (hyoid arch).

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Arteries of the pharyngeal arches	
Arch	Artery
I	Maxillary arteries
II	Hyoid and stapedial arteries
III	Common carotid and the first part of the internal carotid arteries
IV	Left side: Arch of the aortaRight side: Right subclavian artery
VI	Left side: Left pulmonary artery and ductus arteriosusRight side: Right pulmonary artery

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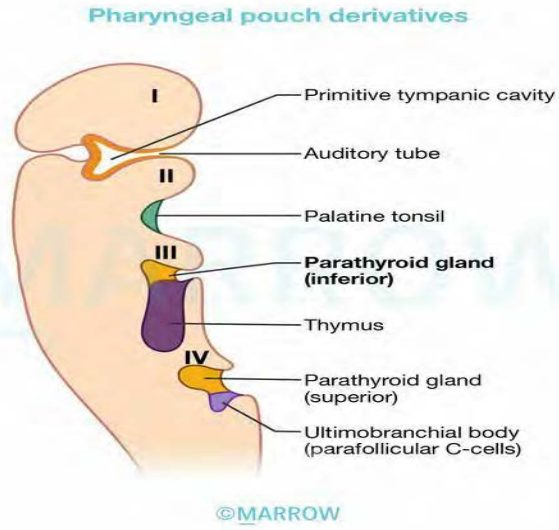
Solution to Question 14:

The given clinical scenario of congenital hypoparathyroidism and thyroid hypoplasia, absent thymus on CT scan is suggestive of DiGeorge syndrome. The defect is most likely to be present in the development of third and fourth pharyngeal pouches.

Structures derived from various pharyngeal pouches (I-IV) are:



Solution to Question 15:

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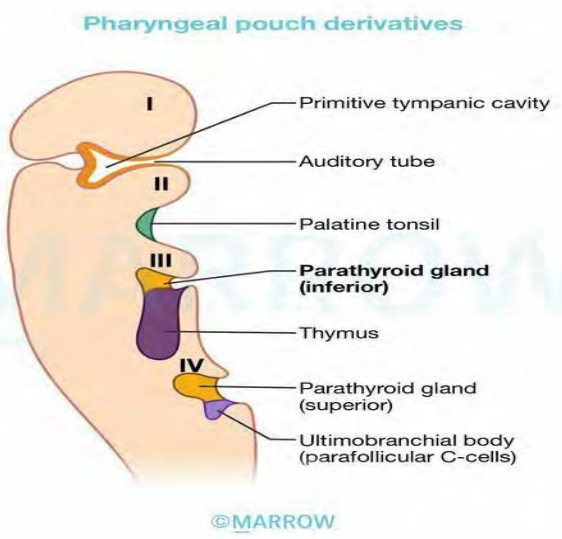
Calcitonin produced by parafollicular C-cells of the thyroid which is derived from the ultimobranchial body (4th pharyngeal pouch derivative).

The 4th pharyngeal pouch develops a small diverticulum medial to the main pouch called the ultimobranchial body. The ultimobranchial body is later incorporated into the thyroid gland and its cells give rise to the parafollicular or C-cells of the thyroid gland. These cells secrete a hormone called calcitonin that is involved in the regulation of the calcium level in the blood.

Clinical consideration: Both chromaffin cells of the adrenal medulla and parafollicular cells (C-cells) of the thyroid originate from the neural crest cells. A common, germ-line mutation in neural crest cells can cause tumors in both the adrenal medulla and the thyroid, as seen in MEN types 2A and 2B.



Solution to Question 16:

The image is showing Hassall's corpuscles (thymic corpuscles) which are derived from the 3rd pharyngeal pouch.

The 3rd pouch gives rise to the thymus in the ventral part and the inferior parathyroid gland in the dorsal part. The thymus then moves away from the pharyngeal wall in a caudal and medial direction, pulling the inferior parathyroid with it. It reaches the anterior part of the thorax, where it fuses with its counterpart from the opposite side.

The endodermal cells of the thymus get invaded by the vascular mesoderm, which contains numerous lymphoblasts. Hassall's corpuscles (thymic corpuscles) are derived from the endoderm of the 3rd pouch. The thymocytes are derived from bone marrow and the cytoreticulum.

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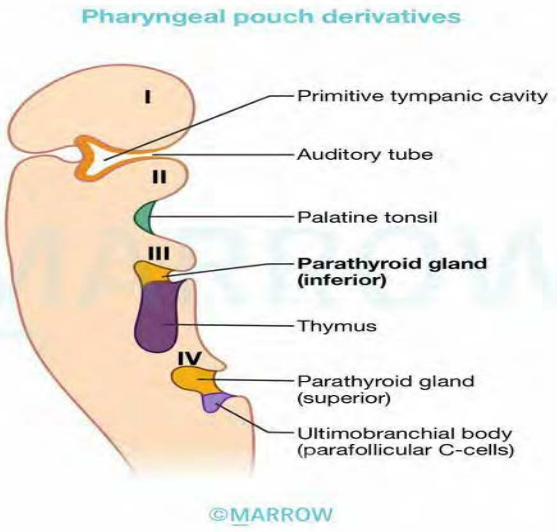

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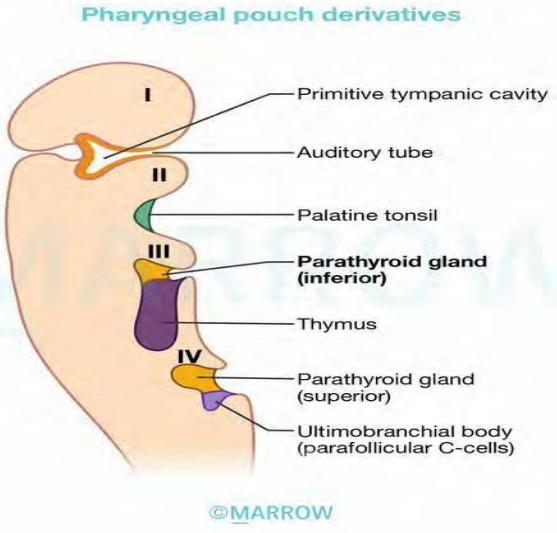
Solution to Question 17:

The diagnosis according to the given clinical vignette is acute tonsillitis affecting palatine tonsils. They are derived from the 2nd pharyngeal pouch.

The epithelium of the 2nd pharyngeal pouch proliferates to form solid cords known as tonsillar buds. The tonsillar buds penetrate into the surrounding mesoderm. These buds are then invaded by the mesodermal tissue to form the palatine tonsil. The capsule of the tonsil is formed by the condensed mesoderm. During the 3rd and 5th months, the tonsil is infiltrated by lymphatic tissue.

The intratonsillar cleft (tonsillar fossa) is the remnant of the 2nd pharyngeal pouch found in the adult.



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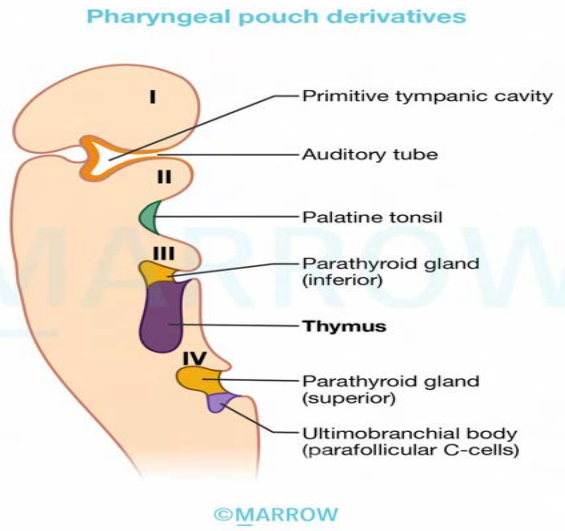
Solution to Question 18:

The given clinical scenario of hypoparathyroidism, absent thymus, and tetany is suggestive of DiGeorge syndrome. It is caused by defective development of the third and fourth pharyngeal pouch. In the image of pharyngeal pouches, "3" points to the thymus (derivative of 3rd pharyngeal pouch). Since in the above question, the thymus is absent, option 3 will be the most appropriate answer.



DiGeorge syndrome is a complex embryopathy that is caused by the hemizygous interstitial deletion of chromosome 22. It is characterized by multiple developmental defects, including conotruncal defects, hypoparathyroidism, and dysmorphic syndrome. It is also known as velocardiofacial syndrome (palate, facial, and cardiac defects).

It has variable presentations including Cleft palate, Abnormal facies, Thymic aplasia leading to T-cell deficiency, Cardiac defects, and Hypocalcemia secondary to parathyroid aplasia (CATCH-22).

Solution to Question 19:

The foramen cecum indicates the site of development of thyroid.

The thyroid gland develops as a midline derivative of the pharynx between the 1st and 2nd pharyngeal pouches. Around the 5th week, a midline diverticulum is formed just caudal to the median tongue bud, at the site where foramen cecum is found later. This midline diverticulum passes caudally as the thyroglossal duct in front of the hyoid bone. The tip of this thyroglossal duct divides into two and their tissue mass proliferates to form the thyroid.

Tissues of the thyroid and their origin:

• The epithelial tissue of the thyroid gland is derived from endoderm.

• The connective tissue of capsule and interlobular septa are derived from the neural crest mesenchyme.

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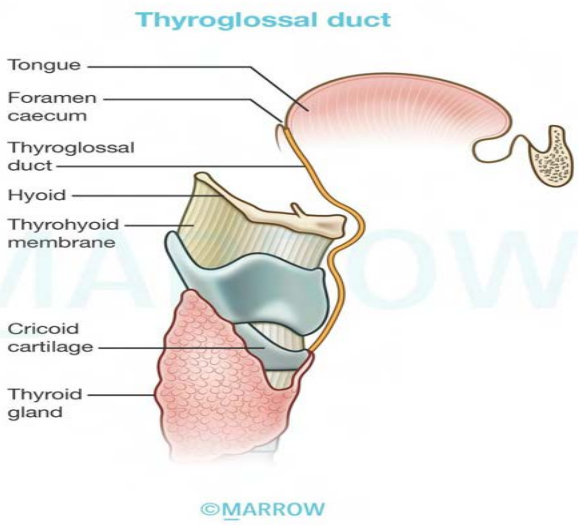
• The parafollicular or C cells are derived from the ultimobranchial body, a small diverticulum of the 4th pharyngeal pouch.

Remnants of the thyroglossal duct can result in the formation of the thyroglossal cyst or fistula.



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Solution to Question 20:

The tongue muscles are derived from the myotomes of the occipital somites.

The tongue muscles get their motor supply from the hypoglossal nerve (12th cranial nerve), except the palatoglossus muscle, which is supplied by the vagus nerve.

Development of the tongue

• The anterior part of the tongue (body) is derived from the 1st pharyngeal arch. It is formed from 2 lateral lingual swellings and one medial swelling called the tuberculum impar.

• The posterior part of the tongue (root) is derived from the mesoderm of the 2nd, 3rd, and part of the 4th arch. This part develops from a medial swelling called copula (hypobranchial eminence).

• The posterior-most part of the tongue and the epiglottis are derived from a third swelling formed in the posterior part of the 4th arch.

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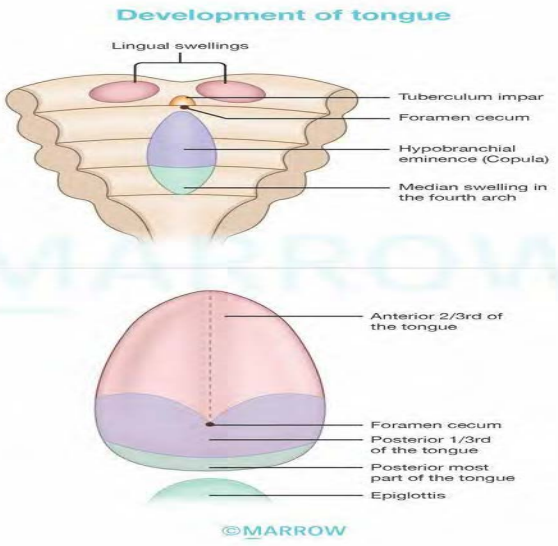

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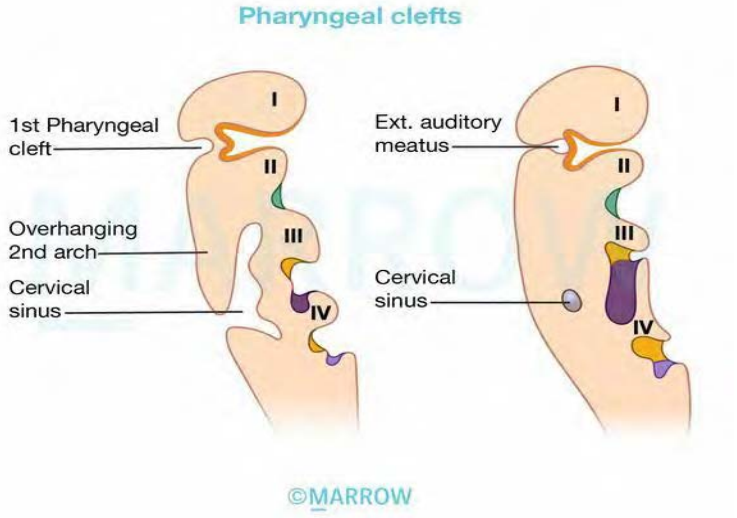
Solution to Question 21:

The given scenario is suggestive of a branchial cyst that develops due to the persistence of the cervical sinus.

The cervical sinus is formed when the 2nd arch mesoderm overgrows the succeeding arches and overhangs them as shown in the image. The space between the overhanging 2nd pharyngeal arch and the 3rd, 4th, and 6th arches is called the cervical sinus. The cavity of the cervical sinus is lined by ectoderm and normally gets obliterated.

In some individuals, a part of the cervical sinus may persist and give rise to swellings known as branchial cysts. It is present in the neck along the anterior border of the sternocleidomastoid muscle. These cysts are most commonly located just below the angle of the mandible. If the branchial cyst opens onto the surface, it becomes a branchial sinus.



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Solution to Question 22:

The cardiac and smooth muscles are derived from the splanchnic mesoderm.

The musculature of the body is derived from the mesoderm as described below:

• Somatic mesoderm: Muscles of limbs and trunk

• Branchial mesoderm: Muscles of head and neck

• Splanchnic mesoderm: Cardiac and smooth muscles

However, there are certain exceptions and some muscles are ectoderm-derived. These include

• Musculature of the iris (spincter and dilator pupillae)

• Erector pili muscles in the skin

• Myoepithelial cells of ducts of sweat glands

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Solution to Question 23:

The structure marked “1” is the outer annulus fibrosus and "2" is the inner nucleus pulposus of the intervertebral disc. They develop from the sclerotome and notochord, respectively.

The vertebral bodies and the annulus fibrosus (peripheral part of the intervertebral disc) are derived from the mesenchymal cells of the sclerotome.

The nucleus pulposus is a remnant of the notochord. The notochord regresses entirely in the region of vertebral bodies, but it persists in the central part of the intervertebral discs as the nucleus pulposus.

Solution to Question 24:

The long left recurrent laryngeal nerve is due to the persistence of the left 6th arch artery.

During the development, the laryngeal nerves initially arise below the 6th arch artery and cross here to innervate the intrinsic muscles of the larynx. As the larynx moves cranially relative to the aortic arch arteries, the recurrent laryngeal nerves on the right and left sides are caught under the 6th arch arteries.

On the right side, the distal 6th arch artery disappears. Since there is no 5th arch artery, the right recurrent laryngeal nerve is caught under the 4th arch artery which becomes the future right subclavian artery.

On the left side, the 6th arch artery persists, which develops into ductus arteriosus, which later forms ligamentum arteriosum. Due to the persistence of the 6th arch artery, the left recurrent laryngeal nerve is caught under it and therefore, has a relatively long course.

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Cardiovascular and Respiratory Systems

Question 1:

The cardiogenic area is formed in which of the following structures?

a) Extraembryonic mesoderm

b) Somatopleuric mesoderm

c) Splanchnopleuric mesoderm

d) Paraxial mesoderm

Question 2:

Arrange the following structures of the primitive heart tube in cranial to caudal order.

a) 2-3-4-1

b) 4-1-2-3

c) 1-4-2-3

d) 1-4-3-2

Question 3:

Which of the following forms the trabeculated part of the right ventricle?

a) Primitive ventricle

b) Distal 1/3 of bulbus cordis

c) Middle 1/3 of bulbus cordis

d) Proximal 1/3 of bulbus cordis

Question 4:

Sinus venosus does not receive blood from which of the following veins?

a) Vitelline vein

b) Umbilical vein

c) Common cardinal vein

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d) Subcardinal vein

Question 5:

A 2-year-old child was found to have an absence of coronary sinus associated with other cardiac defects. Failure in the development of which of the following structures will most likely lead to the given condition?

a) Right umbilical vein

b) Right horn of sinus venosus

c) Left horn of sinus venosus

d) Left vitelline vein

Question 6:

A 40-year-old man had a CT scan to evaluate a lower respiratory tract infection. Incidentally, he was found to have a left-sided superior vena cava draining into the coronary sinus. The patient reported no cardiac symptoms. Failure of regression of which of the following structures during embryonic development leads to the given anatomical variation?

a) Left anterior cardinal vein

b) Right anterior cardinal vein

c) Left common cardinal vein

d) Right posterior cardinal vein

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Question 7:

A major part of the post-renal segment of the inferior vena cava develops from which of the following structures?

a) Supracardinal vein

b) Umbilical vein

c) Anterior cardinal vein

d) Hepato-cardiac channel

Question 8:

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The posterior cardinal vein contributes to the development of which of the following adult structures?

a) Common iliac vein

b) Superior vena cava

c) Internal jugular vein

d) External jugular vein

Question 9:

Which of the following veins is not derived from the vitelline vein?

a) Hepatic vein

b) Superior vena cava

c) Inferior vena cava

d) Superior mesenteric vein

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Question 10:

What is the location of the foramen secundum?

a) Upper part of septum secundum

b) Lower part of septum primum

c) Upper part of septum primum

d) Lower part of septum secundum

Question 11:

The limbus fossa ovalis is the remnant of _____

a) Septum primum

b) Septum secundum

c) Both a and b

d) None of the above

Question 12:

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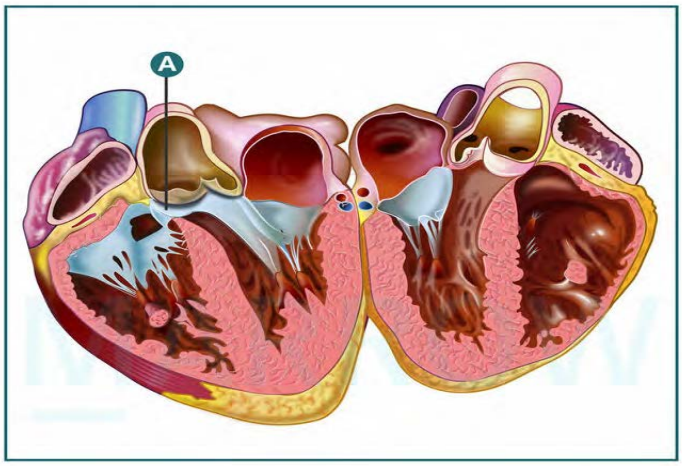
Marked structure is derived from the_____



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a) Endocardial cushions

b) Septum primum

c) Left venous valve

d) Bulbous venosus

Question 13:

Which of the following structures does not contribute to the formation of the arch of the aorta?

a) Left horn of aortic sac

b) Left 4th arch artery

c) Aortic sac

d) Left 2nd arch artery

Question 14:

Which of the following structures is derived from the right 4th aortic arch?

a) Right common carotid artery

b) Right subclavian artery

c) Aortic arch

d) None as it regresses completely

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Question 15:

An infant with a continuous machine-like murmur is diagnosed with patent ductus arteriosus. When does the affected structure normally begin to close?

a) 1-2 months

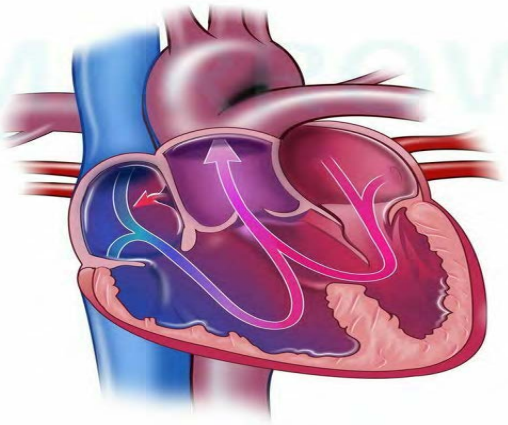
b) 1-2 weeks

c) 1-2 days

d) Immediately

Question 16:

A newborn with persistent cyanosis was being evaluated. He was found to have a congenital heart disease that is schematically represented below. What is the most likely embryological defect causing this?



a) Abnormal spiraling of conotruncal septum

b) Failure in formation of conotruncal ridges

c) Anterior displacement of conotruncal septum

d) Total anomalous pulmonary venous connection

Question 17:

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A newborn developed cyanosis soon after birth. Chest X-ray showed the characteristic egg-on-a-string appearance. Which of the following mechanisms during embryonic development will most likely lead to the given condition?

a) Failure of cono-truncal ridge to fuse and descend

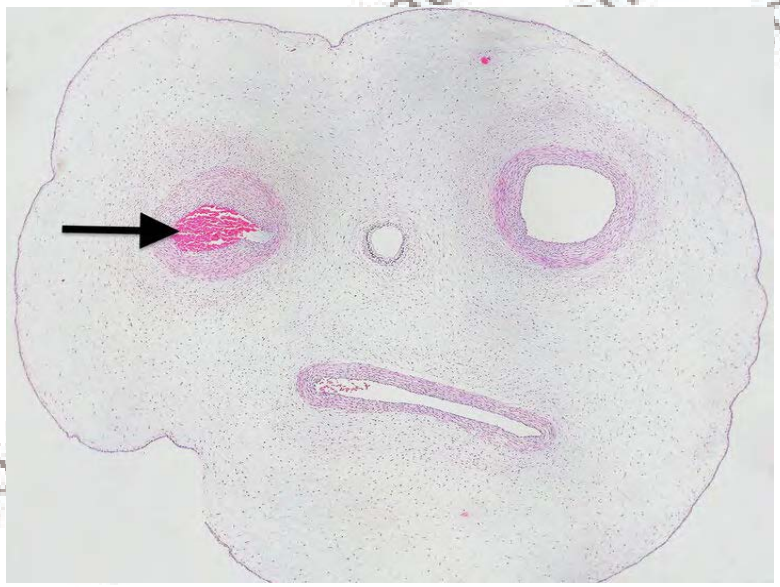
b) Aortico-pulmonary septum not following its spiral course

c) Anterior displacement of aortico-pulmonary septum

d) Non-fusion of aortico-pulmonary septum with truncus arteriosus

Question 18:

A cut section of the umbilical cord is given below. Which of the following is a remnant of the marked structure in an adult?



a) Ligamentum arteriosum

b) Ligamentum teres

c) Median umbilical ligament

d) Medial umbilical ligament

Question 19:

The heart starts to beat in the _____week of development.

a) 2nd week

b) 4th week

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c) 6th week

d) 10th week

Question 20:

The false statement about fetal circulation is:

a) Anatomical closure of foramen ovale is by 3 to 5 days

b) Anatomical closure of ductus venosus is by 3 to 7 days

c) Right umbilical vein is absent

d) Anatomical closure of ductus arteriosus is by 2 to 3 weeks

Question 21:

The appearance of which of the following structures is regarded as the first sign of respiratory system development?

a) Tracheoesophageal septum

b) Hypobranchial eminence

c) Primitive foregut

d) Laryngotracheal diverticulum

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Question 22:

The larynx and the trachea develop from which of the following structures?

a) Laryngotracheal tube

b) Laryngotracheal groove

c) Lung buds

d) Bronchial buds

Question 23:

Which of the following is the most common type of tracheoesophageal fistula (TEF)?

a) Esophageal atresia with proximal TEF

b) Esophageal atresia with distal TEF

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c) H type tracheoesophageal fistula

d) Proximal TEF with distal esophageal atresia

Question 24:

Arrange the following phases of lung development and maturation in order, from the earlier phase to the later phase.

a) 3-2-1-4

b) 2-1-4-3

c) 4-2-1-3

d) 2-4-3-1

Question 25:

A 5-day-old infant was admitted to the NICU as she was suffering from severe dyspnea and cyanosis. Chest X-ray revealed hypoplastic left lung and herniation of the intestines into the left thoracic cavity. Abnormality in which of the following structures during the embryonic development will most commonly lead to the given condition?

a) Mesentery of the oesphagus

b) Pleuropericardial folds

c) Body wall

d) Pleuroperitoneal folds

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Answer Key

Question No.	Correct Option
1	c
2	d
3	d
4	d
5	c
6	a
7	a

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8	a
9	b
10	c
11	b
12	a
13	d
14	b
15	d
16	b
17	b
18	d
19	b
20	a
21	d
22	a
23	b
24	d
25	d

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Detailed Explanations

Solution to Question 1:

The heart develops from angioblastic tissue in the splanchnopleuric mesoderm.

The heart develops from two endothelial heart tubes. These heart tubes are derived from the splanchnic layer of the lateral plate mesoderm also known as splanchnopleuric mesoderm.

Progenitor heart cells form a horseshoe-shaped cluster of cells cranial to the neural fold. This location from which the heart originates is known as the cardiogenic area.

The image below shows location of cardiogenic area during embryological development.

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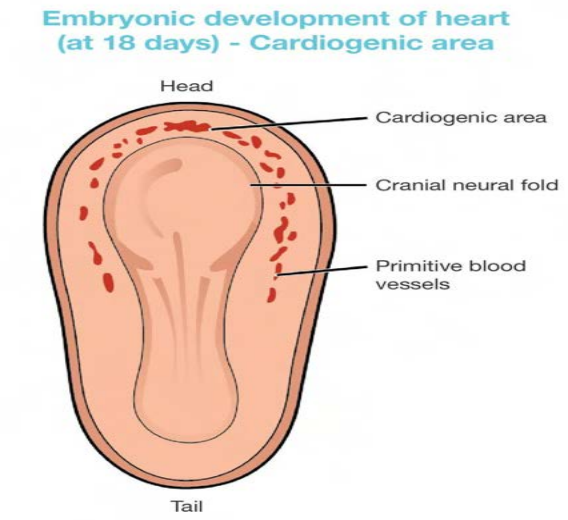

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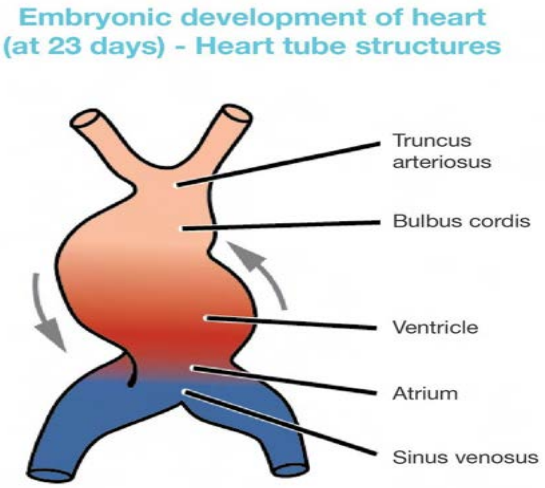
Solution to Question 2:

The correct order of heart tube structures from cranial to caudal is bulbus cordis, primitive ventricle, primitive atrium, and the sinus venosus.



The 2 heart tubes formed in the cardiogenic area fuse, except in their caudal most end, to become an inverted Y-shaped structure. During this fusion, the central part of the heart tube expands to form the future outflow tract and ventricular regions. The caudal pole of the tube receives the venous drainage, while the cranial end pumps out blood into the arterial system.

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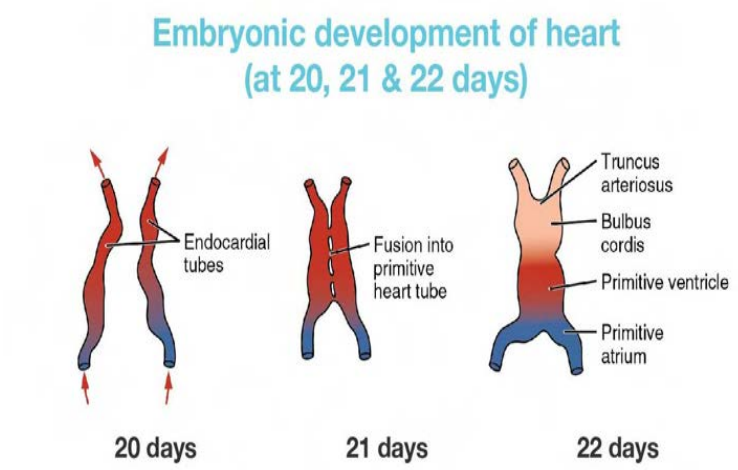

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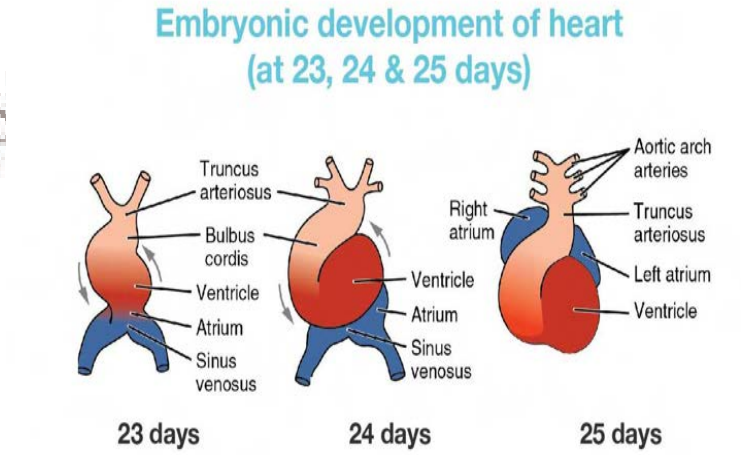
Solution to Question 3:

The trabeculated part of the right ventricle is formed from the proximal 1/3rd of the bulbus cordis.

The heart tube begins to bend by day 23. This bending creates the cardiac loop. The fate of various structures formed as a result of this bending is as follows:



Given below are the heart tube and their derivatives:

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Part of the heart tube	Derivative structure in the heart
Bulbus cordisProximal 1/3Middle 1/3 (conus cordis)Distal 1/3 (truncus arteriosus)	Trabeculated part of Rt.ventricleOutflow tract of Rt. and Lt.ventriclesRoot and proximal portions of aorta and pulmonary artery
Primitive ventricle	Trabeculated part of the Lt.ventricle
Primitive atrium	The common atrium that splits to Rt. and Lt.atrium

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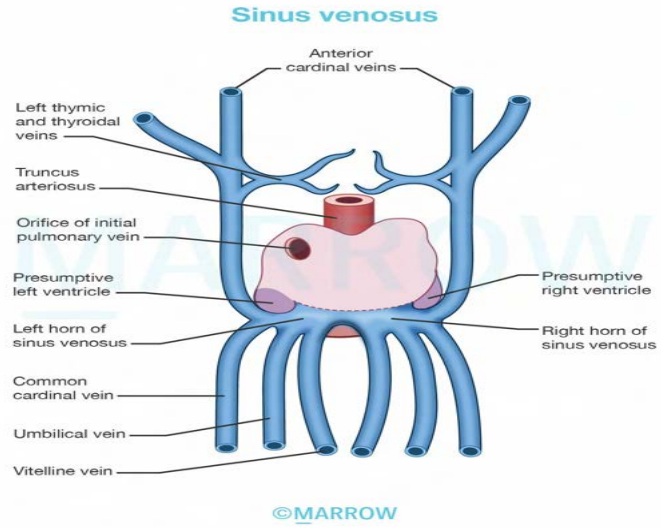
Solution to Question 4:

The sinus venosus does not receive blood from the subcardinal veins. They are found in relation to the urogenital ridges and mainly drain the developing kidney.

Sinus venosus is the caudal-most part of the tubular heart and has right and left horns. Each horn of sinus venosus has 3 branches:

- Vitelline vein receives blood from the yolk sac
- Umbilical vein receives blood from the placenta
- Common cardinal vein receives blood from the body wall



Solution to Question 5:

The coronary sinus develops from the left horn of the sinus venosus. Hence, its developmental failure will lead to defects of the coronary sinus.

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Initially, the communication between the sinus venosus and the atrium is wide. Later, the entrance of the sinus venosus shifts to the right side due to the establishment of left-to-right shunts of blood.

The fate of sinus venosus and its branches near the heart is as follows:

• Right horn of sinus venosus gets incorporated into the right atrium

• Right umbilical vein: obliterates

• Right common cardinal vein: Becomes part of the superior venacava

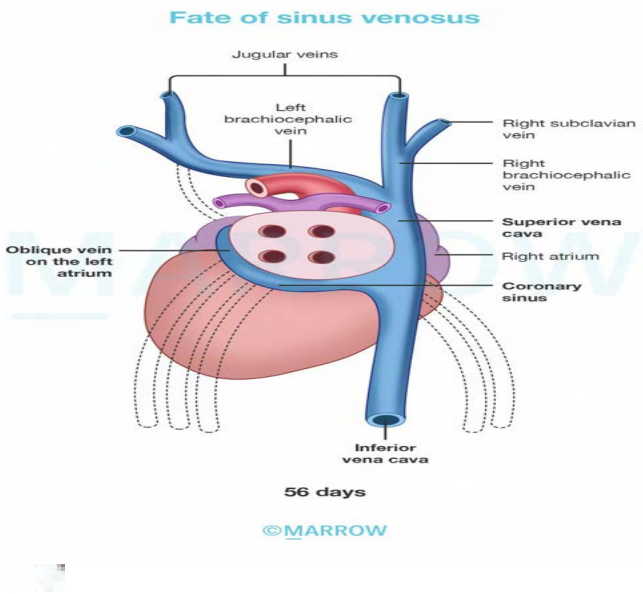
• Right vitelline vein: Becomes the terminal part of inferior venacava

• Left horn of sinus venosus reduces in size and becomes the coronary sinus

• Left umbilical vein: obliterates

• Left common cardinal vein: reduces the size and becomes the oblique vein of the left atrium

• Left vitelline vein: obliterates



Solution to Question 6:

Persistent left-sided superior vena cava occurs due to failure of regression of the left anterior cardinal vein. It may drain either into the coronary sinus or the left atrium.

The formation of the vena cava system begins with the formation of anastomoses between the right and left venous channels. Formation of the major veins takes place as follows:

• The proximal part of the right anterior cardinal vein along with the right common cardinal vein form the superior vena cava

• The distal part of the right anterior cardinal vein between the junction with the subclavian vein and the junction with the transverse anastomosis becomes the right brachiocephalic vein

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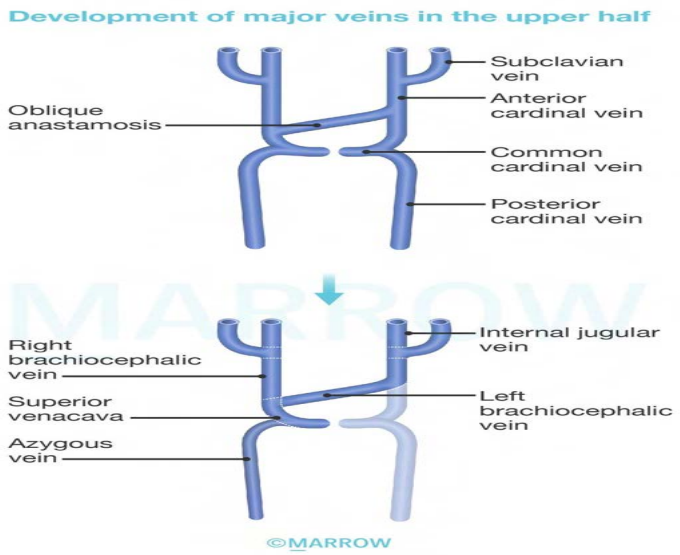
• The distal part of the left anterior cardinal vein and the transverse anastomosis becomes the left brachiocephalic vein

• The most cranial part of both the anterior cardinal veins above its junction with subclavian vein become the internal jugular vein



Solution to Question 7:

The post-renal segment of the inferior vena cava (IVC) mainly develops from the right supracardinal vein.

In embryonic life, the supracardinal veins get a large amount of venous drainage from the growing body wall. The right supracardinal vein persists and forms the greater part of the postrenal segment of the inferior vena cava.

The inferior vena cava is a composite vessel that develops from the remodeling of successive venous complexes. The veins contributing to the formation of IVC from upwards to below are as follows:

• Cardiac termination of the right vitelline vein, also known as the right hepatocardiac channel

• Anastomosis between right vitelline and right subcardinal veins (Hepatic segment of IVC)

• Right subcardinal vein (Subcardinal or Pre-renal segment of IVC)

• Anastomosis between right supracardinal and right subcardinal veins (Renal segment of IVC)

• Part of the right supracardinal vein (Supracardinal or Post-renal segment of IVC)

• Anastomosis between right supracardinal and right postcardinal veins

• Part of the right posterior cardinal vein

• Common iliac veins

MARROW

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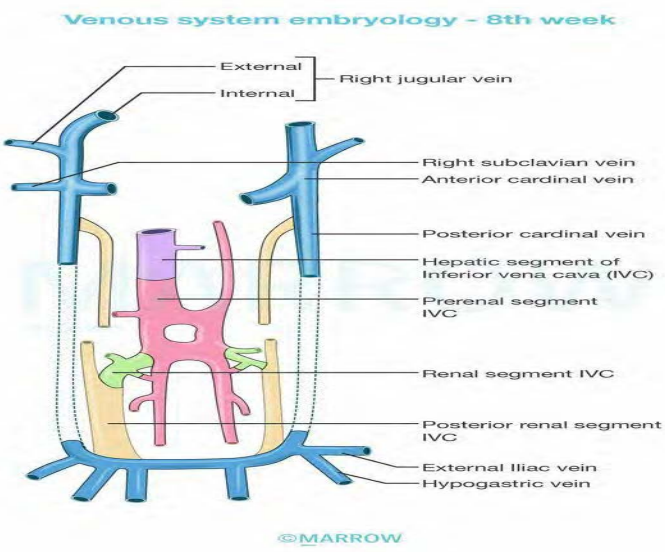

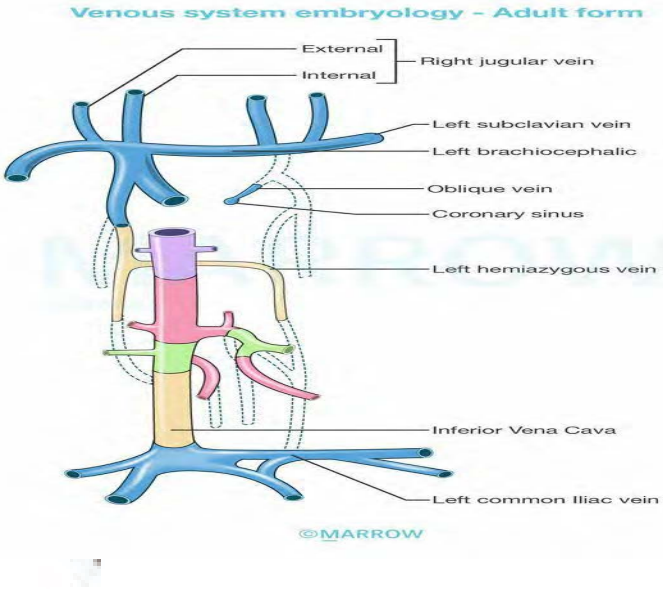

Solution to Question 8:

The posterior cardinal vein contributes to the development of the right common iliac vein.

The common iliac veins develop as follows:

• The right common iliac vein is derived from the most caudal portion of the right posterior cardinal vein.

• The left common iliac vein develops from the anastomosis between the sacrocardinal veins.

Solution to Question 9:

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The superior vena cava is not derived from the vitelline vein.

Vitelline veins are developmental vessels passing between the yolk sac and the sinus venosus of the heart. Vitelline veins contribute to the development of the following structures:

• Hepatic vein: Before entering the sinus venosus, the vitelline veins form a plexus around the duodenum and pass through the septum transversum. The liver cords grow into the septum breaking the course of this vein into an extensive vascular network known as hepatic sinusoids. The sinusoids form the hepatic vein and drain into the inferior vena cava.

• Portal vein: The anastomotic plexus formed by the vitelline veins around the duodenum develops into a single vessel called the portal vein.

• Inferior vena cava: The hepatocardiac portion of IVC develops from the right hepatocardiac channel, which is derived from the right vitelline vein.

• Superior mesenteric vein: This vein is derived from the right vitelline vein and drains the primary intestinal loop.

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Solution to Question 10:

The foramen secundum (ostium secundum) is present at the upper part of the septum primum.

During fetal life, oxygenated blood reaches the right atrium from the placenta. This blood then reaches the left atrium through the gap between the atria. The initial gap is the foramen primum formed at the lower end of the septum primum.

Before the foramen primum is closed, another path has to be created for the flow of blood. This gap is the foramen secundum at the upper part of the septum primum.

Solution to Question 11:

The limbus fossa ovalis (also known as annulus ovalis) represents the remnant of the lower free edge of the septum secundum.

Fossa ovalis is an oval-shaped depression in the septal wall of the right atrium just above the opening of inferior vena cava. It marks the location of embryonic foramen ovale.

• The floor of fossa ovalis is the remnant of septum primum.

• The limbus of fossa ovalis is the prominent upper margin of the fossa ovalis and a remnant of the septum secundum.

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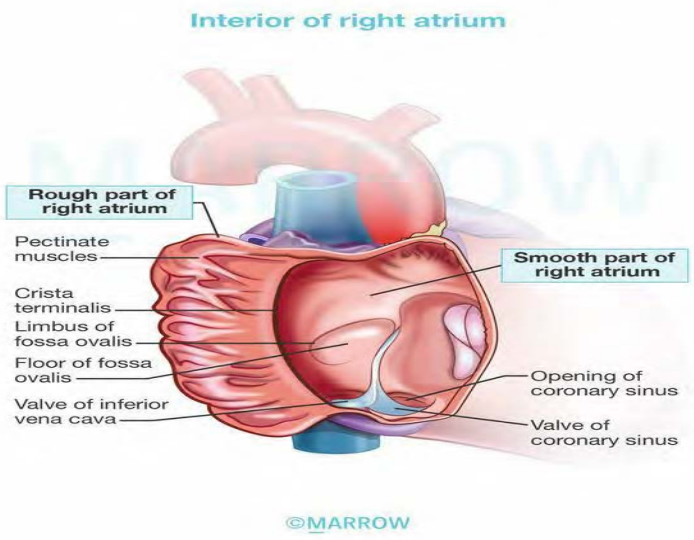

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Solution to Question 12:

The structure marked is the membranous part of the interventricular septum. It is derived from endocardial cushions.

Endocardial cushions are soft tissue masses that protrude in the atrioventricular and conotruncal regions.

• Atrioventricular cushions are derived from overlying endocardial cells.

• The conotruncal cushions are derived from the neural crest cells.

Endocardial cushions contribute to the formation of:

• Atrial septa

• Ventricular septa (membranous portion)

• Atrioventricular canals

• Atrioventricular valves

• Aortic and pulmonary channels

Defects in endocardial cushion formation can result in cardiac malformations, including ASDs, VSDs, and defects involving the great vessels (transposition of the great vessels, common truncus arteriosus, and tetralogy of Fallot).

Solution to Question 13:

The left 2nd arch artery does not contribute towards the formation of the arch of the aorta.

Arch of the aorta develops from the following:

• Ventral part of the aortic sac

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• Left horn of the aortic sac

• Left 4th arch artery

Solution to Question 14:

The proximal part of the right subclavian artery is derived from the right 4th aortic arch.

The distal segment of the right subclavian artery is derived from the right dorsal aorta and the 7th intersegmental artery.

The 4th aortic arch persists on both sides and forms different structures on either side:

• Left side: Part of the arch of the aorta between the left common carotid and the left subclavian arteries

• Right side: Proximal segment of the right subclavian artery

Solution to Question 15:

The ductus arteriosus gets functionally closed through contraction of its muscular wall almost immediately after birth. However, anatomical closure occurs only 2-3 weeks after birth.

In fetal life, prostaglandins relax the vascular smooth muscle and keep the ductus arteriosus open.

After birth, there is high oxygen content in the blood due to ventilation in the lung. This inhibits the production of prostaglandins. The ductus closes due to vascular smooth muscle contraction leaving a ligamentous remnant known as ligamentum arteriosum.

Note: Premature infants can be treated with prostaglandin synthesis inhibitors (such as indomethacin) to promote closure of the ductus arteriosus.

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Solution to Question 16:

The given scenario is suggestive of persistent (patent) truncus arteriosus. Failure in the formation (absence) of conotruncal ridges leads to this condition.

The aortopulmonary septum is also known as the conotruncal septum. The formation of the aortopulmonary septum in the truncus arteriosus divides the outflow channel of the heart into the ventral aorta and the pulmonary trunk.

Persistent truncus arteriosus results when the conotruncal ridges fail to form. As the conotruncal ridges also participate in the formation of the interventricular septum, there will be a defective interventricular septum in this condition. The persistent truncus overrides both the ventricles and receives mixed blood from both sides.

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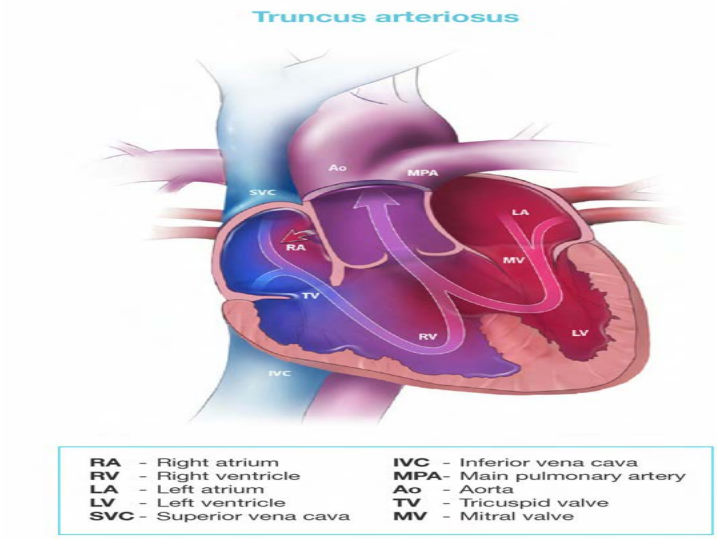

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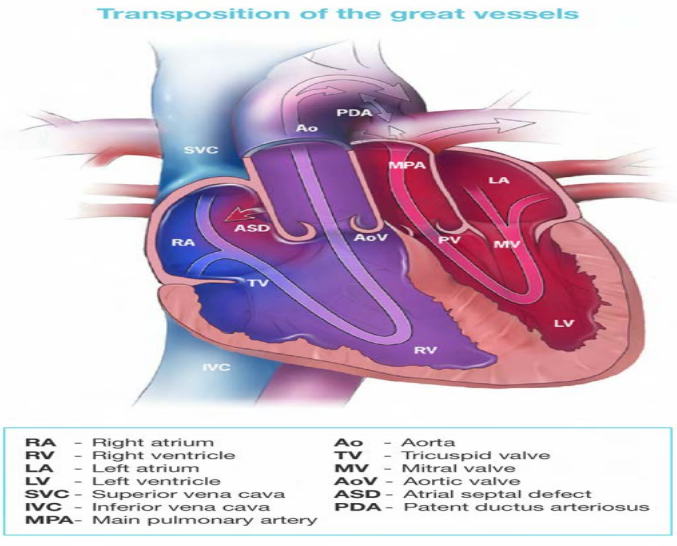
Solution to Question 17:

The egg-on-a-string appearance on chest X-ray is characteristically seen in the transposition of great arteries (TGA). It is considered to arise due to abnormal spiraling of the aortopulmonary septum (conotruncal septum).

In this condition, the aortopulmonary septum fails to follow the normal spiral course and instead runs straight. This results in aorta arising from the right ventricle and the pulmonary trunk from the left ventricle. This condition is seen in 4.8/10,000 births.

Patent ductus arteriosus is commonly seen along with this condition. Sometimes, there is an associated defect in the membranous part of the interventricular septum.



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Solution to Question 18:

The marked structure in the image is an umbilical artery. The medial umbilical ligament is the remnant of this structure.

The umbilical artery has the following fate:

• Proximal parts persist as the superior vesical arteries

• Distal parts get obliterated and form the medial umbilical ligaments

Given below are the embryological remnants at the umbilicus:

Embryological structure	Remnant
Left umbilical vein	ligamentum teres
Umbilical arteries	medial umbilical ligaments
Urachus	median umbilical ligament

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Solution to Question 19:

The heart starts to beat in the 4th week of development.

Solution to Question 20:

The anatomical closure of the foramen ovale takes 1 month to a year.

Given below are the fetal circulatory adjustments after birth:

	Functional closure	Anatomical closure
Ductus venosus	After removal of the placenta	7 days
Foramen ovale	At birth - after breathing is initiated	Months to years
Ductus arteriosus	10–15 hours	10–21 days

Solution to Question 21:

The appearance of the laryngotracheal (respiratory) diverticulum is regarded as the first sign of respiratory system development. It appears in the ventral wall of the pharyngeal part of the

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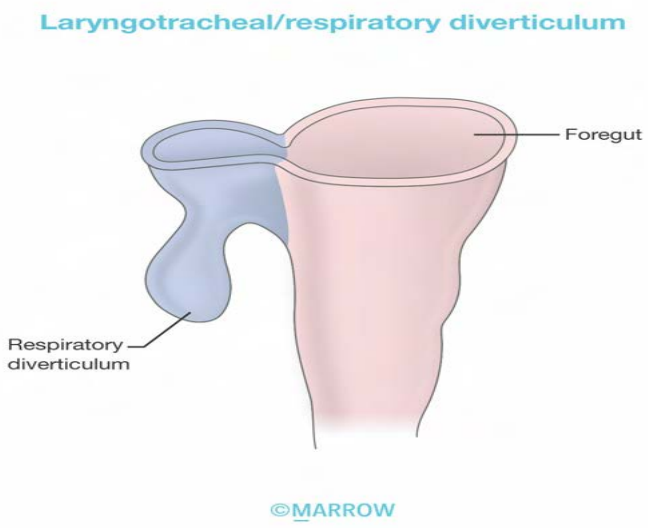
foregut.

The respiratory system is derived from 2 sources:

• Endoderm of the foregut: The lining epithelium of the larynx, trachea, bronchi, bronchioles, and alveoli are derived from the endoderm.

• Splanchnopleuric intraembryonic mesoderm: The cartilages, muscles, and connective tissue of the respiratory tract are derived from the splanchnopleuric intraembryonic mesoderm surrounding the foregut.

The image given below shows the development of the respiratory diverticulum.



Solution to Question 22:

The larynx and trachea develop from the laryngotracheal tube.

The laryngotracheal (respiratory) diverticulum develops from the ventral wall of the pharyngeal part of the foregut.

The free caudal end of the respiratory diverticulum elongates downwards to enter the thorax, where it bifurcates to form the right and left bronchial buds or lung buds, which in turn further develops to form the bronchi and the lung parenchyma.

The part of the diverticulum cranial to the bifurcation is known as laryngotracheal tube, which further develops to form the larynx and trachea.

Solution to Question 23:

The most common type of tracheoesophageal fistula (TEF) is esophageal atresia with distal TEF (also known as type C).

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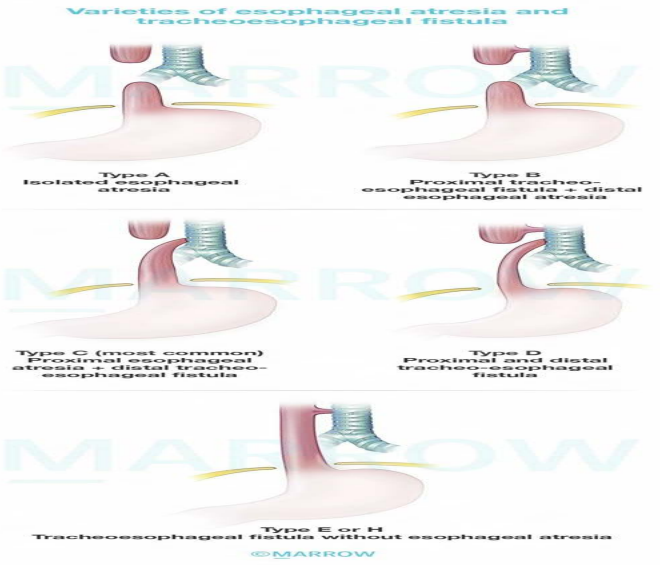
It occurs due to the defective formation of the tracheoesophageal septum. There is an abnormal connection (fistula) between the esophagus and the trachea. These defects occur in approximately 1/3000 births. The condition is commonly associated with esophageal atresia.

TEF can be grossly classified into 5 types, types A to E, as shown in the image below:



Solution to Question 24:

The correct order of phases of lung maturation is as follows: embryonic, pseudoglandular, canalicular, saccular phase.

The development and maturation of the lungs occur mainly in the following phases:

Phase	Developmental events
Embryonicphase (0–7 weeks)	Appearance of lung buds and the main pulmonary arteries
Pseudoglandularphase (7–17 weeks)	Development of airways and blood vessels to the level of t he acinus
Canalicularphase (17–27 wee ks)	Formation of respiratory air ways and the development of the blood-air barrier
Saccularphase/Alveolarphase (28–32 weeks to after birth)	Development and secondary septation of alveoliAdjacent c apillary networks fuse to for m an extensive double capilla ry network

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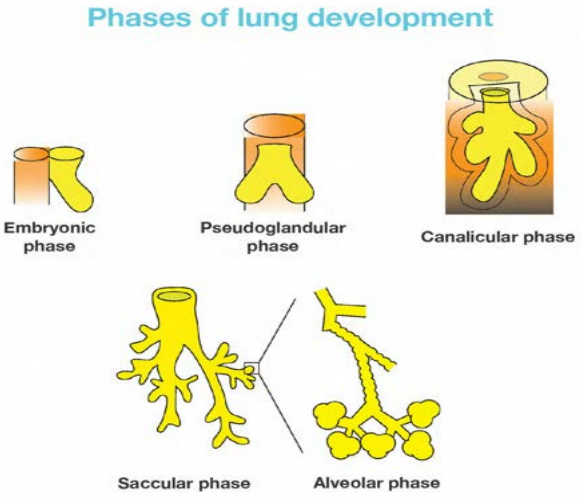

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Solution to Question 25:

The given clinical scenario is suggestive of a congenital diaphragmatic hernia. It most commonly occurs due to failure of fusion of pleuroperitoneal folds during the development of the diaphragm.

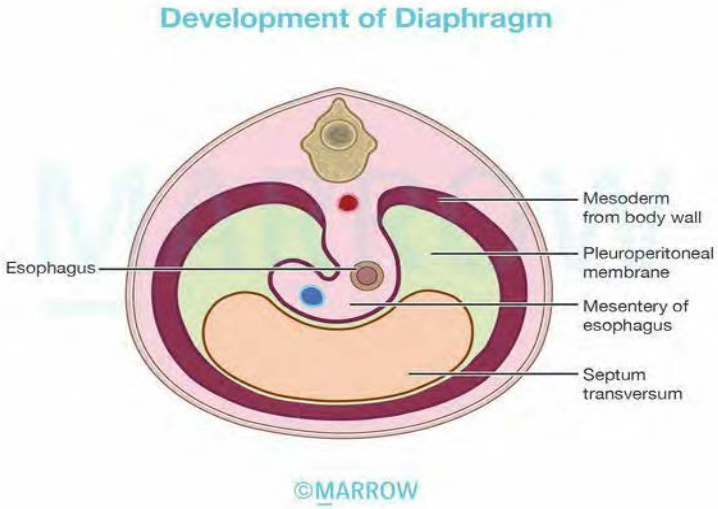
The diaphragm develops from 4 mesodermal sources as follows:

• Septum transversum becomes the anterior and medial part of the diaphragm including the central tendon

• Pleuroperitoneal membranes (paired structures) become the dorsolateral parts of the diaphragm

• Mesoderm of body wall from somites of cervical segments three to five (C3-5) contribute to the peripheral muscular part

• Mesentery of the esophagus forms the crura of the diaphragm



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Congenital diaphragmatic hernia results due to failure of various structures forming diaphragm to fuse. It occurs in 1/2000 births. The defect allows abdominal viscera to enter the pleural cavity. It is most frequently caused by the failure of one or both of the pleuroperitoneal membranes to fuse. Posterolateral defects (Bochdalek's hernia) are the most common (85–90%).

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Alimentary, Hepatobiliary systems, Pancreas and Spleen

Question 1:

The mouth is derived from which of the following germ layers?

a) Endoderm only

b) Endoderm and Mesoderm

c) Ectoderm and Endoderm

d) Ectoderm, Endoderm and Mesoderm

Question 2:

The primitive gut is derived from which of the following structures?

a) Endoderm

b) Ectoderm

c) Amniotic cavity

d) Intraembryonic coelom

Question 3:

Which of the following structures give rise to the duodenum?

a) Foregut only

b) Midgut and Hindgut

c) Foregut and Midgut

d) Midgut only

Question 4:

Which of the following arteries supplies foregut derivatives of the digestive system?

a) Celiac trunk

b) Superior mesenteric artery

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c) Inferior mesenteric artery

d) Abdominal aorta

Question 5:

Which of the following structures give rise to the cecal bud?

a) Pre-arterial segment of midgut loop

b) Post-arterial segment of midgut loop

c) Pre-arterial segment of hindgut loop

d) Post-arterial segment of hindgut loop

Question 6:

How much does the midgut rotate around the superior mesenteric artery?

a) 270° counterclockwise

b) 180° counterclockwise

c) 270° clockwise

d) 180° clockwise

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Question 7:

Which of the following will arise if there is the persistence of the vitellointestinal duct in a baby?

a) Omphalocele

b) Gastroschisis

c) Meckel diverticulum

d) Urachus

Question 8:

Which of the following structures does not develop from the endodermal cloaca?

a) Rectum

b) Anal canal

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c) Sigmoid colon

d) Urinary bladder

Question 9:

A newborn boy had no passage of meconium for two days after birth. Examination revealed anal agenesis with perineal fistula. Which of the following is the most likely■ cause?

a) Degeneration of the anal membrane

b) Failure of perforation of anal membrane

c) Incomplete separation of cloaca by urorectal septum

d) Failure of recanalization of the colon

Question 10:

The midgut loop normally herniates through the primitive umbilical ring into the extra-embryonic celom during the 6th-week of development. Failure of the intestinal loops to return to the abdominal cavity by 11th-week results in the formation of which of the following conditions in a baby?

a) Omphalocele

b) Gastroschisis

c) Exstrophy of bladder

d) Ileal diverticulum

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Question 11:

A baby after delivery was found to have the following finding. The mother had no antenatal care history. Which of the following defects in the intrauterine life is the cause of this condition?

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a) Failure of the intestinal loops to return from umbilicus

b) Defective closure of body wall in abdominal region

c) Defective closure of body wall in pelvic region

d) Defective closure of the vitellointestinal duct

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Question 12:

You note the given finding in a baby admitted to the pediatric ward. Which of the following defects in the intrauterine life is the cause of this condition?

a) Failure of the intestinal loops to return from umbilicus

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b) Defective closure of body wall in the abdominal region

c) Defective closure of body wall in the pelvic region

d) Defective closure of the vitellointestinal duct

Question 13:

Which of the following is not a derivative of the ventral mesentery?

a) Falciform ligament

b) Coronary ligament

c) Lesser omentum

d) Gastrosplenic ligament

Question 14:

The septum transversum develops from which of the following structures?

a) Surface ectoderm

b) Mesoderm

c) Neuroectoderm

d) Endoderm

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Question 15:

Which of the following structures is not derived from the septum transversum?

a) Falciform ligament

b) Ligamentum teres

c) Coronary ligament

d) Lesser omentum

Question 16:

Which of the following structures does not develop in the mesogastrium?

a) Liver

b) Spleen

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c) Kidney

d) Pancreas

Question 17:

The fibrous stroma of the liver is derived from which of the following structures?

a) Foregut endoderm

b) Midgut endoderm

c) Hindgut endoderm

d) Septum transversum

Question 18:

Which of the following statements regarding the development of the pancreas is false?

a) Inferior part of the head develops from the ventral pancreatic bud

b) Accessory duct develops from the dorsal pancreatic duct

c) Superior part of the head develops from the dorsal pancreatic bud

d) The uncinate process develops from the dorsal pancreatic bud

Question 19:

A 45-year-old man presented with chronic abdominal and back pain. CT scan of the abdomen was done, which incidentally revealed pancreatic divisum. Which of the following mechanisms during embryonic development leads to the given condition?

a) Persistence of the proximal portion of dorsal pancreatic bud

b) Failure of fusion of the dorsal and ventral pancreatic buds

c) Failure of regression of dorsal pancreatic bud

d) Failure of regression of ventral pancreatic bud

Question 20:

Mesoderm of which of the following structures give rise to the spleen?

a) Ventral mesogastrium

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b) Dorsal mesogastrium

c) Dorsal mesoduodenum

d) Septum transversum

Question 21:

The rectum develops from _____

a) Hindgut

b) Cloaca

c) Both a and b

d) None of the above

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Answer Key

Question No.	Correct Option
1	c
2	a
3	c
4	a
5	b
6	a
7	c
8	c
9	c
10	a
11	b
12	c
13	d
14	b
15	b
16	c
17	d
18	d
19	b

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20	b
21	c

Detailed Explanations

Solution to Question 1:

The mouth is bidermal and derived partly from the stomatodeum (ectoderm) and partly from the cranial part of the foregut (endoderm).

The buccopharyngeal membrane, which is the demarcation between ectoderm and endoderm disappears by 4th week of development. The ectodermal and endodermal layers then become continuous with each other.

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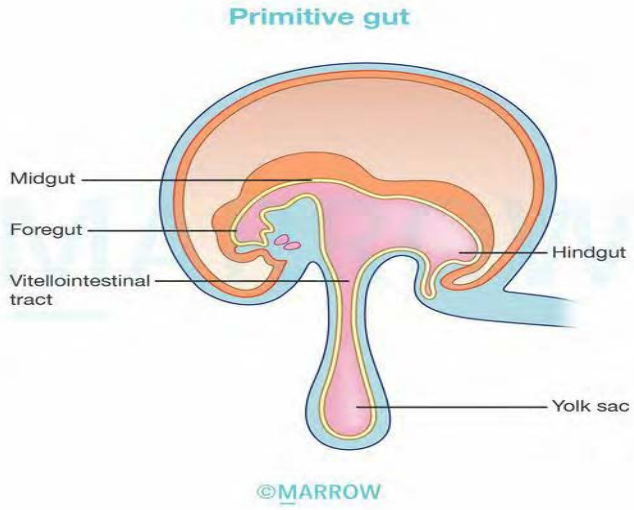
Solution to Question 2:

The primitive gut is endodermal in origin.

When the cephalocaudal and lateral folding of the embryo occurs, a section of the endodermal germ layer gets enclosed within the embryo to form a tube-like structure called the primitive gut. The cephalic and caudal parts of the primitive gut end blindly are now known as the foregut and hindgut, respectively. The middle part is known as the midgut and is connected to the yolk sac through the vitelline duct.



Solution to Question 3:

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The duodenum develops from both the caudal part of the foregut and the cranial part of the midgut.

Structures originating from different sections of the primitive gut are as follows:

• Foregut: pharynx, esophagus, stomach, duodenum (proximal), liver, gall bladder, pancreas

• Midgut: duodenum (distal), small intestine (jejunum, ileum), appendix, cecum, ascending colon, proximal 2/3rd of transverse colon

• Hindgut: distal 1/3rd of transverse colon, descending colon, proximal part of the rectum. From the cloaca (caudal part of hindgut) arise the distal part of the rectum and upper part of the anal canal.

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Solution to Question 4:

The celiac trunk supplies the foregut derivatives of the digestive system.

Arterial supply of the gut:

• Foregut: Celiac trunk

• Midgut: Superior mesenteric artery

• Hindgut: Inferior mesenteric artery

Solution to Question 5:

The cecal bud arises as a diverticulum in the post-arterial segment of the midgut loop.

It enlarges and gives rise to the cecum and the appendix. The proximal part of the cecal bud grows rapidly to form the cecum. The distal part remains narrow and forms the appendix.

The midgut loop consists of:

• Cranial limb - It forms

• Jejunum

• Upper part of the ileum

• Caudal limb - It forms

• Lower part of the ileum

• Cecum

• Appendix

• Ascending colon

• Proximal two-thirds of the transverse colon

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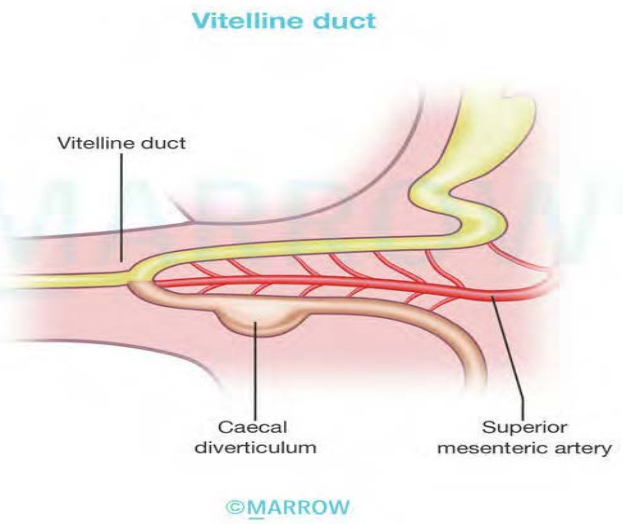

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Solution to Question 6:

The midgut normally undergoes a 270° counterclockwise rotation around the axis formed by the superior mesenteric artery.

The midgut forms a U-shaped loop (midgut loop) that herniates through the primitive umbilical ring into the extra-embryonic celom in the umbilicus. During the development of the intestines, the midgut loop rotates a total of 270° counter-clockwise around the superior mesenteric artery.

• Around 90° rotation of the midgut occurs when returning from the physiological hernia in the umbilicus

• The first part of the intestinal loop to retract from the umbilicus is the proximal portion of the jejunum

• The last part of the intestinal loop to retract from the umbilicus is the cecal bud

• The remaining 180° rotation occurs when the intestinal loops are in the abdominal cavity

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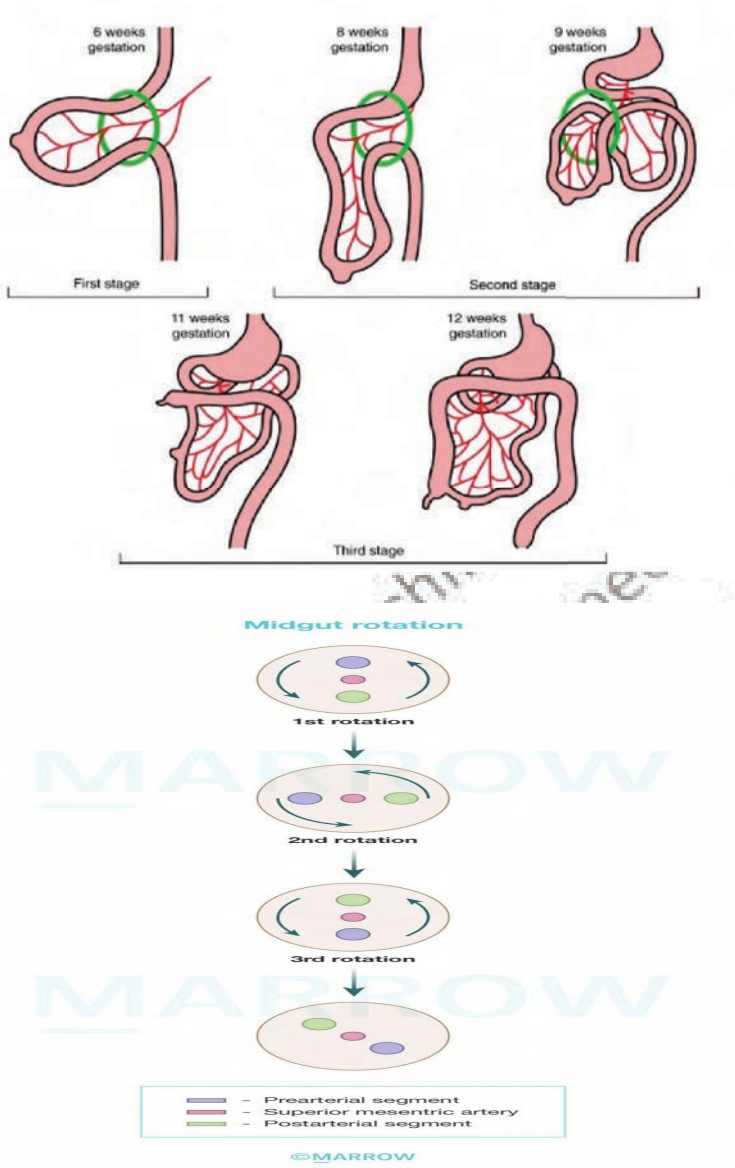

Solution to Question 7:

The persistence of the vitellointestinal duct gives rise to the Meckel diverticulum.

The primitive gut is connected to the definitive yolk sac through a narrow stalk-like communication known as the vitellointestinal duct. In about 2% of the population, a small section of the vitellointestinal duct persists to form an outpouching of the ileum called the Meckel diverticulum or ileal diverticulum.

Abnormalities arising due to incomplete obliteration of the vitellointestinal duct are given below:

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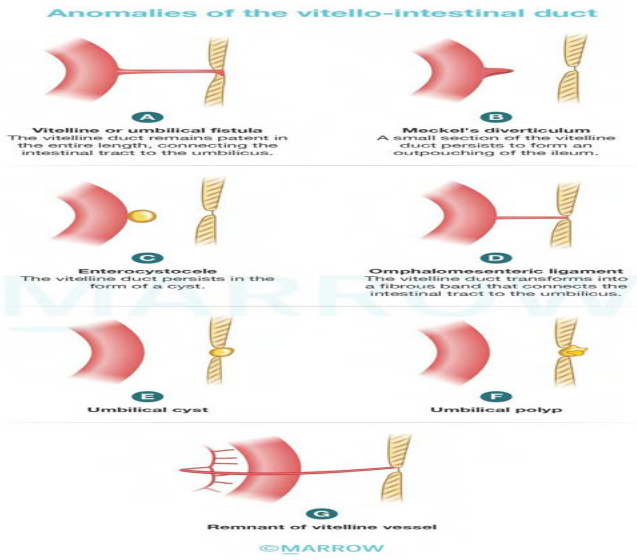

MARROW
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Solution to Question 8:

The sigmoid colon does not develop from the endodermal cloaca.

The part of the hindgut that is present caudal to the attachment of the allantoic diverticulum is called the cloaca. Between the allantois and hindgut, a wedge of mesoderm, called the urorectal septum, grows. The urorectal septum divides the endodermal cloaca into two parts:

• The primitive urogenital sinus in the anterior part develops into the urinary bladder, urethra, and lower part of the vagina (in females)

• The primitive rectum in the posterior part develops into the lower part of the rectum and upper part of the anal canal.

The tip of the urorectal septum forms the perineal body.

Note: The rectum develops from both the hindgut (proximal part) and cloaca (distal part).

Solution to Question 9:

Incomplete separation of cloaca by the urorectal septum causes anal agenesis.

When the urorectal septum is formed, the cloacal membrane gets divided into urogenital membrane anteriorly and anal membrane posteriorly. The ectoderm in the region of the future anal opening is called proctodeum. The proctodeum invaginates and creates the anal pit. The anal membrane now separates the hindgut from the anal pit.

Formation of the anal canal takes place as follows:

• The upper part of the anal canal is formed by the endodermal hindgut and the lower part by the ectodermal anal pit.

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• The anal membrane in between breaks around the 9th week and the anal canal becomes continuous.

• The junction between the endodermal and the ectodermal region of the anal canal is marked by the pectinate line.

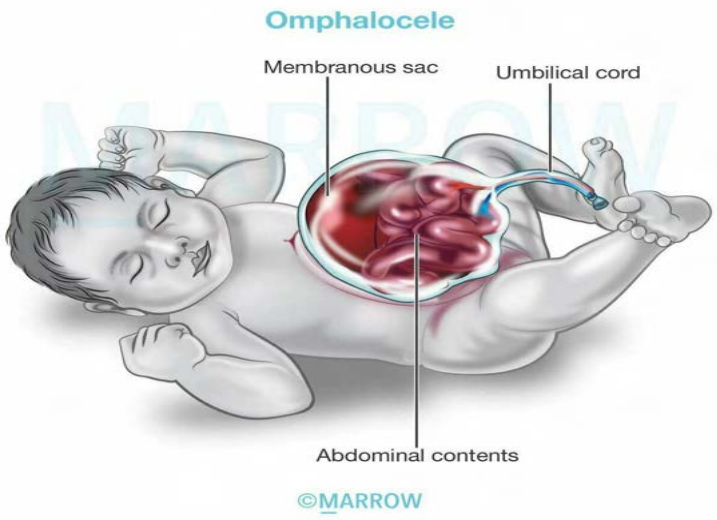
Solution to Question 10:

Failure of the intestinal loops to return to the abdominal cavity during the 6th to 10th weeks results in omphalocele or exomphalos.

Omphalocele is a congenital malformation in which the abdominal viscera protrudes through a wide umbilical defect. The bowel loops are covered by amnion.

A small omphalocele contains only the intestines. A large omphalocele may contain other viscera such as the stomach, liver, spleen, and large intestine, along with the small intestine. Omphalocele is commonly associated with other congenital anomalies (e.g., trisomy 13, trisomy 18, or Beckwith-Wiedemann syndrome) and causes increased levels of α-fetoprotein.

The images given below shows the omphalocele.



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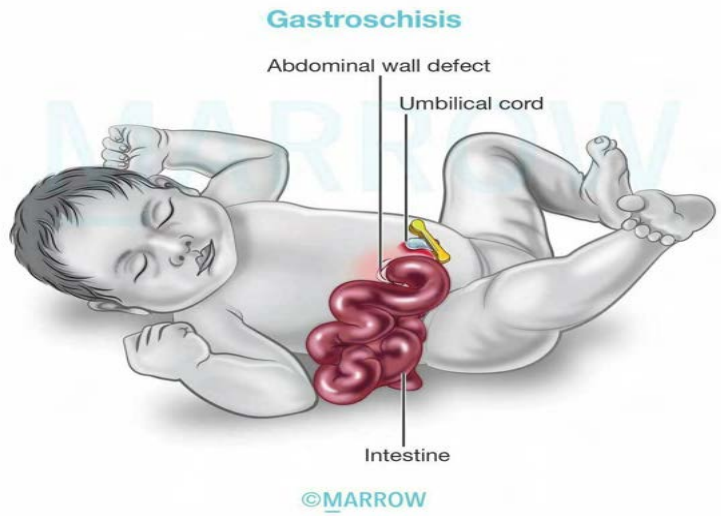
Note: Gastroschisis is the major disorder to consider in the differential diagnosis of an omphalocele. It can be differentiated from omphalocele by its absence of a membranous sac and paraumbilical location (commonly to the right of the umbilicus).



Solution to Question 11:

The given scenario is suggestive of gastroschisis. It is caused due to the failure of the body wall to close in the abdominal region during development.

Ventral wall defects include:

• Gastroschisis: The intestinal loops herniate through the defect in the abdominal wall. The defect usually lies to one side of the umbilicus (right side commonly). The loops of the bowel are not covered by amnion as they herniate through the abdominal wall directly into the amniotic cavity.

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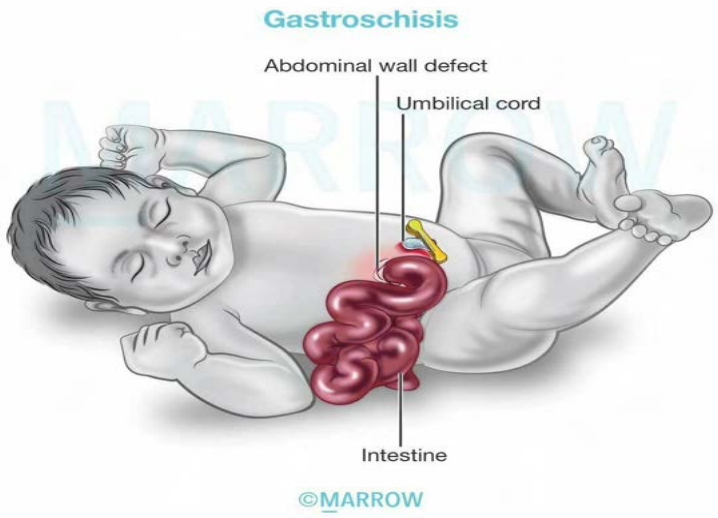
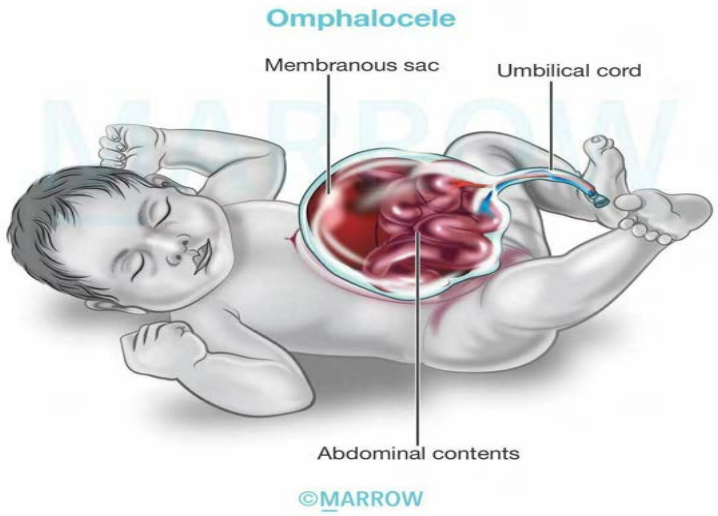
The affected bowel loops can be damaged by exposure to amniotic fluid.



• Omphalocele: The bowel loops fail to return from the physiologic umbilical hernia. Since the umbilicus is covered by a reflection of the amnion, the omphalocele is also covered by amnion.



• Bladder or cloacal exstrophy: Failure of the body wall to close in the pelvic region. Bladder exstrophy is less severe of the 2 and only the bladder is exposed in this condition. Cloacal exstrophy is more severe and both the bladder and rectum, which are derived from the cloaca, are exposed.

• Ectopia cordis: Failure of the lateral body wall folds to close in the midline in the thoracic region. This results in the heart remaining outside the thoracic cavity.

Solution to Question 12:

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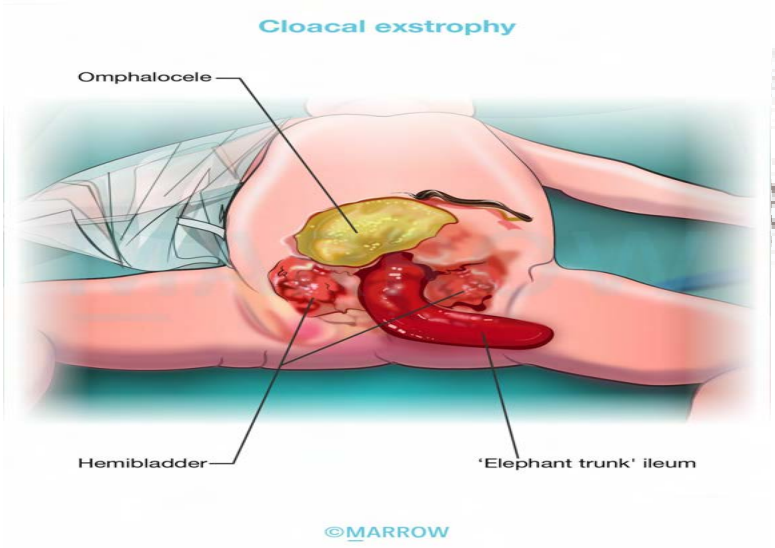
The condition shown in the image is cloacal exstrophy, which is caused by the failure of the body wall to close in the pelvic region.

The given image shows the classic feature of cloacal exstrophy, which includes an exstrophic central bowel area flanked by two hemibladders:

• Bladder exstrophy: The bladder is seen turned inside out (exstrophy means turned inside out) and visible as 2 hemibladders on either side.

• Bowel exstrophy: The central defect is the prolapsed intestinal loop that appears as the elephant trunk deformity. The central bowel field usually contains an ileocecal segment that has prolapsed.

• In addition, omphalocele can be noted in the umbilical region in this image.



Exstrophy of the bladder or cloaca occurs due to abnormal closure of the body wall in the pelvic region:

• Exstrophy of the bladder: The bladder mucosa is exposed to the surface. In male infants, epispadias is seen additionally.

• Exstrophy of the cloaca: The closure of the ventral body wall is more severely affected than in bladder exstrophy. There is the involvement of the bladder and rectum, both of which are derived from the cloaca. In addition, there is defective development of the urorectal septum leading to anal canal malformations and imperforate anus. As the genital swellings are widely separated, external genitalia will be defective.

Cloacal exstrophy can present as part of OEIS syndrome, in which multiple anomalies are seen, where O stands for Omphalocele, E for Exstrophy of bladder or cloaca, I for Imperforate anus, and S for Skeletal anomalies.

Solution to Question 13:

The gastrosplenic ligament is a derivative of the dorsal mesentery.

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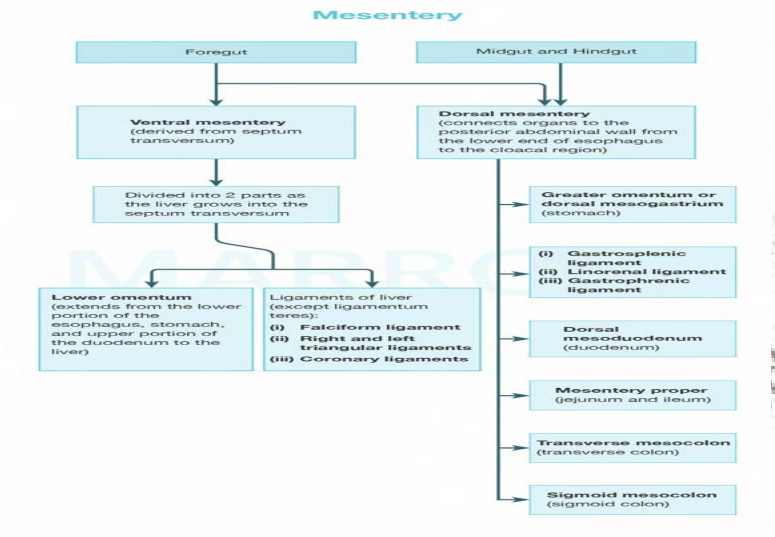
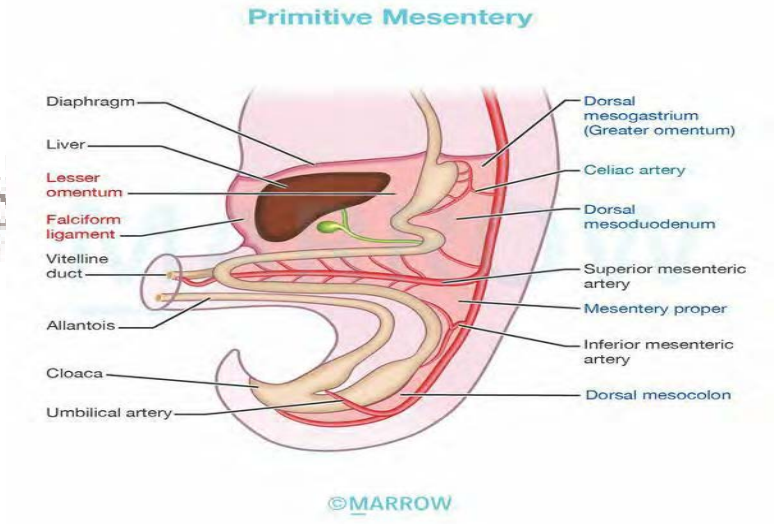
Mesenteries are double layers of the peritoneum that enclose an organ and connect it to the body wall. They provide pathways for vessels, nerves, and lymphatics to and from the abdominal viscera.

The foregut gives rise to both the ventral and dorsal mesentery, whereas the midgut and hindgut give rise to only the dorsal mesentery. The ventral and dorsal mesenteries give rise to the following structures, as shown in the image below:





Solution to Question 14:

Septum transversum develops from the mesoderm.

Septum transversum is a thick mass of mesodermal tissue that occupies the space between the developing thoracic cavity and yolk stalk in the early embryo. It works as a partition to separate thoracic and abdominal cavities.

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The septum transversum gives rise to:

• The central tendon of the diaphragm

• The ventral mesentery of the foregut

• The connective tissue of the liver

Solution to Question 15:

The ligamentum teres is not a derivative of the septum transversum, but a remnant of the left umbilical vein.

The septum transversum gives rise to:

• Central tendon of the diaphragm

• Connective tissue of the liver

• Ventral mesentery of the foregut that has the following parts

• Lesser omentum (ventral mesogastrium)

• Ligaments of the liver (falciform ligament, triangular ligaments, and coronary ligaments)

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Solution to Question 16:

The kidney is a retroperitoneal organ and does not develop in the mesogastrium.

The mesenteries of the stomach include the ventral and dorsal mesogastrium.

• Ventral mesogastrium (Lesser omentum), where the ventral pancreatic bud, liver, and gallbladder develop

• Dorsal mesogastrium (Greater omentum), where the spleen, celiac trunk, and dorsal pancreatic bud develop

Solution to Question 17:

The fibrous stroma of the liver is derived from the septum transversum.

The liver develops as an outgrowth of the endodermal epithelium at the distal end of the foregut. This liver bud or hepatic diverticulum proliferates rapidly and penetrates the septum transversum.

• The rapidly developing endodermal cells of the liver bud give rise to the parenchyma (hepatocytes) and the lining of the biliary ducts. The endoderm-derived epithelial liver cells also intermingle with the vitelline and umbilical veins to form hepatic sinusoids.

• The mesoderm of the septum transversum gives rise to the connective tissue, ligaments of the liver (except ligamentum teres), hematopoietic cells, and Kupffer cells.

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• The connection between the hepatic diverticulum and the foregut (duodenum) narrows, forming the bile duct.

• The bile duct gives rise to a small ventral outgrowth called pars cystica that develops into the gallbladder and the cystic duct.

Solution to Question 18:

The uncinate process develops from the ventral pancreatic bud.

The pancreas develops from two buds, dorsal and ventral, originating from the endodermal lining of the duodenum. When the duodenum rotates and becomes C-shaped, the ventral bud gets positioned immediately below and behind the dorsal bud. This is followed by the fusion of the parenchyma and the duct systems of the dorsal and ventral pancreatic buds.

The parenchyma of the pancreas:

• Ventral pancreatic bud forms the lower part of the head and uncinate process.

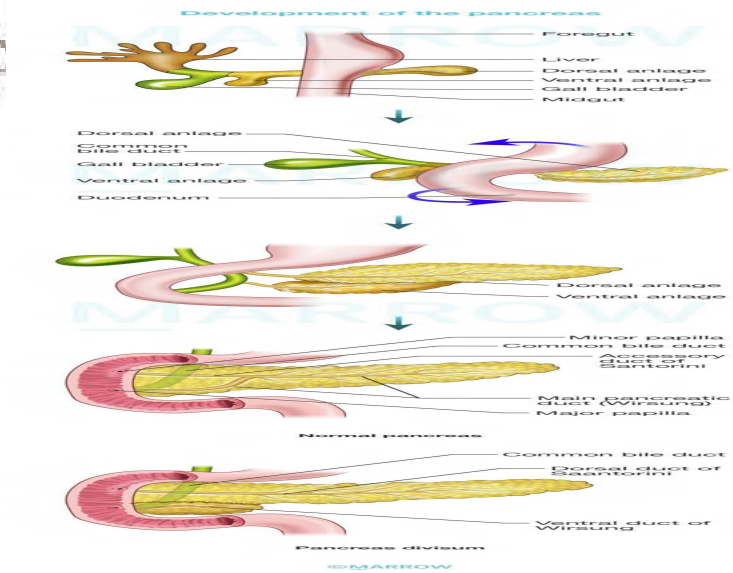
• Dorsal pancreatic bud forms the upper part of the head, neck, body, and tail.

Pancreatic ducts

• The main pancreatic duct (of Wirsung) is formed by the duct of ventral bud (proximal part), oblique cross-communication between the 2 ducts (middle part), and the duct of dorsal bud (distal part).

• The accessory pancreatic duct (of Santorini) is formed by the proximal part of the dorsal pancreatic duct.

The image given below shows the development of pancreas.



Solution to Question 19:

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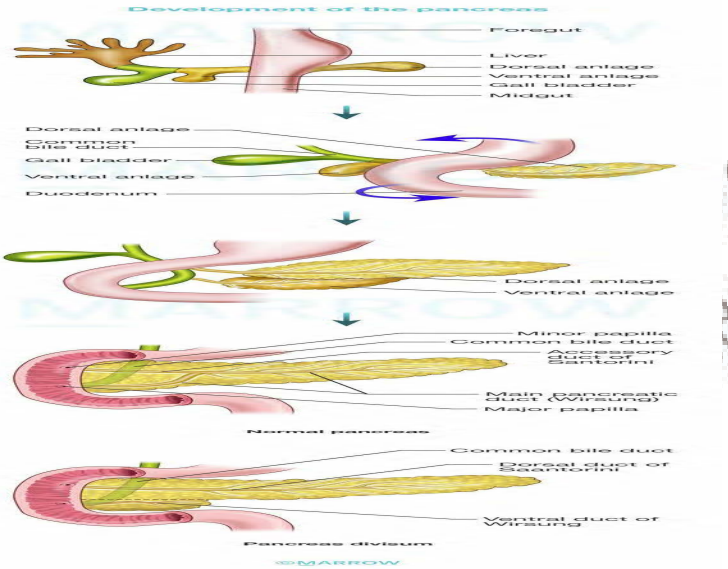
Failure of fusion of the dorsal and ventral pancreatic buds leads to a condition called pancreas divisum.

The developing pancreatic ducts usually fuse in such a way that most of the dorsal duct drains into the proximal part of the ventral duct. The proximal portion of the dorsal duct usually persists as an accessory duct. In about 10% of the population, the two ducts do not fuse, resulting in pancreatic divisum (pancreas divisum) where separate drainage into the duodenum is maintained.

The image given below shows the development of the pancreas.



The annular pancreas occurs when the right portion of the ventral bud migrates along its normal route, but the left migrates in the opposite direction. In this case, the duodenum is surrounded by pancreatic tissue.

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Solution to Question 20:

The spleen develops from the mesoderm in the dorsal mesogastrium.

The mesenchymal cells in the dorsal mesogastrium form small lobular masses of splenic tissue called spleniculi. Later, these lobules fuse to form a single mass of the spleen. The capsule, septa, and connective tissue framework, including reticular fibers, develop from mesoderm. The mesenchymal cells also differentiate into lymphoblasts and other blood-forming cells.

When the spleen develops, the dorsal mesogastrium gets divided into an anterior segment called gastrosplenic ligament that extends from the spleen to stomach, and a posterior part called the lienorenal ligament that extends from the spleen to the left kidney.

Solution to Question 21:

The rectum develops from both the hindgut and cloaca.

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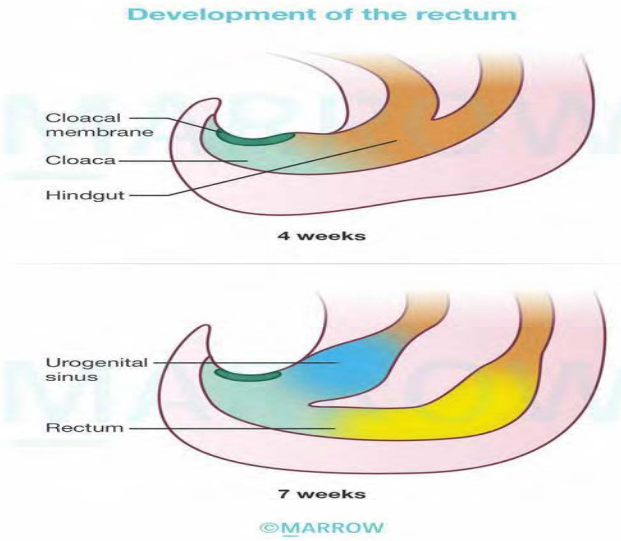
The section of the hindgut present caudal to the attachment of the allantoic diverticulum is called the cloaca.

- The proximal part of the rectum develops from the hindgut
- The distal part of the rectum develops from the dorsal part of the cloaca



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Face, Nose & Palate, Eye, Ear

Question 1:

Which of the following is not an embryologic structure that contributes to the formation of the face?

a) Frontonasal prominence

b) Zygomatic prominence

c) Maxillary prominence

d) Mandibular prominence

Question 2:

What is the upper lip derived from?

a) Maxillary prominence and mandibular prominence

b) Maxillary prominence and medial nasal prominence

c) Maxillary prominence and lateral nasal prominence

d) Mandibular prominence and medial nasal prominence

Question 3:

From which structures do the alae of the nose develop?

a) Frontonasal process

b) Medial nasal process

c) Lateral nasal process

d) Bucconasal membrane

Question 4:

A 2-month-old baby was brought to the clinic with an anomaly as shown in the image. This occurs due to the failure of fusion between which structures?

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a) Lateral nasal prominence and mandibular prominence

b) Lateral nasal prominence and maxillary prominence

c) Medial nasal prominence and mandibular prominence

d) Medial nasal prominence and maxillary prominence

Question 5:

The primary palate is formed from which structure?

a) Medial nasal prominences

b) Lateral nasal prominences

c) Maxillary prominences

d) Frontonasal prominences

Question 6:

An infant underwent palatoplasty for bilateral complete cleft palate. This condition occurs due to:

a) Non-fusion of palatine processes with premaxilla only

b) Non-fusion of palatine processes in midline only

c) Non-fusion of palatine process with premaxilla and with each other

d) Non-fusion of median nasal process with maxillary process

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Question 7:

A 1-week-old infant was diagnosed with congenital nasolacrimal duct obstruction. This structure is derived from which layer?

a) Ectoderm

b) Mesoderm

c) Endoderm and ectoderm

d) Ectoderm and mesoderm

Question 8:

Arrange the following structures formed during the development of the eye in their order of appearance.

a) 1-2-3-4

b) 2-4-3-1

c) 4-1-2-3

d) 1-3-4-2

Question 9:

In an ophthalmology camp, you notice the following finding in a woman who had come for a routine checkup. It was diagnosed as coloboma of the iris. Which of the following mechanisms during embryonic development will most likely lead to the given condition?

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a) Congenital detachment of the retina

b) Cavitation of the posterior chamber

c) Abnormal neural crest formation

d) Failure of closure of the choroid fissure

Question 10:

The muscles that cause constriction and dilation of the pupil are derived from:

a) Ectoderm

b) Endoderm

c) Mesoderm

d) Neural crest cells

Question 11:

A newborn had complete absence of the external auricle and auditory meatus. There are no other physical deformities. Renal function is normal. Abnormalities in the development of which of the following structures during the embryonic development lead to the given condition?

a) Third and fourth pharyngeal arches

b) Second and third pharyngeal arches

c) First and second pharyngeal arches

d) First and third pharyngeal arches

Question 12:

Which of the following structures of the ear develops from all the three germ layers?

a) Ear ossicles

b) External acoustic meatus

c) Middle ear

d) Tympanic membrane

Question 13:

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The tubotympanic recess gives rise to which structure?

a) Auditory tube

b) External auditory meatus

c) Internal auditory meatus

d) Facial canal

Question 14:

The membranous labyrinth develops from which structure?

a) First pharyngeal pouch

b) First pharyngeal cleft

c) Otic vesicle

d) Meckel's cartilage

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Answer Key

Question No.	Correct Option
1	b
2	b
3	c
4	d
5	a
6	c
7	a
8	c
9	d
10	a
11	c
12	d
13	a
14	c

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Detailed Explanations

Solution to Question 1:

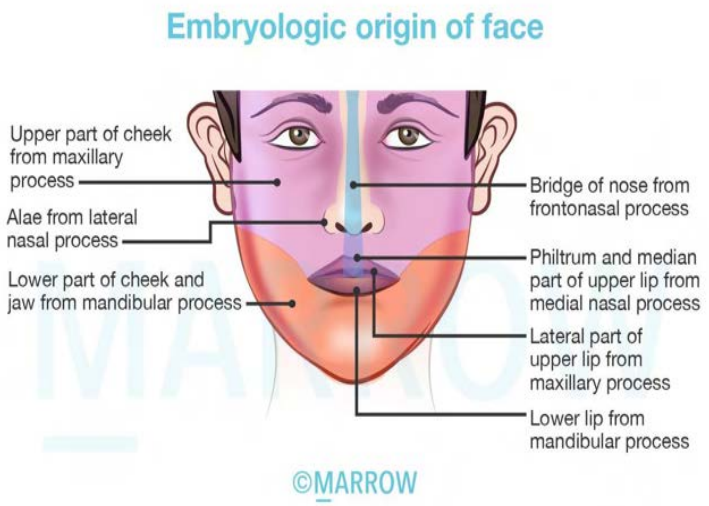
Zygomatic prominence is not an embryological structure that contributes to the formation of the face.

The face is derived from the following structures around the stomatodeum (primitive mouth):

• Mandibular prominences and maxillary prominences of the first arch

• Frontonasal prominence formed by the proliferation of mesenchyme ventral to the brain vesicles. It also gives rise to medial and lateral nasal prominences.

Structures contributing to th e development of face	
Prominence	Structure formed
Frontonasal	Forehead, bridge of the nose, also forms the medial and la teral nasal prominences
Medial nasal	Philtrum of the upper lip, the crest of the nose, and the tip of the nose
Lateral nasal	Alae of nose
Maxillary	Upper part of cheeks, the late ral portion of the upper lip
Mandibular	Lower part of cheeks, chin, lo wer lip



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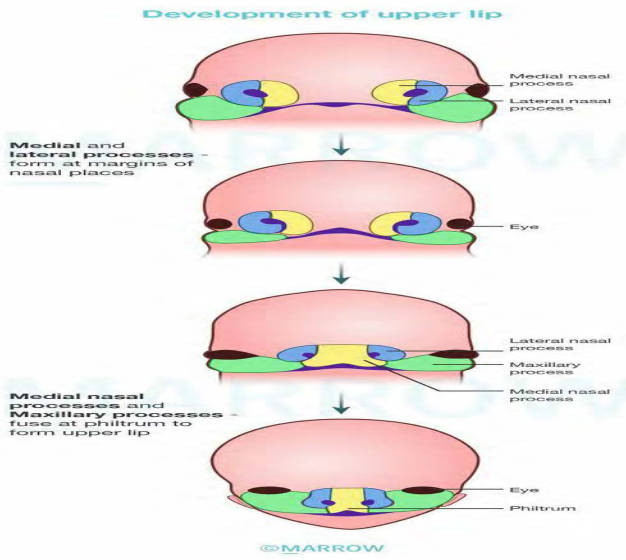
Solution to Question 2:

The upper lip is formed by the fusion of the two maxillary prominences with the two medial nasal prominences.

Initially, two thickenings called nasal placodes are formed in the frontonasal prominence. The nasal placodes get depressed to become nasal pits. Each nasal pit has a ridge of tissue on the outer edge called lateral nasal prominence and on the inner edge called medial nasal prominence.

The 2 maxillary prominences on the lateral part of the stomodeum increase in size and grow medially. They compress the medial nasal prominences toward the midline. Later, the 2 maxillary prominences fuse with the 2 medial nasal prominences to form the upper lip.



Solution to Question 3:

The alae of the nose develop from the lateral nasal processes.

The development of various components of the nose can be summarized as follows:

• Bridge - The frontonasal process

• Dorsum and tip - Fused medial nasal processes

• Alae - The lateral nasal processes

• Anterior nares (nostrils) - The original site of the nasal pit

• Nasal cavity - The nasal sacs formed by the elongation of nasal pits

• Posterior nares (choanae) - Ruptured bucconasal membrane

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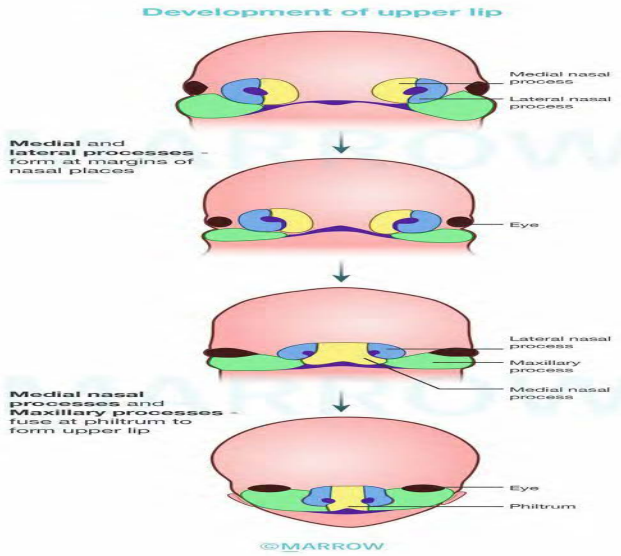
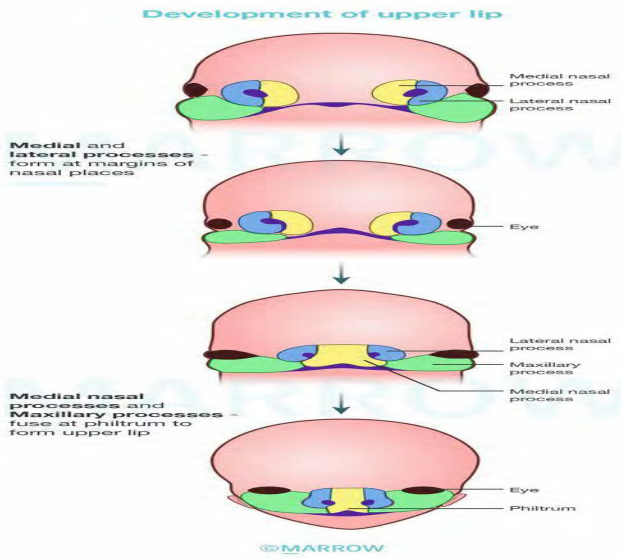


Solution to Question 4:

The image shows cleft lip which occurs when the maxillary prominences fail to fuse with the medial nasal prominences.



Various defects of fusion of prominences in the face region are as follows:

A cleft lip is due to the failure of the fusion of maxillary prominence with medial nasal prominence. It can be unilateral or bilateral. It can vary in severity from a small notch in the upper lip to a double cleft extending into both the nostrils. There is also associated underdevelopment of the part of the maxilla that bears the incisors.

Median (midline) cleft lip is a rare defect occurring due to failure of the two medial nasal prominences to fuse in the midline.

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The oblique facial cleft is caused by the failure of the maxillary prominence to fuse with the lateral nasal prominence along the line of the nasolacrimal groove. The nasolacrimal duct is exposed to the surface in these cases.

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Solution to Question 5:

The primary palate (premaxilla) develops from the intermaxillary segment that is formed by the fusion of the two medial nasal prominences.

The intermaxillary segment has the following components:

• Labial component - forms the philtrum of the upper lip

• Upper jaw component - forms the medial part of the maxillary bone with the four upper incisor teeth

• Palatal component - forms the triangular area in the front called the primary palate (premaxilla)

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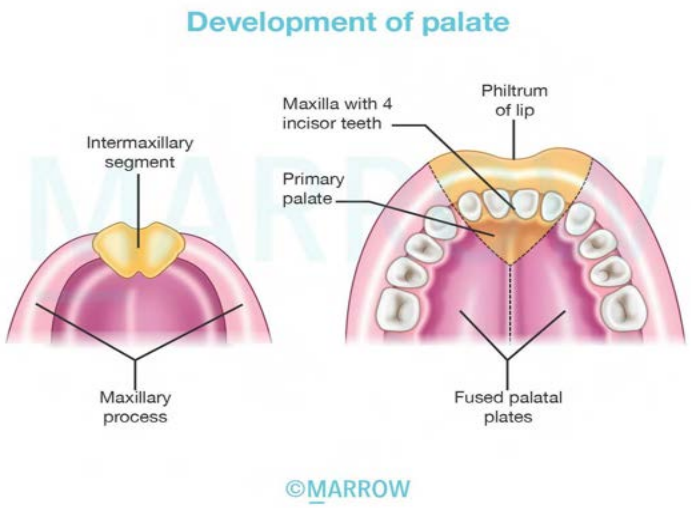

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Solution to Question 6:

Bilateral complete cleft palate is due to the non-fusion of palatine processes with the premaxilla and with each other.

The palate is formed from two main structures:

• Primary palate: The small triangular anterior part of the palate is formed by the fused medial nasal processes (intermaxillary segment or premaxilla).

• Secondary palate: The main part of the palate is formed by the 2 palatine processes that converge from the maxillary processes.

The cleft palate can occur in the primary palate (anterior cleft) or in the secondary palate (posterior palate).

• Complete cleft palate involves both the primary and secondary palate.

• Incomplete cleft palate involves only the secondary palate.

In bilateral complete cleft palate, a Y-shaped cleft is seen with gaps between the primary and secondary palate and between the two halves of the secondary palate. In addition, there is a bilateral cleft upper lip.

Solution to Question 7:

The nasolacrimal duct is derived from the ectoderm of the nasolacrimal groove (also known as naso-optic furrow).

The deep furrow between the maxillary and lateral nasal prominence is known as the nasolacrimal groove.

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• The ectoderm in the floor of this groove becomes a solid epithelial cord and detaches from the overlying ectoderm.

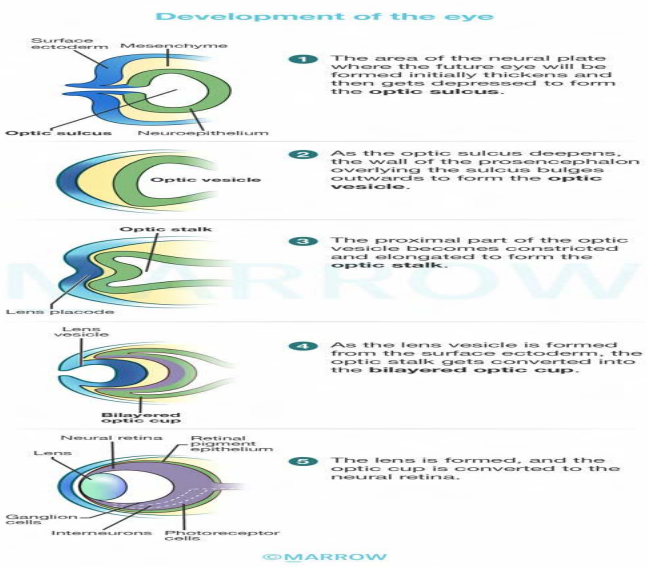
• This solid cord then canalizes to form the nasolacrimal duct.

• The lower end of the duct acquires a connection to the nasal cavity.

• The upper end of the duct widens to form the lacrimal sac.

Solution to Question 8:

The order of the structures formed during eye development is Optic sulcus ° Optic vesicle ° Optic stalk ° Optic cup.



Solution to Question 9:

The condition coloboma of the iris occurs due to failure of the choroid fissure to close in the distal part forming a cleft.

There is a small gap in the inferior surface of the optic cup known as the choroid fissure. This fissure allows the hyaloid vessels to reach the inner chamber of the eye. During the normal development of the eye, the distal part of the hyaloid artery degenerates. The choroid fissure then fuses and this makes the mouth of the optic cup into a round opening (the future pupil).

Failure of fusion of choroid fissure causes clefts in the eye known as coloboma.

• If the failure to fuse is in the distal part, it can result in coloboma of the iris.

• If the failure of fusion occurs in the proximal part, it can lead to coloboma of the retina/ choroid/ optic nerve, depending on the location of the defect.

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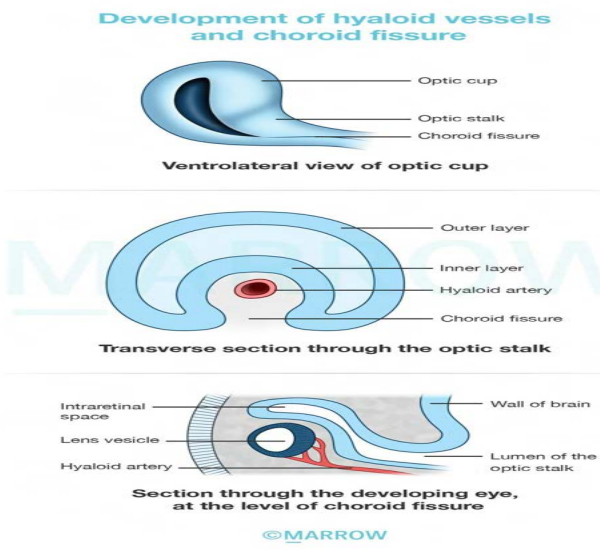

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Solution to Question 10:

The musculature of the iris, including the sphincter pupillae and dilator pupillae, are derived from the ectoderm of the optic cup.

Most of the muscles of the body develop from mesoderm. The muscles which develop from ectoderm are:

• Muscles of the iris (sphincter and dilator pupillae)

• Arrectores pilorum of skin

• Myoepithelial cells lining the ducts of sweat glands

Solution to Question 11:

Anotia (complete absence of the ear pinna) occurs due to the defect in the development of 1st and 2nd pharyngeal arches.

The pinna develops from 6 tissue elevations called the auricular hillocks formed around the margins of the dorsal portion of the 1st pharyngeal cleft.

• 3 hillocks are from the 1st pharyngeal (mandibular) arch

• 3 hillocks are from the 2nd pharyngeal (hyoid) arch.

The mandibular arch contributes to the tragus of the pinna only, while the rest of the pinna is derived from the hyoid arch. Invagination of the first pharyngeal arch gives rise to the external auditory meatus.

Previously, it was believed that the external auditory meatus develops from the first pharyngeal cleft. But recent studies suggest that the first pharyngeal arch gives rise to the external auditory meatus.

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Solution to Question 12:

The tympanic membrane is derived from all three germ layers.

The tympanic membrane is formed by the apposition of the tubotympanic recess of the 1st pharyngeal pouch with the 1st pharyngeal cleft.

• The outer layer of the tympanic membrane is derived from the ectoderm at the bottom of the external auditory meatus (1st pharyngeal cleft).

• The inner layer of the tympanic membrane is derived from the endoderm lining the tympanic cavity (1st pharyngeal pouch).

• The middle layer of the tympanic membrane is connective tissue derived from the mesoderm.

Solution to Question 13:

The tubotympanic recess forms the auditory tube.

Development of the Middle Ear:

• The distal part of the 1st pharyngeal pouch becomes the tubotympanic recess. The tubotympanic recess gives rise to the primitive tympanic cavity distally, while the proximal part remains narrow and forms the auditory tube (eustachian tube). It also forms the lining of the middle ear cavity.

• The 3 ossicles are formed from mesenchymal condensations from the 1st pharyngeal arch (malleus and incus) and 2nd pharyngeal arch (stapes).

• The tympanic membrane is formed where the ectoderm of the 1st pharyngeal cleft dips to meet the endoderm of the 1st pharyngeal pouch, with contribution from the intervening mesoderm.

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Solution to Question 14:

The membranous labyrinth of the internal ear is derived from the otic vesicle.

The surface ectoderm on either side of the hindbrain thickens to form otic placodes. The otic placodes invaginate to form otic vesicles (auditory vesicles).

The otic vesicle further divides into 2 components that develop into structures of the membranous labyrinth:

• The ventral component forms the saccule and cochlear duct

• The dorsal component forms the utricle, semicircular canals, and endolymphatic duct

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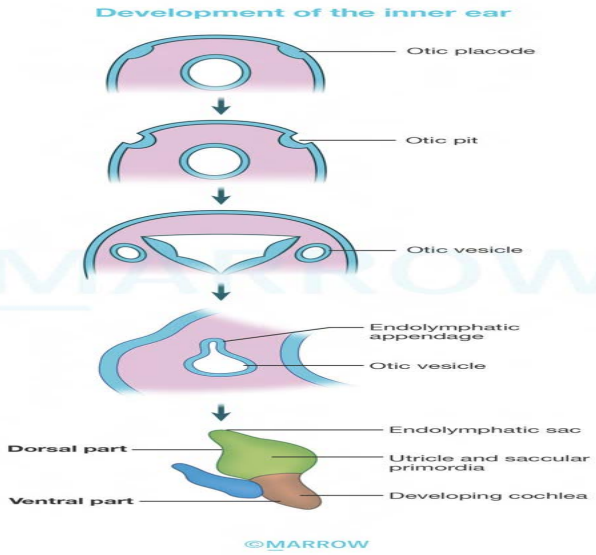

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Nervous System and Endocrine Glands

Question 1:

What is the spinal cord developed from?

a) Neural tube

b) Notochord

c) Primitive streak

d) Rhombencephalon

Question 2:

The neuropore facilitates communication between the neural tube and _____

a) Amniotic cavity

b) Yolk sac

c) Allantoic cavity

d) Uterus

Question 3:

What is the adult representation of the location of anterior neuropore?

a) Septum transversum

b) Terminal ventricle

c) Lamina terminalis

d) Foramen of Munro

Question 4:

A 1-year-old baby with loss of pharyngeal reflex was diagnosed to have infantile progressive bulbar palsy. Which of the following gives rise to the affected structure?

a) Prosencephalon

b) Mesencephalon

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c) Rhombocephalon

d) None of the above

Question 5:

What is the flexure between the metencephalon and the myelencephalon called?

a) Cephalic flexure

b) Mesencephalic flexure

c) Pontine flexure

d) Cerebellar flexure

Question 6:

Which of the following statements best describes the sulcus limitans?

a) It is found in the interpeduncular fossa

b) It is located between the alar and basal plates

c) It separates the medulla from the pons

d) It separates the hypothalamus from the thalamus

Question 7:

Which of the following brainstem nuclei is not derived from the alar plate?

a) Inferior olivary

b) Substantia nigra

c) Dentate

d) Hypoglossal

Question 8:

Which of the following is the first commissure to develop?

a) Fornix

b) Anterior commissure

c) Corpus callosum

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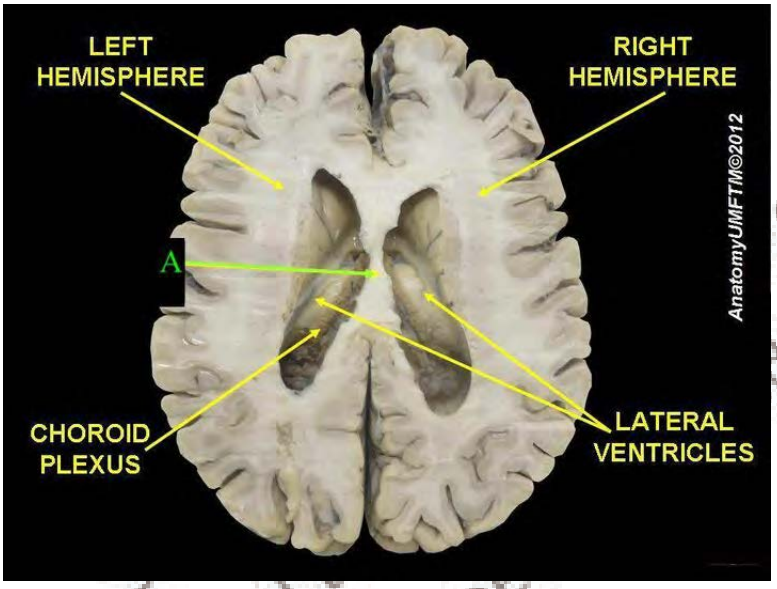
d) Posterior commissure

Question 9:

Where does the structure marked as A develop from?



a) Basal lamina

b) Alar lamina

c) Lamina terminalis

d) Basal plate

Question 10:

The septum pellucidum extends between:

a) Anterior commissure and posterior commissure

b) Anterior commissure and corpus callosum

c) Anterior commissure and the fornix

d) Fornix and corpus callosum

Question 11:

Which of the following neural tube defects is characterized by gaps in the vertebral arches?

a) Encephalocele

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b) Spina bifida

c) Hydrancephaly

d) Syringomyelia

Question 12:

Identify the neural tube defect shown in the image.

a) Spina bifida

b) Rachischisis

c) Encephalocele

d) Myelocele

Question 13:

Identify the defect shown in the image.

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a) Encephalocele

b) Spina bifida

c) Anencephaly

d) Meningoencephalocele

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Question 14:

A neonate was shifted to the NICU due to respiratory distress and periodic seizures. CT scan revealed cystic dilatation of the fourth ventricle due to blockage of the median and lateral apertures. What is the likely diagnosis?

a) Syringomyelia

b) Rachischisis

c) Dandy-Walker syndrome

d) Arnold-Chiari malformation

Question 15:

Which of the following gives rise to the hypophysis cerebri?

a) Surface ectoderm and mesoderm

b) Surface ectoderm and neuroectoderm

c) Neuroectoderm and mesoderm

d) Mesoderm and endoderm

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Question 16:

A 65-year-old male patient underwent an MRI scan for the evaluation of stroke. Incidentally, it was found that the pineal gland was absent. Defect in the development of which of the following structures will■ likely lead to pineal agenesis?

a) Telencephalon

b) Diencephalon

c) Metencephalon

d) Myelencephalon

Question 17:

Where are the cells of the adrenal cortex and medulla respectively derived from?

a) Ectoderm and neural crest cells

b) Mesoderm and endoderm

c) Endoderm and neural crest cells

d) Mesoderm and neural crest cells

Question 18:

Which of the following zones of the adrenal cortex are present at birth?

a) Zona fasciculata and Zona reticularis

b) Zona glomerulosa and Zona fasciculata

c) Zona glomerulosa and Zona reticularis

d) Zona glomerulosa, Zona fasciculata, and Zona reticularis

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Answer Key

Question No.	Correct Option
1	a
2	a

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3	c
4	c
5	c
6	b
7	d
8	b
9	c
10	d
11	b
12	c
13	c
14	c
15	b
16	b
17	d
18	b

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Detailed Explanations

Solution to Question 1:

The spinal cord develops from the caudal part of the neural tube.

The nervous system develops from the neurectoderm i.e. the specialized ectoderm overlying the notochord. The neuroectoderm initially thickens to form the neural plate. The neural plate is then converted to a neural groove, followed by a neural tube.

• The enlarged cranial part of neural tube forms the brain. It has 3 primary vesicles that form:

• Forebrain (prosencephalon)

• Midbrain (mesencephalon)

• Hindbrain (rhombencephalon)

• The narrow caudal part of the neural tube forms the spinal cord.

Solution to Question 2:

The neuropores facilitate communication between the neural tube and the amniotic cavity.

The neural plate first becomes tubular in the middle. The cranial and caudal ends of the neural tube remain open and are called the anterior and posterior neuropores, respectively.

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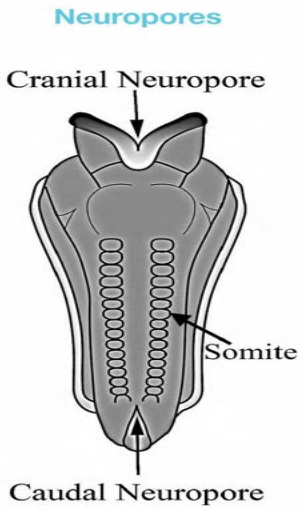
The neuropores facilitate communication between the neural tube and the amniotic cavity. Amniotic fluid provides nutrition to the developing neuroectodermal cells before the circulatory system is established.



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Solution to Question 3:

The location of the anterior neuropore is represented in adults as lamina terminalis.

The anterior neuropore closes around the 25th day of intrauterine life. Its location in adults is represented by the lamina terminalis. The lamina terminalis forms the anterior boundary of the third ventricle.

The posterior neuropore closes around the 28th day of intrauterine life. Its location in adults is represented by the terminal ventricle. The terminal ventricle is present in the proximal 5 to 6 mm of filum terminale.

Solution to Question 4:

In infantile progressive bulbar palsy, the affected structure is the medulla oblongata. It arises from the rhombocephalon (hindbrain).

The rhombencephalon is further subdivided into a cranial part (metencephalon) and a caudal part (myelencephalon).

- Metencephalon - forms the pons and cerebellum
- Myelencephalon - forms the medulla oblongata

Solution to Question 5:

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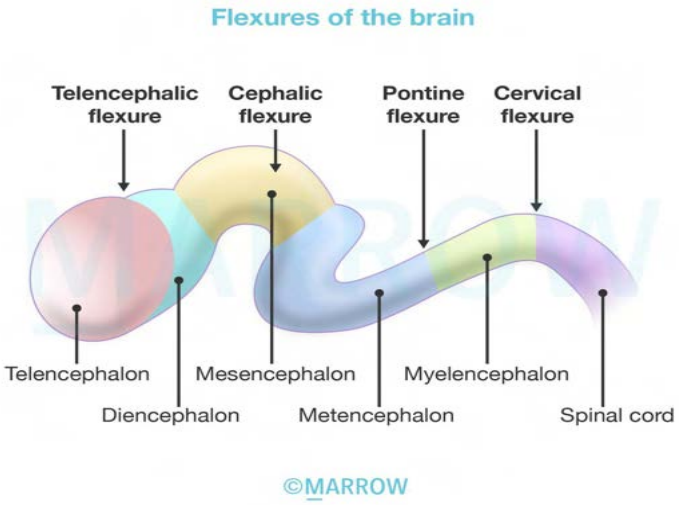
The flexure between the metencephalon and the myelencephalon is called as the pontine flexure.

The prosencephalon, mesencephalon, and rhombencephalon are initially arranged craniocaudally. Due to differential growth of different regions of the brain, various flexures form between them:



Note: A deep furrow called the rhombencephalic isthmus separates the mesencephalon from the metencephalon.

Solution to Question 6:

The sulcus limitans is located between the sensory alar and the motor basal plates.

The cells in the wall of the neural tube proliferate and are subdivided into the inner mantle layer and outer marginal layer. Due to the fast growth of the mantle layer cells, the lumen of the neural tube gets compressed.

The line separating the compressed ventral part from the dorsal part is called the sulcus limitans. When the sulcus limitans is formed, the tube is divided into the dorsal or alar lamina and ventral or basal lamina.

In the spinal cord, the ventral thickenings or basal plates contain ventral motor horn cells. The dorsal thickenings i.e. the alar plates contain the interneurones that receive the terminals of primary sensory neurons.

The images given below show the sulcus limitans:

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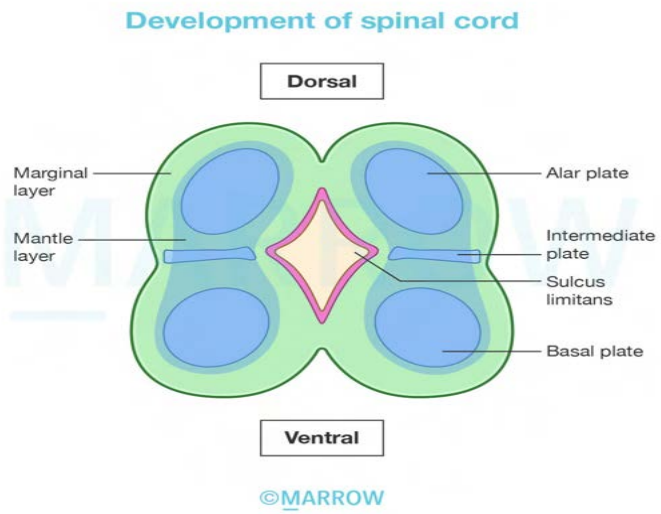

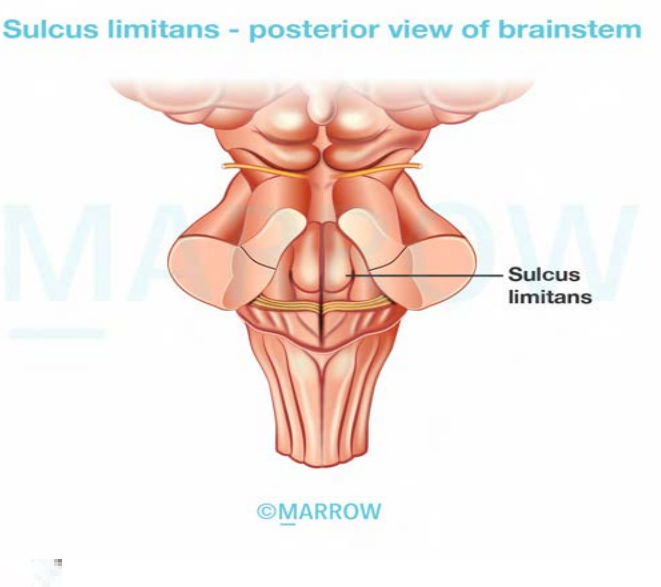

Solution to Question 7:

Hypoglossal nucleus develops from the basal plate of medulla, and not alar plate.

Option A: Inferior olivary nucleus develops from the alar plate of the medulla.

Option B: Substantia nigra develops from the alar plate of the midbrain.

Option C: Dentate nucleus develops from the alar plate in the cerebellum.

Solution to Question 8:

The first commissure to develop is the anterior commissure.

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Commissures are fibre bundles that cross the midline and connect the right and left brain hemispheres. Many important fiber bundles cross at lamina terminalis.

Commissures at lamina terminalis:

• Anterior commissure - first commissure to appear. These fibers connect the olfactory bulb and related brain areas to the corresponding structures in the contralateral hemisphere.

• Hippocampal commissure (fornix commissure) - develops second. The fibers emerge from the hippocampus and reach the lamina terminalis. From here, they arch outside the choroid fissure to the mamillary body and the hypothalamus.

• Corpus callosum - appears by the 10th week. It connects the non-olfactory areas of the right and the left cerebral cortices.

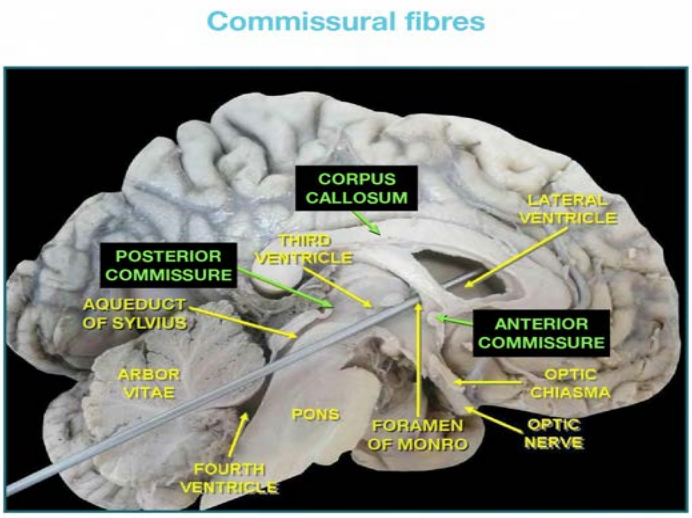
Commissures at other areas are:

• Posterior commissure

• Habenular commissure

• Optic chiasma

The image given below shows the anterior commissure:



Solution to Question 9:

The structure marked as A in the image is the corpus callosum. It develops from the lamina terminalis.

Lamina terminalis is a part of the wall of the neural tube that closes the cranial end of the prosencephalon. The lamina terminalis becomes thickened to form the commissural plate that facilitates the passage of neurons between the two hemispheres.

There are 3 commissures that pass through lamina terminalis:

• Anterior commissure

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• Hippocampal commissure

• Corpus callosum

The corpus callosum is the largest of these commisures. Initially, corpus callosum forms a small bundle in the lamina terminalis. Due to the continuous expansion, it extends anteriorly and posteriorly arching over the thin roof of the diencephalon. It connects the non-olfactory areas of the right and the left cerebral cortices.

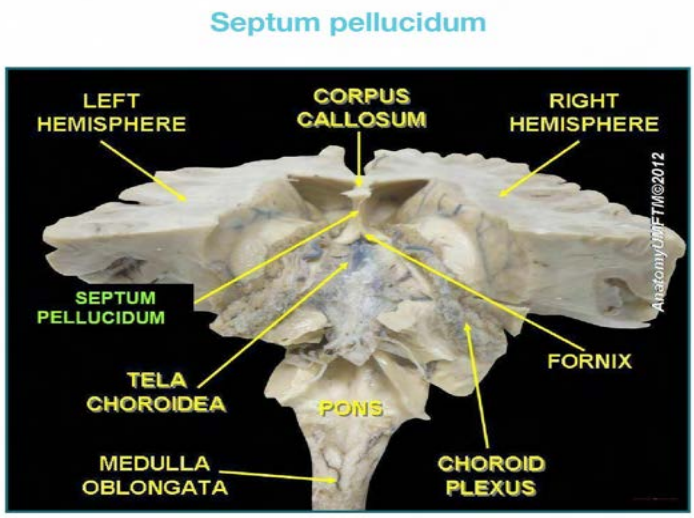
Solution to Question 10:

Septum pellucidum extends between the corpus callosum and the fornix.

The septum pellucidum is a membrane separating the anterior horns of the left and right lateral ventricles of the brain. It extends from the corpus callosum to the fornix.

It develops from the lamina terminalis. The part of the lamina terminalis that stretches between corpus callosum and fornix persists as septum pellucidum.

The image given below shows the septum pellucidum.



Solution to Question 11:

Spina bifida is characterized by gaps in the vertebral arches.

Spina bifida is a general term used for neural tube defects affecting the spinal region and associated with splitting of the vertebral arches. It may or may not involve the underlying neural tissue.

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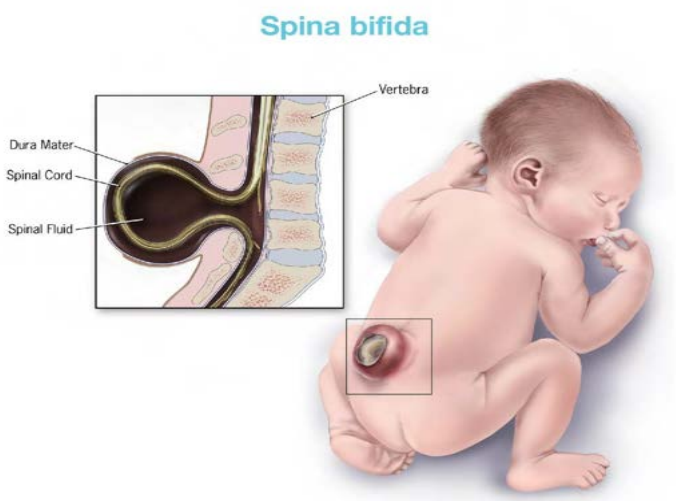
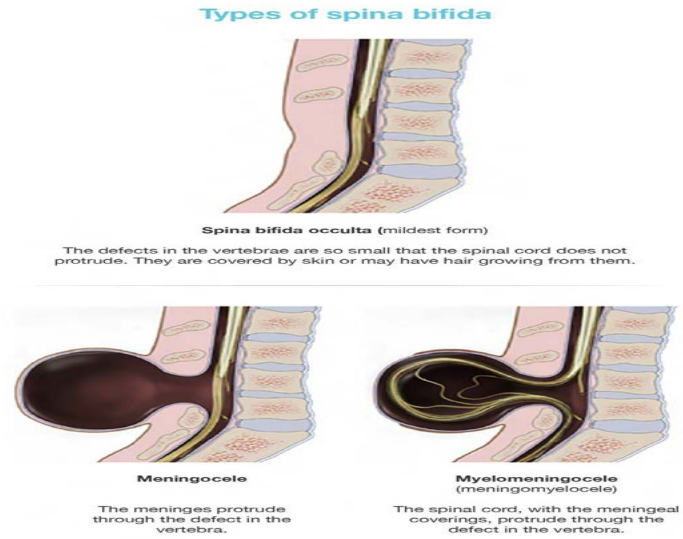


There are 3 types of spina bifida, as shown in the image below:



Rachischisis is the most severe type of neural tube defect, where the entire neural tube fails to close. Rachischisis can occur in the spinal cord or brain regions of the neural tube. The exposed neural tissues often become necrotic.

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Rachischisis

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Solution to Question 12:

The image shows a newborn with encephalocele.

Encephaloceles are caused due to defects in the skull through which the meninges and/or neural tissue herniate. The squamous part of the occipital bone is the most frequently affected bone. The bone may be partially or totally lacking.

Based on the degree of defect and tissues herniating, they are classified as follows:

• Meningocele - Defect is small and only meninges bulge through it

• Meningoencephalocele - Defect is large and a part of brain bulges with the meninges

• Meningohydroencephalocele - Defect is large and a part of the brain and ventricle bulge with the meninges

Solution to Question 13:

The image shows the congenital defect of anencephaly.

Failure of the cranial end of the neural tube to close is known as exencephaly. As a result of this, the skull vault does not form. This leaves the malformed brain exposed.

The exposed brain tissue degenerates, leaving a mass of necrotic tissue. This defect with the absence of a major portion of the brain, skull, and scalp is known as anencephaly. The brain stem remains intact.

In some cases, the closure defect of the neural tube extends caudally, and the spinal cord is affected. This condition is known as craniorachischisis, where there is anencephaly plus a large defect involving the spine.

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Solution to Question 14:

Blockage of the medial and the lateral apertures of the 4th ventricle is seen in Dandy-Walker syndrome (DWS).

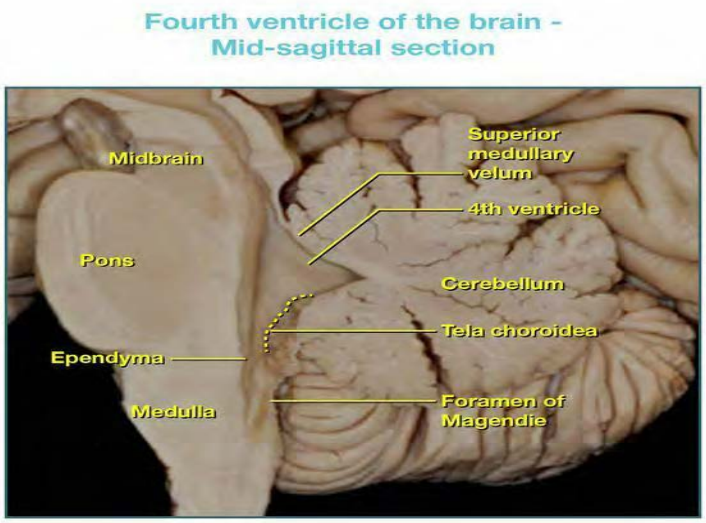
DWS is congenital hydrocephalus associated with atresia of the median aperture (foramen of Magendie) and lateral aperture (foramen of Luschka) of the 4th ventricle. This causes enlargement of the 4th ventricle and hydrocephalus.

The other associated defects seen in DWS include:

• Agenesis of the cerebellar vermis

• Agenesis of the splenium of corpus callosum

The image given below shows the normal 4th ventricle.



Solution to Question 15:

The hypophysis cerebri or pituitary gland develops from two sources i.e. surface ectoderm and neurectoderm.

The adenohypophysis or anterior pituitary, develops from the surface ectoderm. An ectodermal diverticulum, called Rathke's pouch, grows upward from the roof of the stomatodeum (primitive mouth). This becomes the anterior lobe of the pituitary (pars distalis).

The neurohypophysis or posterior pituitary, develops from the neuroectoderm. A downward extension of the diencephalon, called infundibular process, grows down from the floor of the 3rd ventricle, during the 6th week. It gives rise to the stalk and the posterior lobe of pituitary (pars nervosa).

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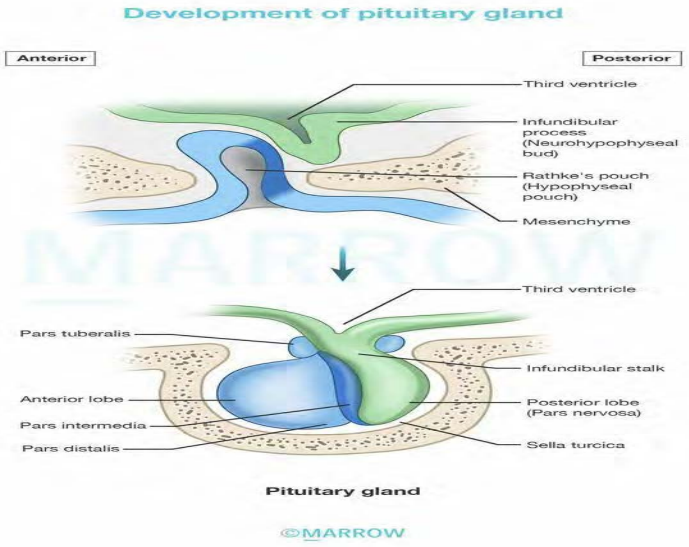
The anterior lobe of pituitary gives rise to a small extension called the pars tuberalis. It grows along the stalk of the infundibulum and eventually surrounds it.

The posterior wall of the Rathke pouch develops into the pars intermedia.

The image given below shows the development of pituitary gland.



Solution to Question 16:

The pineal gland develops from the diencephalon. Hence, defect in its development can cause pineal agenesis.

The most caudal part of the roof plate of the diencephalon develops into the pineal gland. It is also known as the pineal body or epiphysis cerebri. The pineal body initially appears as an epithelial thickening in the midline. It begins to evaginate by the 7th week and becomes a solid organ.

The images given below show the pineal gland:

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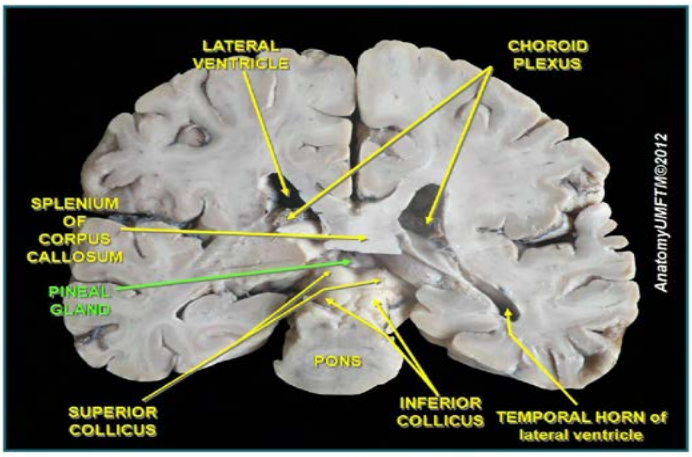
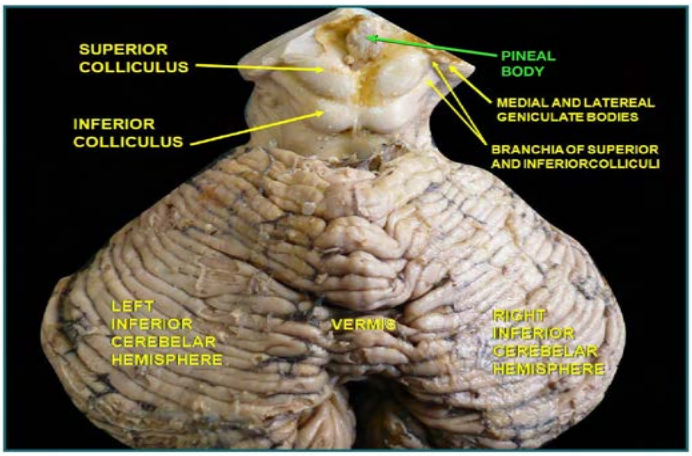
Pineal gland (anterior view)



Pineal gland (posterior view)



Solution to Question 17:

The cells of the adrenal cortex and medulla are respectively derived from the mesoderm and neural crest cells.

The adrenal glands consist of a superficial cortex and deeper medulla.

• Adrenal cortex - formed by proliferation of the coelomic epithelium (mesodermal origin)

• Adrenal medulla - formed by the invading neural crest cells from somite levels 18-24

Solution to Question 18:

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The zona glomerulosa and zona fasciculata of the adult cortex is present at birth.

The differentiation of the cortical zones of the adrenal gland begins during the late fetal period.

• Zona glomerulosa and zona fasciculata of the adult cortex are present at birth

• Zona reticularis is formed during the 3rd year of life

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Urogenital System

Question 1:

The urogenital ridge develops from which layer?

a) Paraxial mesoderm

b) Intermediate mesoderm

c) Lateral plate mesoderm

d) Extraembryonic mesoderm

Question 2:

The proximal convoluted tubules develop from which structure?

a) Mesonephric duct

b) Metanephric blastema

c) Mesonephric tubules

d) Ureteric bud

Question 3:

The ureteric bud develops from which duct?

a) Mesonephric duct

b) Metanephric duct

c) Paramesonephric duct

d) Ureter duct

Question 4:

Arrange the following stages of nephron development in order from the earlier stage to the later stage.

a) 1-2-3-4

b) 4-3-2-1

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c) 1-4-2-3

d) 1-4-3-2

Question 5:

Which of the following is the most common congenital anomaly of the kidney?

a) Renal agenesis

b) Renal duplication

c) Horseshoe kidney

d) Pancake kidney

Question 6:

A 10-year-old boy was brought to the OPD with complaints of abdominal pain and vomiting. He has a history of frequent urinary infections. On CT scan, a horseshoe kidney was seen. Which of the following prevents the ascent of this organ?

a) Inferior vena cava

b) Aorta

c) Ureter

d) Inferior mesenteric artery

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Question 7:

The trigone on the posterior wall of the urinary bladder is formed by which structure?

a) Mesonephric ducts

b) Metanephric blastema

c) Cloacal membrane

d) Urogenital sinus

Question 8:

A 6-year-old girl presents with a large abdominal mass just superior to the pubic symphysis. The mass is tender on palpation and fixed. During surgery, it is seen that the mass is fluid-filled and connected to the umbilicus superiorly and to the urinary bladder inferiorly.

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What is the diagnosis?

a) Vitelline cyst

b) Horseshoe kidney

c) Polycystic disease of the kidney

d) Urachal cyst

Question 9:

The seminiferous tubules are derived from:

a) Mesonephric tubules

b) Paramesonephric duct

c) Primordial germ cells

d) Sex cords

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Question 10:

In males, which of the following structures is derived from the Wolffian duct?

a) Prostatic utricle

b) Appendix of the testis

c) Appendix of the epididymis

d) Rete testis

Question 11:

In males, which of the following structures is a derivative of the paramesonephric duct?

a) Paradidymis

b) Trigone of the bladder

c) Appendix of epididymis

d) Prostatic utricle

Question 12:

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A 2-year-old child was brought with complaints of swellings in the inguinal region on both sides. After investigations, it was diagnosed as bilateral cryptorchidism. It usually results into what condition?

a) Impotence

b) Sterility

c) Male pseudo-intersexuality

d) Female pseudo-intersexuality

Question 13:

The genital swellings in the male differentiate into which of the following?

a) Testes

b) Scrotum

c) Urethra

d) Glans penis

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Question 14:

A 1-year-old male baby was brought to the pediatric clinic with complaints of difficulty in passing urine. On examination, the urethra was present at the inferior aspect of the penis and a downward curve of the penis. This condition occurs due to:

a) Failure of fusion of urethral folds

b) Failure of closure of anterior abdominal wall

c) Failure of development of genital swellings

d) Failure of development of genital tubercle

Question 15:

Which of the following is a derivative of the mesonephric duct?

a) Appendix of testis

b) Appendix of epididymis

c) Prostatic utricle

d) Fallopian tube

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Question 16:

A 32-year-old woman who is G4P0L0A3 was evaluated for the cause of recurrent miscarriage. Hysterosalpingogram revealed a unicornuate uterus. A defect in the development of which of the following structures lead to the given condition?

a) Mullerian duct

b) Wolffian duct

c) Mesonephric duct

d) Urogenital sinus

Question 17:

The organ of Rosenmuller is a remnant of:

a) Endodermal sinus

b) Mullerian duct

c) Mesonephric tubule

d) Paramesonephric duct

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Question 18:

The vagina is derived from which structure?

a) Ectoderm

b) Mesoderm

c) Ectoderm and Mesoderm

d) Mullerian duct and cloaca

Question 19:

The congenital absence of clitoris in an infant is due to a defect in the development of which of the following structures?

a) Urethral folds

b) Urogenital groove

c) Genital tubercle

d) Genital swellings

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Answer Key

Question No.	Correct Option
1	b
2	b
3	a
4	c
5	c
6	d
7	a
8	d
9	d
10	c
11	d
12	b
13	b
14	a
15	b
16	a
17	c
18	d
19	c

Detailed Explanations

Solution to Question 1:

The urogenital ridge develops from the intermediate mesoderm.

After the formation of the peritoneal cavity, the intermediate mesoderm is seen as a bulge in the posterior abdominal wall. This bulge lateral to the attachment of the dorsal mesentery is known as the urogenital ridge.

The urogenital ridge has 2 parts:

• The genital ridge, which is medial and gives rise to the genital system

• The nephrogenic cord, which is lateral and contributes to the urinary system

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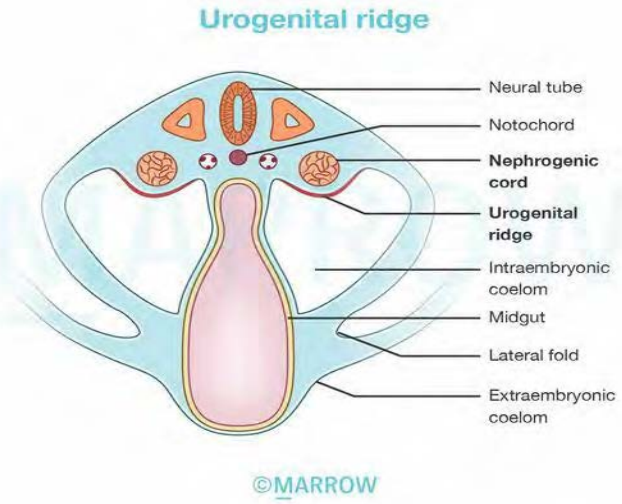

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Solution to Question 2:

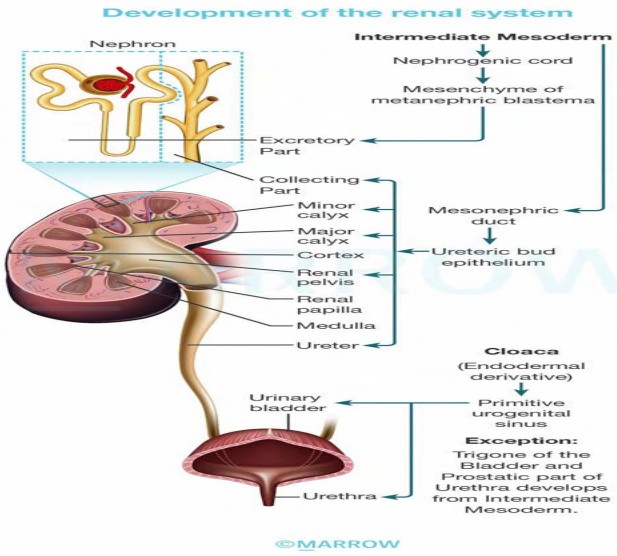
The proximal convoluted tubules develop from the metanephric blastema.

The kidney develops from 3 sources as follows:

• Metanephric blastema gives rise to the excretory system of the kidney. It forms the Bowman's capsule, proximal convoluted tubule, the loop of Henle, and distal convoluted tubule.

• Ureteric bud, which is an outgrowth of the mesonephric duct, gives rise to the collecting system of the kidney. It forms the collecting ducts, minor and major calyces, and renal pelvis.

• Angiogenic mesenchyme, which migrates into the metanephric blastema, gives rise to the glomeruli and the vasa recta.



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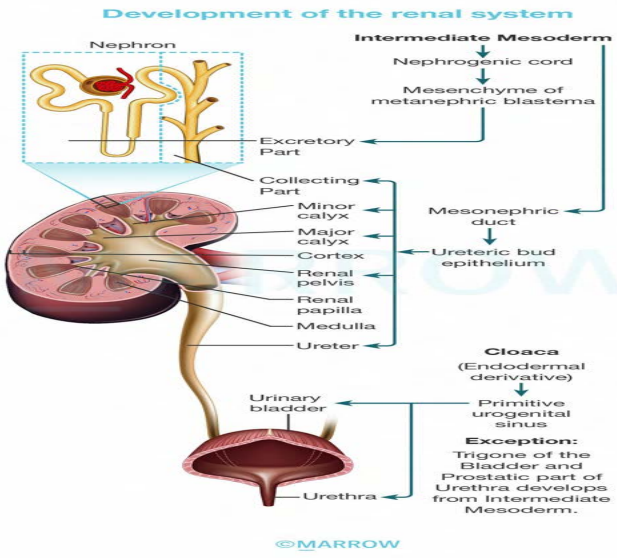
Solution to Question 3:

The ureteric bud develops from the mesonephric duct (Wolffian duct).

The tip of the ureteric bud penetrates the metanephric blastema, which forms a cap over the distal end of this bud. The ureteric bud gives rise to the ureter and the collecting system of the kidney.

Structures arising from the metanephric blastema and ureteric bud are as follows:

Metanephric blastema	Ureteric bud
Bowmans capsule	Collecting ducts
Proximal convoluted tubule	Renal papillae
Loop of Henle	Major and minor calyces
Distal convoluted tubule	Renal pelvis
	Ureter



Solution to Question 4:

The correct order of the stages of development of the nephron from earlier to later is blastema stage --> vesicle stage --> comma 'C' stage --> S-shaped stage.

The tip of the ureteric bud, which is growing towards the metanephric blastema, becomes dilated to form an ampulla. The ampulla induces the cells of the metanephric blastema to develop into a nephron.

The cells of the metanephric blastema pass through the following stages when developing into a nephron:

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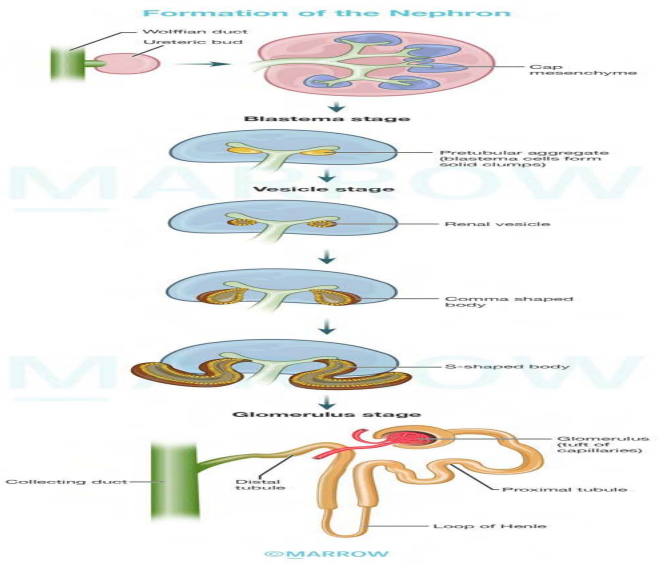

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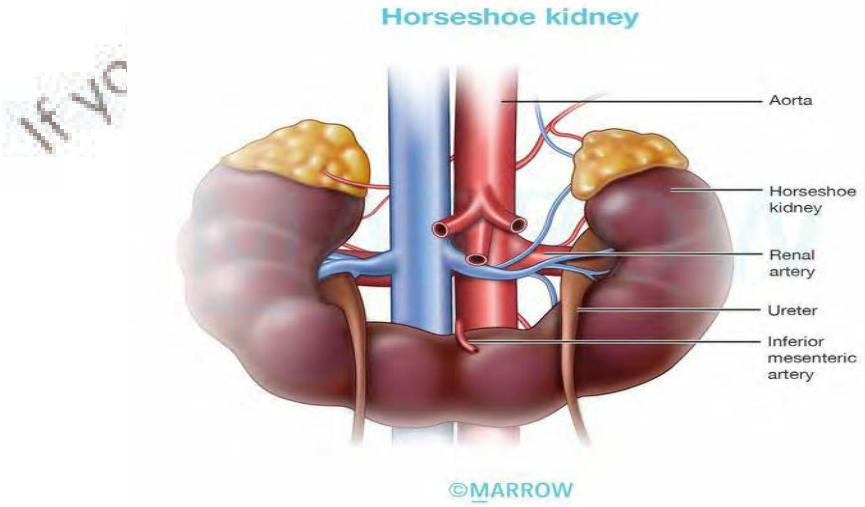
Solution to Question 5:

The horseshoe kidney is the most common congenital anomaly of the kidney.

During development, the kidney is initially located in the pelvic region. Later, the kidneys ascend due to the growth of the body in the lumbar and sacral regions. Sometimes, the kidneys are pushed so close to each other during their ascent that their lower poles fuse, forming a horseshoe kidney.



Solution to Question 6:

The inferior mesenteric artery prevents the ascent of the horseshoe kidney.

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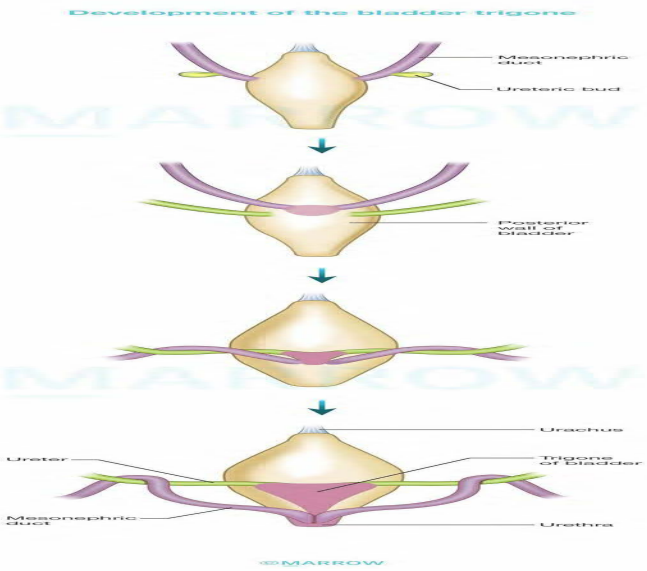
The horseshoe kidney is usually found at the level of the lower lumbar vertebrae. Its ascent is halted by the root of the inferior mesenteric artery. The connecting isthmus of the horseshoe kidney may be present either in front or behind the aorta and the inferior vena cava.

Pelvic kidney: Occasionally, one kidney fails to ascend. It is usually found in the pelvis near the common iliac artery.

Solution to Question 7:

The trigone on the posterior wall of the urinary bladder is formed by the incorporation of the lower ends of the mesonephric ducts.

After this incorporation, the ureters now open separately into the bladder, near the opening of the mesonephric duct. Due to the ascent of the kidneys, the ureteral openings move farther cranially, while the openings of the mesonephric ducts move close together. The triangular area between these ducts (trigone of the bladder) is thought to arise from the terminal portion of the mesonephric ducts.



Recent update: It was considered that the epithelium of the trigone is initially mesodermal and is later replaced by the endoderm-derived transitional epithelium. However, current research indicates that there is no mesodermal epithelial contribution to the bladder at the trigone (Gray's anatomy, 41st edition).

Solution to Question 8:

A palpable fluid-filled mass that is connected to the umbilicus superiorly and urinary bladder inferiorly is diagnostic of the urachal cyst.

During embryonic development, the upper end of the urogenital sinus communicates with the allantois, which lies in the umbilical cord. The allantois normally regresses to form a fibrous cord

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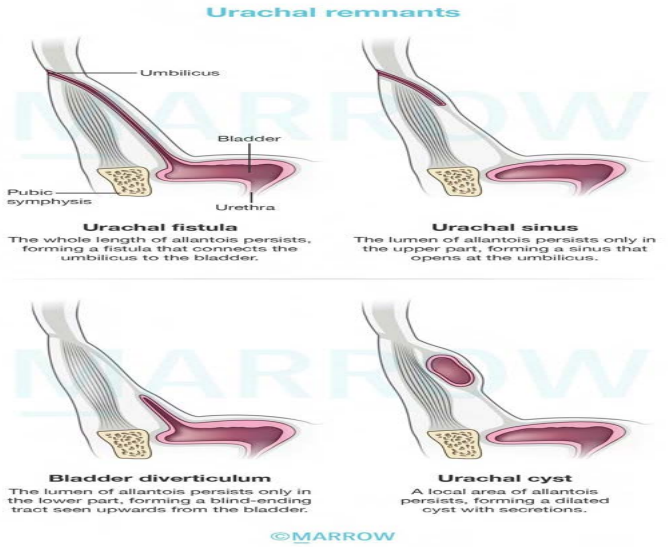
called the urachus. In the adult, the urachus is seen as the median umbilical ligament.

The remnants of the urachus that may be seen after birth are:



Solution to Question 9:

The seminiferous tubules are derived from the sex cords.

The epithelium in the gonadal ridge proliferates to form the primitive sex cords. They multiply further under the influence of the SRY gene on the Y chromosome and penetrate deep into the medulla to form testis cords. Near the hilum of the testis, these cords break into a network of tiny cell strands, which later give rise to rete testis.

Various parts of the testis are derived as follows:

Structure in Testis	Origin
Primordial germ cells	Epiblast
Sertoli cells	Surface epithelium of the earl y gonad
Interstitial cells of Leydig	Mesenchyme of the gonadal r idge
Seminiferous tubules, rete te stis	Sex cords (testis cords)
Tunica albuginea	Mesenchyme of the gonadal r idge beneath the coelomic ep ithelium
Efferent ducts (ductuli effere ntes)	Mesonephric tubules (Wolffia n tubules)
Ductus deferens	Mesonephric duct (Wolffian duct)

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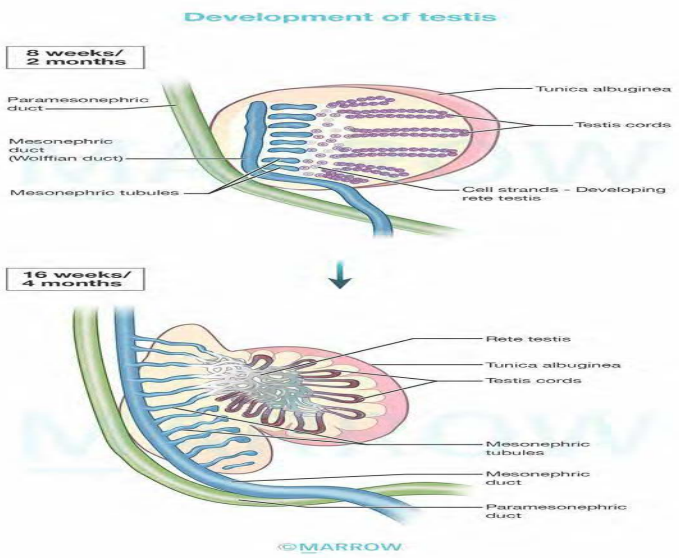

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Solution to Question 10:

The appendix of the epididymis is derived from the Wolffian duct (mesonephric duct).

It is the most cranial portion of the Wolffian duct (mesonephric duct) and remains as a vestigial structure.

Solution to Question 11:

The prostatic utricle is derived from the paramesonephric duct (Mullerian duct).

In males, under the influence of the anti-Mullerian hormone (AMH) produced by the Sertoli cells, the paramesonephric ducts degenerate.

Only two structures are derived from paramesonephric ducts in males:

• The appendix of the testis (also known as hydatid of Morgagni) is derived from the cranial end of the paramesonephric duct.

• The prostatic utricle (also known as utriculus prostaticus) is a small indentation in the prostatic urethra. It is located at the apex of the urethral crest, on the seminal colliculus (verumontanum), laterally flanked by openings of the ejaculatory ducts.

Solution to Question 12:

Bilateral cryptorchidism usually results in sterility.

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In this condition, both testes fail to descend into the scrotum. Therefore, the higher temperature to which they are exposed in the abdominal cavity will inhibit spermatogenesis. The majority of men with untreated bilateral cryptorchidism have azoospermia.

Solution to Question 13:

The genital swellings in the male differentiate into the scrotum.

The genital swellings are a pair of elevations that develop on either side of the urethral folds. The genital swellings later become the scrotal swellings in the male, which give rise to the scrotum.

In females, they differentiate into the labia majora.

Solution to Question 14:

The given condition is hypospadias and it is due to the failure of the urethral folds to fuse completely.

The cloacal folds fuse:

• Cranially to form the genital tubercle

• Caudally they constitute -

• Urethral folds anteriorly

• Anal folds posteriorly

At the end of the third month, the two urethral folds close over the urethral plate forming the penile urethra.

In hypospadias, there is an incomplete fusion of the urethral folds. The urethra opens abnormally on the inferior aspect of the penis usually near the glans, but it can open along the shaft or near the base of the penis. In rare instances, the urethral meatus opens in the scrotal raphe. If the urethral folds fail to fuse completely, a wide vertical slit can be present along the entire length of the penis and the scrotum. The two scrotal swellings then closely resemble the labia majora.

In epispadias, the urethral meatus is found on the dorsum of the penis. It is most commonly seen with exstrophy of the bladder and defects in the closure of the anterior body wall.

Solution to Question 15:

Appendix of the epididymis is a derivative of the mesonephric duct.

Appendix of the testis is a derivative of the paramesonephric duct.

Solution to Question 16:

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A unicornuate uterus is a Mullerian anomaly caused due to the defect in the formation or fusion of paired Mullerian ducts.

The uterus and the cervix develop from the paramesonephric ducts (Mullerian ducts).

Solution to Question 17:

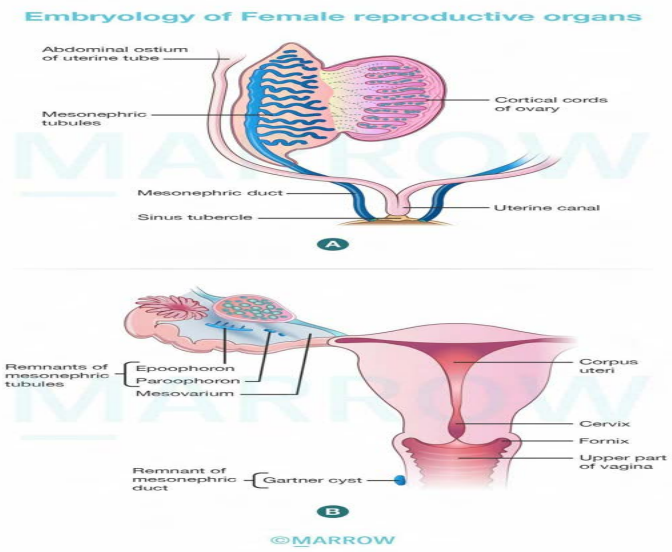
The organ of Rosenmuller, also known as epoophoron, is a remnant of the mesonephric tubule in females.

The mesonephros consists of a series of excretory tubules that develop in the thoracolumbar region. The mesonephric tubules drain into the mesonephric duct. Most of the mesonephric tubules disappear, but some mesonephric tubules take part in the formation of the efferent ductules in males.

The mesonephric tubules give rise to the following structures and remnants:

• Females: epoophoron and paroophoron

• Males: efferent ductules (ductuli efferentes or vasa efferentia), lobules of the head of the epididymis, and paradidymis.



Solution to Question 18:

The vagina has a dual origin: the upper portion is derived from the Mullerian duct (paramesonephric duct) and the lower portion is derived from the cloaca (urogenital sinus).

The solid tips of the paramesonephric ducts come in contact with the urogenital sinus. Two solid evaginations, called the sinovaginal bulbs, develop from the pelvic part of the urogenital sinus. The sinovaginal bulbs proliferate to become a solid vaginal plate. This entire plate is canalized by the 5th month to form the vagina.

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The upper part of the vagina is derived from the Mullerian duct, while the lower part is derived from the urogenital sinus. The vaginal fornices are of paramesonephric origin.

Solution to Question 19:

Agenesis of the clitoris occurs due to a defect in the development of the genital tubercle.

The vestibule is derived from the urogenital groove.

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Cell Structure, Epithelia, Glands & Connective Tissue

Question 1:

Which of the following structures together are■ referred to as protoplasm?

a) Plasma membrane and cytoplasm

b) Cytoplasm and nucleus

c) Nuclear membrane and nucleoplasm

d) Cytosol and organelles

Question 2:

What is the cytoplasm present within the channels of the endoplasmic reticulum called?

a) Hyaloplasm

b) Vacuoplasm

c) Cytosol

d) Protoplasm

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Question 3:

With respect to the mass ratio, the cell membrane predominantly consists of _____.

a) Phospholipids

b) Proteins

c) Carbohydrates

d) Glycolipids

Question 4:

Absorption of the fluids into the cell occurs by a process called _____

a) Endocytosis

b) Phagocytosis

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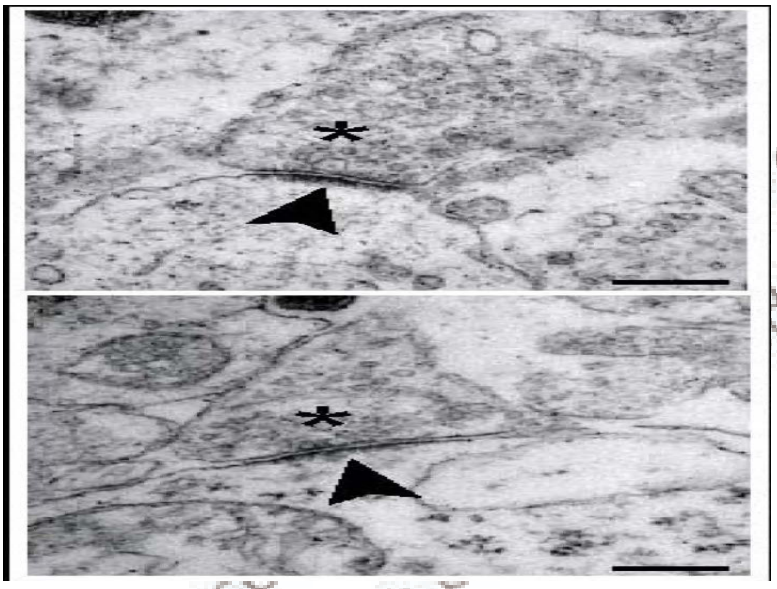
c) Pinocytosis

d) Exocytosis

Question 5:

The structure marked with the asterisk in the electron micrograph indicates _____.



a) Mitochondria

b) Golgi bodies

c) Secretory vesicles

d) Ribosomes

If you purchas... you may have ... else, ...d.

Question 6:

Which of the following chromatins in the nucleus has a loose appearance and stains lightly with hematoxylin and eosin?

a) Polychromatin

b) Heterochromatin

c) Hypochromatin

d) Euchromatin

Question 7:

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The lumen of the rough endoplasmic reticulum is continuous with _____.

a) Cytoplasm

b) Pericytoplasmic space

c) Perinuclear space

d) Nucleoplasm

Question 8:

Which of the following is not a unilayered epithelia?

a) Simple squamous epithelium

b) Pseudostratified columnar epithelium

c) Simple columnar epithelium

d) Seminiferous epithelium

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Question 9:

What type of epithelium lines the parietal peritoneum?

a) Simple squamous

b) Stratified squamous

c) Cuboidal

d) Columnar

Question 10:

The thyroid follicles are lined by _____ epithelium.

a) Stratified cuboidal

b) Cuboidal

c) Stratified columnar

d) Columnar

Question 11:

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Which of the following accurately describes the multilayered epithelium that consists of deeper columnar cells and a surface layer of flat cells?

a) Pseudostratified columnar epithelium

b) Stratified columnar epithelium

c) Pseudostratified squamous epithelium

d) Stratified squamous epithelium

Question 12:

What type of cell is the basal layer of stratified squamous epithelium composed of?

a) Cuboidal

b) Columnar

c) Squamous

d) Transitional

Question 13:

The cornea is lined by _____ epithelium.

a) Simple squamous

b) Stratified squamous keratinized

c) Stratified squamous non–keratinized

d) Non-ciliated pseudostratified columnar

Question 14:

Given below is the histological section showing the excretory duct of the salivary gland. Which of the following ducts of the glands do not have the same lining epithelium?

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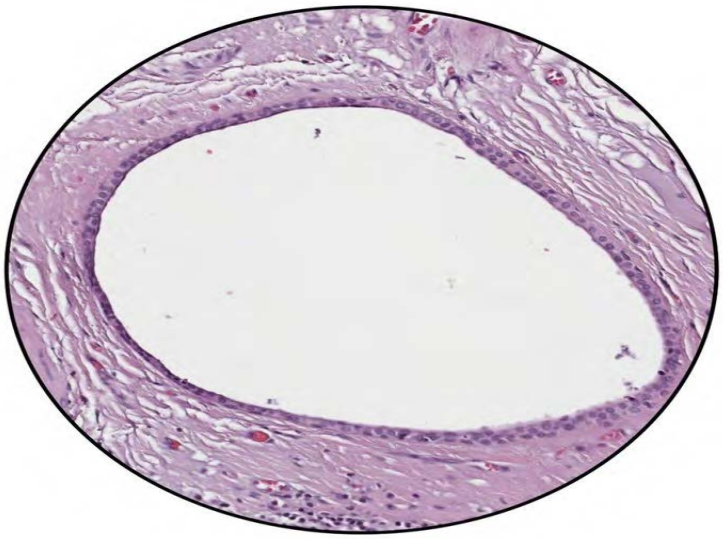

a) Sweat gland

b) Sebaceous gland

c) Salivary gland

d) Exocrine pancreas

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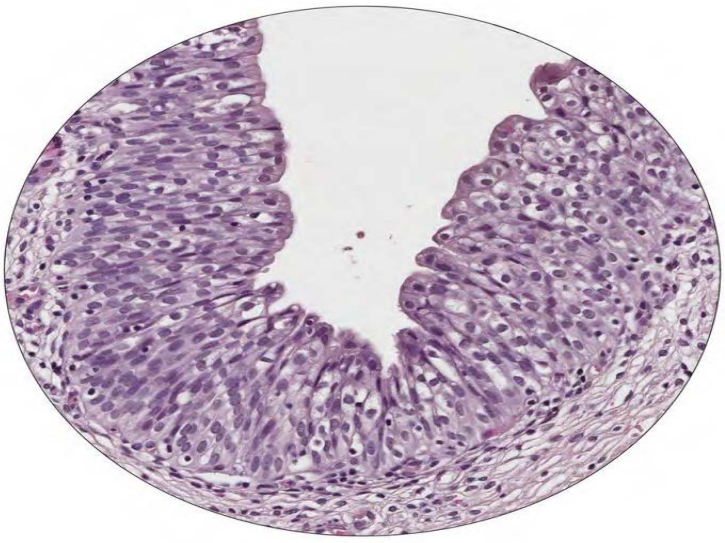
Question 15:

The type of epithelium as shown in the image below is present in _____.



a) Duodenum

b) Common bile duct

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c) Skin

d) Urinary bladder

Question 16:

Ansa nephroni is lined by _____.

a) Squamous and columnar epithelium

b) Cuboidal and columnar epithelium

c) Squamous and cuboidal epithelium

d) Squamous epithelium only

Question 17:

Microvilli are absent in _____.

a) Duodenum

b) Gall bladder

c) Proximal convoluted tubules

d) Collecting ducts

Question 18:

Which type of glands do sweat glands constitute?

a) Simple tubular

b) Simple coiled tubular

c) Compound tubular

d) Compound acinar

Question 19:

Which of the following is a holocrine gland?

a) Sweat gland

b) Mammary gland

c) Exocrine pancreas

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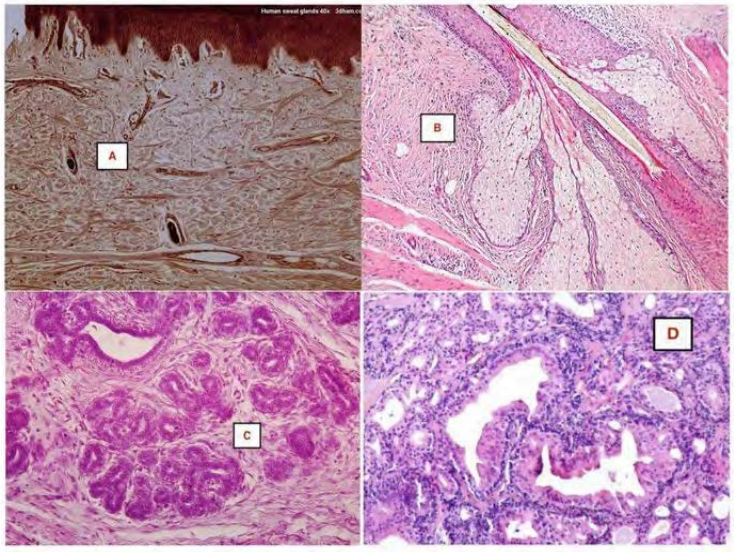
d) Sebaceous gland

Question 20:

Which of the following represents a holocrine gland?



a) A

b) B

c) C

d) D

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Question 21:

Which of the following statements are false about mucous acini?

a) Tall cells with flat nucleus at base

b) Contain zymogen granules

c) Lightly stained with H & E

d) Cell boundaries are distinct

Question 22:

Which of the following fibers of the connective tissue are stained black with silver impregnation?

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a) Type I collagen fibers

b) Elastic fibers

c) Reticular fibers

d) Type II collagen fibers

Question 23:

Which of the following cells are not an intrinsic component of the connective tissue?

a) Fibroblasts

b) Adipocytes

c) Mast cells

d) Pigment cells

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Question 24:

Sudan III and Sudan IV dyes are used for the staining of _____.

a) Elastic tissue

b) Mucoid tissue

c) Adipose tissue

d) Reticular tissue

Question 25:

Which of the following statements is true regarding the cells present in brown adipose tissue?

a) They are larger than in typical adipose tissue.

b) The fat in the cytoplasm occurs as single locule.

c) The cytoplasm contains numerous mitochondria.

d) The cytoplasm and nucleus are pushed to periphery.

Question 26:

Reticular fibres are not present in which of the following structures?

a) Thymus

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b) Lymph node

c) Bone marrow

d) Spleen

Answer Key

Question No.	Correct Option
1	b
2	b
3	b
4	c
5	c
6	d
7	c
8	d
9	a
10	b
11	d
12	b
13	c
14	b
15	d
16	c
17	d
18	b
19	d
20	b
21	b
22	c
23	c
24	c
25	c
26	a

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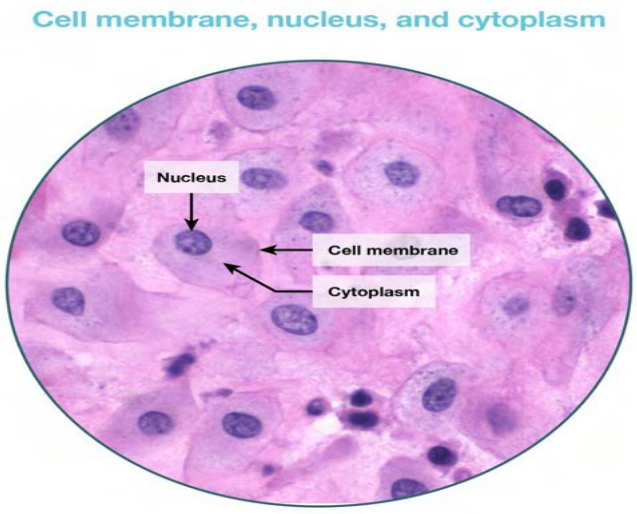
Detailed Explanations

Solution to Question 1:

The cytoplasm and nucleus together are referred to as protoplasm.

A cell is surrounded by a cell membrane (or plasma membrane), which encloses a complex material called protoplasm. It consists of a central, denser part called the nucleus, and an outer less dense part called the cytoplasm. The nucleus is surrounded by a nuclear membrane, which encloses chromatin, nucleolus, and nucleoplasm. The cytoplasm consists of cell organelles and cytosol (also called hyaloplasm), which is the liquid component of the cytoplasm present outside the cell organelles. Vacuoplasm refers to the fluid-filled spaces enclosed within the membrane-bound cell organelles.



Solution to Question 2:

The cytoplasm that is present within the channels of the endoplasmic reticulum is called vacuoplasm.

The presence of the endoplasmic reticulum divides the cytoplasm into two compartments, one within the channels called vaculoplasm and, that outside the channels called hyaloplasm or cytosol.

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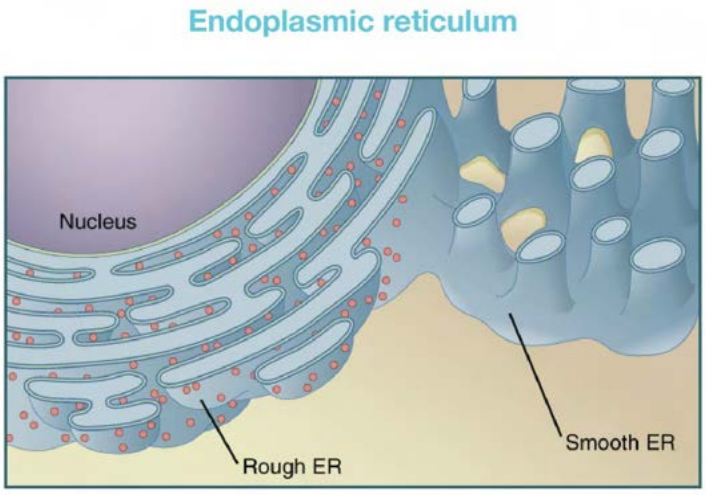

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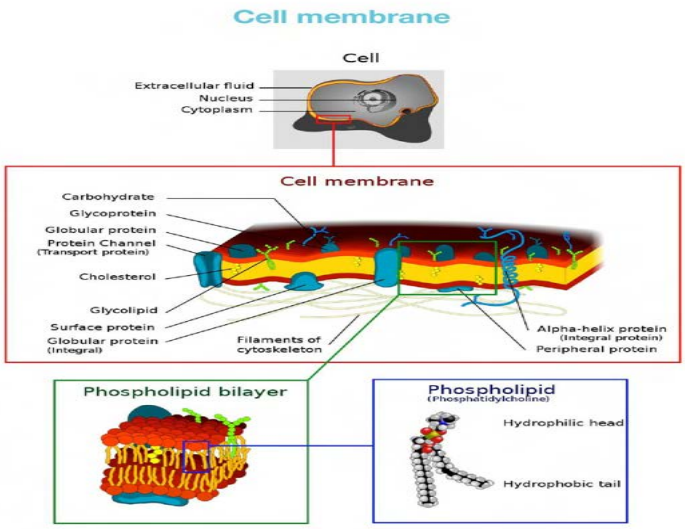
Solution to Question 3:

With respect to the mass ratio, the cell membrane predominantly consists of proteins.

The mass of proteins either equals or exceeds the mass of lipids in nearly all membranes. Most plasma membranes consist of approximately 50% lipid and 50% protein by weight. The lipid molecules in the cell membrane are predominantly phospholipids. The trilaminar structure of membranes is produced by the arrangement of lipid molecules. Each phospholipid molecule consists of an enlarged head with a phosphate portion and two thin tails. The head end is also called the polar end, while the tail end is the non-polar end. The head end is soluble in water and is said to be hydrophilic. The tail end is insoluble in water and is said to be hydrophobic.



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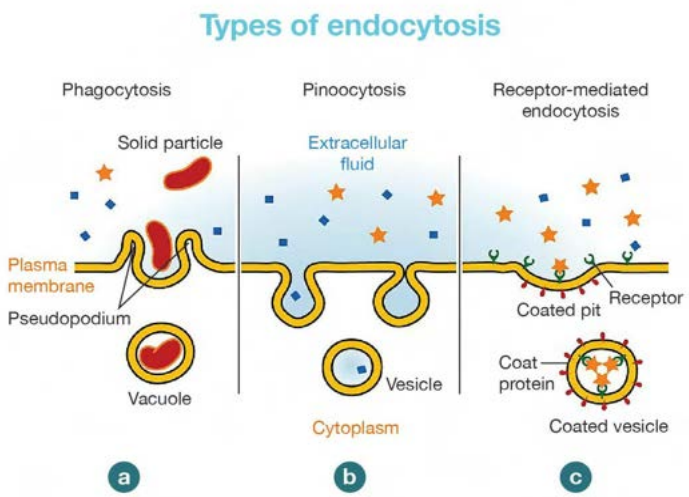
Solution to Question 4:

Absorption of the fluids into the cell occurs by a process called pinocytosis. The vesicles involved in the process are called pinocytotic vesicles.

Option A: Endocytosis is a process in which large molecules enter into the cells by invagination and formation of the vesicle.

Option B: Some cells use the process of endocytosis to engulf foreign matter (e.g., bacteria). The process is then referred to as phagocytosis.

Option D: The process of releasing the molecules that are produced within the cytoplasm to the exterior is called exocytosis or reverse pinocytosis.



Solution to Question 5:

The structure marked with the asterisk in the electron micrograph indicates presynaptic secretory vesicles. The structure marked with the arrowhead is postsynaptic density.

The secretory vesicles are synthesized by the neurons and are involved in electrochemical signalling in the brain and neuromuscular junctions.

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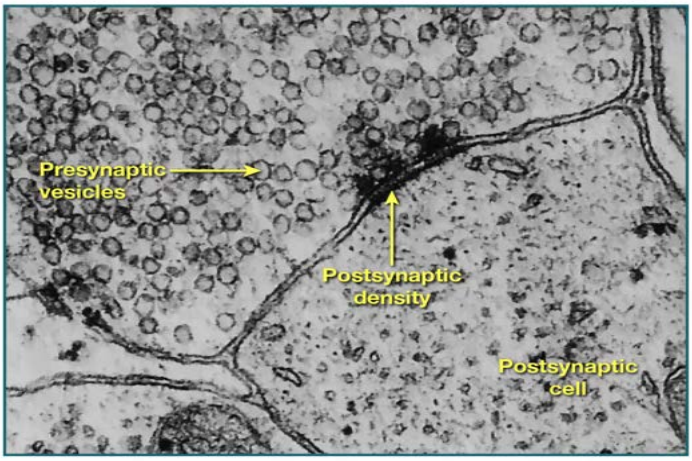
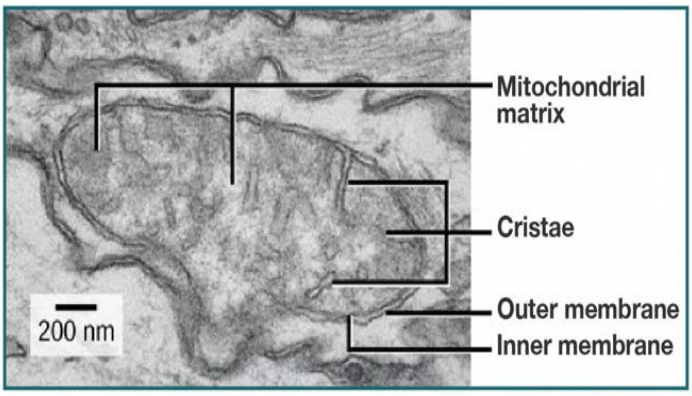
Synapse - electron microscopy



On electron microscopy:

• Mitochondria appear as round or elliptical bodies of 0.5-2.0 micron long on an electron microscope, consisting of an outer and an inner mitochondrial membrane, cristae, and mitochondrial matrix.

Mitochondria - electron microscopy



• Golgi bodies (or Golgi apparatus) appear as stacks of flatenned membranous cisternae surrounded by clusters of vesicles.

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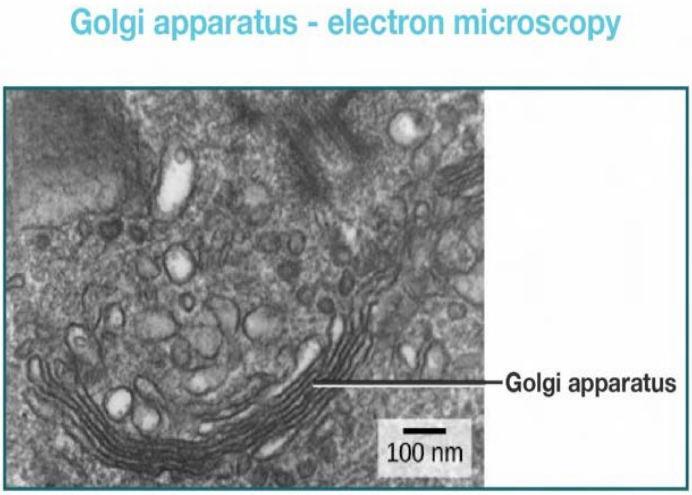
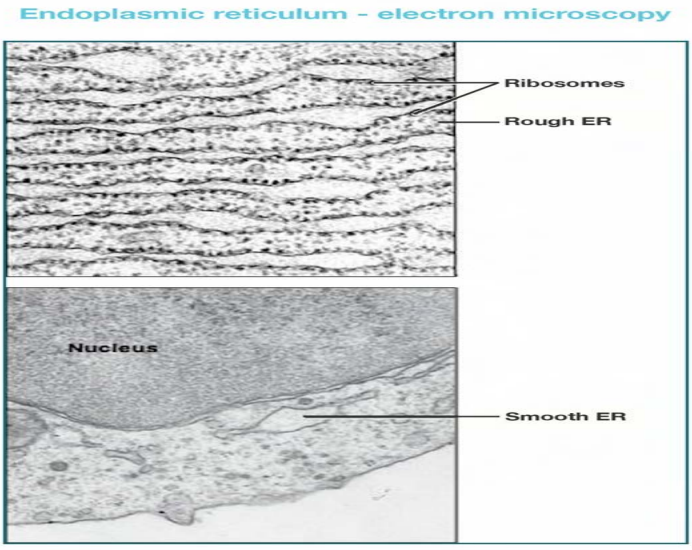


• Ribosomes may be attached to the membrane of the rough endoplasmic reticulum (as shown in the image below), or else, they may exist as monosomes or as a chain of granular structures called polyribosomes associated with mRNA.



Solution to Question 6:

The euchromatin in the nucleus of a cell has a loose appearance and stains lightly with hematoxylin and eosin (H&E).

On staining with H&E, the nucleus stains dark purple or blue, while the cytoplasm usually stains pink. However, in some cells, the nuclei are relatively large and stain lightly due to the presence of a delicate network of fibers called chromatin. At some places (in the nucleus), the chromatin is seen in the form of irregular dark masses called heterochromatin and some other places, the network is loose and stains lightly and is referred to as euchromatin.

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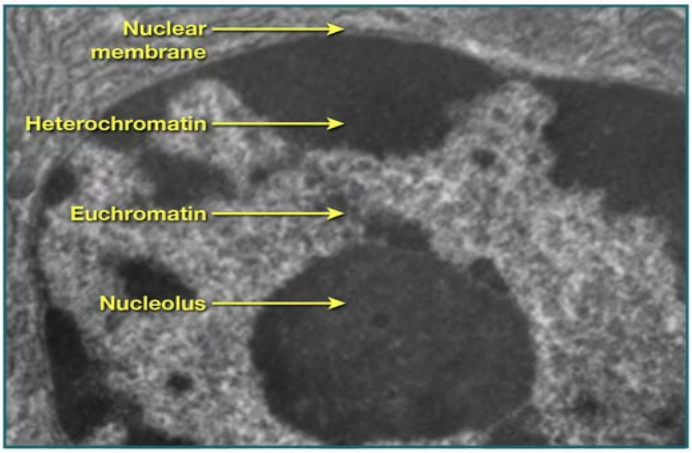
Nucleus - electron microscopy



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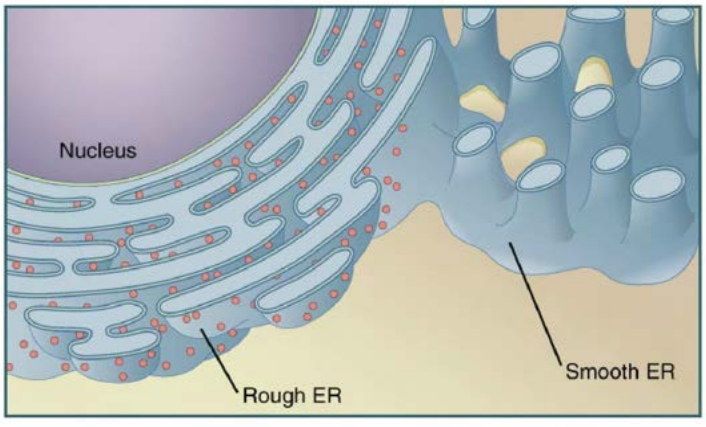
Solution to Question 7:

The lumen of the rough endoplasmic reticulum is continuous with perinuclear space.

Rough endoplasmic reticulum (ER) arises from the outer nuclear membrane. Hence, its lumen is continuous with the perinuclear space (space between inner and outer nuclear membranes). The lumen is also continuous with the lumen of the smooth ER.

The ER is an organelle that consists of a network of flattened membrane-bound structures called cisternae. The ER is classified into rough ER and smooth ER, depending on whether the ribosomes are attached or not, respectively.

Endoplasmic reticulum



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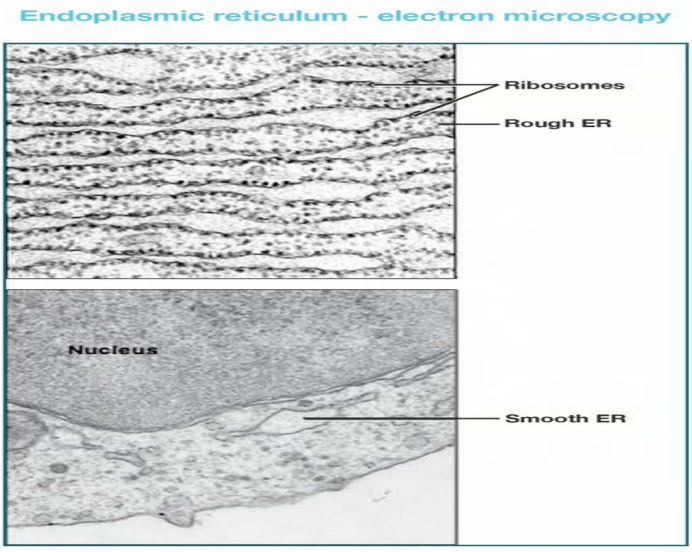

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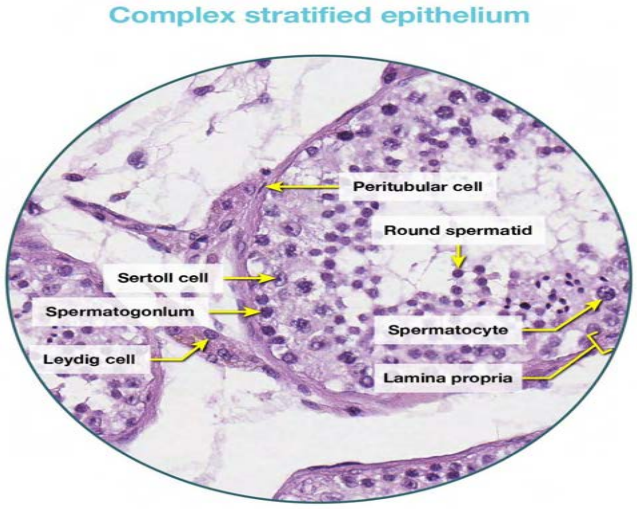
Solution to Question 8:

The seminiferous epithelium is a complex stratified epithelium, consisting of cells that form a lineage of spermatozoa (spermatogonia, spermatocytes, spermatids) and Sertoli cells.

Given below is a histological image showing the complex stratified epithelium of seminiferous ducts.



Simple epithelia and pseudostratified epithelium are both uni-layered epithelia.

Simple epithelium - typically present in sites at which absorption, secretion, and filtration occur. Depending on the shape of the cells, the simple epithelia are further classified as:

• Squamous epithelium

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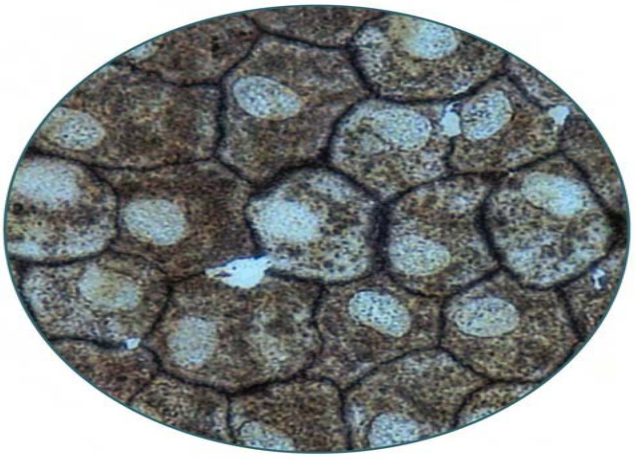
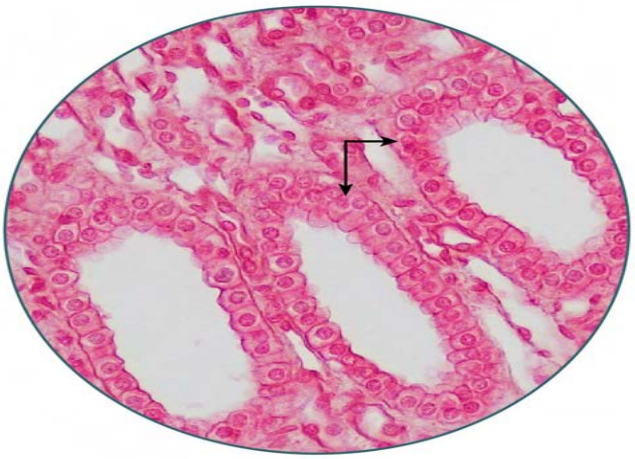
Simple squamous epithelium



• Cuboidal epithelium

Simple cuboidal epithelium



• Columnar epithelium

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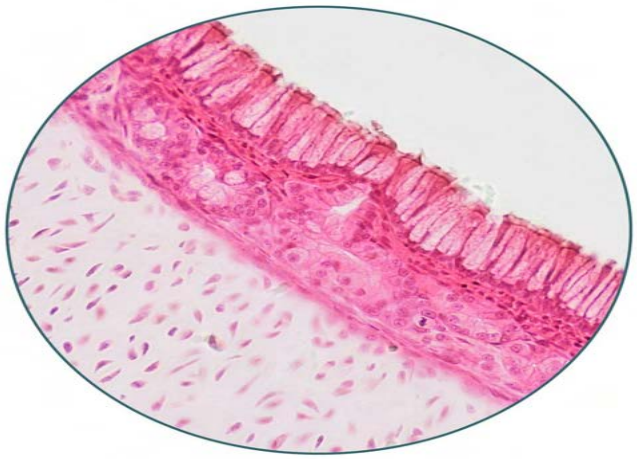
Simple columnar epithelium

Pseudostratified epithelium - comprises only a single layer of cells but has its cell nuclei positioned at various levels in a manner falsely suggestive of stratified epithelia.

Given below is a histological image showing the pseudostratified columnar epithelium of the trachea.

Pseudostratified columnar epithelium



Solution to Question 9:

Parietal peritoneum is lined by simple squamous epithelium.

The simple squamous epithelium is seen at the following sites:

• Alveoli of the lungs

• Thin segment of the loop of Henle

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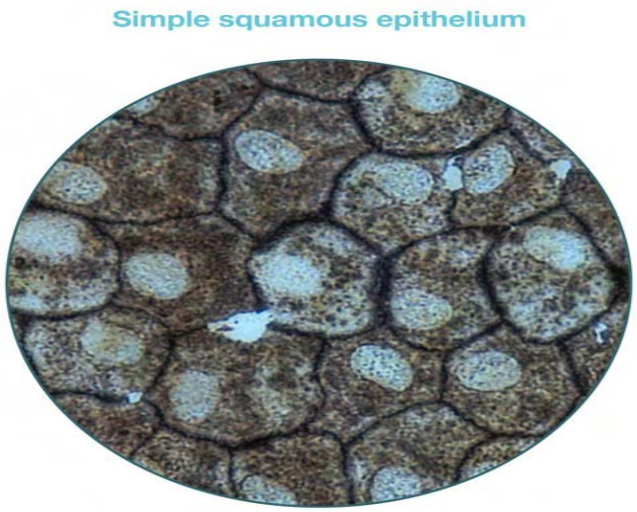
• Lining of the blood and lymphatic vessels, where it is called endothelium

• Lining of the body cavities such as pleura, peritoneum, and pericardium, where it is called mesothelium.

• Lining of the inside of the heart, where it is known as endocardium.



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Solution to Question 10:

Thyroid follicles are lined by cuboidal epithelium.

The cuboidal epithelium consists of a single layer of cells in which the height of the cells is about the same as their width. The nuclei are usually rounded.

Cuboidal cells are seen in:

• Follicles of the thyroid gland

• Surface of the ovary (where it is called the germinal epithelium).

• Choroid plexuses,

• Inner surface of the lens

• Pigment cell layer of the retina.

• Proximal convoluted tubules of the kidneys (brush border cuboidal)

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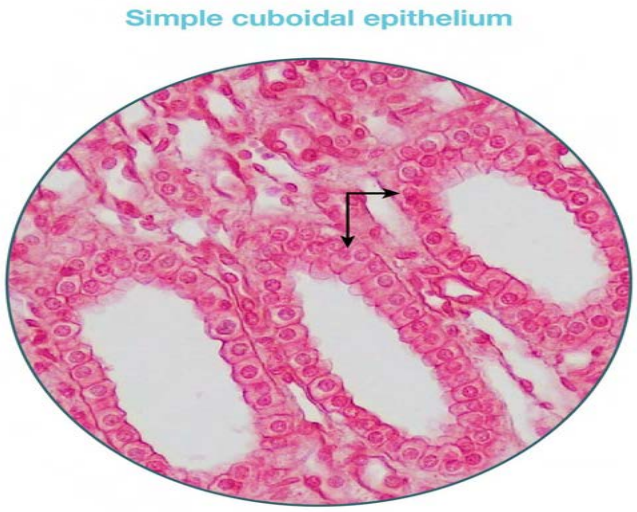

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Solution to Question 11:

The multilayered epithelium that consists of deeper columnar cells and a surface layer of flat cells is known as the stratified squamous epithelium.

Stratified (multi-layered) epithelia are of the following types:

1. Stratified squamous epithelium:

• The deepest layer is usually columnar, above which there are layers of cuboidal cells, and as it proceeds towards the surface of the epithelium the cells become increasingly flattened (or squamous).

• It is further classified into keratinized and non-keratinized epithelium.

The given histological images show keratinized stratified squamous epithelium of the oral mucosa and the non-keratinized stratified squamous epithelium of the esophagus.

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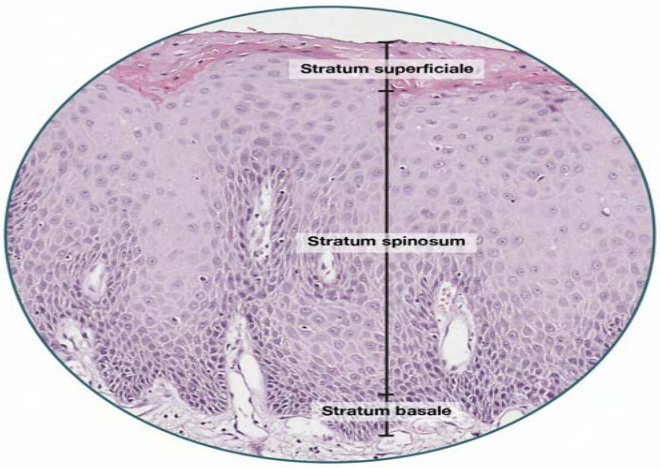
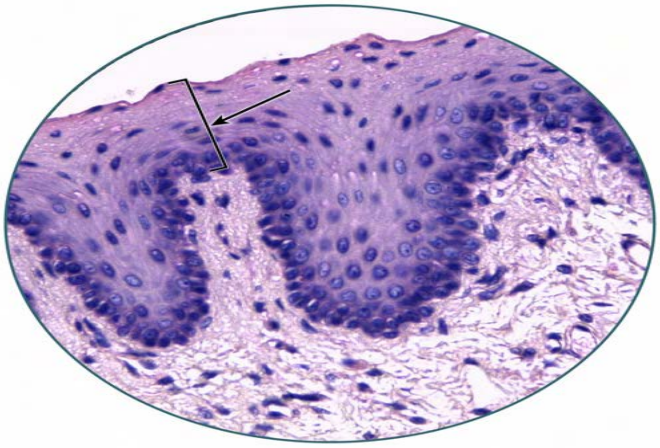
Keratinized stratified squamous epithelium



Non-keratinised stratified squamous epithelium



2. Stratified cuboidal/columnar epithelium:

• It consists of two or more layers of cuboidal or columnar cells, respectively.

The given histological image shows stratified cuboidal epithelium of salivary glands.

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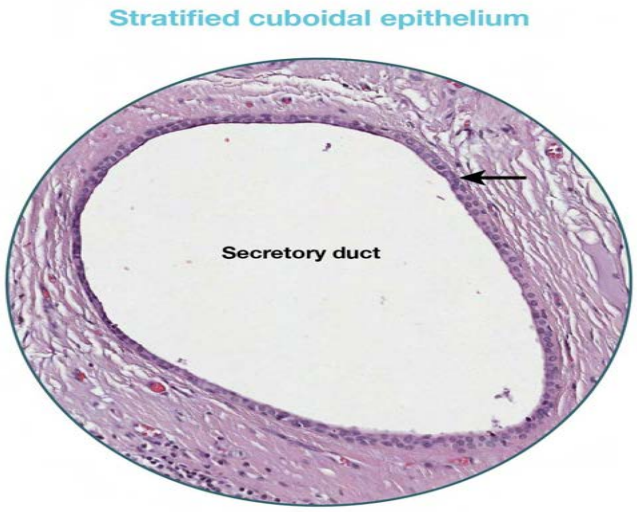


3. Transitional epithelium:

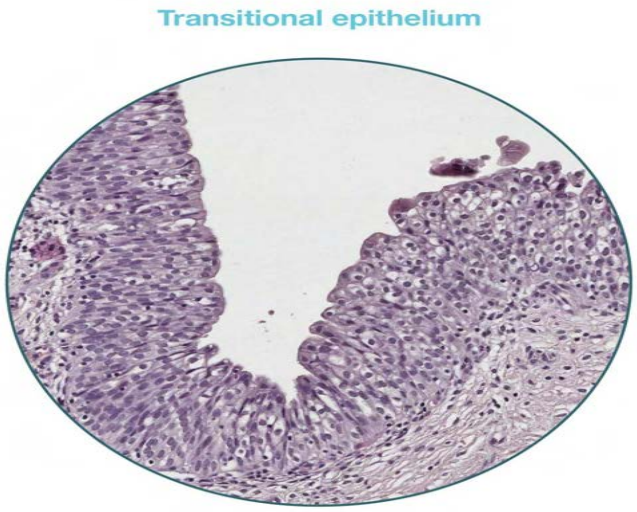
• It is a specialized epithelium lining most of the urinary tract; hence, it is also called urothelium.

• The deepest layer consists of columnar or cuboidal cells, and the middle layer consists of polyhedral or pear-shaped cells.

• The surface layer consists of large, polypoid, dome-shaped or umbrella-shaped cells. As the epithelium gets stretched to accommodate urine, the surface cells become flattened.

• The cells are called transitional due to this apparent change (transition) from stratified cuboidal epithelium in a relaxed state to stratified squamous epithelium when it is stretched.

The given histological image shows transitional epithelium of the urinary bladder.



Solution to Question 12:

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The basal layer of cells present in the stratified squamous epithelium is composed of columnar cells.

The stratified squamous epithelium is made up of several layers of cells notably:

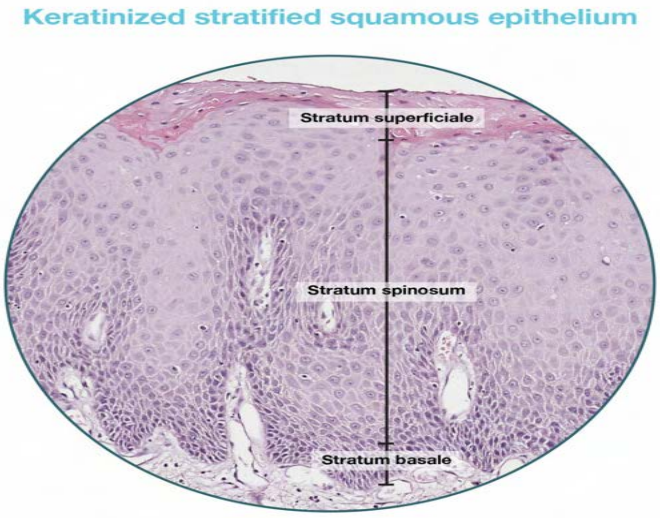
• Columnar cells - deepest layer

• Polygonal cells - middle layers

• Flattened squamous cells - superficial layers

Stratified squamous epithelium may be keratinized or non-keratinized.

Given below is a histological image of keratinized stratified squamous epithelium of the oral mucosa.



Solution to Question 13:

The cornea is lined by stratified squamous non–keratinized epithelium.

The cornea is made up of five layers. The outermost layer is made of non-keratinised stratified squamous epithelium (corneal epithelium) which can regenerate rapidly after damage.

Given below is a histological image of non-keratinised stratified squamous epithelium of the esophagus.

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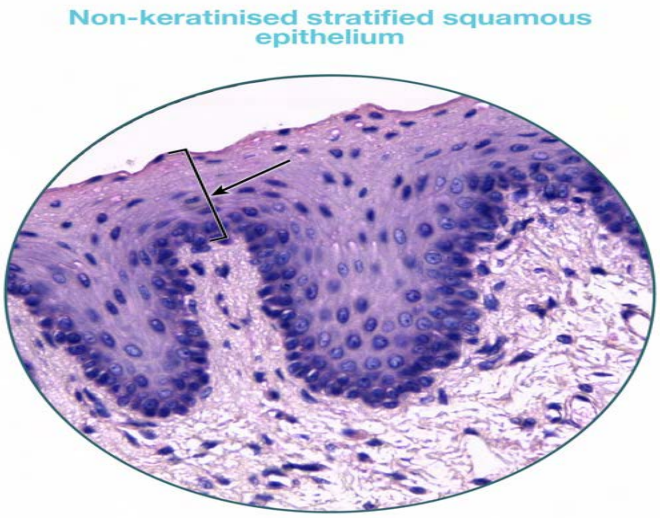

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Solution to Question 14:

The ducts of the sebaceous glands are lined by keratinised stratified squamous epithelium, whereas the ducts of sweat glands, salivary glands, and exocrine pancreas are lined by stratified cuboidal epithelium.

Solution to Question 15:

The type of epithelium shown in the image is the transitional epithelium and it is present in the urinary bladder.

Transitional epithelium is a specialized epithelium lining most of the urinary tract, hence it is also called the urothelium. The deepest layer consists of columnar or cuboidal cells, and the middle layer consists of polyhedral or pear-shaped cells. The surface layer consists of large, polypoid, dome-shaped, or umbrella-shaped cells. As the epithelium gets stretched to accommodate urine, the surface cells become flattened. The cells are called transitional due to this apparent change (transition) from stratified cuboidal epithelium in a relaxed state to stratified squamous epithelium when it is stretched.

They are present in:

- Collecting ducts
- Renal pelvis and calyces
- Ureter
- Urinary bladder
- Pre-prostatic and prostatic parts of urethra

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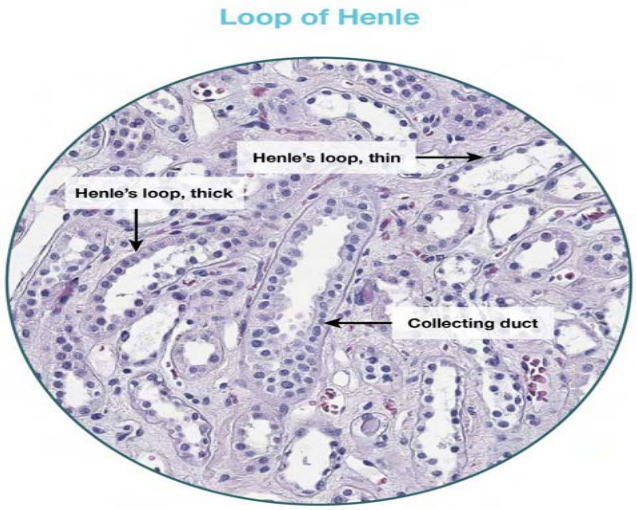
Solution to Question 16:

The loop of Henle is also called ansa nephroni. It is lined by both the squamous and cuboidal epithelium at different parts.

The tubular epithelial cells grow progressively taller throughout the segment until those in the collecting duct form a simple columnar epithelium.

The given histological image shows a cross-section of the kidney showing the thin and thick loops of Henle.



Solution to Question 17:

Microvilli are absent in collecting ducts. They are lined by simple columnar epithelium without microvilli.

The simple cuboidal or columnar epithelium may undergo certain specializations such as:

• Microvilli - long finger-like projections arising from the surface of the epithelium, which increases the surface area of absorption. If the microvilli are long and are arranged regularly, parallel to one another, it gives a striated appearance on light microscopy. However, if the microvilli are arranged irregularly, it gives a brush border appearance. Microvilli are located at:

• Small intestine - columnar cells with striated microvilli.

• Gall bladder - columnar cells with brush border microvilli.

• Proximal convoluted tubule - cuboidal cells with brush border microvilli

• Stereocilia - long and branching microvilli. Unlike the cilia, the stereocilia are non-motile and hence, the preferred name is stereovilli. They are located at:

• Epididymis (increase the surface area of absorption)

• Cochlear and vestibular receptor cells (function as sensory transducers)

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• Cilia - hair-like projections on the epithelial cells that are concerned with the movement. The ciliated columnar epithelium is seen in the lining of the following structures:

• Respiratory tract except in lower pharynx and vocal folds.

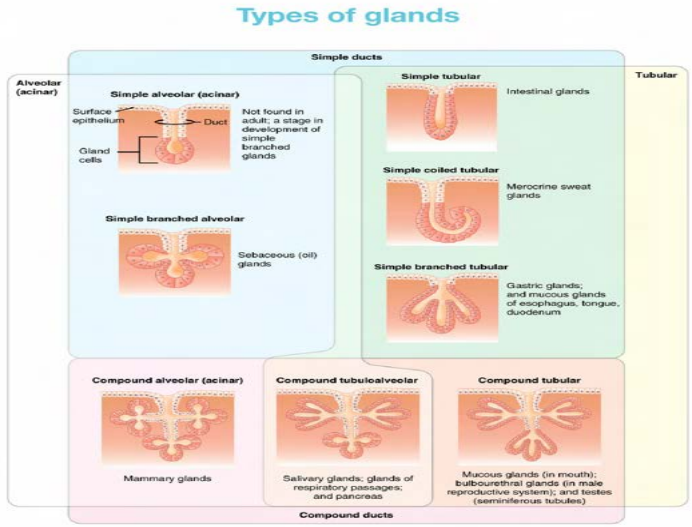
• Tympanic cavity and auditory tube.

• Uterine tube and efferent ductules of the testis.

• Secretory - columnar cells may be specialized for secretions where they are referred to as glandular cells. Such cells form the mucin secreting and chief cells of the gastric epithelium.

Solution to Question 18:

Sweat glands are simple coiled tubular glands.



Solution to Question 19:

The sebaceous gland is a holocrine gland.

The exocrine glands are classified into 3 types, depending on the mode of secretion:

• Merocrine glands - They are also known as eccrine or epicrine glands, in which the secretions are released out of the cell through a process called exocytosis with the cell remaining intact. The examples of such glands are:

• Eccrine sweat glands

• Salivary glands

• Exocrine pancreas

• Secretion of milk protein casein by mammary glands

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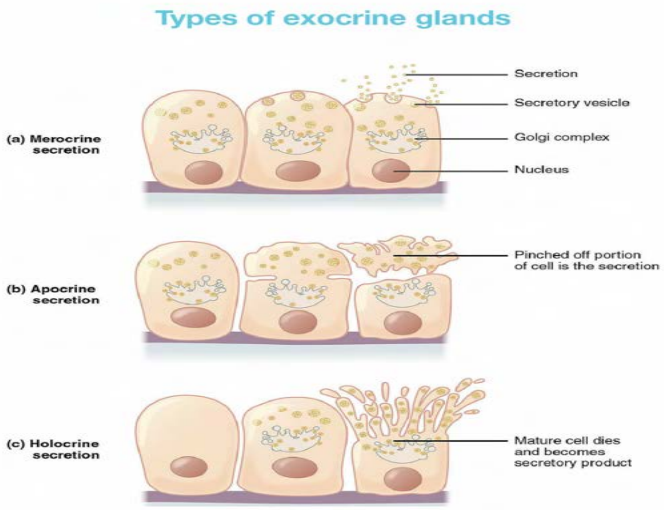
• Holocrine glands - In these glands, the entire cell disintegrates while discharging its secretion. It is typically seen in sebaceous glands.

• Apocrine glands - In these glands, the apical parts of the cells are shed off to discharge the secretion. Examples of apocrine glands are

• Sweat glands in axilla and anogenital regions

• Secretion of milk fat by mammary glands



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Solution to Question 20:

The histopathological image marked 'B' represents the sebaceous gland, which is a type of holocrine gland.

Holocrine secretions are produced in the cytoplasm of the cell and released by the rupture of the plasma membrane, which destroys the cell and results in the secretion of the product into the lumen.

Examples of holocrine glands are

• Sebaceous glands of the skin and

• Meibomian glands of the eyelid

Image A: Sweat glands - Eccrine/merocrine glands; glands remain intact

Image C: Mammary gland - Apocrine gland; apical part sheds to secrete

Image D: Ceruminous gland - Apocrine glands

Solution to Question 21:

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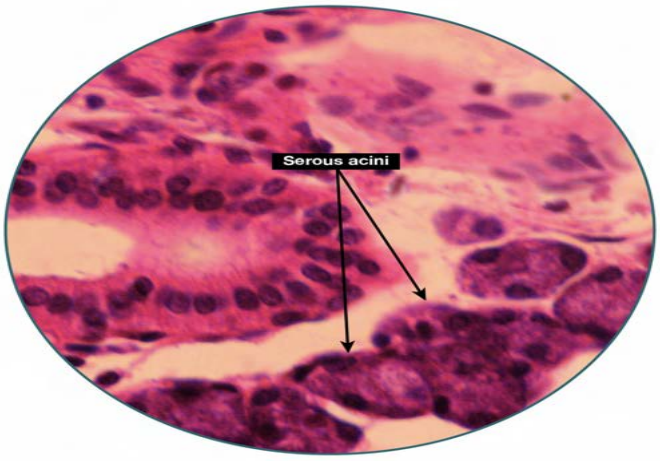
The zymogen granules are present in serous acini, whereas the mucous acini consists of mucoid material.

The following table shows a comparison between serous and mucous acini:

Serous acini	Mucous acini
Triangular cells with rounded nucleus at the base	Tall cells with flat nucleus at the base
The cell boundaries are indist inct	The cell boundaries are distin ct
Contains zymogen granules	Contain mucoid material
Darkly stained with H&E	Lightly stained and appear e mpty with H&E
Thin watery secretion	Thick mucoid secretion
Example: Parotid gland	Example: Sublingual gland

Serous acini



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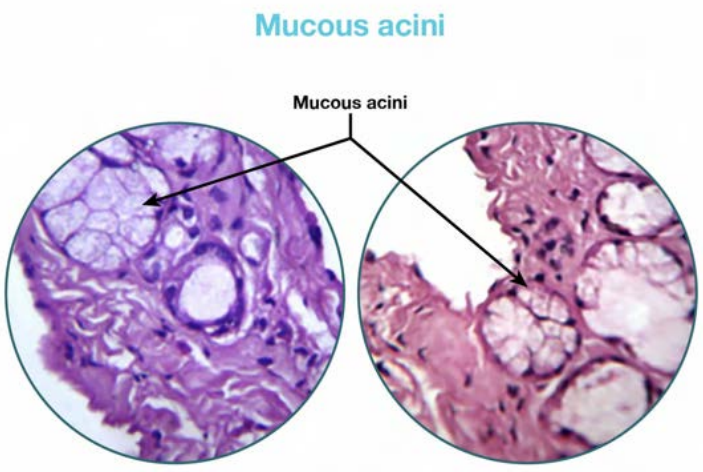

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Solution to Question 22:

Reticular fibers are stained black with silver impregnation method. Reticular fibers are also called argentophil fibers, due to their specific affinity for silver salts.

The fibers of connective tissue are of three main types. These include:

• Collagen fibers

• Reticular fibers

• Elastic fibers

The staining characters of each of these fibers are as follows:

The image below shows reticular fibers in reticular connective tissue, stained black with silver impregnation method.

Connective tissue fibers	Stain	Appearance
Collagen fibers	Unaided dye	White
Hematoxylin and eosin	Light pink	
Masson's trichrome	Blue	
Verhoeff-Van Gieson	Red	
Silver impregnation	Brown	
Reticular fibers	Silver impregnation	Black
Elastic fibers	Verhoeff-Van Gieson	Black
Aldehyde fuchsin	Purple	

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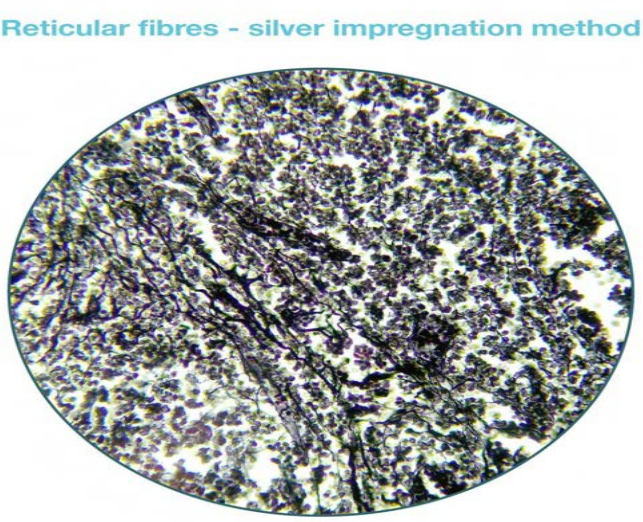
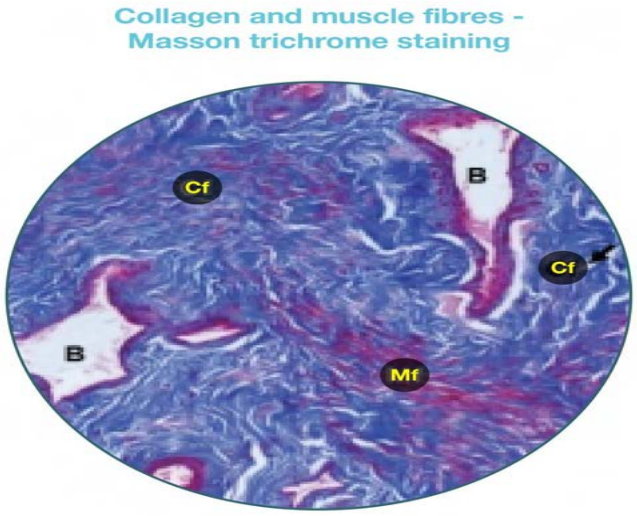
Connective tissue fibers	Stain	Appearance
Orcein	Purplish brown	



The images below show specimens of glans penis showing collagen fibers (Cf) stained blue and muscle fibers (Mf) stained red using Masson trichrome stain, and elastic fibers (Ef) stained black using Verhoeff-Van Gieson stain.



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Solution to Question 23:

Mast cells are not part of the intrinsic component of the connective tissue.

The various types of cells that are present in connective tissue are classed into two distinct categories that are namely:

- Cells that are intrinsic components of connective tissue:
- Fibroblasts
- Undifferentiated mesenchymal cells
- Pigment cells
- Adipocytes
- Cells that belong to the immune system:
- Macrophage cells (or histiocytes)
- Mast cells
- Lymphocytes
- Plasma cells
- Monocytes
- Eosinophils

Solution to Question 24:

Sudan III and Sudan IV dyes are used for the staining of adipose tissue.

The image below shows adipose tissue stained with Sudan dye.

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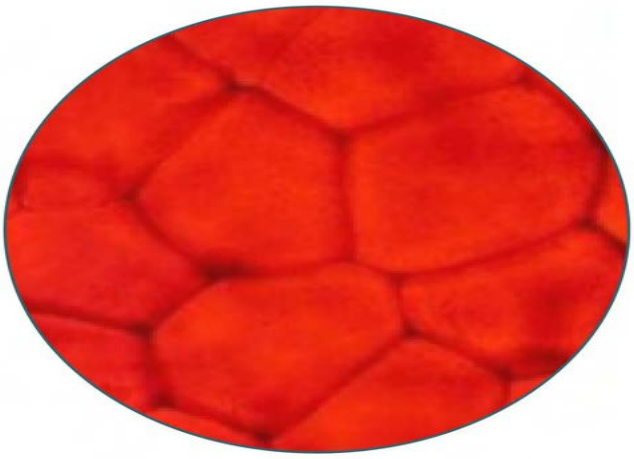
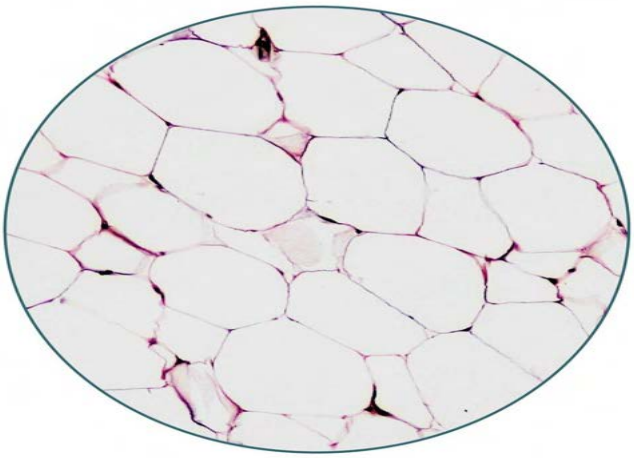
Adipose tissue - Sudan dye staining



However, during the routine preparation of slides, the tissues are treated with fat solvents (like xylene or benzene), which dissolve the fat. Therefore, in such preparations, fat cells look like rounded empty spaces, as shown in the image below.

Adipose tissue - fat solvent treatment



Solution to Question 25:

The cytoplasm of the cells of brown adipose tissue contains numerous mitochondria.

The adipose tissue is mainly of two types:

• Yellow or white adipose tissue.

• Brown adipose tissue (embryonic type).

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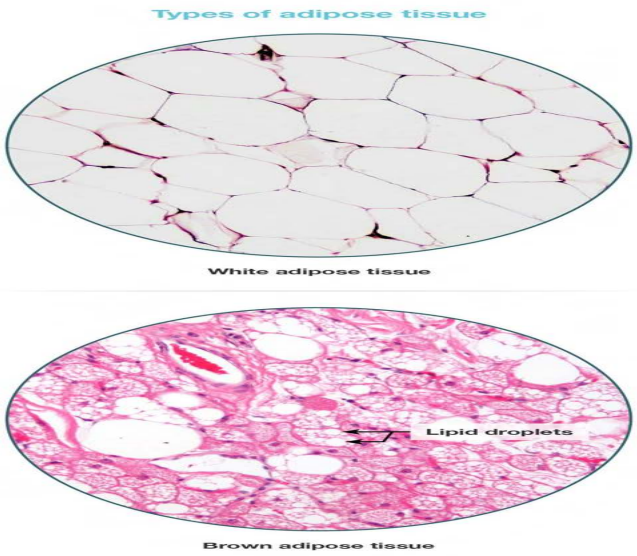
Features	White adipose tissue	Brown adipose tissue
Seen in	Adults	Newborn
Cell size	Larger	Smaller
Fat droplet(s)	Single	Multiple
Also called	Unilocular adipose tissue	Multilocular adipose tissue
Cytoplasm and nucleus	Pushed to periphery	Not pushed to periphery
Mitochondria	Few	Numerous



Solution to Question 26:

Reticular fibres are not present in the thymus.

Reticular fibres are fine, anastomosing fibres composed of mainly type III collagen. They differ from type I collagen fibres in that, they are finer and are arranged in the form of a network (reticulum). The fibres appear black in colour on staining with silver impregnation. Due to this affinity to silver salts, they are also known as argentophil fibres.

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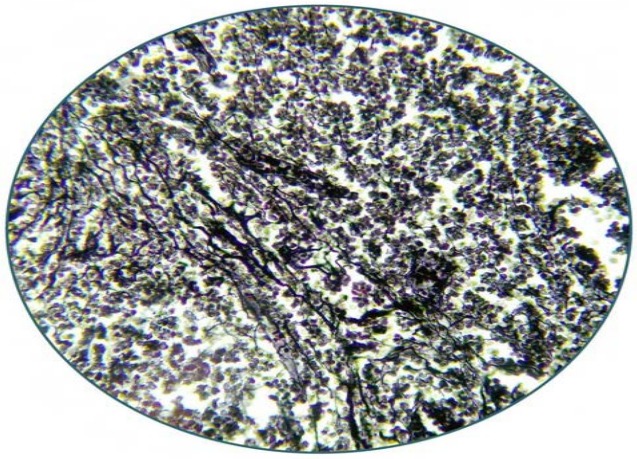
Reticular fibres - silver impregnation method



Reticular fibres are mainly found in:

- All lymphoid organs like spleen, lymph node, and bone marrow (except thymus).
- Glands, liver and kidneys.
- The basement membrane of all epithelia.
- Smooth muscle and nerve cells.

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Bone, Cartilage & Muscular Tissue

Question 1:

The marrow cavity in the shaft of the fetal long bone mainly contains _____.

a) Red marrow

b) Yellow marrow

c) Gelatinous marrow

d) White marrow

Question 2:

Which of the following cells do the osteoprogenitor cells give rise to?

a) Osteocytes

b) Osteoblasts

c) Chondrocytes

d) Chondroblasts

Question 3:

Which of the following statements is true regarding the constituents of bone matrix?

a) The inorganic calcium salts make the bone tough and resilient.

b) The organic connective tissue affords resistance against compressive and impact forces.

c) Calcium phosphate is the major constituent of the inorganic salts present in the bone.

d) The organic matrix constitutes about 65% of the dry weight of the bone.

Question 4:

Which of the following accurately describes the term osteoid?

a) Osteoblasts and the collagen fibers

b) Gelatinous matrix and inorganic mineral salts

c) Collagen fibers and gelatinous matrix

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d) Inorganic component of bone

Question 5:

The image shows the microscopic appearance of the lamellar bone. Identify the structure marked as A.

a) Volkmann's canal

b) Haversian canal

c) Interstitial lamellae

d) Circumferential lamellae

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Question 6:

Which of the following is a false statement regarding the ossification of bones?

a) Membranous bones are formed from primitive mesenchyme.

b) Cartilaginous bones are derived from preformed cartilaginous models.

c) Membranocartilaginous bones are also known as dermal bones.

d) Clavicle is a membranocartilaginous bone.

Question 7:

The type of cartilage as shown in the image is present in _____

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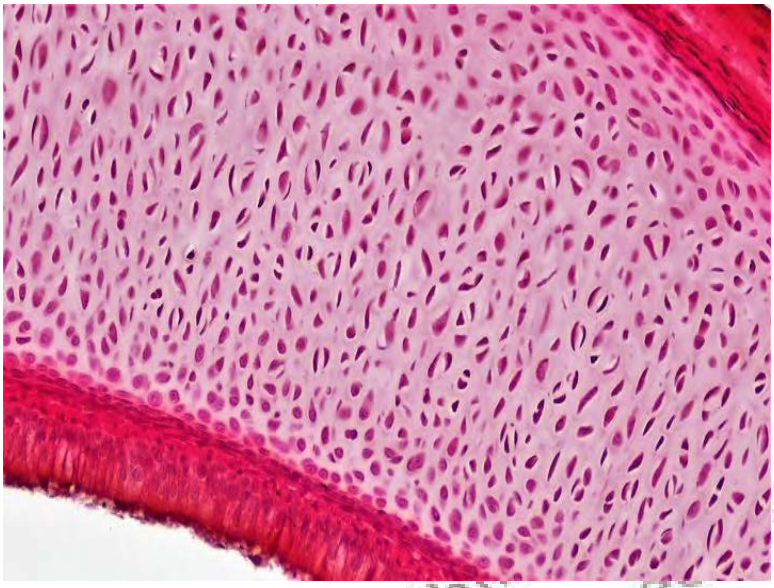

a) Terminal bronchioles

b) Intervertebral discs

c) Bronchi

d) Epiglottis

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Question 8:

Which of the following cartilage is referred to as the yellow cartilage?

a) Hyaline catilage

b) Elastic cartilage

c) Fibrous cartilage

d) Fibroelastic cartilage

Question 9:

Identify the type of cartilage shown in the image below:

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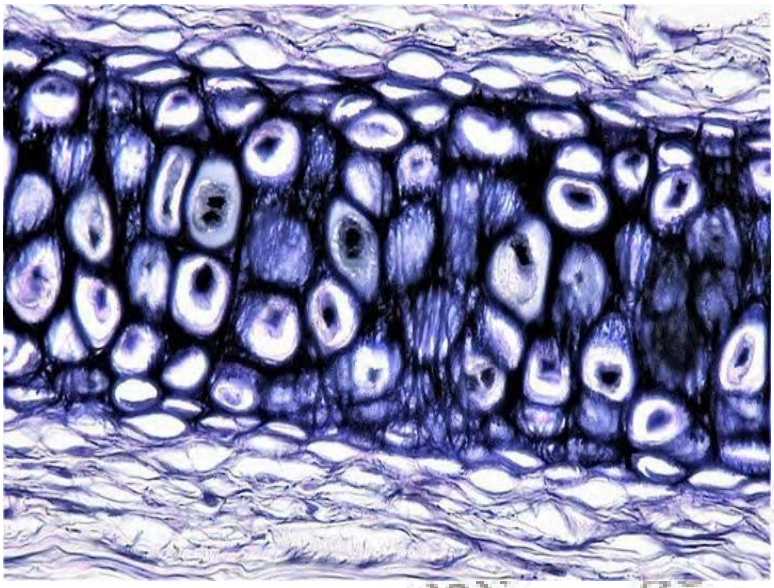

a) Hyaline cartilage

b) Elastic cartilage

c) Articular cartilage

d) Fibrocartilage

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Question 10:

Which of the following stains are used to visualize the elastic fibers present in the elastic cartilage?

a) Haematoxylin and eosin stain

b) Verhoeff's stain

c) GMS Silver stain

d) Alcian Blue stain

Question 11:

In which of the following types of cartilages is type 1 collagen present?

a) Hyaline cartilage

b) Fibrocartilage

c) Elastic cartilage

d) Articular cartilage

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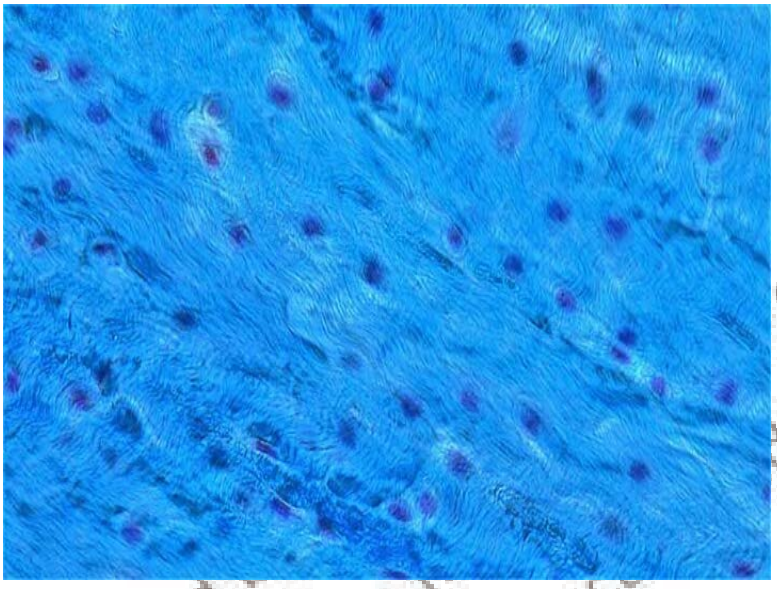
Question 12:

Which of the following statements is true about the type of cartilage shown in the histological image below?



a) It is present in epiphyseal plate

b) Consists of thin collagen fibres

c) Not covered with perichondrium

d) It is present in bronchi

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Question 13:

Each bundle of muscle fibres is surrounded by_____

a) Epimysium

b) Perimysium

c) Endomysium

d) Sarcolemma

Question 14:

Identify the type of muscle tissue shown in the image below.

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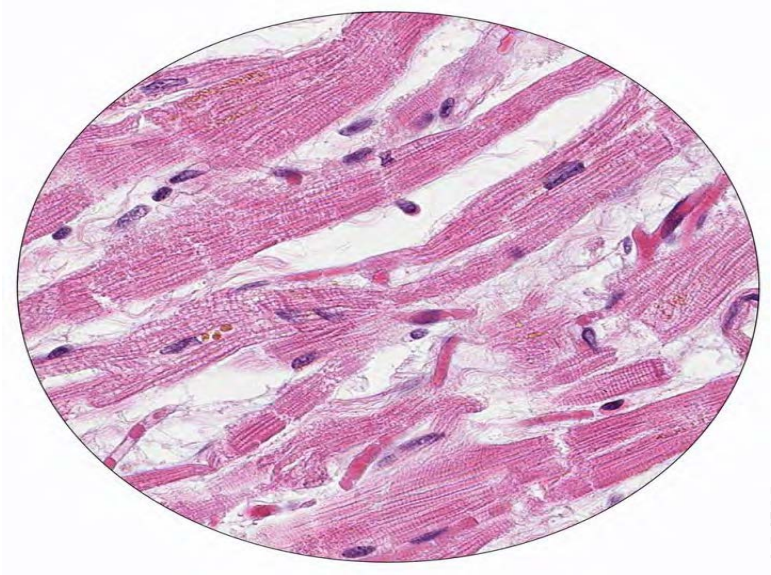

a) Skeletal muscle

b) Visceral smooth muscle

c) Cardiac muscle

d) Vascular smooth muscle

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Question 15:

Which of the following muscle fibers consists of spindle-shaped myocytes?

a) Skeletal muscle

b) Smooth muscle

c) Cardiac muscle

d) Striated muscle

Answer Key

Question No.	Correct Option
1	a
2	b
3	c
4	c
5	a

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6	c
7	c
8	b
9	b
10	b
11	b
12	c
13	b
14	c
15	b

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Detailed Explanations

Solution to Question 1:

The marrow cavity in the shaft of the fetal long bone mainly contains red marrow.

Bone marrow is a soft, pulpy tissue found in the marrow cavity and the spaces of spongy bone. It is mainly of two types:

• Yellow marrow - made up predominantly of fat cells and may contain few islands of hemopoietic tissue. It is seen in the shaft of the long bones of an adult.

• Red marrow - It is made up predominantly of hemopoietic tissue. It is seen throughout the skeleton of the fetus. It persists till about five years of age after which, the red marrow in the shaft of long bones is gradually replaced by the yellow marrow. By around 20-25 years of age, the sites where the red marrow persists include:

• Vertebrae

• Sternum

• Ribs

• Clavicles

• Scapulae

• Pelvis

• Cranial bones

• Proximal ends of femur and humerus

The term gelatinous marrow refers to the degenerated bone marrow in the cranial bones, seen in old age. There is no white marrow.

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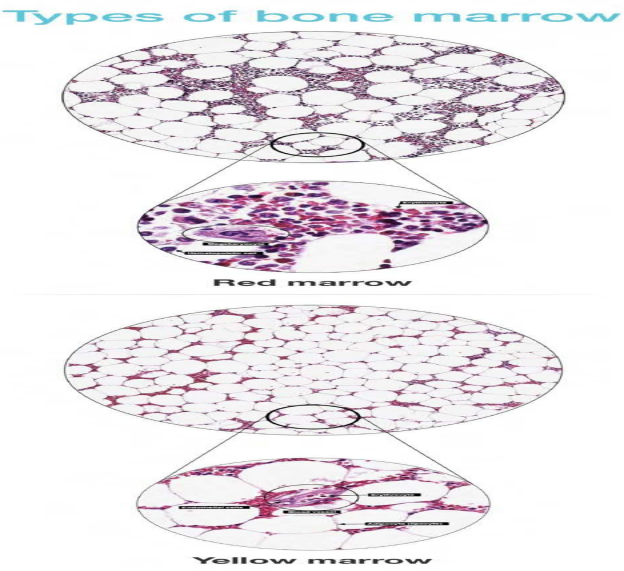

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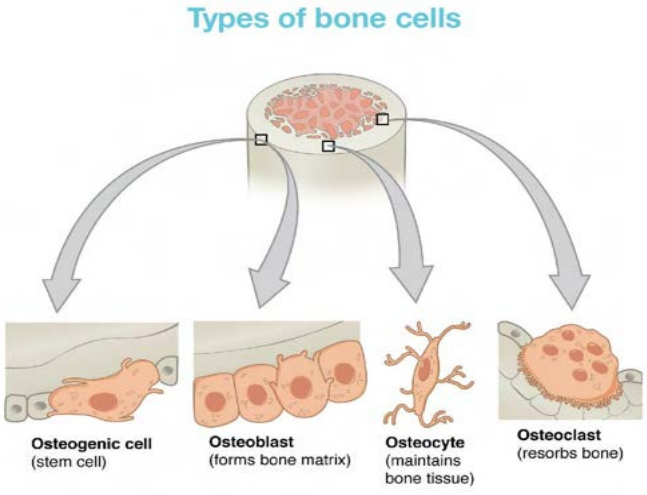
Solution to Question 2:

The osteoprogenitor cells give rise to osteoblasts. They are the stem cells of mesenchymal origin and microscopically resemble fibroblasts.



The image below shows light micrograph of osteoprogenitor cells forming a nidus.

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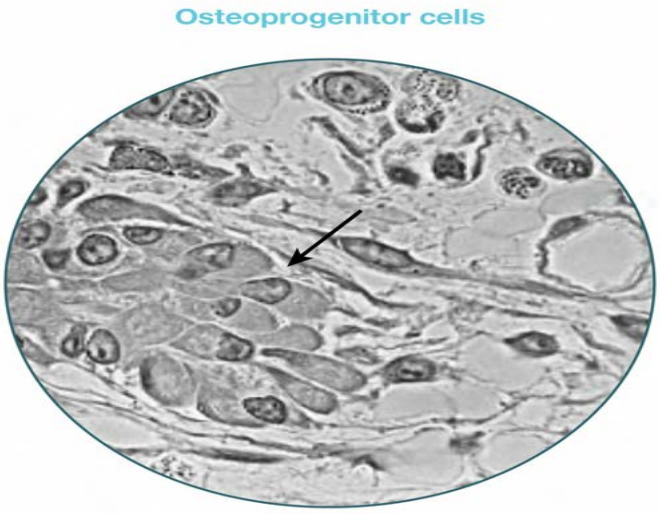
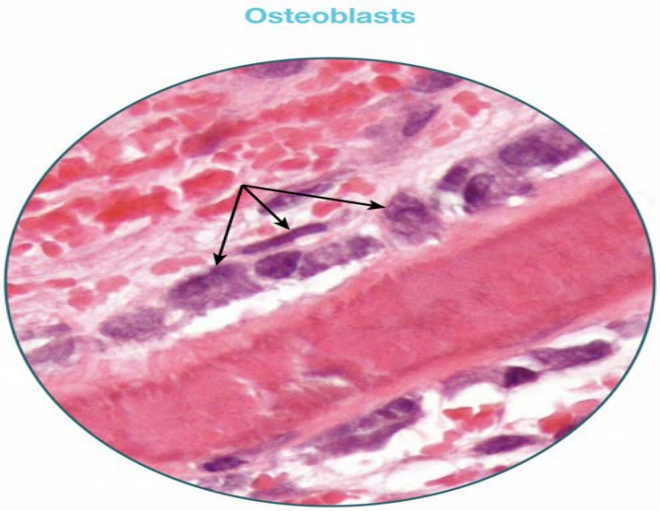


The image below shows a light micrograph showing osteoblasts.



Solution to Question 3:

Calcium phosphate in the form of calcium hydroxyapatite is the major constituent of the inorganic salts present in the bone.

The ground substance of the bone (bone matrix) is predominantly made up of inorganic mineral salts, which constitute about 60-70% of the dry weight of the bone. These inorganic salts are deposited within the organic matrix.

• Inorganic mineral salts - makes the bone hard and rigid, and thus provides resistance to the compressive and impact forces as in weight-bearing or jumping respectively. Its constituents are:

• Calcium phosphate in the form of calcium hydroxyapatite (85% of total salts)

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• Calcium carbonate (10% of total salts), magnesium, chloride, fluoride, citrate, sodium, and potassium.

• Organic matrix - makes the bone tough and resilient (flexible) and thus provides resistance to the tensile forces. Its constituents are:

• Type I collagen (predominantly)

• Glycosaminoglycans, proteoglycans, and water.

• Osteonectin and osteocalcin - predominant glycoproteins present in bone. These bind to calcium and help in the mineralization of the bone.

• Other substances include chondroitin sulfates, phospholipids, and phosphoproteins.

Note: Histological preparation of bone sections involves a process called decalcification, wherein the inorganic mineral salts of the bone are removed by treating the bone with weak acids or chelating agents such as EDTA or citrate. The decalcification causes the bone to lose its rigidity.

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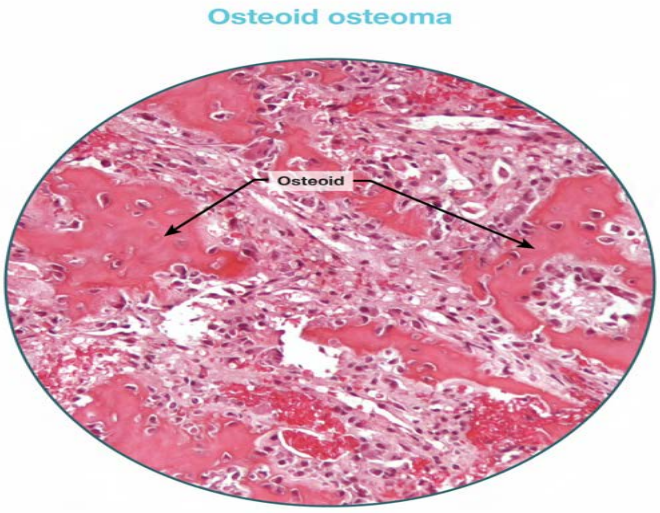
Solution to Question 4:

During the formation of bone, the mesenchymal cells and osteoblasts secrete type I collagen and gelatinous matrix (unmineralized bone matrix), which together forms the osteoid.

The collagen fibers swell up within the gelatinous matrix and become indistinct. Calcium salts are deposited into the gelatinous matrix under the influence of osteoblasts and this process is called mineralization.

The below image shows the microscopic appearance of osteoid in a patient with osteoid osteoma.



Solution to Question 5:

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The structure marked as A in the above image is Volkmann's canal. The Haversian canals communicate with each other by the transverse perforating canals, which are called Volkmann's canals.

The Haversian system or osteon constitute most part of the compact bone. Each Haversian system contains a central canal within which the small blood vessels, nerves, and endosteum are present. This canal is surrounded by multiple layers or lamellae of the calcified matrix containing type I collagen fibers. These canals communicate with each other by Volkmann's canal.

Successive lamellae are separated from each other by lacunae containing osteocytes. These osteocytes are in communication with each other, the central canal and the periphery of the osteon via the dendritic processes present within the canaliculi. The parallel lamellae present between osteons is called interstitial lamellae and the parallel lamellae present near the periosteum are called the circumferential lamellae.

On microscopy, osteon can be identified by

- Presence of Haversian canal with concentric lamellae around it
- Volkmann's canal
- Osteocytes with canaliculi
- Interstitial lamellae
- Circumferential lamellae

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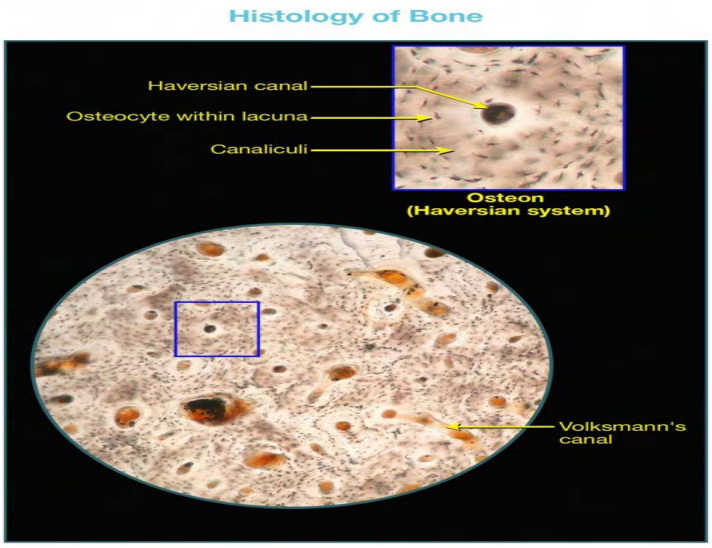

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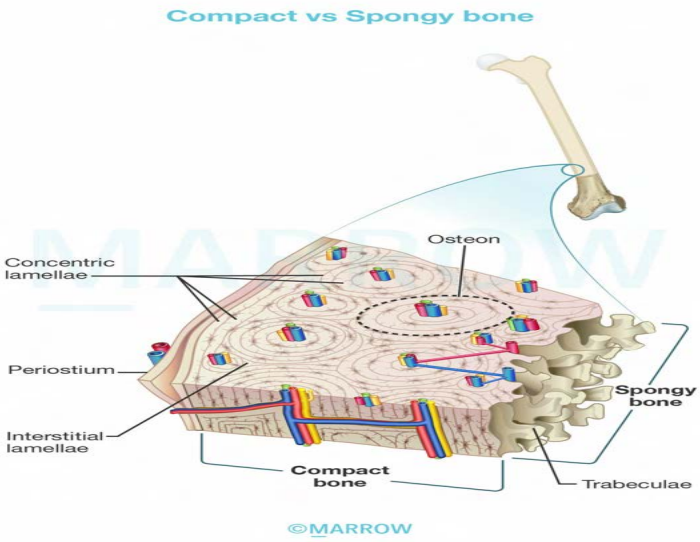

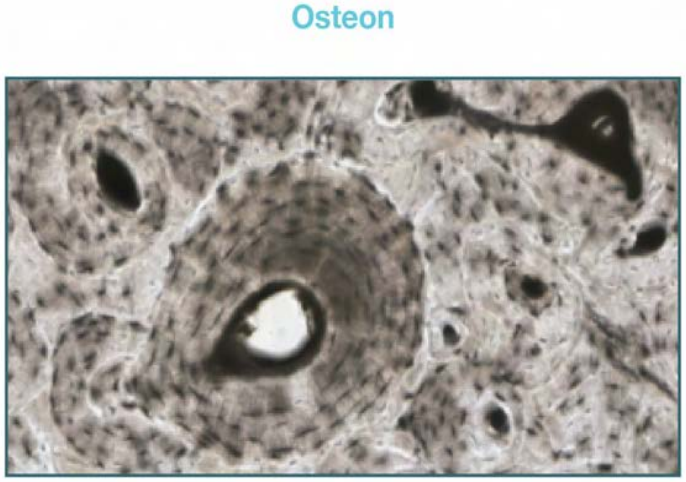

Solution to Question 6:

Membranous bones (and not membranocartilagenous bones) are also known as dermal bones.

The bone is classified into three categories on the basis of pattern of development as follows:

• Membranous bones - These bones ossify from highly vascular membranes of primitive mesenchyme. At centres of ossification, mesenchymal stem cells differentiate into osteoprogenitor cells which give rise to osteoblasts. These osteoblasts help in the formation of bone. e.g., bones of the skull and facial bones.

• Cartilaginous bones - These bones ossify from hyaline cartilage. The deeper layers of the perichondrium surrounding the cartilage contain osteoprogenitor cells which help in bone formation. e.g., bones of limbs, vertebral column and thoracic cage.

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• Membranocartilaginous bones - These bones ossify partly from cartilage and partly from mesenchymal condensations. e.g., clavicle, mandible, occipital, temporal and sphenoid.

Solution to Question 7:

The type of cartilage shown in the above image is hyaline cartilage and it is present in bronchi.

Hyaline cartilage is made up of chondrocytes and matrix. The chondrocytes in the deeper matrix are rounded in shape and may appear in a group of eight that originate by the mitotic divisions of a single chondroblast. These groups of cells are called isogenous cell aggregates or cell nests. The important components of the matrix are type II collagen, aggrecan (proteoglycan) and chondronectin (glycoprotein). The matrix which immediately surrounds the chondrocytes is basophilic and is known as the territorial matrix and the matrix which are more distant from the cells appears pale and is known as the interterritorial matrix.

On microscopy, hyaline cartilage can be identified by:

• Presence of chondrocytes within lacunae.

• Group of two or more chondrocytes which are known as isogenous cell aggregates or cell nests.

• Basophilic territorial matrix and pale interterritorial matrix

• Presence of perichondrium with outer fibrous and the inner cellular layer

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Solution to Question 8:

The elastic cartilage is also known as yellow fibrocartilage.

The elastic cartilage resembles the hyaline cartilage in that it contains individual or small groups of chondrocytes that are surrounded by type II collagen fibrils. However, it differs from hyaline cartilage in that, much of the interterritorial matrix consists of fine yellow elastic fibres containing elastin protein.

On microscopy, elastic cartilage can be identified by:

• Presence of chondrocytes within lacunae

• Presence of elastic fibres in the matrix

• Perichondrium with outer fibrous layer and the inner cellular layer

Solution to Question 9:

The above image shows an elastic cartilage.

The elastic cartilage, like the hyaline cartilage, contains individual or small groups of chondrocytes that are surrounded by type II collagen fibrils. However, it differs from hyaline cartilage in that, much of the interterritorial matrix consists of fine yellow elastic fibres containing elastin protein.

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On microscopy, elastic cartilage consists of:

• Chondrocytes within lacunae

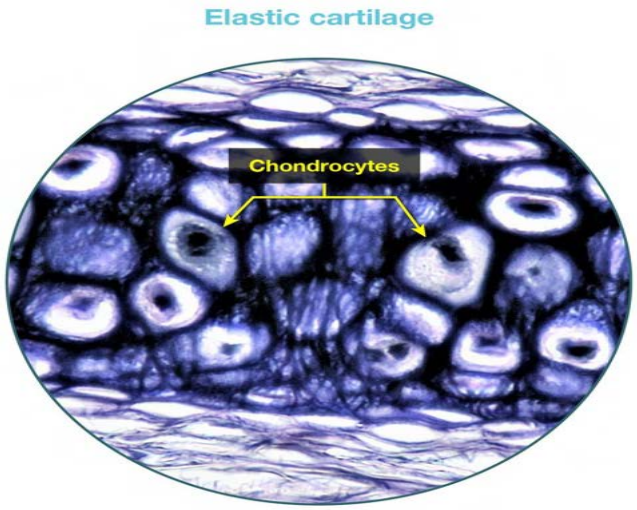
• Elastic fibres in the matrix

• Perichondrium with outer fibrous layer and the inner cellular layer

Solution to Question 10:

The elastic fibers present in the elastic cartilage can be visualised by Verhoeff's stain. The fibers stain dark purple/black with Verhoeff's stain. The Verhoeff's stain binds to the elastin protein, which is the main constituent of elastic fibers.

The below image shows dark purple/black coloured elastin fibres stained with Verhoeff's stain.



Solution to Question 11:

Type I collagen is present in fibrocartilage.

• Fibrocartilage (also known as white fibrocartilage) contains both type I and type II collagen.

• Hyaline and elastic cartilage contains only type II collagen

Solution to Question 12:

The above image shows a section of fibrocartilage stained with trichrome stain. Fibrocartilage is not covered by perichondrium.

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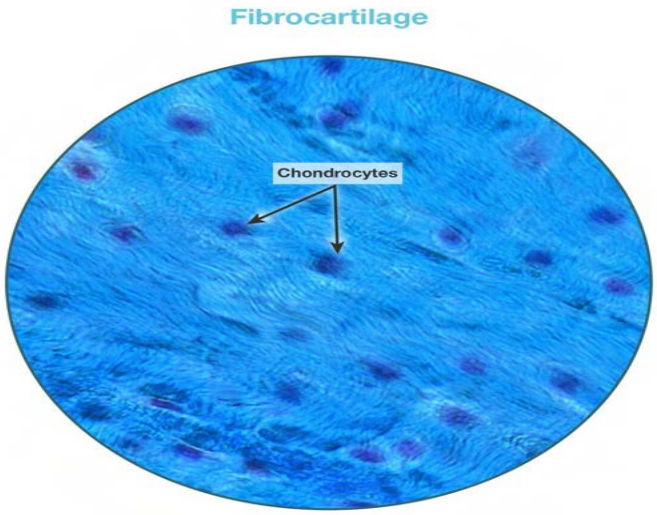
The fibrocartilage is an intermediate between dense fibrous connective tissue (tendon and ligaments) and hyaline cartilage. It consists of bundles of thick collagen fibres (both type I and II) with rows of chondrocytes present between the bundles.

On microscopy, fibrocartilage can be identified by:

• Presence of chondrocytes

• Matrix containing abundant collagen fibres



Options A & D: Both the epiphyseal plate and bronchi have the hyaline type of cartilage.

Note: The colour of cartilage should not be considered while deciding its type, as it largely depends on the type of stain used. Instead, the structure or organisation of the cartilage tissue should be considered.

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Solution to Question 13:

Each bundle of muscle fibres is surrounded by the perimysium.

Organization of skeletal muscle:

• Muscle fibre or myocyte - made up of myofibrils and consists of several elongated nuclei, which lie along the periphery of the fibre just under the cell membrane. The cell membrane of the muscle fibre is called the sarcolemma, while the cytoplasm is called sarcoplasm. Each muscle fibre is surrounded by a delicate connective tissue called endomysium.

• Fascicle - Group of muscle fibres together form fascicle. Each fascicle is surrounded by the perimysium. The perimysium serves as a pathway for nerves and blood vessels.

• Muscle - Group of fascicles together form a skeletal muscle. The entire skeletal muscle is surrounded by epimysium. Epimysium contains larger nerves, blood vessels and lymphatics of the muscle.

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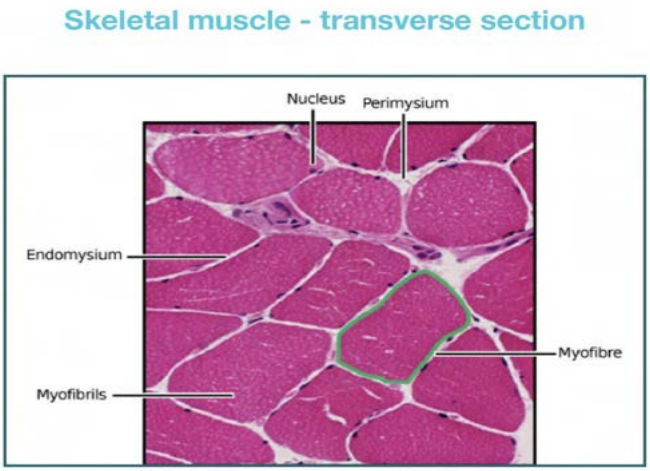

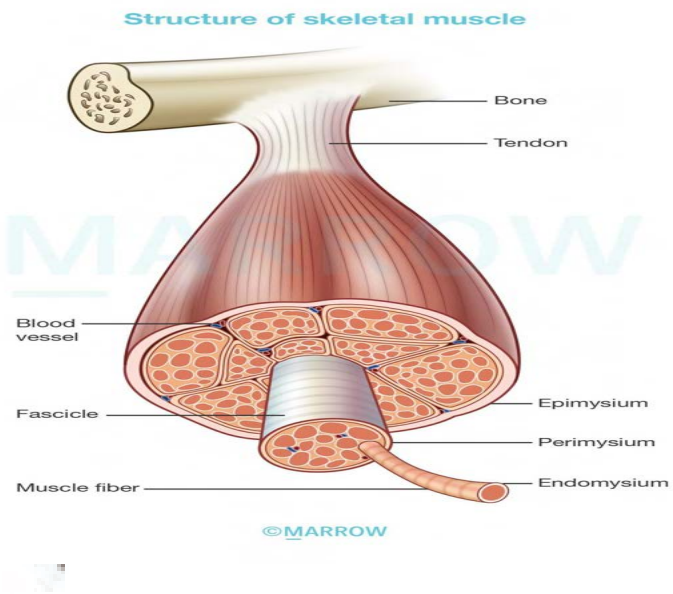

Solution to Question 14:

The above image shows a longitudinal section of the cardiac muscle stained by hematoxylin and eosin.

On microscopy, cardiac muscle can be identified by:

• Presence of striations similar to the skeletal muscle.

• Presence of single and centrally placed nucleus. A perinuclear halo may be seen surrounding the nucleus.

• The junctions between adjoining cardiac myocytes are seen as dark staining transverse lines running across the muscle fibre. These lines are called intercalated discs.

• Cells within one fibre branch and join the cells in adjacent fibres.

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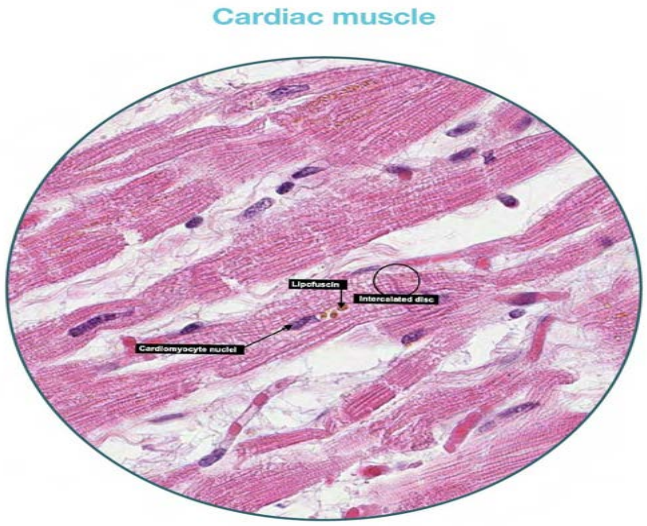

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Solution to Question 15:

Smooth muscles consist of spindle-shaped myocytes.

Smooth muscles are specialised for slow steady contraction under the influence of autonomic nerves and various hormones. They are also called as visceral muscles.

They are the major component of blood vessels, digestive, respiratory, urinary and reproductive tracts.

In microscopy, smooth muscles can be identified by:

• In longitudinal section, the spindle-shaped muscle cells are seen. They are elongated, tapering and unstriated cells with a centrally placed elongated nucleus.

• In transverse section, the spindle-shaped cells are cut at different places along its length and hence are seen as a group of cells with different shapes and sizes. The nucleus is seen only in those cells, which are cut through the centre.

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Nervous and Endocrine Systems

Question 1:

Which of the following constitutes neurites of the neurons?

a) Neurofibrils and dendrites

b) Dendrites and axons

c) Neurofibrils and axons

d) Neurofibrils, dendrites and axons

Question 2:

What is the Nissl-free zone from where an axon arises from a neuron called?

a) Initial segment

b) Mesaxon

c) Axon hillock

d) Nodes of Ranvier

Question 3:

A 23-year-old patient was referred for evaluation of a progressive left-hand weakness and pain involving his right medial elbow, forearm, wrist and thumb. Suspecting pure neuritic leprosy, a nerve biopsy was taken and the image of the histological section is given below. What is the stain used in this section?

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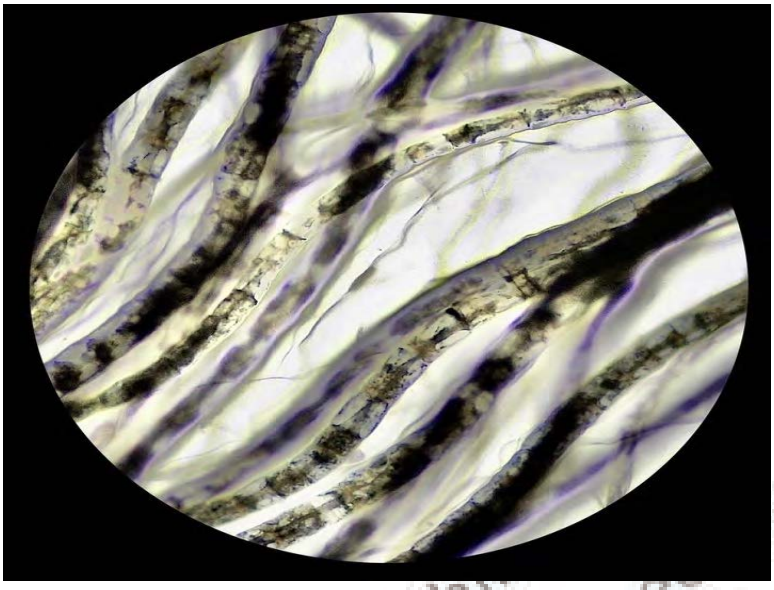

a) Sudan Black

b) Giemsa

c) Osmium tetroxide

d) Silver stain

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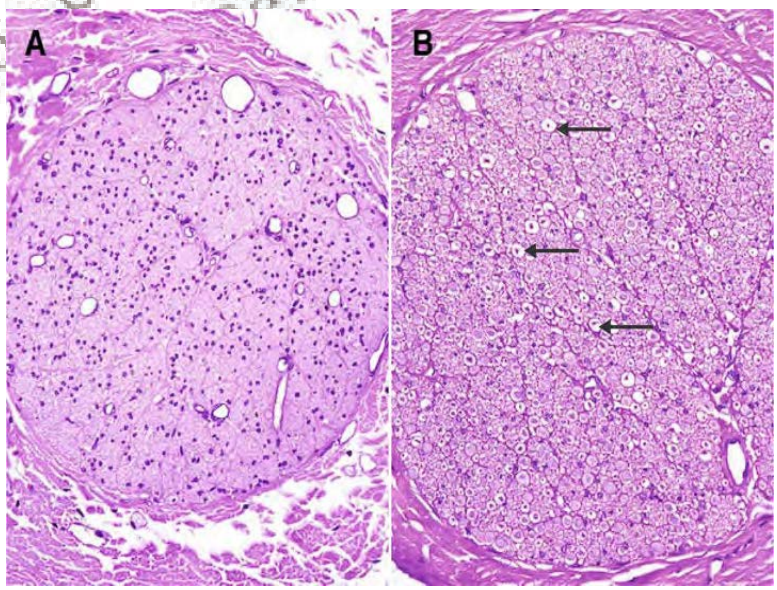
Question 4:

Identify the types of nerve fibers from images A and B.



a) A-myelinated & B-unmyelinated

b) A-unmyelinated & B-myelinated

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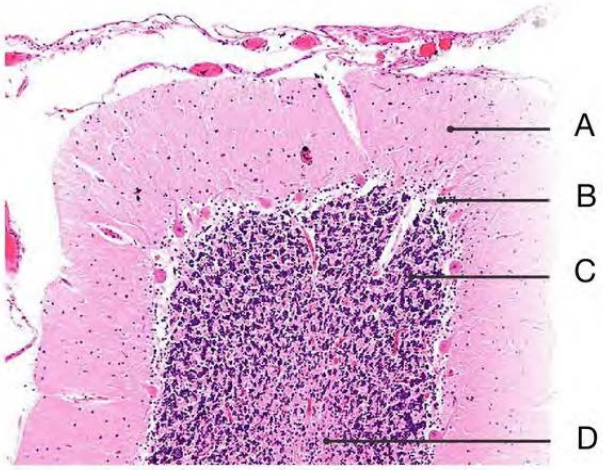
c) A-myelinated & B-myelinated

d) A-unmyelinated & B-unmyelinated

Question 5:

Match the marked structures to the correct layers of the cerebellar cortex.



a) A - 2, B - 4, C - 3, D - 1

b) A - 2, B - 3, C - 4, D - 1

c) A - 3, B - 2, C - 4, D - 1

d) A - 3, B - 4, C - 2, D - 1

Question 6:

Arrange the following layers of the cerebral cortex in the correct order from superficial to deep.

a) 1-3-2-4-6-5

b) 1-5-2-3-4-6

c) 1-4-2-3-6-5

d) 1-6-2-5-3-4

Question 7:

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In which layer of the cerebral cortex is the outer band of Baillarger seen?

a) External pyramidal layer

b) Internal granular layer

c) Internal pyramidal layer

d) External granular layer

Question 8:

Which of the following cells of the pituitary gland are stained by eosin?

a) Cells producing TSH

b) Cells producing ACTH

c) Cells producing Prolactin

d) Cells producing FSH

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Question 9:

An 80-year-old man was brought to the hospital with a history of a fall. Suspecting a skull bone fracture a lateral view X-ray of the skull was taken which incidentally revealed a radio-opaque structure at the site of the pineal gland. Which of the following could be the most likely cause for the opacity?

a) Pinealocytes

b) Corpora arenacea

c) Nervous conarii

d) Corpora amylacea

Question 10:

Given below is a histological section of the thyroid gland. Identify the structure marked X in the image.

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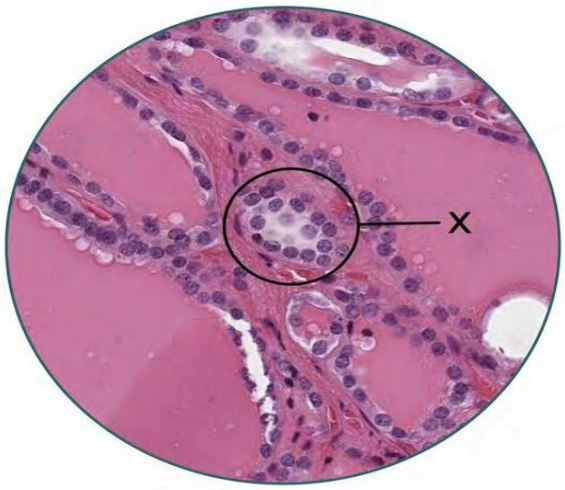


a) Follicular cells

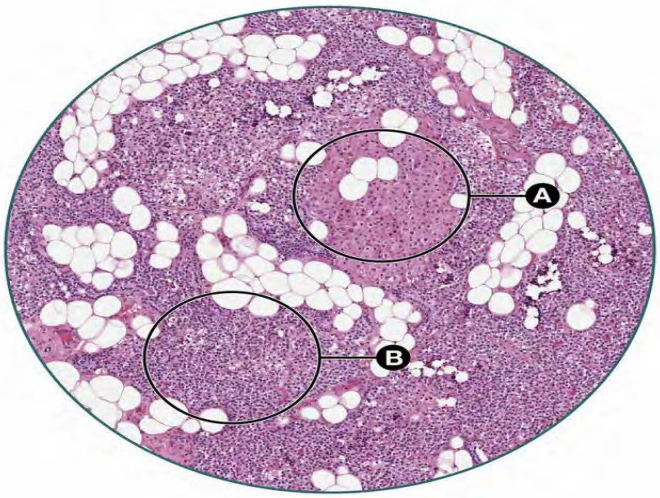
b) C-cells

c) Colloid

d) Hürthle cells

Question 11:

A 24-year-old lady presented with a several-month-long history of abdominal pain, prolonged fatigue, bone, and joint pain. An MRI revealed a parathyroid gland tumour which was surgically resected. Given below is a section of the parathyroid gland. Identify the structures marked A and B.



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a) A - follicular cells; B - chief cells

b) A - Oxyphil cells; B - follicular cells

c) A - Oxyphil cells; B - Chief cells

d) A - Chief cells; B - Oxyphil cells

Question 12:

In which of the following layers of adrenal cortex are the cells arranged in straight columns?

a) Zona fasciculata

b) Zona glomerulosa

c) Zona reticularis

d) Zona medullaris

Question 13:

Which of the following cells are included under the APUD cell system?

a) 1, 2, 3,4 & 5

b) 1, 2, 3 & 5

c) 1, 2 & 3

d) 1, 2, 4 & 5

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Answer Key

Question No.	Correct Option
1	b
2	c
3	c
4	b
5	b
6	c
7	b
8	c
9	b

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10	b
11	c
12	a
13	d

Detailed Explanations

Solution to Question 1:

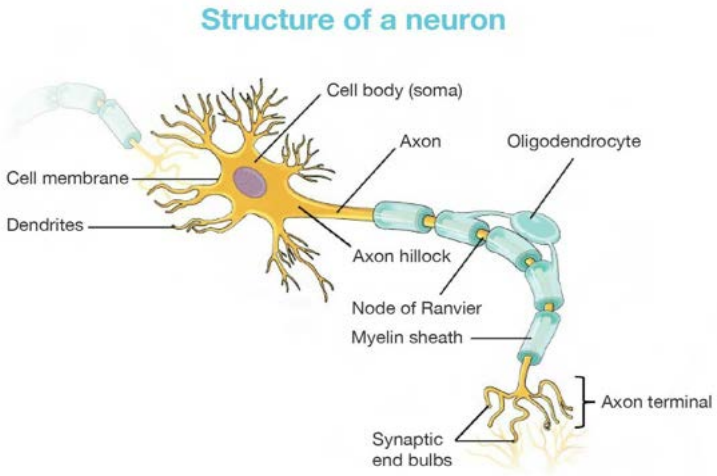
The neurites of the neurons constitute the dendrites and the axon.

Neurites or neuronal processes refer to any projection arising from the cell body (soma) of a neuron. They are of two types:

• Axon - a single, long projection arising from the cell body that carries the impulse away from the cell body. The axon ends by dividing into several branches called axon terminals, which synapses with the dendrites of another neuron. An axon may also end in relation to an effector organ such as muscle or a gland. It is free of Nissl granules.

• Dendrites - multiple short projections arising from the cell body, that carry the nerve impulse towards the neuron. Nissl granules are present here.

The neuronal cytoskeleton consists of neurofilaments and microtubules. These are abundantly seen in the cell body, dendrites and the axon. The neurofilaments are heteropolymers of proteins that give tensile strength to the axon. Bundles of neurofilaments constitute a neurofibril. Microtubules assist in axonal transport.



Solution to Question 2:

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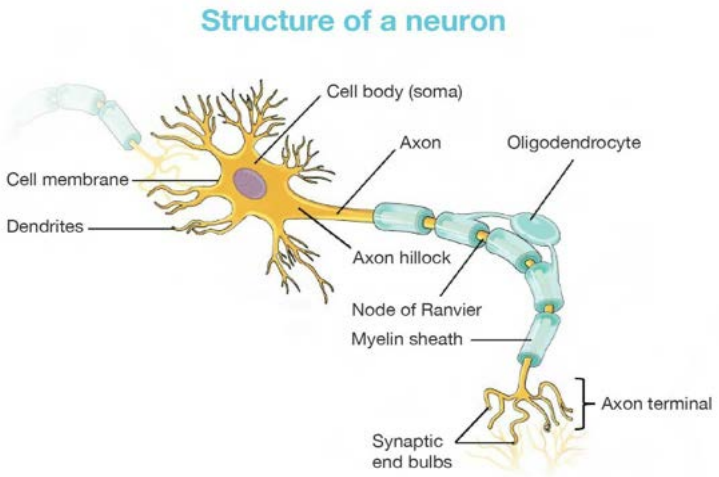
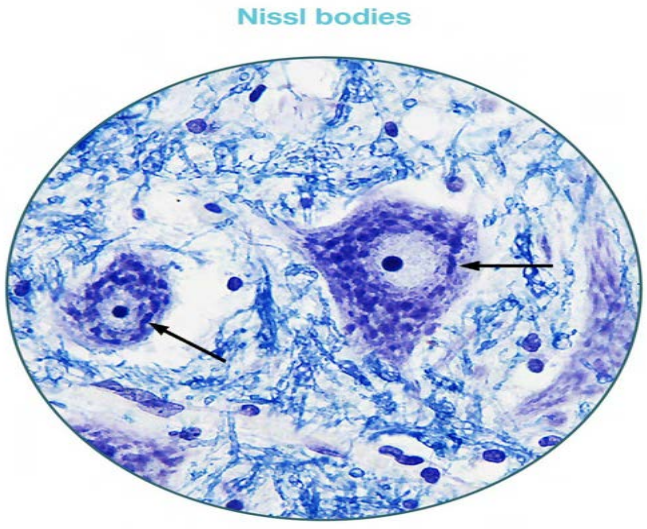
The Nissl-free zone of a neuron from where an axon arises is called an axon hillock.



Nissl bodies or granules are aggregates of polyribosomes and rough endoplasmic reticulum. They are present in the cell body of a neuron and in large dendrites. Under light microscopy, they appear as basophilic granules. The affinity towards the basic dyes is due to the presence of a large amount of RNA which is acidic in nature.

The image below shows a photomicrograph of bluish-coloured Nissl bodies (indicated by arrows) in the cytoplasm of motor neurons.



Option A: The initial segment refers to the proximal part of the axon, that lies just beyond the axon-hillock. Thus, an axon-hillock is part of the cell body while the initial segment is part of an axon.

Option B: Mesaxon refers to the area where the plasma membrane of the Schwann cell fuses with itself around the axon. During the formation of the myelin sheath, the axon invaginates the Schwann cell. The plasma membrane of the Schwann cell fuses with itself and continues to wrap

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around the axon to form multiple layers of the plasma membrane called the myelin sheath. The cytoplasm and nucleus of the Schwann cell are pushed to the periphery. The thin layer of the cytoplasm of the Schwann cell surrounding the myelin sheath is called neurilemma.

Option D: Each Schwann cell myelinates only a short segment of the axon. Hence, along the length of the axon, there are several Schwann cells myelinating it. The unmyelinated portions of the axon present in between myelinated segments are known as nodes of Ranvier.

Solution to Question 3:

The stain used in this section is osmium tetroxide.

Osmium tetroxide is reduced to a black substance by unsaturated fatty acids present in the myelin sheath of the nerve fibers and hence, appears black on the section.

The pure neuritic form is a variant of leprosy characterized by the isolated involvement of peripheral nerve trunks with the absence of skin lesions. Nerve biopsy is the gold standard method for the diagnosis of pure neuritic leprosy.

Solution to Question 4:

In the above-given images showing the cross-section of the nerve fibers stained with H & E,

• Image A shows an unmyelinated nerve identified by the absent empty spaces around nerve fibers.

• Image B shows a myelinated nerve identified by the empty spaces around the nerve fibers (marked with arrows).

Staining of myelin:

• H&E stain - Fails to colour the myelin (shows as white region/empty space around nerve fiber).

• Special stains for Myelin such as Luxol Fast Blue, Sudan blue can stain but with less intensity.

• Osmium tetroxide stains myelin black.

Solution to Question 5:

The structures marked in the given image are:

A - Molecular layer

B - Purkinje layer

C - Granular layer

D - White matter

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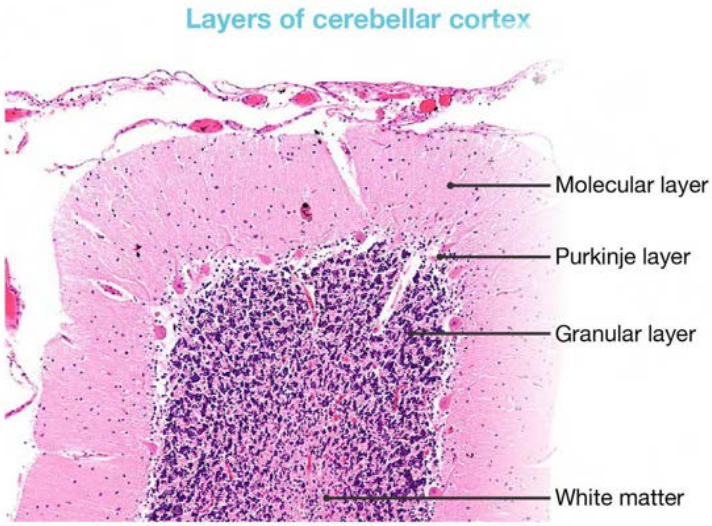
The cerebellum is covered by pia mater which is seen as thin connective tissue, with blood vessels lying under it. The cerebellum consists of an outer grey matter (cerebellar cortex) and inner white matter.



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Solution to Question 6:

The correct order of the layers of the cerebral cortex from superficial to deep are:

- Molecular layer (Plexiform layer)
- External granular layer
- External pyramidal layer
- Internal granular layer - contains the outer band of Baillarger
- Ganglionic layer (Internal Pyramidal layer) - contains the inner band of Baillarger
- Multiform layer (Layer of Polymorphic cells)

Solution to Question 7:

The outer band of Baillarger is seen in the internal granular layer of cerebral cortex.

The cerebral cortex contains nerve fibers that run radially and tangentially. The tangential fibers are concentrated in the internal granular layer (layer IV) referred to as the outer band of Baillarger and in the ganglionic layer (layer V) referred to as the inner band of Baillarger. These bands are well developed in the sensory areas because of the concentration of terminal parts of the thalamocortical fibers. In the visual cortex, the outer band of Baillarger can be seen with the naked eye and is known as the stria of Gennari. It is because of this stria that the visual cortex is also referred to as the striate cortex.

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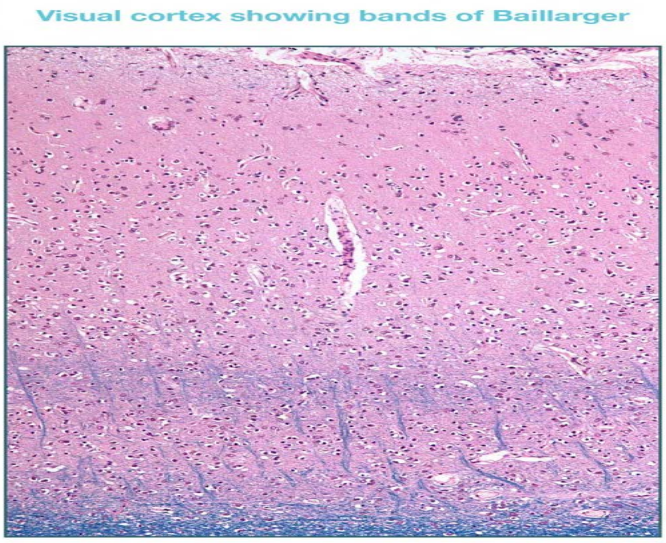
The given image shows a micrograph of the visual cortex. The blue, horizontal band in the lower half of the image are the bands of Baillarger/the stria of Gennari. Subcortical white matter (predominantly blue) is seen at the very bottom of the image.



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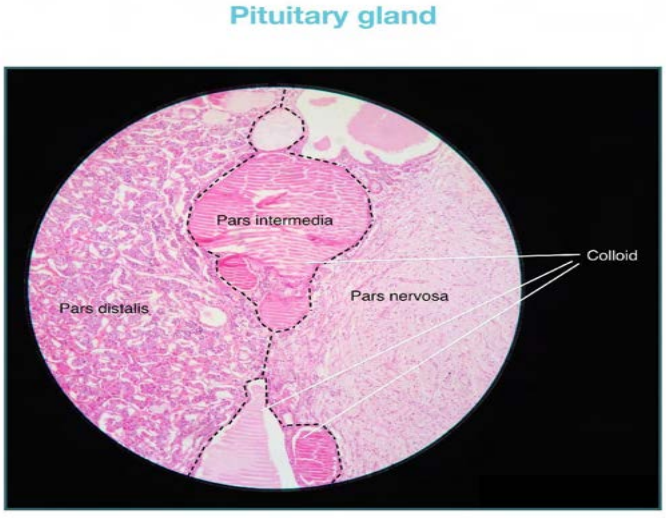
Solution to Question 8:

The cells producing prolactin from the pituitary gland are stained by eosin.

The pituitary gland is divided into the pars anterior, pars intermedia and pars posterior (or pars nervosa).



The pars anterior (aka pars distalis) consists of chromophil cells and chromophobe cells.

The chromophil cells have brightly staining granules in their cytoplasm. They include:

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• Acidophil cells - stain with acidic dyes like eosin or orange G and appear pink on H and E stain. They are also called alpha cells. They include:

• Somatotrophs - producing growth hormone

• Lactotrophs - producing prolactin

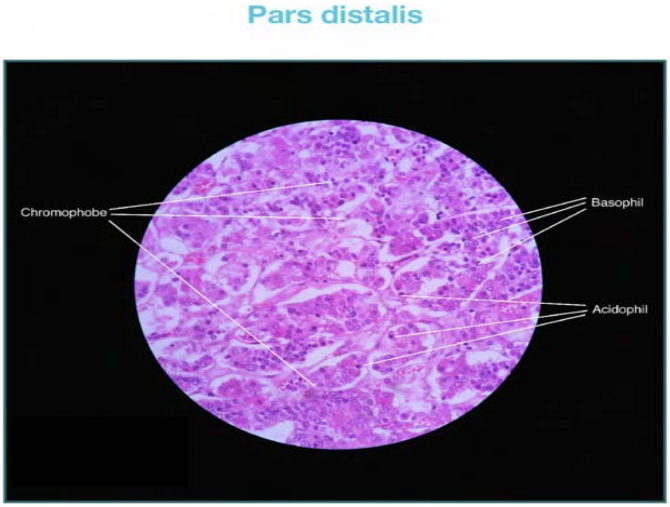
• Basophil cells - stain with basic dyes like hematoxylin and appear blue on H and E stain. These cells are also periodic acid Schiff (PAS) stain positive. They are also called beta cells. They include:

• Corticotrophs - producing ACTH

• Thyrotrophs - producing TSH

• Gonadotrophs - producing FSH and LH

The chromophobe cells do not contain granules that stain and hence appear colorless on an H and E stain.



The pars intermedia contains colloid filled vesicles, which are remnants of the pouch of Rathke.

The pars posterior consists of nerve fibers from the neurons of the hypothalamus and specialized supporting cells called pituicytes.

Solution to Question 9:

The most likely cause for the opacity at the site of the pineal gland is corpora arenacea.

The pineal gland has a structure called the corpora arenacea (brain sand) located within the gland. These bodies are prone to an increase in calcification with advancing age. They are visible on x-ray and can be used as landmarks. Chemical analysis of the calcium deposits shows the different compositions, including calcium phosphate, magnesium phosphate, calcium carbonate, and ammonium phosphate.

Option A: The cells of the pineal gland are called pinealocytes that produces the hormone melatonin which works with the hypothalamus to regulate sleep-wake cycles.

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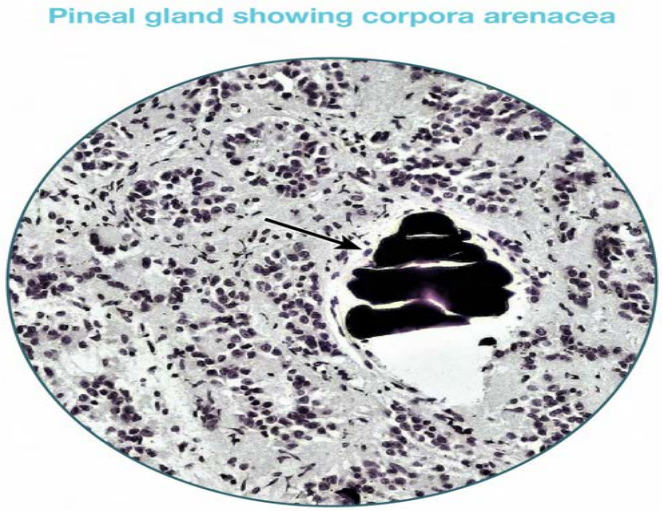
Option D: Corpora amylacea are small eosinophilic inclusions frequently seen in histological sections of the brain, prostate, lung and uterus.

The image below is a histology section of the pineal gland showing dark stained corpora arenacea within the gland.



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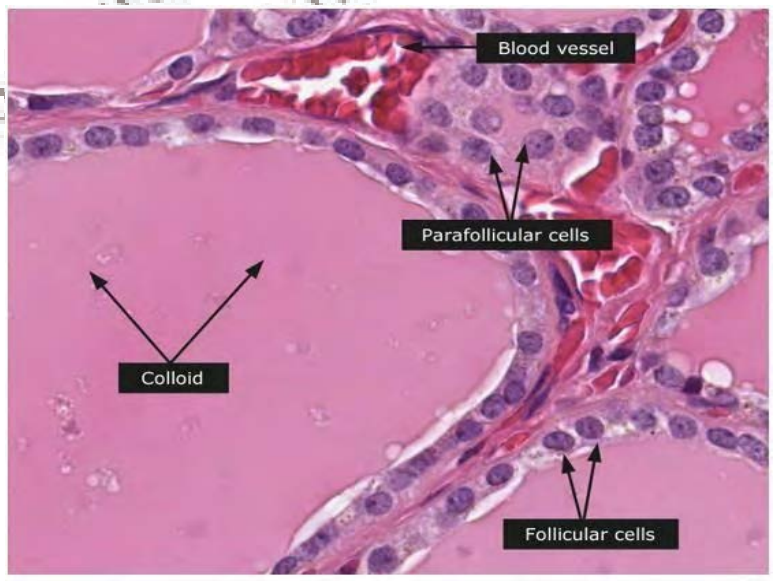
Solution to Question 10:

The structure marked X is the C-cells or the parafollicular cells of the thyroid gland.



The C-cells are present between the follicular cells and the basement membrane or between the follicles. They secrete calcitonin.

The thyroid gland is covered by a fibrous capsule with septae dividing it into lobules. These lobules contain follicles lined by follicular cells. The shape of the follicular cells depends on the

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activity of the gland. They're squamous in the inactive state, cuboidal to columnar in the active state. The cavity of the follicle contains colloid which appears pink in H and E staining.

Option D: Hürthle cells are oncocytes with eosinophilic granular cytoplasm and a vesicular nucleus with a large nucleolus found in the thyroid arising from follicular cells. They are seen in Hashimoto thyroiditis, Hürthle cell adenoma and Hürthle cell carcinoma of the thyroid.

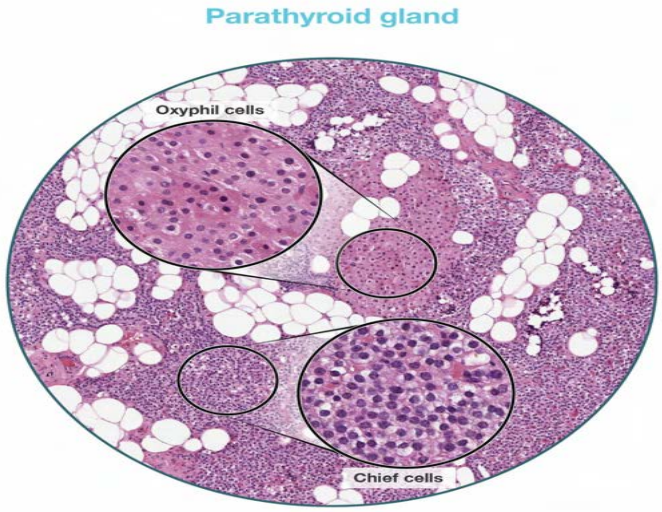
Solution to Question 11:

The structures marked are A and B are oxyphil cells and chief cells respectively. The clinical history and the MRI findings are strongly suggestive of primary hyperparathyroidism secondary to a parathyroid adenoma.

The parathyroid gland has two cell types:

• Chief cells (principal cells) - They are small round cells with vesicular nuclei, surrounded by a small amount of cytoplasm. They are numerous and produce parathormone.

• Oxyphil cells - They are fewer and scattered between the chief cells. These are larger cells with a smaller nucleus with eosinophilic cytoplasm (pink colored). Their function is not known



Primary hyperparathyroidism is usually due to a solitary parathyroid adenoma. The clinical signs associated with it can be remembered with the mnemonic - “bones, stones, groans, moans with fatigue overtones”.

Solution to Question 12:

The cells are arranged in straight columns in the zona fasciculata of the adrenal cortex.

The adrenal cortex is divided into three layers. From outermost to deep, they are:

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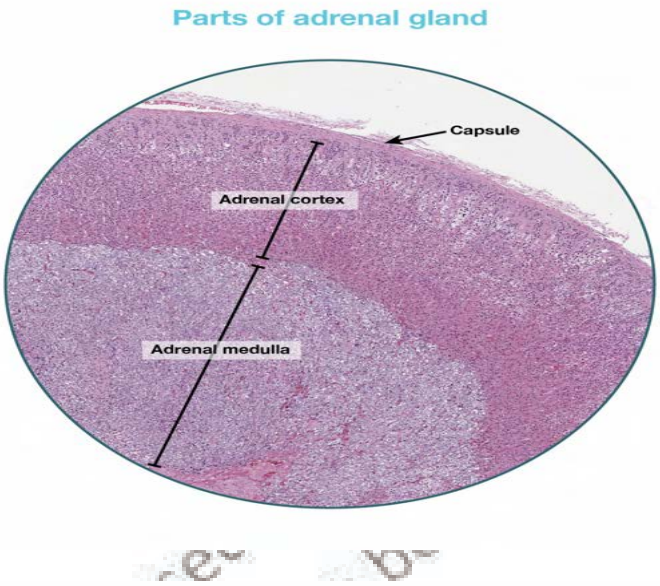
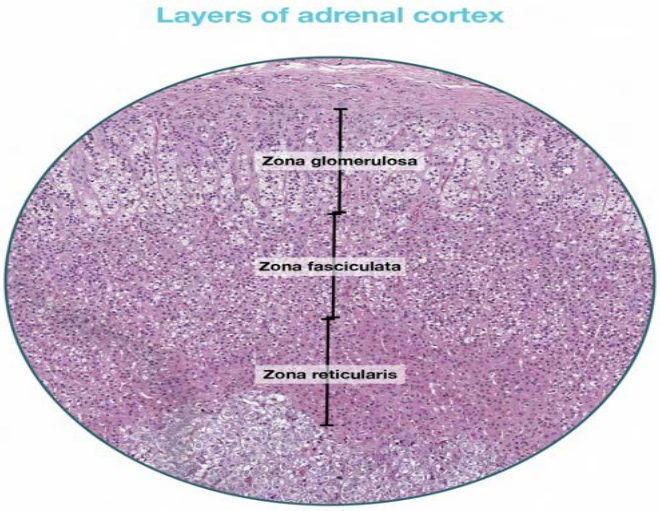
• Zona glomerulosa - consists of small polyhedral cells arranged in inverted U-shaped formations or acinus-like groups. These cells produce mineralocorticoids

• Zona fasciculata - consists of cells arranged in straight columns with sinusoids between the columns. These cells produce glucocorticoids.

• Zona reticularis - It is so-called because it is made up of columns of cells that branch and anastomose with each other to form a kind of reticulum. These cells produce sex hormones - progesterone, oestrogens and androgens.





Solution to Question 13:

All the above-mentioned cells except type II alveolar cells are included under the APUD cell system.

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The APUD (Amine Precursor Uptake and Decarboxylation) cell system consists of cells scattered in different parts of the body, which take up precursor substances from the circulation and process them (by decarboxylation) to form amines or peptides. The APUD cell system is also called the diffuse neuroendocrine system.

Some of the important cells included under the APUD cell system are:

• Cells of the adenohypophysis

• Neurons in the hypothalamus that synthesize the hormones of the neurohypophysis

• Chief cells of the parathyroid glands

• C- cells of the thyroid

• Cells of the adrenal medulla

• Cells of the gastro-entero-pancreatic endocrine system which includes cells of pancreatic islets

• Glomus cells of the carotid bodies

• Melanocytes of the skin

• Renin producing cells of the kidneys

• Some cells in the pineal gland, the placenta, and modified myocytes of the heart called myoendocrine cells.

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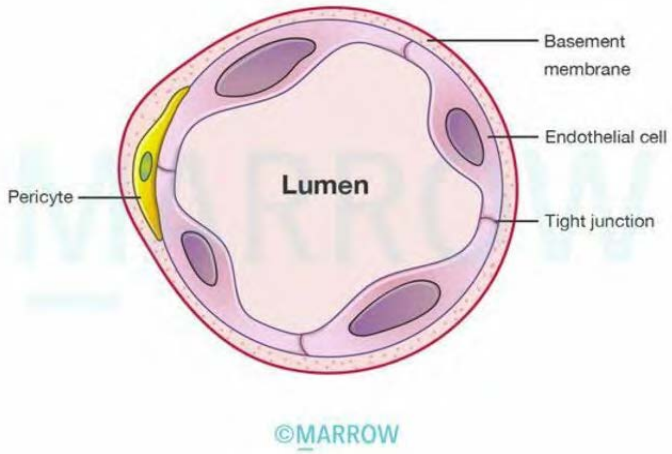
Cardiovascular, Lymphatic and Respiratory Systems

Question 1:

Identify the structure shown in the image below.



a) Artery

b) Venule

c) Capillary

d) Arteriole

Question 2:

Which of the following statements is true regarding the arteries?

a) The fibrous elements present in the tunica intima and media run circularly

b) The fibrous elements of the tunica adventitia run longitudinally

c) Collagen fibers are predominantly present in the tunica media

d) Collagen fibers are predominantly present in the tunica intima

Question 3:

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Which of the following statements is true regarding elastic arteries?

a) They are also known as distributing arteries

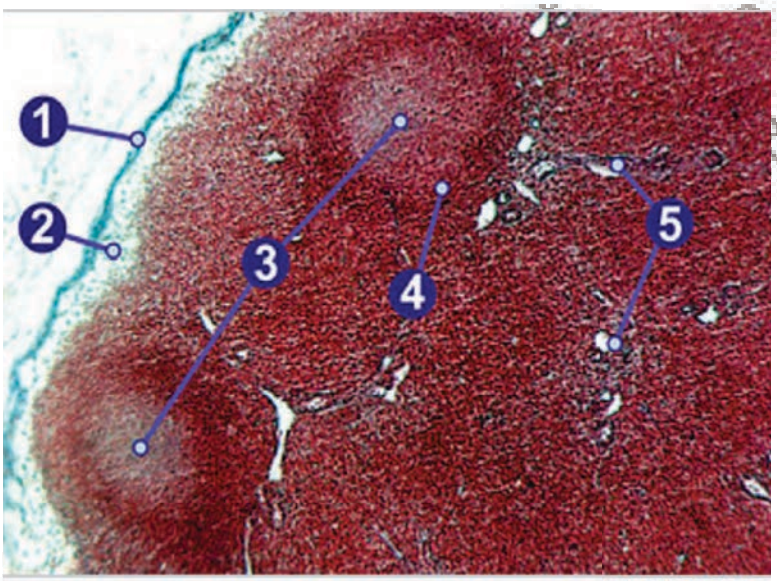
b) The internal elastic lamina is distinct from the tunica media

c) Smooth muscles are absent in the tunica media

d) The elastic recoil helps in continuous flow of the blood

Question 4:

Match the following marked structures to the correct areas of the lymph node.



a) 1 - E, 2 - A, 3 - D, 4 - C, 5 - B

b) 1 - A, 2 - D, 3 - B, 4 - C, 5 - E

c) 1 - E, 2 - D, 3 - A, 4 - B, 5 - C

d) 1 - A, 2 - E, 3 - B, 4 - D, 5 - C

Question 5:

The arterioles present in the spleen divides into a number of straight vessels that are called _____

a) Stave cells

b) Ellipsoid

c) Penicilli

d) Ampulla

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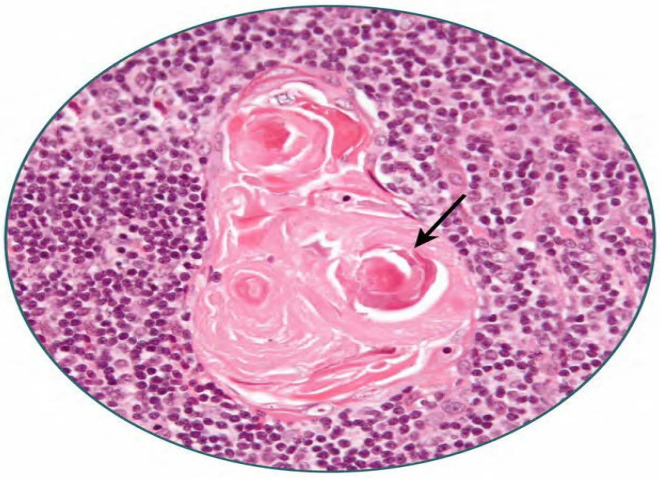
Question 6:

A mislabeled sample of tissue was sent over to the pathology lab for histopathological examination. On microscopy, a characteristic corpuscle as seen in the image was visualised. Which of the following structures is the sample most likely to be from?



a) Spleen

b) Palatine tonsil

c) Thymus

d) Bone marrow

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Question 7:

Given below is an image of a section of the small intestine. Identify the structure marked X

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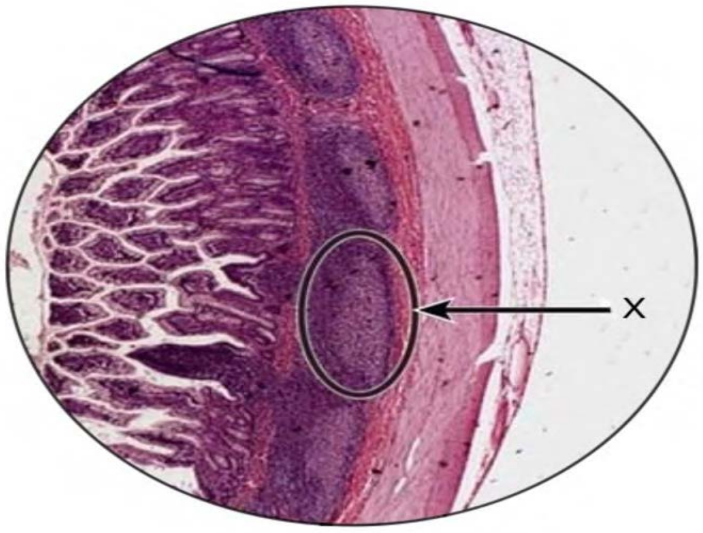

a) Thymus

b) Spleen

c) MALT

d) Lymph node

Question 8:

A researcher studying the COVID-19 virus recently discovered that anosmia is caused by the temporary loss of function of the sustentacular cells of the olfactory epithelium. Which of the following accurately describes these cells?

a) Olfactory cells

b) Supporting cells

c) Receptor cells

d) Basal cells

Question 9:

Identify the structure shown in the histological image below.

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a) Trachea

b) Bronchus

c) Bronchiole

d) Alveolus

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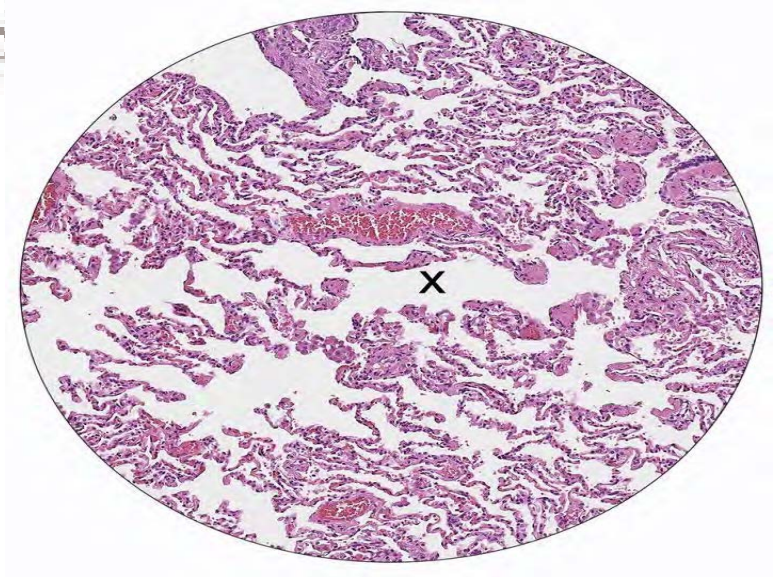
Question 10:

Given below is a histological section of the lung. Identify the structure marked X.



a) Alveolus

b) Alveolar duct

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c) Respiratory bronchiole

d) Terminal bronchiole

Question 11:

The rounded secretory cells bearing microvilli present in the epithelial lining of the alveoli are _____

a) Type I pneumocytes

b) Type II pneumocytes

c) Alveolar cells

d) Brush cells

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Answer Key

Question No.	Correct Option
1	c
2	b
3	d
4	c
5	c
6	c
7	c
8	b
9	a
10	b
11	b

Detailed Explanations

Solution to Question 1:

Among the given options the given structure is of the capillary.

The wall of the capillary is formed mainly by endothelial cells that are lined on the outside by a basal lamina made of glycoprotein. There is no adventitia that differentiates it from a venule.

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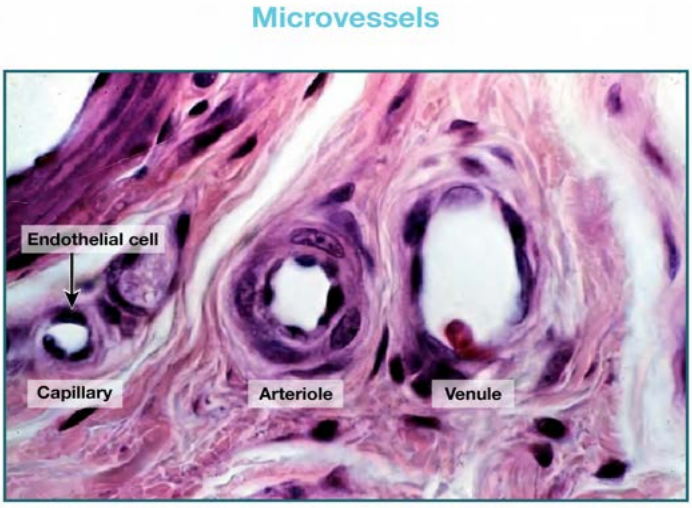
The image below shows the microvessels - arteriole, venule, and capillary.

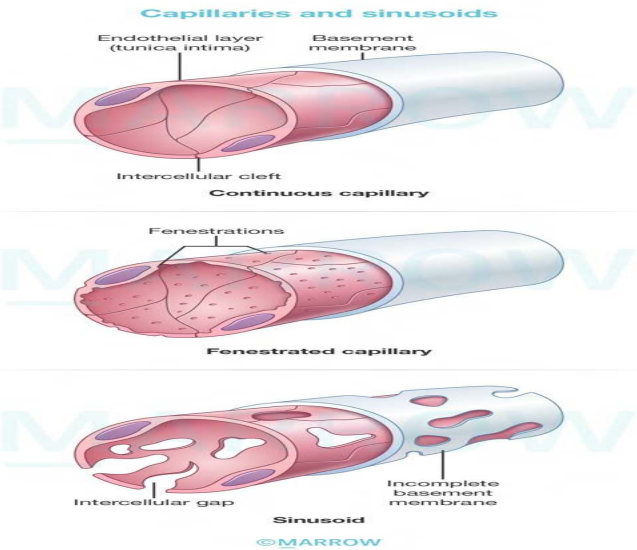


The capillaries can be classified into two types:

• Continuous capillaries - The edges of endothelial cells fuse completely with those of adjoining cells to form a continuous wall. The exchange of material between the blood and tissue occurs through the cytoplasm of the endothelial cells or through the intercellular material adjoining the cells.

• Fenestrated capillaries - The walls of these capillaries have apertures in their endothelial lining which are closed by a thin diaphragm. The fenestration may also be present as pores, which passes through the entire thickness of the cell. The exchange of material occurs by diffusion through these fenestrae. They are mainly seen in renal glomeruli, intestinal villi, endocrine glands, and pancreas.

Sinusoids differ from the capillaries in that the wall sinusoid has only endothelium, which is supported by a thin layer of connective tissue. The endothelium has larger deficiencies in the form of fenestrations or long slits.



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Solution to Question 2:

The fibrous elements in the intima and the adventitia (mainly collagen) run longitudinally (i.e., along the length of the vessel), whereas those in the media (elastic tissue or muscle) run circularly.

The tunica adventitia consists of connective tissue in which collagen fibres are prominent. This layer prevents undue stretching or distension of the artery.

Structure of arterial wall:

The wall of an artery is made up of three layers, from inside out these include:

1. Tunica intima:

• It is the innermost layer and consists of endothelium, which lies on the basal lamina.

• Beneath the endothelium, there is a delicate layer of sub-endothelial connective tissue.

• A membrane formed by elastic fibers surrounds the basal lamina. This membrane is called the internal elastic lamina.

2. Tunica media:

• It consists of smooth muscle or elastic tissue, depending on which there are two types of arteries: muscular artery and elastic artery respectively.

• The smooth muscle or elastic tissue is surrounded by a membrane made up of elastic fibers called, external elastic lamina.

3. Tunica adventitia:

• It is the outermost layer and predominantly consists of connective tissue formed by collagen fibres.

• This layer prevents the artery from being overstretched or excessively distended.

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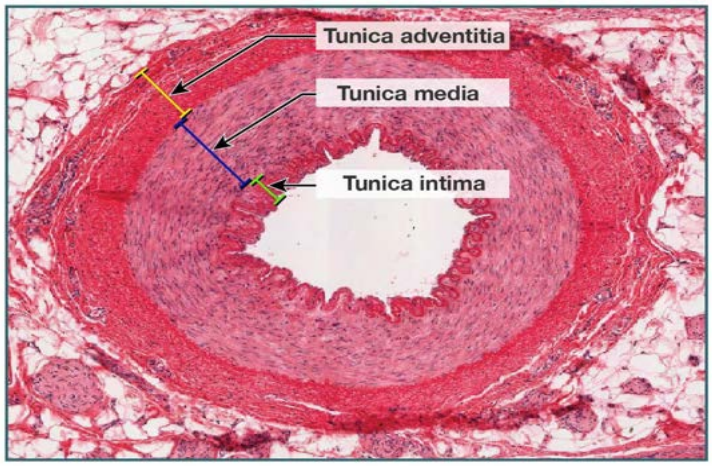
Layers of Artery



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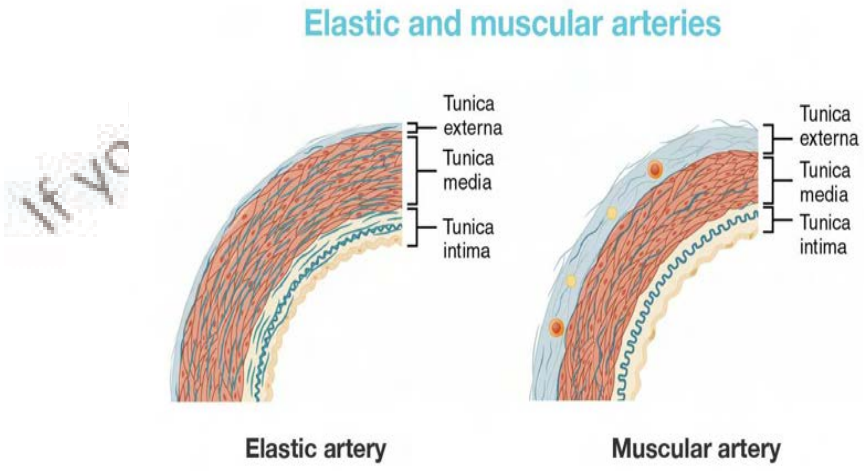
Solution to Question 3:

The elastic recoil of the elastic arteries helps in continuous blood flow.

The large elastic arteries distend and recoil during systole and diastole respectively due to abundant elastic tissue. The recoiling acts as an additional force that pushes blood into smaller arteries. So, blood flows continuously through arteries but with some fluctuation in pressure during systole and diastole.

The main differences between the elastic and muscular arteries are shown in the table given below:

Structure	Elastic artery	Muscular artery
Tunica intima	The internal elastic lamina cannot be distinguished from the surrounding tunica media	The internal elastic lamina is distinct
Tunica media	Predominantly of elastic fibers.Few smooth muscle cells.	Predominantly of smooth muscle cells.Very few elastic fibers.
Tunica adventitia	Relatively thin and consists mainly of elastic fibers	Relatively thicker and consists of fibroblastic tissue.



Other options:

Option A: The elastic arteries are also known as conducting vessels, as their main function is to conduct the blood from the heart, whereas the muscular arteries are known as distributing vessels.

Option B: The internal elastic lamina in the elastic arteries is not distinct and cannot be differentiated from the tunica media as the structure of the internal elastic lamina is same as that of the elastic fibers present in tunica media of elastic arteries.

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Option C: The tunica media of the elastic arteries is predominantly made up of elastic tissue. Between the elastic membranes, there is some loose connective tissue. Some smooth muscle cells may be present.

Solution to Question 4:

The structures marked in the above histological section of the lymph node are as follows:

1 - Capsule

2 - Subcapsular sinus

3 - Germinal centre

4 - Lymphoid nodule

5 - Trabeculae

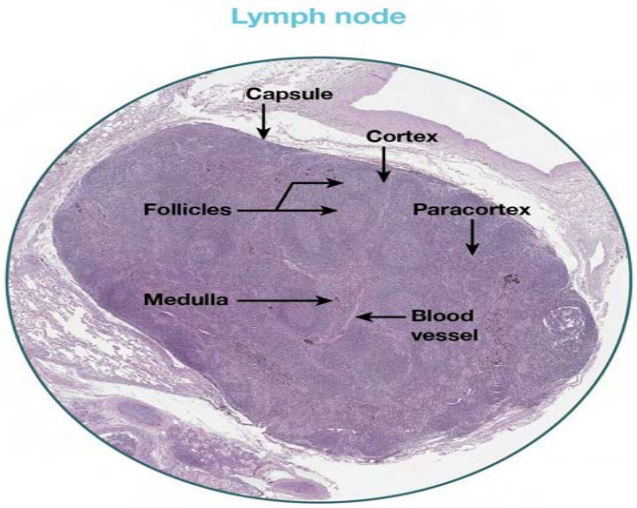
Each lymph node consists of a connective tissue framework and of numerous lymphocytes of all types which are arranged in a stroma of reticulin fibers and cells. They form 3 major regions within each lymph node:

• Cortex - It contains subcapsular sinuses, lymphoid nodules, and densely packed lymphocytes. It stains darkly. Each nodule has a lightly stained germinal center surrounded by a zone of densely packed lymphocytes.

• Paracortex - It lacks nodules and has fewer lymphocytes. It is, therefore, lightly stained.

• Medulla - with prominent draining sinusoids adjacent to the hilum.

Given below is a histological section of a lymph node showing the cortex, paracortex, and medulla.



Solution to Question 5:

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The arterioles present in the spleen divide into a number of straight vessels that are called penicilli.

The splenic artery after entering the hilum of the spleen divides into about five branches that enter the organ independently. Each branch divides and subdivides as it travels through the trabecular network. Arterioles arising from this network leave the trabeculae to pass into the inter-trabecular spaces.

The spleen is histologically composed of:

• White pulp - For some distance, each arteriole is surrounded by a dense sheath of lymphocytes. These lymphocytes constitute the white pulp of the spleen.

• Penicilli - The arteriole then divides into a number of straight vessels that are called penicilli.

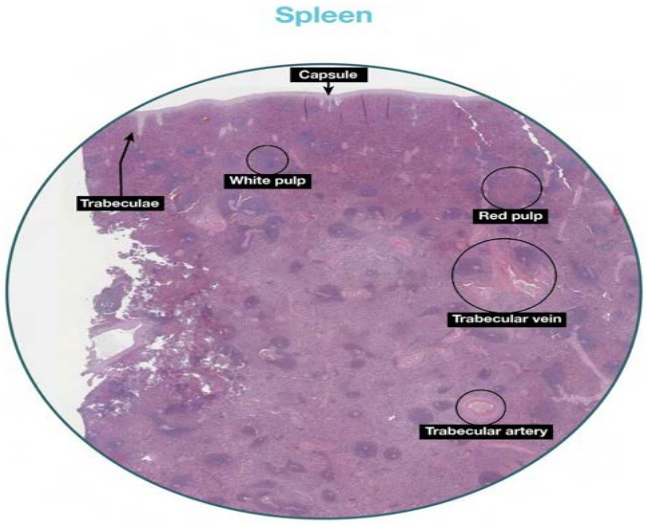
• Ellipsoid - Each of the penicilli shows a localised thickening of its wall that is called an ellipsoid. The ellipsoid consists of concentric lamellae formed by aggregation of fibroblasts and macrophages.

• Ampulla - Distal to the ellipsoid, the vessel dilates to form an ampulla, the walls of which become continuous with the reticular framework.

• Red pulp - As a result, blood flows into spaces lined by reticular cells, coming into direct contact with lymphocytes there. The part of splenic tissue, which is infiltrated with blood in this way is called the red pulp.

• Sinusoids - Blood from spaces of the red pulp is collected by wide sinusoids that drain into veins in the trabeculae.

Stave cells: The sinusoids of the spleen are lined by a somewhat modified endothelium. The endothelial cells here are elongated and are shaped like bananas. They are referred to as stave cells.



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Solution to Question 6:

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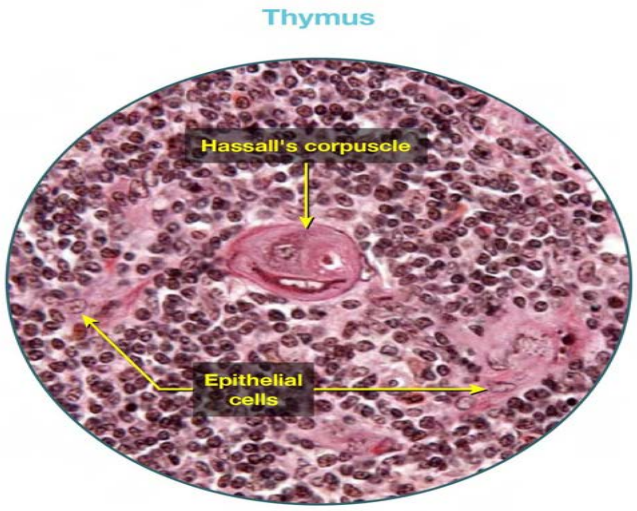
The sample is most likely to be of the thymus because of the presence of the corpuscle of Hassal as seen in the image above.

These are small rounded structures formed from eosinophilic type VI epithelial reticular cells present in the medulla of the thymus. Each corpuscle has a central core formed by degenerated epithelial cells appearing as pink stained hyaline mass. Around this mass, there is a wall formed by concentrically arranged epithelial cells which stain bright pink in H and E staining.



Solution to Question 7:

The structure marked X in the above given image of a section of ileum is the MALT (Mucosal associated lymphoid tissue), also known as gut-associated lymphoid tissue. These are seen as aggregated lymphatic follicle or Peyer's patch present in the submucosa of the ileum.

The mucosal associated lymphoid tissues are present in other regions as follows:

• Tonsils - near the junction of the oral cavity with the pharynx, as collections of lymphoid tissue. The largest of these are the right and left palatine tonsils, present on either side of the oropharyngeal isthmus.

• Solitary lymphatic follicles - small collections of lymphoid tissue, similar in structure to the follicles of lymph nodes, present anywhere along the length of the gut.

• Aggregated lymphatic follicles (Peyer's patches) - larger aggregations of lymphoid tissue, each consisting of 10 to 200 follicles present in the small intestine.

The image below of an ileal section shows Peyer's patches within the submucosa.

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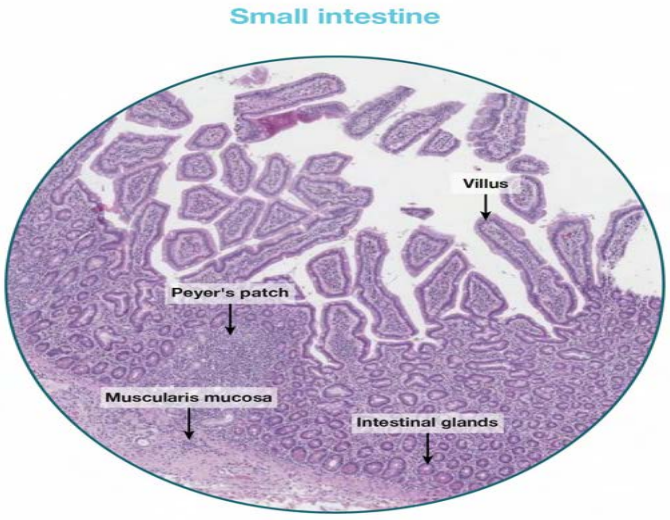

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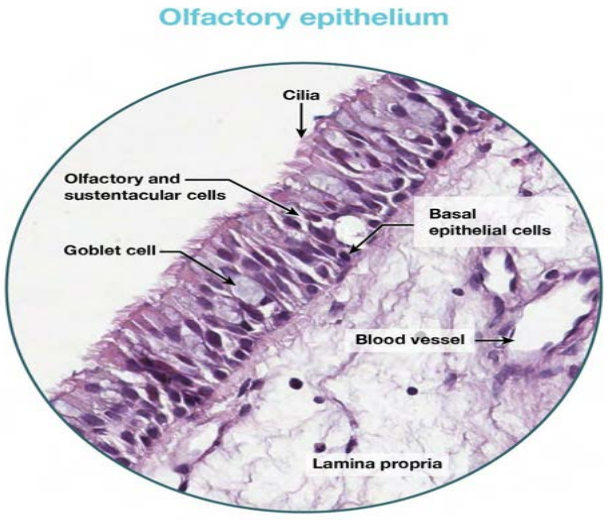
Solution to Question 8:

The sustentacular cells are supporting cells of the olfactory epithelium.

Their nuclei are oval and lie near the free surface of the epithelium. The free surface of each cell bears numerous microvilli (embedded in overlying mucous). The cytoplasm contains a yellow pigment (lipofuscin) that gives olfactory mucosa its yellow colour. In addition to their supporting function, sustentacular cells may be phagocytic, and the pigment in them may represent remnants of phagocytosed olfactory cells.



Solution to Question 9:

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The above histological image is that of the trachea as identified by the presence of pseudostratified ciliated columnar epithelium lining, the serous and mucous glands and hyaline cartilage.

The histological section of the trachea shows the following structures:

• Respiratory epithelium

• Basement membrane

• Submucosal glands (both serous and mucous parts)

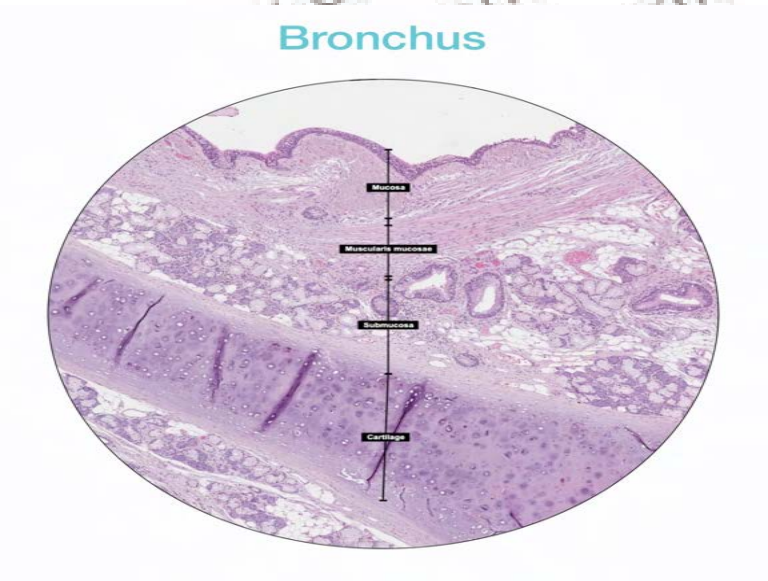
• Perichondrium

• Tracheal cartilage

• Trachealis muscle (smooth muscle).

The bronchi differ from the trachea in having plates rather than rings of cartilage, and in having a layer of smooth muscle between the lamina propria and submucosa. In smaller branches, the amount of cartilage decreases, whereas the amount of smooth muscles increases. Also, the number of glands and goblet cells decreases.

The image below is a histological section of the bronchus.



Solution to Question 10:

The structure marked X in the above image is the lumen of the alveolar duct, which are tiny ducts that connect the respiratory bronchioles to alveolar sacs, each of which contains a collection of alveoli (small mucus-lined pouches made of flattened epithelial cells).

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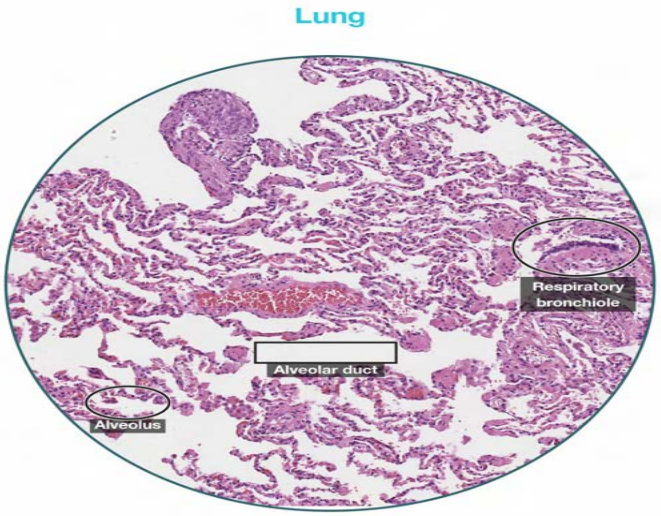

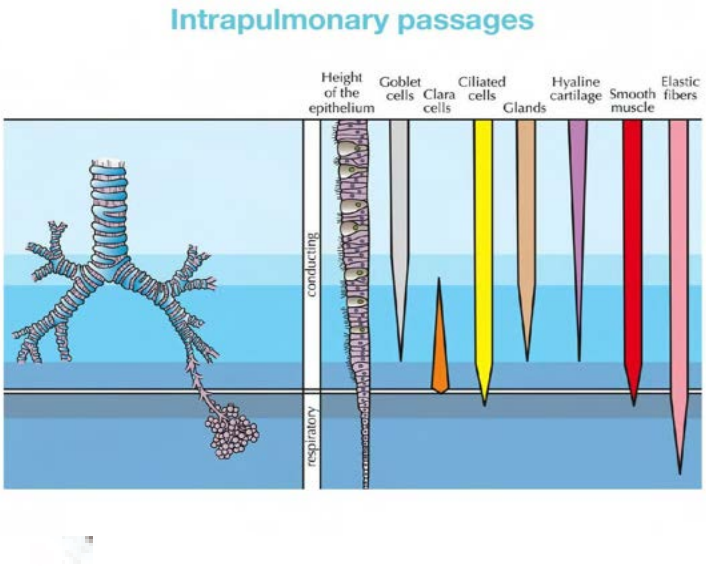

The coloured strips in the above image represent the location of different cells/structures in the trachea and bronchial tree.

On entering the lung, the principal bronchus divides into secondary, or lobar bronchi. Each lobar bronchus divides into tertiary, or segmental bronchi which further divides into the lobular bronchioles and then into terminal bronchioles.

Terminal bronchioles represent the most distal parts of the conducting passage. Each terminal bronchiole ends by dividing into respiratory bronchioles. Each respiratory bronchiole ends by dividing into a few alveolar ducts. Each alveolar duct ends in a passage, the atrium, which leads into a number of rounded alveolar sacs. Each alveolar sac is studded with a number of air sacs or alveoli.

Solution to Question 11:

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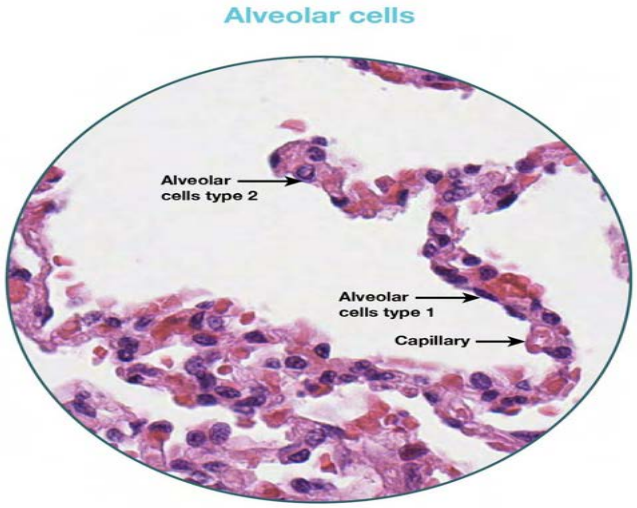
The secretory cells bearing microvilli present in the epithelial lining of the alveoli are the type II pneumocytes.

The cells forming the lining epithelium of alveoli (also called pneumocytes) are mainly of the following types:

• Type I pneumocytes - large flattened cells which present a very thin diffusion barrier for gases. They are connected to each other by tight junctions.

• Type II pneumocytes - These are rounded secretory cells bearing microvilli on their free surfaces. These cells secrete the surfactant which decreases the surface tension between the thin alveolar walls, and thus prevents alveoli from collapsing during respiration.

• Type III alveolar cells (brush cells) - function is not clearly known.



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d.
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Digestive, Hepatobiliary & Genitourinary Systems

Question 1:

The hard palate contains _____

a) Keratinised epithelium, submucosa, minor salivary glands

b) Keratinised epithelium, absent submucosa, no salivary glands

c) Non-keratinised epithelium, submucosa, minor salivary glands

d) Non-keratinised epithelium , absent submucosa, minor salivary glands

Question 2:

The muscularis externa layer of the gut wall has _____

a) Inner longitudinal and outer circular muscle fibres

b) Inner circular and outer longitudinal muscle fibres

c) only circular muscle fibres

d) only longitudinal muscle fibres

Question 3:

A patient with suspected oesophagal carcinoma is planned for an endoscopic biopsy. A section of the lesion was taken and sent for histopathological examination. Which of the following layers of the gastrointestinal tract is not expected to be seen on microscopic examination of the section?

a) Mucosa

b) Muscularis propria

c) Submucosa

d) Serosa

Question 4:

Which of the following statements regarding the esophagus is false?

a) It is lined by stratified squamous epithelium

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b) The upper third contains only skeletal muscle

c) The middle third contains both skeletal and smooth muscles

d) The lower third contains only skeletal muscle

Question 5:

Within which part of the gastric gland are the chief cells located?

a) Gastric pit

b) Isthmus

c) Neck

d) Base

Question 6:

Which of the following statements regarding the gastric glands is false?

a) Pyloric antrum has many acid secreting cells

b) Oxyntic cells secrete hydrochloric acid

c) Cardiac region has many mucus secreting cells

d) Parietal cells secrete intrinsic factor

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Question 7:

The Brunner's glands are seen in _____

a) Jejunum

b) Upper duodenum

c) Lower duodenum

d) Appendix

Question 8:

An intern accidentally sent an incompletely labelled sample of the resected bowel wall from a patient with intestinal obstruction for histopathological examination. Given below is the microscopic image of the section of the sample. Which part of the gastrointestinal tract is being visualised here?

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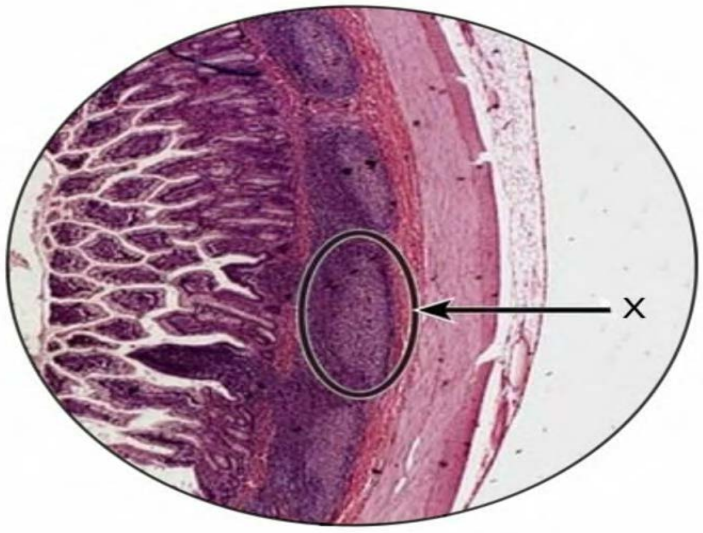

a) Esophagus

b) Stomach

c) Ileum

d) Duodenum

Question 9:

Which of the following statements is false about Paneth cells?

a) They are rich in rough endoplasmic reticulum

b) Rich in zinc

c) Contain lysozyme

d) Foamy appearance

Question 10:

A 42-year-old man presented to the clinic with a history of anemia, non-bloody diarrhoea and poor appetite. A diagnosis of celiac disease is suspected and a duodenal biopsy is taken for histopathological examination. Which of the following cells are not likely to be seen on microscopic examination of the section?

a) Stem cells

b) Goblet cells

c) Paneth cells

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d) Neck cells

Question 11:

In which of the following structures are centroacinar cells mainly present?

a) Pancreas

b) Parotid gland

c) Prostate

d) Liver

Question 12:

Which of the following structures does not form the portal triad of the liver?

a) Hepatic artery

b) Hepatic vein

c) Bile duct

d) Portal vein

Question 13:

The space of Disse consists of all of the following except _____

a) Microvilli

b) Blood plasma

c) Kupffer's cells

d) Fat cells

Question 14:

Sinusoids are present in

a) 1, 2, 3, 4, & 5

b) 1, 3, 4, & 5

c) 1, 2, 4, & 5

d) 2, 3, 4, & 5

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Question 15:

The transitional epithelium lines all of the following except _____

a) Ureters

b) Minor calyx

c) Urinary bladder

d) Membranous urethra

Question 16:

Which of the following accurately describes the lining epithelium of the vagina?

a) Pseudostratified keratinized columnar epithelium

b) Keratinized stratified squamous epithelium

c) Non-keratinized stratified squamous epithelium

d) Pseudostratified non-keratinized columnar epithelium

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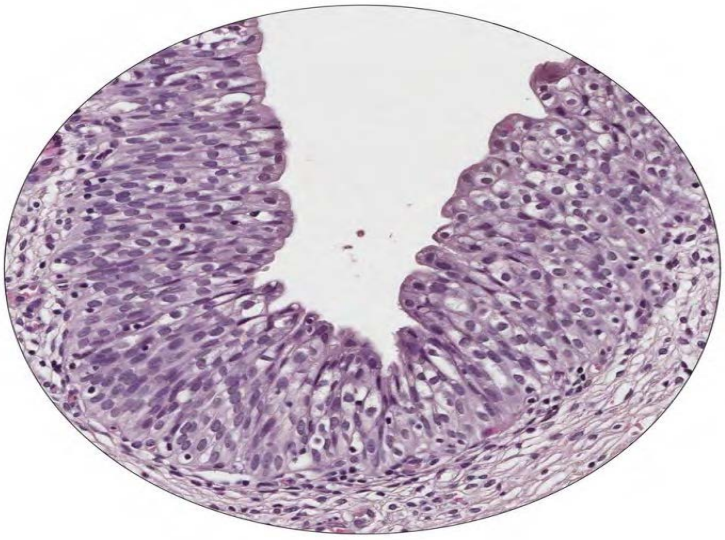
Question 17:

In which of the following structures is the type of epithelium as shown in the image seen?



a) Bile duct

b) Common bile duct

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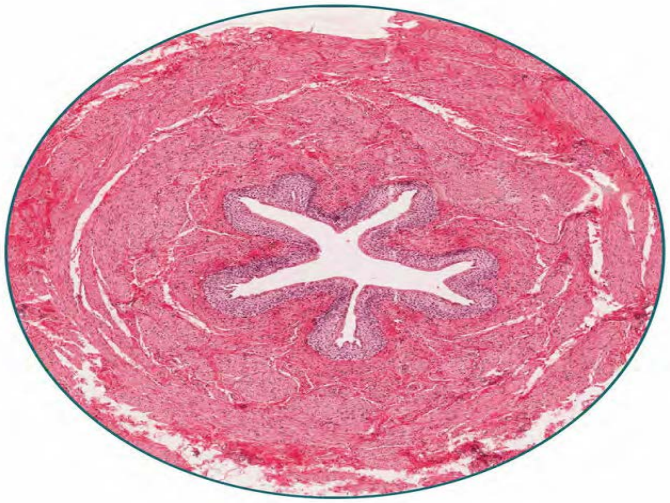
c) Skin

d) Urinary bladder

Question 18:

Identify the structure shown in the histological image below.



a) Female urethra

b) Male urethra

c) Ureter

d) Vas deferens

Question 19:

Which of the following are the epithelial supporting cells of the seminiferous tubules?

a) Germ cells

b) Leydig cells

c) Sertoli cells

d) Peritubular cells

Question 20:

Identify the structure shown in the histological image below.

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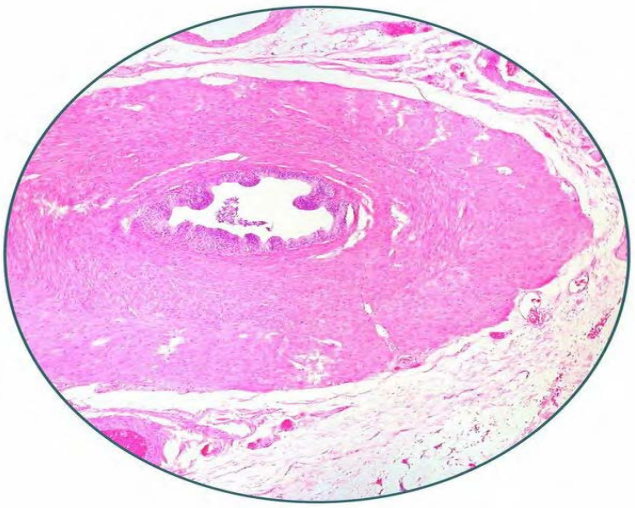

a) Ureter

b) Epididymis

c) Seminal vesicle

d) Vas deferens

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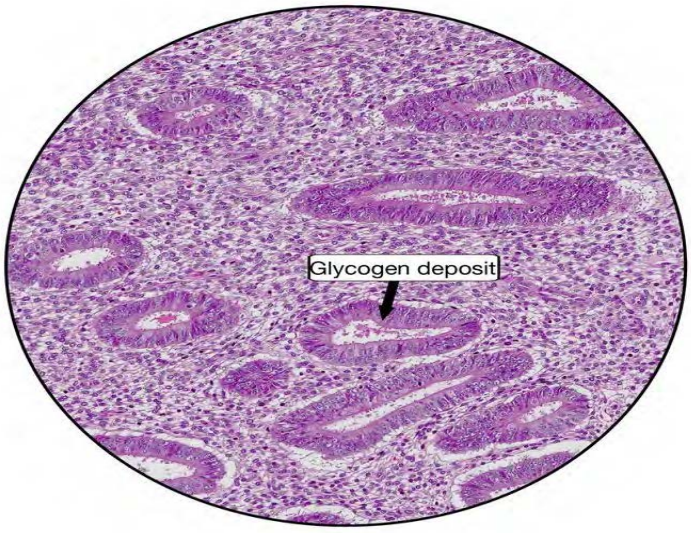
Question 21:

Identify the structure shown in the image below.



a) Seminiferous tubule

b) Prostate

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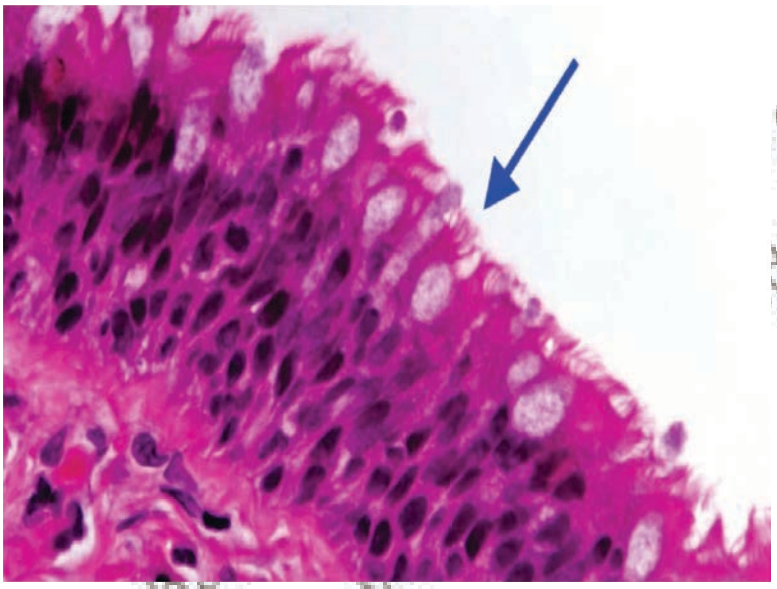
c) Endometrium

d) Mammary gland

Question 22:

The structures marked in the image below are found in the epithelial lining of all of the following sites, except:



a) Oviduct

b) Epididymis

c) Bronchi

d) Ependyma

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Answer Key

Question No.	Correct Option
1	a
2	b
3	d
4	d
5	d
6	a

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7	b
8	c
9	d
10	d
11	a
12	b
13	c
14	b
15	d
16	c
17	d
18	c
19	c
20	d
21	c
22	b

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Detailed Explanations

Solution to Question 1:

The hard palate contains keratinised stratified squamous epithelium, has a submucosa, and contains minor salivary gland. This keratinised stratified squamous epithelium has regional variations and may be orthokeratinised or parakeratinised(found in hard palate and gingiva).

The bony structure of the hard palate is covered by a firmly attached mucosa in the central part. In the lateral parts, the hard palate also has a submucosal layer containing blood vessels. There are minor mucous type salivary glands in the submucosa in the posterior part of the hard palate.

(Note: In the orthokeratinized epithelium the cell nuclei disappear in the keratinized layer, whereas in the parakeratinized epithelium flattened, highly condensed nuclei remain in the cell cytoplasm of the keratinized layer until exfoliation)

Solution to Question 2:

The muscularis externa has an inner circular muscle fibers and outer longitudinal muscle fibers.

The gut wall receives its strength mainly from the muscularis externa, which is the thick layer of muscle that surrounds the submucosa. It is responsible for gut movements such as peristalsis.

Note:

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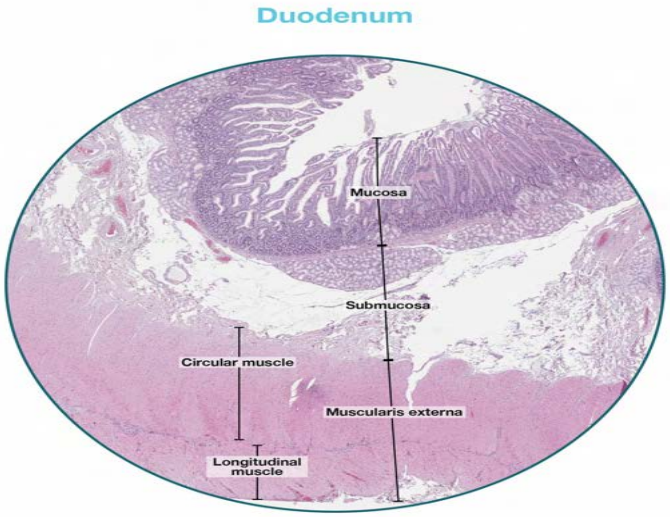
• Muscularis externa contains smooth muscle, except in upper part of esophagus where it has only striated muscle fibres.

• The stomach has 3 layers in the muscularis externa, with an extra oblique layer.

• In the colon, the outer longitudinal fibers join to form prominent bundles called the taenia coli.

Given below is a histological section of the duodenum showing the inner and outer layers of muscularis externa.



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Solution to Question 3:

The serosa is absent in the oesophagus and hence, is not expected to be seen on microscopic examination.

The oesophagus has an adventitia which is made up of dense fibrous tissue covering the muscularis externa. Only the lower part of the esophagus which is intra-abdominal has a layer of peritoneum covering it.

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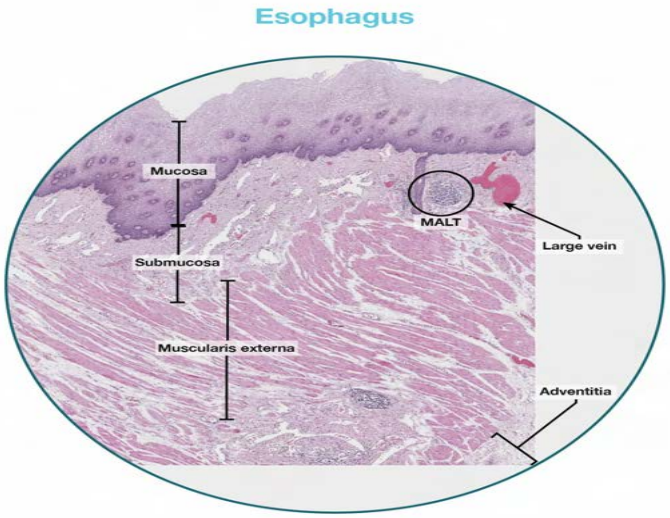


In general, the gut tube is made of the following layers (inner to outer side):

• Mucosa - The inner-most layer is the mucous membrane with the following sub-layers:

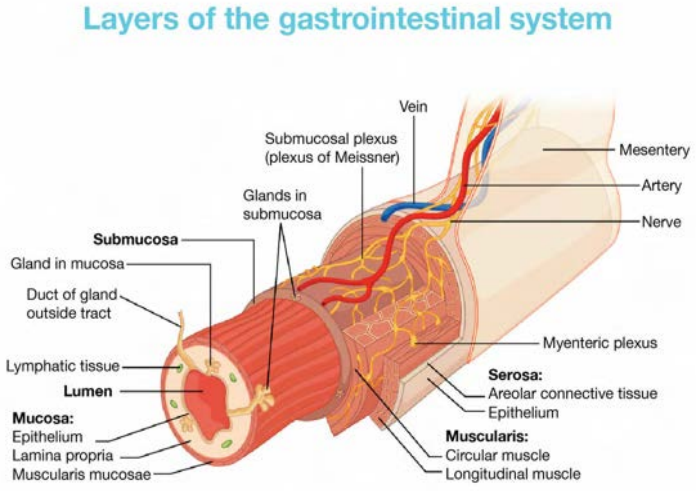
• Lining epithelium

• Lamina propria - A layer of connective tissue supporting the lining epithelium

• Muscularis mucosae - A thin layer of smooth muscle

• Submucosa - Made of loose areolar tissue on which the mucous membrane rests

• Muscularis externa - Thick layer of muscle around the submucosa (with inner circular and outer longitudinal fibres)



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Solution to Question 4:

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The lower third of the oesophagus consists of only the smooth muscles.

The oesophagus consists of the following layers:

• Mucosa - consists of a non-keratinized stratified squamous epithelium, lamina propria, and muscularis mucosae

• Submucosa - A special feature of the submucosa is the presence of compound tubuloalveolar mucous glands

• Muscularis externa - with the usual circular and longitudinal layers

• Upper 1/3rd - Only skeletal muscle fibres are present

• Middle 1/3rd - Both skeletal and smooth muscle fibres are present

• Lower 1/3rd - Only smooth muscle fibres are present

• Adventitia - Most of the oesophagus has a dense fibrous tissue covering called the adventitia. Only a short length of the oesophagus in the lower part has a peritoneal covering (serosa).

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Solution to Question 5:

Chief cells are located mostly in the basal part of the gastric glands.

Gastric glands are simple or branched tubular glands that lies perpendicular to the gastric mucosa. They can be identified to have 3 main sections:

• Basal part (deep part)

• Neck

• Isthmus (connects to gastric pit) - Gastric glands open into the gastric pits.

Types of cells in the gastric glands

Chief cells (also called peptic or zymogen cells)

• Mostly found in the basal or deep portion of the gastric glands

• Cells are cuboidal or low columnar shaped

• The cytoplasm is basophilic and contains prominent secretory granules

• Secrete pepsinogen (precursor of pepsin) and lipase

Oxyntic cells (or parietal cells)

• Found in the upper part of the gland

• Cells are large, ovoid or polyhedral

• Stain strongly with eosin

• Produce hydrochloric acid (HCl) and intrinsic factor

Mucous neck cells:

• Prominently found at the neck part of the gastric glands

• They secrete mucus

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Neuroendocrine cells:

• Situated mostly in the basal or deeper parts of the glands, along with the chief cells. T

• Cells are pleomorphic-shaped and display irregular nuclei surrounded by granular cytoplasm

• Synthesize many important biogenic amines and polypeptides such as:

• G cells - Gastrin

• D cells - Somatostatin

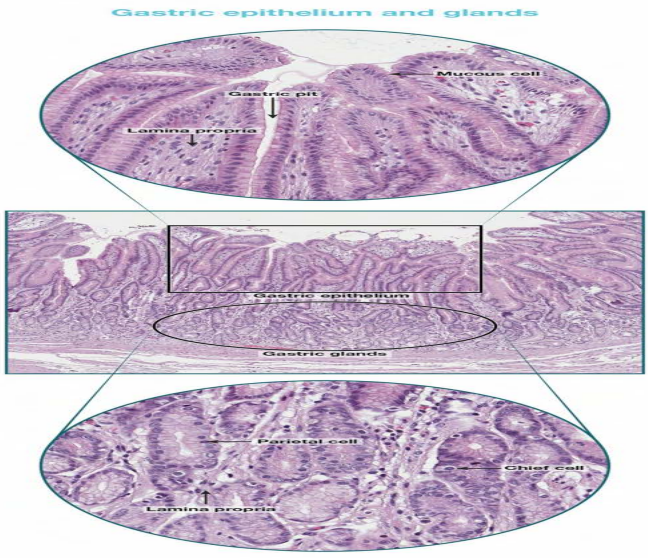
• Enterochromaffin cells - Serotonin

• ECL cells (enterochromaffin-like cells) - Histamine

• P/D1 cells - Ghrelin

Stem cells:

• Undifferentiated cells that multiply and replace other cells



Solution to Question 6:

The pylorus consists of mainly mucus-secreting glands.

The gastric glands can be divided into 3 groups which are namely:

• Principal gastric glands - They are found in the body and fundus. About 3-7 principal glands open into the gastric pit. These glands contain at least 5 different types of cells:

• Chief cells

• Parietal cells

• Mucous neck cells

• Neuroendocrine cells

• Stem cells.

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• Cardiac gastric glands - They are found in the small area near the cardiac orifice. Some are simple tubular glands, others are compound branched tubular. They contain mucus-secreting cells predominantly. Parietal and chief cells are sparsely present.

• Pyloric gastric glands - Found in the pyloric antrum. About 2-3 convoluted tubes open into deep gastric pits. They mainly have mucus-secreting cells. They also have neuroendocrine cells, especially gastrin-secreting G cells. Parietal and chief cells are scarce.

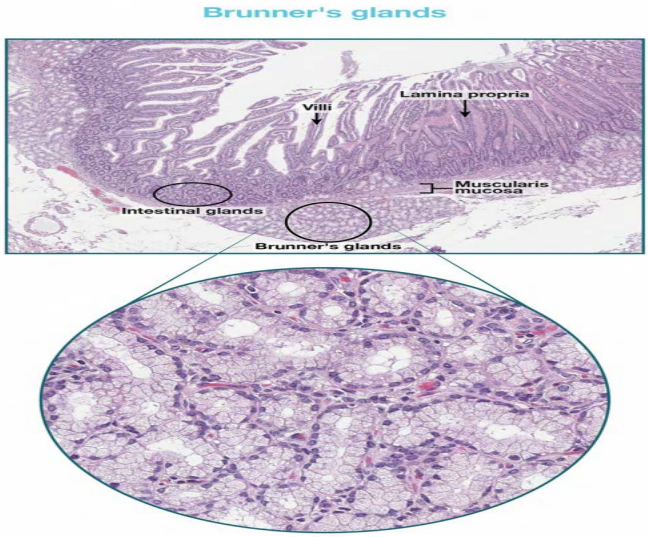
Solution to Question 7:

Brunner's glands (or duodenal glands) are compound tubular submucosal glands present in the upper duodenum (above the sphincter of Oddi).

The alveoli of duodenal glands are lined mostly by mucous secreting columnar cells. Their ducts pass through the muscularis mucosae and empty into the intestinal crypts (of Lieberkuhn).

The duodenum can be easily differentiated from the jejunum or ileum by the presence of these submucosal glands. The jejunum and ileum do not have glands in their submucosa.

Given below is the histological section of normal duodenum showing the Brunner's glands at the submucosal layer.



Solution to Question 8:

The image is a section through the ileum as evident by the thin and slender villi and an aggregated lymphatic follicle (Peyer's patch) in the submucosa.

These aggregations of lymphatic follicles are known as Mucosa Associated Lymphoid Tissue (MALT), and also as gut-associated lymphoid tissue (GALT). Peyer's patches in submucosa are found in large size and numerously in the terminal ileum.

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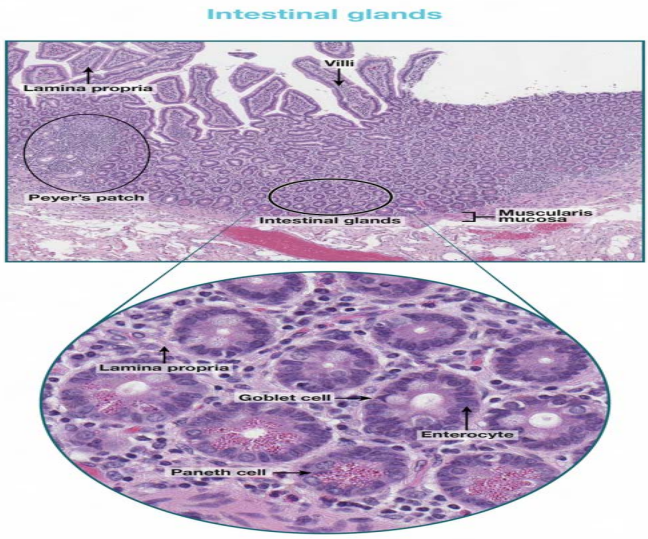
Solution to Question 9:

The foamy appearance or frothy cytoplasm is not a feature of Paneth cells, but of Goblet cells. Mucus-secreting Goblet cells contain lipid or mucinous material with a foamy appearance.

Paneth cells (Enzyme cells) are present only in the deeper portions of the intestinal crypts. They contain many eosinophilic secretory granules. On microscopic examination, the Paneth cells are seen to contain a significant amount of rough endoplasmic reticulum. They are also rich in zinc. The function of Paneth cells is to produce lysozyme that kills bacteria. They may also produce other enzymes.



Solution to Question 10:

Neck cells are not likely to be seen on microscopy as they are not present in the small intestine. The neck cells are the mucous secreting cells that are present in the upper end (or 'neck') of the main gastric glands of the stomach.

Option A: Stem cells are the undifferentiated cells present in the wall of the intestinal crypts.

Option B: Goblet cells are mucous secreting cells. Each goblet cell has an expanded upper part that is distended with mucin granules. The nucleus is flattened and is situated near the base of the cell.

Option C: Paneth Cells (zymogen cells) are found only in the deeper parts of intestinal crypts. They contain prominent eosinophilic secretory granules.

Solution to Question 11:

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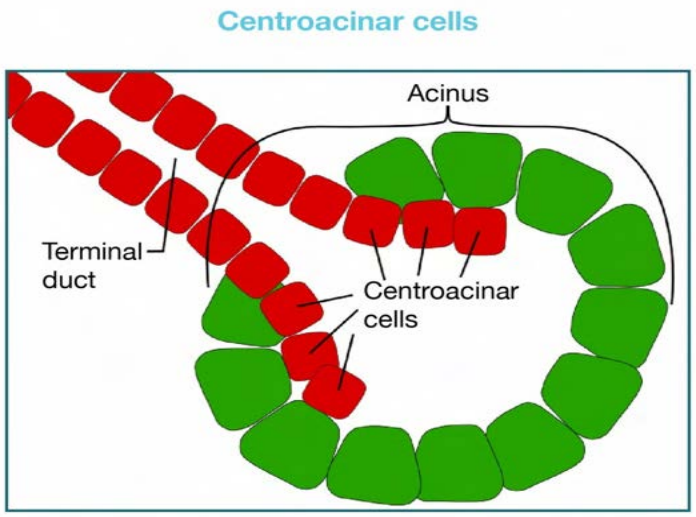
Centroacinar cells are mainly present in the pancreas.

Centroacinar cells are present in the alveoli of the exocrine pancreas. They are called so because they are visible near the centre of the acinus (or alveolus). These cells actually are actually part of the intercalated ducts that are invaginated into the secretory elements of the pancreas.



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Solution to Question 12:

Hepatic vein does not form part of the portal triad.

Portal canals are present at the angular intervals at the periphery of each hepatic lobule. They are filled with connective tissue and form a connective tissue network across the entire liver substance.

Each 'canal' consists of

• A branch of the portal vein

• A branch of the hepatic artery

• An interlobular bile duct.

These three structures collectively form a portal triad.

The image given below shows a cross-section of the normal hepatic tissue showing the portal triad.

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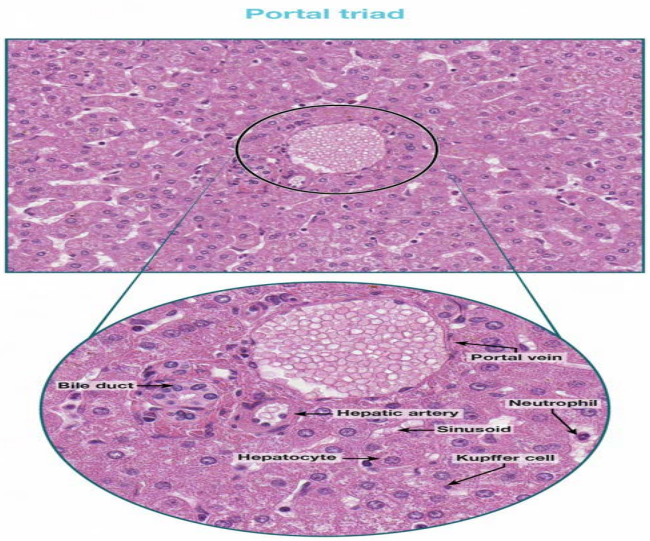

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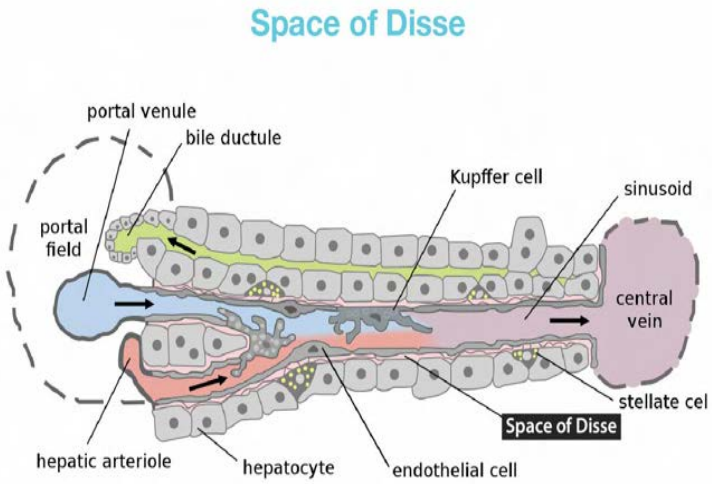
Solution to Question 13:

The space of Disse consists of all of the following mentioned above except Kupffer cells. They are present in the lining of the walls of the sinusoids, not in the Space of Disse (perisinusoidal space).

Kupffer cells are also known as stellate macrophages or Kupffer-Borowicz cells. They are specialized macrophages present in the liver and are part of the mononuclear phagocyte system.

Space of Disse or the perisinusoidal space is present in the liver between the hepatocyte and a sinusoid. This space contains the blood plasma. The microvilli of hepatocytes extend into this space. This allows absorption of proteins and other plasma components from the sinusoids by the hepatocytes. This space may also have some fat cells.



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Solution to Question 14:

The sinusoids are present in all the above-mentioned structures except kidneys.

They are present in:

• Liver

• Spleen

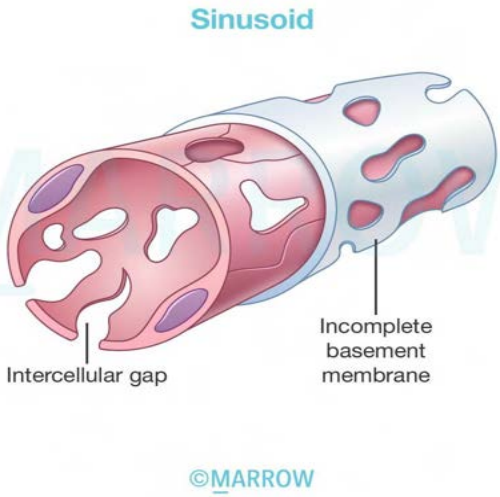
• Lymph nodes

• Endocrine glands (adrenal medulla, parathyroid)

• Bone marrow

• Carotid body

The given image is a graphical representation of sinusoids (sinus-like) which are small blood channels formed by subdivision of the lumen of large blood vessels (sinuses) by the invasion of developing parenchymal cell-cords.



Solution to Question 15:

Transitional epithelium lines all the above structures except the membranous urethra.

Transitional epithelium is found in the renal pelvis and calyces, the ureter, the urinary bladder, and pre-prostatic & prostatic parts of the urethra. Because of this distribution, it is also called the urothelium.

Both in the male and female, the greater part of the urethra is lined by pseudostratified columnar epithelium. A short part adjoining the urinary bladder is lined by transitional epithelium, while the part near the external orifice is lined by stratified squamous epithelium.

The following are various parts of the urethra in males and their lining epithelium:

• Pre-prostatic & prostatic urethra - Transitional epithelium

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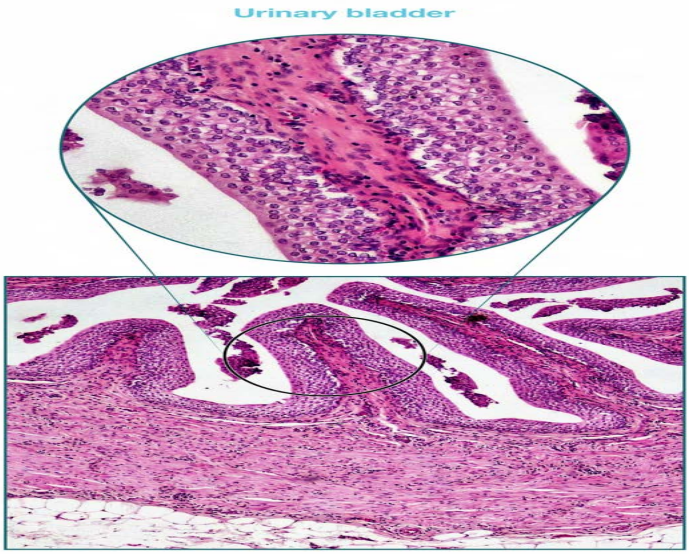
• Membranous urethra - Pseudostratified/stratified columnar

• Penile/spongy urethra - Proximally by pseudostratified columnar, distally by stratified squamous

Given below is the histological section of the urinary bladder showing the transitional epithelium.



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Solution to Question 16:

The lining epithelium of the vagina is made up of non-keratinised stratified squamous epithelium.

Other sites lined by the non-keratinised squamous epithelium are:

• Mouth

• Tongue

• Pharynx

• Oesophagus

• Cornea

Keratinised stratified squamous epithelium covers the skin of the whole body and forms the epidermis.

The given image shows a histological section of the vaginal epithelium showing the non-keratinised stratified squamous epithelium.

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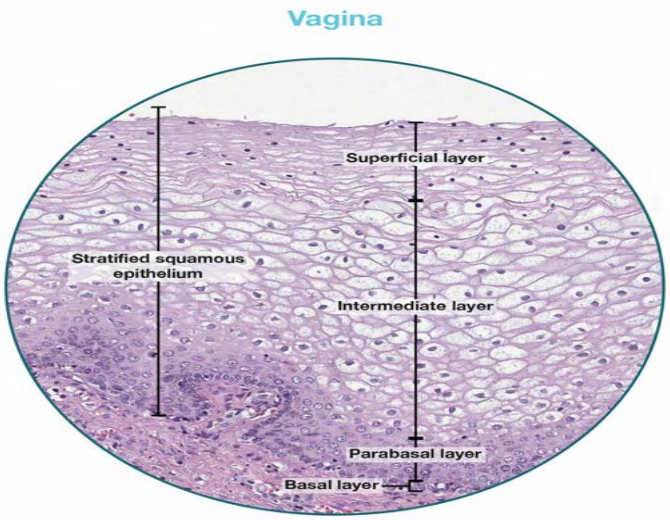

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Solution to Question 17:

The above image shows transitional epithelium and is seen in the urinary bladder.

The deepest layer has columnar cells, the middle layers are made up of polyhedral cells and the surface layer has cells that are large and shaped like an umbrella.

Transitional epithelium is found in the renal pelvis and calyces, the ureter, the urinary bladder, and part of the urethra. Because of this distribution, it is also called the urothelium. In the urinary bladder, it is usually observed that transitional epithelium can be stretched considerably without being damaged. When stretched it appears to be thinner and the cells become flattened or rounded.

Solution to Question 18:

The above image shows histological section of ureter.

The image shows a thick, fibroelastic, lamina propria lying underneath the stratified, transitional epithelium. There are no mucosal or submucosal glands and no submucosa. There is a layer of smooth muscle outside the mucosa. The outer adventitial layer has fibroelastic connective tissue, with blood vessels, lymphatics and nerves.

Given below is a cross-section of the ureter showing the transitional epithelium and the layer of smooth muscle.

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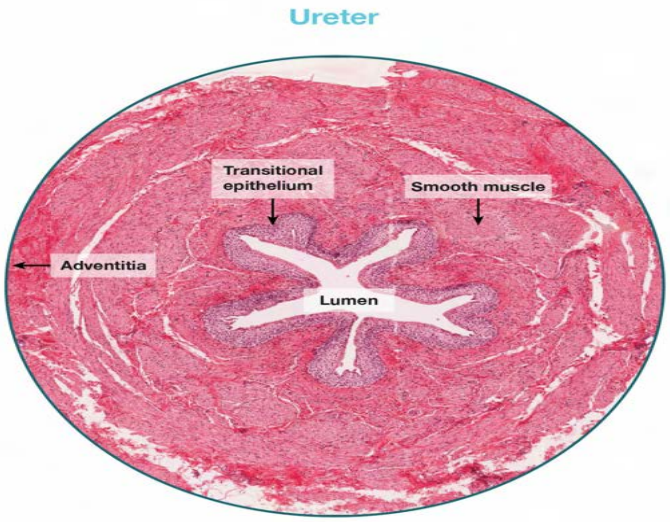

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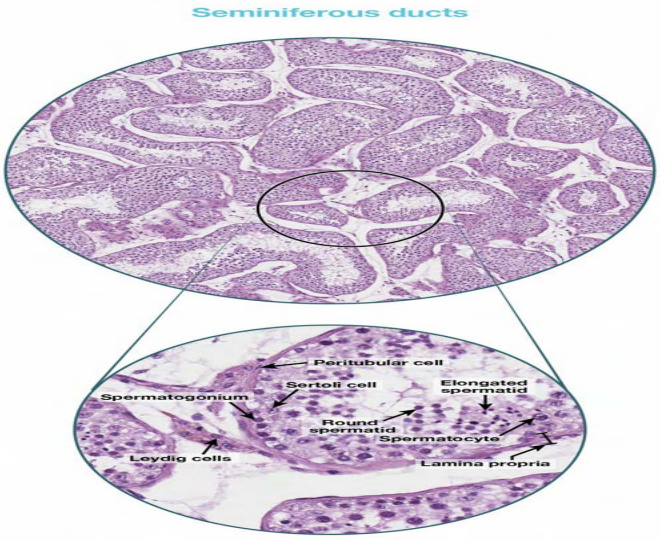
Solution to Question 19:

Sertoli cells also called sustentacular cells are the epithelial supporting cells of the seminiferous tubules.

Sertoli cells are derived from the epithelial sex cords of the developing gonads. They are tall simple columnar cells. They surround the proliferating and differentiating germ cells forming pockets around these cells. Sertoli cells provide nutrients and phagocytose excess cytoplasm from the newly forming spermatozoa.

The given image is a section of seminiferous ducts showing the different types of cells.



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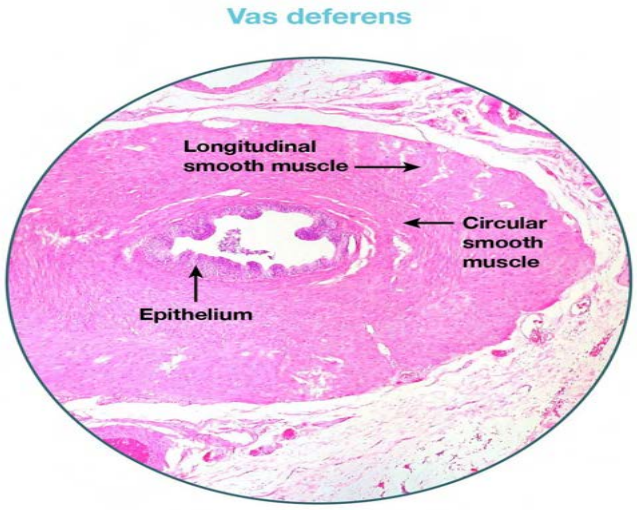
Solution to Question 20:

Among the given options the histological section is most likely to be of the vas deferens or the ductus deferens.

The epithelium of this tube displays a pseudostratified columnar epithelium. It is surrounded by a prominent muscular layer. This layer contains inner and outer longitudinal muscle and a middle circular layer. An adventitia of connective tissue surrounds the muscularis layer. The ductus deferens extends from the epididymis to the ejaculatory ducts.



Solution to Question 21:

Among the given options, the histological image is likely to be of the endometrium. It shows the presence of glycogen masses in the basal cytoplasm of the epithelial cells lining the glands which are the features of the early secretory phase of the endometrium.

The uterus is made up of an external layer of smooth muscle called the myometrium, and an internal layer called the endometrium. The endometrium has three layers which are namely:

• Stratum compactum,

• Stratum spongiosum (which make up the stratum functionalis)

• Stratum basalis.

The changes observed in the endometrium during the menstrual cycle are continuous and may be summarized as follows:

• Increase in thickness of endometrium - The endometrium progressively increases in thickness. In the postmenstrual phase, it is 0.5–1 mm thick; in the proliferative phase it is 2–3 mm thick, and in the secretory phase, its thickness reaches 5–7 mm.

• Increase in dimensions of uterine glands - The uterine glands grow in length. At first, they are straight but gradually become convoluted. Because of these convolutions, the glands acquire a 'saw-toothed' appearance when seen in the longitudinal section. The glands also increase in

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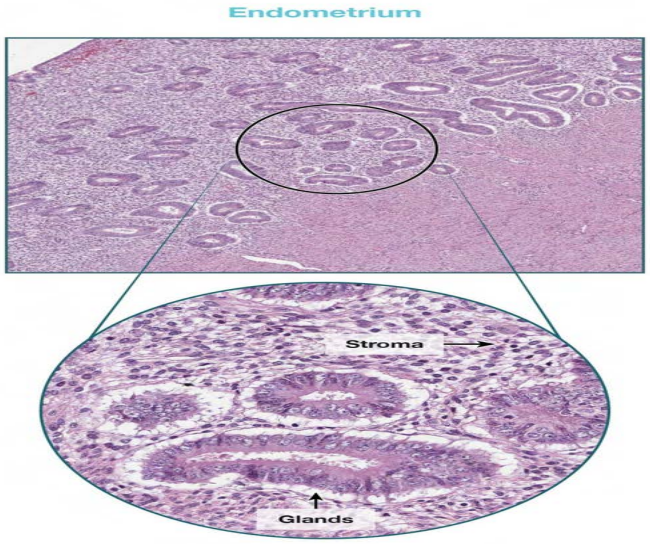
diameter.

• Change in the epithelial lining of glands - The epithelium lining the glands is at first cuboidal. During the proliferative stage, it becomes columnar. Glycogen accumulates in the basal portion of the epithelial cell, pushing the nucleus nearer the lumen. During the secretory phase, the apical part of the cell is shed off as part of the secretion and the cell again becomes cubical.

Given below is a histological section of the endometrium in the proliferative phase.



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Solution to Question 22:

The image shows an arrow mark pointing towards the cilia. All the structures given in the options have a ciliated lining epithelium except epididymis, which is lined by pseudostratified columnar epithelium with stereocilia.

The given image is a histological section of the epididymis showing the pseudostratified columnar epithelium with stereocilia.

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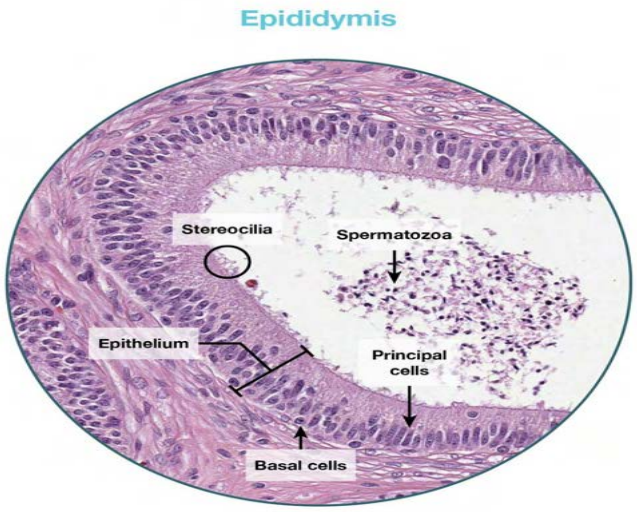

Cilia are minute hair-like projections, while stereocilia are very long, thick microvilli measuring about 5–10 μm in length.

Ciliated epithelium:

• The epithelium bears cilia, which moves in a coordinated fashion, and help in the movement of the mucus, or propel the movement of any other structures such as ova or spermatozoa.

• The ciliated columnar epithelium is found in most of the respiratory tract, the uterus, and the uterine tube (oviduct), efferent ductules of the testis, parts of the middle ear and auditory tube; the ependyma lining the central canal of the spinal cord and the ventricles of the brain.

• The pseudostratified ciliated columnar epithelium is seen in the trachea and in large bronchi.

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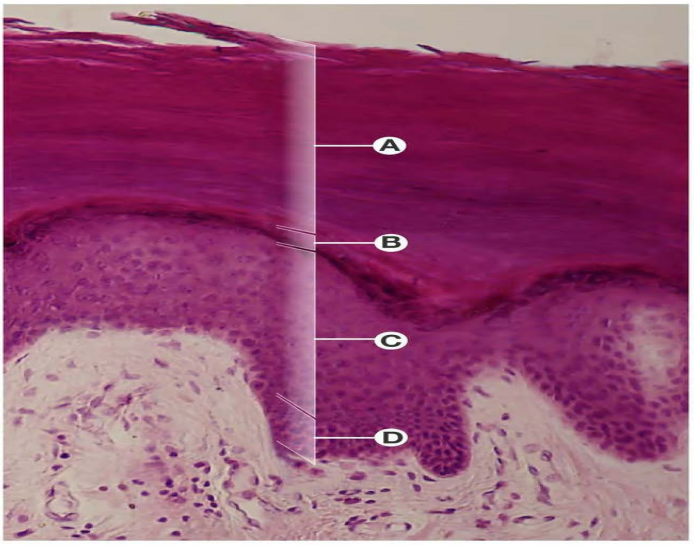
Skin & Special Senses, Eye and Ear

Question 1:

Match the following marked structures to the correct layers of the epidermis.



a) A-3, B-4, C-2, D-1

b) A-3, B-2, C-4, D-1

c) A-2, B-4, C-3, D-1

d) A-2, B-1, C-3, D-4

Question 2:

Which of the following layers of epidermis is referred to as the prickle cell layer?

a) Stratum basale

b) Stratum spinosum

c) Stratum granulosum

d) Stratum corneum

Question 3:

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In which of the following layers of the epidermis are multiple layers of intertwining anucleate keratinocytes seen?

a) Stratum lucidum

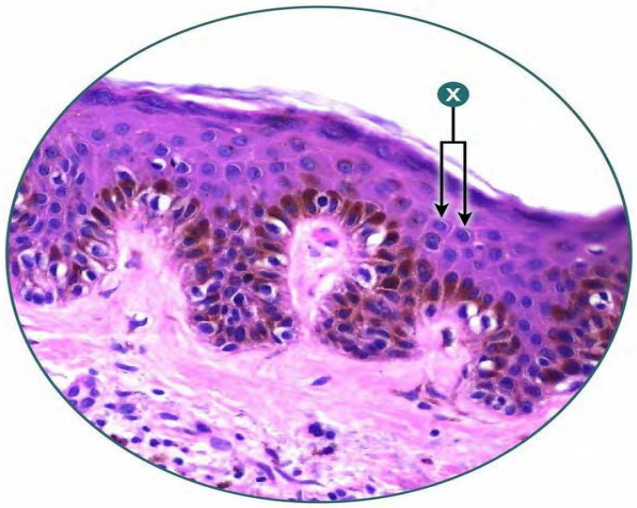
b) Stratum basale

c) Stratum granulosum

d) Stratum corneum

Question 4:

Given below is a histological section showing the layers of the skin. The region marked X points to the location of_____



a) Melanocytes

b) Duct of sweat glands

c) Desmosomes

d) Hemidesmosomes

Question 5:

A young patient presented with an itchy, rough rash with silvery scales along the extensor surface of her elbows, knees and scalp. Histopathological examination of the skin sample showed marked elongation and clubbing of the structure marked X in the given image. Identify the structure marked X.

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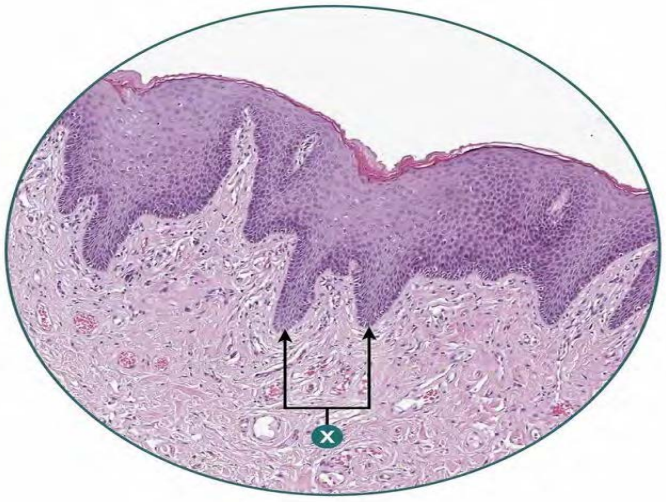

a) Reticular dermis

b) Hair follicle

c) Papillary dermis

d) Epidermal pegs

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Question 6:

In which of the following layers of the skin are melanocytes present?

a) Stratum corneum

b) Stratum granulosum

c) Stratum basale

d) Dermis

Question 7:

Which of the following cells act as slow-adapting touch receptors?

a) Melanocytes

b) Keratinocytes

c) Langerhans cells

d) Merkel cells

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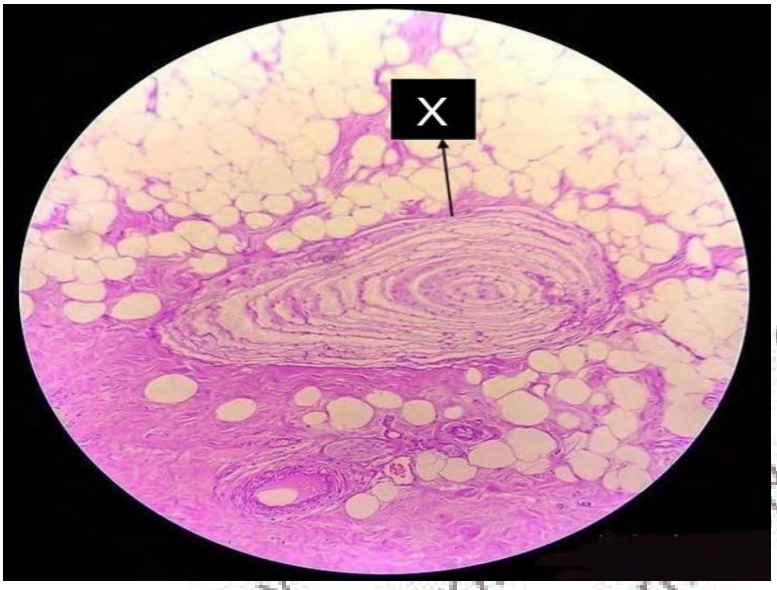
Question 8:

Identify the structure marked X in the given histological image of the dermis.



a) Merkel cell

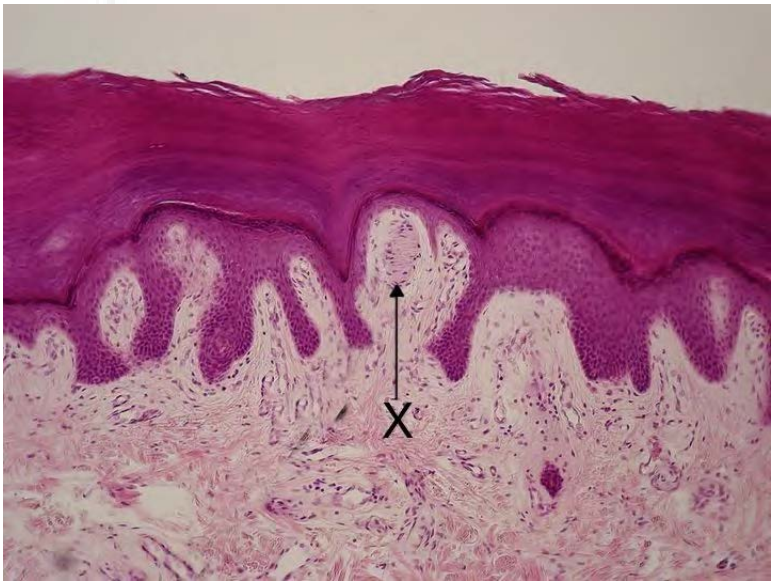
b) Meissner's corpuscles

c) Pacinian corpuscles

d) Ruffini's corpuscles

Question 9:

Given below is an image of a histological section of the skin. Identify the structure marked X.



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a) Merkel cell

b) Meissner corpuscles

c) Pacinian corpuscles

d) Ruffini's corpuscles

Question 10:

Panniculus adiposus is present in:

a) Axilla

b) Scrotum

c) Eyelid

d) Penis

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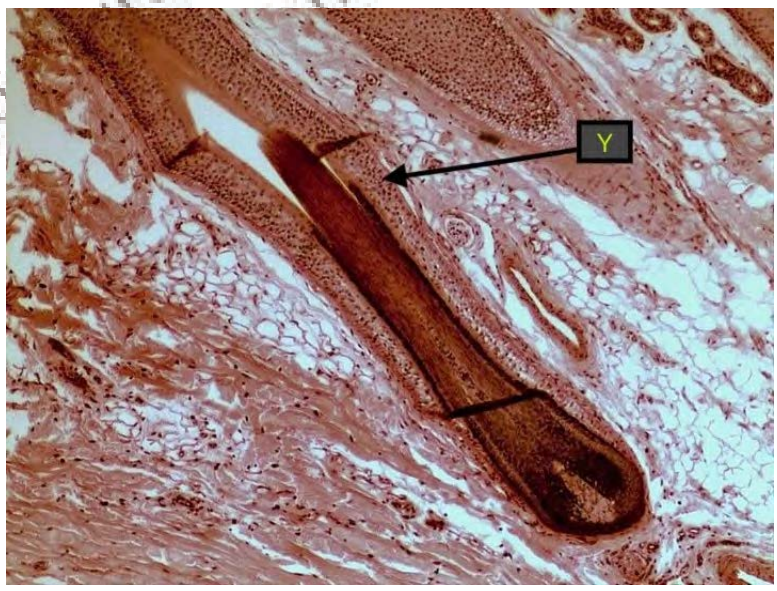
Question 11:

A 28-year-old man presented to the dermatology OPD with complaints of patchy hair loss. A punch biopsy of the scalp was taken to assess the cause of the hair loss. Given below is the histological section of the hair follicle. Identify the structure marked Y in the image



a) Cuticle

b) Medulla

c) Inner root sheath

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d) Outer root sheath

Question 12:

Which of the following accurately describes the arrector pili muscle?

a) Skeletal muscles

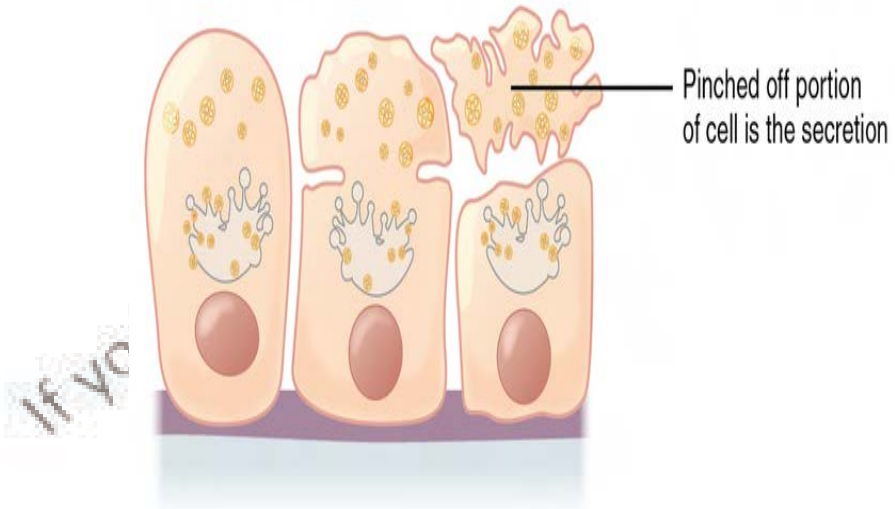
b) Smooth muscles

c) Mixture of skeletal and smooth muscle, with dominant skeletal muscle

d) Mixture of skeletal and smooth muscle, with dominant smooth muscle

Question 13:

Identify the type of gland depicted in the following image.



a) Holocrine

b) Merocrine

c) Apocrine

d) Endocrine

Question 14:

Given below is the histological section of the cornea. Identify the structures marked X and Y in the image.

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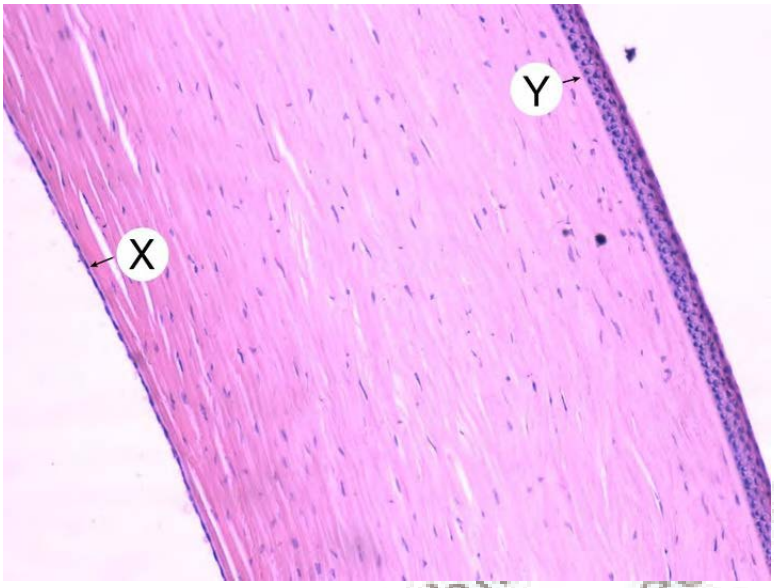

a) Bowman's membrane & corneal epithelium

b) Descemet's membrane & corneal epithelium

c) Endothelium & Bowman's membrane

d) Corneal epithelium & stroma

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Question 15:

Arrange from outer to inner the layers of the retina given below: A-Retinal pigment epithelium B-Inner plexiform layer C-Nerve fiber layer D-Inner nuclear layer E-external limiting membrane.

a) E,D,C,B,A

b) A,B,D,C,E

c) A,E,D,B,C

d) E,A,D,B,C

Question 16:

Identify the structure shown in the histological image below.

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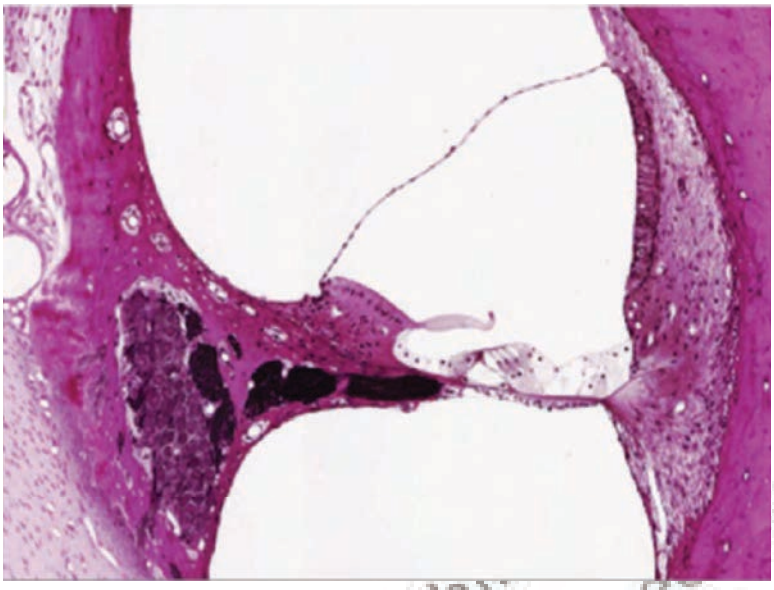

a) Vestibule

b) Semicircular canals

c) Cochlea

d) Tympanic membrane

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Question 17:

The gelatinous component of the crista ampullaris that extends from the crista to the roof of the ampullae is known as _____

a) Calix

b) Spiral ganglion

c) Cupula

d) Spiral ligament

Answer Key

Question No.	Correct Option
1	d
2	b
3	d
4	c

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5	d
6	c
7	d
8	c
9	b
10	a
11	d
12	b
13	c
14	c
15	c
16	c
17	c

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Detailed Explanations

Solution to Question 1:

The image shows the histological section of the epidermis. The structures marked are respectively:

- Stratum corneum
- Stratum granulosum
- Stratum spinosum
- Stratum basale

The above 4 layers are present in the thin hairy skin.

The thick glabrous skin over the palms and the soles alone contains a clear homogenous 5th layer between the stratum corneum and stratum granulosum, called the stratum lucidum.

Solution to Question 2:

Stratum spinosum of the epidermis is also referred to as the prickle cell layer.

Stratum spinosum consists of inter-cellular attachments called desmosomes. During the H&E mounting, the cells shrink and retract at places other than their attachment at the desmosomes. Thus, these desmosomes appear like spines on the cells on microscopy, and hence the cells are called as prickle cells.

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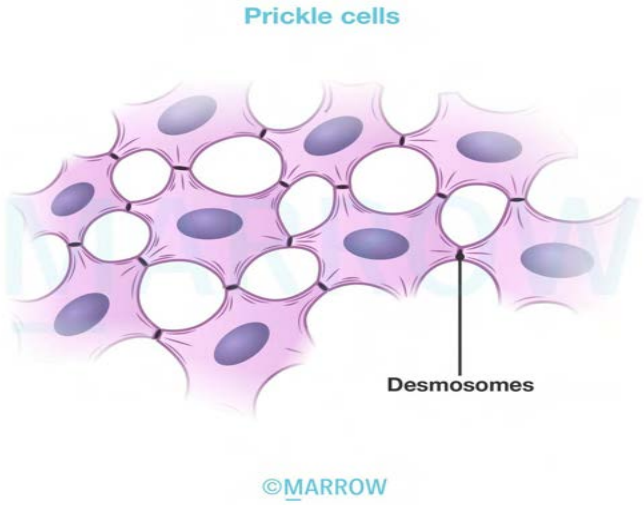

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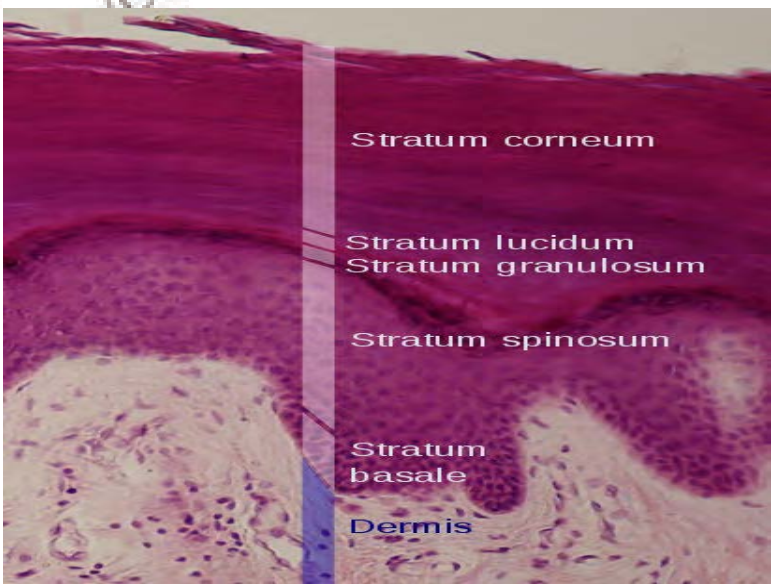
Solution to Question 3:

The stratum corneum (horny layer) consists of multiple layers of anucleate keratinocytes that often intertwine resulting in a basketweave appearance.

The deepest layer, stratum basale, contains the stem cells which divide and start moving superficially. As cells move more superficially, they begin to lose their nuclei and become progressively dehydrated, flattened and intertwined. Traces of flattened nuclei may be seen in some cells of stratum lucidum.

Stratum corneum, because of its thickness, prevents entry of microbes from the environment into the body as well as preventing leakage of fluids from the body to the environment. This is called barrier function.



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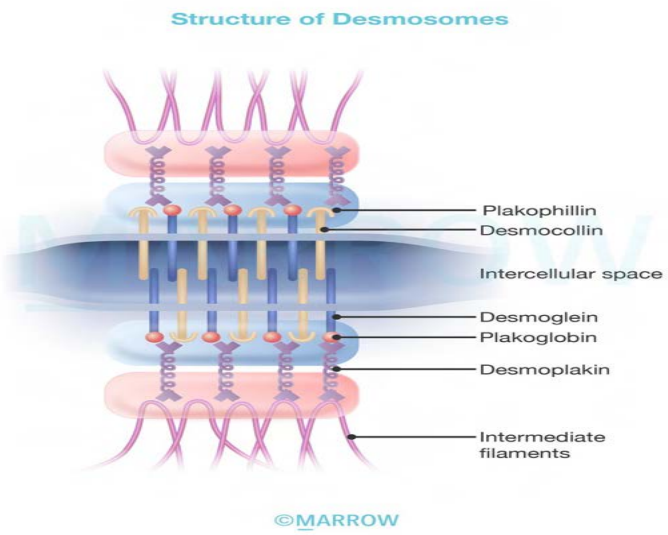
Solution to Question 4:

Among the given options, the region marked X points towards the location of intercellular adhesions formed by desmosomes.

Desmosomes (maculae adherens) are specialized adhesive protein complexes that localize to intercellular junctions. They are responsible for maintaining the mechanical integrity of tissues and resisting shearing forces. They are made of intercellular filaments, dense cytoplasmic plaques within the cells on either side and intermediate filaments.

Hemidesmosomes are specialized structures for the cell to extracellular material adhesions.



The schematic representation shows the desmosomal proteins and relative distance from the plasma membrane. The desmosomal cadherins, the desmogleins and desmocollins, extend into the intercellular space and outer dense plaque to establish contact and adhere to neighbouring cells. The cadherin cytoplasmic tails associate linker proteins, plakoglobin, plakophilins, and desmoplakin. The desmoplakin binds to keratin intermediate filaments within the inner dense plaque, serving to tether the intermediate filaments to the plasma membrane.

Solution to Question 5:

The clinical history is suggestive of psoriasis and the structure marked X are the epidermal pegs or Rete ridges, which are downward projections of the epidermis in the intervals between the dermal papillae.

Histopathological examination of the skin in a case of psoriasis will show clubbing and elongation of the Rete ridges as shown in the given image.

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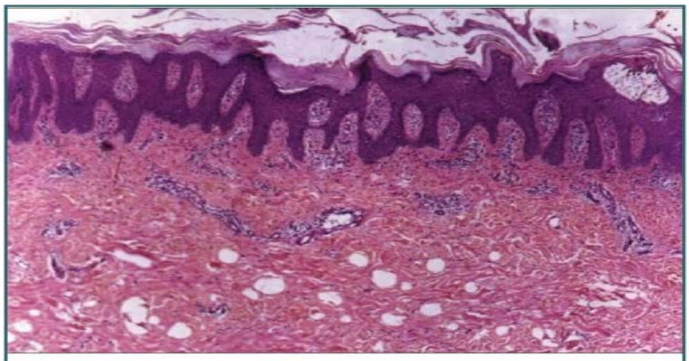
Psoriasis



Epidermis shows psoriasiform hyperplasia with markedly elongated rete ridges, clubbing of rete ridges at the base, and thinning of suprapapillary epidermal plates. The dermis shows dilated blood vessels and edema.

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Solution to Question 6:

Melanocytes are present in the stratum basale of the epidermis.

They are the neural crest derivatives that migrate to the stratum basale during the embryonic period. One melanocyte accumulates for every five or six basal keratinocytes.

Melanocytes synthesise the pigment, melanin. This is then transferred along the dendritic processes of the melanocyte in vesicles called melanosomes. The tips of these processes are then phagocytosed by the surrounding keratinocytes, which then take up the melanin.

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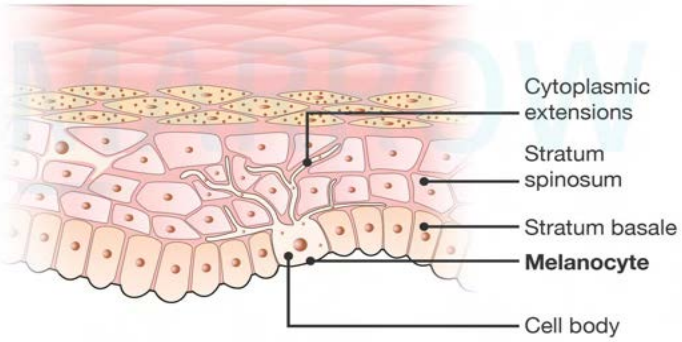
Melanocyte



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The image below shows multiple melanocytes marked with arrows in the stratum basale of the epidermis.

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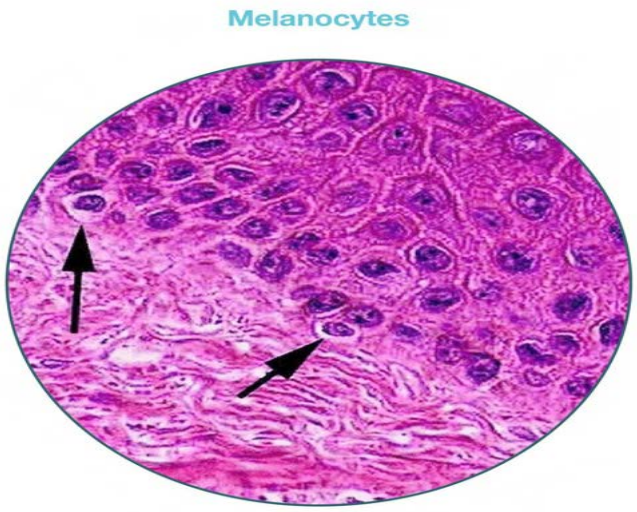

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Solution to Question 7:

Merkel cells act as slow-adapting mechanoreceptors and are sensitive to light touch sensation.

They are present in the stratum basale of the highly sensitive skin like fingertips and bases of the hair follicle. The base of the Merkel cells is connected to the unmyelinated sensory fibres penetrating the basal lamina.

Solution to Question 8:

The structure marked X in the histological image of the dermis is the Pacinian corpuscle which appears as a large (~ 1 mm), onion-like structure in the dermis and hypodermis.

It consists of concentric lamellae of flattened Schwann cells and collagen surrounding an unmyelinated axon. They are very rapidly adapting mechanoreceptors and specialised for sensing coarse touch, pressure (sustained touch) and vibration.

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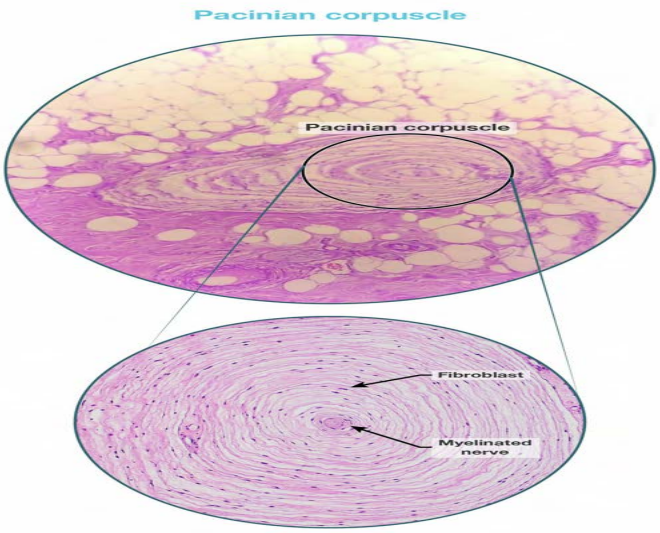

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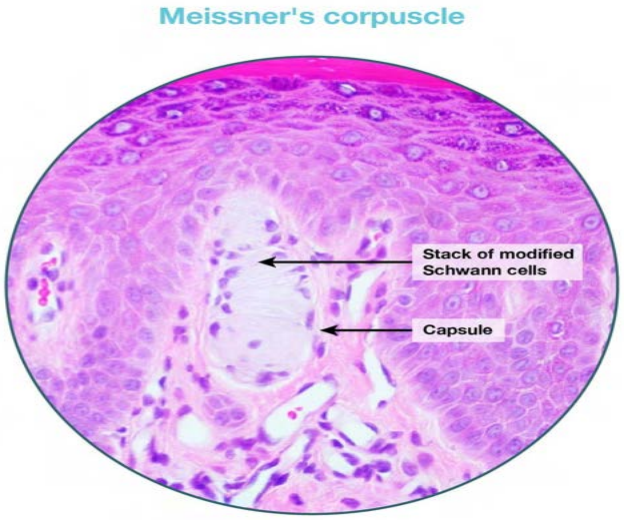
Solution to Question 9:

The structure marked X in the histological image of the skin is the Meissner's corpuscle which is located in the papillary dermis.

Each corpuscle consists of a connective tissue capsule and a central core composed of a stack of flat modified Schwann cells (Coiled spring-like morphology). They are present in the dermal papillae of all parts of hands and foot, anterior aspect of the forearm, lips and mucous membrane of the apical part of the tongue.

They are rapidly acting mechanoreceptors and are specialised for light touch and low-frequency stimuli. They are sensitive to shape and textural changes and provide the neural basis for reading Braille text.

The histological image below shows Meissner's corpuscles in the dermal papillae.



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Solution to Question 10:

Panniculus adiposus is present in the axilla.

Panniculus adiposus refers to a layer/sheet of fat present subcutaneously and is found over most of the body except the scrotum, penis, and eyelids. It is responsible for giving a smooth contour to the skin.

Solution to Question 11:

The structure marked Y in the above image is the outer root sheath.

The hair is made up of the following layers (from within outwards):

• Medulla - consisting of vacuolated and moderately keratinised cells.

• Cortex - Consisting of densely packed and heavily keratinised cells.

• Inner root sheath - This includes cuticle, inner Huxley's layer and outer Henle's layer.

• Outer root sheath - These appear as clear cells as they contain glycogen.

• Glassy membrane

• Connective tissue sheath

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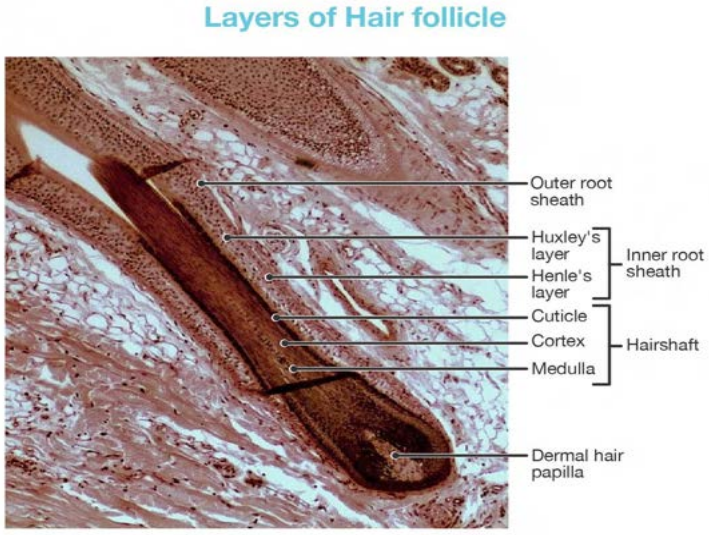

Solution to Question 12:

Arrector pili muscles are smooth muscles.

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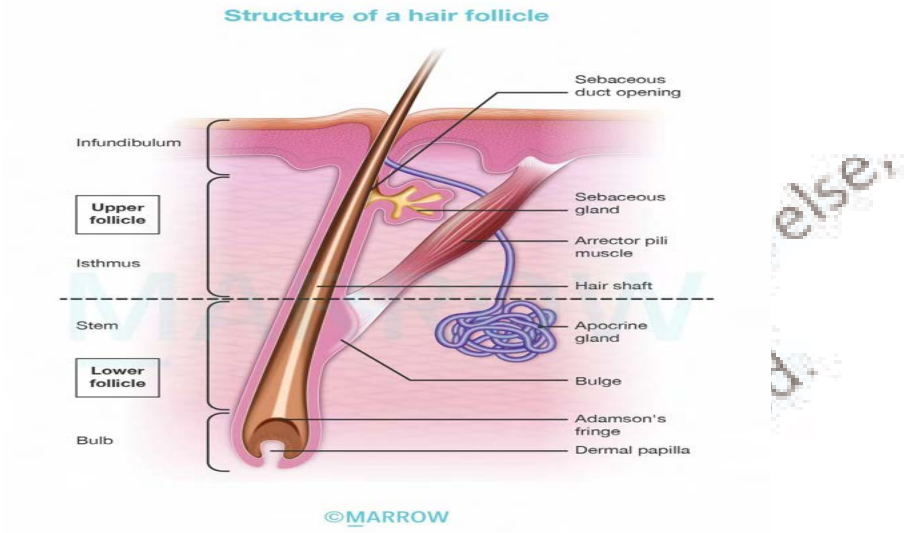
They connect the undersurface of the hair follicles to the papillary dermis and are supplied by sympathetic nerves. Contraction of these muscles leads to the erection of hair, tiny bumps on the skin and thus produces a 'goose flesh' appearance. The other effect of the contraction of arrector pili is the squeezing out of the secretions of the sebaceous glands into the hair follicle. They are absent in facial, axillary and pubic hairs, eyelashes, eyebrows and hairs around the nostrils and external auditory meatus.



Solution to Question 13:

The image shows an apocrine gland. There is shedding of the apical portion of the cell during the secretion.

Types of glands:

Apocrine	Holocrine	Eccrine(Merocrine)
Apical partof cellsheds offdur ing discharge	Whole-cell disintegratesdurin g discharge	Thecell is intactandsecretions are thrown out by exocytosis
Eg:Apocrine sweat glands in axilla and groin, mammary gl ands, the external auditory ca nal (ceruminous glands) and eyelids (glands of Moll)	Eg:Glands of Zeis and Meibo mian glandMontgomery tube rcle: Nipple and areolaTyson' s gland: External fold of the p repuceFordyce' spot: Vermilli on border of lips and mucosa	Eg:Sweat glands on palms an d solesFound everywhere exc ept clitoris, glans penis, labia minora, external auditory ca nal and lips

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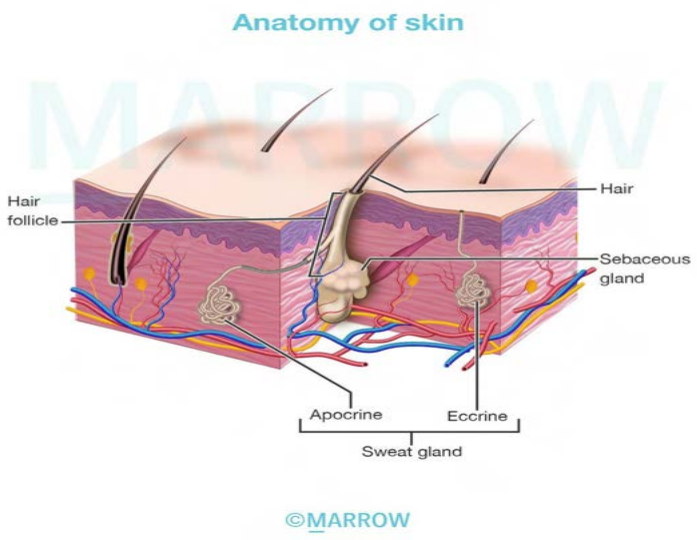
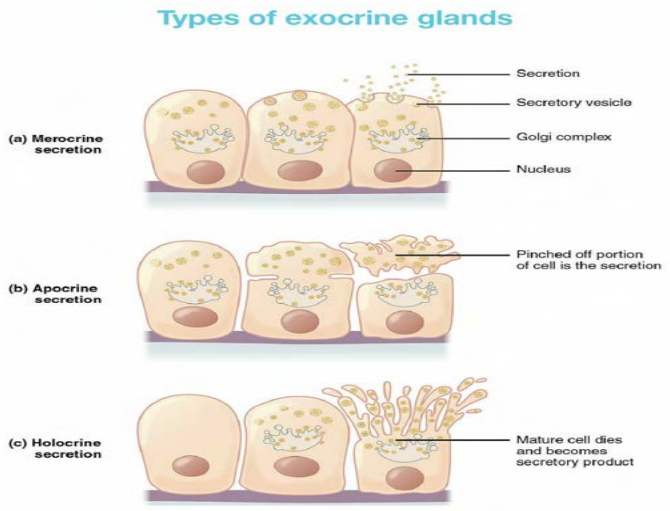


Notice that for the sweat glands, the duct mostly goes to the skin surface v/s Sebaceous gland which mostly opens to the hair follicle.



Solution to Question 14:

The structures marked X and Y are the endothelium and Bowman's membrane, respectively.

The human cornea has five layers. From the anterior to posterior, the layers of the human cornea are as follows:

• Corneal epithelium - It is the outermost layer made up of non-keratinized stratified squamous epithelium. It is continuous with the conjunctival epithelium.

• Bowman's layer - The anterior-limiting lamina lies behind the corneal epithelium. It contains a dense mass of collagen (mainly type I collagen fibrils) set in a matrix similar to that of the

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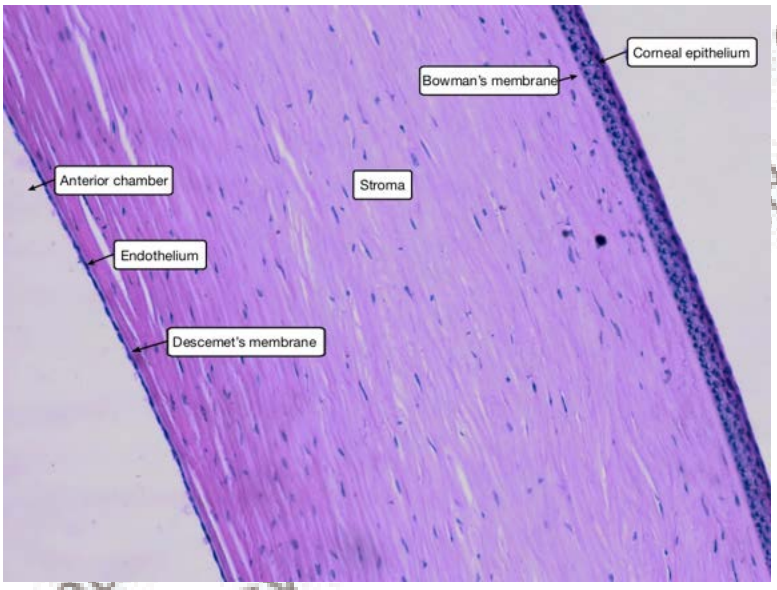
substantia propria.

• Corneal stroma (also substantia propria) - It is a thick, transparent middle layer, consisting of regularly arranged collagen fibers along with sparsely distributed interconnected keratocytes.

• Descemet's membrane - It is a thin acellular layer that serves as the modified basement membrane of the corneal endothelium, from which the cells are derived. This layer is composed mainly of collagen type IV fibrils.

• Corneal endothelium - The endothelium covers the posterior surface of the cornea and consists of a single layer of squamous cells.

The sixth layer called Dua's layer or pre-Descemet's layer has been recently discovered, located between the stroma and the Descemet's membrane.



Solution to Question 15:

From the given options, the correct sequence from outer to inner is:

• retinal pigment epithelium (A),

• external limiting membrane (E),

• inner nuclear layer (D),

• inner plexiform layer (B),

• nerve fiber layer (C)

Solution to Question 16:

The above histological image is that of the cochlea which can be identified by the presence of characteristic organ of Corti.

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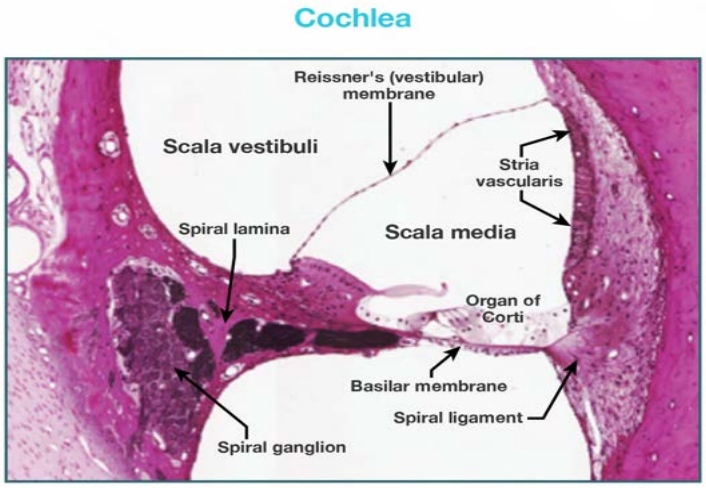
The cochlea consists of a bony canal that makes 2.75 spiral turns around an axis of bone known as the modiolus. A shelf of bone from the modiolus forms a ridge known as the spiral lamina.

The basilar membrane supporting the organ of Corti extends from the spiral lamina to the outer wall of the cochlea. The vestibular membrane runs from the spiral lamina to the outer wall above the basilar membrane. These two membranes divide the bony labyrinth into three cavities:

• Scala vestibule - located between the roof of the labyrinth and the vestibular membrane, is lined by mesenchymal cells and contains perilymph.

• Scala media - located between the vestibular membrane and basilar membrane, contains endolymph.

• Scala tympani - located between the basilar membrane and the floor of the labyrinth, is lined by mesenchymal cells and contains perilymph.



Solution to Question 17:

The gelatinous component of the crista ampullaris that extends from the crista to the roof of the ampullae is known as the cupula.

The ampullary cupula, or cupula, provides a sense of spatial orientation. It is located in each of the ampullae of the three semicircular canals. In the crista ampullaris, hair cells that have several stereocilia associated with each kinocilium, are embedded into the gelatinous matrix of the cupula in a specific pattern that is functionally significant. The lag of endolymph on the rotational movement of the head deflects the cupula and hence stimulates the hair cells.

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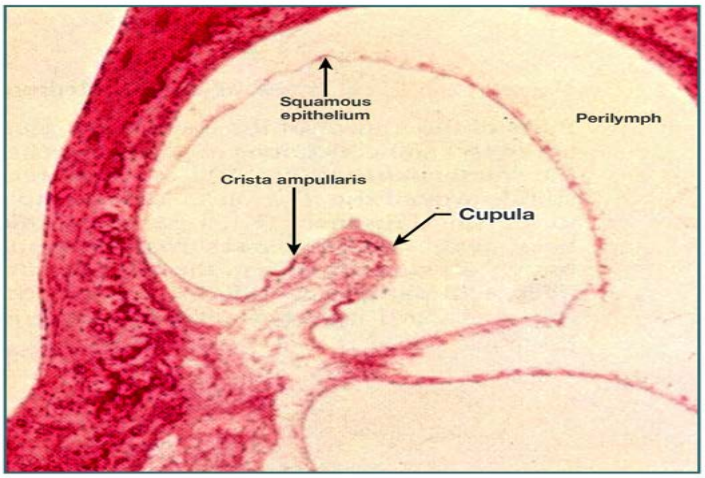
Semicircular canal - ampulla



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Cranial Nerves

Question 1:

Which of the following cranial nerves is a pure sensory nerve?

a) Olfactory

b) Trochlear

c) Trigeminal

d) Glossopharyngeal

Question 2:

Which of the following brainstem nuclei is not derived from the alar plate?

a) Inferior olivary nucleus

b) Hypoglossal nucleus

c) Dentate nucleus

d) Mesencephalic nucleus

Question 3:

The arrangement of the functional columns of cranial nerve nuclei from ventral to dorsal aspect in the brainstem is as follows:

a) Visceral Efferent > Somatic Efferent > Visceral Afferent > Somatic Afferent

b) Somatic Efferent > Visceral Efferent > Visceral Afferent > Somatic Afferent

c) Somatic Afferent > Visceral Afferent > Visceral Efferent > Somatic Efferent

d) Visceral Efferent > Visceral Afferent > Somatic Afferent > Somatic Efferent

Question 4:

Which of the following cranial nerves does not contain neurons from the general somatic efferent column?

a) III nerve

b) IV nerve

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c) VI nerve

d) VII nerve

Question 5:

Which of the following is not included in the special visceral efferent?

a) Motor nucleus of V nerve

b) Motor nucleus of VII nerve

c) Dorsal nucleus of X nerve

d) Nucleus ambiguus

Question 6:

Which of the following nuclei do not belong to the general visceral efferent column?

a) Dorsal nucleus of vagus

b) Edinger-Westphal nucleus

c) Nucleus ambiguus

d) Inferior salivatory nucleus

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Question 7:

Which cranial nerve nuclei are present in both the general somatic efferent and general visceral efferent column?

a) Oculomotor nerve

b) Trochlear nerve

c) Facial nerve

d) Glossopharyngeal nerve

Question 8:

Which of the following cranial nerve nuclei is not a part of the special visceral afferent (SVA) column?

a) Facial nerve

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b) Trochlear nerve

c) Vagus nerve

d) Glossopharyngeal nerve

Question 9:

Which of the following nerves is not involved in olfaction?

a) Trigeminal nerve

b) Vagus nerve

c) Glossopharyngeal nerve

d) Hypoglossal nerve

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Question 10:

A 72-year-old patient who suffered a stroke is unable to swallow food. On examination, the gag reflex is absent. The motor nucleus of the vagus nerve involved here emerges from _____ of the brainstem.

a) Postero-lateral sulcus

b) Anterolateral sulcus

c) Body of pons

d) At the ponto-medullary junction

Question 11:

A 69-year-old male presented with diplopia. Investigations revealed an aneurysm of the right anterior inferior cerebellar artery that is directly impinging on the nerve arising at the pontomedullary junction. Which of the following extraocular muscles is likely to be paralyzed?

a) Superior oblique

b) Inferior oblique

c) Medial rectus

d) Lateral rectus

Question 12:

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A 34-year-old presents to the casualty with a history of blunt force trauma to the head. A small lesion was found on the dorsal aspect of the brainstem on imaging. Which of the following nerves could be injured at the site?

a) Hypoglossal nerve

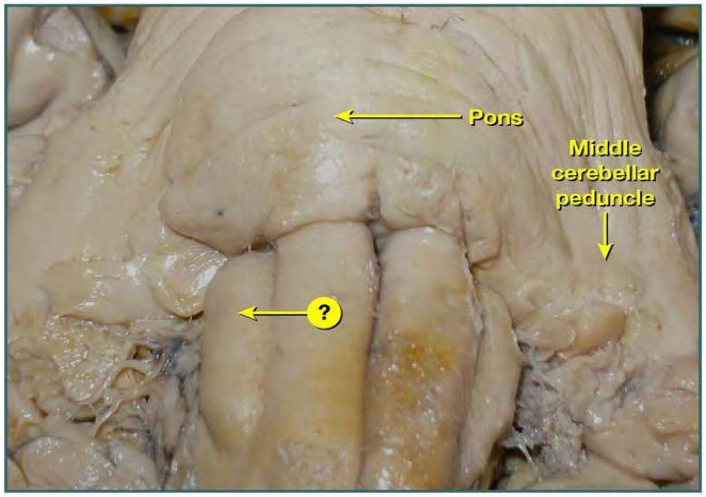
b) Trigeminal nerve

c) Trochlear nerve

d) Facial nerve

Question 13:

Which of the following nerves exits anterior to the marked structure?



a) Glossopharyngeal

b) Vagus

c) Acessory nerve

d) Hypoglossal nerve

Question 14:

Which is the thickest cranial nerve?

a) Trigeminal

b) Facial

c) Trochlear

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d) Vagus

Question 15:

Which of the following cranial nerves does not carry parasympathetic fibers?

a) Trochlear

b) Facial

c) Oculomotor

d) Glossopharyngeal

Question 16:

Which of the following sensations is not perceived by the spinal nucleus of the trigeminal nerve?

a) Temperature

b) Pain

c) Touch

d) Proprioception

Question 17:

A patient with trigeminal neuralgia presents with a flare-up of the condition. The nucleus receiving the sensory afferent extends from the chief sensory nucleus in the pons up to the _____.

a) Lower end of medulla

b) 2nd cervical spinal segment

c) 5th cervical spinal segment

d) Upper end of medulla

Question 18:

Which of the following statements regarding the nerve involved in the palsy shown below is false?

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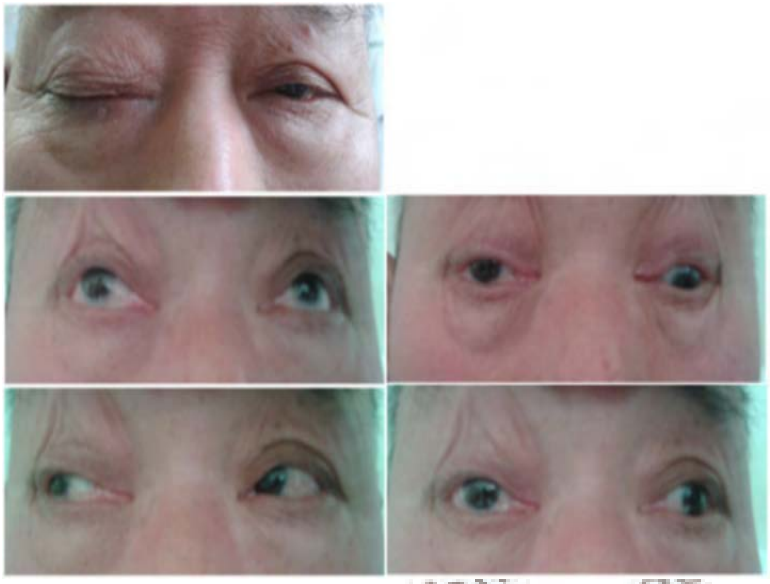

a) It divides into upper and lower divisions in the anterior part of the cavernous sinus.

b) Its divisions enter the orbit through the middle part of the superior orbital fissure.

c) It lies between the posterior cerebral and superior cerebellar arteries in the interpeduncular fossa.

d) The nerve to inferior rectus carries parasympathetic fibers to the ciliary ganglion.

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Question 19:

A 36-year-old male was brought to the emergency department after suffering a head injury in a road traffic accident. CT revealed a skull base fracture. The fracture line extended along the apex of the petrous bone involving the Dorello's canal. Which of the following cranial nerves is susceptible to injury?

a) Vestibulocochlear nerve

b) Abducens nerve

c) Glossopharyngeal nerve

d) Trochlear nerve

Question 20:

Which of the following is not used for the identification of the facial nerve trunk?

a) Retrograde dissection from distal branch

b) Tragal pointer

c) Inferior belly of omohyoid muscle

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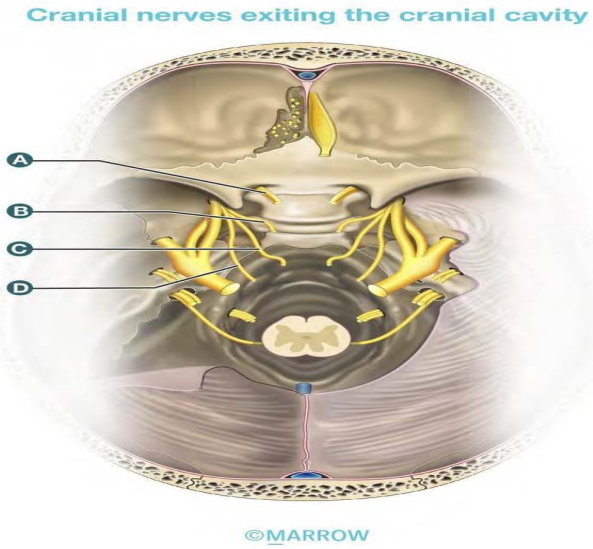
d) Posterior belly of digastric

Question 21:

All of the following nerves are involved in the movement of the eyeball except:



a) A

b) B

c) C

d) D

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Answer Key

Question No.	Correct Option
1	a
2	b
3	b
4	d
5	c
6	c
7	a
8	b

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9	d
10	a
11	d
12	c
13	d
14	a
15	a
16	d
17	b
18	d
19	b
20	c
21	a

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Detailed Explanations

Solution to Question 1:

The olfactory nerve is a pure sensory nerve. It carries no motor fibers.

Mnemonic: Some Say Money Matters But My Brother Says Big Brains Matter More.

S - Purely sensory

M - Purely motor

B - Both sensory and motor

The placement of the words in the mnemonic corresponds to the cranial nerve number i.e; "Some" corresponds to the 1st cranial nerve (olfactory), "Say" corresponds to the 2nd cranial nerve (optic), and so on.

Pure sensory	Pure motor	Mixed-sensory and mo tor
Olfactory (1)	Oculomotor (3)	Trigeminal (5)
Optic (2)	Trochlear (4)	Facial (7)
Vestibulocochlear (8)	Abducent (6)	Glossopharyngeal (9)
	Spinal Accessory (11)	Vagus (10)
	Hypoglossal (12)	

Solution to Question 2:

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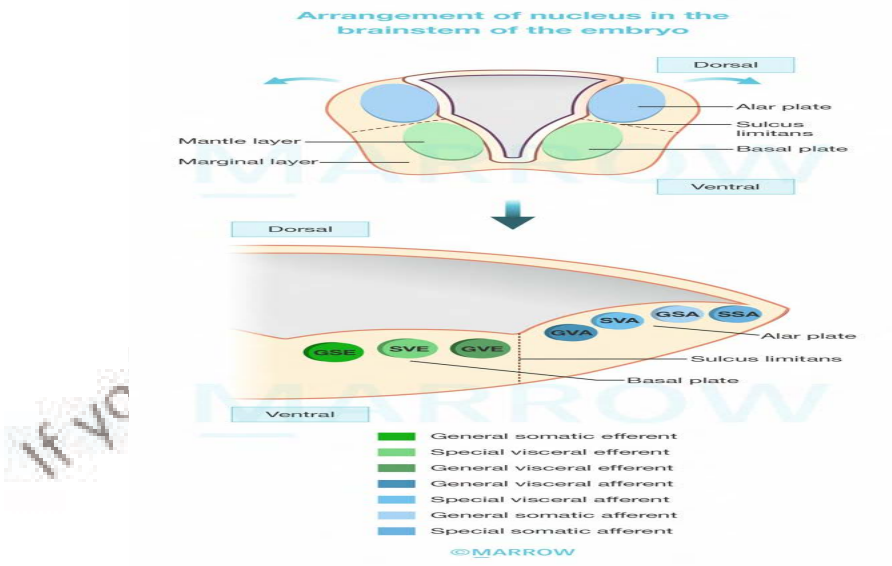
The hypoglossal nucleus is not derived from the alar plate. The hypoglossal nucleus is a motor nucleus derived from the basal plate.

Embryologically, the continuous addition of neuroblasts to the mantle layer of the neural tube produces thickenings ventrally and dorsally - producing the basal and alar plates respectively. A longitudinal groove, called sulcus limitans, marks the boundary between the two.

Basal Plate	Alar plate
Ventralthickening	Dorsalthickenings
Give rise tomotor nuclei-general visceral efferent nuclei, special visceral efferent of CN IX, X, and XII; and somatic efferent of XII	Give rise tosensory nucleiCN V, VII, VIII, IX, X, inferior olivary nucleus, and mesencephalic nucleus of CN V
Forms the motor part of the spinal cord (ventral horns)	Forms the sensory part of the spinal cord (dorsal horns).The rhombic lip develops into the cerebellum and its nuclei.



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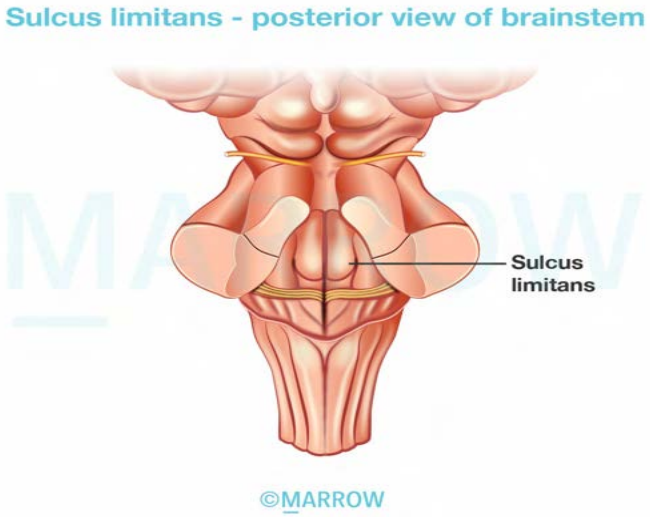

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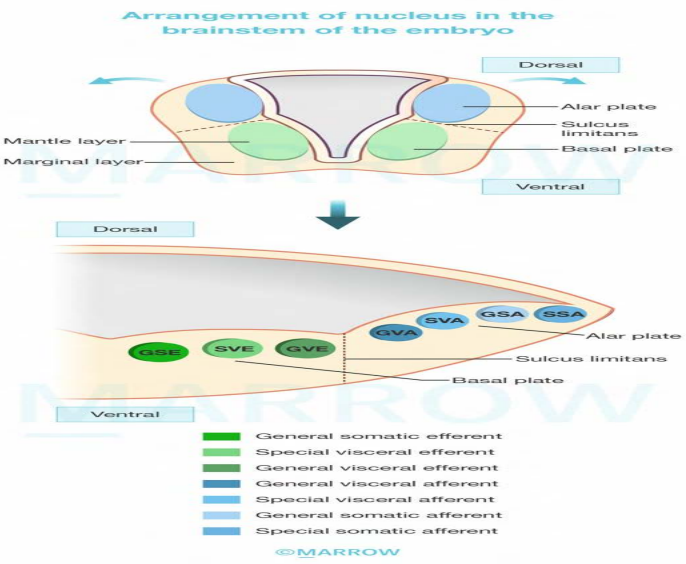
Solution to Question 3:

The pattern of the arrangement of cranial nerve nuclei from the ventral to dorsal aspect is:

Somatic Efferent > Visceral Efferent > Visceral Afferent > Somatic Afferent

The basal and alar cranial nerve nuclei of the brainstem are organized into 7 columns. The sequence of the columns from ventral to dorsal is shown in the image below - 3 motor columns in the ventral basal plate (green) and 4 sensory columns in the dorsal alar plate (blue). The visceral nuclei are closer to the sulcus limitans than the somatic nuclei.



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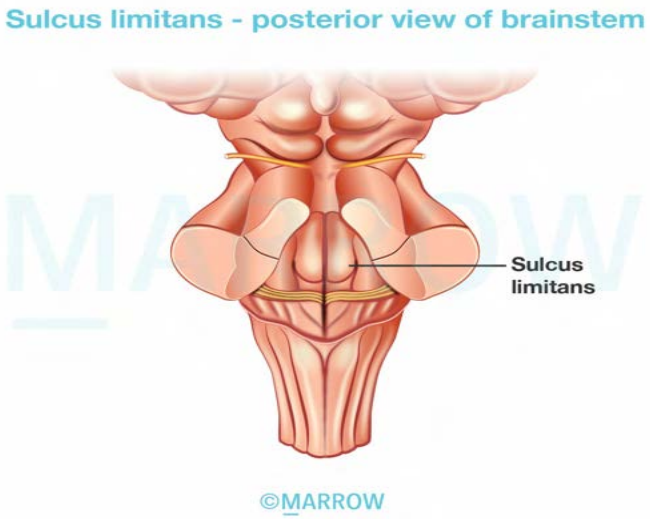

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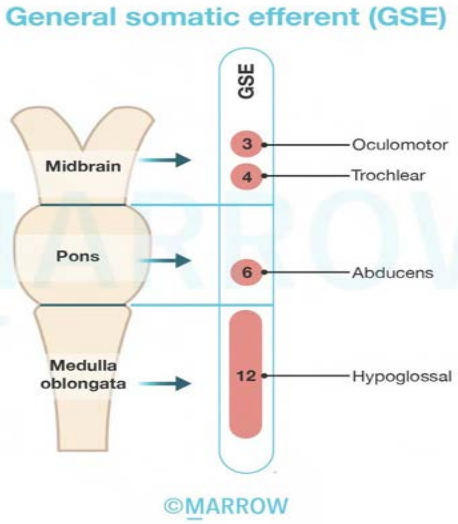
Solution to Question 4:

The VII nerve (facial) does not contain neurons from the somatic efferent column.

The general somatic efferent (GSE) is the most ventral column in the basal plate. It is represented by the oculomotor (III), trochlear (IV), abducens (VI), and hypoglossal (XII) nuclei.



The facial (VII) nerve contains neurons from:

• Special visceral efferent (SVE) column - supplies facial muscles derived from the second pharyngeal arch.

• General visceral efferent (GVE) column - from the superior salivatory nucleus, is parasympathetic to the lacrimal gland, submandibular and sublingual salivary glands.

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Solution to Question 5:

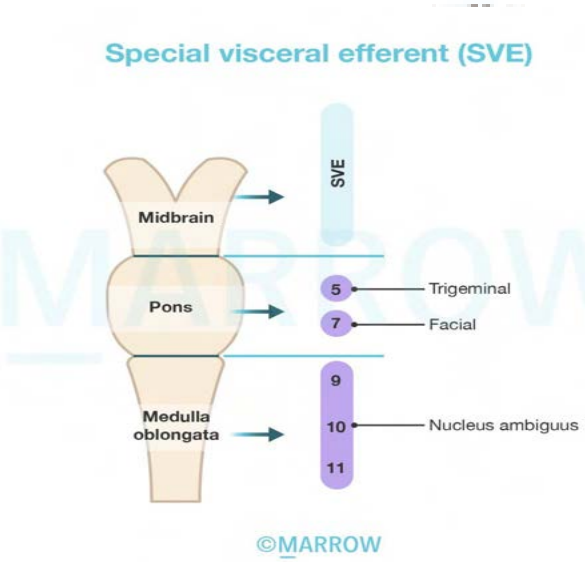
The special visceral efferent column does not include the dorsal nucleus of the vagus.

The special visceral efferent column contains neurons innervating muscles developed from the pharyngeal arches:

• Motor nucleus of V nerve - muscles of mastication

• Motor nucleus of VII nerve - muscles of facial expression

• Nucleus ambiguus (IX, X, XI) - stylopharyngeus, pharyngeal, external laryngeal, oesophageal striated muscles, muscles of the soft palate, sternocleidomastoid, and trapezius.



The dorsal nucleus of vagus contains neurons from the general visceral efferent column and it sends parasympathetic fibers to the glands and smooth muscles in the pharynx, larynx, thoracic and abdominal viscera.

Solution to Question 6:

Nucleus ambiguus does not belong to the general visceral efferent (GVE) column.

The general visceral efferent columns contain nuclei of parasympathetic cranial nerves:

• III - Edinger-Westphal nucleus

• VII - Superior salivatory nucleus

• IX - Inferior salivatory nucleus

• X - Dorsal motor nucleus of vagus.

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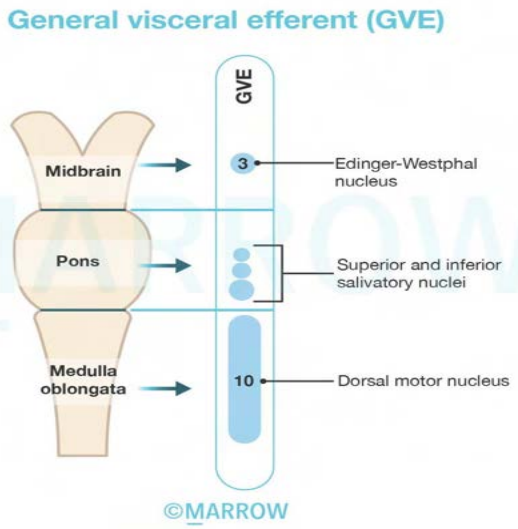

Nucleus ambiguus belongs to the special visceral efferent (SVE) column.

The special visceral efferent column contains neurons innervating muscles developed from the pharyngeal arches:

• Motor nucleus of V nerve- muscles of mastication

• Motor nucleus of VII nerve- muscles of facial expression

• Nucleus ambiguus (IX, X, XI)- stylopharyngeus, pharyngeal, external laryngeal, oesophageal striated muscles, muscles of the soft palate, sternocleidomastoid, and trapezius.

Solution to Question 7:

Oculomotor nerve nuclei are present in both general somatic efferent (GSE) and general visceral efferent (GVE) columns in the brainstem.

Solution to Question 8:

The trochlear nerve nucleus is a part of the general somatic efferent (GSE) column, not the special visceral afferent column.

The trochlear nerve is a motor nerve that innervates superior oblique muscle in the orbit.

The neurons of the general somatic efferent (GSE) column innervate the extrinsic ocular muscles and muscles of the tongue (III, IV, VI, and XII cranial nerves).

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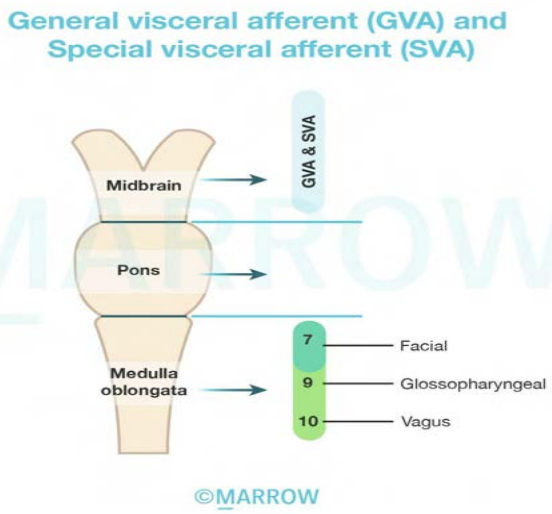

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Solution to Question 9:

The hypoglossal nerve is purely motor cranial nerve and is not involved in olfaction.

The other three cranial nerves—trigeminal, glossopharyngeal, and vagus nerves are mixed cranial nerves and contribute to olfaction.

Vagal nerve stimulation modifies the electrical activity of the olfactory bulb.

Solution to Question 10:

The fibers from the nucleus ambiguus emerge through the postero-lateral sulcus of the brainstem.

Nucleus ambiguus is made of cranial nerves IX, X, and XI.

The following table describes the components of the vagal nerve and the associated nuclei.

Component	Associated Nucleus	Innervated Structures
Parasympathetic	Dorsal vagal nucleus	Autonomic ganglia of thorax and abdomen
Motor	Nucleus ambiguus	Pharynx, larynx, palate
Viscero-sensory	Nucleus tractus solitarius	Pharynx, larynx, esophagus, thoracic and abdominal viscera
Chemosensory	Nucleus tractus solitarius	Taste buds on epiglottis
Somatosensory	Spinal nucleus of trigeminal	Outer ear canal, pinna, dura

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Solution to Question 11:

The lateral rectus muscle is likely to be paralyzed as it is innervated by the VI cranial nerve, which emerges from the pontomedullary junction (PMJ).

Cranial nerves VI, VII, and VIII arise at the PMJ.

Extraocular muscles are innervated by the III, IV, and VI cranial nerves. The superior oblique is innervated by CN IV, the lateral rectus by CN VI, and all the other muscles by CN III.

Solution to Question 12:

The trochlear nerve is the only nerve that exits the brainstem on the dorsal surface and thus can be injured in this patient.

All other cranial nerves exit the brainstem from the ventral surface.

Solution to Question 13:

The structure marked is the olive. The hypoglossal nerve emerges anterior to the olive, from the groove between the pyramid and the olive—anterolateral sulcus.

The olivary bodies are rounded, oval prominences on the surface of the medulla oblongata in the brain. Nerve fibers in the olivopontocerebellar pathway connect the olives to the pons and cerebellum.

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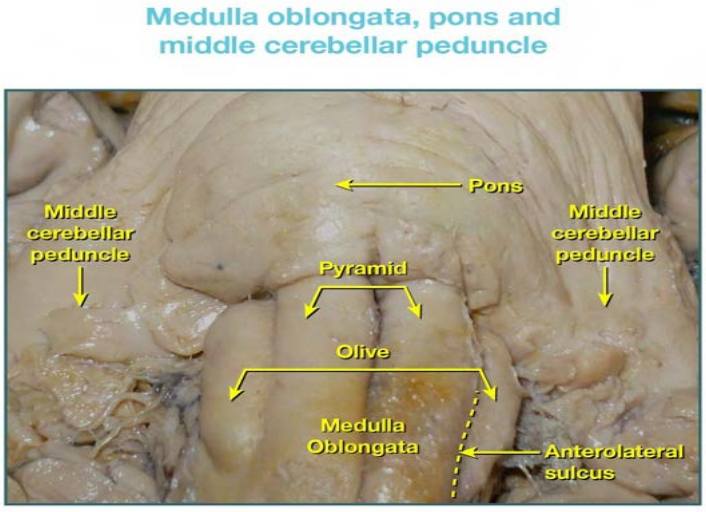

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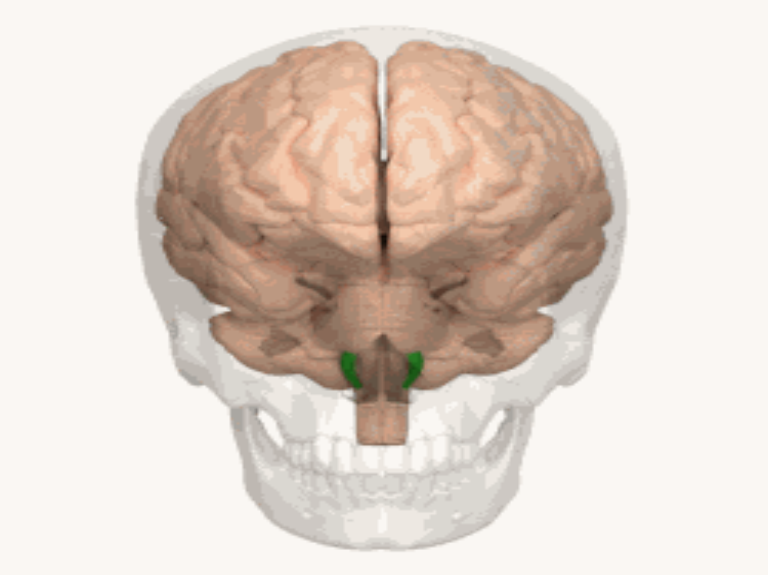

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Solution to Question 14:

The trigeminal nerve is the thickest cranial nerve.

The trochlear nerve is the most slender cranial nerve.

Solution to Question 15:

The trochlear nerve does not carry parasympathetic fibers.

The cranial nerves carrying parasympathetic fibers are listed below:

Cranial nerve	Associated Ganglion
Oculomotor(III)	Ciliary ganglion
Facial(VII)	Pterygopalatine and subman dibular ganglion
Glossopharyngeal(IX)	Otic ganglion
Vagus(X)	Visceral ganglions

Solution to Question 16:

Proprioception is perceived by the mesencephalic nucleus of the trigeminal nerve, not the spinal nucleus.

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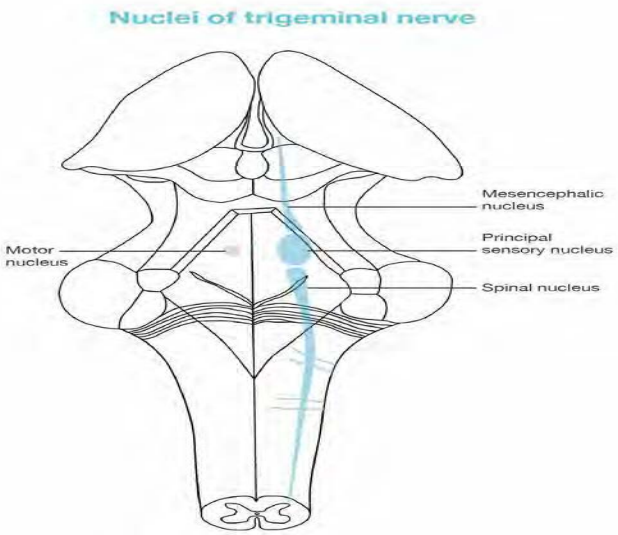
The trigeminal nerve consists of 4 nuclei: 3 sensory (Mesencephalic, spinal, and principal sensory nucleus) and 1 motor.

Nucleus	Location	Function
Mesencephalic Nucleus	Composed of a column ofuni polar nervecells situated in th e midbrain and extends inferi orly into the pons as far as th e main sensory nucleus	Receives the sensation ofpro prioceptionfrom the muscles of mastication and from the f acial and extraocular muscles
Principal sensory nucleu s	Posterior part of the pons lat eral to the motor nucleus	Receives the sensations oftou ch and pressurefrom the face
Spinal nucleus	Continuous superiorly with t he main sensory nucleus and extends inferiorly the whole of the medulla oblongatatill t he 2ndCervical Segment	Receives the sensation ofpain and temperaturefrom the fac e and some fibers oftouch
Motor nucleus	The pons medial to the main sensory nucleus	Supplies the muscles of masti cation, the tensor tympani, t he tensor veli palitini and the mylohyoid and the anterior belly of digastric muscle



Solution to Question 17:

Excruciating pain is the principal symptom of trigeminal neuralgia. The afferent fibers carrying pain and temperature from the face relay in the spinal nucleus of the trigeminal nerve. It extends from the chief sensory nucleus in the upper part of the pons through the medulla and into the upper 2 segments of the spinal cord.

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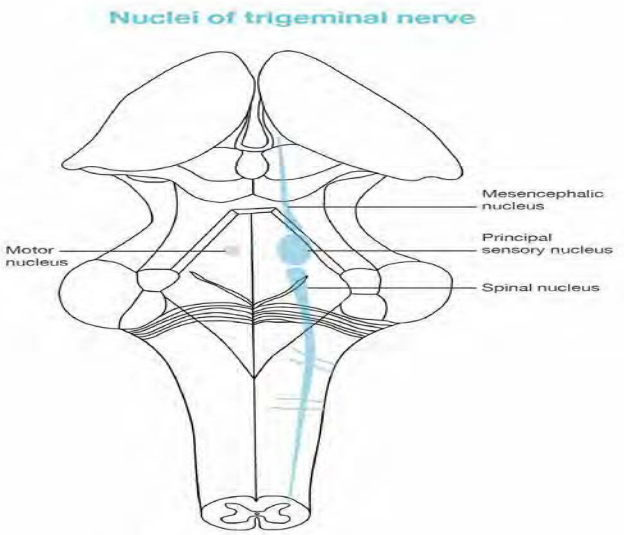
The trigeminal nerve consists of 4 nuclei: 3 sensory (mesencephalic, spinal, and principal sensory nucleus) and 1 motor.

Nucleus	Location	Function
Mesencephalic nucleus	Composed of a column ofuni polar nervecells situated in th e midbrain and extends inferi orly into the pons as far as th e main sensory nucleus	Receives the sensation ofpro prioceptionfrom the muscles of mastication and from the f acial and extraocular muscles
Principal sensory nucleu s	Posterior part of the pons lat eral to the motor nucleus	Receives the sensations oftou ch and pressurefrom the face
Spinal nucleus	Continuous superiorly with t he main sensory nucleus and extends inferiorly the whole of the medulla oblongatatill t he 2ndcervical segment	Receives the sensation ofpain and temperaturefrom the fac e and some fibers oftouch
Motor nucleus	The pons medial to the main sensory nucleus	Supplies the muscles of masti cation, tensor tympani, tenso r veli palitini, mylohyoid, and anterior belly of digastric m uscle



Solution to Question 18:

The image shows oculomotor nerve palsy. The nerve to inferior oblique carries parasympathetic fibers to the ciliary ganglion, not the nerve to inferior rectus.

Course of the oculomotor nerve:

• The nerve lies on the anterior surface of the midbrain in between the posterior cerebral artery and the superior cerebellar artery in the interpeduncular fossa.

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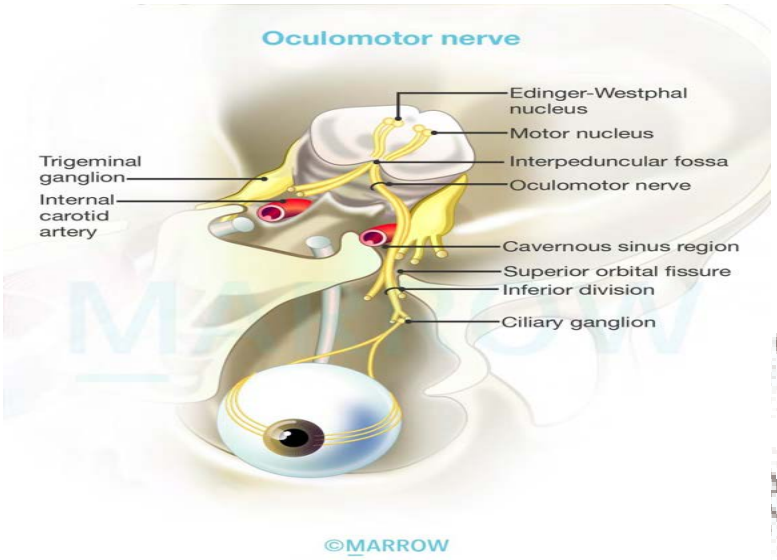
• It then passes to the middle cranial fossa along the lateral dural wall of the cavernous sinus and divides into superior and inferior in its anterior part.

• It enters the superior orbital fissure through the common tendinous ring.



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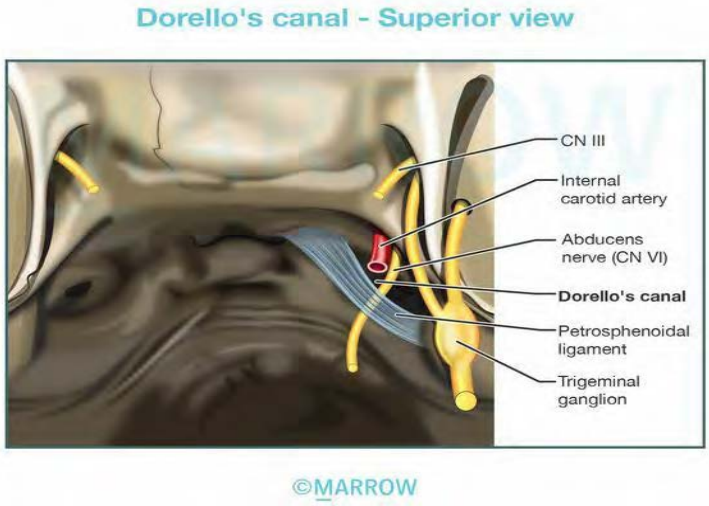
Solution to Question 19:

The abducens nerve forms the content of Dorello's canal and hence is susceptible to injury in this case.

Dorello's canal is located at the petrous apex of the temporal bone and is formed by the petrosphenoidal/petroclinoid/Gruber's ligament.



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Solution to Question 20:

The inferior belly of the omohyoid muscle is not used as an anatomical landmark for the identification of the facial nerve trunk.

There are two methods for localization of the facial nerve trunk:

1. Anterograde method: The facial nerve trunk is identified based on the anatomical landmarks after it exits from the stylomastoid foramen. This includes:

• Tragal pointer/Conley's pointer - It is the inferior portion of the cartilaginous canal. The facial nerve trunk lies 1 cm deep and inferior to its tip.

• Posterior belly of digastric - The facial nerve lies superior to the upper border of the muscle.

• Squamotympanic fissure - It is a fissure in the temporal bone, which runs from TMJ to the tympanic cavity. The facial nerve runs through this fissure.

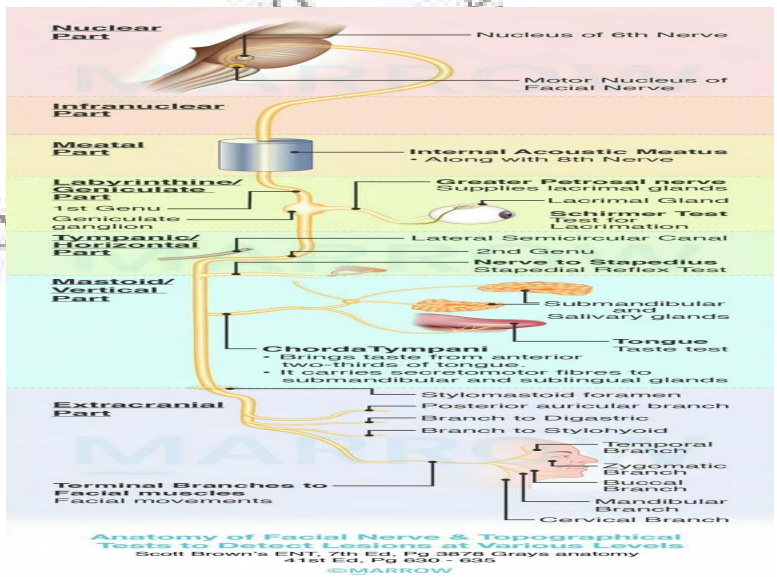
• Styloid process - The facial nerve lies superficial to it.

• Mastoid process - Upon drilling it, the nerve is identified proximally.

2. Retrograde method: The main branches of the facial nerve trunk are identified and are then traced proximally until the main tunk is identified. Some branches used for tracing the facial nerve trunk include:

• Buccal branch - It lies in relation to the parotid gland.

• Marginal mandibular branch - It lies in relation to the facial vessels.



Solution to Question 21:

The nerve marked as 'A' is the optic nerve (II CN), and is not involved in the movement of the eyeball.

The nerves marked in the image are:

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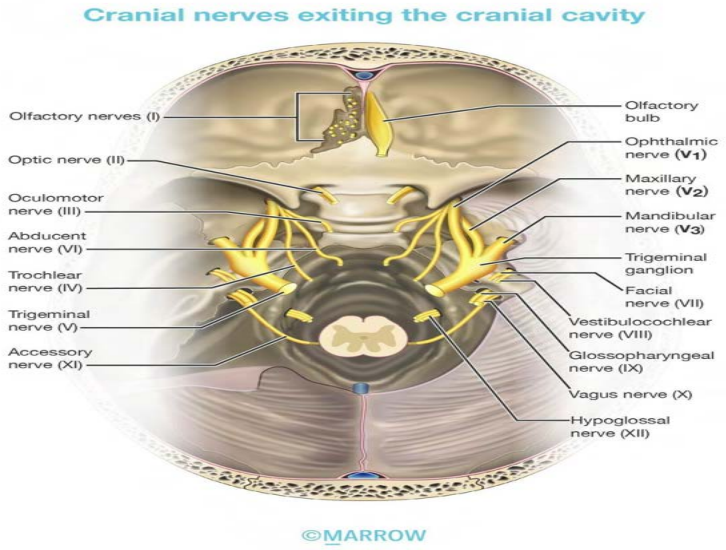
• Optic nerve (II CN)

• Oculomotor nerve (III CN)

• Abducens nerve (VI CN)

• Trochlear nerve (IV CN)



Extraocular muscles involved in the movement of the eyeball:

• Superior rectus, inferior rectus, medial rectus, inferior oblique, and levator palpebrae superioris muscles - supplied by the oculomotor (III) nerve.

• Lateral rectus - supplied by abducens (VI) nerve.

• Superior oblique - supplied by trochlear (IV) nerve.

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Meninges and dural venous sinuses

Question 1:

A 52-year-old woman on treatment for breast cancer presented with headaches and vomiting. CSF cytology showed malignant cells. MRI revealed leptomeningeal enhancement suggestive■ of metastases. Which of the following meningeal layers are affected?

a) Dura mater, arachnoid mater, and piamater

b) Arachnoid mater and piamater

c) Dura mater and arachnoid mater

d) Dura mater and piamater

Question 2:

Which of the following statements about meninges is false?

a) Endosteal layer of the dura mater is the periosteum of skull bones

b) Meningeal layer divides the cranial cavity into freely communicating spaces

c) Dural venous sinuses are present between the endosteal and the meningeal layer

d) Both endosteal and meningeal layer contain fibroblasts and osteoblasts

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Question 3:

A 42-year-old lady presented with sudden onset severe headache, aphasia, and diplopia. Imaging shows an empty delta sign of superior sagittal sinus thrombosis. Choose the correct statement about the dural fold containing the affected sinus.

a) It separates the cerebellum from the occipital lobes of the cerebrum.

b) It contains the occipital sinus.

c) It contains the straight sinus.

d) It separates the two cerebellar hemispheres.

Question 4:

Which of the following nerves do not innervate the marked structure?

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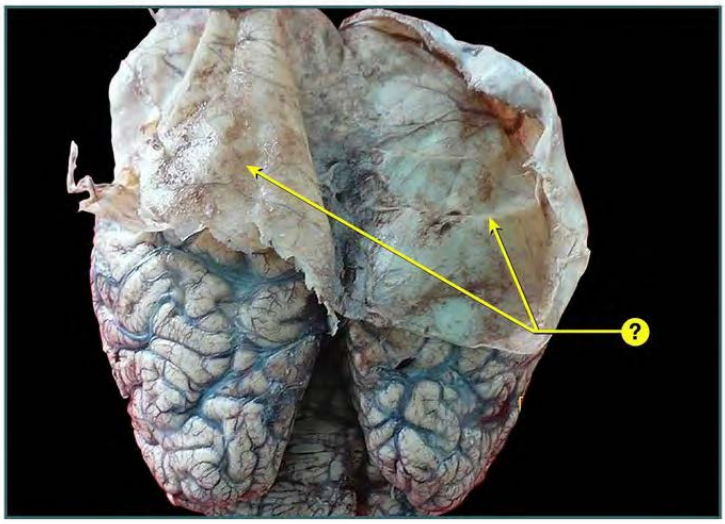

a) Trigeminal nerve branches

b) C2, C3 spinal neves

c) Cervical sympathetic trunk

d) Facial nerve branches

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Question 5:

Which part of the dura mater is supplied by all the three branches of the trigeminal nerve?

a) Dura of the anterior cranial fossa

b) Dura of the the middle cranial fossa

c) Dura of the posterior cranial fossa

d) Dura around the foramen magnum

Question 6:

What is the nerve supply of the dura covering the marked region?

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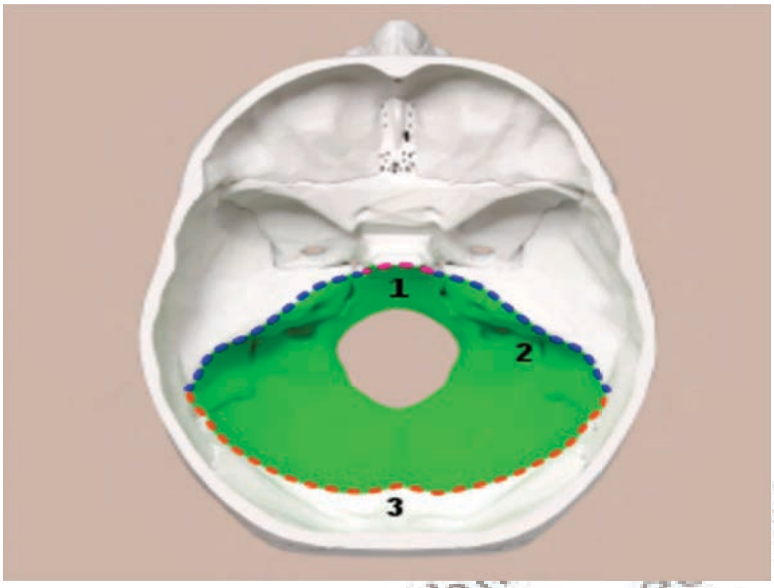

a) C2-C3 via cranial nerves X and XII

b) Anterior and posterior ethmoidal nerves

c) Nervi meningeus medius and spinosus

d) Cranial nerves VII and IX only

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Question 7:

Which of the following arteries does not supply the corresponding region of the dura mater?

a) Middle meningeal artery – Anterior cranial fossa

b) Accessory meningeal branch of maxillary artery – Middle cranial fossa

c) Meningeal branch of internal carotid artery – Posterior cranial fossa

d) Meningeal branch of anterior and posterior ethmoid artery – Anterior cranial fossa

Question 8:

What is Meckel's cave formed by?

a) Evagination of the falx cerebelli

b) Evagination of the lower layer of the falx cerebri

c) Evagination of the diaphragma sellae

d) Evagination of lower layer of the tentorium cerebelli

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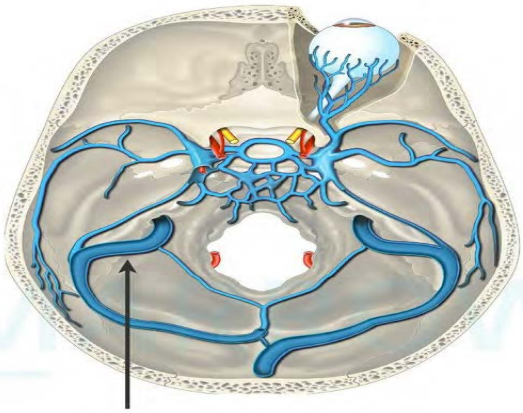
Question 9:

A patient with chronic otitis media and mastoiditis develops thrombosis of the sinus marked below. Which of the following sinuses does it drain from?



a) Sigmoid sinus

b) Transverse sinus

c) Inferior petrosal sinus

d) Straight sinus

Question 10:

A 54-year-old male came to the hospital with a ■severe headache. CT scan revealed an aneurysm of the internal carotid artery within the cavernous sinus. Which of the following nerves is likely to be affected first?

a) Trochlear nerve

b) Abducens nerve

c) Ophthalmic division of the trigeminal nerve

d) Maxillary division of the trigeminal nerve

Question 11:

A diabetic lady with a history of chronic sinusitis presents with seizures and altered mental status. On examination, she is febrile and you note a left-sided lateral rectus palsy. On

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fundoscopy, papilledema is present bilaterally. Which of the following is not a tributary of sinus involved here?

a) Sphenoparietal sinus

b) Deep middle cerebral vein

c) Middle meningeal sinus

d) Inferior ophthalmic vein

Answer Key

Question No.	Correct Option
1	b
2	d
3	c
4	d
5	a
6	a
7	c
8	d
9	b
10	b
11	b

Detailed Explanations

Solution to Question 1:

Leptomeninges refer to the arachnoid mater and pia mater.

Terminologies for meninges:

• Outer Pachymeninx - Dura mater

• Inner Leptomeninges - Arachnoid + Pia mater (L-AP)

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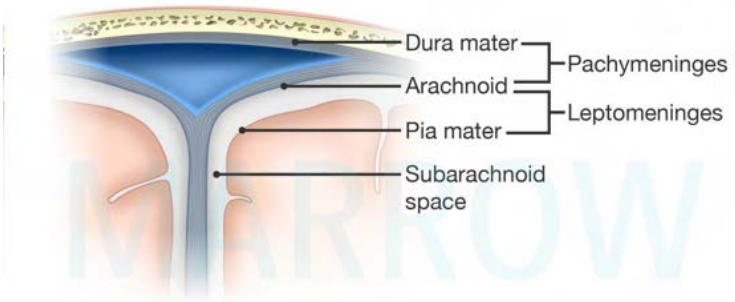
Layers of meninges



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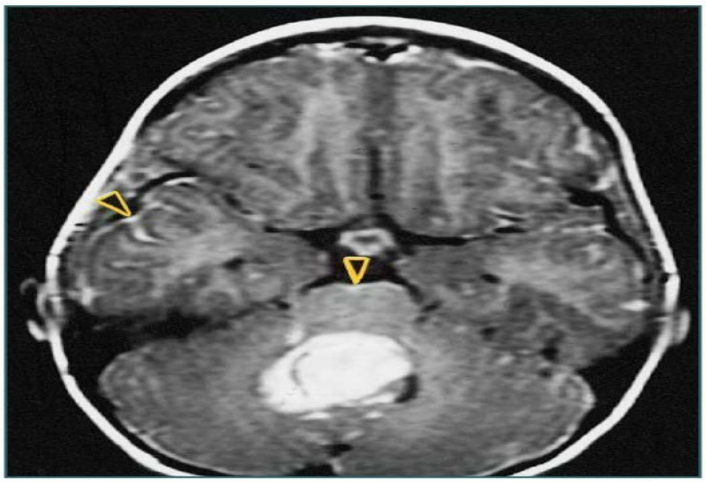
Radiological importance: Pachymeningeal and leptomeningeal enhancement may be diffuse or focal and can aid in the diagnosis of some conditions.

Conditions that may show meningeal enhancement:

- Meningitis
- Encephalitis
- Tumors
- Metastasis
- Inflammatory vasculitides
- Post-ictal
- Post-traumatic and post-operative scarring

The MRI of medulloblastoma below shows leptomeningeal enhancement (arrows).

Medulloblastoma



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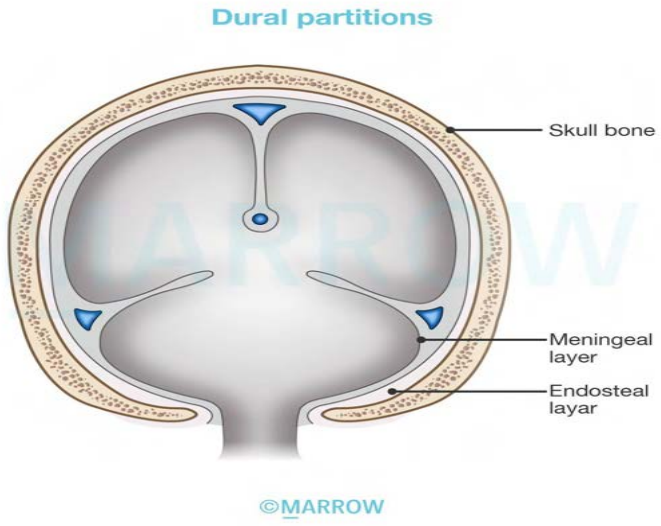
Solution to Question 2:

Both the endosteal and meningeal layers contain fibroblasts, but only the endosteal layer contains osteoblasts.

The dura mater is made of the following 2 layers:

The dural venous sinuses are present between the meningeal and the endosteal layer of the dura mater.

Endosteal layer	Meningeal layer
Periosteum of the skull bones	Dura mater proper
Contains fibroblasts and oste oblasts	Contains only fibroblasts (no osteoblasts)
Not continuous with the spin al dura mater	Continuous with the spinal d ura mater
	It forms 4 septa that divide t he cranial cavity into spaces r estricting the displacement of the brain



The four septa that divide the cranial cavity into freely communicating spaces are:

- Falx cerebri
- Tentorium cerebelli
- Falx cerebelli
- Diaphragma sellae

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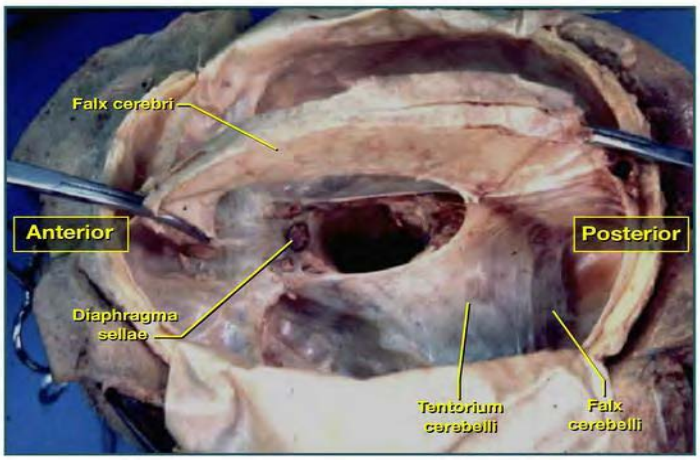
Dural folds



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Solution to Question 3:

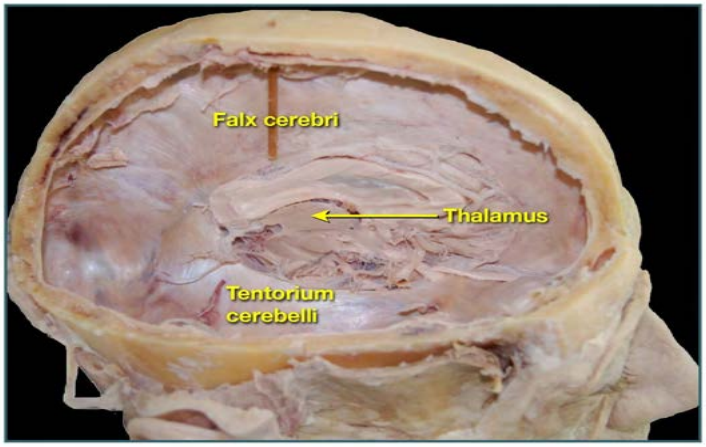
The superior sagittal sinus is present in the falx cerebri. Falx cerebri is a sickle-shaped dura mater fold that seperates the two cerebral hemispheres. The superior sagittal sinus runs along its upper fixed margin, the inferior sagittal sinus runs along its lower free margin, and the straight sinus runs along its attachment to the tentorium cerebelli.

Option A: Tentorium cerebelli separates the cerebellum from the occipital lobes of the cerebrum.

Options B and D: Falx cerebelli separates the cerebellar hemispheres and contains the occipital sinus.

The image below shows the falx cerebri and tentorium cerebelli.

Falx cerebri and tentorium cerebelli



The image below shows the dural folds.

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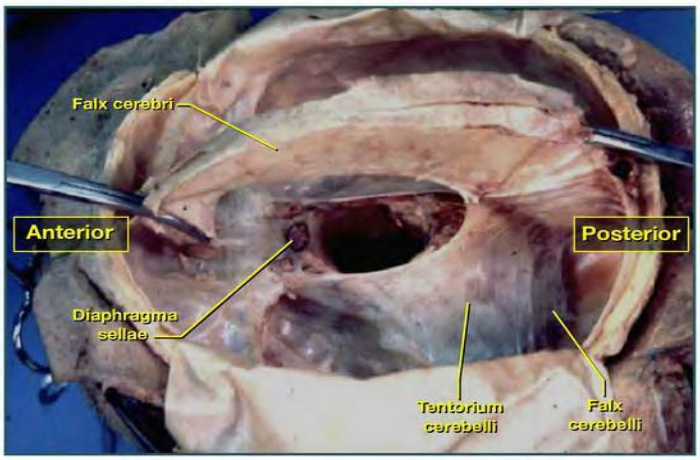
Dural folds



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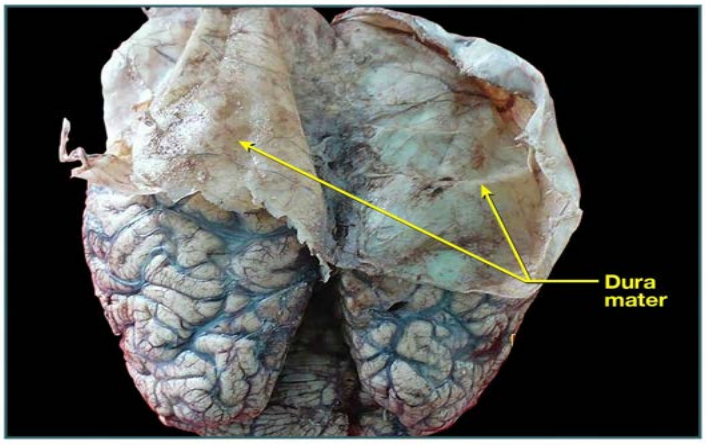
Solution to Question 4:

The marked structure is the cranial dura mater and this structure is not innervated by facial nerve branches.

The innervation of the cranial dura mater is derived mainly from:

- The three divisions of the trigeminal nerve
- C2 and C3 spinal nerves
- Cervical sympathetic trunk.

Dura mater



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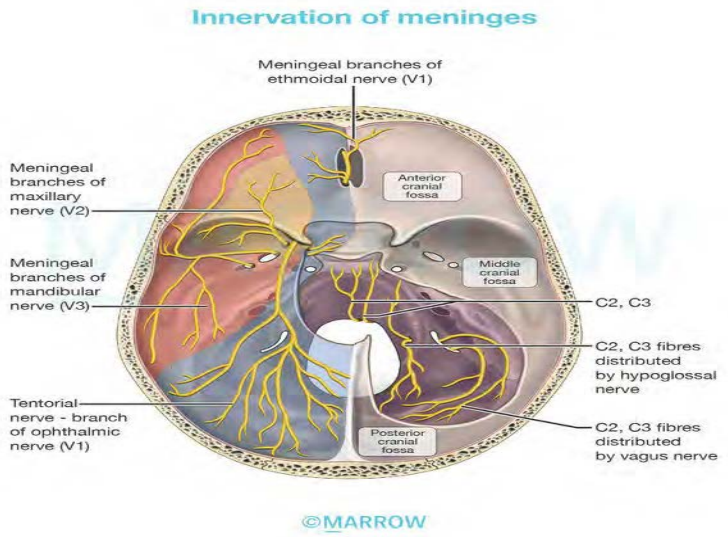
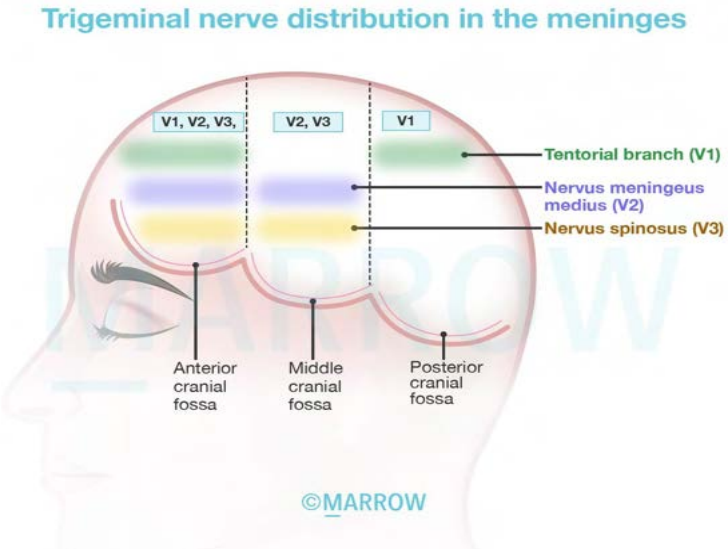


Solution to Question 5:

The dura of the anterior cranial fossa is supplied by all three branches of the trigeminal nerve.

The nerves involved are:

- Ophthalmic division - anterior and posterior ethmoidal nerves
- Maxillary division - nervus meningeus medius
- Mandibular division - nervus spinosus



Solution to Question 6:

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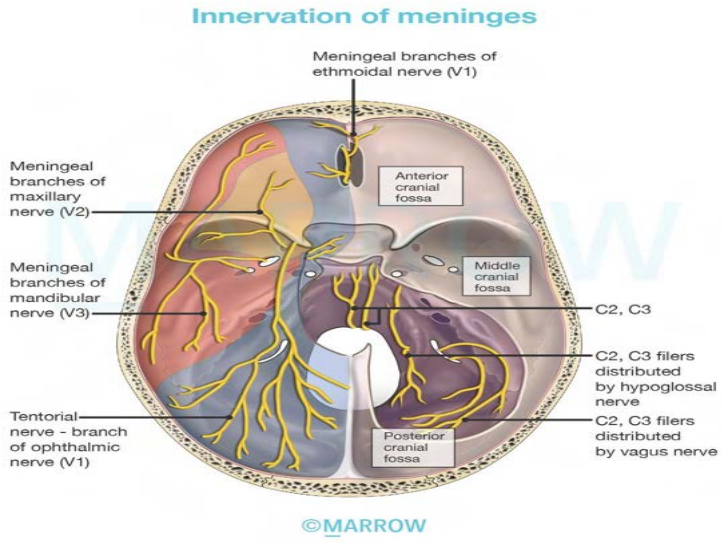
The dura mater of the posterior cranial fossa is mainly innervated by C2 and C3 nerves via cranial nerves X and XII.

These fibers may be distributed by the vagus and hypoglossal nerves.



Solution to Question 7:

The meningeal branch of the internal carotid artery (ICA) does not supply the posterior cranial fossa. It supplies the anterior cranial fossa.

The dura mater is supplied by meningeal arteries that pass along the inner periosteum (endosteum) of the skull over the endosteal layer of the dura and supply the following regions.

Region	Arteries
Anterior cranial fossa	Meningeal branches of anteri or and posterior ethmoid arte riesMeningeal branchesofinte rnal carotid arteriesA branch of themiddle meningealartery
Middle cranial fossa	Middle meningeal artery and accessory meningeal branche s of the maxillary arteryA bra nch of the ascending pharyng eal arteryBranches of the inte rnal carotid arteryA recurren t branch of the lacrimal arter y

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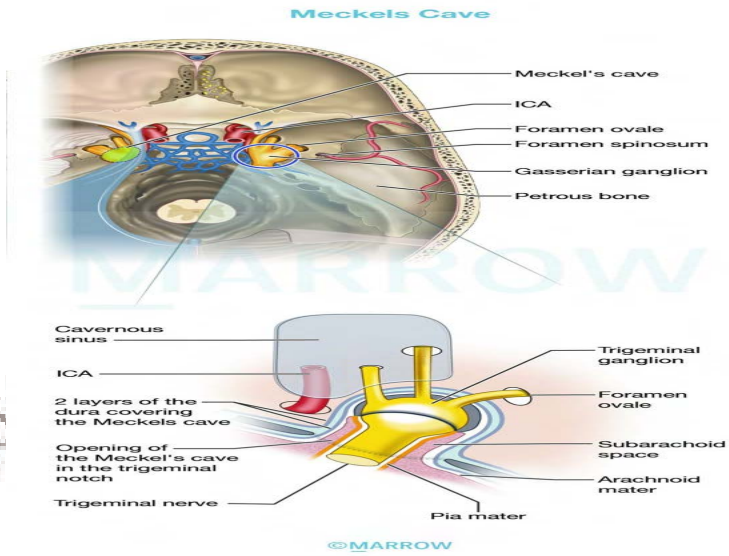
Region	Arteries
Posterior cranial fossa	Meningeal branches of the occipital arteryPosterior meningeal branches of the vertebral arteryDorsal meningeal and tentorial arteries arising from the meningohypophyseal trunk

Solution to Question 8:

Evagination of the lower layer of the tentorium cerebelli at the petrous apex is called Meckel's cave.

It is a dural recess in the middle cranial fossa that houses the Gasserian ganglion and proximal rootlets of the trigeminal nerve.



Solution to Question 9:

The sinus marked in the image is the sigmoid sinus. It drains from the transverse sinus.

It passes through an S-shaped groove in the mastoid process of the temporal bone, courses over the jugular process of the occipital bone, and emerges posterior to the jugular foramen.

The sigmoid sinus receives tributaries:

- Mastoid emissary veins
- Condylar emissary veins
- Venous plexus of the hypoglossal canal

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• Inferior cerebellar veins

• Unnamed tributaries from the pons and medulla

It joins the inferior petrosal sinus to form the internal jugular vein.

Sigmoid/lateral sinus thrombosis occurs as a complication of ear or mastoid infection.

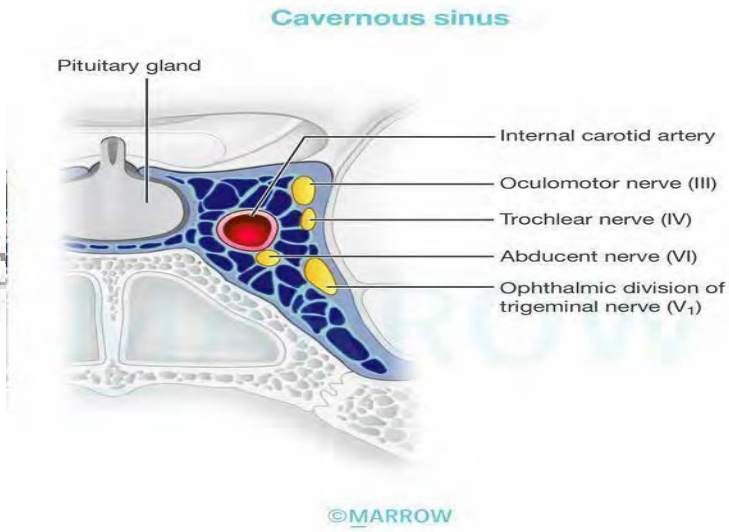
Solution to Question 10:

The abducens nerve is likely to be affected first.

The abducent nerve runs within the cavernous sinus in close proximity to the internal carotid artery. Therefore, an aneurysm of the ICA may impinge on the nerve and may lead to sixth nerve palsy.

The oculomotor nerve, trochlear nerve, and the ophthalmic division of the trigeminal nerve lie in the lateral wall of the cavernous sinus. They are involved in the pathologies of the sinus much later.

The maxillary division of the trigeminal nerve does not run through the cavernous sinus or its lateral wall. It passes beneath the dura of the middle cranial fossa underneath the cavernous sinus.



Solution to Question 11:

The history and examination findings suggest cavernous sinus thrombosis.

The deep middle cerebral vein is not a tributary of the cavernous sinus. It joins the anterior cerebral and striate veins to form the basal vein.

The tributaries of cavernous sinus are:

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• From orbit - superior and inferior ophthalmic veins

• From cranium - sphenoparietal sinus, superficial middle cerebral vein, inferior cerebral vein.

The cavernous sinus drains into:

• Transverse sinus via superior petrosal sinus

• Internal jugular vein via inferior petrosal sinus

• Pterygoid plexus of veins via emissary veins

• Superior ophthalmic vein

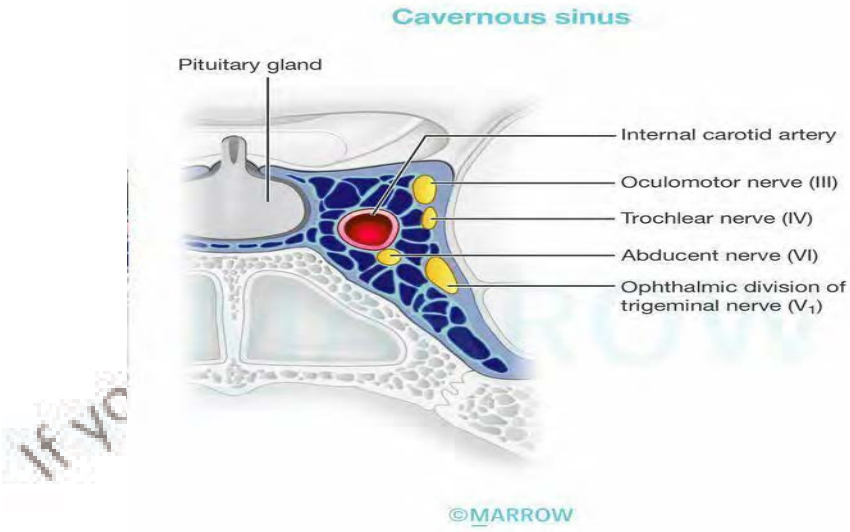
The contents of the cavernous venous sinus include:

• Cavernous segment of the internal carotid artery

• Perivascular sympathetic plexus

• Abducens nerve (running through the Dorello's canal)

• Oculomotor nerve, trochlear nerve, and the ophthalmic division of the trigeminal nerve as part of the lateral wall.



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Ventricular System and Subarachnoid Space

Question 1:

The CT scan of a child with congenital toxoplasmosis is shown below. Which of the following cells form the lining of the involved structure?

a) Ependymocytes

b) Astrocytes

c) Oligodendrocytes

d) Podocytes

Question 2:

What structure forms the roof of the anterior horn of the marked ventricle?

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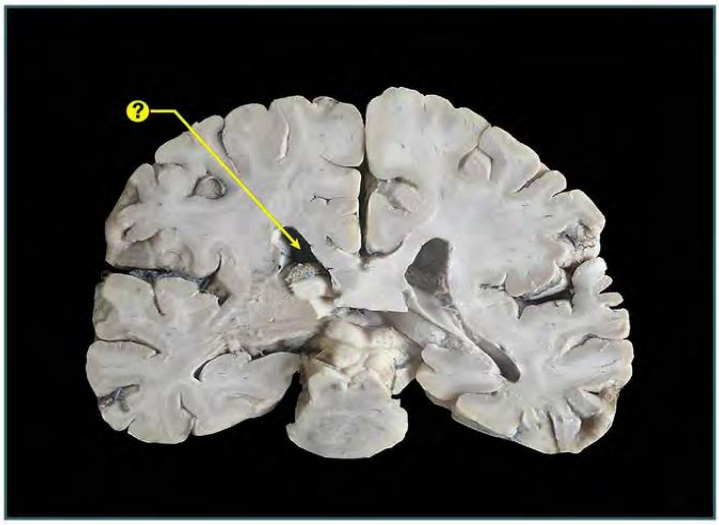

a) Genu of corpus callosum

b) Rostrum of corpus callosum

c) Body of corpus callosum

d) Septum pellucidum

Question 3:

The two elevations on the medial wall of the posterior horn of the lateral ventricle are due to _____.

a) Tapetum of the corpus callosum and calcar avis

b) Forceps minor and collateral eminence

c) Forceps major and calcar avis

d) Forceps major and collateral eminence

Question 4:

A patient was undergoing endoscopic third ventriculostomy for treatment of hydrocephalus. During the procedure, the resident accidentally advanced the instrument, perforating through the floor of the third ventricle. Which of the following structures is not likely to be injured?

a) Infundibulum

b) Oculomotor nerve

c) Mamillary body

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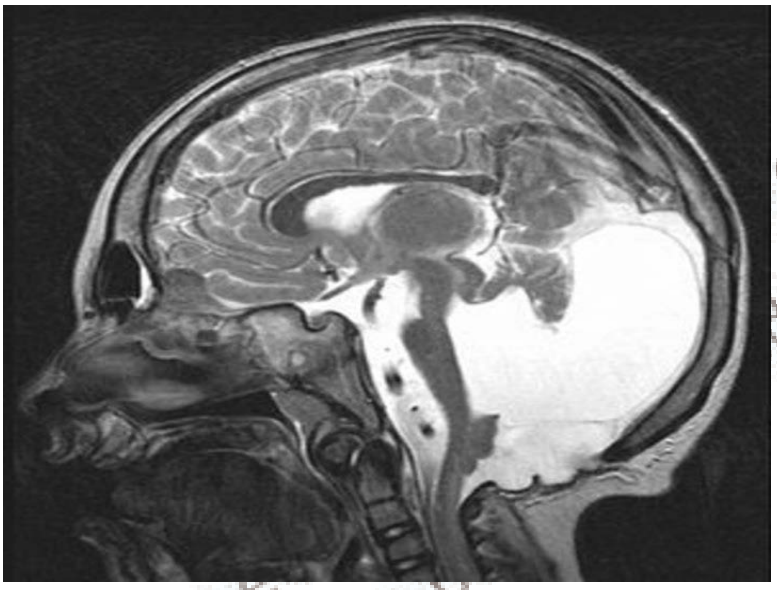
d) Optic chiasma

Question 5:

The T2 weighted MRI of a child is given below. Which of the following is true about the ventricle primarily involved in this condition?



a) Foramen of Magendie is a central aperture that pierces the superior medullary velum

b) Inferior medullary velum is a sheet of white matter

c) Foramina of Luschka are the lateral openings

d) The choroid plexus is formed from folds of arachnoid called tela choroidea

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d.

Question 6:

Which cranial nerve nucleus is not found on the floor of the fourth ventricle?

a) VI cranial nerve

b) VII cranial nerve

c) VIII cranial erve

d) X cranial nerve

Question 7:

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Imaging done in a 66-year-old man with a suspected brainstem infarct showed a lesion at the facial colliculus. Which of the following structures are present here?

a) Facial nerve nucleus

b) Abducent nerve nucleus

c) Fibers from the facial nerve which cover the facial nucleus

d) Fibers from the facial nerve which cover the abducent nucleus

Question 8:

Substantia ferruginea is present in _____.

a) White matter

b) Gray matter

c) Hypothalamus

d) Pituitary gland

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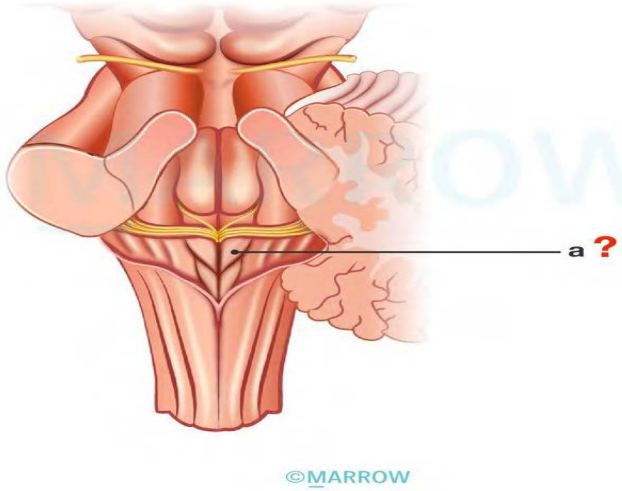
Question 9:

Identify the area marked 'a' in the figure below.



a) Facial colliculus

b) Vagal triangle

c) Vestibular triangle

d) Hypoglossal triangle

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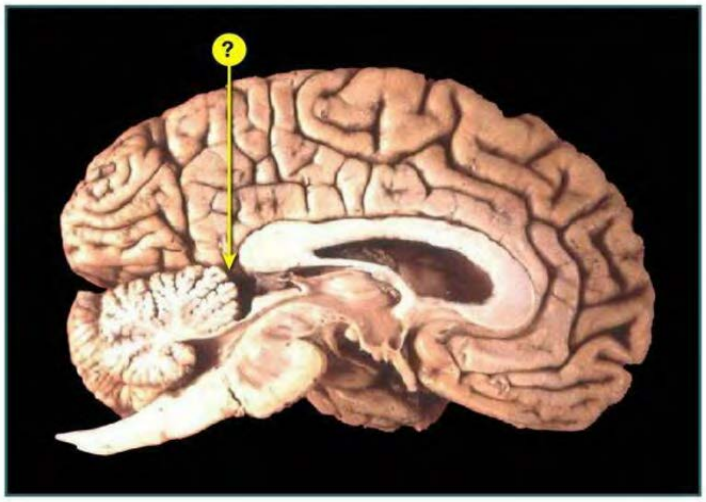
Question 10:

A child is diagnosed to have an aneurysmal malformation of a vessel located in the marked structure. Identify the structure and the vessel present in it.



a) Cisterna magna, Inferior retrotonsillar vein

b) Quadrigeminal cistern, Great cerebral vein

c) Supracallosal cistern, Great cerebral vein

d) Sylvian cistern, Occipital artery

Question 11:

Which is the largest subarachnoid cistern?

a) Cisterna pontis

b) Cerebellomedullary cistern

c) Cisterna ambiens

d) Sylvian cistern

Question 12:

A 2-year-old child was brought by his mother with complaints of delayed gait development and a large head. Examination revealed cystic obstruction of the median outlet of the fourth

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ventricle causing ballooning of the inferior medullary velum into the cisterna magna. Imperforation of which of the following structures leads to the given condition?

a) Foramen of Luschka

b) Foramen of Monro

c) Foramen of Magendie

d) Aqueduct of Sylvius

Question 13:

Which of the following statements is not true about arachnoid villi?

a) Arachnoid villi are the major sites of absorption of cerebrospinal fluid (CSF)

b) Arachnoid villi do not serve as valves

c) Rate of absorption through arachnoid villi controls the CSF pressure

d) All of the above

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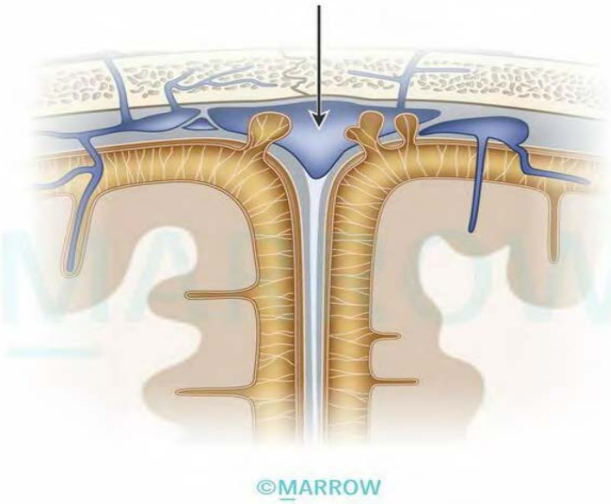
Question 14:

The structure marked with arrow in the image given below is concerned with _____.



a) Secretion of the CSF into the subarachnoid space

b) Transport of neurochemicals from subjacent neurons and glia into CSF

c) Absorption of the CSF by the arachnoid villi

d) CSF return through the tela choroidea

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Question 15:

What are Pacchionian bodies?

a) Focal pouches of arachnoid mater and subarachnoid space

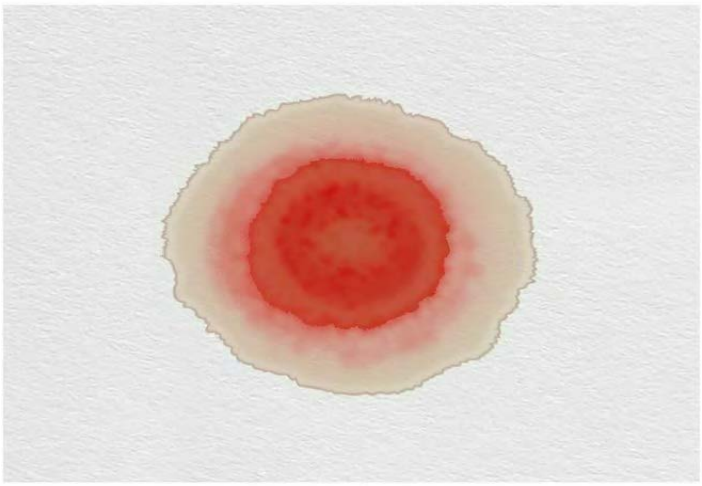
b) Tuft of capillaries enclosed by the piamater

c) Calcareous deposits in the astrocytes of pineal gland

d) Shrunken yellow brown cystic lesions in the gyri, associated with head injury

Question 16:

While assessing a 33-year-old lady who had been in a road traffic accident, you note watery discharge from her nose mixed with the blood. The following sign is seen on filter paper. Which structures produce the majority of this fluid?



a) Ependymal cells lining the ventricles

b) Choroid plexus

c) Brain substance through perivascular space

d) Microglia

Question 17:

Which of the following is not a circumventricular organ?

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a) Organum Vasculosum

b) Median Eminence

c) Adenohypophysis

d) Pineal Gland

Answer Key

Question No.	Correct Option
1	a
2	c
3	c
4	b
5	c
6	b
7	d
8	b
9	d
10	b
11	b
12	c
13	b
14	c
15	a
16	b
17	c

Detailed Explanations

Solution to Question 1:

The CT shows hydrocephalus, enlargement of the ventricles due to build-up of CSF. The ventricles of the brain are lined by ependymocytes.

Ependymocytes are a type of glial cell that line the ventricles of the brain and the central canal of the spinal cord. They are simple columnar cells. Some are ciliated in order to facilitate the circulation of CSF.

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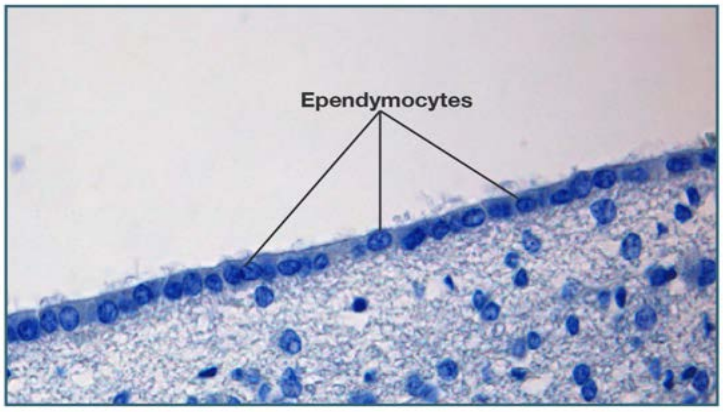
Their functions include secretion of CSF and transport of neurochemicals to and fro from the CSF. They also have a function in neuroregeneration.

Ependyma



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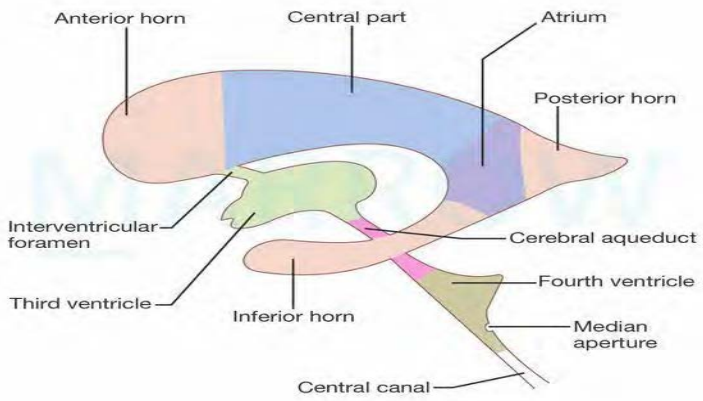
Solution to Question 2:

The structure marked is the lateral ventricle. The roof of the anterior horn of the lateral ventricle is formed by the anterior part of the body of the corpus callosum.

The lateral ventricle is divided into the body and 3 horns. The locations of the parts are:

- Body - parietal lobe
- Anterior horn - frontal lobe
- Posterior horn - occipital lobe
- Inferior horn - temporal lobe.

Parts of the lateral ventricle



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The anterior horn extends from the genu of the corpus callosum up to the interventricular foramen. The relations of the anterior horn are:

• Anteriorly - Genu and rostrum of the corpus callosum

• Roof - Anterior part of the body of the corpus callosum

• Floor and lateral wall - Caudate nucleus

• Medial wall - Septum pellucidum and anterior column of fornix

The body or central part extends from the interventricular foramen to the splenium of the corpus callosum. The relations of the body are:

• Roof - Body of the corpus callosum

• Medial wall - Septum pellucidum

• Floor (from lateral to medial) - Caudate nucleus, stria terminalis, thalamostriate vein, thalamus, choroid plexus, and body of the fornix

The posterior horn extends from the splenium to the occipital pole. The relations are:

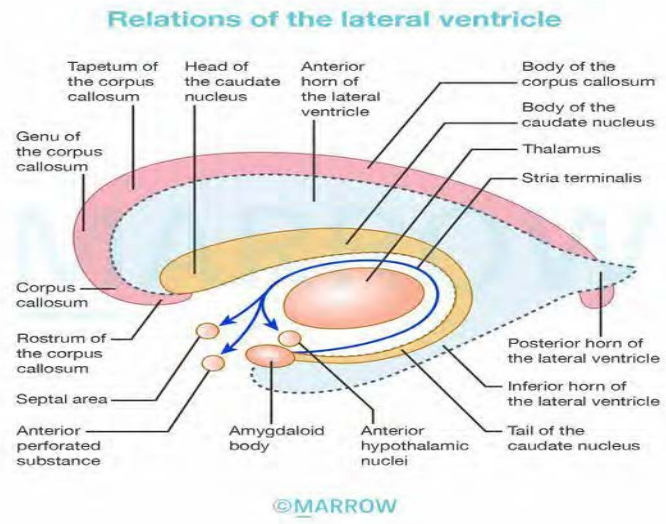
• Roof and lateral wall - Tapetum of corpus callosum

• Medial wall - Forceps major and calcar avis (calcarine sulcus)

The inferior horn is the largest compartment of the lateral ventricle and extends up to 2.5 cm from the temporal pole. The relations are:

• Roof - Tapetum of corpus callosum and tail of caudate nucleus

• Floor (lateral to medial) - Collateral eminence produced by collateral fissure, hippocampus.



Note: There is no lateral wall for the lateral ventricle.

Solution to Question 3:

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The two elevations on the medial wall of the posterior horn of the lateral ventricle are due to the forceps major and calcar avis.

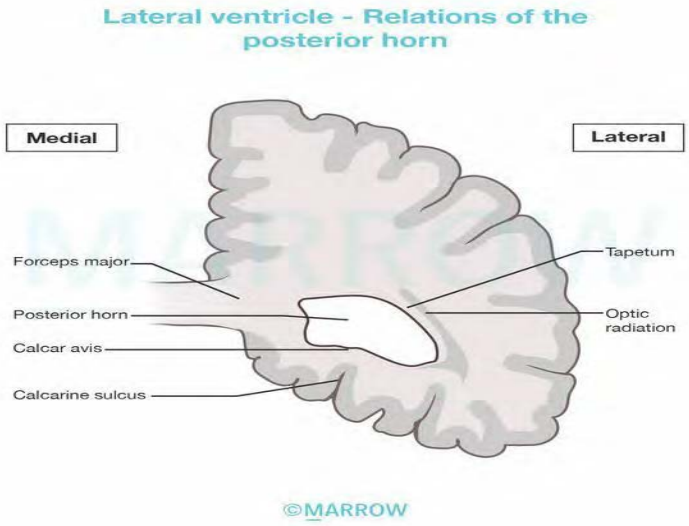
The posterior horn extends from the splenium to the occipital pole. The relations are:

• Roof and lateral wall - Tapetum of corpus callosum

• Medial wall - Forceps major and calcar avis (calcarine sulcus)

The forceps major is the fibers of the splenium of the corpus callosum.

The calcar avis is formed by the white matter of the calcarine sulcus.



Forceps minor is formed by the anterior part of the corpus callosum.

The collateral eminence is formed by the collateral sulcus and is related to the floor of the inferior horn of the lateral ventricle.

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Solution to Question 4:

The oculomotor nerve is not related to the floor of the third ventricle.

The structures related to the floor of the third ventricle (from anterior to posterior) include:

• Optic chiasma

• Infundibulum

• Mamillary bodies

• Posterior perforating substance

• Tegmentum of the midbrain.

Solution to Question 5:

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The MRI shows a Dandy-Walker malformation. It is a rare congenital malformation involving the cerebellum and the fourth ventricle. The foramina of Luschka are the lateral openings in the fourth ventricle. These openings allow the flow of CSF from the ventricle into the subarachnoid space.

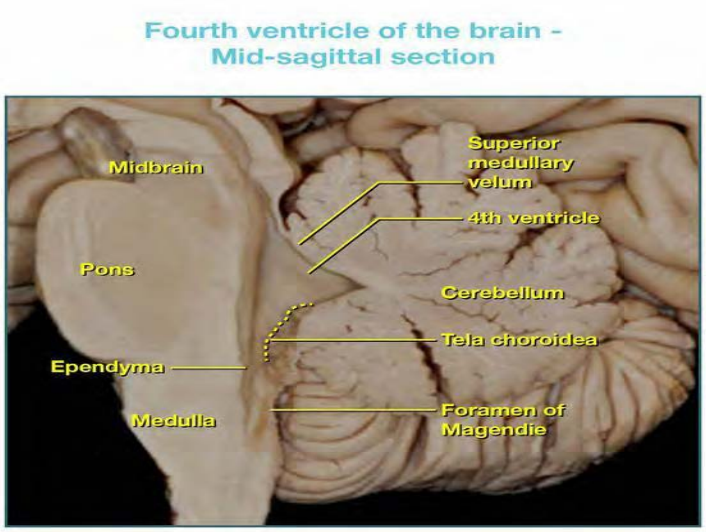
The fourth ventricle is a tent-shaped ventricle lying between the brainstem and the cerebellum. It is widest at the level of the pontomedullary junction.

The roof of the fourth ventricle is formed by:

• Superior medullary velum - White matter sheet stretching between the superior cerebellar peduncles.

• Inferior medullary velum - Made of ventricular ependyma and pia mater of tela choroidea, and has no nervous tissue. It is pierced by the foramen of Magendie in the midline, opening into the cisterna magna.

The T-shaped choroid plexus of the fourth ventricle is formed from the tela choroidea, made of two layers of pia mater.



Solution to Question 6:

The VII cranial nerve nucleus is not present on the floor of the fourth ventricle.

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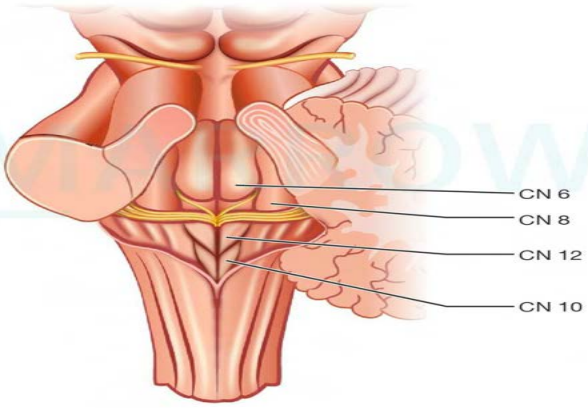
Cranial nerve nuclei in the floor of the 4th ventricle



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The floor of the fourth ventricle is diamond-shaped and lies on the dorsal surface of the pons and superior half of the medulla.

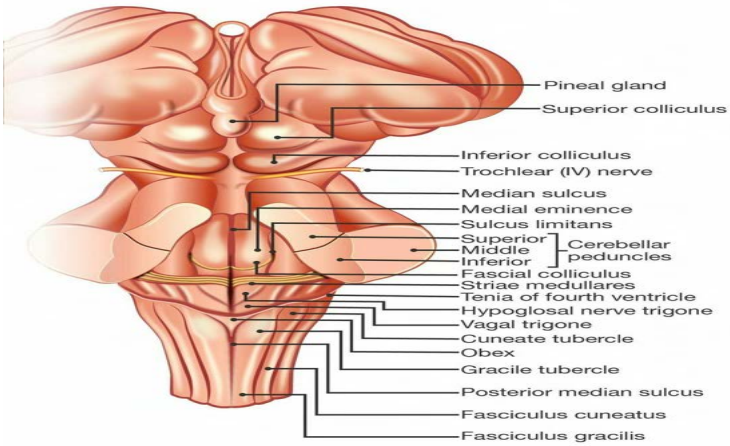
It is divided into two symmetrical halves by the longitudinal median sulcus. Each half is further divided by sulcus limitans into a medial region, medial eminence, and a lateral region, vestibular area. The vestibular nuclei lie beneath the vestibular area.

At the superior end of the sulcus limitans, a bluish-gray area is produced by a cluster of nerve cells containing melanin pigment called substantia ferruginea.

At the inferior end of the medial eminence, the fibers from the motor nucleus of the facial nerve looping over the abducens nucleus are represented by the facial colliculus.

Inferiorly, the medial eminence is represented by the hypoglossal triangle overlying the hypoglossal nucleus and the vagal triangle overlying the dorsal nucleus of the vagus.

Floor of the fourth ventricle



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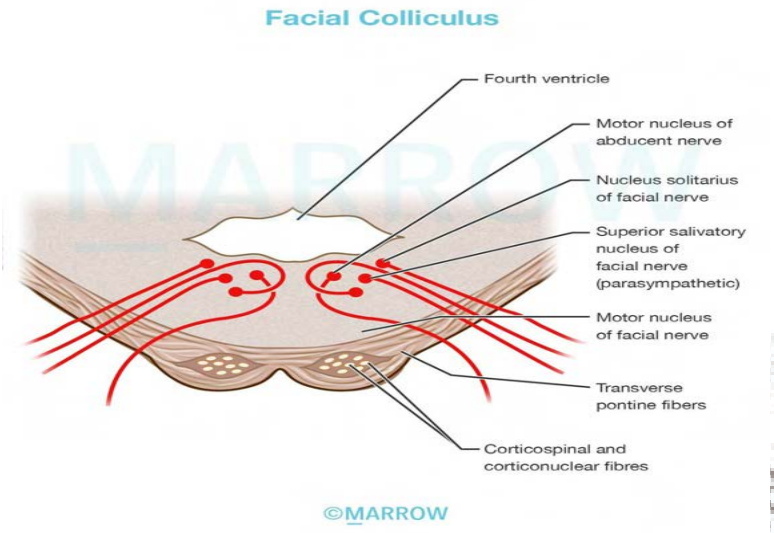
Solution to Question 7:

The facial nerve fibers, which cover the abducent nucleus, lie deep to the facial colliculus.



Facial colliculus is a small bilateral bulge in the floor of the 4th ventricle. Beneath this, the fibers from the motor nucleus of the facial nerve loop around the abducens nucleus. This is due to a phenomenon called neurobiotaxis - a shift of nerve cells during the development over the course of evolution.

Solution to Question 8:

Substantia ferruginea is present in the gray matter.

It is a cluster of nerve cells containing melanin pigment located at the superior end of sulcus limitans in the floor of the 4th ventricle.

Solution to Question 9:

The image is of the floor of the 4th ventricle, and the area marked 'a' is the hypoglossal triangle.

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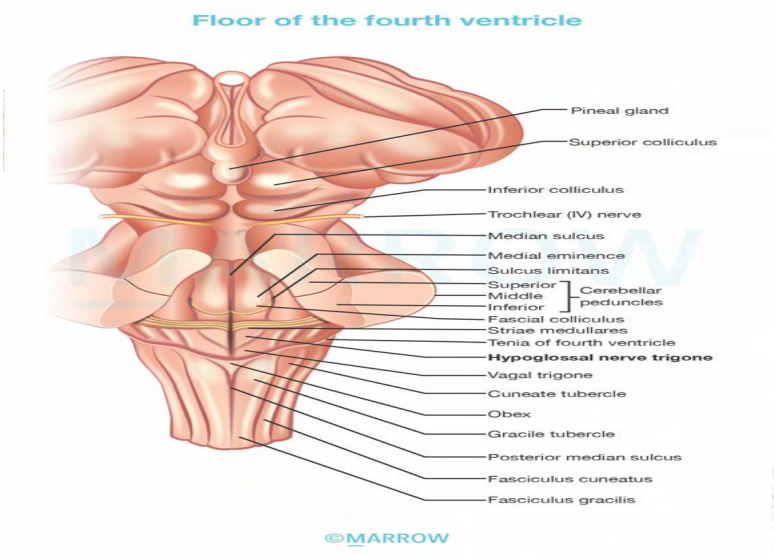

The floor of the 4th ventricle is diamond-shaped and lies on the dorsal surface of the pons and superior half of the medulla. It is divided into two symmetrical halves by the longitudinal median sulcus. Each half is further divided by sulcus limitans into a medial region, medial eminence, and a lateral region, vestibular area.

The vestibular nuclei lie beneath the vestibular area.

At the superior end of the sulcus limitans, a bluish-gray area is produced by a cluster of nerve cells containing melanin pigment called substantia ferruginea/locus coeruleus.

At the inferior end of the medial eminence, the fibers from the motor nucleus of the facial nerve looping over the abducens nucleus are represented by the facial colliculus.

Inferiorly, the medial eminence is represented by the hypoglossal triangle overlying the hypoglossal nucleus and the vagal triangle overlying the dorsal nucleus of the vagus.

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Solution to Question 10:

The area marked "A" is the quadrigeminal cistern, and it contains the great cerebral vein of Galen.

Aneurysmal malformation of the great cerebral vein of Galen is a congenital anomaly occurring due to the persistence of the embryonic prosencephalic vein of Markowski.

The image below is a CT cerebral angiogram of a vein of Galen malformation and an abnormal falcine sinus.

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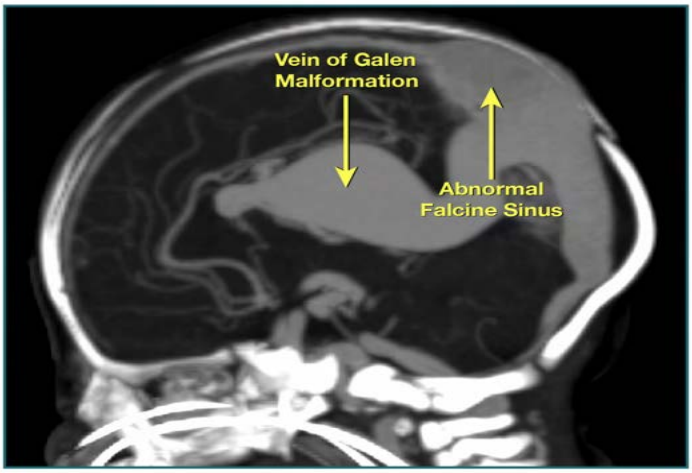
Vein of Galen malformation



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Solution to Question 11:

The largest subarachnoid cistern is the cerebellomedullary cistern.

Solution to Question 12:

The clinical scenario described is of Blake's pouch cyst, caused due to an imperforate foramen of Magendie.

The roof of the fourth ventricle communicates posteriorly with the cisterna magna through a median aperture called the foramen of Magendie.

During fetal development, the roof of the fourth ventricle is formed by the anterior and posterior membranous areas (AMA, PMA).

Blake's pouch is a temporary finger-like growth of the PMA which communicates with the fourth ventricle. During the 9th week of the development, Blake's pouch perforates to form the foramen of Magendie.

Communications of the ventricular system:

• Foramen of Monro - Lateral ventricle to the third ventricle

• Cerebral aqueduct of Sylvius - III ventricle to IV ventricle

• IV ventricle to subarachnoid space:

• Foramen of Magendie (midline) - Cisterna magna

• Foramina of Luschka (laterally) - Subarachnoid space

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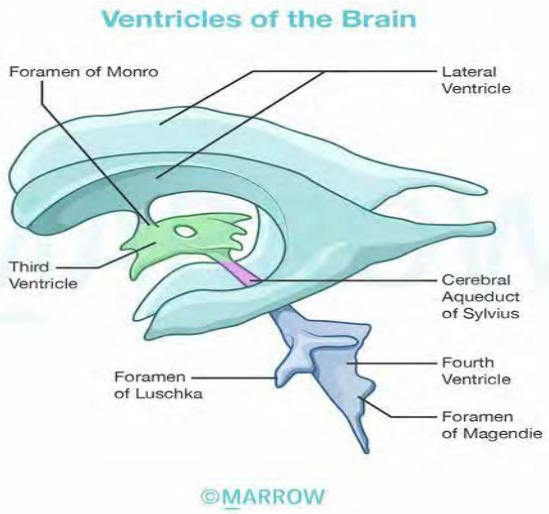

The outflow of CSF from the IV ventricle is via the medial outlet. This is covered by a membrane in the fetus which perforates later. The persistence of this membrane causes cystic obstruction.

In Dandy-Walker malformation, there is the presence of many posterior fossa anomalies such as:

- Cystic dilation of the fourth ventricle
- Hydrocephalus
- Hypoplasia of the cerebellar vermis
- Enlarged posterior fossa.

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Solution to Question 13:

Arachnoid villi act like valves. If venous pressure exceeds CSF pressure, arachnoid villi close the tubules to prevent the entry of blood into the subarachnoid space.

Arachnoid villi are diverticulums of the subarachnoid space that pierces the dura mater. Grouped arachnoid villi produce elevations called arachnoid granulations.

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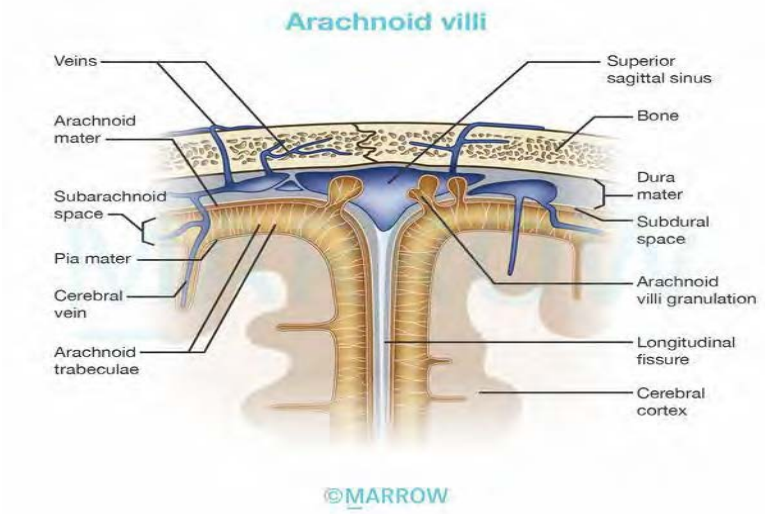
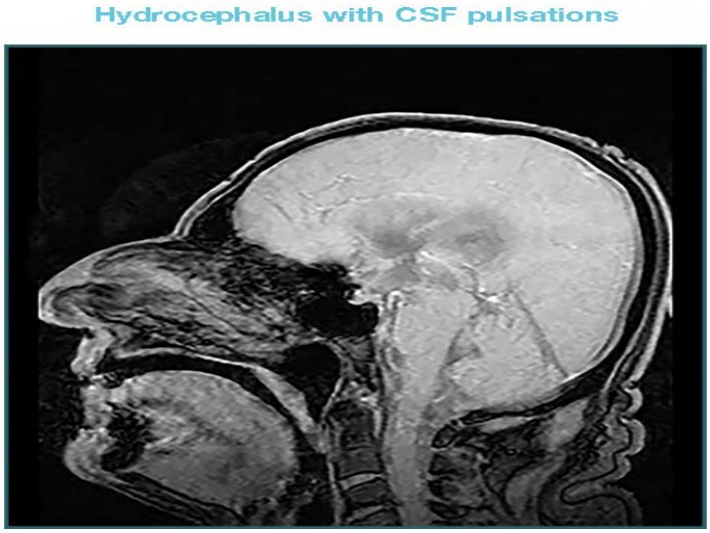


When the CSF pressure is higher than the venous pressure of the sinus, CSF flows from the subarachnoid space into the venous sinuses via the arachnoid villi.

If the venous pressure exceeds CSF pressure, the arachnoid villi close and prevent the reflux of blood into the arachnoid space. Some CSF is also directly absorbed into the veins in the subarachnoid space.

The CSF production from choroid plexuses is usually constant. Therefore, the rate of absorption through the arachnoid villi controls the CSF pressure.

The image below shows the pulsatile CSF movement.



Solution to Question 14:

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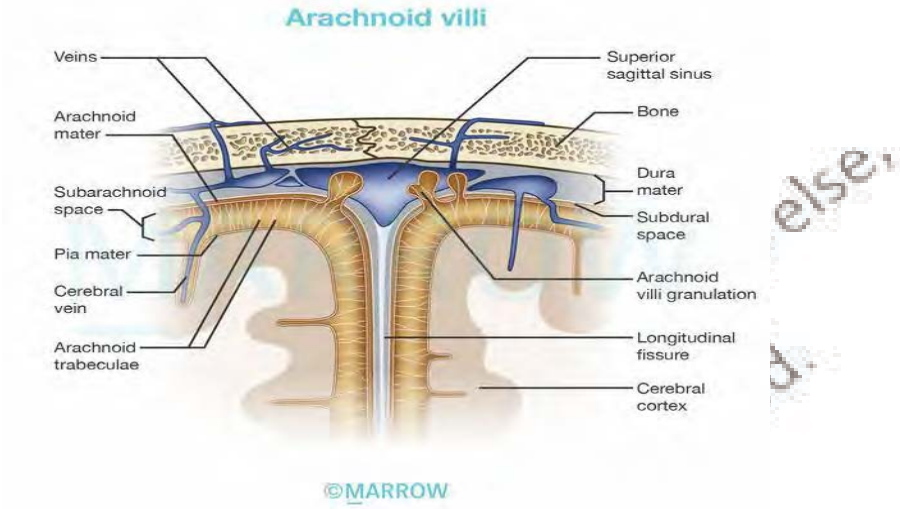
The structure marked in the above image is a dural venous sinus, and the CSF is absorbed into this sinus through arachnoid villi.

Tela choroidea gives rise to the choroid plexus, from which CSF is secreted into the ventricles.

Tancytes/specialized glial cells in circumventricular organs help with the transport of neurochemicals to CSF.



Solution to Question 15:

Pacchionian bodies (arachnoid granulations) are focal pouches of arachnoid mater and subarachnoid space protruding through the walls of dural venous sinuses.

Option B: Tuft of capillaries enclosed by pia mater lined by ependymal cells forms tela choroidea. It secretes CSF.

Option C: Calcareous deposits in the astrocytes of the pineal gland are known as brain sand or corpora arenacea.

Option D: Shrunken, yellow-brown, cystic lesions in the gyri and subarachnoid space associated with head injury are called plaque jaune.

Solution to Question 16:

The case suggests CSF rhinorrhea and the image shows the double-ring sign. CSF mainly forms in the choroid plexus. It is absorbed back by the arachnoid villi.

Formation of CSF:

• Major contributor - Choroid plexuses

• Minor contributors - Ependymal cells lining the ventricles, brain substance through the perivascular spaces

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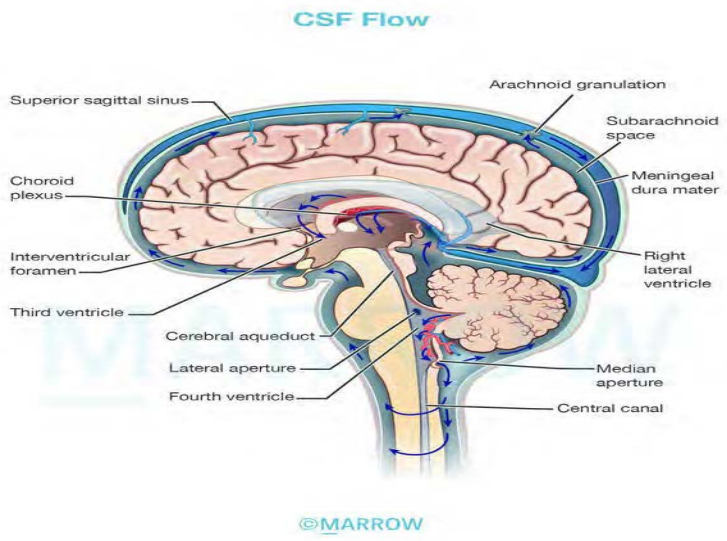
CSF is produced at a rate of 550 ml/day. The normal adult volume of CSF is 150ml, and it is cycled about 3.7 times a day. The normal CSF pressure is 70-180 mm H2O.



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Solution to Question 17:

Circumventricular organs are those structures in the brain that are devoid of the blood-brain barrier. Adenohypophysis is not devoid of a blood-brain barrier (BBB).

Neurohypophysis is devoid of the blood-brain barrier.

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Cerebrum

Question 1:

Which of the following is a complete sulcus?

a) Lateral sulcus

b) Collateral sulcus

c) Lunate sulcus

d) Calcarine sulcus

Question 2:

Anterior part of the calcarine sulcus is a _____.

a) Limiting sulcus

b) Operculated sulcus

c) Axial sulcus

d) Complete sulcus

Question 3:

Where is Heschl's gyrus located?

a) Primary auditory cortex

b) Medial frontal lobe

c) Visual cortex

d) Parietal association area

Question 4:

Which of the following statements is true?

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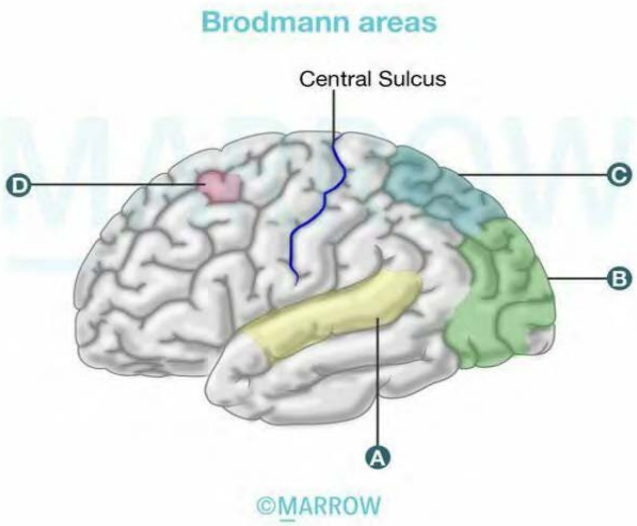

a) Area marked A is Broca's area (44, 45) and is present in the inferior frontal gyrus

b) Area marked B is the visual association Area (17, 18) and is present around the calcarine sulcus

c) Area marked C is the motor association area (5, 6) and is found in the superior parietal lobule

d) Area marked D is the frontal eye field (8) and is found in the middle frontal gyrus

Question 5:

A patient presents to you with inability to form words but can make noises. He also knows what he wants to say. What area of the brain has been damaged in this patient?

a) Wernicke's area

b) Broca's area

c) Heschl's gyrus

d) Striate area

Question 6:

In individuals with a history of substance abuse and addiction, the marked structure is believed to trigger cravings on exposure to environmental cues. Which of the following is not true about the structure?

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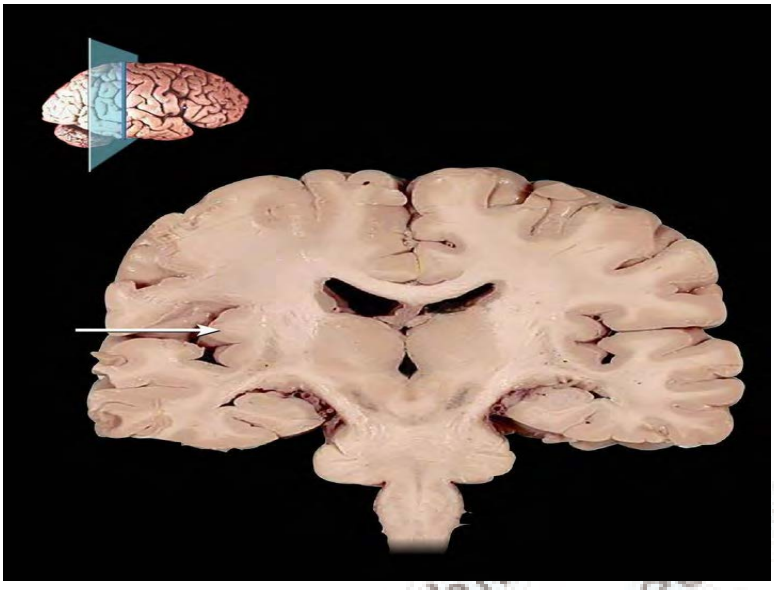

a) It is entirely agranular

b) It forms the base of the sylvian cistern

c) It lies between the frontal and temporal lobe

d) It receives somatosensory inputs from the entire body

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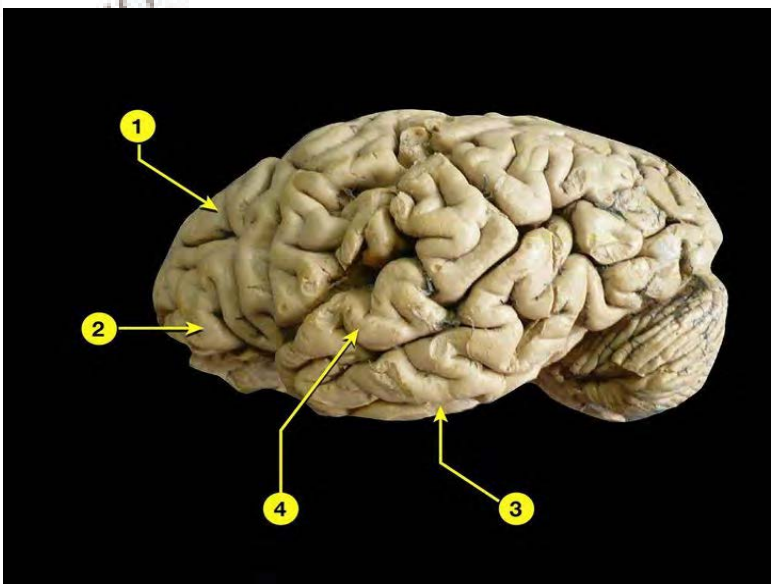
Question 7:

A 72-year-old man presents with a speech abnormality following a hemorrhagic stroke. He does not understand any written words or conversation. His speech is fluent but is incomprehensible. Repetition is also impaired. Where is the lesion located?



a) 4

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b) 3

c) 2

d) 1

Answer Key

Question No.	Correct Option
1	b
2	d
3	a
4	d
5	b
6	a
7	a

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Detailed Explanations

Solution to Question 1:

The collateral sulcus is a complete sulcus. A complete sulcus is one that is deep enough to indent the wall of a ventricle.

The posterior part of the calcarine sulcus is an axial sulcus and the anterior part is a complete sulcus.

Therefore, among the options provided, the collateral sulcus is the best answer.

Solution to Question 2:

The anterior part of the calcarine sulcus is considered a complete sulcus because its depth creates an elevation in the medial wall of the occipital horn of the lateral ventricle. This is called the calcar avis.

However, the posterior part of the calcarine sulcus is considered an axial sulcus as its axis is along the visual cortex.

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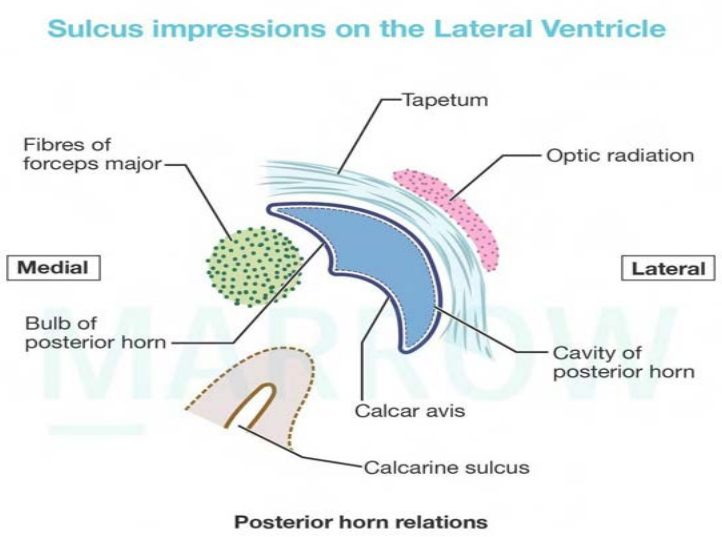
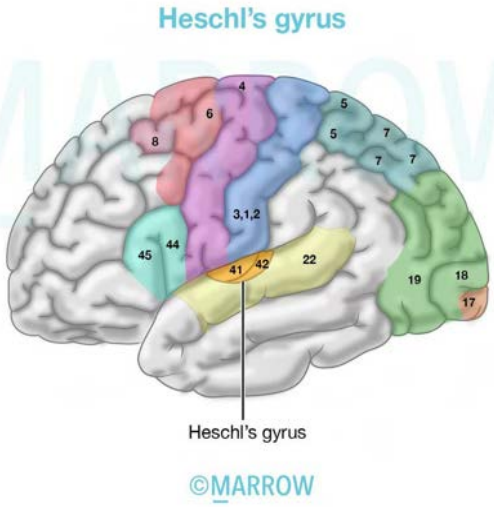


Posterior horn relations

Solution to Question 3:

Heschl's gyrus is located in the primary auditory cortex (area 41, 42).



Solution to Question 4:

Area marked D is the frontal eye field (8) and is located in the posterior part of the middle frontal gyrus. It controls the conjugate movements of the eyes. It is connected to the visual part of the occipital cortex.

Lesions here cause loss of horizontal conjugate movements.

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Brodman Area	Location	Function	Lesion produces
Wernicke'sarea (22) (A)	Present with auditory association areas in the superior temporal gyrus	Sensorylanguage area	Sensory aphasia
Broca'sarea (44,45)	Pars triangularis and pars opercularis in the inferior frontal gyrus.	Motorspeech area	Motor aphasia.
Visual associationarea (18,19) (B)	Present surrounding the striate area	Correlation of visual impulses with memory, recognition of objects seen, and depth perception	Visual agnosia.
Primary visual cortex(17)	Around the post-calcarine sulcus	Reception and perception of isolated visual impressions of color, size form, motion, illumination, and transparency	Homonymous hemianopia with macular sparing
Sensory associationarea (5,7) (C)	Between the sensory and visual areas in the superior parietal lobule	Stereognosis and sensory speech	Astereognosis and sensory aphasia

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Solution to Question 5:

The given clinical scenario is suggestive of Broca's aphasia in which the Broca's area will be affected.

In Broca's aphasia/ Motor aphasia / Non-fluent aphasia, areas 44 and 45 in the prefrontal and premotor facial regions of the cerebral cortex are affected. The affected individuals will have difficulty forming verbal or written words. The comprehension aspect of speech is preserved but the person cannot repeat or name the words and lacks fluency.

Patients in whom the area is severely affected may have very few words to express all of their emotions.

Solution to Question 6:

The structure marked by the arrow is the insular lobe. The insular cortex is not entirely agranular. The posterior part of the insular cortex is granular and the anterior part is agranular.

The insula forms the base of the Sylvian cistern and lies between the frontal and temporal lobes. It receives somatosensory, viscerosensory, homeostatic, and nociceptive information from the entire body. It receives inputs from the thalamus.

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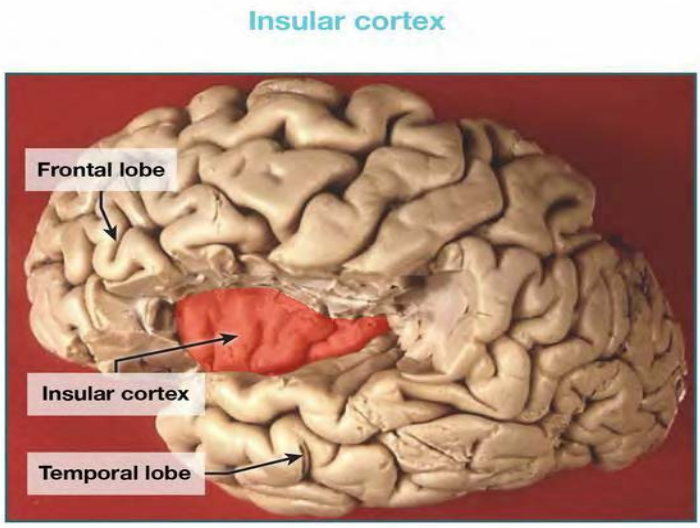

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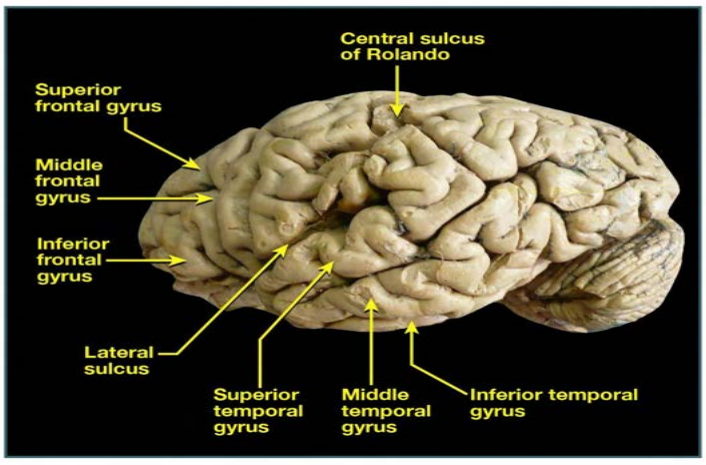
Solution to Question 7:

In the clinical scenario, comprehension and repetition are impaired while the fluency is intact. This points to Wernicke's aphasia. The area affected is Wernicke's area located in the superior temporal gyrus (marked 4).

Broca's motor speech area (44,45) is located in the inferior frontal gyrus.



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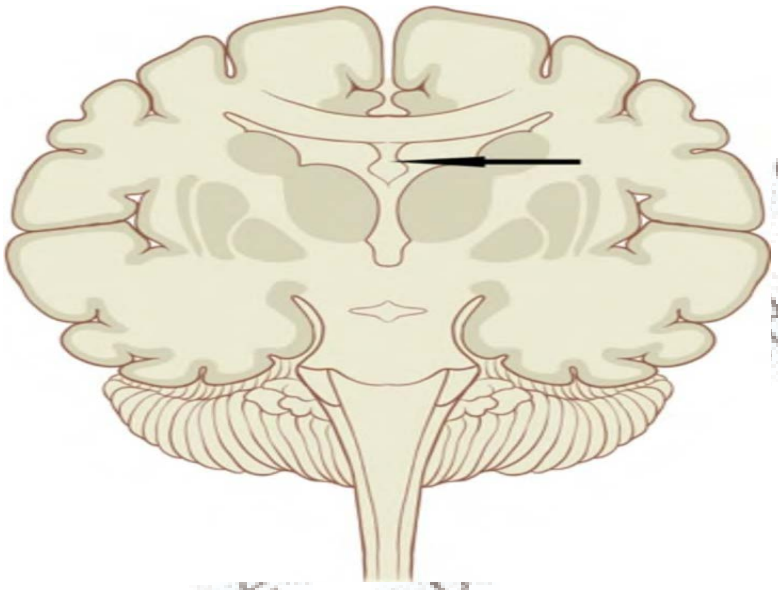
White Matter of the Brain

Question 1:

The structure marked in the given picture arises from the _____.



a) Mamillary body

b) Hippocampus

c) Thalamus

d) Amygdala

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Question 2:

Which fibre is marked by the arrow in the image given below?

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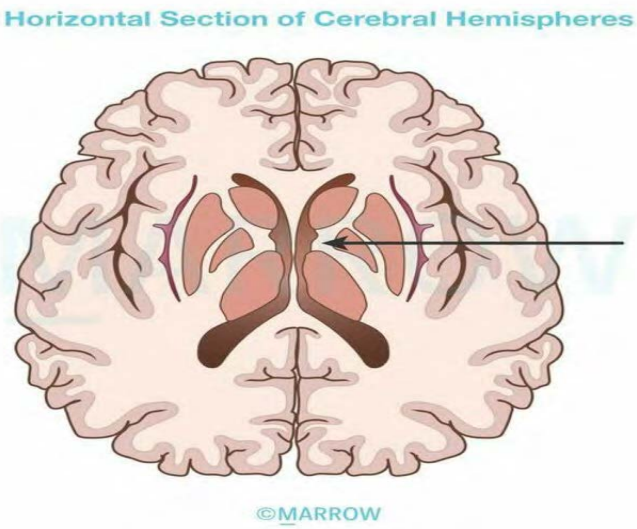

a) Short association

b) Long association

c) Projection

d) Commissural

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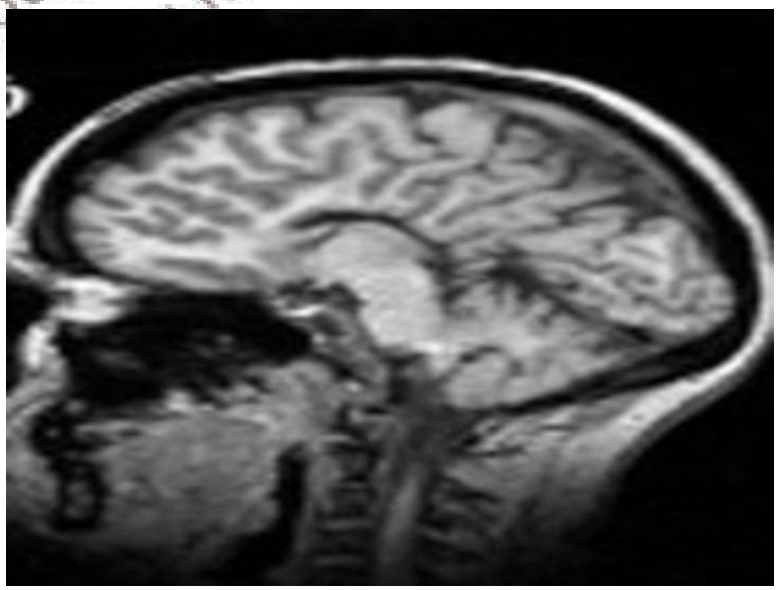
Question 3:

An infant is referred to neurology due to an abnormal MRI report as shown below. What is the most anterior part of the missing brain structure?



a) Rostrum

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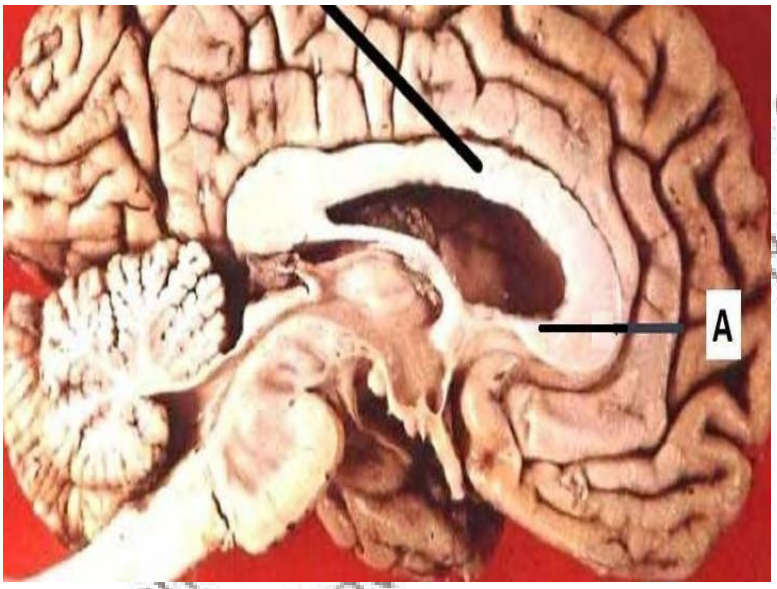
b) Genu

c) Splenium

d) Trunk

Question 4:

What is the area marked as 'A' in the image below?



a) Striate cortex

b) Hippocampus

c) Rostrum

d) Dentate nucleus

Question 5:

An infant is brought to the casualty with the symptom given below. MRI revealed the agenesis of a crucial cranial structure. Which part of this structure give rise to tapetum?

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a) Body only

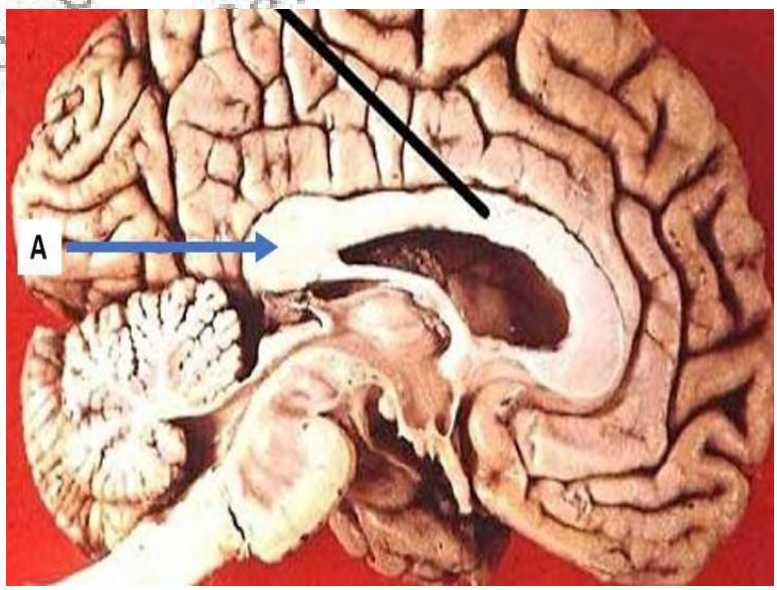
b) Genu and rostrum both

c) Rostrum only

d) Body and splenium both

Question 6:

Which of the following is connected to the structure marked as A in the image below?



a) Orbital cortex

b) Hippocampus

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c) Striate cortex

d) Optic chiasma

Question 7:

A woman presented with split-brain syndrome following an experimental brain surgery to manage severe epileptic seizures. Which fibres constitute the surgically resected structure?

a) Projection fibers

b) Commissural fibers

c) Short association fibers

d) Long association fibres

Question 8:

The cingulum of the brain is classified under _____.

a) Projection fibers

b) Long association fibers

c) Short association fibers

d) Commissural fibers

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Question 9:

Following road traffic accident, a man developed head injury resulting in a defect in the association fibres. Which of the following is not classified under these fibres?

a) Cingulum

b) Corona radiata

c) Fornix

d) Arcuate fasciculus

Question 10:

A woman presented with self-inflicted injuries, auditory hallucinations and delusions. MRI revealed a tumour involving the posterior limb of the internal capsule and the structure medial to it. Which structure is likely to be affected?

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a) Globus pallidus

b) Putamen

c) Thalamus

d) Caudate nucleus

Question 11:

A man presented with dysarthria suggestive of a lesion involving the corticonuclear tract. MRI revealed an ischemic stroke. Which part(s) of the internal capsule were most likely affected?

a) Anterior limb

b) Genu

c) Posterior limb

d) Both genu and posterior limb

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Question 12:

An 81-year-old man presented with ipsilateral paralysis. Examination showed hypertonia, hyperreflexia and the following finding. Which region of white matter do not contain the damaged fibres?

a) Pyramid of medulla oblongata

b) Lateral white column of the spinal cord

c) Cerebral peduncle of the midbrain

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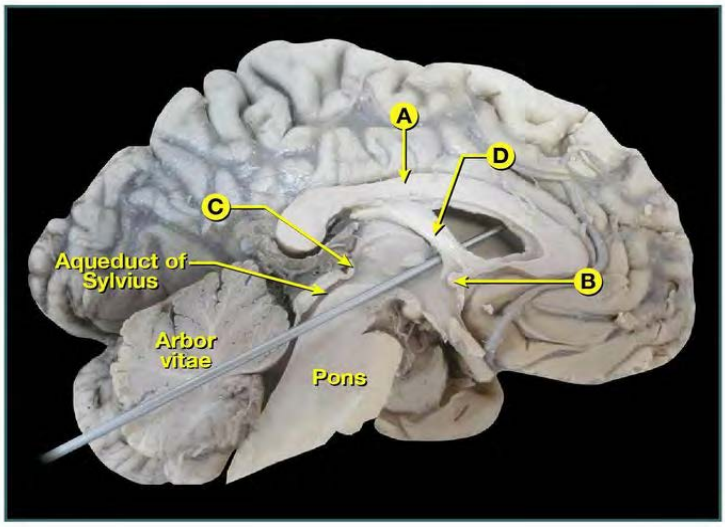
d) Anterior limb of the internal capsule

Question 13:

Identify the structures which consist of commissural fibres:



a) A, B, C, and D

b) A, B and C only

c) A and B only

d) D only

Question 14:

The habenular commissure is located in the _____.

a) Splenium of corpus callosum

b) Superior lamina of pineal gland

c) Inferior lamina of pineal gland

d) Lamina terminalis

Question 15:

What is the origin of the fibers marked by the arrow?

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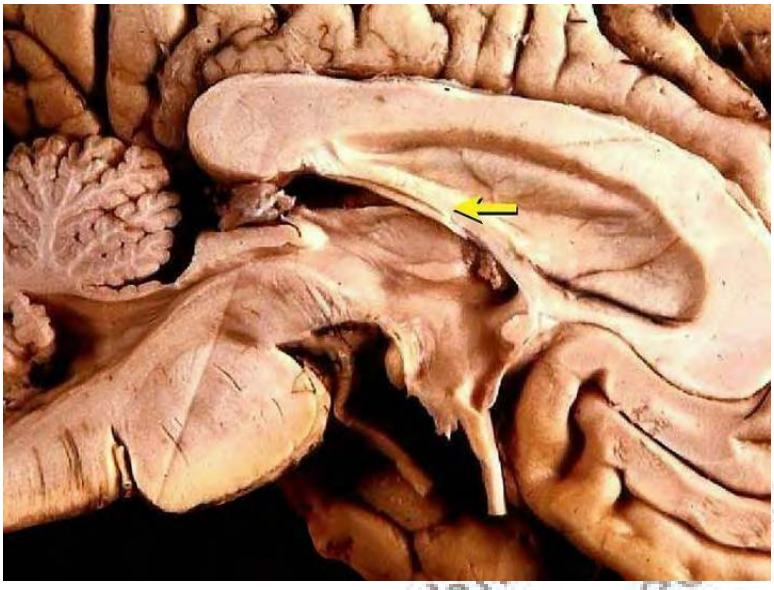

a) Hippocampus

b) Habenular

c) Mamillary body

d) Amygdala

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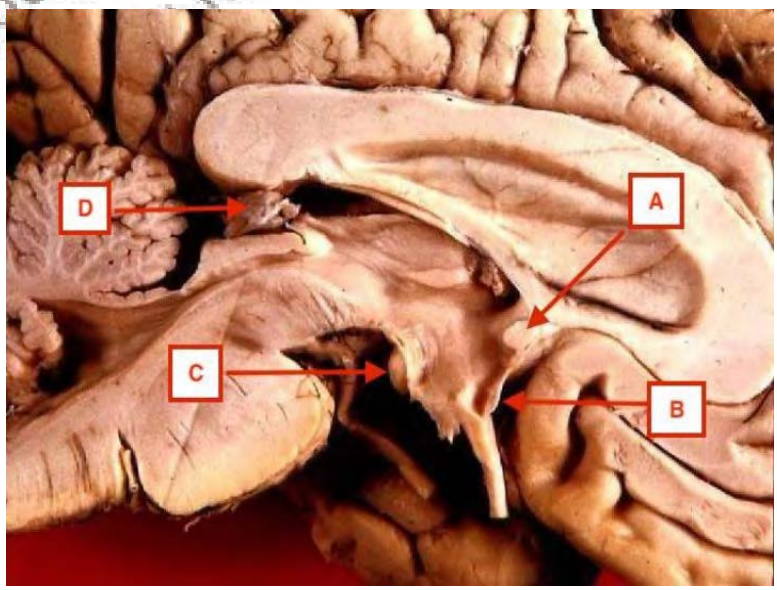
Question 16:

Which of the following statements is incorrect regarding the areas marked in the given image?



a) B is lamina terminalis

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b) A is a type of association fiber

c) C is content of interpeduncular fossa

d) D is devoid of blood brain barrier

Answer Key

Question No.	Correct Option
1	b
2	c
3	b
4	c
5	d
6	c
7	b
8	b
9	b
10	c
11	b
12	d
13	b
14	b
15	a
16	b

Detailed Explanations

Solution to Question 1:

This is a coronal section of the brain and the marked structure is the fornix. It arises from the hippocampus and ends in the mammillary body of the hypothalamus.

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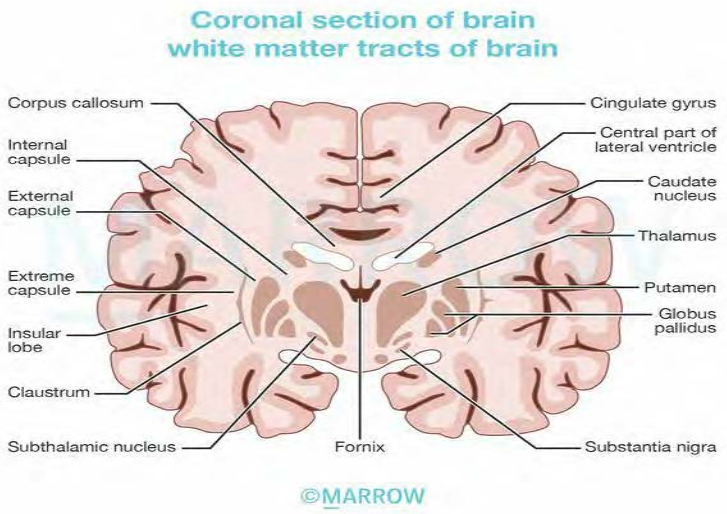

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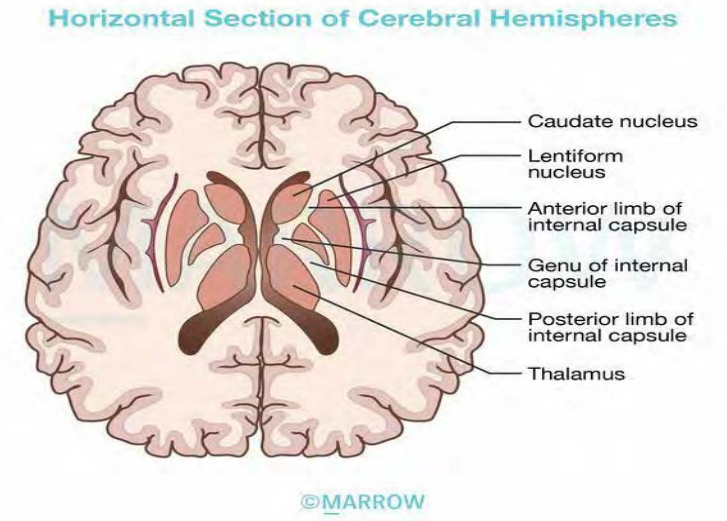
Solution to Question 2:

The marked structure is the internal capsule, which is a form of projection fiber.



Solution to Question 3:

The given clinical scenario is suggestive of total agenesis of the corpus callosum. The most anterior part of the missing brain structure i.e. the corpus callosum is the genu.

The image given below shows an MRI scan of the sagittal section of a normal brain followed by an image showing corpus callosum agenesis.

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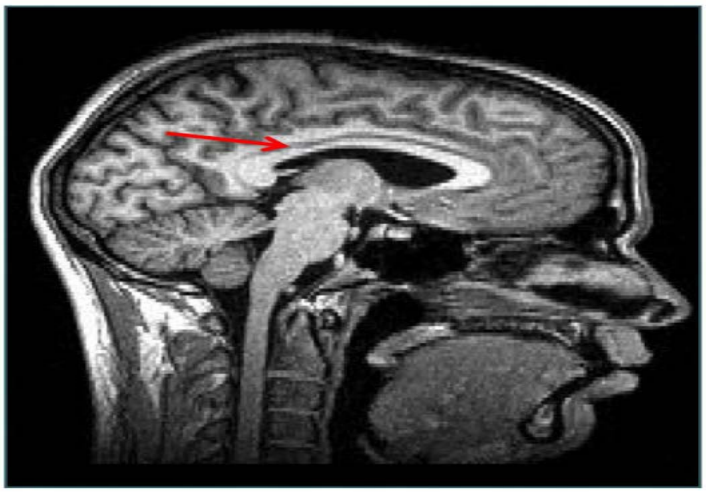
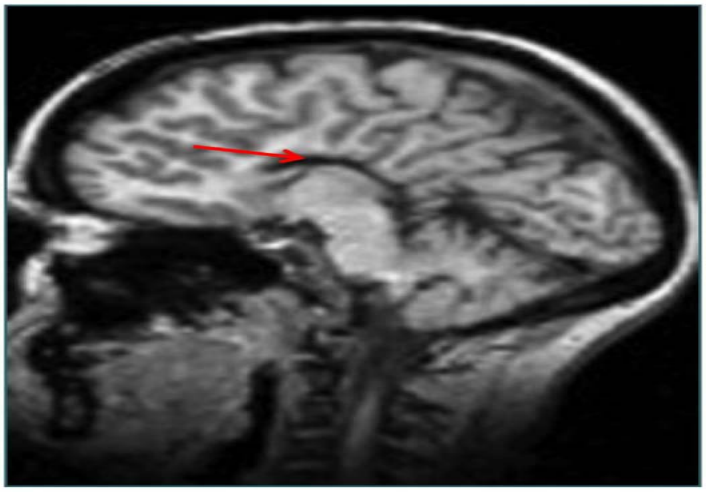
Normal brain - saggital section



Complete agenesis of corpus callosum



Solution to Question 4:

The area marked 'A' in the image is rostrum of the corpus callosum. It connects the orbital surfaces of the frontal lobes.

Solution to Question 5:

The given clinical scenario along with the image showing infantile spasms is suggestive of Aicardi syndrome, an X-linked dominant disorder associated with agenesis of the corpus callosum. The fibres of the tapetum originate from both the body and splenium of the corpus callosum.

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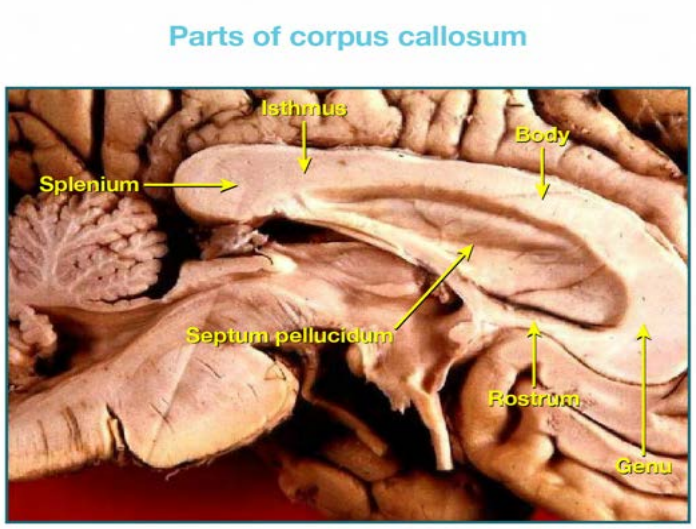
Solution to Question 6:

The structure marked A is the splenium of the corpus callosum and it is connected to the striate cortex.

The body of the corpus callosum arches posteriorly and ends as the thickened posterior portion called the splenium. The fibers from the splenium form the forceps major and arch backward into the occipital lobe (striate cortex).

The hippocampus is not connected directly to the splenium, but situated inferior to the splenium.

The image given below shows the parts of the corpus callosum.



Solution to Question 7:

The given clinical scenario of split-brain syndrome is a type of disconnection syndrome following corpus callosotomy. Commissural fibres constitute the surgically resected structure i.e. the corpus callosum.

Corpus callosotomy is a procedure where the corpus callosum is resected as a last resort to manage intractable epileptic seizures. The resultant predicament is that the patient would behave in some ways as if it were two separate minds.

Solution to Question 8:

The cingulum of the brain is classified under long association fibers.

The cingulum lies within the cingulate gyrus, connecting the frontal and parietal lobes with the parahippocampal and temporal cortical regions

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Solution to Question 9:

Corona radiata is not classified under association fibers. It an example of projection fiber.

Option A: Cingulum is a long association fiber connecting the frontal and parietal lobes with the parahippocampal and temporal cortical region.

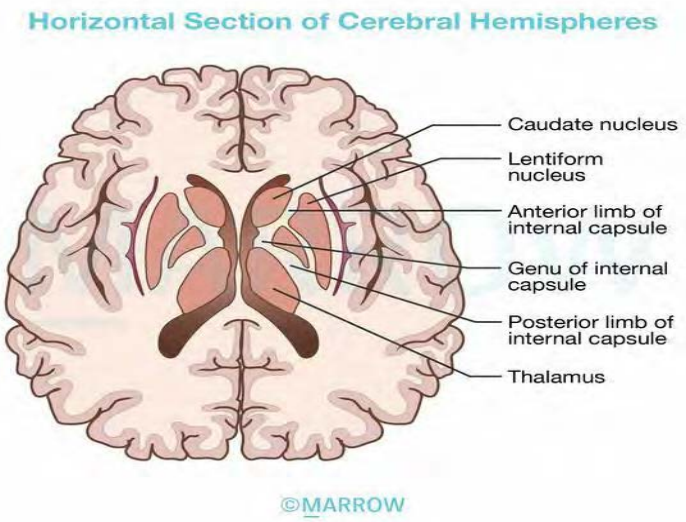
Option C: Fornix is an example of association fiber but only Hippocampal commissure of fornix is a commisural fibre as it has transverse fibers connecting the two crura of the fornix.

Option D: Arcuate fasciculus is a short association fiber.

Solution to Question 10:

The given clinical scenario is suggestive of tumour-associated psychosis. The thalamus lies medial to the posterior limb of the internal capsule and is most likely to be affected in this patient.

The internal capsule separates the thalamus and the caudate nucleus from the lentiform nucleus (globus pallidus + putamen). It is V-shaped in horizontal section and is divided into the anterior limb, genu, posterior limb, retrolenticular part, and sublenticular part. The anterior limb is located between the head of the caudate nucleus medially and the lentiform nucleus laterally. The posterior limb is located between the thalamus medially and the lentiform nucleus laterally.



Solution to Question 11:

The corticonuclear fibres pass through the genu of the internal capsule and hence, is most likely to be affected in this patient.

The majority of corticonuclear fibers cross in the median plane before supplying the cranial nerve nuclei. All cranial motor nuclei receive bilateral corticonuclear connections except, facial nucleus supplying the lower part of the face and the hypoglossal nucleus supplying the genioglossus

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muscle. Hence, a lesion of these fibers causes contralateral clinical manifestations.

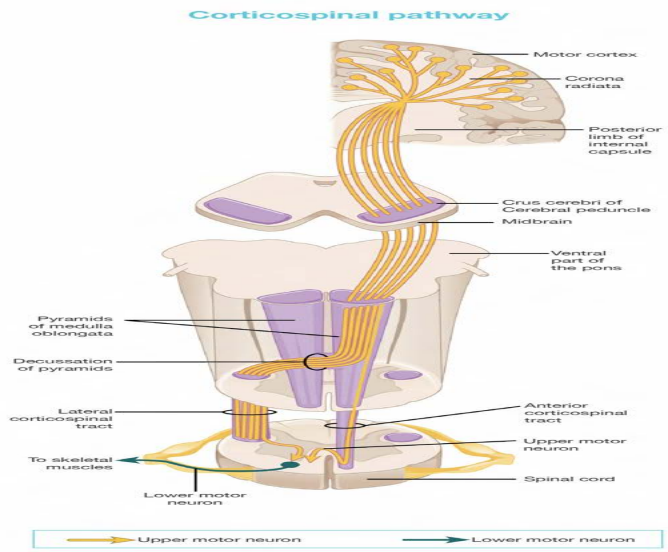
Option A: Anterior limb of the internal capsule carries fronto-pontine fibers. A lesion here produces confusion, impaired attention, agitation, and dysarthria.

Option C: Posterior limb of the internal capsule carries cortico-spinal motor fibers in the anterior part and a lesion here produces contralateral hemiparesis. The posterior part of the posterior limb of the internal capsule carries sensory fibers and lesions here may produce contralateral hemi-sensory deficits.

Solution to Question 12:

The given scenario of ipsilateral paralysis, hypertonia, hyperreflexia and ankle clonus (image) is suggestive of a corticospinal tract lesion. The anterior limb of the internal capsule does not contain corticospinal fibres. It passes through the posterior limb of internal capsule.

Corticospinal fibres have the following course as shown in the image below:



Solution to Question 13:

The correct answer is A, B, and C only.

The structure marked as 'D' is the body of the fornix and it mainly contains association fibres. The commissure of the fornix (hippocampal commissure) contains the commissural fibers.

A- Corpus callosum

B- Anterior commissure

C- Posterior commissure

D- Body of the Fornix

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The locations of the commissural fibers are:

• Corpus callosum- Medial surface of the brain

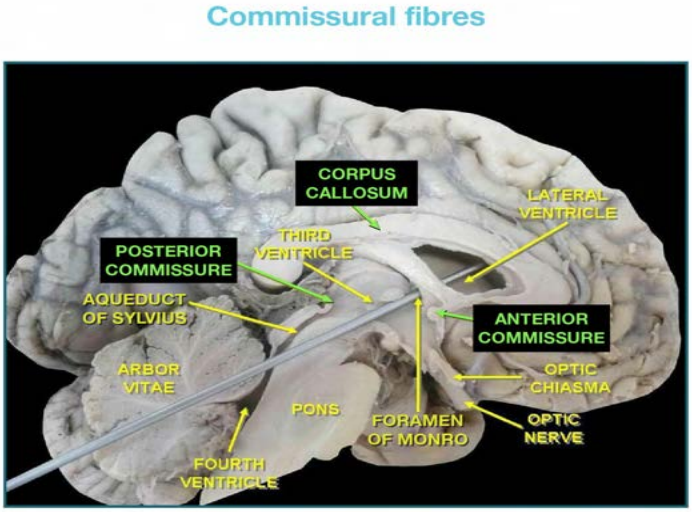
• Anterior commissure- Beneath the rostrum of the corpus callosum

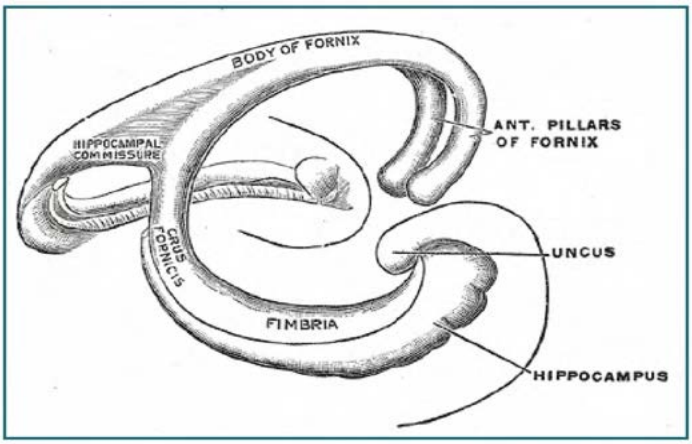
• Posterior commissure- In the inferior lamina of the pineal gland

• Habenular commissure- In the superior lamina of the pineal gland

• Hippocampal commissure- Between the right fornix and the left fornix

(Note: Varied information regarding the fibers present in the Fornix. 41st edition Gray's Clinical anatomy mentions Fornix under association fibers, the commissure of the fornix under commissural fibers. Whereas, Snell's Neuroanatomy textbook mentions the Fornix under commissural fibers.)





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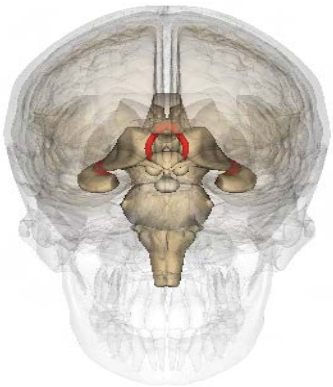

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Solution to Question 14:

The habenular commissure is located in the superior lamina of the pineal gland.

The locations of the commissural fibers are:

- Corpus callosum- Medial surface of the brain
- Anterior commissure- Beneath the rostrum of the corpus callosum
- Posterior commissure- In the inferior lamina of the pineal gland
- Habenular commissure- In the superior lamina of the pineal gland
- Hippocampal commissure- Between the right fornix and the left fornix

Solution to Question 15:

The arrow indicates the fornix. It arises from the hippocampus and ends in the mamillary body of the hypothalamus.

Fornix is an example of association fiber. It is supplied by the anterior cerebral artery.

Solution to Question 16:

A is anterior commissure, which is a type of commissural fiber, not association fiber.

B is lamina terminalis

C is the mamillary body and is a content of interpeduncular fossa.

D is the pineal gland, which does not have blood-brain barrier.

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Basal Ganglia and Limbic System

Question 1:

A 13-year-old boy presents with involuntary dancing movements of his right hand. He was diagnosed with rheumatic fever. What constitutes the ganglia involved in the presenting complication?

a) Caudate nucleus and globus pallidus

b) Globus pallidus and putamen

c) Globus pallidus and lentiform nucleus

d) Caudate nucleus and putamen

Question 2:

Which of the following is false regarding the lentiform complex?

a) The internal capsule separates the lentiform complex from caudate nucleus.

b) The external capsule separates the claustrum from putamen.

c) Putamen and globus pallidus are separated by the internal medullary lamina.

d) Putamen and globus pallidus are separated by the external medullary lamina.

Question 3:

Wilson's pencils are related to?

a) Striatum

b) Amygdala

c) Hippocampus

d) Dentate gyrus

Question 4:

A 64-year-old man presented with a reduced range of motion in his limbs. On examination, cogwheel rigidity and resting tremors were noticed. What is the direct pathway involved in this disorder?

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a) Cortex > Striatum > Globus pallidus > Subthalamic nucleus > Premotor cortex

b) Cortex > Striatum > Globus pallidus > Thalamus > Premotor cortex

c) Cortex > Globus pallidus > Subthalamic nucleus > Thalamus > Premotor cortex

d) Cortex > Globus pallidus > Striatum > Thalamus > Premotor cortex

Question 5:

A man presented with sudden violent flinging movements confined to the proximal parts of the right limb. This condition is caused due to the lesion involving which structure?

a) Striatum

b) Subthalamic nucleus

c) Globus pallidus

d) Substantia nigra

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Question 6:

Which of the following is not a part of the limbic system?

a) Cingulate gyrus

b) Amygdala

c) Hippocampal formation

d) Medial thalamic nuclei

Answer Key

Question No.	Correct Option
1	d
2	c
3	a
4	b
5	b
6	d

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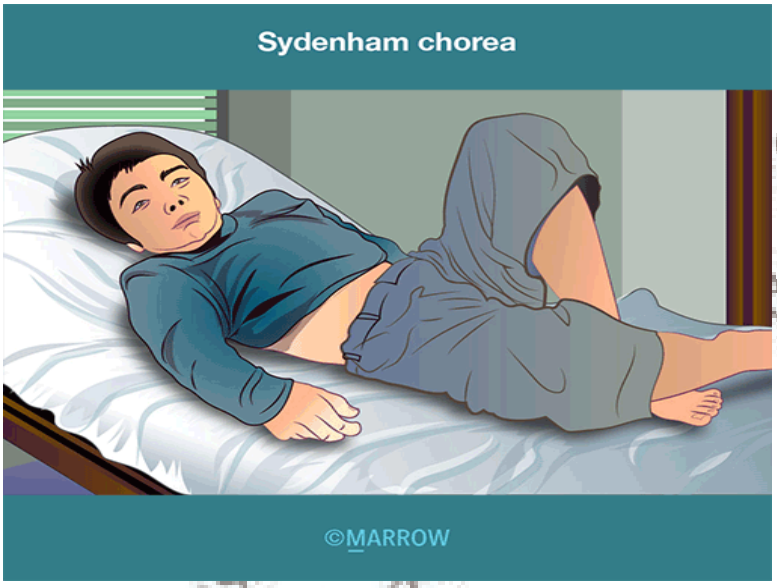
Detailed Explanations

Solution to Question 1:

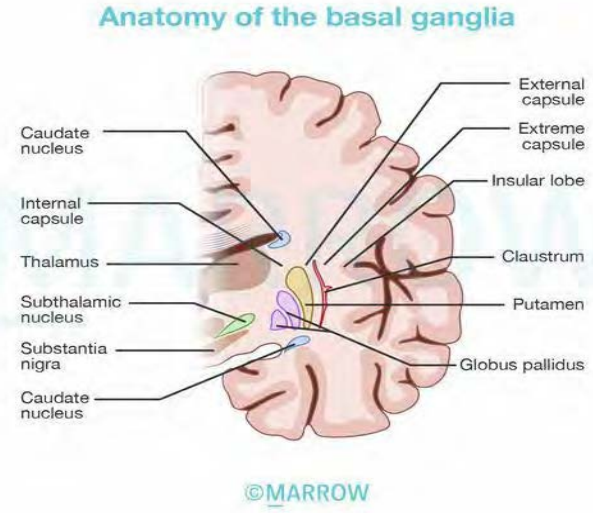
The given clinical scenario is suggestive of Sydenham's chorea, a complication of rheumatic fever. The choreic movements are caused by the destruction of D2 neurons of the striatum. The neostriatum consists of the caudate nucleus and putamen.

The image given below shows Sydenham's chorea in a patient.



Nomenclature of basal ganglia:

- Corpus striatum: Caudate nucleus + putamen+ globus pallidus
- Lentiform nucleus: Putamen + globus pallidus
- Neostriatum: Caudate nucleus + putamen



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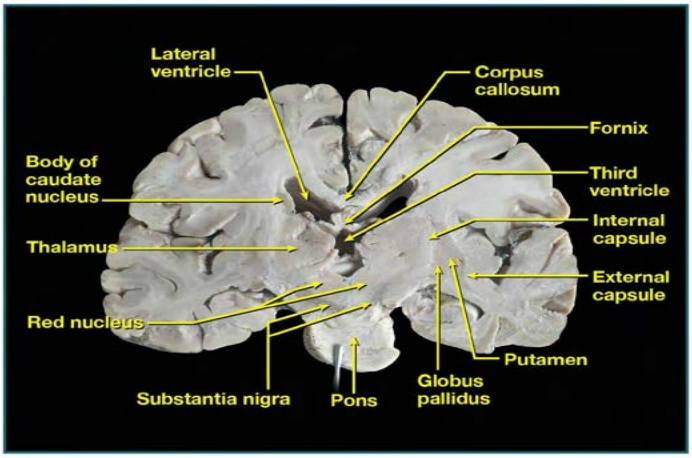
Coronal section of human brain



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Solution to Question 2:

Putamen and globus pallidus are separated by the external medullary lamina.

From deep to superficial, the order of structures of basal ganglia in horizontal section is as follows:

- Caudate nucleus (innermost)
- Internal capsule
- Globus pallidus internal (GPi)
- Internal medullary lamina
- Globus pallidus external (GPe)
- External medullary lamina
- Putamen
- External capsule
- Claustrum
- Extreme capsule
- Insular cortex (outermost)

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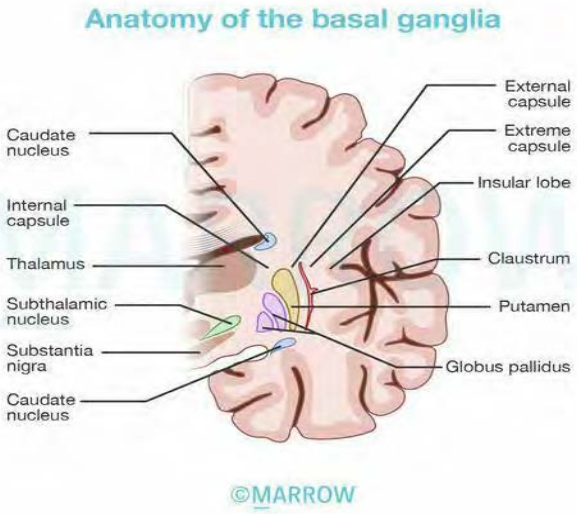

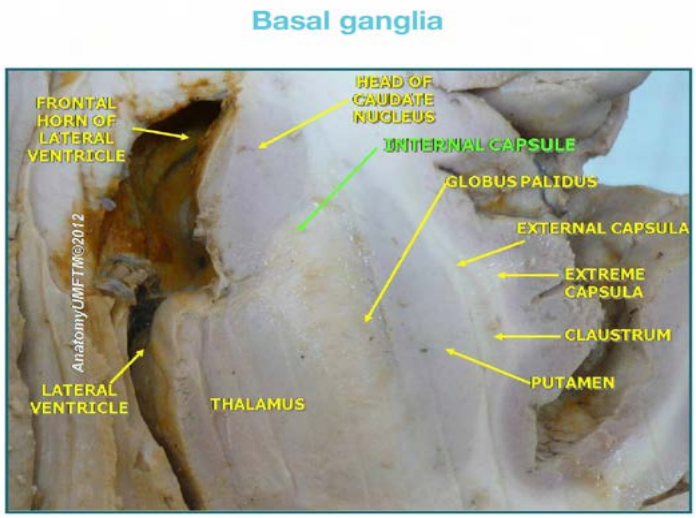

Solution to Question 3:

Wilson's pencils are thin myelinated or unmyelinated axons, which are afferents and efferents passing through the striatum.

The image given below shows micrograph of the putamen (top-right) and external globus pallidus (bottom-left), showing Wilson's pencils (blue, diagonal, linear structures).

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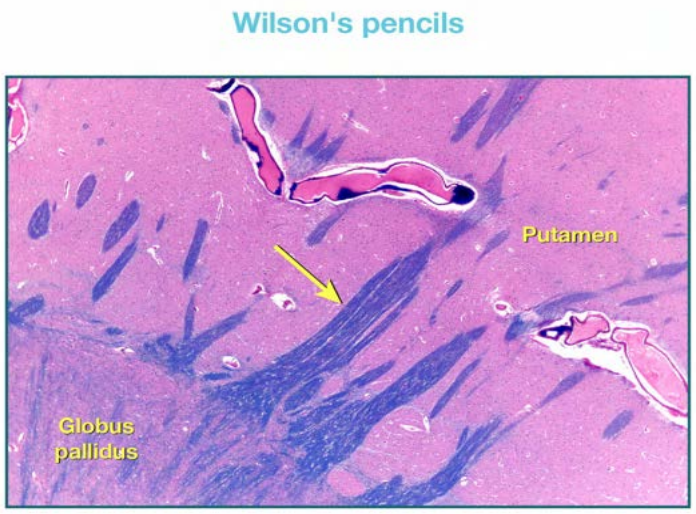

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Solution to Question 4:

The given clinical scenario is suggestive of Parkinson's disease, a disorder involving the destruction of the substantia nigra in the basal ganglia. The most accurate representation of the direct pathway in the basal ganglia is cortex > striatum > globus pallidus> thalamus > premotor cortex.

Parkinson's disease is a chronic progressive neurodegenerative disease that is clinically manifested by a triad of cardinal motor symptoms- rigidity, bradykinesia and tremor.

The indirect pathway is represented as follows:

Cortex > Striatum > Globus pallidus externa > Subthalamic nucleus > Globus pallidus interna and Substantia nigra reticulata >Thalamus > Premotor cortex

The direct pathway stimulates the cortex to produce movement and the indirect pathway inhibits movement.

Solution to Question 5:

A lesion in the subthalamic nucleus causes sudden, violent, involuntary movements confined to one side of the body, commonly affecting the proximal extremity musculature, a condition called hemiballismus. The movements are seen contralateral to the side of the lesion, i.e., involuntary movements of the right arm and leg are seen in the lesion of the left subthalamic nucleus and vice versa.

Solution to Question 6:

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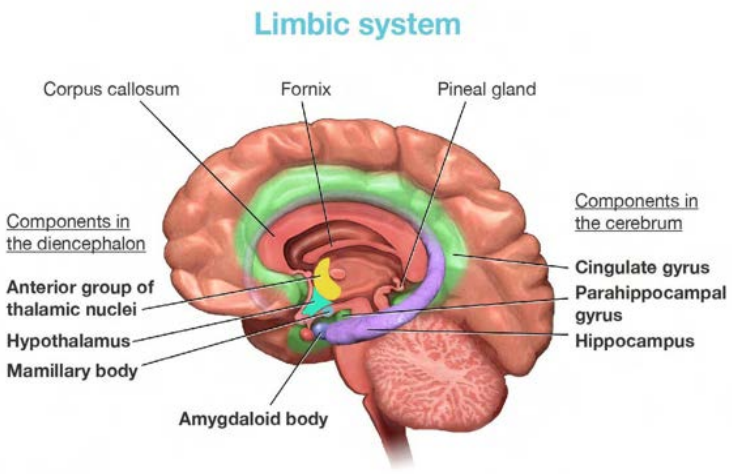
Medial thalamic nuclei are not part of the limbic system. The anterior nucleus of the thalamus is a part of the limbic system.

The limbic system controls emotional behavior and is involved in the conversion of short-term memory to long-term memory. It consists of both the grey mater and white mater. It is located between the cerebral cortex and the hypothalamus.



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Diencephalon

Question 1:

A man presented with frequent urination and increased thirst. MRI revealed the absence of the posterior pituitary bright spot. He was initiated on desmopressin which improved his symptoms. The affected structure is derived from:

a) Metencephalon

b) Myelencephalon

c) Telencephalon

d) Prosencephalon

Question 2:

Which of the following is false regarding the anatomical relations of the thalamus?

a) Anterior pole of thalamus forms the posterior boundary of the interventricular foramen.

b) Pulvinar projects over the superior colliculus.

c) Medial surface of thalamus forms the inferior boundary of III ventricle.

d) The posterior limb of the internal capsule is laterally related to the thalamus.

Question 3:

The following section of the brain is given to you. Which of the following is true about the marked structure?

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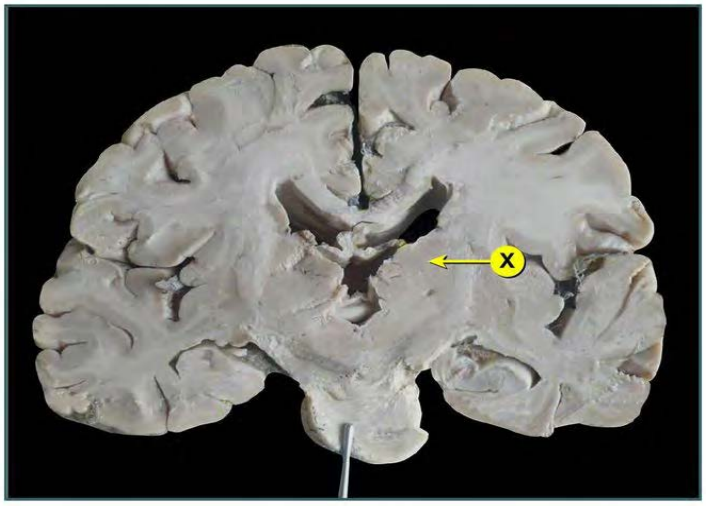

a) The external medullary lamina is a sheet of grey matter on the lateral surface of thalamus.

b) The intralaminar nuclei lie outside the internal medullary lamina.

c) The internal medullary lamina divides the thalamus into three parts.

d) The internal medullary lamina divides the thalamus into two parts.

Question 4:

Which of the following is false about the anterior thalamic nuclei?

a) Largest subdivison is the anteromedial nucleus

b) Receives fibers from the mamillary body

c) Lesion on this nuclei can cause amnesia

d) Involved in regulation of alertness and attention

Question 5:

The medial nucleus of the thalamus predominantly receives input from the ____ and sends output to the _____.

a) Mamillary bodies, Cingulate gyrus

b) Hypothalamus, Prefrontal cortex

c) Substantia nigra, Motor cortex

d) Cerebellum, Motor cortex

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Question 6:

A 56-year-old woman was diagnosed with thalamic syndrome. The largest division of the affected structure is:

a) Anterior thalamic nuclei

b) Lateral thalamic nuclei

c) Medial thalamic nuclei

d) Intralaminar nuclei

Question 7:

Which of the following correctly matches the thalamic nuclei with the region it receives input from?

a) Ventral anterior nucleus - Medial lemniscal pathway

b) Ventral lateral nucleus - Spinothalamic pathway

c) Ventral posterolateral nucleus - Gustatory pathway

d) Ventral posteromedial nucleus - Trigeminothalamic pathway

Question 8:

Choose the incorrect statement with respect to thalamic nuclei.

a) Intralaminar nuclei influences the levels of consciousness

b) Medial geniculate body receives information from both the ears, but predominantly from contralateral ear

c) Lateral geniculate body receives visual information from opposite field of vision

d) Medial geniculate body receives information from both the ears, but predominantly from ipsilateral ear

Question 9:

MRI of the coronal section of the brain is given to you. Which of the following nuclei of the marked structure does not project to neocortex?

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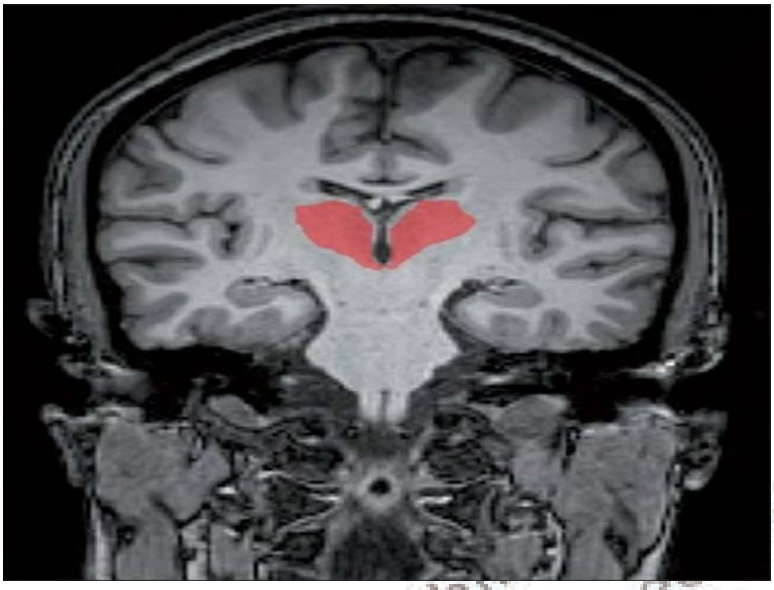

a) Intralaminar nuclei

b) Pulvinar nuclei

c) Reticular nuclei

d) Midline nuclei

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Question 10:

A man sustained a head injury 6 weeks back, following a road traffic accident. Now, he complains of increased frequency of urination and excessive thirst. An injury to which nucleus is likely to cause the given condition?

a) Preoptic nucleus

b) Supraoptic nucleus

c) Suprachiasmatic nucleus

d) Paraventricular nucleus

Question 11:

What structure is not a part of the epithalamus?

a) Tuber cinereum

b) Habenular nuclei

c) Stria medullaris

d) Posterior commissure

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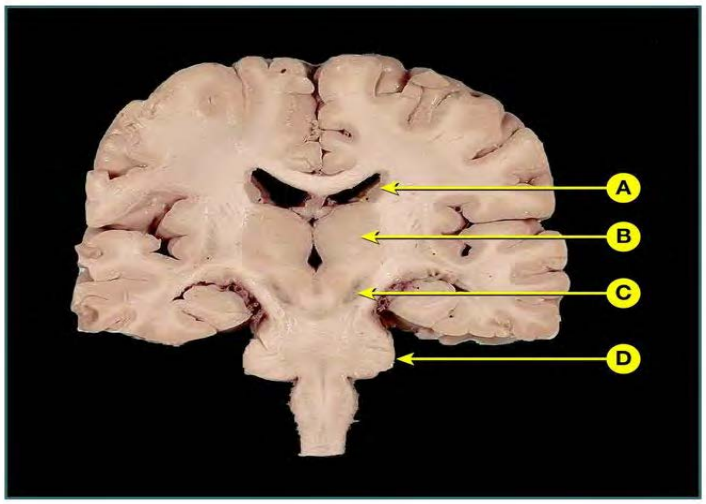
Question 12:

A woman with right-sided loss of sensations of both the upper and lower limb complains of shooting pain from her fingers to the right shoulder and a burning sensation when touching cold water. Motor functions are normal. Which of the following structures is likely to be involved?



a) A

b) B

c) C

d) D

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Answer Key

Question No.	Correct Option
1	d
2	c
3	c
4	a
5	b
6	b

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7	d
8	d
9	c
10	b
11	a
12	b

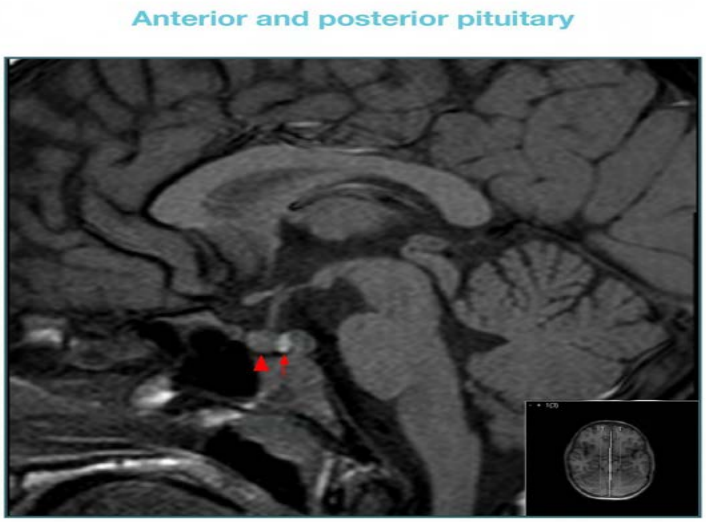
Detailed Explanations

Solution to Question 1:

The given clinical scenario of polyuria and polydipsia along with the investigation findings is suggestive of central diabetes insipidus. It involves the diencephalon, a structure that is derived from the prosencephalon.

The diencephalon forms the thalamus, epithalamus, subthalamus, and hypothalamus.

The MRI given below shows the posterior pituitary bright spot. The arrow points at the posterior pituitary and the arrowhead at the anterior pituitary.



Solution to Question 2:

The medial surface of the thalamus does not form the inferior boundary of the third ventricle. It forms the lateral wall of the IIIrd ventricle.

The thalamus is an ovoid shape mass of grey matter that forms a relay station for all information passing to the cerebral cortex, basal ganglia, hypothalamus, and brainstem.

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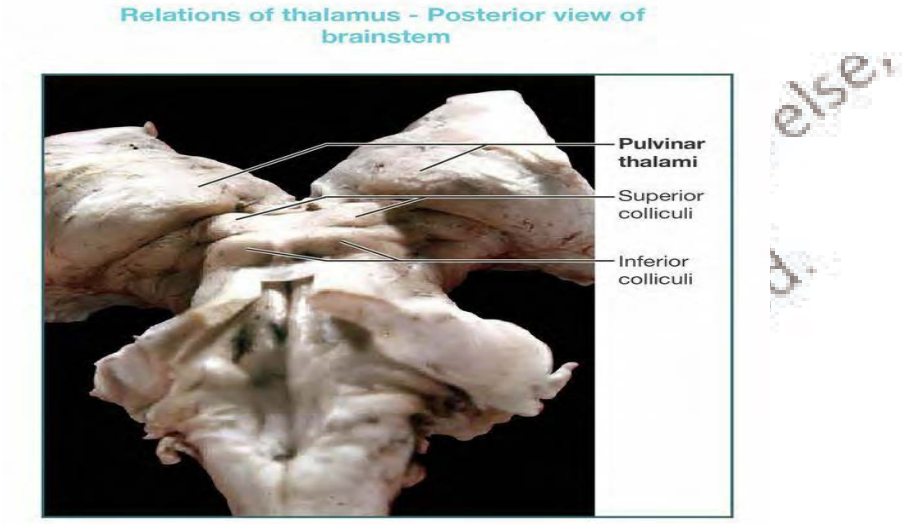
Relations of the thalamus:

• Anteriorly: Interventricular foramen

• Superiorly: It is covered by a sheet of white matter called stratum zonale. Above the stratum zonale lies the body of fornix and the ventricle

• Posteriorly: The posterior end is expanded to form the pulvinar, which overhangs above the superior colliculus.

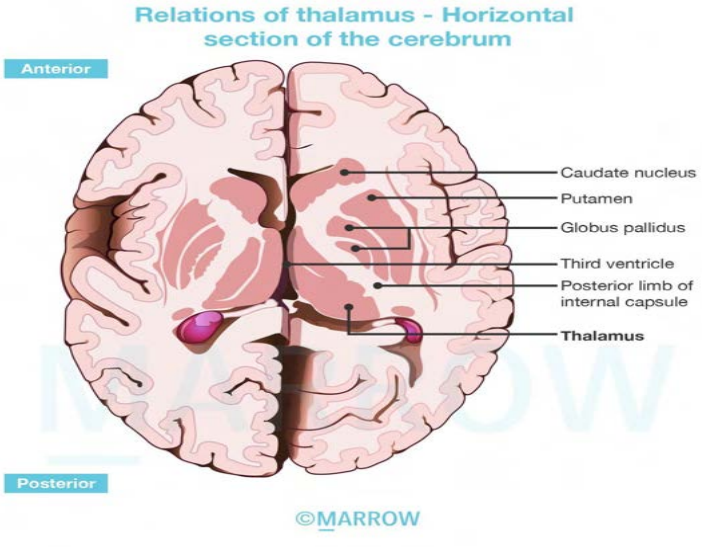
• Inferiorly: Plane connecting the hypothalamic sulci



• Medially: Lateral wall of the third ventricle

• Laterally: Posterior limb of the internal capsule

The image below demonstrates the lateral and medial relations of the thalamus.



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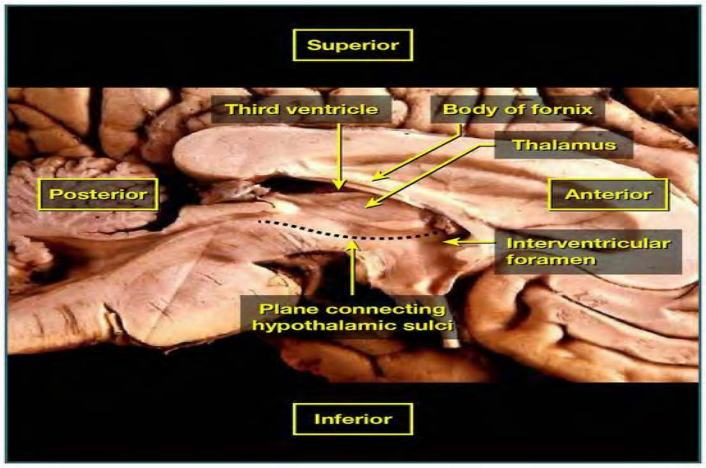
Relations of Thalamus -
Sagittal section of brain



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Solution to Question 3:

The marked structure 'X' is thalamus. Internal medullary lamina is a Y-shaped sheet of white matter dividing the thalamus to 3 parts:

- Anterior nuclear groups
- Medial nuclear groups
- Lateral nuclear groups

External medullary lamina is a sheet of white matter on the lateral surface of the thalamus that separates the thalamus from the reticular nucleus.

The intralaminar nuclei lie embedded within the internal medullary lamina and the midline nuclei lie close to the lateral walls of the third ventricle.

The thalamus plays an important role in sensory and motor integration.

Input and output of the thalamus:

- Pre-cortical input- All sensory system (except olfactory system)
- Cerebral cortex input- Largest input (from modified pyramidal cells of layer VI)
- Projection fibers to other areas-
- Cerebral cortex (most fibers)
- Basal nuclei and hypothalamus (few fibers)

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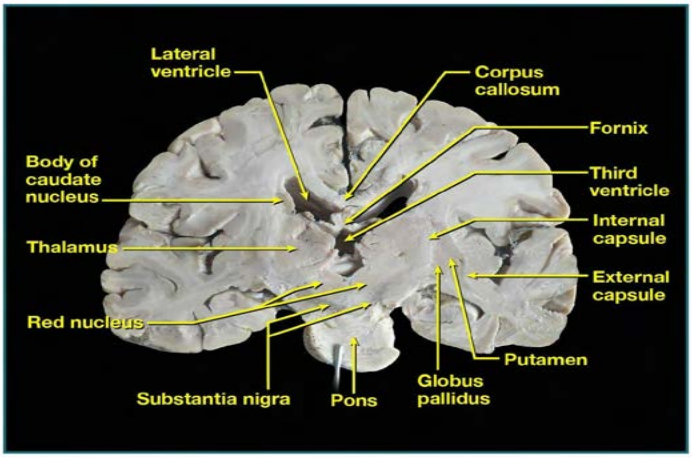
Coronal section of human brain



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Solution to Question 4:

The largest subdivision of anterior thalamic nuclei is the anteroventral nucleus (and not the anteromedial nucleus).

The anterior thalamic nuclei have 3 subdivisions—anteroventral nucleus, anteromedial nucleus and anterodorsal nucleus.

• Major input: Mamillothalamic tract from the mammillary nuclei of the hypothalamus.

• Major cortical output: Anterior limbic area, cingulate, and the parahippocampal gyrus

• Major function:

• Regulation of alertness and attention

• Acquisition of memory

Solution to Question 5:

The medial nucleus of the thalamus predominantly receives input from the hypothalamus and sends output to the prefrontal cortex.

The medial thalamic nuclei contain the large dorsomedial nucleus and several smaller nuclei:

• Internally, the dorsomedial nucleus is connected to all other thalamic nuclei.

• Externally, it has 2 major connections—the prefrontal cortex and the hypothalamus. Its functions include integration of somatic, visceral, and olfactory sensory information as well as relation of this sensory information to emotional feelings and subjective states.

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Solution to Question 6:

The largest division of the affected structure i.e. the thalamus is the lateral thalamic nuclei.

The lateral thalamic nuclei are further divided into the dorsal and ventral nuclei, as shown below.

Solution to Question 7:

The ventral posteromedial nucleus receives inputs from the trigeminothalamic pathway.

Solution to Question 8:

The medial geniculate body receives auditory input from both the ears, but predominantly from the contralateral ear (not ipsilateral ear).

Solution to Question 9:

The marked structure is the thalamus. The reticular nucleus of the thalamus does not project to the neocortex. Its output is mainly to the other thalamic nuclei.

All other thalamic nuclei send output to the neocortex.

Solution to Question 10:

Lesion of the supraoptic nucleus of the hypothalamus causes inhibition of the synthesis of vasopressin leading to diabetes insipidus.

The hypothalamus is a part of the diencephalon that lies below the thalamus.

• Anteriorly, the preoptic area is included in the hypothalamus.

• Posteriorly, it merges with the tegmentum of the midbrain.

• Laterally, it is bounded by the internal capsule.

Microscopically, the hypothalamus is divided into multiple nuclei.

Solution to Question 11:

Tuber cinereum is not a part of the epithalamus. It is a part of the hypothalamus.

The epithalamus consists of:

• Anterior and posterior paraventricular nuclei

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- Medial and lateral habenular nuclei
- Stria medullaris thalami
- Posterior commissure
- Pineal gland

Solution to Question 12:

The given clinical stem of a hemi-sensory loss and severe excruciating pain of the affected areas is suggestive of thalamic pain syndrome also known as Dejerine Roussy syndrome. Hence, thalamus marked as B is most likely to be involved.

Occlusion of these thalamic and thalamogeniculate branches results in the thalamic pain syndrome. It is characterized by C/L hemisensory loss which starts as numbness and progresses to cause severe burning pain in the affected regions. As the thalamus is the site for the relay of sensory information between the periphery and cortex, a lesion in the thalamus causes a miscommunication between the afferent pathway and cortex of the brain. Pain occurs during the recovery from the thalamic infarct. This pain responds poorly to analgesics. Anticonvulsants such as carbamazepine or gabapentin or tricyclic antidepressants may be beneficial.

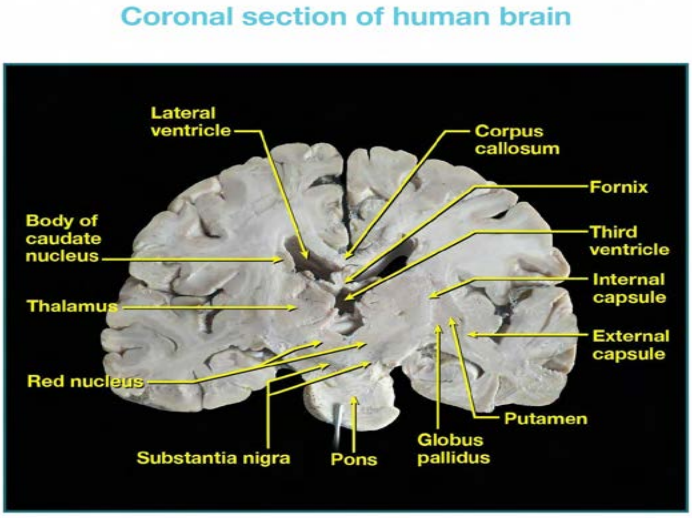
Other markings:

A: Caudate nucleus

C: Substantia nigra

D: Pons

The image below shows the coronal section of the brain with different parts of the basal ganglia:



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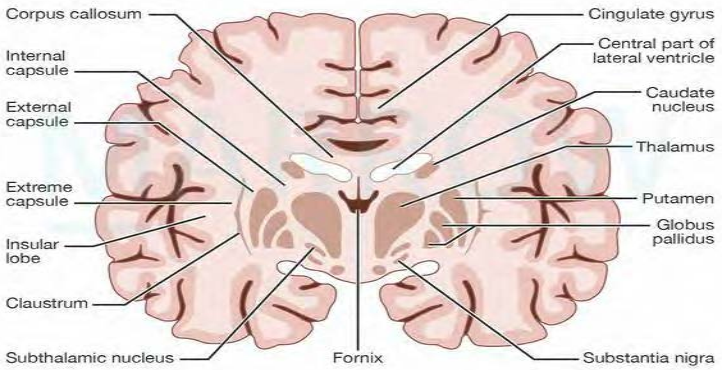
Coronal section of brain
white matter tracts of brain



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Brainstem

Question 1:

Red nucleus is situated at the level of the _____.

a) Midbrain--superior colliculus

b) Midbrain--inferior colliculus

c) Pons

d) Medulla

Question 2:

A woman presented with diplopia and conjugate nystagmus suggestive of a left-sided oculomotor paralysis. She also had right-sided hemiplegia. Choose the correct statement about the affected structure.

a) The superior brachium passes from the superior colliculus to the medial geniculate body

b) The trochlear nerve emerges above the inferior colliculus

c) The substantia nigra separates the tegmentum from the tectum

d) The tectum lies posterior to the cerebral aqueduct

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Question 3:

Radiography in a 34-year-old patient revealed damage to the midbrain at the level of the superior colliculus following road traffic accident. Which tract is not likely to be injured?

a) Medial lemniscus

b) Spinal lemniscus

c) Trigeminal lemniscus

d) Lateral lemniscus

Question 4:

Ventral tegmental decussation in the cerebral peduncle is due to:

a) Tectospinal tract

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b) Tectobulbar tract

c) Vestibulospinal tract

d) Rubrospinal tract

Question 5:

Fibres passing through the most medial part of crus-cerebri are:

a) Corticospinal and corticonuclear fibres

b) Frontopontine fibres

c) Tempropontine fibres

d) Corticonuclear fibres

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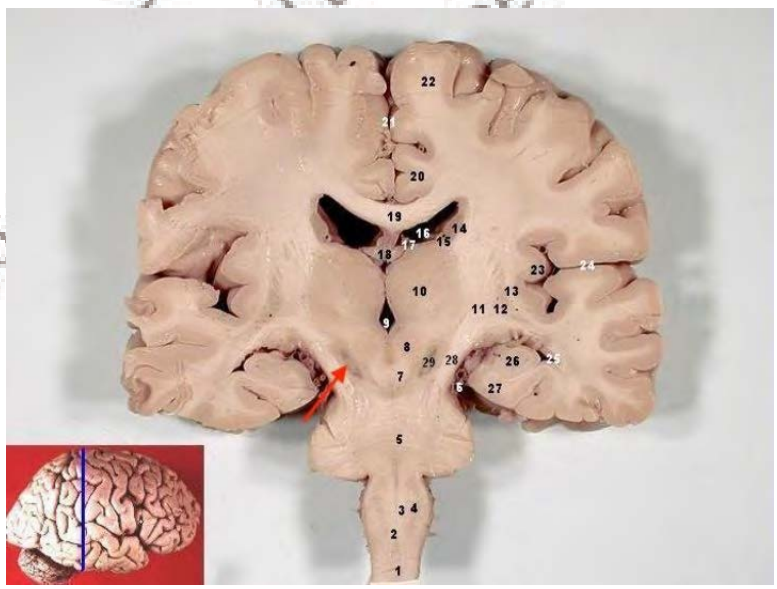
Question 6:

The following structure was affected in a man diagnosed with a movement disorder. What is the likely diagnosis?



a) Paralysis agitans

b) Creutzfeldt–Jakob disease

c) Multiple system atrophy

d) Huntington's chorea

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Question 7:

Which of the following structures are not present in interpeduncular fossa?

a) Mamillary bodies

b) Tuber cinerum

c) Oculomotor nerve

d) Ophthalmic nerve

Question 8:

A patient presented with weakness of the right side of the face with the loss of pain and temperature. Pain and temperature sensation of the left leg is also lost. The lesion is most likely located at?

a) Medial medulla

b) Lateral pons

c) Medial pons

d) Lateral medulla

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Question 9:

An electrician experienced a 10,000 V shock through his body and suffered third-degree burns on his hands and scalp. Diffusion tensor imaging showed damage to the right medial lemniscus tract. This is formed by:

a) Anterior external arcuate fibres

b) Internal arcuate fibres

c) Posterior external arcuate fibres

d) External arcuate fibres

Question 10:

A gross specimen of the brainstem is given below. The marked structure is seen in which part of the brain?

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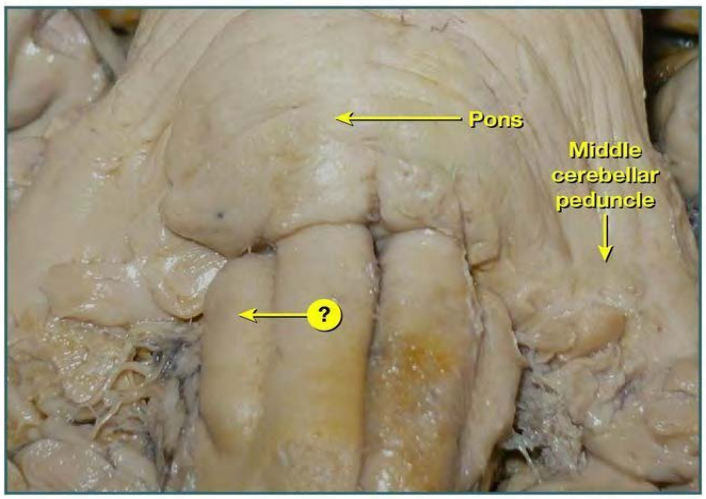


a) Midbrain

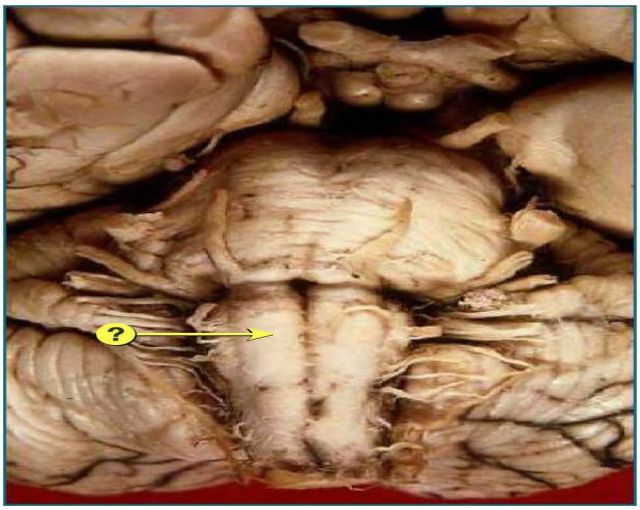
b) Pons

c) Medulla

d) Cerebellum

Question 11:

A lesion of the structure marked in the image below causes?



a) Contralateral hemiplegia

b) Ataxia

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c) Tinnitus

d) Ipsilateral facial palsy

Question 12:

Which structure is present on the floor of the fourth ventricle in the medullary cross-section at the level of olives?

a) Dorsal nucleus of vagus

b) Trapezoid body

c) Superior vestibular nucleus

d) Nucleus gracilis

Question 13:

A woman presented with sudden onset of dysphagia, dysarthria and gait ataxia. MRI revealed an acute infarct in the right dorsolateral medulla. What is the likely diagnosis?

a) Dejerine's anterior bulbar syndrome

b) Wallenberg syndrome

c) Babinski-Nageotte syndrome

d) Weber syndrome

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Question 14:

A 62-year-old man presented with sudden onset of loss of pain and temperature on the right side of his face and left side of his body. He also has dysphagia and dysarthria. Thrombosis of which vessel is likely to cause the given condition?

a) Subclavian artery

b) Anterior inferior cerebellar artery

c) Posterior inferior cerebellar artery

d) Posterior cerebral artery

Answer Key

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Question No.	Correct Option
1	a
2	d
3	d
4	d
5	b
6	a
7	d
8	b
9	b
10	c
11	a
12	a
13	b
14	c

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Detailed Explanations

Solution to Question 1:

The red nucleus is situated at the level of the superior colliculus in the midbrain.

Level	Inferior colliculus	Superior colliculus
Cavity	Cerebral aqueduct	Cerebral aqueduct
Nuclei	Inferior colliculus, substantia nigra, trochlear nucleus, mesencephalic nucleus of V nerve	Superior colliculus, substantia nigra, trochlear nucleus, mesencephalic nucleus of V nerve, oculomotor nucleus, Edinger- Westphal nucleus, red nucleus
Motor tract	Corticospinal and corticonuclear tracts, temporopontine, frontopontine, medial longitudinal fasciculus	Corticospinal and corticonuclear tracts, temporopontine, frontopontine, medial longitudinal fasciculus, decussation of rubrospinal tract
Sensory tract	Lateral, trigeminal spinal, and medial lemnisci, decussation of superior cerebellar peduncles	Trigeminal spinal and medial lemnisci

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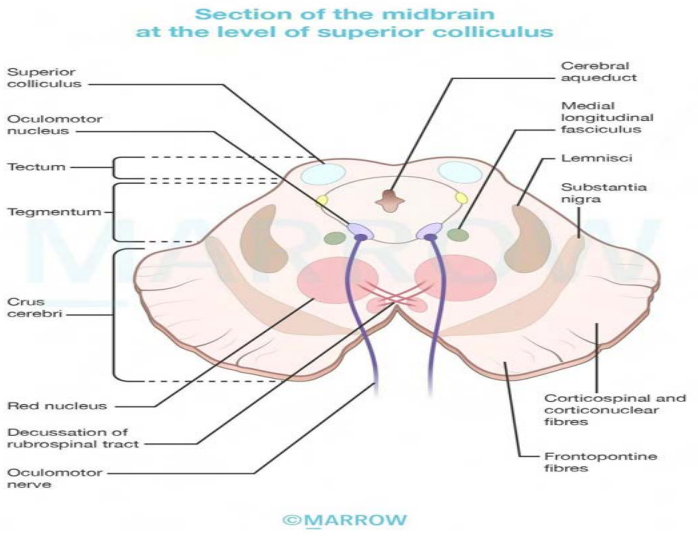

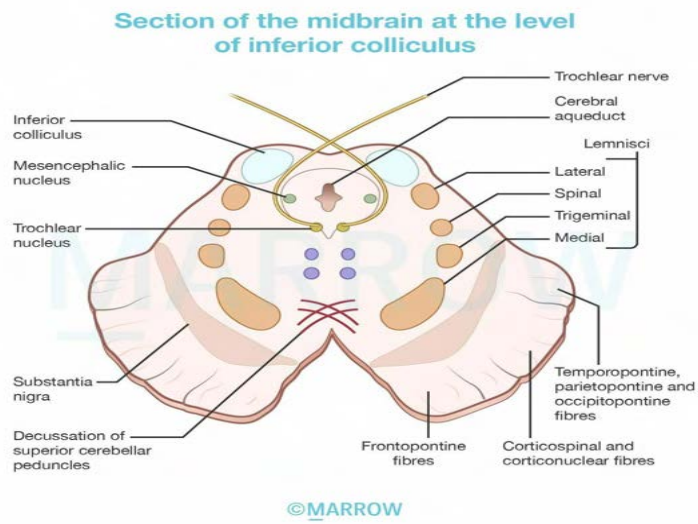

Solution to Question 2:

The given clinical scenario of contralateral hemiplegia and paralysis of the third cranial nerve is suggestive of Weber syndrome involving the midbrain. In this, the tectum lies posterior to the cerebral aqueduct.

The midbrain connects the pons and cerebellum with the forebrain. Externally, on the posterior surface, there are two pairs of colliculi—the corpora quadrigemina:

• The superior colliculi are centers for visual reflexes. The superior brachium connects the superior colliculi to the lateral geniculate body and the optic tract.

• The inferior colliculi are auditory centres, and the inferior brachium connects the inferior colliculus to the medial geniculate body.

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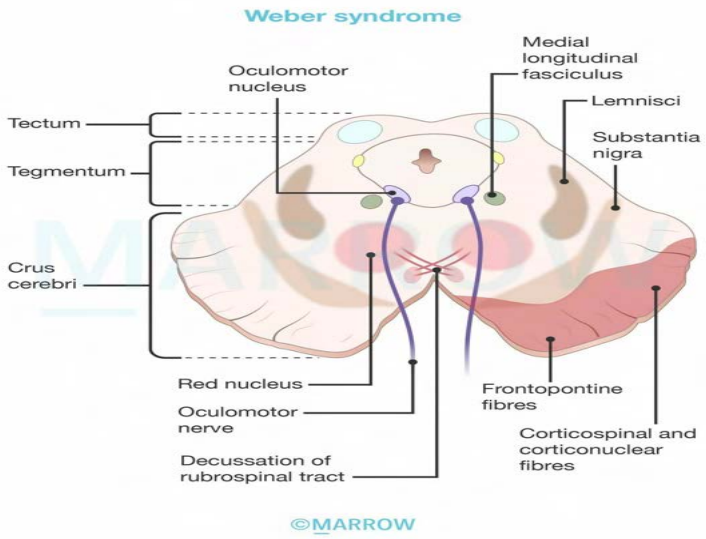
The trochlear nerve emerges in the midline below the inferior colliculi.

Internally, the midbrain comprises two cerebral peduncles. Each one is divided into an anterior crus cerebri and a posterior tegmentum by the substantia nigra. The oculomotor nerve emerges from a groove on the medial side of crus cerebri and passes to the lateral wall of the cavernous sinus.



Solution to Question 3:

Lateral lemniscus is not seen at the level of the superior colliculus, therefore it is not susceptible to injury in this case. It is a part of the auditory pathway and ends at the level of the inferior colliculus of the midbrain.

Level	Superior colliculus	Inferior colliculus
Cavity	Cerebral aqueduct	Cerebral aqueduct
Nuclei	Superior colliculus, substatia nigra, oculomotor nucleus, E dinger- Westphal nucleus, m esencephalic nucleus of V ner ve	Inferior colliculus, substatia nigra, trochlear nucleus, mes encephalic nucleus of V nerv e
Motor tract	Corticospinal and corticonucl ear tracts, temporopontine, fr ontopontine, medial longitud inal fasciculus, decussation o f rubrospinal tract	Corticospinal and corticonucl ear tracts, temporopontine, fr ontopontine, medial longitud inal fasciculus
Sensory tra ct	Trigeminal, spinal and media l lemnisci	Lateral, trigeminal spinal and medial lemnisci, decussation of superior cerebellar pedun cles

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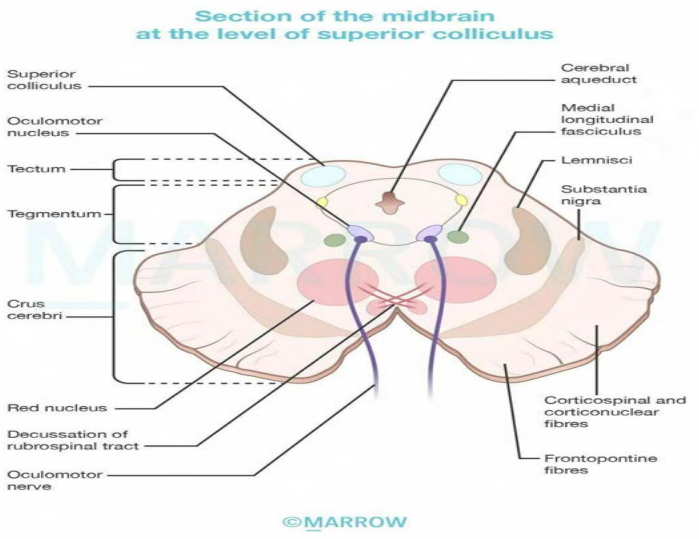

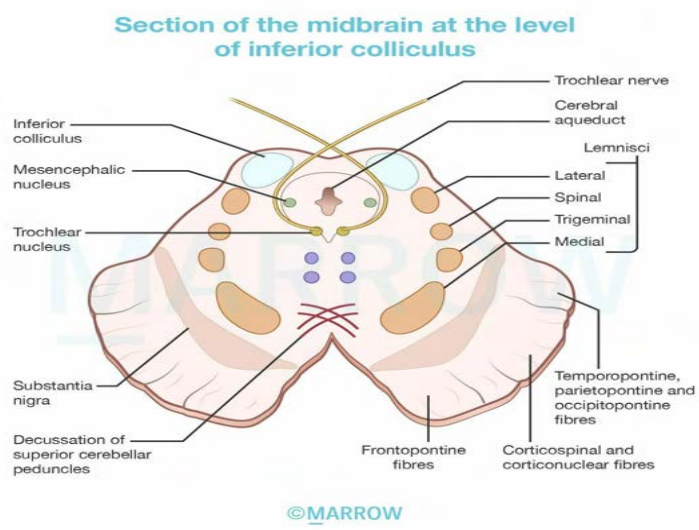

Solution to Question 4:

The ventral tegmental decussation in the midbrain is due to the rubrospinal tract.

The red nucleus is situated at the level of superior colliculus.

• It receives afferents from the corticorubral fibers in the cortex and the cerebellorubral fibers in the cerebellum.

• It sends out efferent fibers as the rubrospinal tract.

• It decussates as ventral tegmental decussation at the level of the superior colliculus and descends to the spinal cord.

The midbrain has four decussations:

• At the level of the superior colliculus

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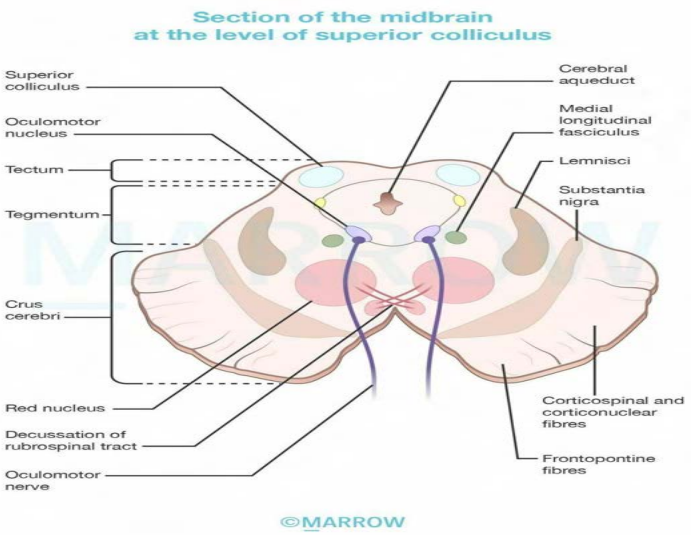
• Ventral tegmental decussation of the rubrospinal tract

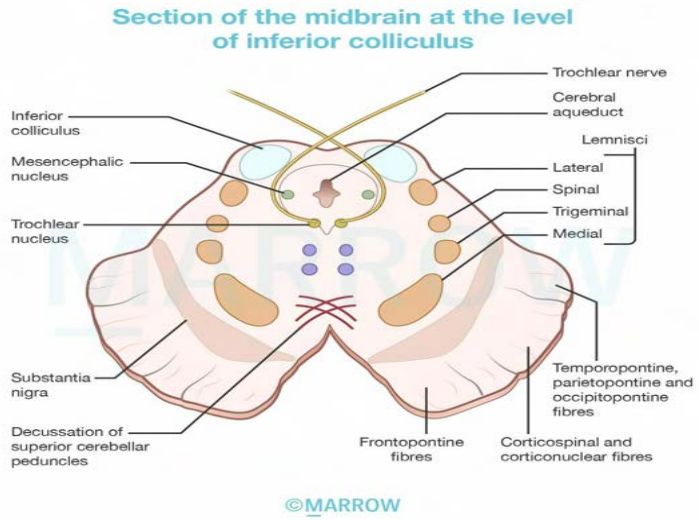
• Dorsal tegmental decussation of the tectospinal tract

• At the level of the inferior colliculus

• Decussation of superior cerebellar peduncles

• Decussation of trochlear nerve





Solution to Question 5:

Fibres passing through the most medial part of crus cerebri are frontopontine fibers.

The crus cerebri contains important descending tracts:

• Middle two-thirds: Corticospinal and corticonuclear fibers

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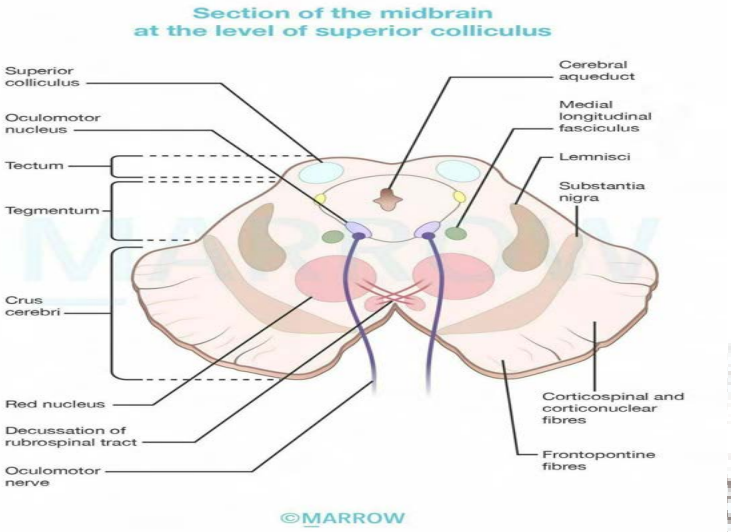
- Medial part: Frontopontine fibers
- Lateral part: Temporopontine fibers



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Solution to Question 6:

The given clinical scenario is suggestive of paralysis agitans(parkinsonism). The structure marked in the image is the substantia nigra in the coronal section of the midbrain.

Solution to Question 7:

The ophthalmic nerve is not a content of the interpeduncular fossa.

The floor of the interpeduncular fossa anteriorly to posteriorly contains - tuber cinerum, infundibular stalk, mamillary bodies, and posterior perforated substance. The posterior perforated substance is pierced by the posterior cerebral arteries. The oculomotor nerve emerges between the superior cerebellar and posterior cerebral arteries in the interpeduncular fossa.

The image given below shows the interpeduncular fossa.

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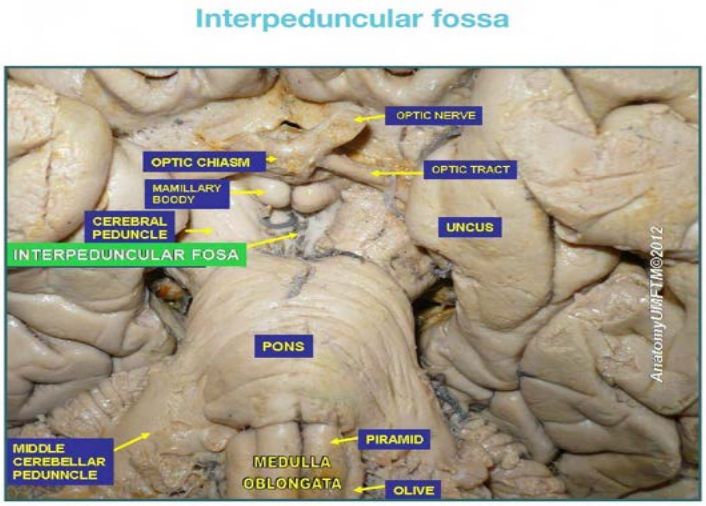

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Solution to Question 8:

The above clinical scenario is suggestive of lateral pontine syndrome which occurs due to a lesion located at lateral pons.

Lateral pontine syndrome occurs due to the involvement of the anterior inferior cerebellar artery.

• Ipsilateral manifestations include:

• CN VII: Facial paralysis

• CN V: loss of pain and temperature sensation over the face.

• Vestibular nerve or nucleus: Horizontal and vertical nystagmus, vertigo, nausea, vomiting, oscillopsia.

• Auditory nerve or cochlear nucleus: Deafness, tinnitus.

• Middle cerebellar peduncle: Ataxia of limb and gait.

• Contralateral manifestations include:

• Spinothalamic tract: Loss of pain and temperature sensation over the body.

Medial pontine syndrome occurs due to the involvement of the paramedian branch of the basilar artery.

• Ipsilateral manifestation

• CN VI: Diplopia(lateral rectus muscle paralysis - the affected eye looks downwards and inwards)

• Vestibular nucleus: Nystagmus.

• Middle cerebellar peduncle: Ataxia of limb and gait.

• Contralateral manifestation

• Corticobulbar and corticospinal tract: Paralysis of face, arm, and leg.

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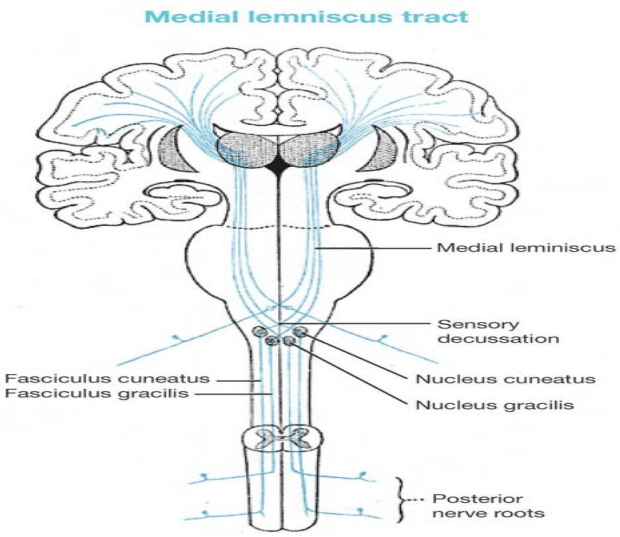
• Medial lemniscus: loss of touch and proprioception from the body.

Solution to Question 9:

The given clinical scenario is suggestive of medial lemniscus tract lesion following a high voltage electrical injury. The medial lemniscus is formed by the internal arcuate fibres. It is also called Reil's ribbon.

The internal arcuate fibres are axons of the second-order neurons from nucleus gracilis and nucleus cuneatus. In the upper medulla, they decussate and form the medial lemniscus which synapses in the thalamus.

The image given below depicts the medial lemniscus tract.



Solution to Question 10:

The marked structure i.e. olive is seen in the medulla. The external features of medulla oblongata are:

Anteriorly, the anterior median fissure is continuous with the anterior median fissure of the spinal cord. On either side of the fissure are pyramids containing the corticospinal tracts. Posterolateral to the pyramids are olives. Olives are elevations produced by the underlying inferior olivary nuclei. Posterior to the olives, the inferior cerebellar peduncles connect the medulla with the cerebellum.

Posteriorly, the superior half forms the floor of the fourth ventricle. Inferiorly, there is a posterior median sulcus. On either side of this sulcus, the nucleus gracilis is situated. The nucleus cuneatus lies lateral to nucleus gracilis.

The anterolateral sulcus lies in the groove between the pyramid and the olive and the XII cranial nerve emerges from there. The posterolateral sulcus lies in the groove between the olives and the

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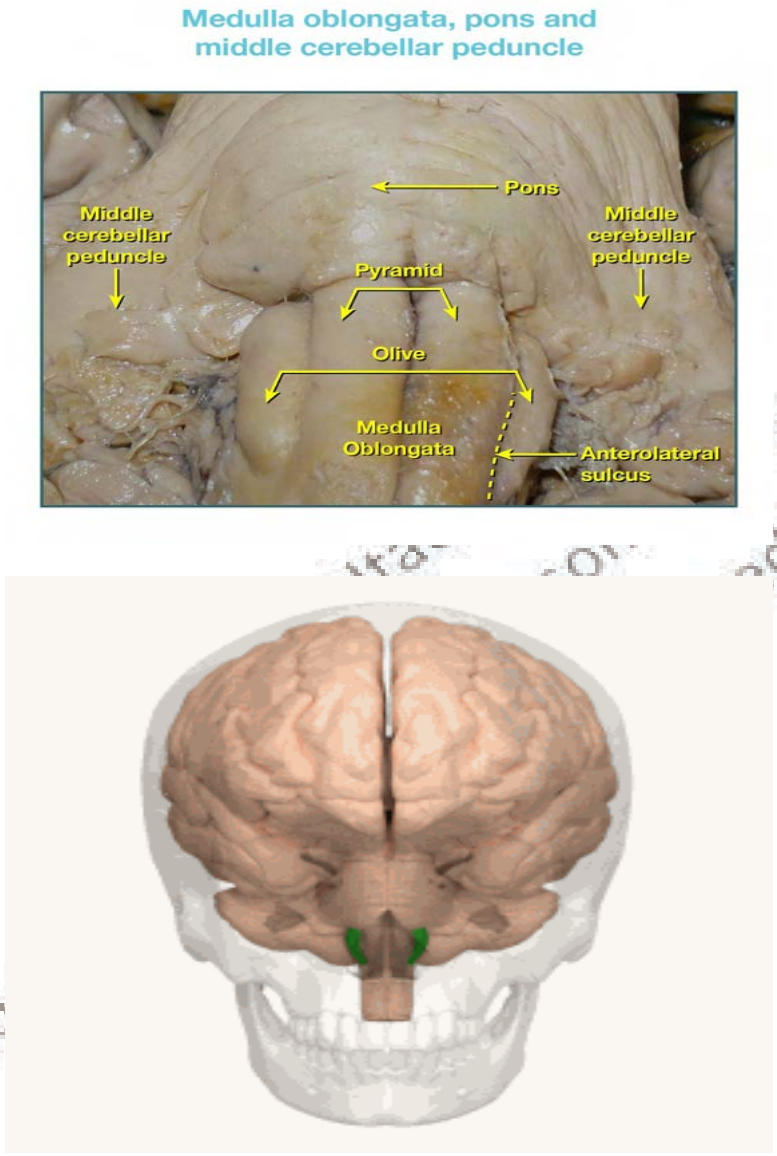
inferior cerebellar peduncles. The IX, X, and XI cranial nerves emerge from here.



Solution to Question 11:

The structure marked in the image is the pyramid containing the pyramidal tracts. A lesion here leads to contralateral hemiplegia.

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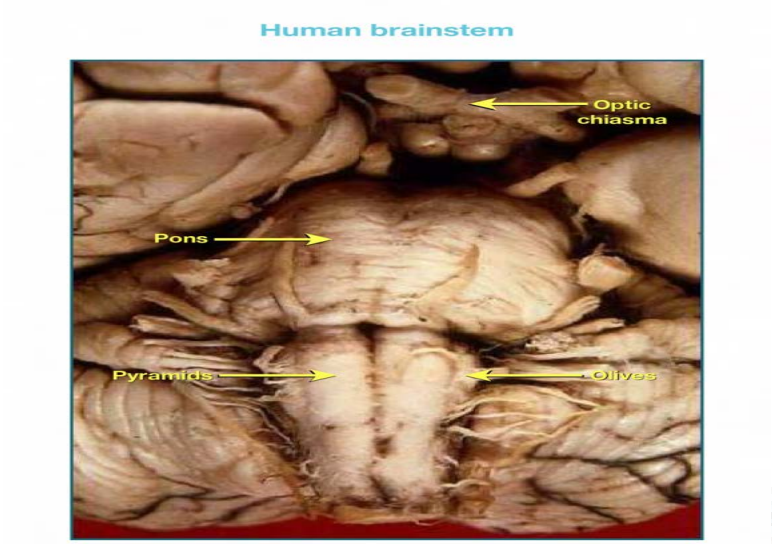

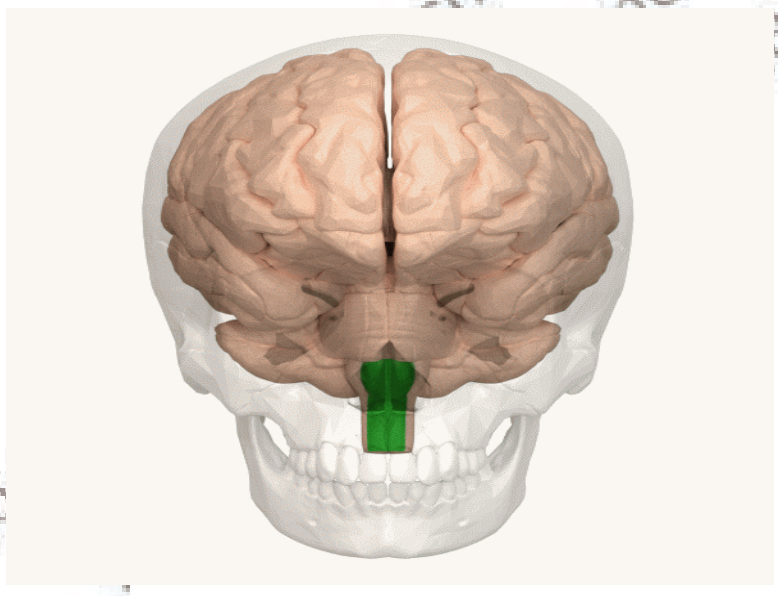

Solution to Question 12:

The dorsal nucleus of vagus is present through the floor of the fourth ventricle seen in a cross-section of the medulla at the level of olives.

The following table describes major structures seen in cross-sections at different levels in the medulla oblongata:

The trapezoid body and the superior vestibular nucleus are seen in the section of lower pons.

Level	Just inferior to the pons	Olives, inferior cerebellar peduncle	Decussation of medial lemnisci	Decussation of the pyramids
Cavity	Fourth ventricle	Fourth ventricle	Central canal	Central canal

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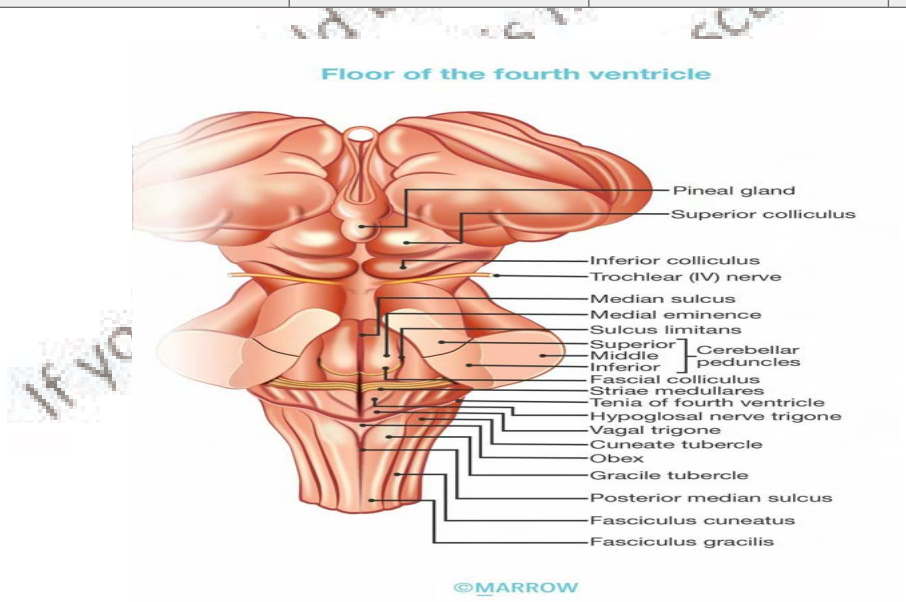
Level	Just inferior to the pons	Olives, inferior cerebellar peduncle	Decussation of medial lemnisci	Decussation of the pyramids
Nuclei	Arcuate nucleiInferior olivary nucleusSpinal nucleus of V nerveDorsal nucleus of vagusVIII, XI nerve nucleiNucleus ambiguus	Arcuate nucleiInferior olivary nucleusSpinal nucleus of V nerveDorsal nucleus of vagusVIII, IX, X, XII nerve nucleiNucleus ambiguusNucleus tractus solitarius	Inferior olivary nucleusNucleus gracilisNucleus cuneatusSpinal nucleus of V nerveAccesory nucleusHypoglossal nucleus	Nucleus gracilisNucleus cuneatusSpinal nucleus V nerveAccesory nucleus
Motor tracts	Pyramid	Pyramids	Pyramids	Decussation of cortico spinal tracts, pyramids
Sensory tracts	Medial longitudinal fasciculusTectospinal tractMedial lemniscusSpinal tract of V nerve Anterior spinocerebellar tractLateral spinothalamic tract	Same as at the section just inferior to pons	Medial longitudinal fasciculusDecussation of medial lemnisciFasciculus gracilis and cuneatusSpinal tract of V nerveAnterior and posterior spinocerebellar tractLateral spinothalamic tract	Spinal tract of V nerve Anterior and posterior spinocerebellar tractLateral spinothalamic tract



Solution to Question 13:

The given clinical scenario is suggestive of Wallenberg syndrome. The symptoms of dysphagia and dysarthria are due to the involvement of nucleus ambiguus. Ataxia is a feature of inferior cerebellar peduncle involvement.

Option A: Medial medullary syndrome is also known as Dejerine's anterior bulbar syndrome.

Option B: Lateral medullary syndrome is also known as Wallenberg syndrome.

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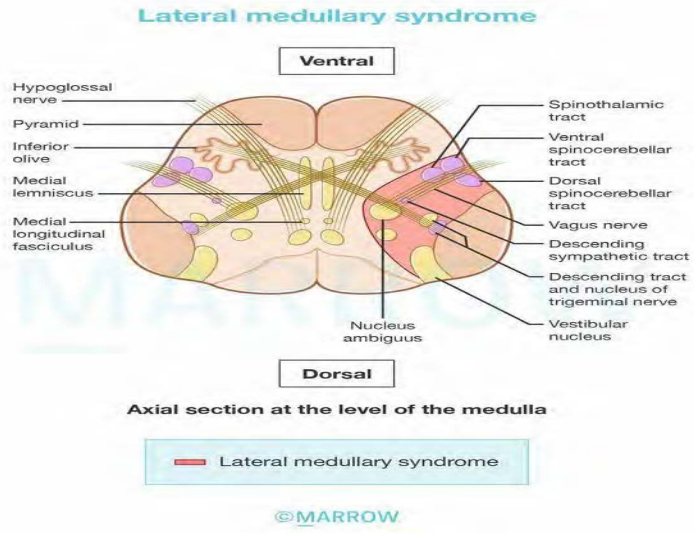
Option C: Medullary tegmental paralysis is also known as Babinski-Nageotte syndrome.

Option D: Midbrain stroke syndrome is also known as Weber syndrome.



Solution to Question 14:

The given clinical features are suggestive of lateral medullary syndrome or Wallenberg syndrome, which is seen in thrombosis of the posterior inferior cerebellar artery.

The lateral part of the medulla is supplied by the posterior inferior cerebellar artery, a branch of the vertebral artery. Injury or thrombosis to this artery results in lateral medullary syndrome leading to:

Signs and symptoms:	Affected structures:
Contralateral loss of pain and temperature on the body	Lateral spinothalamic tract
Ipsilateral loss of pain and te mperature on the face	Spinal sensory nucleus of V n erve
Ataxia and intention tremors	Spinocerebellar tract
Vertigo, nausea, vomiting, an d nystagmus	Vestibular nuclei
Dysphagia, dysarthria and ho arseness of voice	Nucleus ambiguus
Ipsilateral Horner syndrome	Sympathetic fibers

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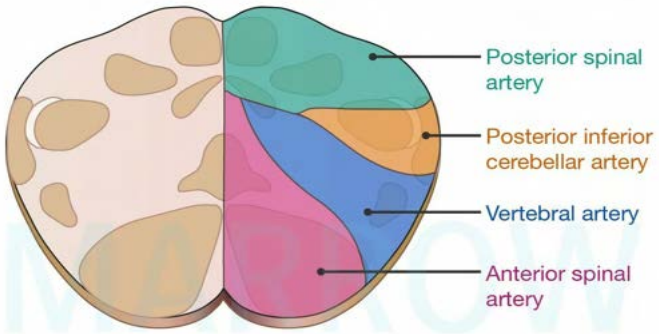
Blood supply of medulla oblongata



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Cerebellum

Question 1:

A 27-year-old man had an RTA resulting in the following gait abnormality. What is the largest part of the affected structure?

a) Anterior lobe

b) Middle lobe

c) Flocculonodular lobe

d) Vermis

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Question 2:

Which of the following represents the arrangement of cerebellar nuclei from lateral to medial:

a) Emboliform, dentate, globose, and fastigial

b) Dentate, emboliform, globose, and fastigial

c) Dentate, globose, emboliform, and fastigial

d) Emboliform, dentate, fastigial, and globose

Question 3:

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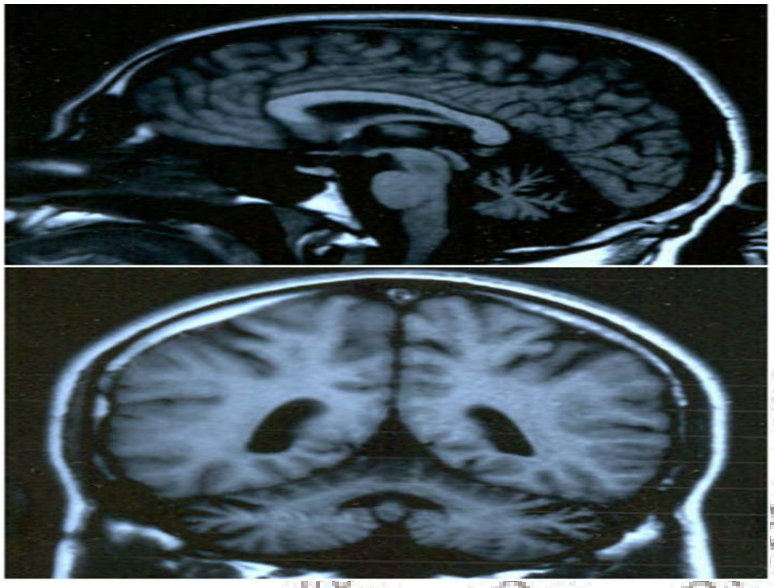
The MRI report of a patient admitted with gait disturbances is given below. Phylogenetically, the oldest part of the atrophied structure is concerned with which nuclei?



a) Fastigial nucleus

b) Globose nucleus

c) Emboliformis nucleus

d) Dentate nuclei

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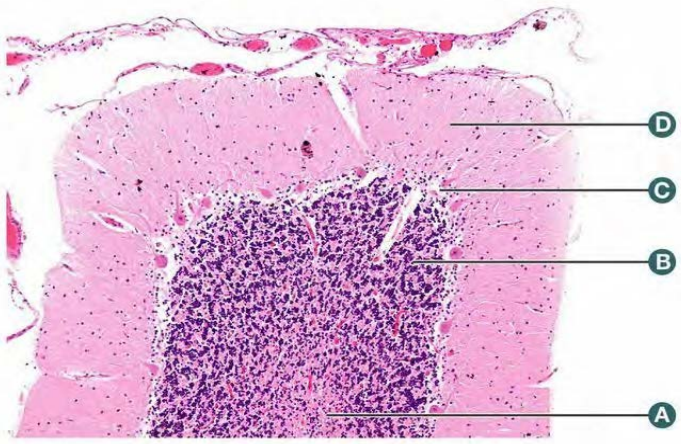
Question 4:

Cerebellar glomeruli are seen in which layer of the cerebellar cortex?



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a) Layer D

b) Layer C

c) Layer B

d) Layer A

Question 5:

A 52-year-old man presents with ataxia-telangiectasia. Which of the following is an excitatory cell lost in this disorder?

a) Golgi cell

b) Purkinje cell

c) Basket cell

d) Granule cell

Question 6:

A man presented with tremors caused due to progressive degeneration of the cells that form the output of the cerebellar cortex. Which of the following cells are affected?

a) Deep cerebellar nuclei

b) Purkinje cells

c) Granule cells

d) Stellate cells

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Question 7:

Which of the following structures does the cell pointed in arrow inhibit?

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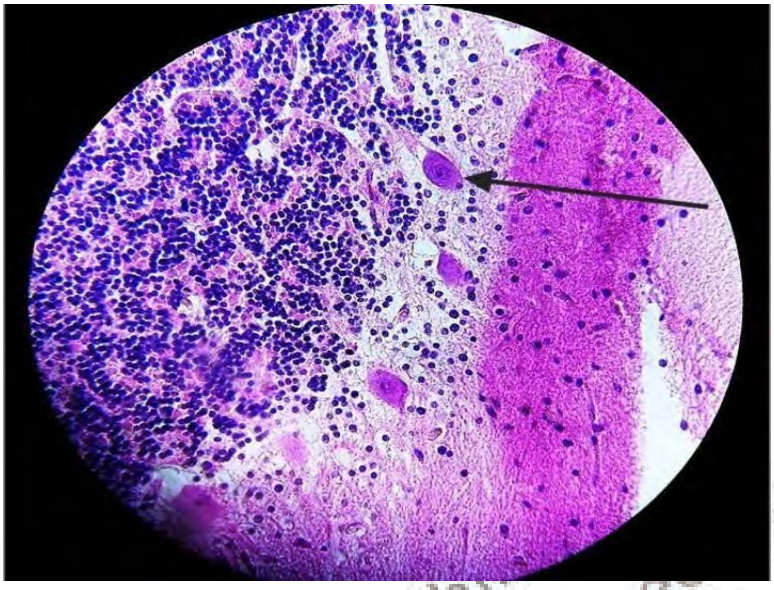

a) Vestibular nuclei

b) Anterior horn of spinal

c) Basal ganglia

d) Deep nuclei of cerebellum

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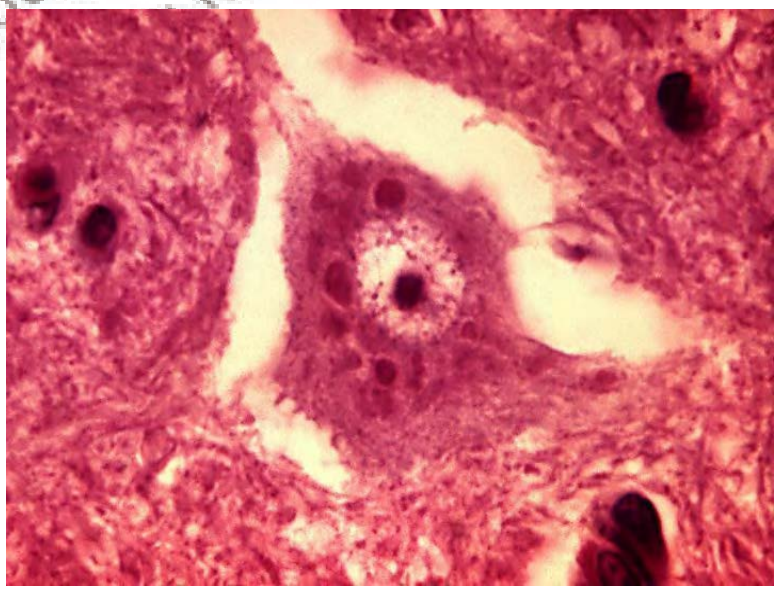
Question 8:

The following slide from a rabies patient shows inclusion bodies in the Purkinje cells receiving input from:



a) Golgi cells

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b) Granule cells

c) Climbing fibers

d) Mossy fibers

Question 9:

A patient recovering from COVID-19 presented with sudden onset slurred speech and difficulty walking. On examination, cerebellar signs are positive. What is true about the affected circuitry?

a) Climbing and mossy fibers are inhibitory and use GABA as the neurotransmitter.

b) Mossy fibers end by forming a synapse with dendrites of Purkinje cells.

c) All climbing fibers originate from the contralateral inferior olivary nucleus.

d) Efferent fibers from all the cerebellar nuclei leave the cerebellum through superior cerebellar peduncle.

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Question 10:

A patient with acoustic neuroma presented with ataxia. MRI brain revealed the tumour impinging on the middle cerebellar peduncle. What fibres are transmitted from this structure?

a) Pontocerebellar pathway

b) Tectospinal pathway

c) Spinocerebellar pathway

d) Olivocerebellar pathway

Question 11:

Purkinje cells of cerebellum relay into _____

a) Caudate nucleus

b) Lentiform nucleus

c) Dentate nucleus

d) Red nucleus

Question 12:

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A patient was diagnosed with glioblastoma multiforme involving the inferior cerebellar peduncle. All of the following tracts may be involved by the tumor except:

a) Posterior spinocerebellar

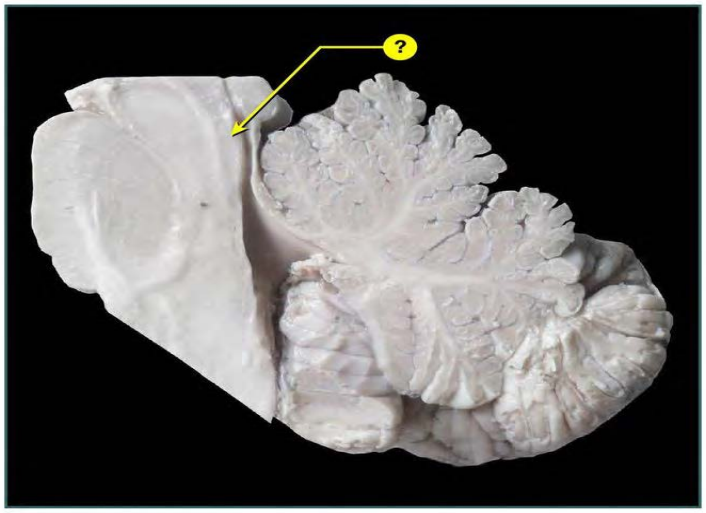
b) Anterior spinocerebellar

c) Cuneocerebellar

d) Olivocerebellar

Question 13:

Fibers from the marked structure terminate at which of the following?



a) Fastigial nucleus

b) Inferior olivary nucleus

c) Red nucleus

d) Subthalamus

Question 14:

A patient presented with clinical features of ataxia and incoordination. This is due to thrombosis of which artery?

a) Posterior cerebral

b) Middle cerebral

c) Internal carotid

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d) Superior cerebellar

Answer Key

Question No.	Correct Option
1	b
2	b
3	a
4	c
5	d
6	b
7	d
8	c
9	c
10	a
11	c
12	b
13	c
14	d

If you pu... you may... else, ...d.

Detailed Explanations

Solution to Question 1:

The given clinical scenario is suggestive of post-traumatic cerebellar ataxia presenting with impaired balance. The largest part of the affected structure i.e. the cerebellum is the middle lobe, also known as the posterior lobe. The gait shown in the above video is a cerebellar ataxic gait. Here, the patient is seen attempting tandem walking and displaying improper heel-toe coordination, erratic foot placement, and truncal swaying.

The cerebellum consists of two hemispheres (right and left) joined by a median vermis. It is divided into three lobes:

• Anterior lobe - lies superiorly above the primary fissure

• Middle lobe - lies inferiorly below the primary fissure

• Flocculonodular lobe - lies posterior to the uvulonodular fissure

It has two surfaces, superior and inferior, separated by a horizontal fissure. It is connected to the other parts of the central nervous system via three peduncles.

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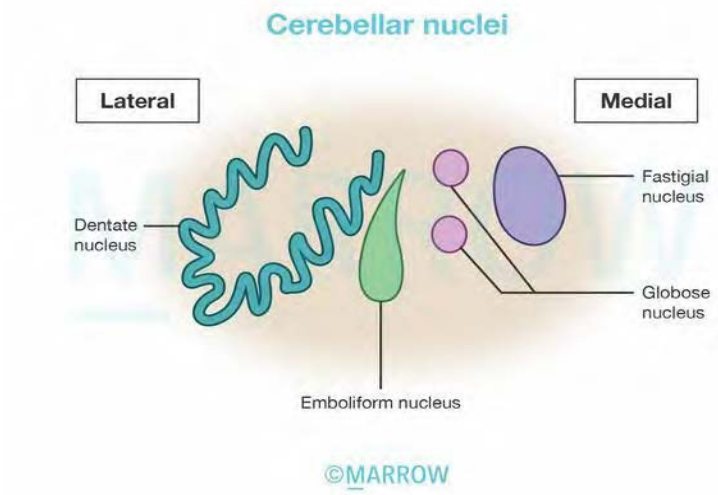
Solution to Question 2:

The arrangement of cerebellar nuclei from lateral to medial is dentate, emboliform, globose, and fastigial.



Solution to Question 3:

The given clinical scenario is suggestive of cerebellar syndrome. Phylogenetically, the oldest part of the atrophied structure i.e. the cerebellum is archicerebellum/ vestibulocerebellum and it is concerned with fastigial nucleus (connected to vestibular nuclei via descending pathways along with medullary/pontine reticular formations).

The image given below shows MRI scans of two brains. The brain on the left shows atrophy of the cerebellum in a person with cerebellar degeneration. The brain on the right shows a normal cerebellum.

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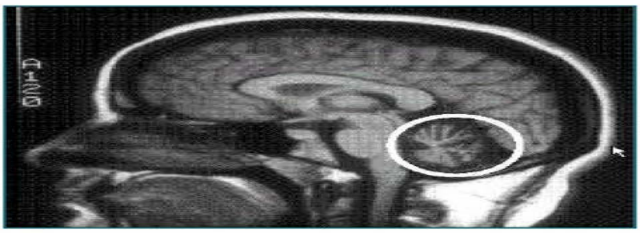
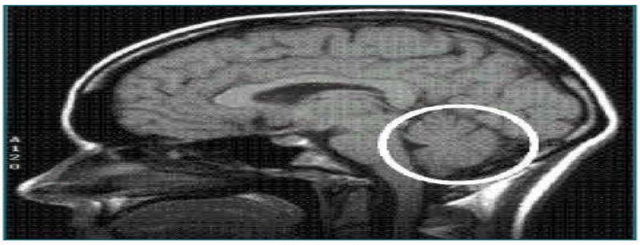
Cerebellar degeneration



Cerebellar degeneration



Normal

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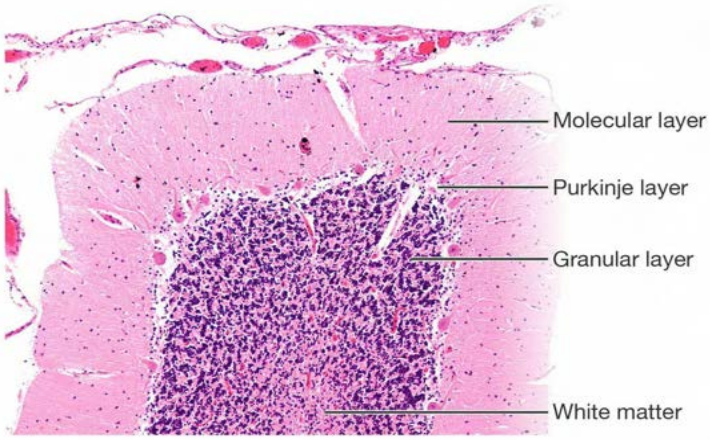
Solution to Question 4:

Cerebellar glomeruli are seen in the granular layer (layer B) of the cerebellar cortex.

Layers of cerebellar cortex



Solution to Question 5:

Ataxia-telangiectasia is characterized by progressive neuronal degeneration with a loss of Purkinje and granule cells in the cerebellum. The granule cells are the only excitatory cells in the cerebellar cortex.

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Solution to Question 6:

The tremors are caused due to progressive degeneration of the Purkinje cells that form the output of the cerebellar cortex. They form the only output neurons of the cerebellar cortex.

The output of the whole cerebellum is from the deep cerebellar nuclei namely fastigial, globose, emboliform and dentate.

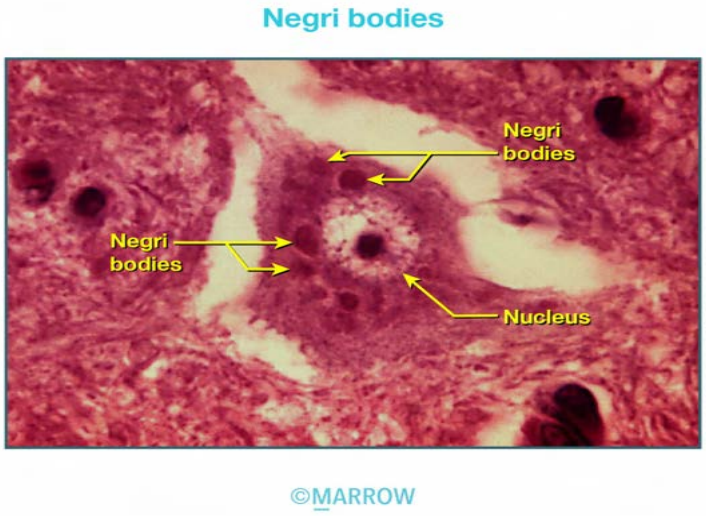
Solution to Question 7:

The image shows a histopathological section of the cerebellum. The cells marked with the arrow are Purkinje cells and they inhibit deep nuclei of the cerebellum.

Solution to Question 8:

The given slide shows Negri bodies, which are eosinophilic, cytoplasmic inclusions found in the neurons of the Purkinje cells in a patient with rabies. The input to the Purkinje cells of the cerebellum come from the climbing fibers.

The image given below shows Negri bodies.



Solution to Question 9:

The given clinical scenario is suggestive of acute viral cerebellitis secondary to COVID-19. The true statement regarding the cerebellar circuitry is that that all climbing fibres originate from the contralateral inferior olivary nucleus.

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Option A: Climbing and mossy fibers are excitatory and use glutamate and aspartate as the neurotransmitters.

Option B: Mossy fibers terminate on the granule cells forming glomeruli.

Option D: Efferents of the cerebellum pass through the superior and inferior cerebellar peduncles.

Solution to Question 10:

The middle cerebellar peduncle transmits fibers of pontocerebellar pathway.

Solution to Question 11:

Purkinje cells of the cerebellum relay into the dentate nucleus which is one of the deep cerebellar nuclei.

The input to the Purkinje cells come from the climbing fibres. The output of Purkinje cells is inhibitory to the deep cerebellar nuclei.

Options A and B: Caudate and lentiform nuclei are part of the basal ganglia.

Option D: Red nucleus receives afferents from the cerebellum and plays a role in modulating signals to the upper motor neurons of the cerebral cortex.

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Solution to Question 12:

The anterior spinocerebellar tract does not pass through the inferior cerebellar peduncle. It enters the cerebellum through the superior cerebellar peduncle.

Glioblastoma multiforme is the most malignant and frequently occurring type of primary astrocytomas. It has the worst long-term prognosis (median survival of roughly 1 year).

Solution to Question 13:

The peduncle highlighted in the image is the superior cerebellar peduncle. The superior cerebellar peduncle includes fibers from deep cerebellar nuclei that project to the brainstem, red nucleus, and thalamus. It also contains the ventral spinocerebellar tract fibers.

The superior cerebellar peduncle contains all the efferent fibers from the dentate, emboliform, and the globose nuclei, and a small fascicle from the fastigial nucleus. Its fibers decussate in the caudal mesencephalon and are destined to synapse in the contralateral red nucleus and thalamus. The middle cerebellar peduncle contains only afferent fibers from the contralateral pontine nuclei. The inferior cerebellar peduncle is a mixture of afferent fibers from the brainstem and spinal cord and efferent fibers to the vestibular nuclei.

The image below summarizes the various tracts in the cerebellar unit.

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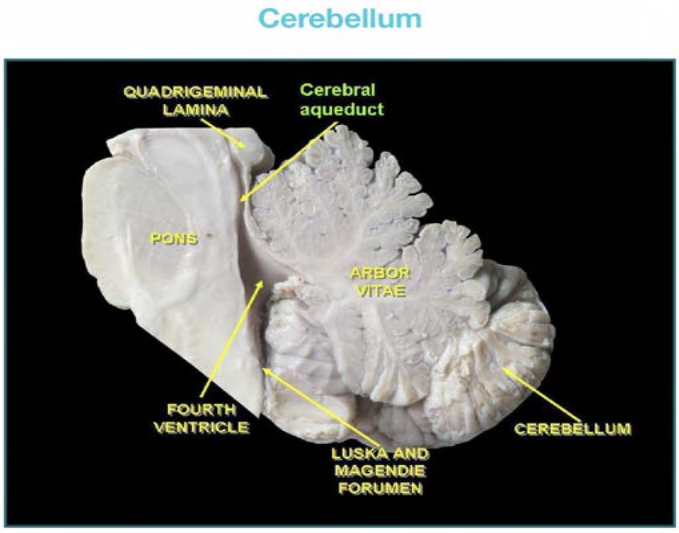

The cerebellum consists of two hemispheres (right and left) joined by a median vermis. It is divided into three lobes:-

• Anterior lobe - lies superiorly above the primary fissure

• Middle lobe - lies inferiorly below the primary fissure. It is the largest lobe. It is also called the posterior lobe.

• Flocculonodular lobe - lies posterior to the uvulonodular fissure

It has two surfaces - superior and inferior separated by a horizontal fissure. It is connected to the other parts of the central nervous system via three peduncles

• Superior cerebellar peduncle -connecting to the midbrain

• Middle cerebellar peduncle - connecting to the pons

• Inferior cerebellar peduncle - connecting to the medulla oblongata

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Solution to Question 14:

Thrombosis of the superior cerebellar artery causes cerebellar lesion which presents with ataxia and incoordination.

Blood supply of cerebellum:

• Superior cerebellar artery

• Posterior inferior cerebellar artery

• Anterior inferior cerebellar artery

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Vascular supply of Brain

Question 1:

Which of the following is not a branch of the cavernous part of the internal carotid artery?

a) Inferior hypophyseal branch

b) Meningeal branch

c) Cavernous branch

d) Pterygoid branch

Question 2:

A 73-year-old hypertensive patient was rushed to the casualty following a transient ischemic attack. Angiography revealed stenosis of the internal carotid artery. Which part of this artery does not give any branch?

a) Cervical part

b) Petrous part

c) Cavernous part

d) Supracavernal part

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Question 3:

A man presented with an excruciating headache and double vision. On examination, the following findings were observed. MRI revealed an aneurysm of the posterior communicating artery. The affected artery is a branch of _____.

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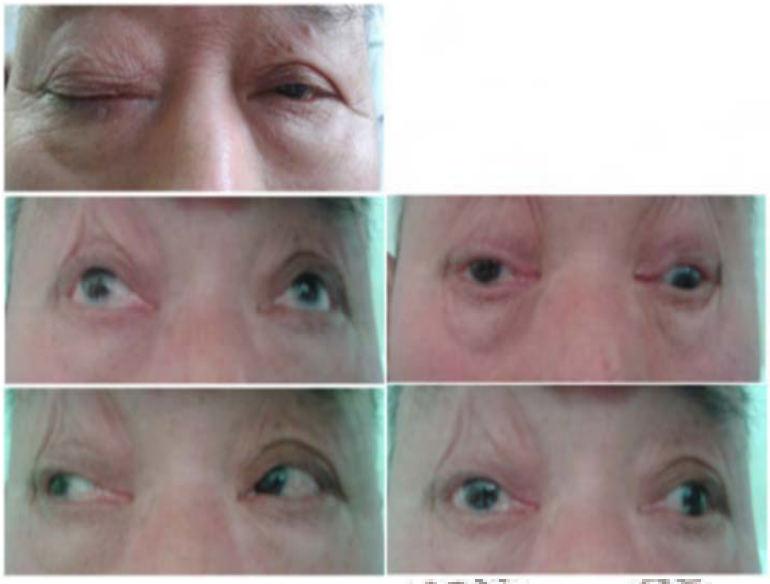

a) Posterior cerebral artery

b) Basilar artery

c) Internal carotid artery

d) Middle cerebral artery

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Question 4:

Which of the following is an unpaired vessel in the central nervous system?

a) Basilar artery

b) Vertebral artery

c) Anterior spinal artery

d) Both A and C

Question 5:

The labyrinthine artery most commonly arises from which of the following arteries?

a) Basilar artery

b) Anterior Inferior Cerebellar Artery (AICA)

c) Superior cerebellar artery

d) Posterior Inferior Cerebellar Artery (PICA)

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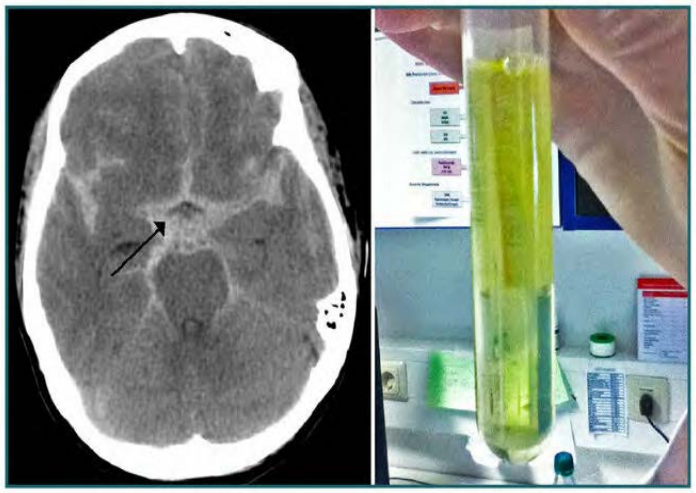
Question 6:

A 62-year-old man presents to the casualty with a severe headache, fever, and vomiting for the past 8 hours. His CT scan and CSF appearance are shown below. The affected vessels do not get a contribution from:



a) Anterior cerebral artery

b) Middle cerebral artery

c) Posterior communicating artery

d) Posterior cerebral artery

Question 7:

A man presented with hemiparesis involving the entire left side of the body except for the left leg. MRI revealed a stroke involving the right primary motor cortex. Which vessel is likely to be thrombosed?

a) Posterior cerebral artery

b) Anterior cerebral artery

c) Middle cerebral artery

d) Anterior and middle cerebral arteries

Question 8:

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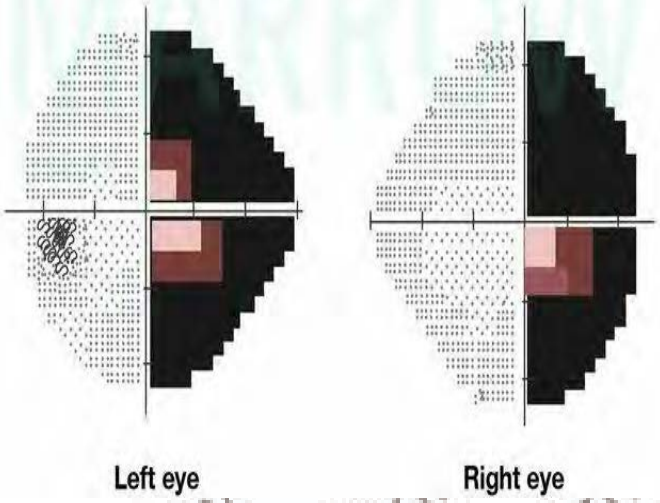
A woman presents with homonymous hemianopia with macular sparing as shown below. She complains of an inability to distinguish objects when they are placed in front of her. But when moved, she can observe and distinguish them. This is due to the occlusion of which artery?



a) Middle cerebral artery

b) Posterior cerebral artery

c) Posterior inferior cerebellar artery

d) Posterior choroidal artery

Question 9:

The chief artery of the superolateral surface of the cerebral hemisphere is:

a) Anterior cerebral artery

b) Middle cerebral artery

c) Posterior cerebral artery

d) Lateral cerebral artery

Question 10:

A 62-year-old man was diagnosed with stroke. A thrombus in the marked vessel will affect all of the following structures except:

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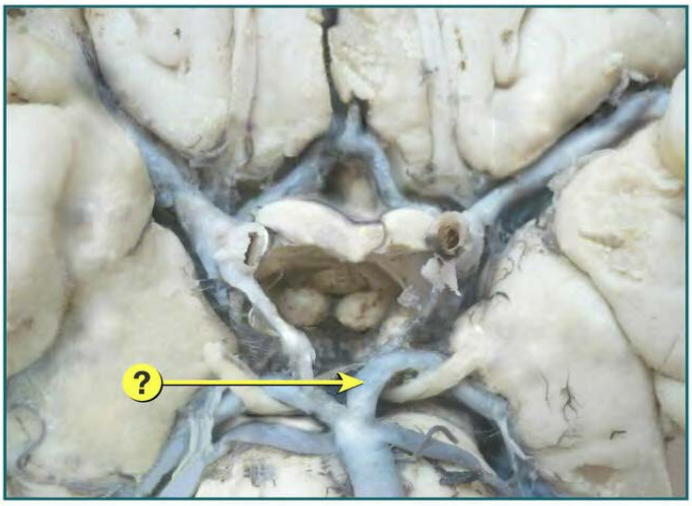


a) Choroid plexus of III ventricle

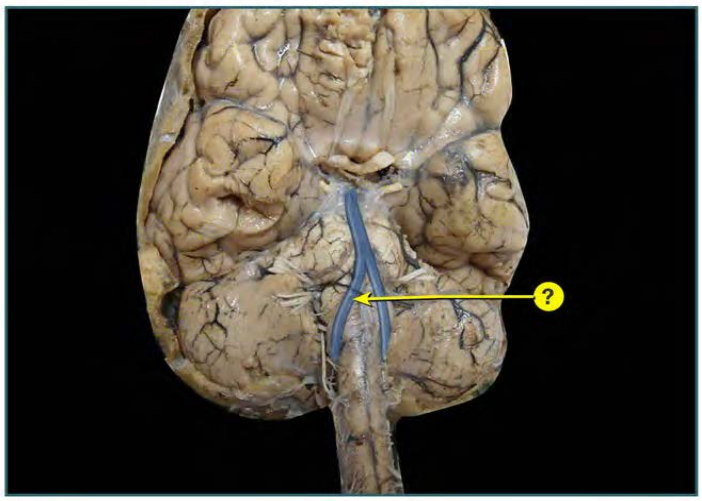
b) Midbrain

c) Pons

d) Lentiform nucleus

Question 11:

A patient presents with vertigo, nystagmus, left-sided Horner's syndrome with numbness of left face and right limbs. What is the largest branch of the affected artery marked in the image as 'X'?



a) Anterior spinal artery

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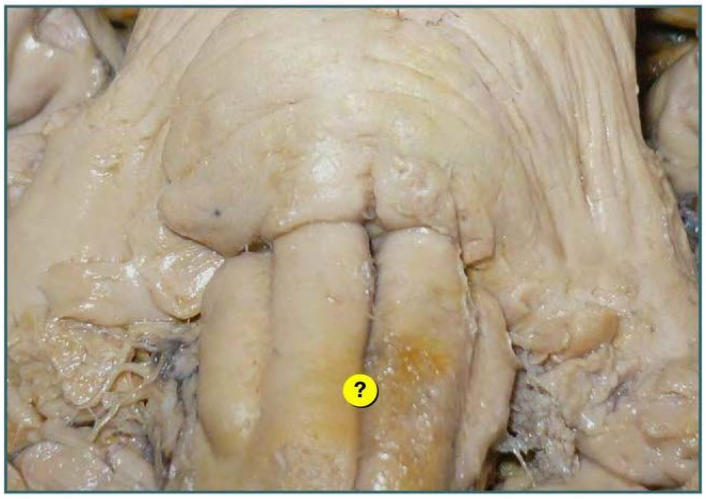
b) Posterior spinal artery

c) Posterior inferior cerebellar artery

d) Medullary artery

Question 12:

Which of the following arteries do not supply the marked structure?



a) Anterior spinal artery

b) Posterior spinal artery

c) Superior cerebellar artery

d) Posterior inferior cerebellar artery

Question 13:

The blood supply to the structure marked in the image is by:

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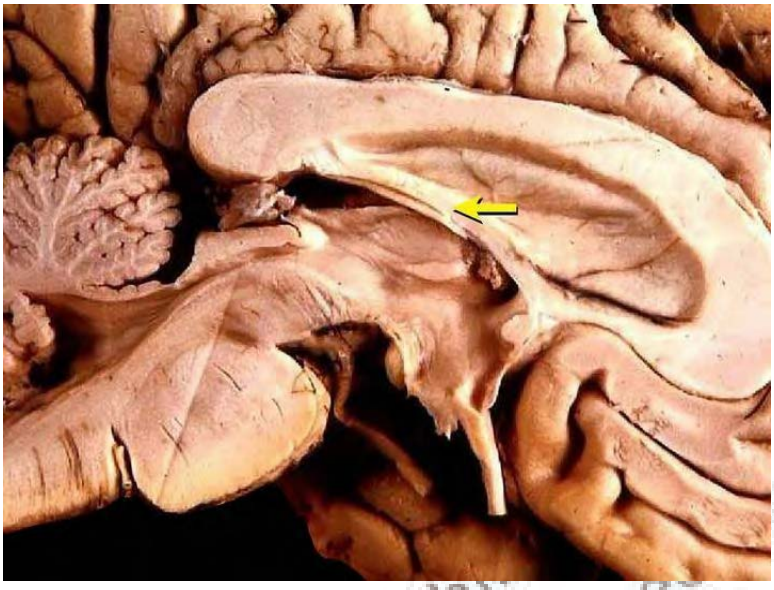

a) Vertebral artery

b) Internal carotid artery

c) Anterior cerebral artery

d) Middle cerebral artery

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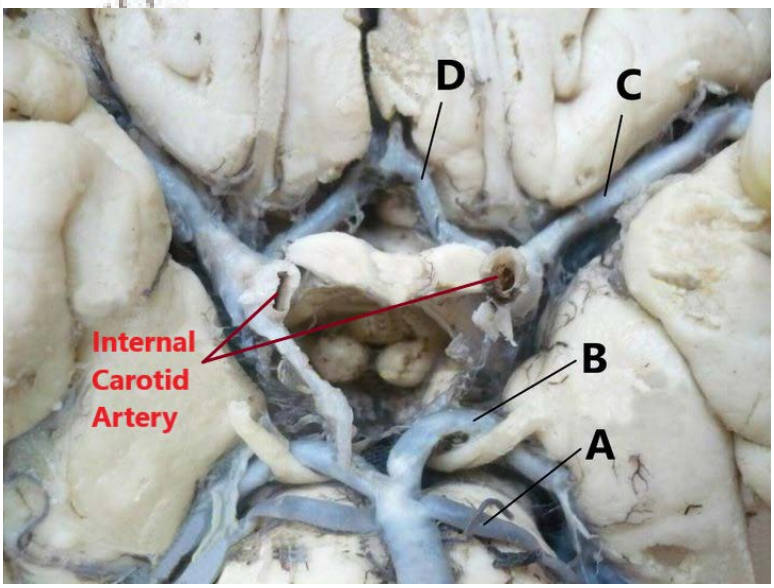
Question 14:

A hypertensive man suffered a sudden right brachiofacial paresis with dysarthria. CT showed a haemorrhage in the left basal ganglia and angiography revealed a Charcot-Bouchard aneurysm. The affected artery is a branch of:



a) B

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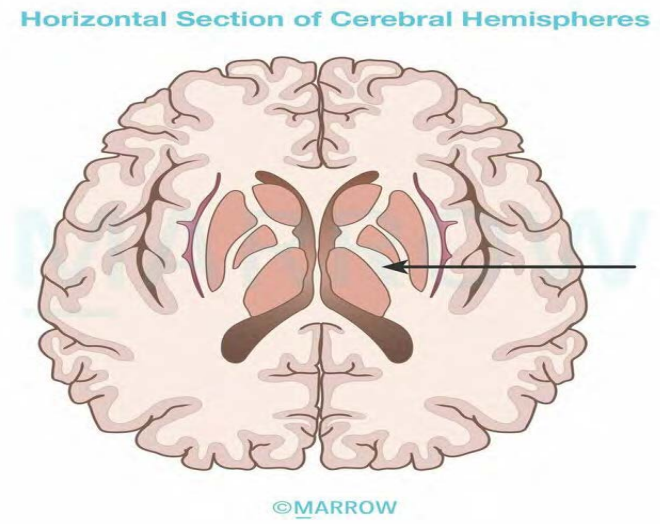
b) C

c) D

d) A

Question 15:

Which of the following is not the blood supply of the marked structure?



a) Middle cerebral artery

b) Reccurent artery of Heubner

c) Anterior choroidal

d) Posterior cerebral artery

Question 16:

Which of the following is not included in the blood supply of putamen?

a) Medial striate artery

b) Lateral striate artery

c) Anterior choroidal artery

d) Posterior communicating artery

Question 17:

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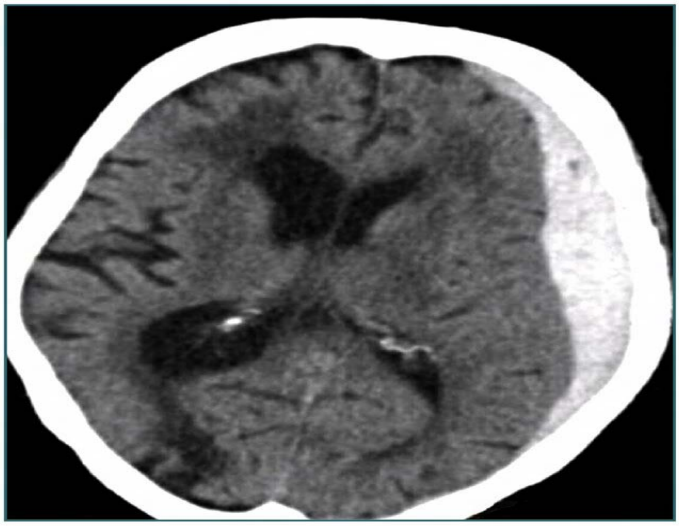
A 62-year-old man had a severe head injury resulting in headaches, nausea, and vertigo. His CT scan is shown below. Where does the affected cerebral vein drain into?



a) Great cerebral vein

b) Vein of Galen

c) Superior sagittal sinus

d) Inferior sagittal sinus

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Question 18:

What structure receives drainage from the superficial middle cerebral vein?

a) Transverse sinus

b) Cavernous sinus

c) Superior sagittal sinus

d) Straight sinus

Question 19:

Two internal cerebral veins join to form:

a) Anterior cerebral vein

b) Middle cerebral vein

c) Great cerebral vein

d) Inferior cerebral vein

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Question 20:

Where does the great cerebral vein of Galen drain into?

a) Inferior petrosal sinus

b) Straight sinus

c) Sigmoid sinus

d) Occipital sinus

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Answer Key

Question No.	Correct Option
1	d
2	a
3	c
4	d
5	b
6	b
7	c
8	b
9	b
10	c
11	c
12	c
13	c
14	b
15	b
16	d
17	c
18	b
19	c
20	b

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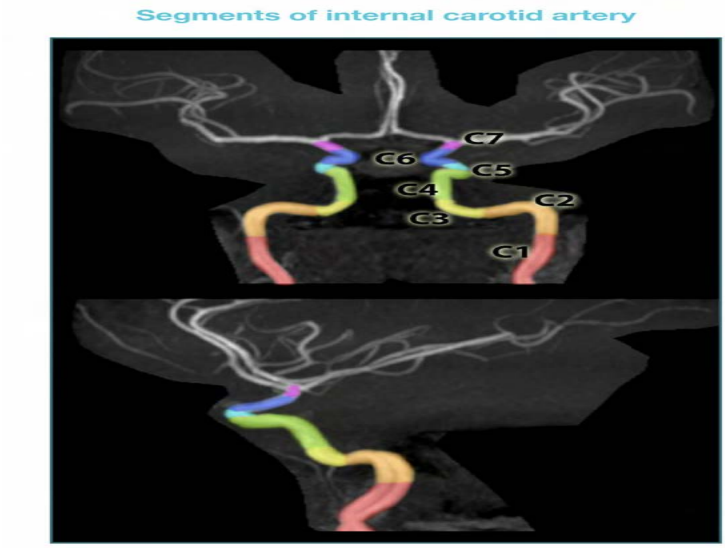
Detailed Explanations

Solution to Question 1:

The pterygoid branch is not a branch of the cavernous part of the internal carotid artery. It is a branch of the petrous part.

Angiography reveals the characteristic finding of carotid siphon showing multiple bends and producing an S-shaped shadow. The image given below is a magnetic resonance angiogram showing the segments of internal carotid artery.



Solution to Question 2:

The given clinical scenario is suggestive of transient ischemic attack due to internal carotid artery stenosis. The cervical part of the internal carotid artery does not give off any branches.

The image given below shows the internal carotid artery.

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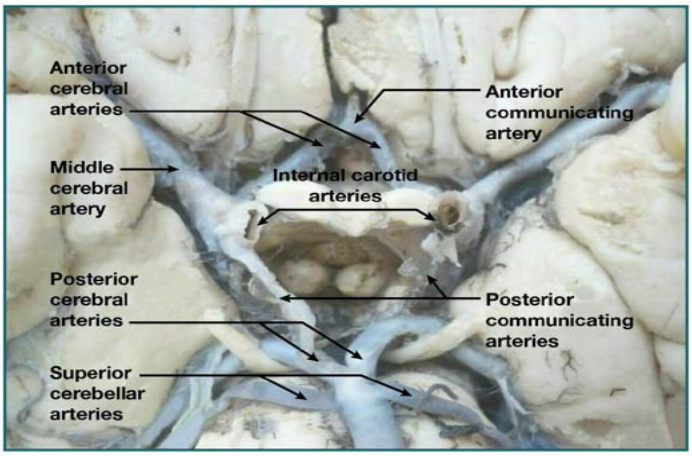
Circle of Willis



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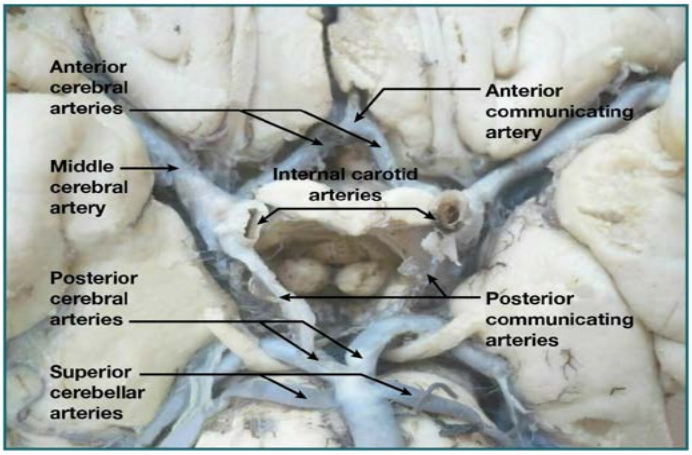
Solution to Question 3:

The clinical scenario of ptosis, down and out eyes and dilated pupils is suggestive of an oculomotor nerve palsy secondary to a posterior communicating artery aneurysm. The posterior communicating artery is a branch of the cerebral part of the internal carotid artery.

The image given below shows the posterior communicating arteries in the circle of Willis.

Circle of Willis



Solution to Question 4:

The basilar artery and the anterior spinal artery are unpaired arteries in the central nervous system.

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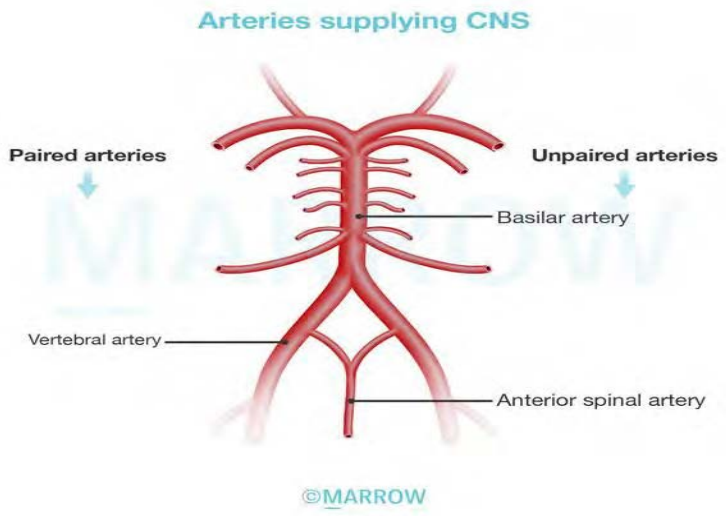
The basilar artery is a single artery formed by the union of two vertebral arteries.

The anterior spinal artery is a single artery formed from a branch from each vertebral artery near its termination.



Solution to Question 5:

The labyrinthine artery is most commonly a branch of the anterior inferior cerebellar artery (AICA). It can also be a direct branch of the basilar artery at times.

The basilar artery is formed by the union of two vertebral arteries. At the upper border of the pons, it divides into two posterior cerebral arteries.

Solution to Question 6:

These patient's clinical features as well as the CT scan showing blood in the cistern and the xanthochromatic CSF appearance are suggestive of subarachnoid haemorrhage. The affected vessels i.e. the circle of Willis do not get a contribution from the middle cerebral artery.

The circle of Willis is located in the interpeduncular fossa at the base of the brain. It is an anastomosis between the internal carotid arteries and vertebral arteries. It allows the blood entering from either artery to be distributed to both the cerebral hemispheres.

The arteries forming the circle of Willis are:

• Anterior communicating artery

• Anterior cerebral arteries

• Internal carotid arteries

• Posterior communicating arteries

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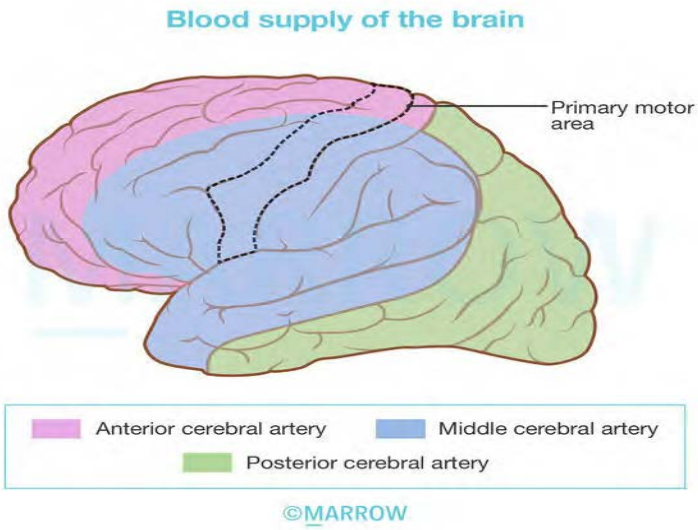
• Posterior cerebral arteries

• Basilar artery

Solution to Question 7:

The middle cerebral artery supplies the entire motor area except for the leg area. Thus, a lesion in the middle cerebral artery causes contralateral hemiparesis, sparing the leg area.



Anterior cerebral artery:

• It is the smaller terminal branch of the internal carotid artery.

• It runs in the sagittal fissure and anastomoses with the posterior cerebral artery.

• It supplies the medial surface of the cerebral cortex and parts of lentiform, caudate nuclei and the internal capsule.

Middle cerebral artery:

• It is the larger terminal branch of the internal carotid artery.

• It runs in the lateral sulcus.

• It supplies the entire lateral surface of the cerebral hemisphere except for a narrow strip (supplied by the anterior cerebral artery) and the occipital pole and the inferolateral surface (supplied by the posterior cerebral artery).

Posterior cerebral artery:

• It is the terminal branch of the basilar artery.

• It supplies the occipital lobe, inferolateral and medial surfaces of the temporal lobe, and parts of the brainstem.

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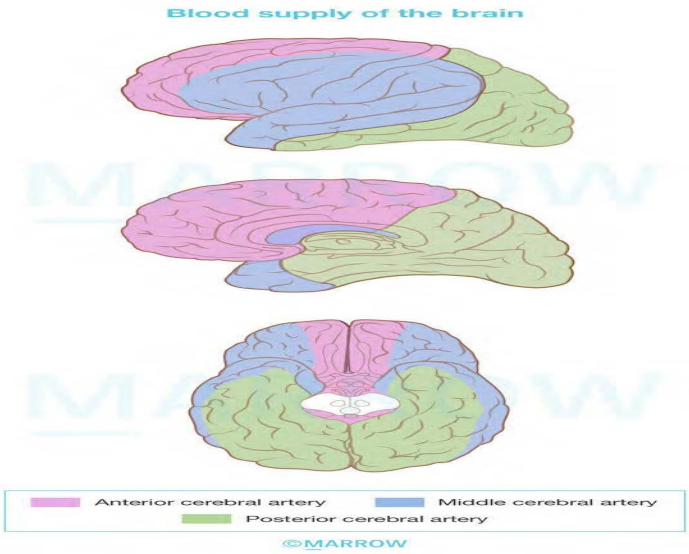

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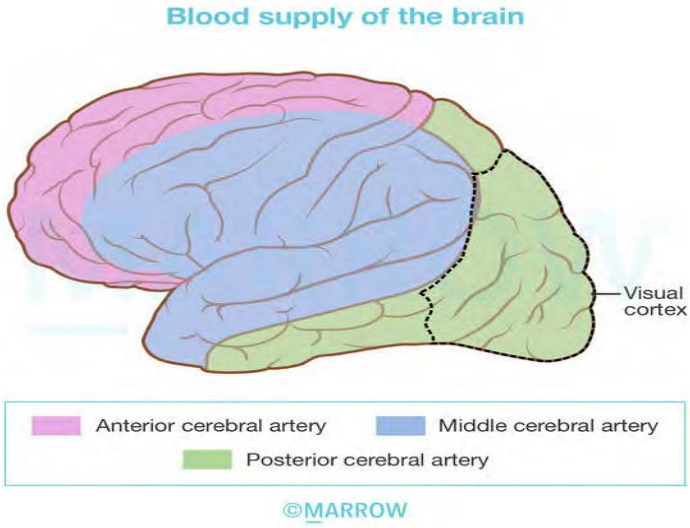
Solution to Question 8:

The given clinical scenario with visual field defects and Riddoch phenomenon is suggestive of occipital lobe lesion occurring due to the occlusion of the posterior cerebral artery.

The visual cortex is supplied by the posterior cerebral artery. Its occlusion is commonly seen in head injury and may be associated with visual hallucinations, denial of blindness (Anton syndrome), and the Riddoch phenomenon (only moving visual targets are perceived). These lesions generally spare the central vision/macular vision.

The anatomical reason for this sparing is attributed to the uniqueness in the blood supply. The part of the occipital lobe representing the peripheral field vision is supplied by the posterior cerebral artery. Whereas, the area at the tip of the calcarine cortex representing the central macular vision, is supplied by a branch of the middle cerebral artery.



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Solution to Question 9:

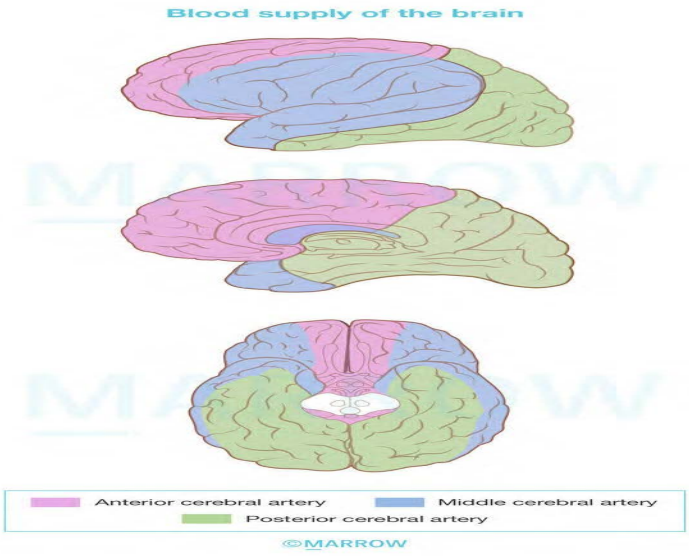
The chief artery of the superolateral surface of the cerebral hemisphere is the middle cerebral artery.

Both the anterior and middle cerebral artery supply the superolateral surface of the brain but anterior cerebral artery supplies only a narrow strip at the upper superolateral surface rest is supplied by the middle cerebral artery. Therefore, the chief artery is the middle cerebral artery.

The chief artery of the medial surface of the brain is an anterior cerebral artery.

The chief artery of the inferior surface of the brain is the posterior cerebral artery.

Lateral cerebral artery is not an artery.



Solution to Question 10:

The marked vessel is posterior cerebral artery. It does not supply the pons, hence a thrombus in this artery will not affect the pons.

The branches of the posterior cerebral artery are:

- Cortical branches
- Occipital lobe - visual cortex
- Temporal lobe - medial and inferolateral surfaces
- Central branches
- Thalamus
- Subthalamus
- Lentiform nucleus

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• Midbrain

• Pineal gland

• Superior and inferior colliculi

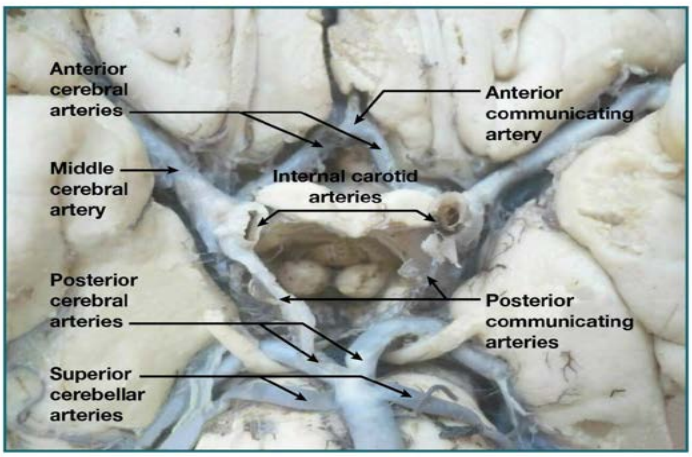
• Medial and lateral geniculate bodies

• Choroidal branches- choroid plexus of

• Lateral ventricle

• Third ventricle

The image given below shows the posterior cerebral arteries in the circle of Willis.



Solution to Question 11:

The given clinical scenario is suggestive of Wallenberg's syndrome (lateral medullary syndrome) and the marked vessel is the vertebral artery. The largest branch of this artery is the posterior inferior cerebellar artery.

The vertebral artery is a branch of the first part of the subclavian artery. It enters the skull through the foramen magnum and terminates by joining the vertebral artery of the opposite side forming the basilar artery. The branches of the cranial portion of the vertebral artery are:

• Meningeal branches - supplying dura of posterior cranial fossa

• Posterior spinal arteries - supply posterior one-third of the spinal cord

• Anterior spinal artery - supply anterior two-thirds of the spinal cord

• Posterior inferior cerebellar artery - supplies the lateral part of the medulla, cerebellar hemisphere, and the choroid plexus of the fourth ventricle.

• Medullary branches - supplying the medulla

The image given below shows the vertebral artery.

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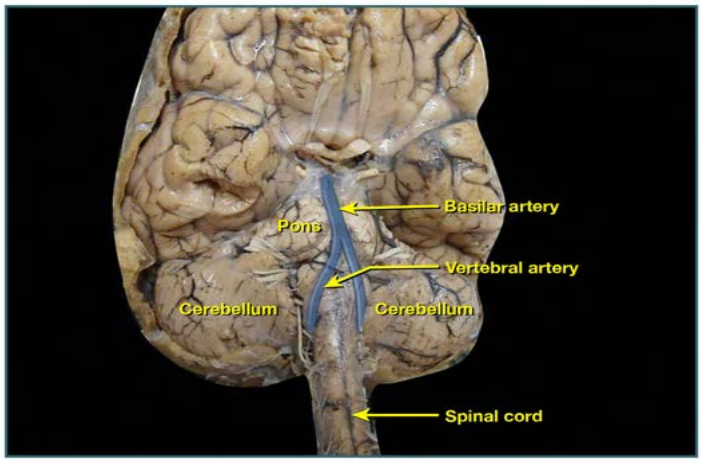
Basilar and Vertebral arteries



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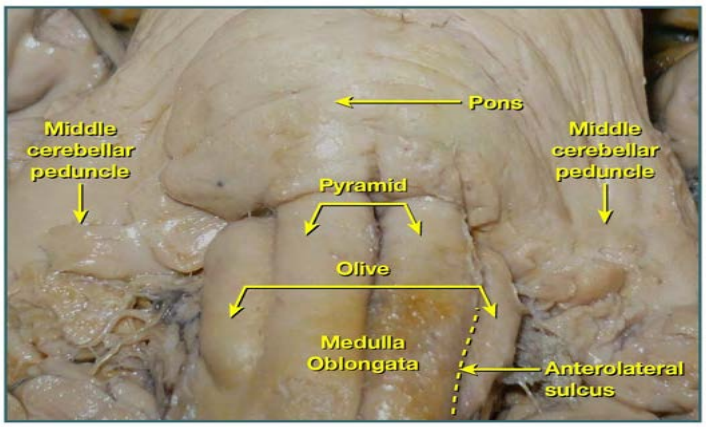
Solution to Question 12:

The marked structure is medulla oblongata. The superior cerebellar artery does not supply the medulla oblongata.

Medulla oblongata, pons and middle cerebellar peduncle



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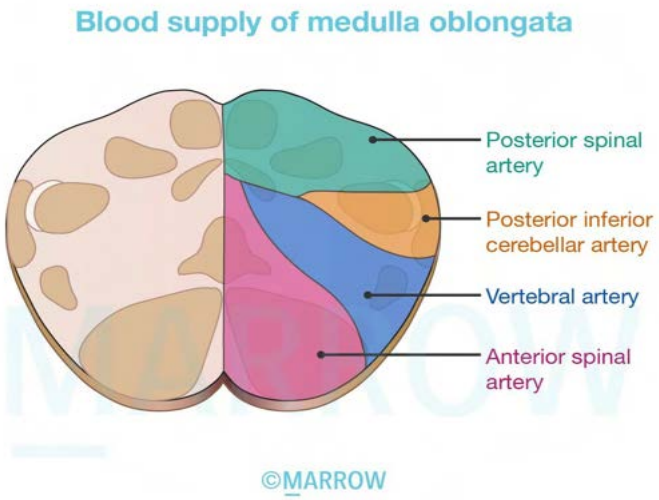
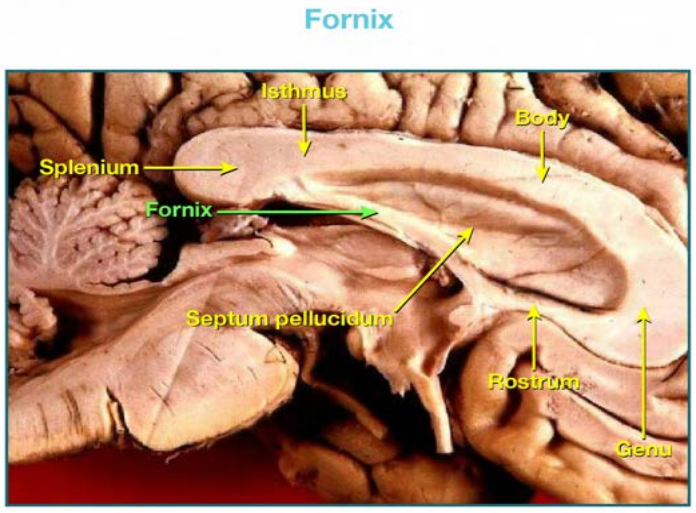


Solution to Question 13:

The marked structure is fornix which is supplied by the anterior cerebral artery.

The anteromedial central branches from the anterior cerebral artery supply the fornix along with optic chiasma, lamina terminalis, hypothalamus, para-olfactory areas, and cingulate gyrus.



Solution to Question 14:

The given clinical scenario is suggestive of a Charcot-Bouchard aneurysm. The affected artery is the Charcot's artery which is the striate branch of the middle cerebral artery marked as 'C' in the above image.

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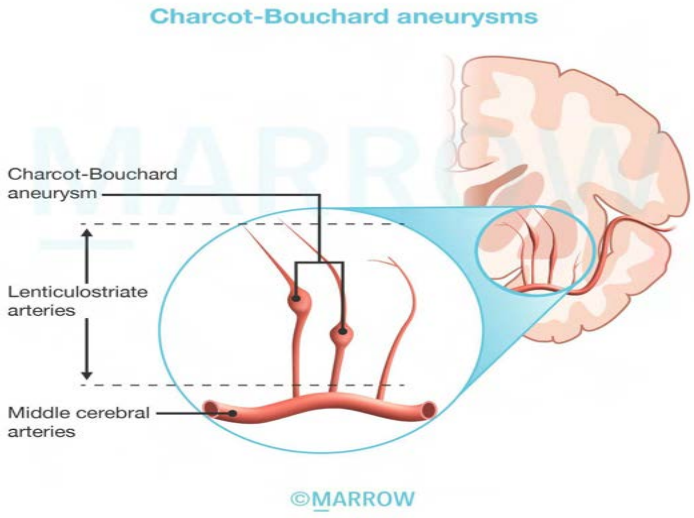
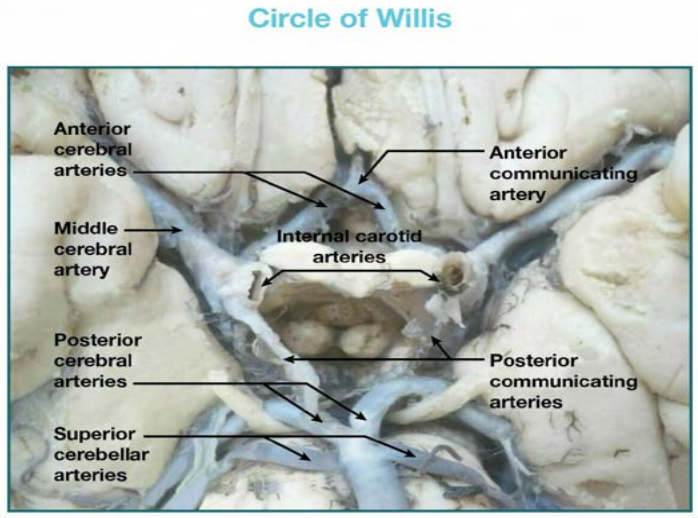
Charcot-Bouchard aneurysms are located in the lenticulostriate vessels of the basal ganglia and are commonly associated with hypertension. Charcot's artery supplies the internal capsule and basal ganglia. It is also known as the 'Charcot's artery of cerebral haemorrhage'.



The image given below shows the circle of Willis at the base of the brain.



Solution to Question 15:

The marked structure is the posterior limb of the internal capsule and the recurrent artery of Heubner is not a part of its blood supply.

The posterior limb of internal capsule is supplied by:

• Charcot's artery (branch of middle cerebral artery)

• Anterior choroidal artery (branch of internal carotid artery)

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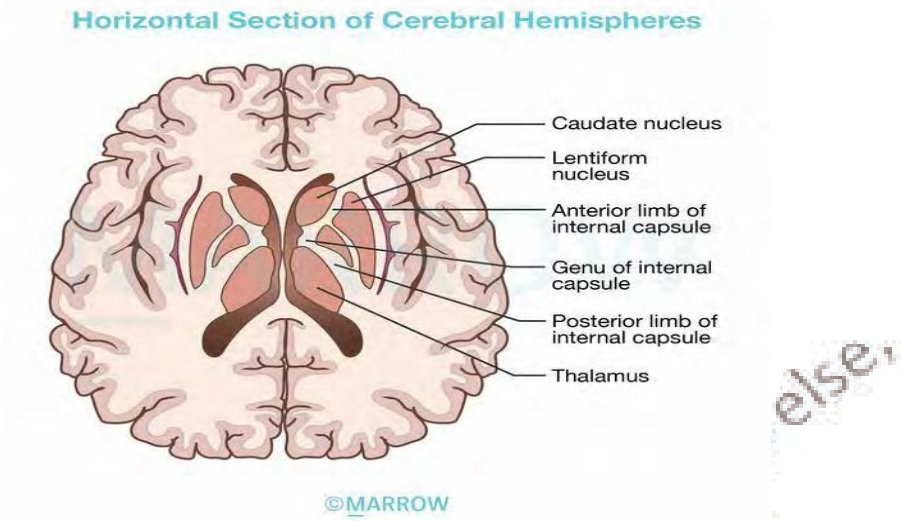
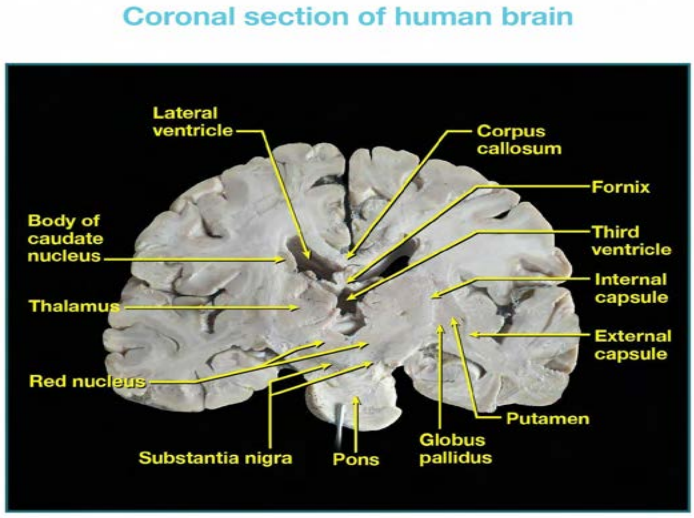
• Posterolateral branches of posterior cerebral artery.





Solution to Question 16:

Posterior communicating artery does not supply the putamen.

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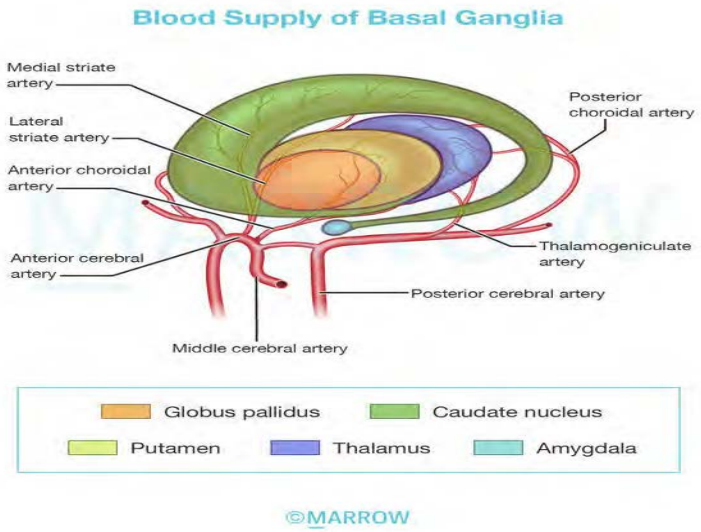

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Solution to Question 17:

CT image showing a crescent-shaped hyperdense lesion, is suggestive of acute subdural hematoma. The head injury leads to a tear in the cerebral veins (predominantly the bridging veins like the superior cerebral vein) causing the hematoma. The superior cerebral vein drains into the superior sagittal sinus.

Veins of the cerebral hemispheres can be categorized into superficial and deep. The superficial veins chiefly drain the cerebral cortex, while the deep veins return blood from the deep structures of the cerebrum.

Superficial veins:

• Superior cerebral veins:

These veins drain the upper parts of the superolateral and medial surfaces of the cerebral hemisphere. They drain blood into the superior sagittal sinus.

• Inferior cerebral veins:

These veins return blood from the inferior aspect of the cerebral hemisphere into the transverse, superior petrosal, cavernous and sphenoparietal sinuses. Some also drain into the inferior sagittal sinus.

• Superficial middle cerebral vein:

This vein receives blood from veins on the superolateral surface. It terminates in the cavernous sinus.

Deep veins:

• Internal cerebral veins:

This pair of veins originates at the foramen of Munro and eventually anastomoses to form the great vein of Galen.

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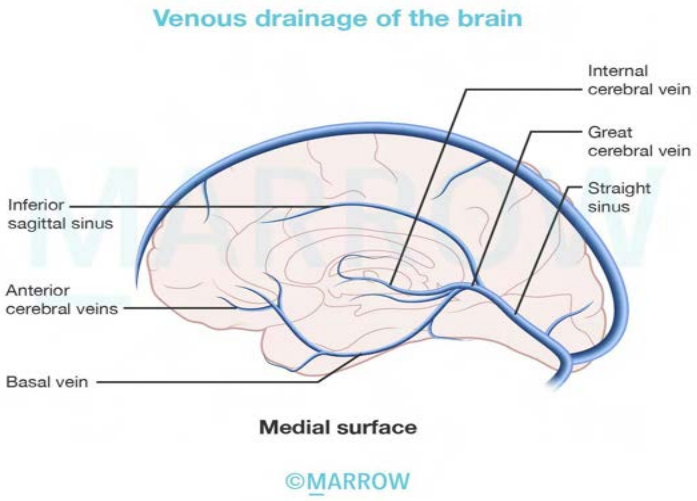
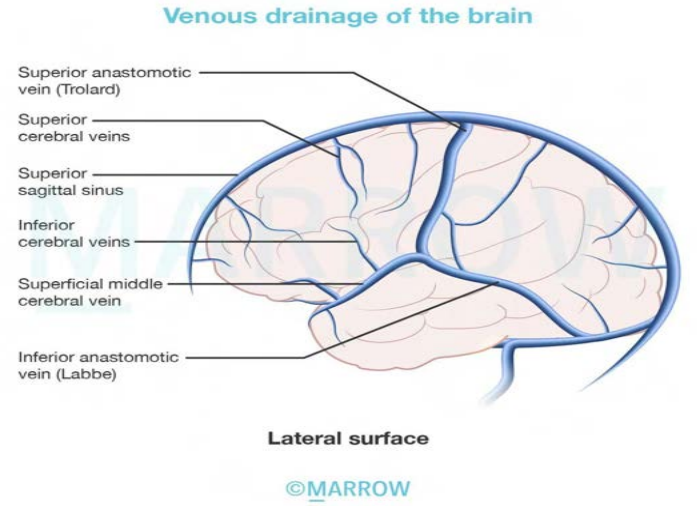
• Basal veins:

The two basal veins are closely related to the midbrain structures and drain into the great vein of Galen.

• Great cerebral vein:

The two internal cerebral veins unite to form the great cerebral vein before it passes beneath the corpus callosum and anastomoses with the straight sinus.





Solution to Question 18:

The superficial middle cerebral vein drains into the cavernous sinus.

Superficial middle cerebral vein lies in the lateral sulcus and drains most of the lateral surface of the hemispheres. It drains into the cavernous sinus.

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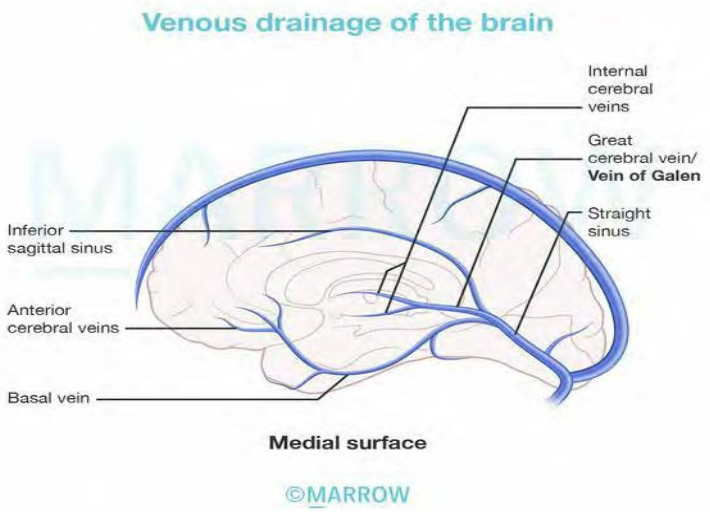
Superficial middle cerebral vein is connected to the superior sagittal sinus through the superior anastomotic vein of Trolord and to the transverse sinus through the inferior anastomotic vein of Labbe.

Solution to Question 19:

Two internal cerebral veins join to form the great cerebral vein of Galen beneath the splenium of the corpus callosum. It receives the basal veins and drains into the straight sinus.



Solution to Question 20:

The great cerebral vein of Galen drains into the straight sinus.

The image given below shows the venous drainage of cerebral veins.

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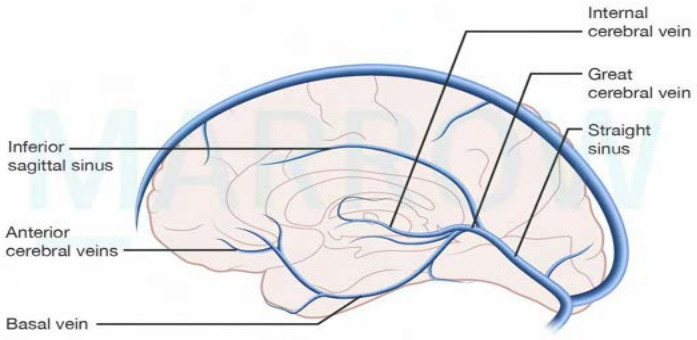
Venous drainage of the brain



Medial surface

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Spinal Cord

Question 1:

Filum terminale extends upto what vertebra?

a) S1 vertebra

b) S3 vertebra

c) 1st coccygeal vertebra

d) 4th coccygeal vertebra

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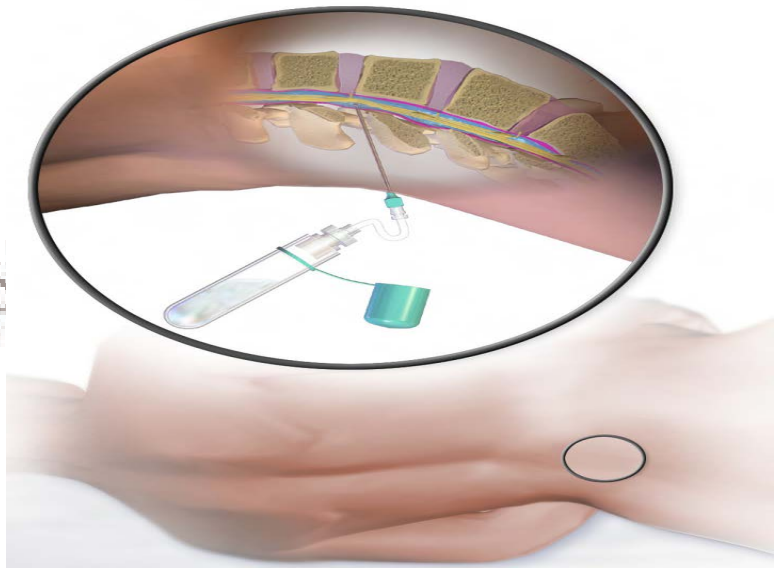
Question 2:

A needle is inserted into a particular space to withdraw CSF in an adult as shown below. At which level does this space terminate?



a) S1

b) S2

c) L4

d) L2

Question 3:

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A 29-year-old woman in labour requested for epidural analgesia. Below which level would you administer the anaesthesia?

a) Upper border of L1

b) Upper border of L3

c) Lower border of L1

d) Lower border of L3

Question 4:

What is the total number of nerve pairs in the spinal cord?

a) 30

b) 33

c) 32

d) 31

Question 5:

All of the following are true about grey rami communicantes except:

a) Unmyelinated

b) Connected to spinal nerve

c) Preganglionic

d) Present medial to white rami communicantes

Question 6:

Which spinal segment lies at the level of the spinous process of the T7 vertebra?

a) T7

b) T8

c) T9

d) T10

Question 7:

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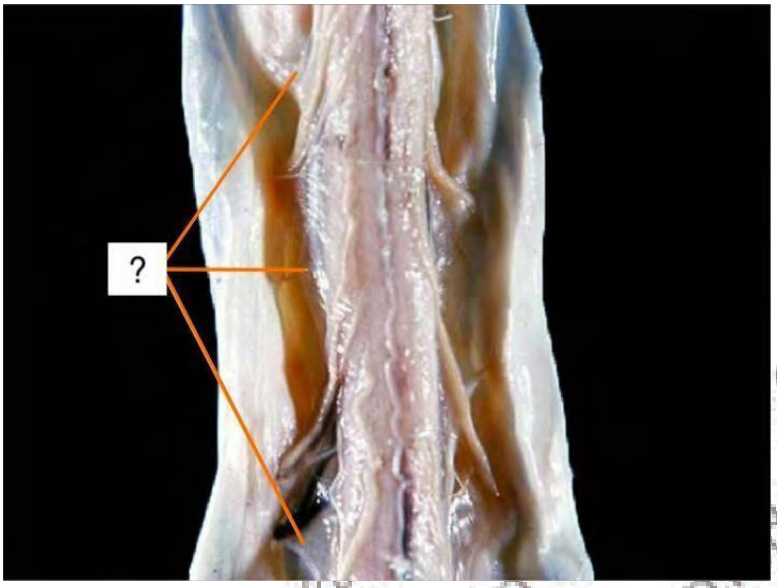
You are given the following section of the spinal cord. The lowest projection of the marked structure lies at which level of the spinal nerves?



a) T9, T10

b) T12, L1

c) S2, S3

d) S4, S5

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Question 8:

All of the following statements regarding ligamentum denticulatum are true except:

a) It is a modification of arachnoid mater

b) There is one on each side with 21 triangular processes

c) It serves as a neurosurgical landmark for hemisectioning of spinal cord

d) It has a serrated appearance

Question 9:

Angiography in a 62-year-old man presenting with paraplegia revealed a thrombus in the anterior spinal artery. Which region of the spinal cord is likely to be affected?

a) Whole segment of spinal cord

b) Anterior 1/3rd of the spinal cord

c) Anterior 2/3rd of the spinal cord

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d) Anterior 3/4th of the spinal cord

Question 10:

A 64-year-old man was undergoing aortic bypass surgery. During the procedure, the surgeon accidentally injured an artery arising from the aorta. This artery provides major blood supply to the spinal cord on the left side at the lower thoracic level. Which region is likely to be affected?

a) Upper two thirds of the spinal cord

b) Lower two thirds of the spinal cord

c) Upper one third of the spinal cord

d) Lower one third of the spinal cord

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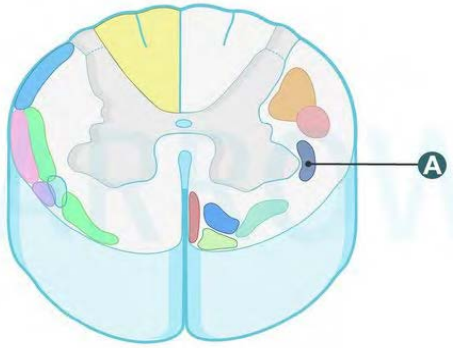
Question 11:

Identify the tract marked "A" in the given section of the spinal cord.



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a) Lateral reticulospinal tract

b) Lateral Corticospinal tract

c) Lateral spinothalamic tract

d) Rubrospinal tract

Question 12:

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A 58-year-old man presented with loss of sensation below the level of the umbilicus. MRI revealed infarction affecting the posterior white columns in the T-10 segment of the spinal cord. Which sensation would be intact in this patient?

a) Position Sense

b) Pain

c) Pressure

d) Vibration

Question 13:

Which of the following descending tracts in the spinal cord remains uncrossed?

a) Tectospinal Tract

b) Rubrospinal Tract

c) Vestibulospinal Tract

d) Pyramidal Tract

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Question 14:

A woman presented with hemiparesis due to a spinal cord tumour. The doctor diagnosed this as a case of Brown- Séquard syndrome. All are true about this syndrome except:

a) Hemisection of Spinal cord

b) Ipsilateral loss of vibration sensations

c) Ipsilateral loss of crude touch sensations

d) Ipsilateral paralysis below the level of lesion

Question 15:

A lady with a history of lumbar back pain presented with a loss of sensation in the perianal area. An urgent MRI showed compression of the cauda equina by a herniated disc. The conus syndrome differs from this syndrome in that the former shows:

a) Radicular pain

b) Lower motor neuron injury

c) Symmetrical weakness of lower limbs

d) Urinary retention

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Answer Key

Question No.	Correct Option
1	c
2	b
3	c
4	d
5	c
6	d
7	b
8	a
9	c
10	b
11	a
12	b
13	c
14	c
15	c

If you pu... you may ... else, ...d.

Detailed Explanations

Solution to Question 1:

Filum terminale extends up to the 1st coccygeal vertebra. It is a filament of connective tissue descending from the apex of conus medullaris.

Solution to Question 2:

The procedure shown in the image is a lumbar puncture. In this, the needle is introduced in the subarachnoid space which ends at the lower border of the S2 vertebra.

A lumbar puncture can be done anywhere from L1 to S2 vertebra. Beyond S2, there are only meninges. However, lumbar puncture is most commonly performed at the level of L3 or L4.

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Solution to Question 3:

Epidural anaesthesia is given during labour and the placement is usually preferred below L1 to avoid injury to the spinal cord. This is because the adult spinal cord terminates at the lower border of the L1 vertebra.

In children, it usually terminates at the upper border of the L3 vertebra.

Note: Coverage from dermatomes T10 to S1 is necessary for epidural analgesia during labor. For a cesarean section, a block from T4 to S1 is needed. However, since the spinal cord ends at the lower border of L1 in most adults, epidural analgesia is given below this level.

Solution to Question 4:

There are a total of 31 pairs of spinal nerves.

In contrast, the number of vertebrae is 33. Due to the difference in the number of spinal segments and the number of vertebrae, the spinal segments don't correspond to the respective vertebrae.

The table below shows the vertebral level corresponding to different regions of the spinal cord:

The T11 spine overlies the L3 spinal segment.

The T12 spine overlies the S1 spinal segment.

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Regions	Spinal Segment(s)	Vertebral spine	Spinal segment corresponds to
Upper cervical	C2	C2	Same level
Lower cervical	C6	C5	One vertebra above
Upper thoracic	T5	T3	Two vertebrae above
Lower thoracic	T10	T7	Three vertebrae above

Solution to Question 5:

The grey rami communicantes are not preganglionic fibers. They are postganglionic fibers.

The sympathetic trunks on either side of the vertebral columns consist of a series of ganglia. They are connected to the spinal nerves by white and grey rami communicantes. The cell bodies of the preganglionic sympathetic neurons are located in the lateral horn in the spinal grey matter. They leave the cord in the ventral nerve roots to form spinal nerves. These fibers enter the sympathetic trunk in white rami communicantes. They synapse with the postganglionic sympathetic neurons in the sympathetic ganglia. The axons of the postganglionic neurons return to the spinal nerve through the grey rami communicantes.

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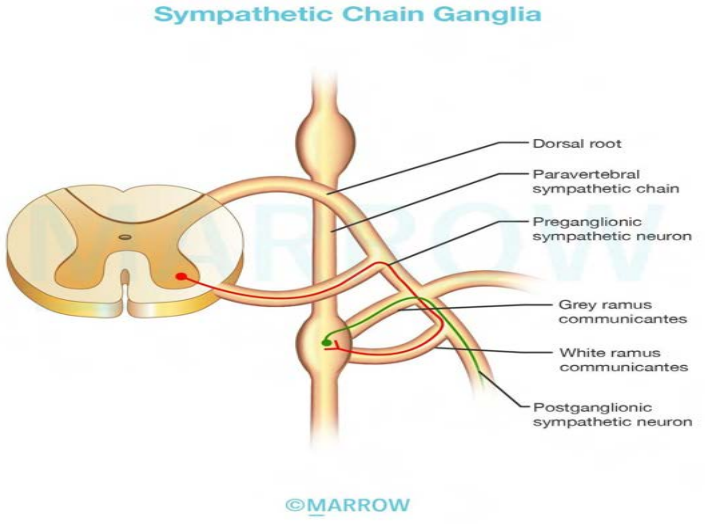
Fibers	White rami communicantes	Grey rami communicantes
Location	Preganglionic	Postganglionic
Myelination	Myelinated	Unmyelinated
Principal neurotransmitter	Acetylcholine	Noradrenaline



Solution to Question 6:

The T10 spinal segments lie at the level of the spinous process of the T7 vertebra.

The table below shows the vertebral level corresponding to different regions of the spinal cord:

The T11 spine overlies the L3 spinal segment.

The T12 spine overlies the S1 spinal segment.

Regions	Spinal Segment(s)	Vertebral spine	Spinal segment corresponds to
Upper cervical	C2	C2	Same level
Lower cervical	C6	C5	One vertebra above
Upper thoracic	T5	T3	Two vertebrae above
Lower thoracic	T10	T7	Three vertebrae above

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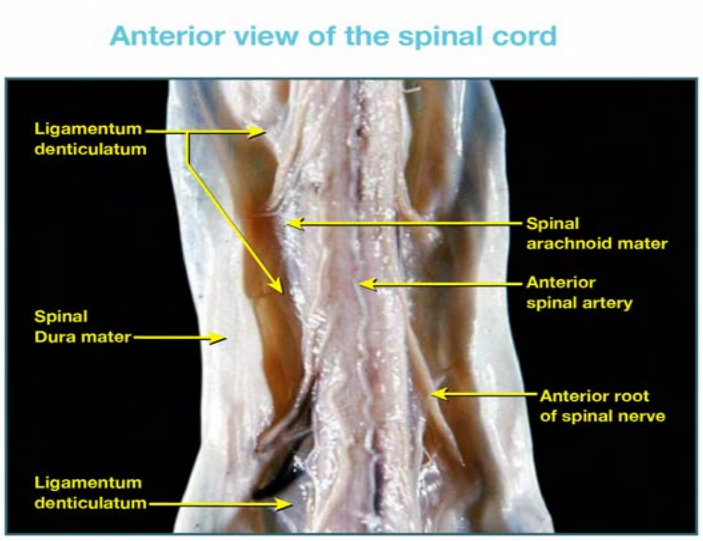
Solution to Question 7:

The structure marked as "?" in the above image is ligamentum denticulatum.
Its lowest projection lies at the level of T12 and L1 spinal nerves.



Solution to Question 8:

Ligamentum denticulatum is not a modification of arachnoid mater. It is a modification of the pia mater.

The ligamentum denticulatum is a flat fibrous sheet on either side of the spinal cord present between the ventral and dorsal spinal roots. It serves as a neurosurgical landmark for hemisectioning of the spinal cord.

Its medial border is continuous with the subpial connective tissue. Its lateral border forms a series of 21 triangular processes on each side connecting it to the dura mater giving it a serrated appearance.

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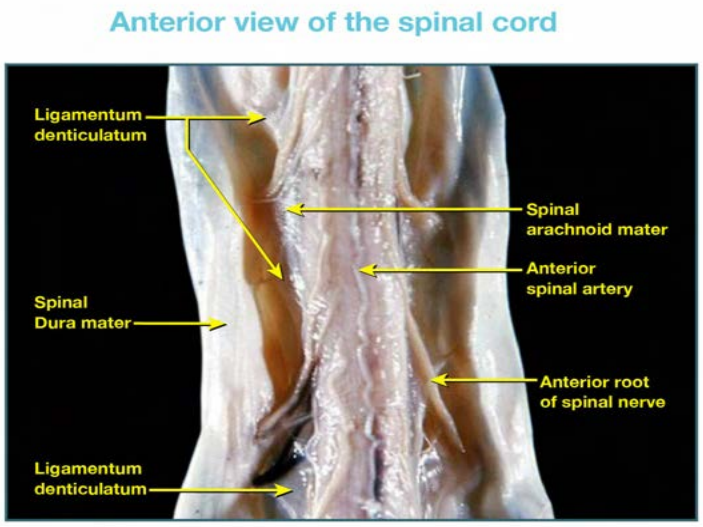

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Solution to Question 9:

Thrombosis of the anterior spinal artery affects the anterior 2/3rd of the spinal cord.

The spinal cord is supplied by the longitudinal arteries and segmental arteries.

The longitudinal arteries are:

Anterior spinal artery supplies anterior 2/3rd of the cord. Occlusion of the anterior spinal artery causes-

• Bilateral paraplegia below the level of lesion due to damage to bilateral corticospinal tracts.

• Bilateral thermoanesthesia and analgesia below the level of lesion due to damage to bilateral spinothalamic tracts.

• Weakness of limb muscles due to damage to bilateral anterior grey horns in cervical or lumbar regions of the cord.

• Loss of bowel and bladder functions due to damage to the descending autonomic tracts.

• Sense of position, vibration, and fine touch are intact as the posterior white column is unaffected, which is supplied by the posterior spinal artery.

Posterior spinal arteries supplies posterior 1/3rd of the cord. Occlusion of the posterior spinal artery causes-

• Loss of sensation of position, vibration and fine touch due to damage to the bilateral posterior white columns.

• The corticospinal tracts, spinothalamic tracts, anterior grey horns, and descending autonomic tracts are unaffected, as they are supplied by the anterior spinal artery.

The segmental arteries are branches of arteries outside the vertebral column.These are branches of-

• Deep cervical artery

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- Intercostal artery
- Lumbar arteries

Solution to Question 10:

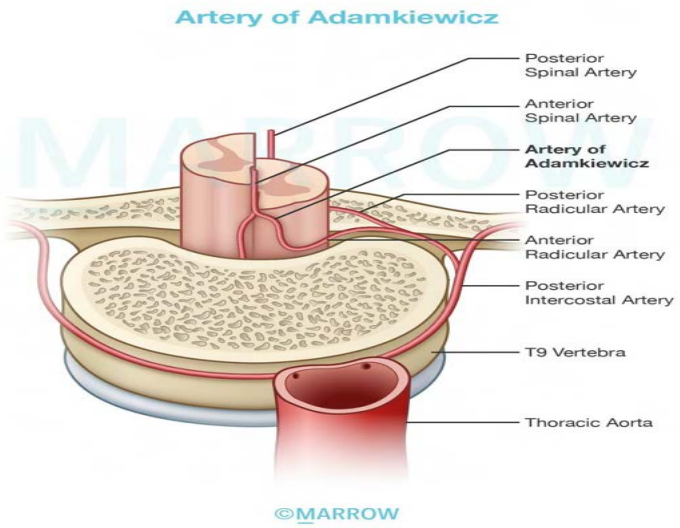
The artery of Adamkiewicz supplies the lower two-thirds of the spinal cord. It is unilateral and in majority of the people, enters the spinal cord from the left side.

The anterior spinal artery (ASA) is augmented by numerous radicular arteries. The most prominent of these is the artery of Adamkiewicz. It originates from the aorta in the lower thoracic or upper lumbar vertebral levels and has the following course:

Aorta - posterior intercostal artery - radicular artery - artery of Adamkiewicz - anastomosis with the anterior spinal artery(ASA).

Clinical significance:

It is a major source of blood supply for the lower 2/3rd of the cord. Damage to this artery can lead to paraplegia. Ischemia of the anterior segment is associated with the aortic bypass procedure.



Solution to Question 11:

The tract marked "A" in the image is the lateral reticulospinal tract.

They originate from the reticular formation of the brain and terminate on the α and γ motor neurons in the spinal cord. They inhibit or facilitate voluntary movement.

Solution to Question 12:

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In the given scenario, the pain sensation will be intact because the posterior white column (dorsal column) doesn't carry the pain sensation. Pain sensation is carried by the anterolateral column.

Option C: Pressure sensation related to a finer degree of pressure intensity judgment is carried by the dorsal column. On the other hand, relatively crude sensations of touch and pressure are carried by the anterolateral system.

Options B and D: Position sense and vibration sensation will be affected in this case as they are carried by the dorsal column.

Solution to Question 13:

The vestibulospinal tract remains uncrossed through the medulla and through the length of the spinal cord in the anterior white column.

Ascending tracts - All tracts decussate except dorsal and rostral spinocerebellar tracts.

Descending tracts - All tracts decussate except reticulospinal and vestibulospinal tracts

Solution to Question 14:

The given clinical scenario is suggestive of Brown- Séquard syndrome. Ipsilateral loss of crude touch sensation is not seen in this syndrome.

Brown- Séquard syndrome is the hemisection of the spinal cord. This causes damage to ascending sensory (dorsal column pathway, spinothalamic tract) and descending motor (corticospinal tract) pathways.

• The damage to the dorsal column pathway leads to ipsilateral loss of fine touch, vibration, and proprioception below the level of the lesion.

• The damage to the spinothalamic tract leads to contralateral loss of pain and temperature sensation beginning one or two segments below the lesion.

• The damage to the corticospinal tract produces ipsilateral paralysis of the body.

Solution to Question 15:

The given clinical scenario is suggestive of cauda equina syndrome. The conus medullaris syndrome typically shows the symmetrical weakness of lower limbs, whereas the cauda equina syndrome, presents with asymmetrical weakness of lower limbs.

Radicular pain, lower motor neuron injury, and urinary retention are common to both conus medullaris and cauda equina syndrome.

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Osteology, Scalp and Face

Question 1:

How many pairs of synovial articulations are associated with the exterior of the skull?

a) 1

b) 2

c) 3

d) 4

Question 2:

Which skull bone is known as Inca?

a) Parietal bone

b) Temporal bone

c) Interparietal bone

d) Occipital bone

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Question 3:

While counselling the parents of a baby with anterior plagiocephaly, you explain that one of the skull sutures has prematurely fused. The affected suture is present between:

a) Both frontal bones

b) The frontal and parietal bones

c) The occipital and parietal bones

d) Both parietal bones

Question 4:

Which of the following structures passes through the marked foramen?

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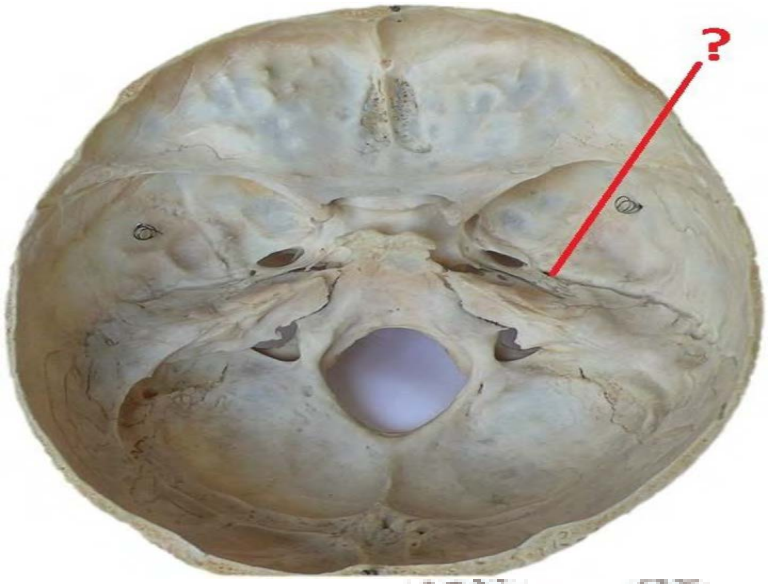

a) Accessory meningeal artery

b) Lesser petrosal nerve

c) Maxillary nerve

d) Middle meningeal artery

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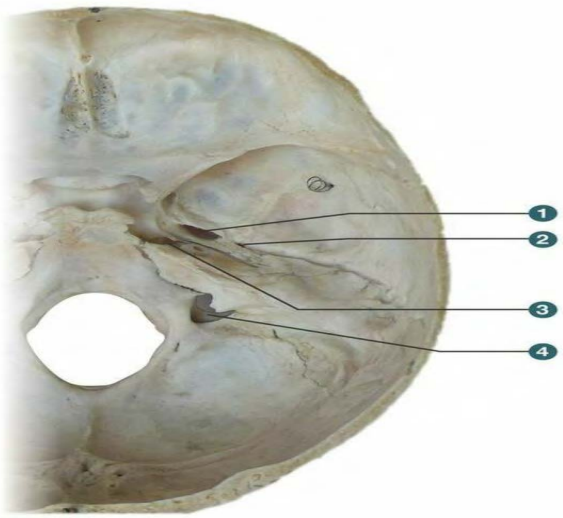
Question 5:

A 40-year-old man presents with bruxism. The nerve supplying the muscles involved in this condition passes through:



a) 1

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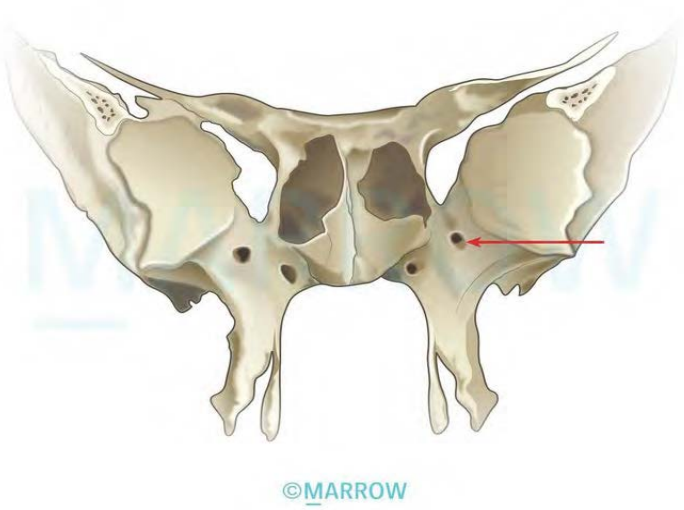
b) 2

c) 3

d) 4

Question 6:

Identify the foramen marked in the image below.



a) Foramen rotundum

b) Foramen ovale

c) Vidian canal

d) Foramen spinosum

Question 7:

A patient presenting with right-sided shoulder droop and an absent gag reflex was diagnosed with Vernet's syndrome. Which of the following structures passes through the posterior part of the involved foramen?

a) Spinal accessory nerve

b) Sigmoid sinus

c) Inferior petrosal sinus

d) Vagus nerve

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Question 8:

Which of the following ligaments passes through the foramen magnum?

a) Transverse ligament of atlas

b) Membrana tectoria

c) Anterior longitudinal ligament

d) Ligamentum flavum

Question 9:

A dentist performing a wisdom tooth extraction injects lidocaine at the structure marked X below. Which of the following nerves is blocked here?

a) Lingual nerve

b) Mandibular nerve

c) Chorda tympani nerve

d) Inferior alveolar nerve

Question 10:

Identify the cranial nerve that passes through the marked foramen marked in the image below.

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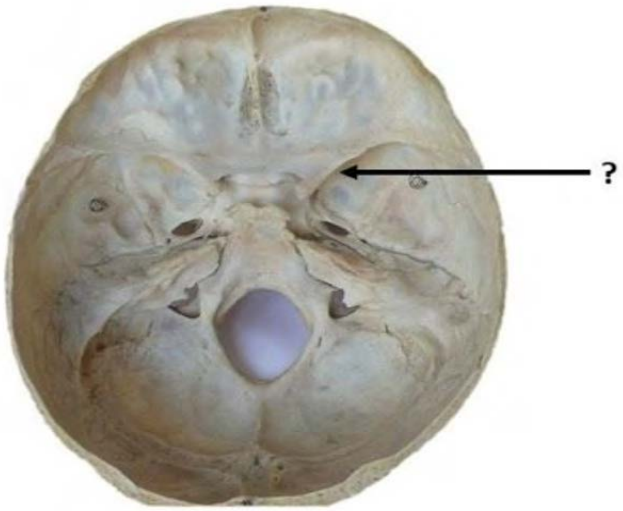

a) Oculomotor nerve

b) Olfactory nerve

c) Optic nerve

d) Facial nerve

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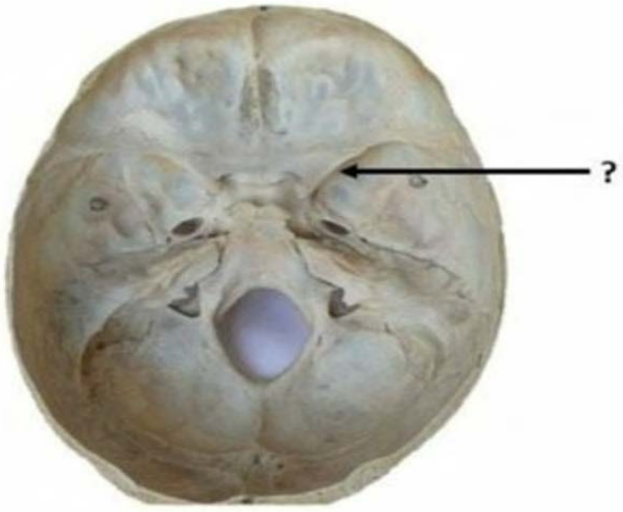
Question 11:

Identify the structure passing through the foramen marked.



a) Abducens nerve

b) Spinal accessory nerve

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c) Ophthalmic artery

d) Middle meningeal artery

Question 12:

A 24-year-old man presents to the ER after receiving a punch to the right side of his face. His X-ray is shown below. Which of the following bones maximally contributes to the region fractured?

a) Maxilla

b) Sphenoid bone

c) Palatine bone

d) Zygomatic bone

Question 13:

A detective is brought to the casualty with an upper eyelid laceration following a knife fight. The plastic surgeon palpates for a landmark to administer lignocaine before suturing. Where is the local anesthetic injection given?

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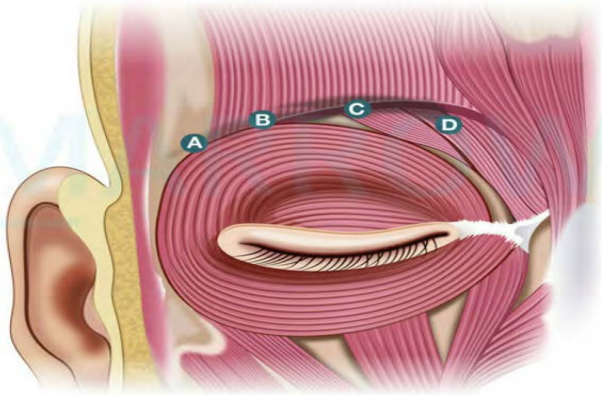


a) A

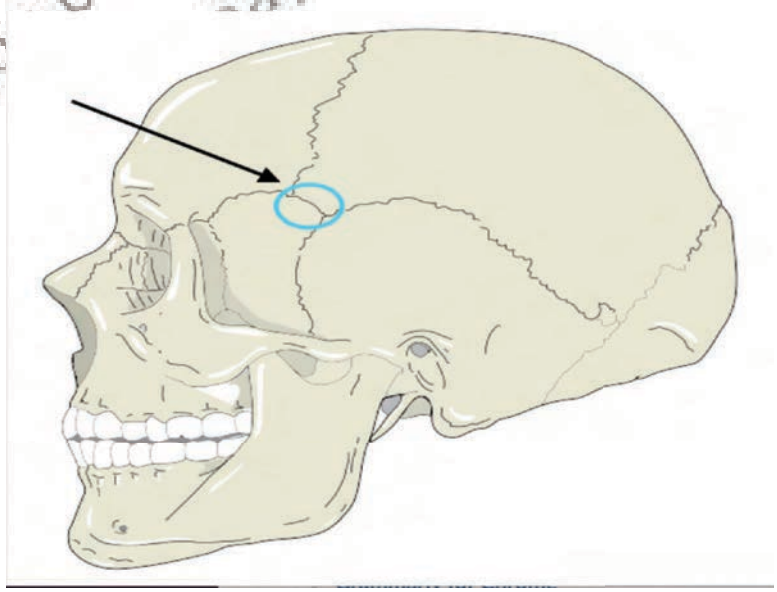
b) B

c) C

d) D

Question 14:

Which of the following bony structures is present behind the marked area?



a) Post clivus

b) Lesser wing of sphenoid

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c) Sella turcica

d) Carotid canal

Question 15:

A cricket player was rushed to the emergency department, unconscious after being hit in the head with the ball. NCCT head revealed an extradural hematoma at the pterion. Which of the following vessels is likely to be injured?

a) Superficial temporal artery

b) Maxillary artery

c) Middle meningeal artery

d) Deep temporal artery

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Question 16:

Which of the following fontanelles is most likely to be open in an 18-month old infant?

a) Anterior

b) Posterior

c) Occipital

d) Mastoid

Question 17:

While resecting an acoustic neuroma via the middle cranial fossa approach, the surgeon drills over the arcuate eminence of the petrous temporal bone. What is the inferior relation of the structure being drilled?

a) Lesser petrosal nerve

b) Greater petrosal nerve

c) Superior semicircular canal

d) Posterior semicircular canal

Question 18:

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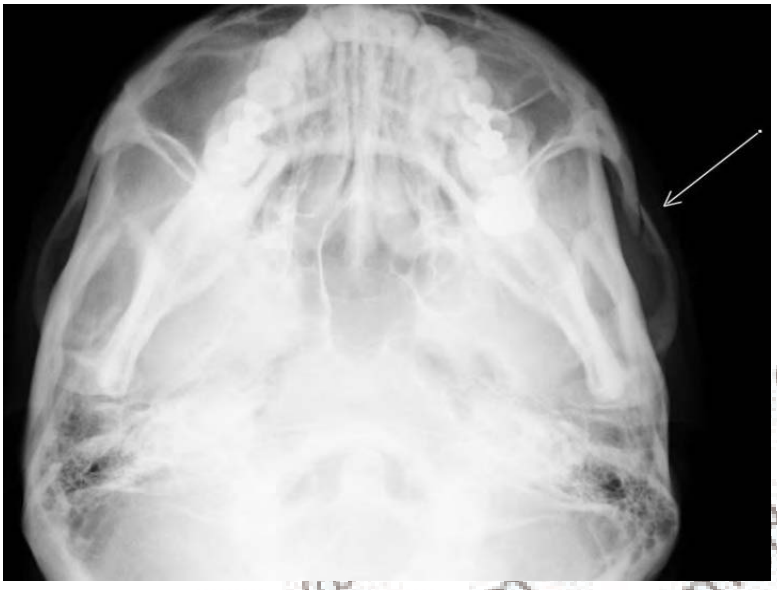
A man was hit on his face during a fight and suffered the following fracture. Which of the following bones is likely to be fractured?



a) Frontal bone

b) Maxilla

c) Sphenoid bone

d) Temporal bone

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Question 19:

Which of the following nerves provides sensory innervation to the scalp?

a) Infratrochlear nerve

b) Lesser occipital nerve

c) Anterior division of greater auricular nerve

d) Facial nerve

Question 20:

A 2 week-old neonate developed meningitis following a scalp abscess. What is the likely route of spread?

a) Superficial fascia

b) Aponeurosis

c) Subaponeurotic tissue

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d) Pericranium

Question 21:

A 41-year-old man was brought to the emergency with a profusely bleeding scalp laceration following a road traffic accident. What is the nature and layer of origin of the bleed?

a) Venous bleed, Loose areolar tissue

b) Venous bleed, Dense connective tissue

c) Arterial bleed, Dense connective tissue

d) Arterial bleed, Loose areolar tissue

Question 22:

Which of the following muscles is unlikely to be involved in a patient with Bell's palsy?

a) Orbicularis oris

b) Frontalis

c) Orbicularis oculi

d) Levator palpebrae superioris

Question 23:

Match the following muscles of facial expression with their actions.

a) 1-A ; 2-E ; 3-D ; 4-B ; 5-C

b) 1-C ; 2-D ; 3-E ; 4-A ; 5-B

c) 1-C ; 2-E ; 3-D ; 4-B ; 5-A

d) 1-A ; 2-D ; 3-C ; 4-E ; 5-B

Question 24:

Which of the following muscles plays a role in winking?

a) Levator palpebrae superioris

b) Corrugator supercilii

c) Orbicularis oculi

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d) Frontalis

Question 25:

A patient presents with a loss of sensation over the marked area. Which nerve may be damaged?

a) Auriculotemporal nerve

b) Maxillary nerve

c) Great auricular nerve

d) Facial nerve

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Question 26:

While testing the cranial nerves in a stroke patient, you ask her to try to whistle. Which of the following structures doesn't pierce the muscle responsible for this action?

a) Parotid duct

b) Molar glands of the cheek

c) Buccal branch of the facial nerve

d) Buccal branch of the mandibular nerve

Question 27:

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Which of the following nerves is related to Dorello's canal?

a) Trochlear nerve

b) Oculomotor nerve

c) Abducens nerve

d) Trigeminal nerve

Answer Key

Question No.	Correct Option
1	b
2	c
3	b
4	d
5	a
6	a
7	b
8	b
9	d
10	a
11	a
12	a
13	c
14	b
15	c
16	a
17	c
18	d
19	b
20	c
21	c
22	d
23	c
24	c
25	c

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26	c
27	c

Detailed Explanations

Solution to Question 1:

There are 2 pairs of synovial articulations that are associated with the exterior of the skull. They are temporomandibular joint and lateral joints (part of atlantooccipital joints).

Joints of the cranial vault:

• Fibrous joints/ Sutures - Facilitate the growth of the skull. (majority of the skull joints fall in this category)

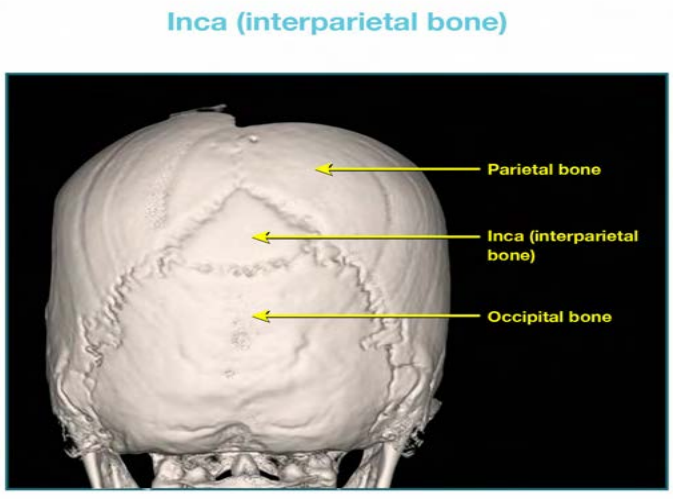
• Primary cartilaginous joints - Present between the bones in the skull base

• Synovial joints - temporomandibular joints and atlantooccipital joints.

Solution to Question 2:

The interparietal bone of the skull is known as Inca. It is a sutural bone that lies between the occipital and the parietal bones. It is also called Goethe's ossicle.

Sutural or wormian bones are islands of bone that are commonly found within the lambdoid suture in some individuals. They may arise from separate centers of ossification and they appear to have no clinical significance.



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Solution to Question 3:

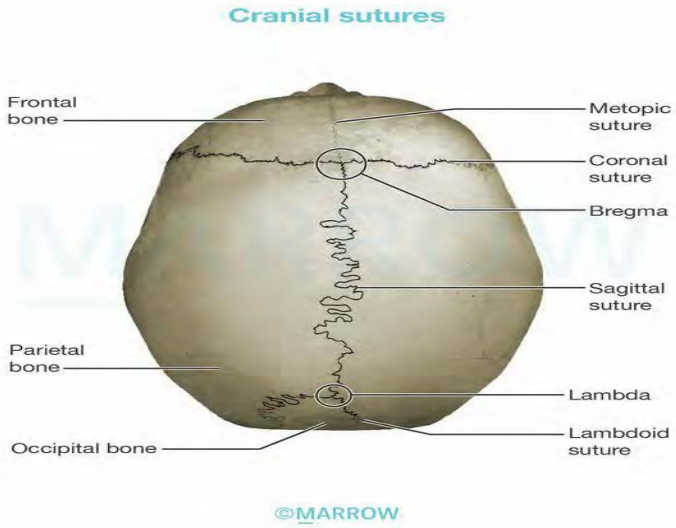
In anterior plagiocephaly, the premature fusion of the coronal sutures is seen. The coronal suture is present between the frontal and parietal bones.

Major sutures of the skull are:

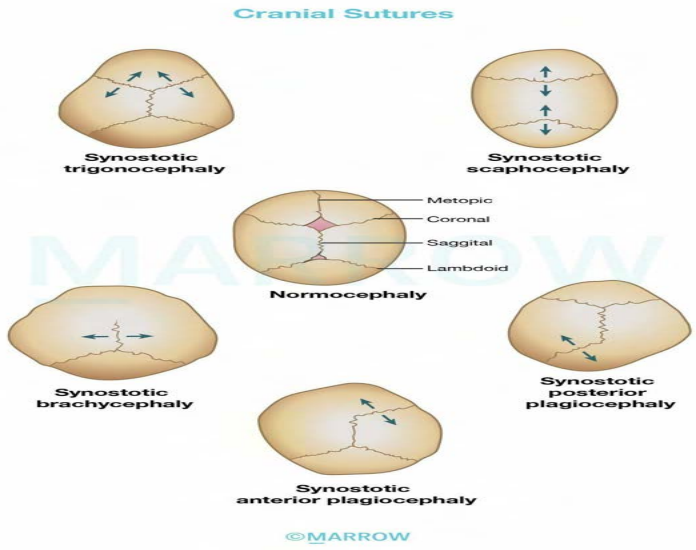
• Lambdoid suture - between parietal and occipital bones.

• Sagittal suture - between the two parietal bones.

• Metopic suture - between the two frontal bones.



Craniosynostosis consists of premature fusion of one or more cranial sutures, resulting in an abnormal head shape.



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Solution to Question 4:

The foramen marked is the foramen spinosum. The structures passing through it are:

• Middle meningeal artery

• Nervus spinosus

• Middle meningeal vein

Solution to Question 5:

Bruxism or teeth grinding mainly involves the temporalis, lateral pterygoids, and the masseter (muscles of mastication). These are supplied by the mandibular nerve. It passes through the foramen ovale (marked A).

Other foramina marked are:

2. Foramen spinosum

3. Foramen lacerum

4. Jugular foramen

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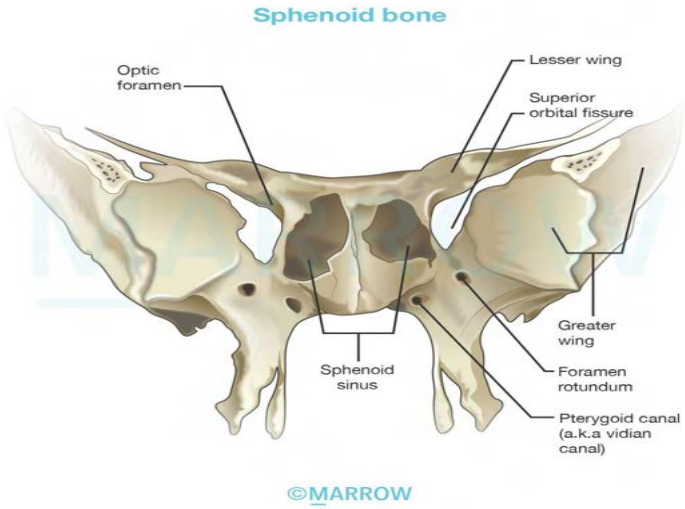
Solution to Question 6:

The image shows the sphenoid bone. The foramen marked is the foramen rotundum. Maxillary branch of trigeminal nerve passes through it.



Solution to Question 7:

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Vernet's syndrome or jugular foramen syndrome refers to the palsies of IX, X, and XI cranial nerves traversing the jugular foramen. The sigmoid sinus passes through the posterior aspect of the jugular foramen.

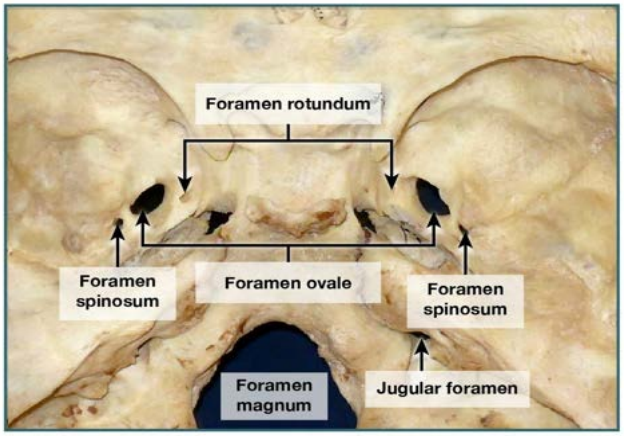
Jugular foramen can be divided into three compartments:

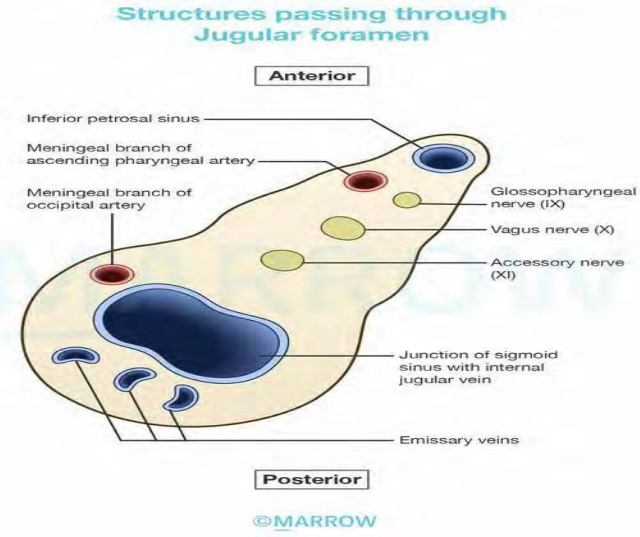
• Anterior - Inferior petrosal sinus

• Intermediate - CN IX, X, XI

• Posterior - Sigmoid sinus continuing as the internal jugular vein

The arteries passing through the foramen are the meningeal branch of ascending pharyngeal artery and the meningeal branch of the occipital artery. Emissary veins may also traverse it.





Solution to Question 8:

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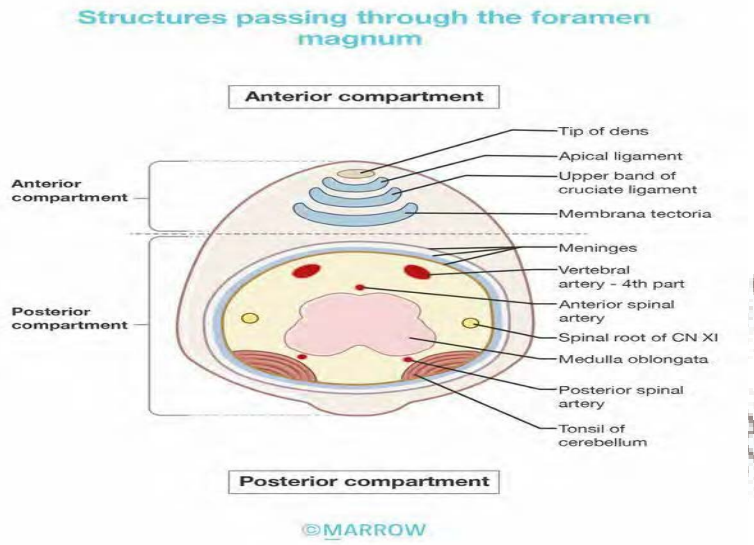
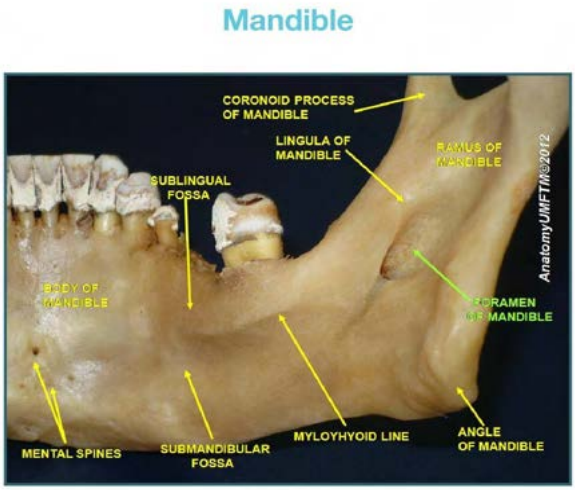
The membrana tectoria of atlanto-axial joint passes through the foramen magnum.

Certain structures pass through two compartments of the foramen magnum -
the osseo-ligamentous (anterior) and neuro-vascular (posterior) compartments - as shown in the image below:



Solution to Question 9:

The marked structure is mandibular foramen and the inferior alveolar nerve passes through it.
The inferior alveolar nerve is blocked by injecting a local anaesthetic at the mandibular foramen.



Given below is an image showing the administration of inferior alveolar nerve block before it enters the mandibular foramen.

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Inferior alveolar nerve block

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Solution to Question 10:

The marked structure is the superior orbital fissure and the oculomotor nerve passes through this fissure.

Superior orbital fissure is divided into three compartments by the common tendinous ring. The oculomotor nerve passes through its intermediate compartment.

Solution to Question 11:

The marked foramen is the superior orbital fissure and the abducens nerve passes through it.

The abducens nerve is the 6th cranial nerve and arises from the brainstem at the pontomedullary junction. It runs through the Dorello's canal which is present at the medial most end of the petrous ridge and then enters the cavernous sinus where it lies lateral to the internal carotid artery. It enters the orbit through the superior orbital fissure within the common tendinous ring and supplies the lateral rectus.

Other options:

Spinal accessory nerve passes through the foramen magnum along with the medulla oblongata and the verterbral arteries

Ophthalmic artery passes through the optic canal along with the optic nerve.

Middle meningeal artery and vein pass through the foramen spinosum along with the meningeal branch of mandibular nerve.

Solution to Question 12:

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The X-ray shows a fracture of the floor of the orbit. The maximum contribution to the floor of the orbit is by the maxilla.

Boundaries of the bony orbit:

• Roof:

• Orbital plate of frontal bone

• Sphenoid bone (small part)

• Floor: Thin plate of bone that also forms the roof of the maxillary sinus

• Orbital plate of maxilla

• Zygomatic bone (anterolateral)

• Orbital process of palatine bone (posteromedial)

• Medial wall:

• Maxilla

• Lacrimal bone

• Ethmoid bone

• Sphenoid bone

• Lateral wall:

• Zygomatic bone (anterior)

• Greater wing of sphenoid (posterior)

• Sphenozygomatic suture.

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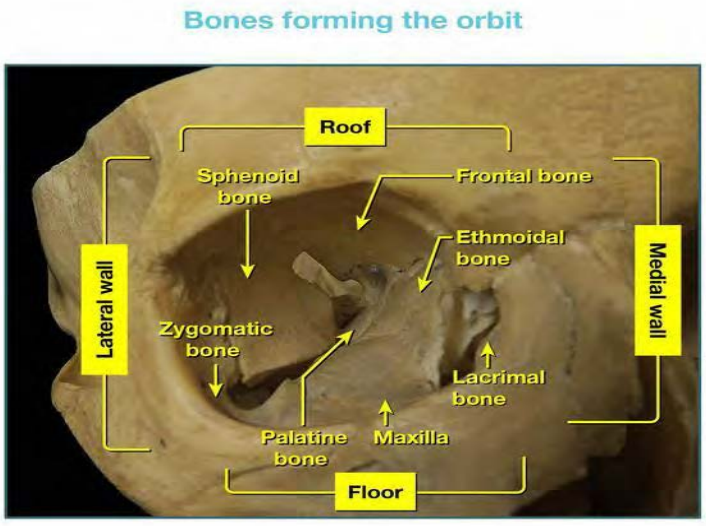

The orbital floor can be fractured by trauma to the orbit as seen in falls, motor vehicle accidents, and assaults. The image given shows X-ray Water's view with a 'teardrop' sign. The orbital contents leak out of the fractured orbital floor, giving it a teardrop-like appearance.

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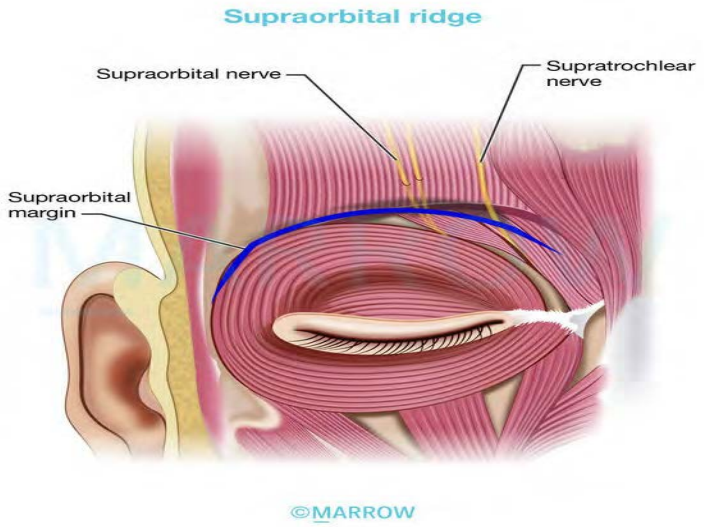
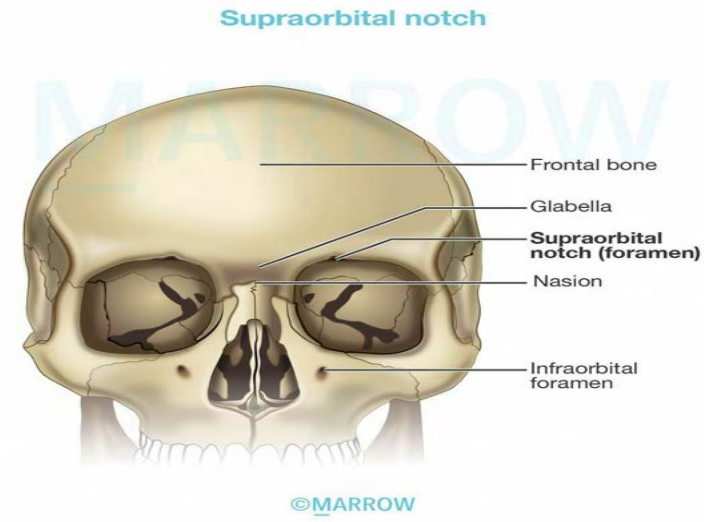
Solution to Question 13:

Upper eyelid lacerations are sutured under supraorbital nerve block. The anesthesia is achieved by approaching the nerve at the supraorbital foramen/notch. The supraorbital notch is present at the junction of lateral two-third and medial one-third of the supraorbital margin (point C). It transmits the supraorbital nerve and vessels.





Solution to Question 14:

The structure marked in the image is pterion, and the bony structure that is present behind it is the lesser wing of the sphenoid.

The pterion is an H-shaped sutural junction between four bones of the skull:

• Frontal bone

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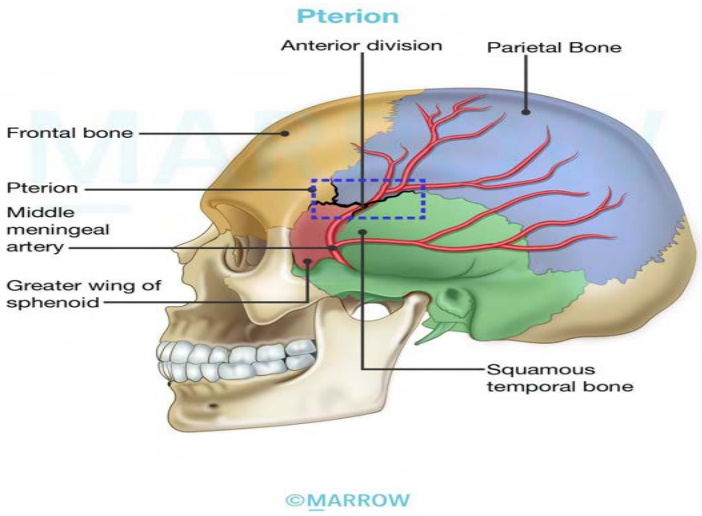
• Squamous part of the temporal bone

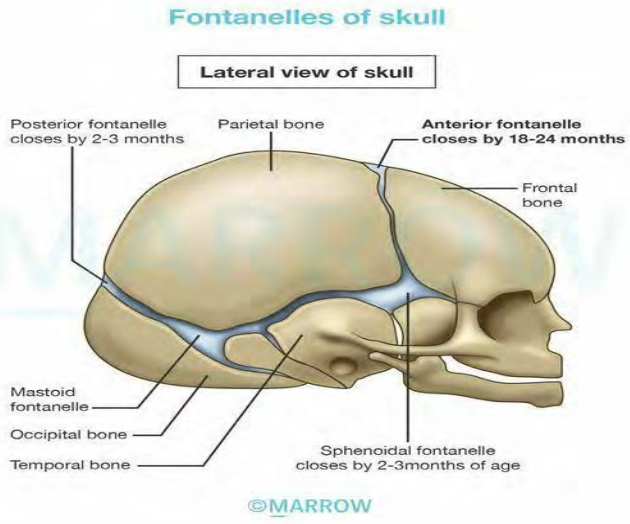
• Greater wing of the sphenoid bone

• Parietal bone



The pterion overlies the anterior branch of the middle meningeal artery and lateral fissure of the cerebral hemisphere. The bone in this area is thin and any injury to this area may lead to rupture of the middle meningeal artery leading to extradural hematoma.

The pterion also corresponds to the site of the anterolateral (sphenoidal) fontanelle of the neonatal skull, which closes in the third month after birth.



Solution to Question 15:

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An extradural hematoma at the pterion is a result of an injury of the anterior division of the middle meningeal artery.

The pterion is an H-shaped sutural junction between four bones of the skull:

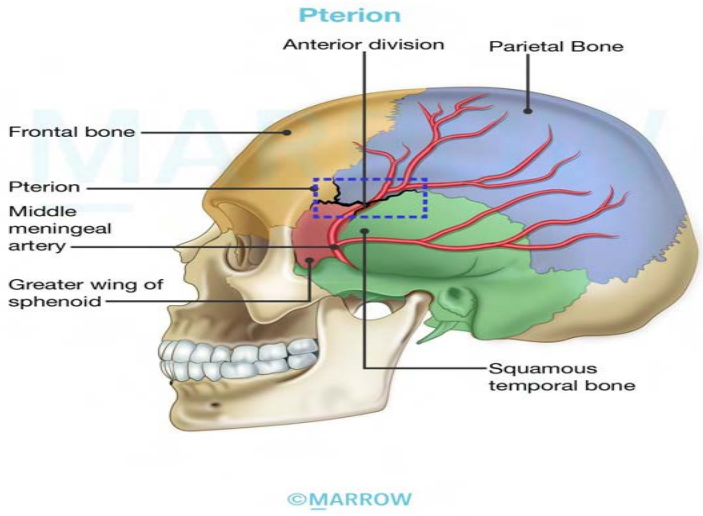
• Frontal bone

• Squamous part of the temporal bone

• Greater wing of sphenoid bone

• Parietal bone.

It also overlies the lateral fissure of the cerebral hemisphere, the hematoma can cause compressive lesions here.



Solution to Question 16:

The anterior fontanelle is most likely to be open as it is the last fontanelle to close. It closes at around 18-24 months of age.

Fontanelles of the skull:

Fontanelle	Location	Closes at
Anterior	Between frontal and parietal bonesJunction marked by br egma	18-24 months
Posterior	Sagittal and lambdoid suture s	2-3 months
Sphenoid	Pterion	2-3 months
Mastoid/Posterolatera l	Intersection of temporal, pari etal, and occipital bones.	6-18 months (average 12 mon ths)

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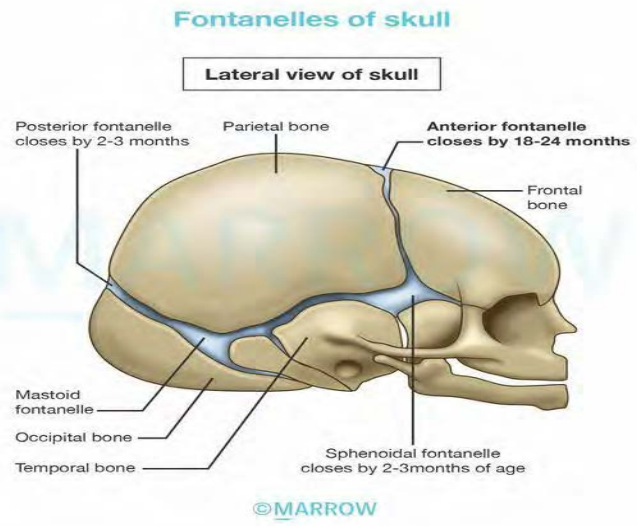

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Solution to Question 17:

The superior semicircular canal is present beneath the arcuate eminence of the petrous temporal bone. The arcuate eminence is used as a neurosurgical landmark for the superior semicircular canal in surgeries done by the middle cranial fossa approach.

The temporal bone consists of the following parts:

- Squamous
- Mastoid
- Petrous
- Tympanic
- Styloid process
- Zygomatic process

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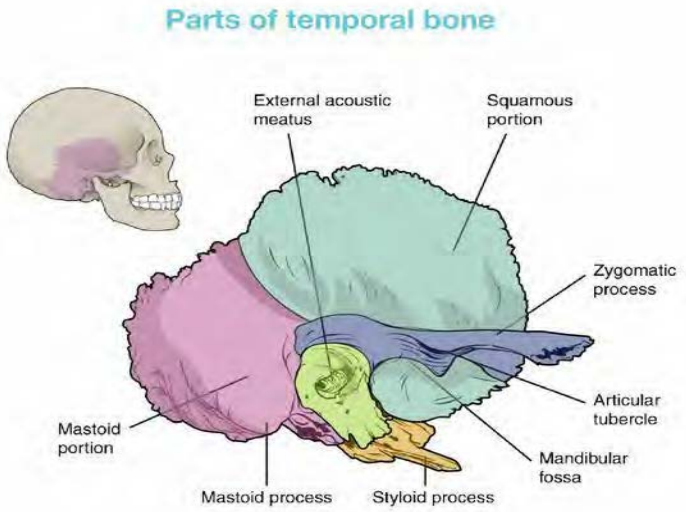
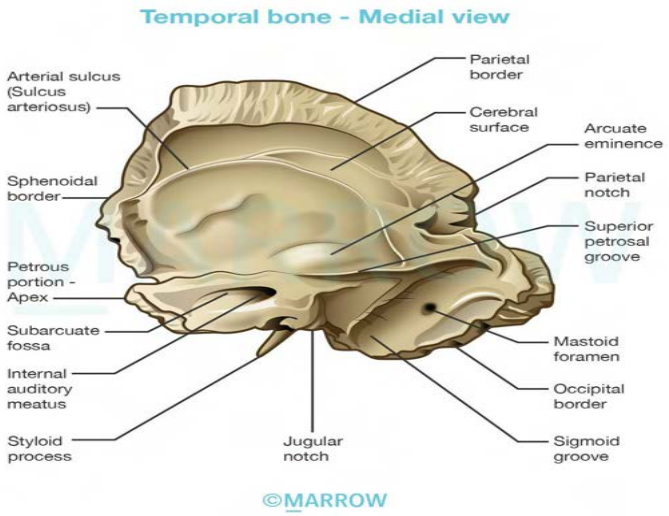


The petrous temporal bone is a pyramid-shaped structure. Its relations are:

• Inferior to arcuate eminence - superior semicircular canal .

• Posterior surface - internal auditory meatus (IAM) and vestibular aqueduct

• Inferior surface - carotid canal and the jugular fossa (jugular notch)



Solution to Question 18:

The X-ray shows a fracture of the left zygomatic arch. The zygomatic process of the temporal bone contributes to the formation of the zygomatic arch.

Zygomatic arch is made up of the temporal process of the zygomatic bone and the zygomatic process of the temporal bone. They articulate at the zygomaticotemporal suture.

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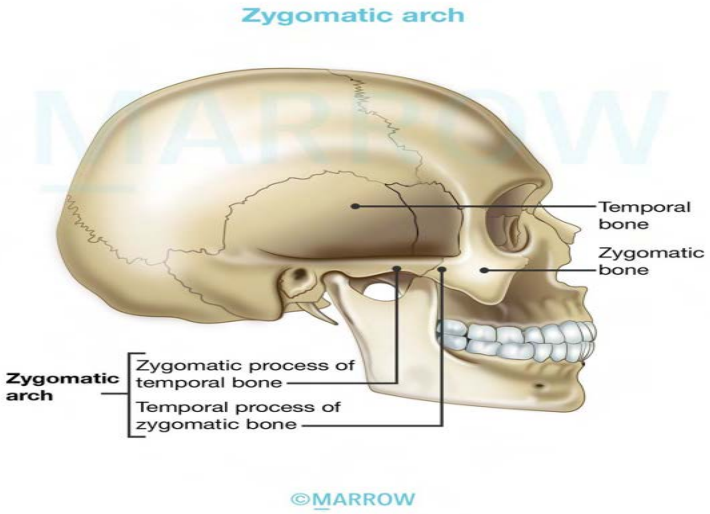
Masseter originates from the lower border of the zygomatic arch.

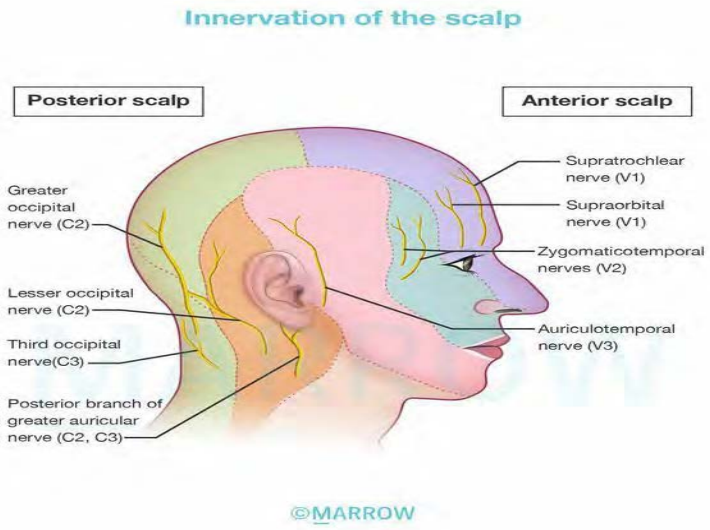


Solution to Question 19:

The lesser occipital nerve provides sensory innervation to the scalp.

- Anterior to ear and vertex: Branches of the trigeminal nerve branches and facial nerve.
- Posterior to the ear and vertex: Spinal nerves

Sensory innervation of the anterior and posterior scalp is shown in the image below:



The temporal and posterior auricular branches of the facial nerve constitute the motor supply to the anterior and posterior scalp, respectively.

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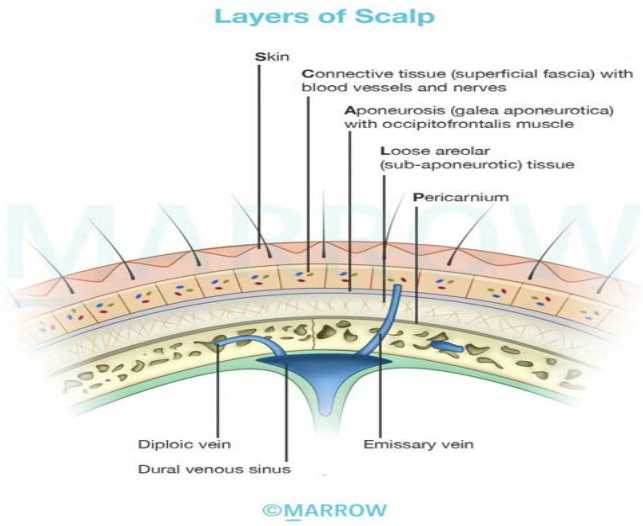
Solution to Question 20:

The infection has likely spread from the sub-aponeurotic tissue.

The sub-aponeurotic loose areolar tissue of the scalp is referred to as the dangerous area of the scalp. Infection from this layer can pass into the cranial cavity through small emissary veins, which pass through parietal foramina in the calvaria. It can reach intracranial structures causing meningitis and intracranial abscesses.

The scalp is a soft tissue that covers the calvaria of the skull. It consists of 5 layers as shown in the image below (mnemonic - SCALP):



Solution to Question 21:

Scalp bleeding is predominantly arterial, from the dense connective tissue of the scalp.

Profuse bleeding from scalp injuries occurs due to:

• Low venous pressure in the erect posture

• The dense connective tissue holds the arteries open and does not allow them to retract causing profuse bleeding.

The scalp has an extremely rich blood supply from the external carotid arteries. Profuse bleeding from a scalp laceration is usually fatal unless it's quickly controlled by sutures.

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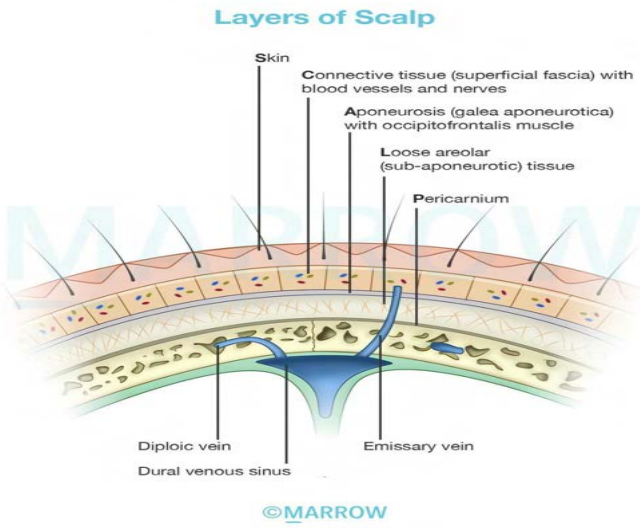

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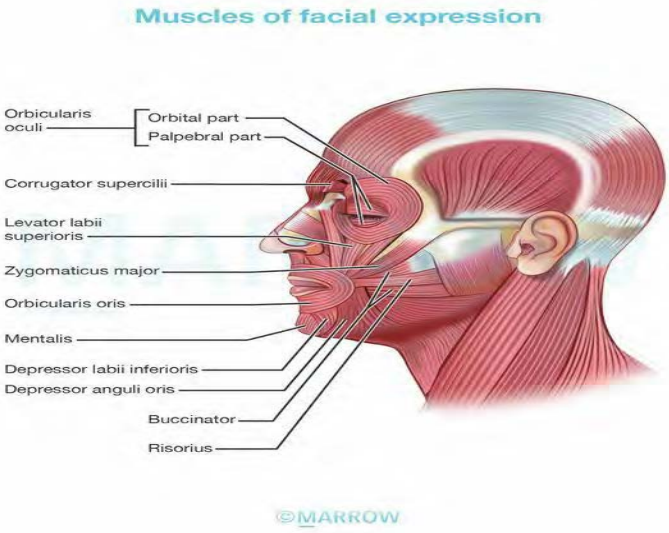
Solution to Question 22:

The motor component of the levator palpebrae superiors is innervated by the oculomotor (III cranial) nerve and the smooth muscle component is innervated by the sympathetic nerves. It is uninvolved in Bell's palsy.

All the other facial muscles are innervated by the facial nerve and thus will be paralyzed in Bell's palsy.



Solution to Question 23:

The following are some muscles of facial expression and their actions:

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• Orbicularis oculi - Closing eyelids

• Risorius - Retracts angle of the mouth, grinning muscle

• Orbicularis oris - Closes mouth

• Mentalis - wrinkles chin

• Corrugator supercilli - frowning

• Zygomaticus major - smiling and laughing

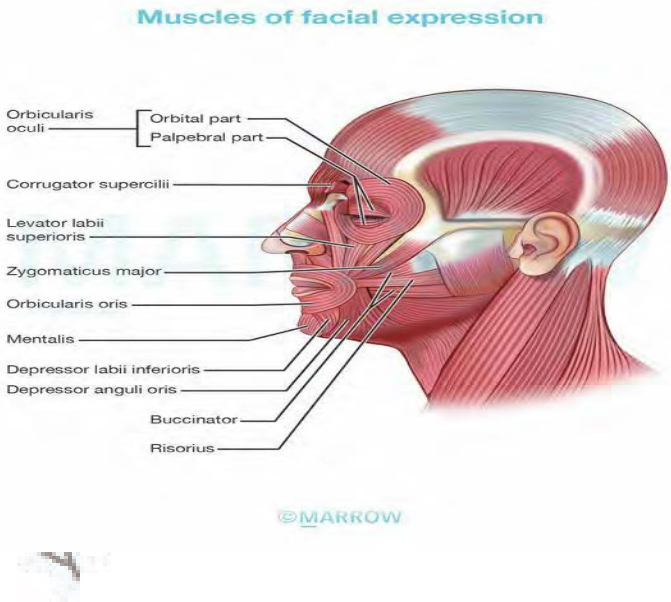
• Depressor anguli oris - depresses angle of mouth

• Levator labii superioris - elevates upper lip

• Depressor labii inferioris - depresses lower lip

• Buccinator - known as whistling muscle, it flattens the cheeks against the gums and teeth

Note: Modiolus is a fibromuscular structure formed by the interlacing of 5 muscles.



Solution to Question 24:

The orbicularis oculi muscle plays a role in winking.

The orbicularis oculi are circumorbital muscles that are broad, flat and elliptical. They surround the circumference of the orbit and spread into the adjascent regions. It has orbital, palpebral and lacrimal parts. It plays an important role in modulating facial expression and various ocular reflexes. It mainly closes the eyelids.

It is supplied by branches of the facial, superficial temporal, maxillary and ophthalmic arteries. It is innervated by the temporal and zygomatic branches of the facial nerve.

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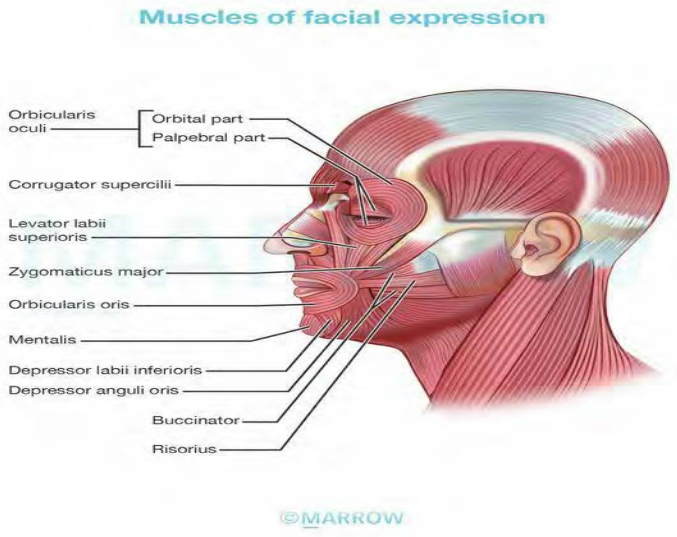

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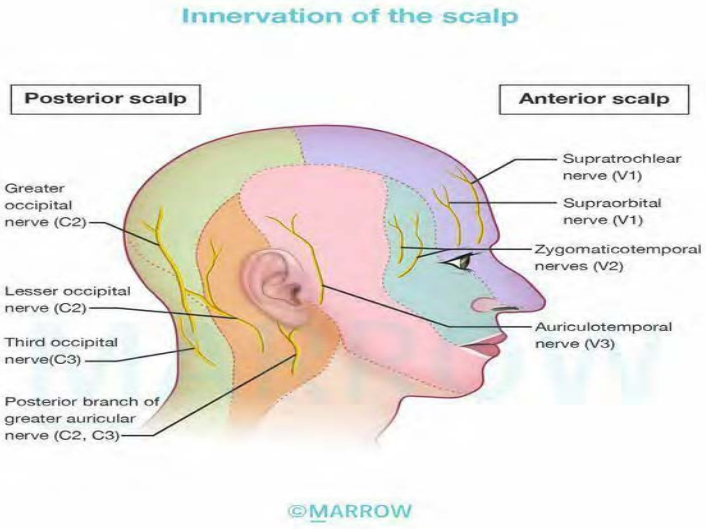
Solution to Question 25:

The skin over the angle of the mandible is innervated by the great auricular nerve.

Most of the skin covering the face is innervated solely by branches of the trigeminal nerve except the skin over the angle of the mandible which is supplied by the great auricular nerve from the C2 cervical plexus and the ear supplied by the vagus nerve, the facial nerve, and the cervical plexus.



Solution to Question 26:

The buccinator muscle is involved in flattening the cheeks against the gums and teeth. Hence, it is known as the whistling muscle. The buccal branch of the facial nerve innervates the buccinator

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muscle but does not pierce it.

The structures piercing the buccinator muscle are:

• Parotid duct

• Buccal branch of the mandibular nerve

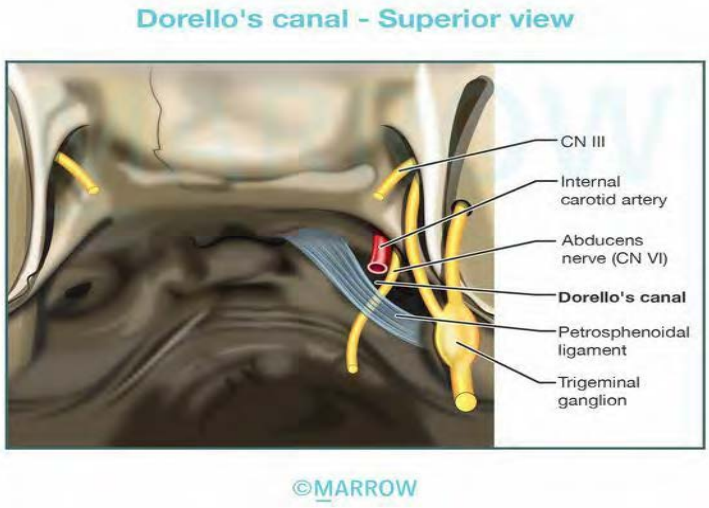
• Molar mucous glands which lie on the buccopharyngeal fascia around the parotid duct

Solution to Question 27:

Abducens nerve is related to Dorello's canal. The abducens nerve enters the cavernous sinus by passing within this canal.

Dorello's canal is an interdural space limited superiorly by the petrosphenoidal ligament, laterally by the petrous apex, and medially by the dorsum sellae. This is a confluence of superior petrosal, inferior petrosal, cavernous sinus, and basilar plexus venous sinuses.

Dorello's canal anatomy was noted to be clinically significant in understanding sixth nerve palsy. The clinical implications turned toward its relevance to skull base surgery, mostly for petroclival lesions.



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Deep fascia and Triangles of the neck

Question 1:

A surgeon performing a radical neck dissection wants to start at the anterior triangle. Which of the following areas will she not dissect?

a) Subclavian triangle

b) Submental triangle

c) Digastric triangle

d) Carotid triangle

Question 2:

Which of the following structures does not form both the roof, and is a content of the posterior triangle?

a) Lesser occipital nerve

b) Supraclavicular nerve

c) Suprascapular nerve

d) Great auricular nerve

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Question 3:

Which of the following is true about deep cervical fascia?

a) Investing layer covers parotid gland and submandibular gland

b) Pretracheal layer covers both thyroid and parotid gland

c) Axillary sheath is formed by the pretracheal fascia

d) Investing layer forms the floor of posterior triangle

Question 4:

A 54-year-old woman with papillary thyroid carcinoma developed a palpable lymph node in the suprasternal space of Burns. Which of the following structures is not closely related to these metastatic lymph nodes?

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a) Anterior jugular vein

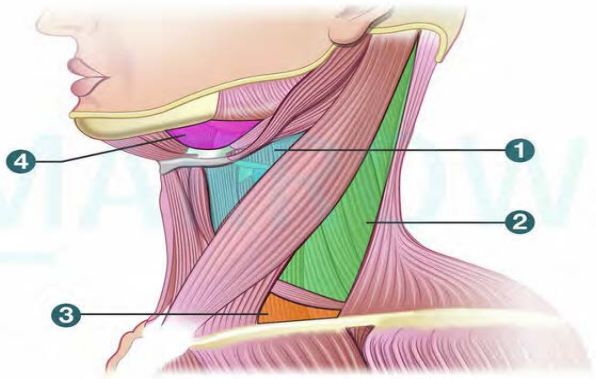
b) Interclavicular ligament

c) Sternal head of sternocleidomastoid

d) External jugular vein

Question 5:

A 21-year-old student presents with a single episode of loss of consciousness. He was about to give a speech at his graduation ceremony when he suddenly turned pale and collapsed to the ground. Which of the following areas contain the nerve responsible for it?



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a) 2

b) 1

c) 4

d) 3

Question 6:

Which of the following branches of the external carotid artery is not given off in the carotid triangle?

a) Posterior auricular artery

b) Occipital artery

c) Ascending pharyngeal artery

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d) Superior thyroid artery

Question 7:

You are auscultating for bruit in a patient suspected to have an internal carotid artery stenosis. Which of the following muscles does not form the floor of the triangle you are auscultating?

a) Middle constrictor

b) Mylohyoid

c) Inferior constrictor

d) Hyoglossus

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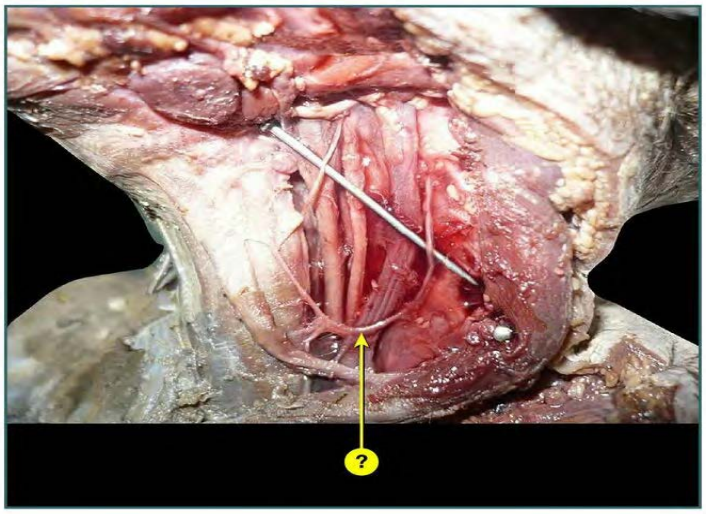
Question 8:

Which of the following muscles is not supplied by the structure marked in the image?



a) Thyrohyoid

b) Sternothyroid

c) Sternohyoid

d) Inferior belly of omohyoid

Question 9:

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Which of the following structures does not form deep relations of the hyoglossus muscle?

a) Lingual artery

b) Lingual nerve

c) Stylohyoid ligament

d) Glossopharyngeal nerve

Question 10:

You are assessing the post-operative condition of a 65-year-old man who underwent a hemiglossectomy for carcinoma of the tongue. During the procedure, all posterior triangle lymph nodes were removed. You suspect a nerve injury has occurred. Which of the following movements will you expect to be intact?

a) Shrugging of shoulder

b) Retraction of scapula

c) Adduction of arm

d) Overhead abduction

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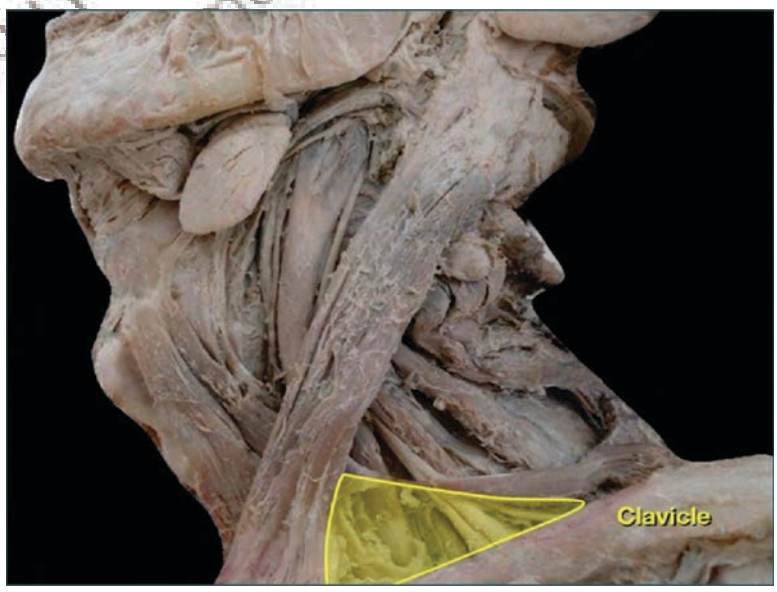
Question 11:

Which of the following is not the content of the marked triangle?



a) Dorsal scapular nerve

b) 3rd part of the subclavian artery

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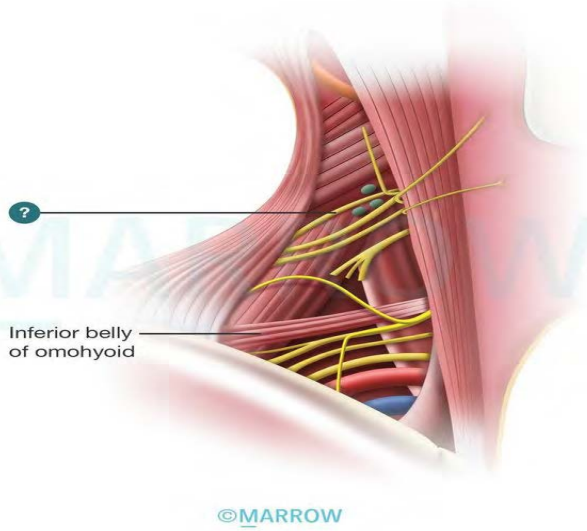
c) Nerve to subclavius

d) Suprascapular nerve

Question 12:

While performing a modified radical neck dissection, the surgeon preserves the structure marked below. Which of the following is supplied by this structure?



a) Diaphragm

b) Trapezius

c) Skin over parotid gland

d) Supraspinatus

Question 13:

A 1-year-old child diagnosed with roseola infantum has palpable lymph nodes in the region marked in green. Which of the following structures is present here?

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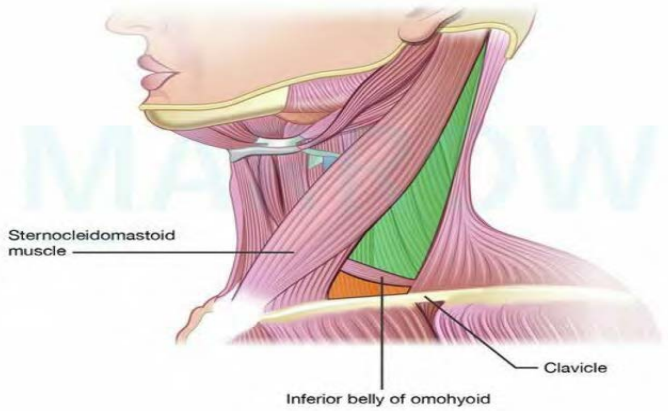


a) 2nd part of subclavian artery

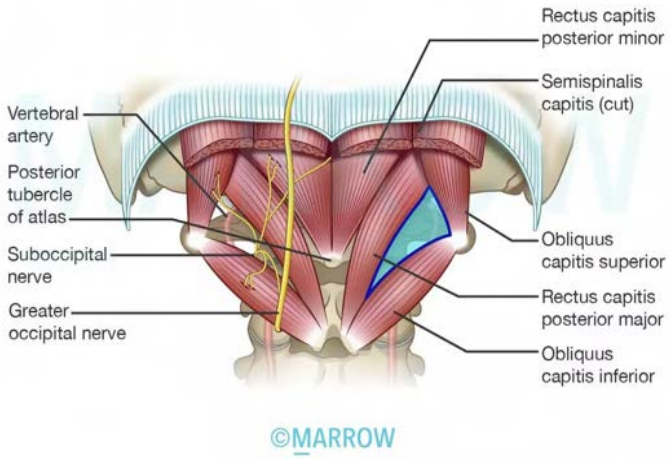
b) Nerve to rhomboids

c) Suprascapular vein

d) Nerve to serratus anterior

Question 14:

Which of the following structures is not a part of the regions marked in blue?



a) Occipital artery

b) Vertebral artery

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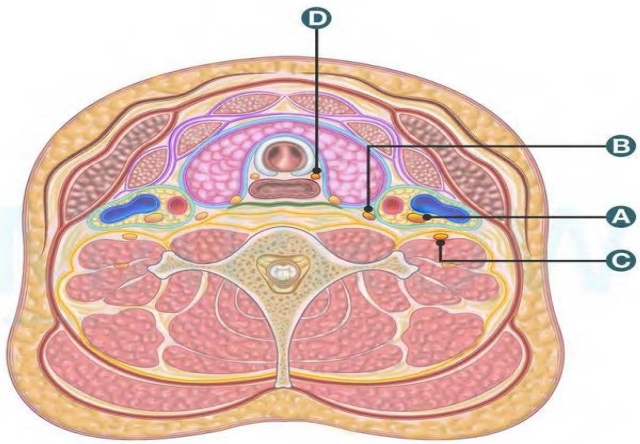
c) Suboccipital nerve

d) Suboccipital venous plexus

Question 15:

A patient presents to you with ptosis, miosis, and anhydrosis. Which of the following structures marked is most likely to be damaged?



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a) A

b) B

c) C

d) D

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Answer Key

Question No.	Correct Option
1	a
2	c
3	a
4	d
5	b
6	a

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7	b
8	a
9	b
10	c
11	a
12	b
13	b
14	a
15	b

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Detailed Explanations

Solution to Question 1:

The subclavian triangle is a posterior triangle of the neck.

Anterior triangles in the neck are:

- Submental triangle
- Digastric triangle
- Muscular triangle
- Carotid triangle

Posterior triangles in the neck are:

- Occipital triangle
- Subclavian triangle

Solution to Question 2:

The suprascapular nerve is the content of the lower part of the posterior triangle of the neck. It does not contribute to the roof.

Lesser occipital nerve, supraclavicular nerve, and great auricular nerve form both, the roof and are contents of the posterior triangle.

Boundaries of the posterior triangle:

- Anteriorly - the posterior border of the sternocleidomastoid
- Posteriorly - the anterior border of the trapezius
- Inferiorly - the middle third of the clavicle
- Roof - superficial fascia containing external jugular vein, posterior jugular vein, the investing layer of deep fascia and cutaneous nerves. The cutaneous nerves include:

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• Great auricular nerve

• Lesser occipital nerve

• Supraclavicular nerve

• Transverse cutaneous nerve

• Floor - the prevertebral fascia overlying splenius capitis, levator scapulae, and the scalene muscles

Solution to Question 3:

The investing layer of the deep cervical fascia covers the parotid and submandibular gland.

Option B: The pretracheal fascia covers the thyroid gland and forms its false capsule. The parotid gland is covered by the superficial lamina of the investing layer of deep cervical fascia.

Option C: Axillary sheath is formed by the prevertebral fascia.

Option D: The investing layer forms the roof of anterior and posterior triangles

Solution to Question 4:

The external jugular vein is not present in the suprasternal space of Burns. It is present in the supraclavicular space, along with the supraclavicular nerve.

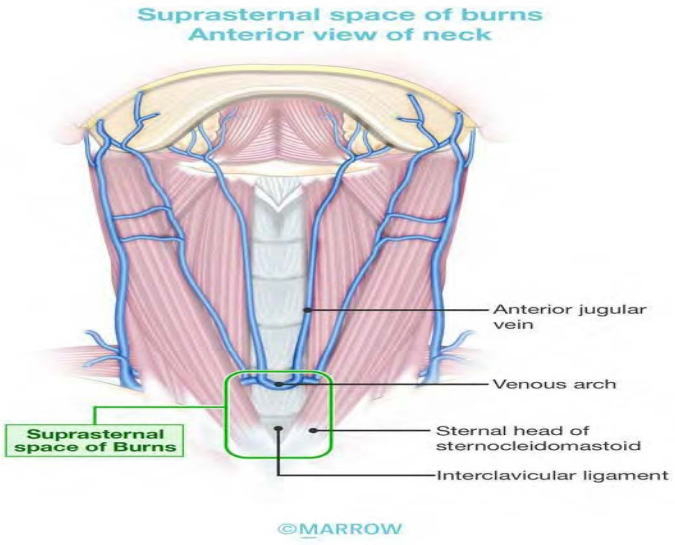
Contents of the suprasternal space of Burns include:

• The jugular venous arch, formed by the anterior jugular veins

• Sternal head of right and left sternocleidomastoid

• Lymph nodes

• Interclavicular ligament.



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Investing layer of deep fascia encloses:

• 2 muscles - sternocleidomastoid, trapezius

• 2 glands - parotid and submandibular gland

• 2 spaces - suprasternal space and supraclavicular space

• 2 ligaments - stylomandibular and sphenomandibular ligament

The supraclavicular space includes:

• Supraclavicular nerve

• External jugular vein

Solution to Question 5:

The given scenario describes a vasovagal syncope triggered by a stressful event. The vagus nerve is a content of the carotid triangle marked as 1.

In the given image:

• Carotid triangle

• Occipital triangle

• Subclavian triangle

• Digastric triangle

Contents of the carotid triangle:

• Arteries:

• Common carotid artery, internal and external carotid artery

• Branches of external carotid – superior thyroid, lingual, facial, ascending pharyngeal, and occipital artery

• Veins:

• Internal jugular vein

• Common facial vein

• Lingual vein

• Nerves:

• Vagus nerve

• Hypoglossal nerve

• Spinal part of accessory

• Sympathetic chain

• Ansa cervicalis

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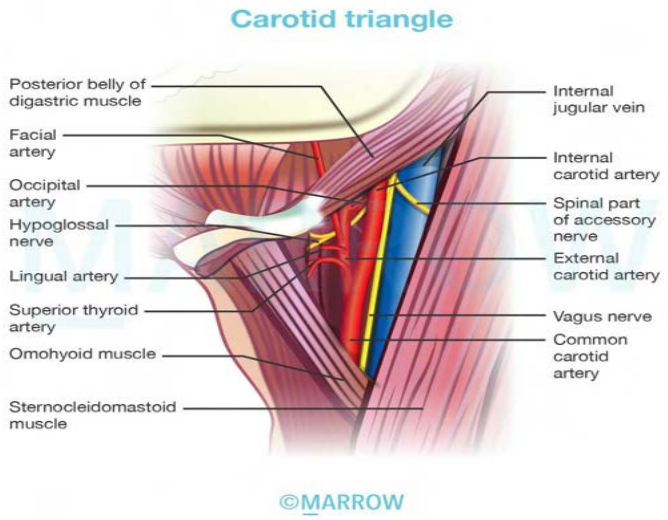

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Solution to Question 6:

The posterior auricular artery, maxillary artery and superficial temporal artery are branches of the external carotid artery which are not given off in the carotid triangle.

The external carotid artery gives off 5 branches in the carotid triangle. They are:

- Anterior branches:
- Superior thyroid artery
- Lingual artery
- Facial artery
- Medial branch - Ascending pharyngeal artery
- Posterior branch - Occipital artery

The image given below shows the carotid triangle and the branches of the external carotid artery within it.

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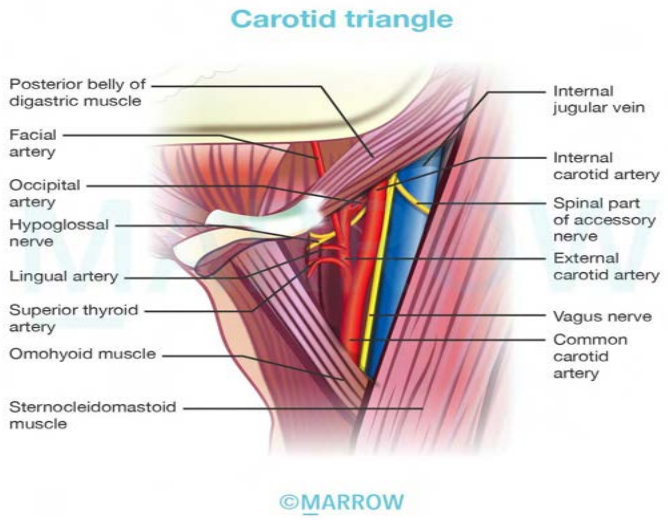

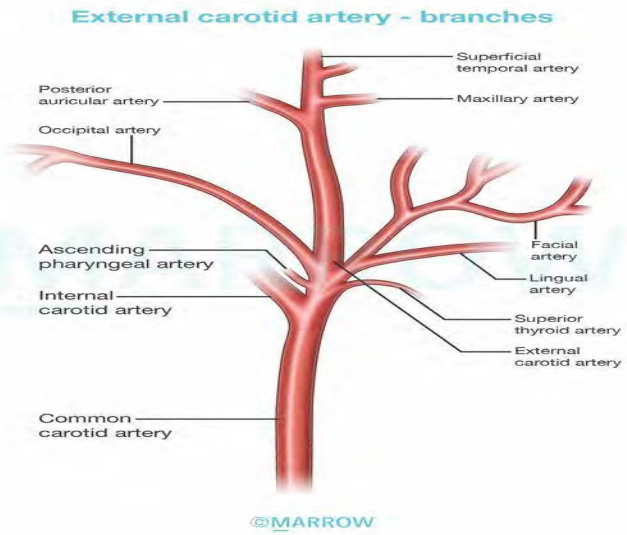

Solution to Question 7:

Carotid bruit is identified by auscultating the carotid artery, which is located in the carotid triangle. The mylohyoid muscle does not form the floor of the carotid triangle.

Floor:

- Thyrohyoid
- Hyoglossus
- Middle constrictor
- Inferior constrictor

Roof:

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• Skin

• Superficial fascia

• Platysma

• Deep fascia containing branches of facial and cutaneous cervical nerves.

Posterior border:

• Sternocleidomastoid muscle

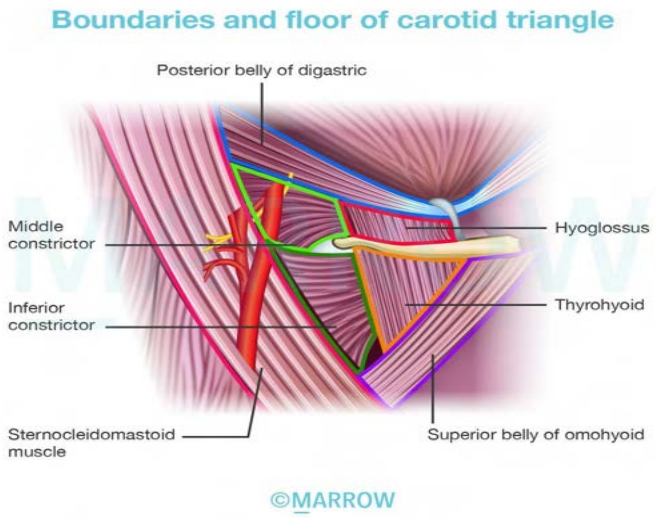
Anteroinferior border:

• The superior belly of omohyoid

Superior border:

• Posterior belly of digastric

• Stylohyoid



Solution to Question 8:

The marked structure is ansa cervicalis and thyrohyoid is not supplied by it. Thyrohyoid is supplied by the C1 fibers through the hypoglossal nerve.

The muscles supplied by ansa cervicalis are:

• Sternothyroid

• Sternohyoid

• Omohyoid both inferior and superior belly

The ansa cervicalis is a nerve loop embedded in the anterior wall of the carotid sheath. It is formed by two roots:

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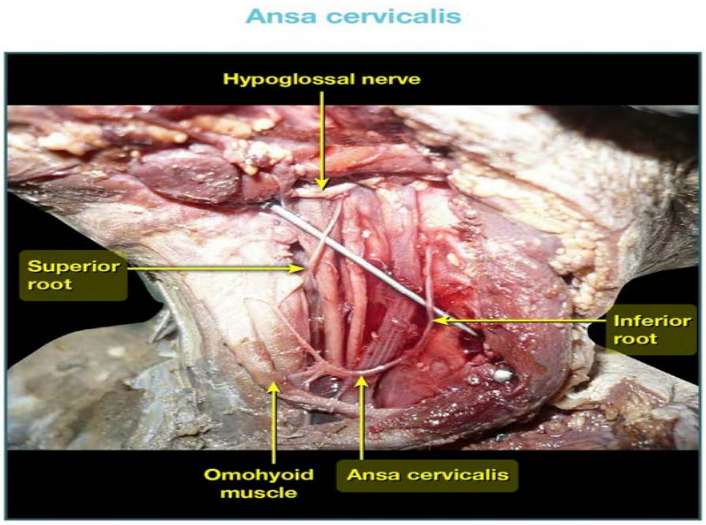
• The superior root is a continuation of the descending branch of the hypoglossal nerve. It is derived from the 1st cervical nerve (C1) and supplies the superior belly of the omohyoid.

• The inferior root is derived from the 2nd and 3rd cervical spinal nerves (C2, C3).



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Solution to Question 9:

The lingual nerve lies in superficial relation to the hyoglossus muscle.

Superficial or lateral relations of the hyoglossus include:

• Digastric tendon

• Styloglossus, and mylohyoid

• Lingual nerve and submandibular ganglion

• Sublingual gland, the deep part of the submandibular gland and duct

• Hypoglossal nerve

• The deep lingual vein

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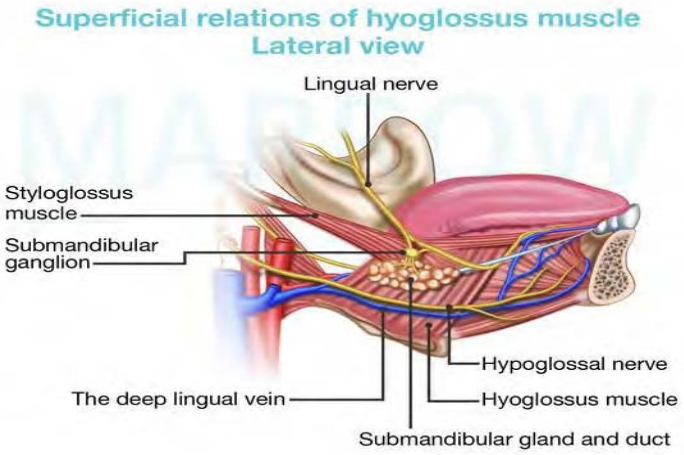
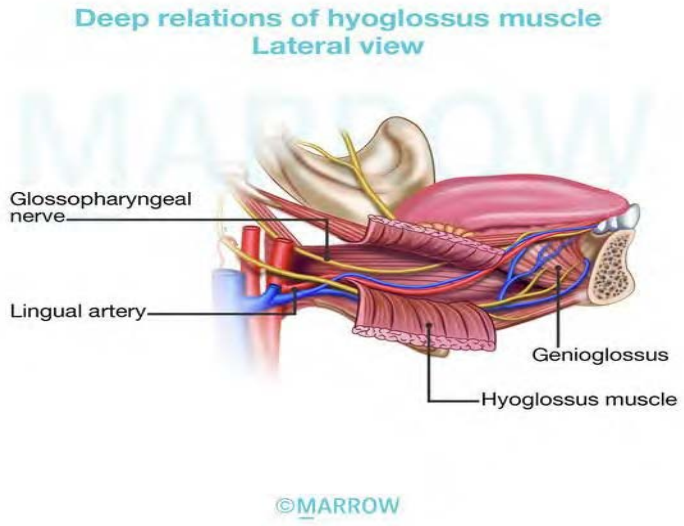


Deep or medial relations of hyoglossus are:

- Glossopharyngeal nerve
- Lingual artery.
- Stylohyoid ligament
- Genioglossus
- Middle constrictor
- Inferior longitudinal muscles of the tongue.



Solution to Question 10:

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In the given scenario, the patient most likely suffered an iatrogenic injury to the spinal accessory nerve as it is placed superficially in the middle of the posterior triangle, therefore the actions of trapezius and sternocleidomastoid can be affected. Adduction of the arm will be intact here, as this action is caused by pectoralis major which is supplied by the medial and lateral pectoral nerves.

Injury to the spinal accessory nerve affects the movements of the muscles supplied by it. They are:

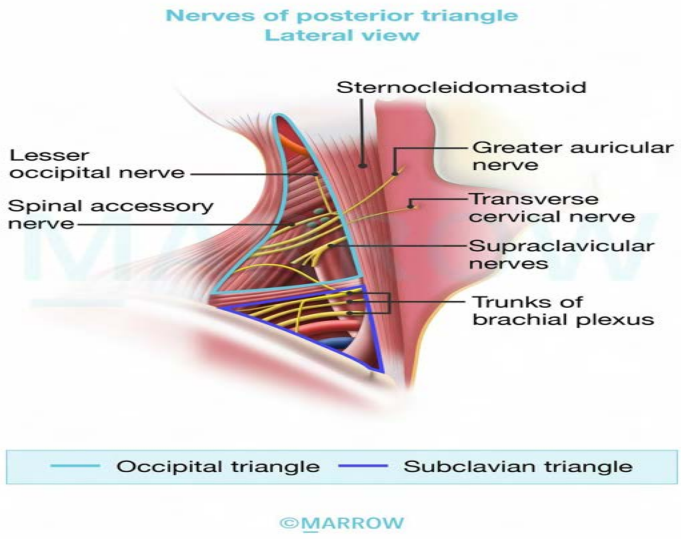
• Trapezius - overhead abduction, elevation, and retraction of scapula. It is tested by asking the patient to shrug the shoulders.

• Sternocleidomastoid - turning the chin to the opposite side, tilting the head towards the shoulder of the same side. When both act together they draw the head forwards.

The spinal accessory nerve innervates the sternocleidomastoid just before entering the posterior triangle.

• If the nerve is injured before it enters the posterior triangle, actions of the sternocleidomastoid will be affected.

• If the nerve is injured within the posterior triangle, the sternocleidomastoid will be spared.



Solution to Question 11:

The given image shows the subclavian triangle marked. Dorsal scapular nerve/nerve to rhomboideus is a content of the occipital triangle and not the subclavian triangle.

Contents of the subclavian triangle:

• 3rd part of subclavian artery and vein

• Suprascapular artery and vein, transverse cervical artery

• Supraclavicular lymph node

• Trunks of the brachial plexus

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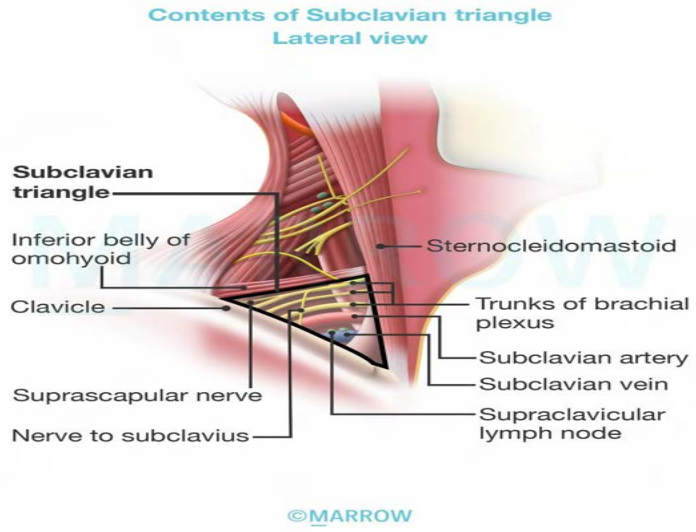
• Branches from upper trunk of the brachial plexus – nerve to subclavius, suprascapular nerve



Solution to Question 12:

The structure marked above is the spinal accessory nerve. The spinal accessory nerve enters the posterior triangle passing deep to the sternocleidomastoid muscle and runs in an oblique direction within the triangle to supply the trapezius.

Option A: Phrenic nerve is seen related to the anterior surface of scalenus anterior, and supplies the diaphragm.

Option C: The greater auricular nerve supplies the skin over the angle of the jaw, skin over the mandible, and lower 1/3rd of the auricle, greater auricular nerve (C2,3).

Option D: The suprascapular nerve (C5, C6) arises from the upper trunk of the brachial plexus. It supplies the supraspinatus and infraspinatus muscles

Clinical note:

There are three types of modified radical neck dissection (MRND). Structures preserved are:

• MRND 1 - Only spinal accessory nerve

• MRND 2 - Accessory nerve and internal jugular vein

• MRND 3 i.e., functional neck dissection - Accessory nerve, sternocleidomastoid, and internal jugular veins.

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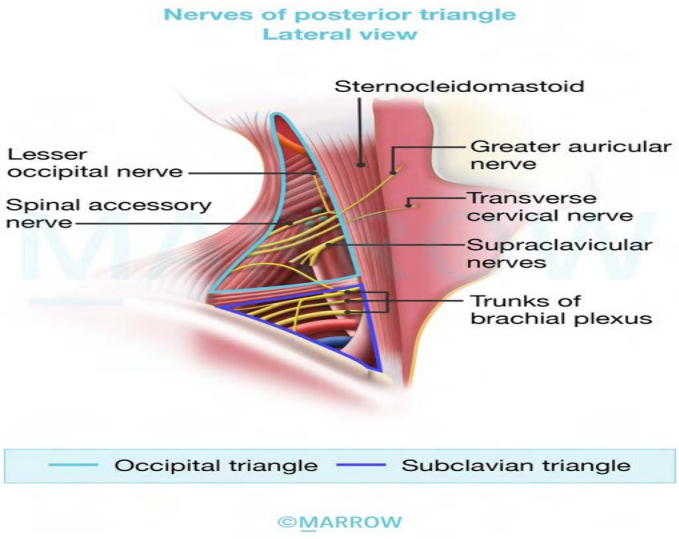

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Solution to Question 13:

Roseola infantum is a viral fever caused by human herpesvirus 6 and 7. It presents with fever, rash, cervical and occipital lymphadenopathy. These lymph nodes are present in the occipital triangle. Nerve to rhomboids is a content of the occipital triangle.

Contents of the occipital triangle are:

- Occipital lymph nodes
- Nerve to rhomboids
- Spinal accessory nerve
- Lesser occipital nerve
- Great auricular nerve
- Supraclavicular nerves
- Muscular branches to levator scapulae and trapezius
- Uppermost part of brachial plexus
- Transverse cervical artery
- Occipital artery

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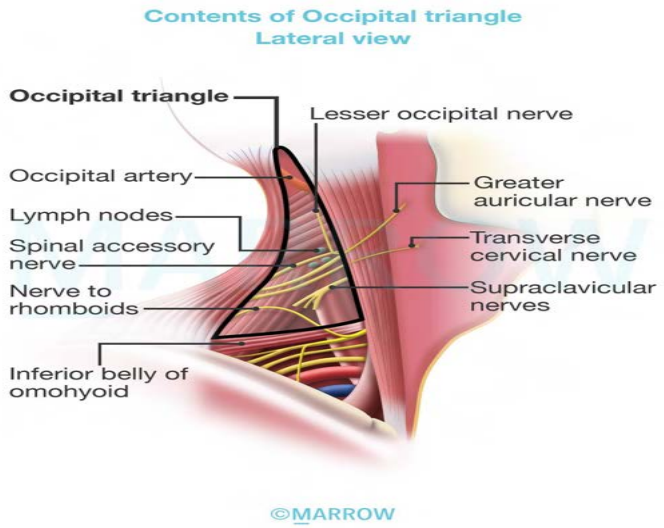

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Solution to Question 14:

The given region is the suboccipital triangle. It does not contain the occipital artery.

The suboccipital triangle is bounded by:

• Superomedially - rectus capitis posterior major

• Superolaterally - obliquus capitis superior

• Inferiorolaterally - obliquus capitis inferior

• Roof - dense adipose tissue deep to semispinalis capitis, longissimus capitis muscle, and sometimes splenius capitis.

• Floor -posterior atlantooccipital membrane and the posterior arch of the atlas.

• Contents:

• 3rd part of the vertebral artery

• suboccipital nerve (dorsal ramus of C1)

• suboccipital venous plexus.

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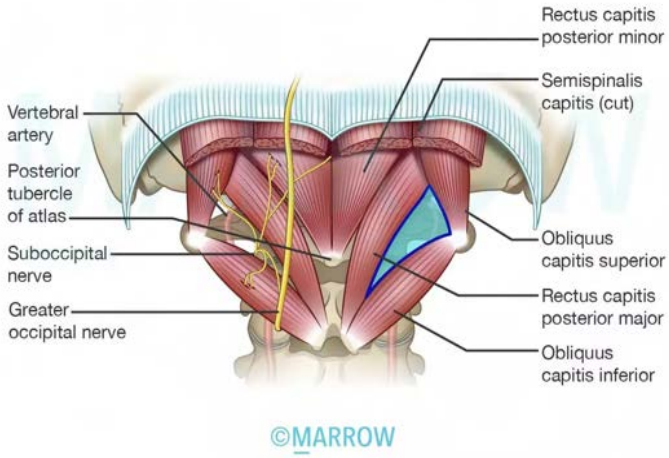

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Solution to Question 15:

The given clinical scenario of ptosis, miosis, and anhydrosis is suggestive of Horner's syndrome which can be caused by damage to the cervical sympathetic trunk (marked B).

In the given image:

- Vagus nerve
- Cervical sympathetic trunk
- Phrenic nerve
- Recurrent laryngeal nerve

The cervical part of the sympathetic trunk lies anterior to longus colli and longus capitis muscles (enclosed in prevertebral fascia) and posterior to the common carotid artery. The sympathetic trunk lies outside the carotid sheath.

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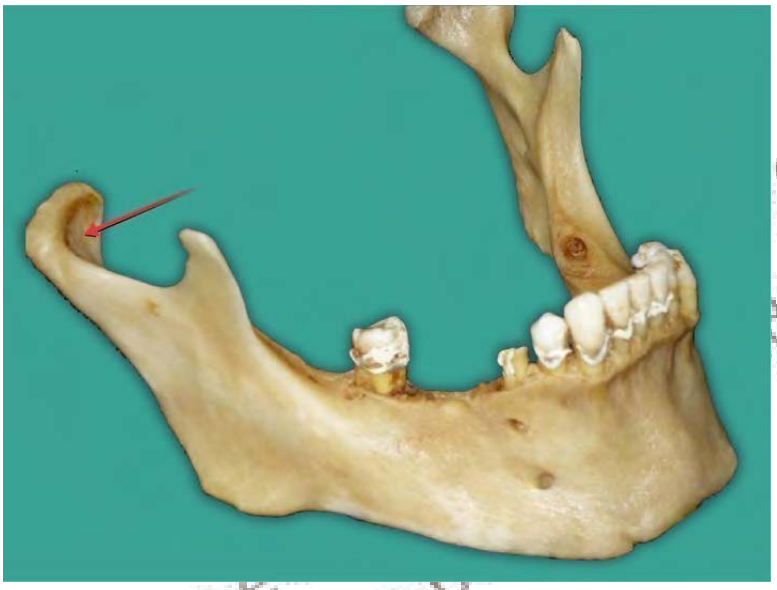
Muscles, Neurovascular Anatomy of Head & Neck

Question 1:

Which of the following is the action of the muscle inserted to the area marked below?



a) Depresses and protrudes mandible

b) Elevates and protrudes mandible

c) Elevates and retracts mandible

d) Depresses and retracts mandible

Question 2:

What is the main action of the muscle marked below?

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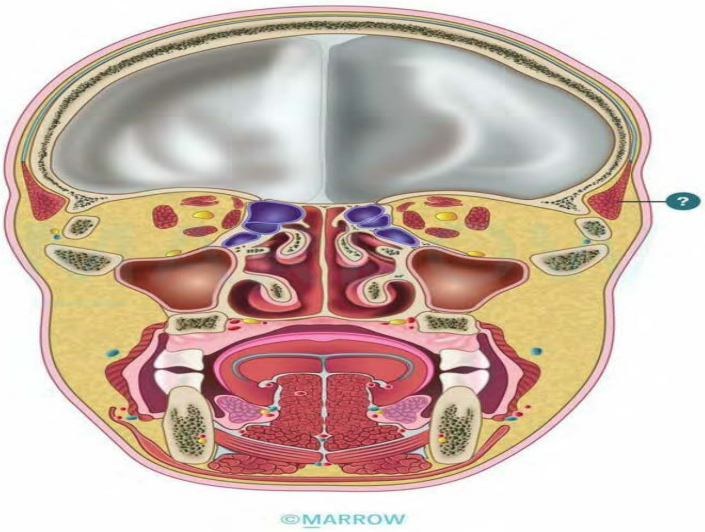

a) Elevation

b) Depression

c) Protrusion

d) Retraction

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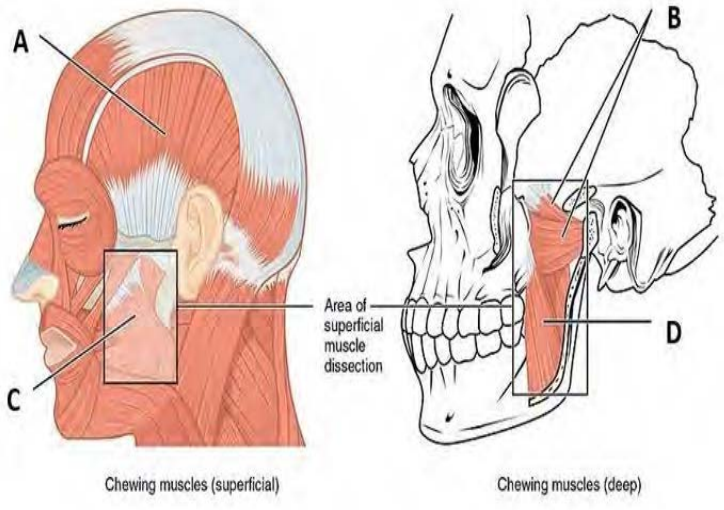
Question 3:

In the image given below, identify the muscle responsible for the opening of the mouth.



a) A

b) B

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c) C

d) D

Question 4:

A 26-year-old man presented with the inability to close his mouth after yawning. On evaluation, there is an anterior dislocation of the temporomandibular joint. This condition is caused by the excessive contraction of which of the following muscles?

a) Temporalis

b) Lateral pterygoid

c) Buccinator

d) Masseter

Question 5:

An elderly woman presents to you with the following findings. She gives a history of chickenpox in her childhood. Which of the following is false about the cranial nerve involved in this case?

a) It is is predominantly sensory

b) Motor innervation is exclusively carried by maxillary division

c) The cornea is primarily innervated by ophthalmic division

d) It provides motor supply to medial pterygoid

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Question 6:

A dentist provides local anesthesia by injecting lidocaine at the site marked X to block a division of the trigeminal nerve. Which of the following muscles is not supplied by the trunk of this nerve?

a) Medial pterygoid

b) Tensor tympani

c) Tensor veli palatini

d) Lateral pterygoid

Question 7:

A patient with past history of parotidectomy now presents with sweating and flushing of skin over the cheek during mastication. Which of the following nerves is involved in this case?

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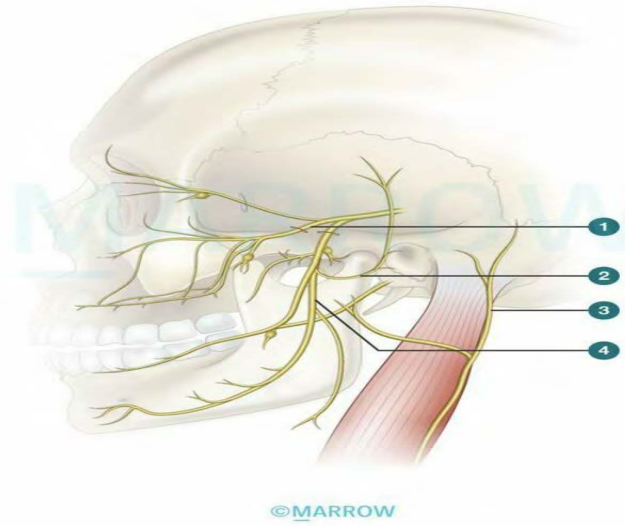

a) 3

b) 1

c) 4

d) 2

Question 8:

In which of the following compartments of temporomandibular joint do the rotatory movements of the jaw take place?

a) Joint space above the articular disc

b) Joint space below the articular disc

c) Joint space medial to the articular disc

d) Intermediate zone

Question 9:

A patient with diplopia was found to have paralysis of the muscle marked below. What is its nerve supply?

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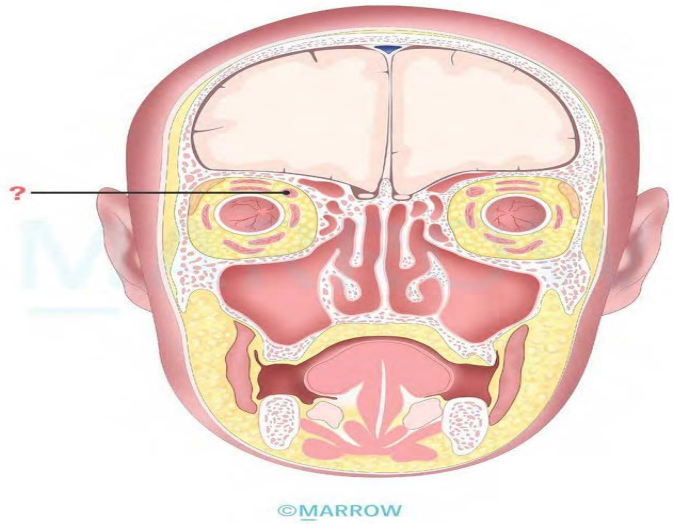

a) Oculomotor nerve

b) Trochlear nerve

c) Trigeminal nerve

d) Abducens nerve

Question 10:

A 34-year-old woman comes to the Ophthalmology OPD with complaints of a right-sided squint. On asking her to look straight, you observe the following. What is the nerve supply of the muscle paralyzed in this case?

a) Superior division of CN III

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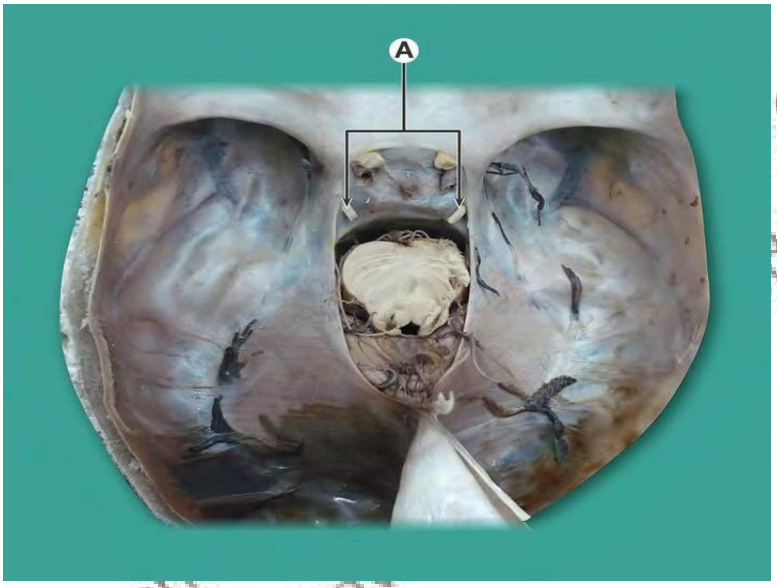
b) Abducens nerve

c) Inferior division of CN III

d) Trochlear nerve

Question 11:

Which of the following muscle is not supplied by the structure marked A?



a) Superior rectus

b) Superior oblique

c) Medial rectus

d) Levator palpebrae superioris (LPS)

Question 12:

A 43-year-old woman presented with hyperacusis. She recently underwent reconstructive surgery for fracture of mandible at the TMJ. Investigations revealed paralysis of the stapedius muscle. A branch of which of the following nerves is likely to cause the given condition?

a) VII cranial nerve

b) VIII cranial nerve

c) V cranial nerve

d) VI cranial nerve

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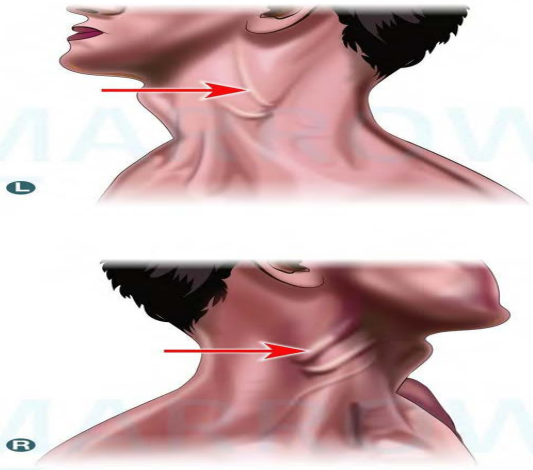
Question 13:

Identify the thickened nerve marked in the arrow in the image shown below:



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a) Great auricular nerve

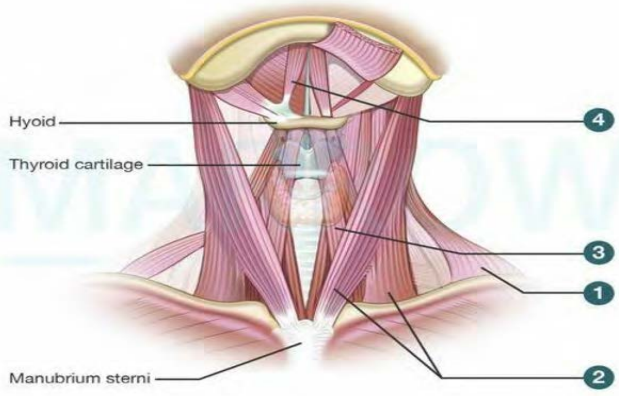
b) Lesser occipital nerve

c) Facial nerve

d) Auriculotemporal nerve

Question 14:

Which of the following is not a hybrid muscle?



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a) 1

b) 2

c) 3

d) 4

Question 15:

The carotid angiography of a 30-year-old with a carotid body tumor shows splaying at the bifurcation of the carotids as seen in the image below. At what level do you expect to find this?

a) Lower border of thyroid cartilage

b) Upper border of thyroid cartilage

c) Lower border of cricothyroid cartilage

d) Upper border of cricothyroid cartilage

Question 16:

The only branch of the external carotid artery which is given from its medial side is:

a) Superior thyroid artery

b) Facial artery

c) Ascending pharyngeal artery

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d) Lingual artery

Question 17:

Which of the following branches of internal carotid artery are given off in the cervical region?

a) Pharyngeal branches

b) Pterygoid branch

c) Caroticotympanic branch

d) None of the above

Question 18:

A patient with a history of cavernous sinus thrombosis died of an arterial ischemic stroke. An autopsy revealed carotid artery narrowing. Which of the following branches of the internal carotid artery will not be involved in this case?

a) Meningeal artery

b) Inferior hypophyseal artery

c) Ophthalmic artery

d) Branches to the trigeminal ganglion

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Question 19:

In a patient undergoing mandibular fracture repair, the facial artery is ligated at the mandible. Which of the following branches will not be affected?

a) Ascending palatine artery

b) Superior labial branch

c) Premasseteric artery

d) Dorsal nasal branch

Question 20:

A 34-year-old man presented to the ER with a history of a head injury following an RTA. CT head revealed a displaced fracture of the floor of the middle cranial fossa involving the pterygoid canal. Which of the following nerves are susceptible to injury?

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a) Lesser petrosal nerve and greater petrosal nerve

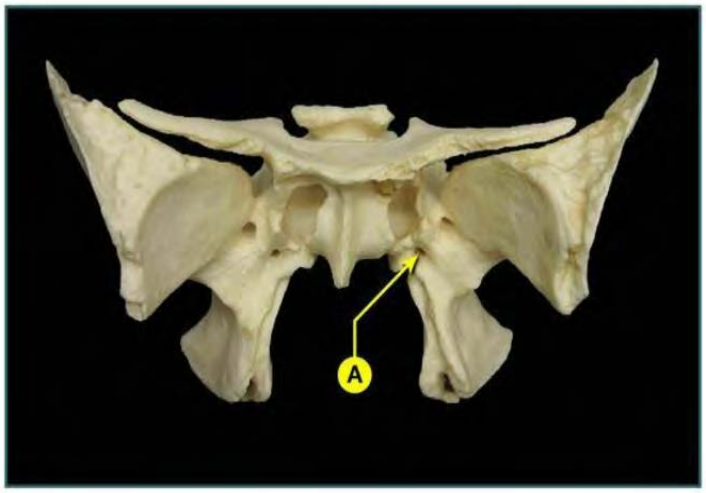
b) Greater petrosal nerve and deep petrosal nerve

c) Greater petrosal nerve and chorda tympani

d) Lesser petrosal nerve and deep petrosal nerve

Question 21:

The artery passing through the structure marked A is a branch of _____ part of the maxillary artery.



a) Mandibular part

b) Pterygoid part

c) Pterygopalatine part

d) Petrous part

Question 22:

A patient with tricuspid regurgitation has an engorged neck vein as shown in the given image. What are its formative tributaries?

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a) Retromandibular vein and facial vein

b) Posterior auricular vein and retromandibular vein

c) Superficial temporal vein and maxillary vein

d) Retromandibular vein and deep facial vein

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Question 23:

Which of the following is a part of the dangerous area of the face?

a) Middle 1/3rd of the upper lip

b) Middle 1/3rd of the lower lip

c) Lateral 1/3rd of the lower lip

d) Periorbital area

Question 24:

The correct pair of lymph node level in the neck and anatomical boundaries amongst the following are:

a) Level 3 - Cricoid to clavicle

b) Level 4 - Hyoid to cricoid

c) Level 5 - Base of skull to cricoid

d) Level 6 - Hyoid to clavicle

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Answer Key

Question No.	Correct Option
1	a
2	a
3	b
4	b
5	b
6	d
7	d
8	b
9	b
10	c
11	b
12	a
13	a
14	c
15	b
16	c
17	d
18	c
19	d
20	b
21	c
22	b
23	a
24	d

Detailed Explanations

Solution to Question 1:

The marked area on the mandible is the pterygoid fovea where the lateral pterygoid muscle is inserted. The action of this muscle is depression, protrusion, and side to side movement of the jaw.

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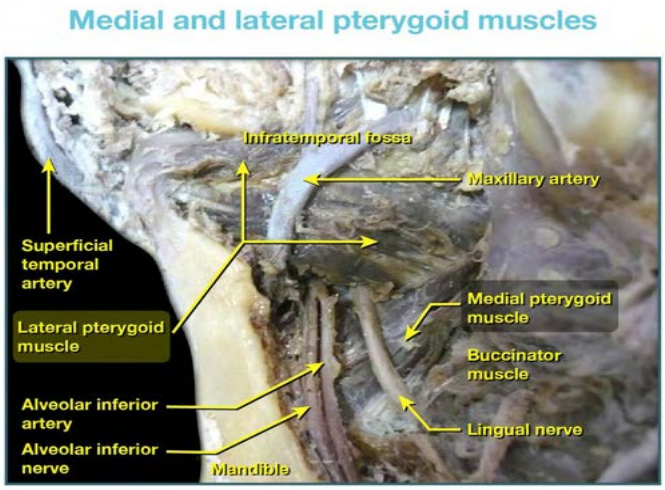
Lateral pterygoid muscle:

• Origin - Upper head arises from the infratemporal surface and infratemporal crest of the greater wing of the sphenoid bone. The lower head arises from the lateral surface of the lateral pterygoid plate.

• Insertion - It is inserted into the pterygoid fovea, the capsule of the temporomandibular joint, and the articular disc.



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Solution to Question 2:

The muscle marked in the image is the temporalis and its main action is elevation of the mandible.

Other actions are:

• It helps in the side-to-side grinding movements of the mandible.

• The posterior fibres which are horizontal, help in the retraction of the mandible.

Solution to Question 3:

In the given image the structure marked B represents the lateral pterygoid muscle which is responsible for the opening of the mouth.

Lateral pterygoid:

• Origin -

• Upper head - Infratemporal surface and infratemporal crest of the greater wing of the sphenoid bone.

• Lower head - Lateral surface of the lateral pterygoid plate.

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• Insertion - It is inserted into the pterygoid fovea, capsule of the temporomandibular joint, and the articular disc.

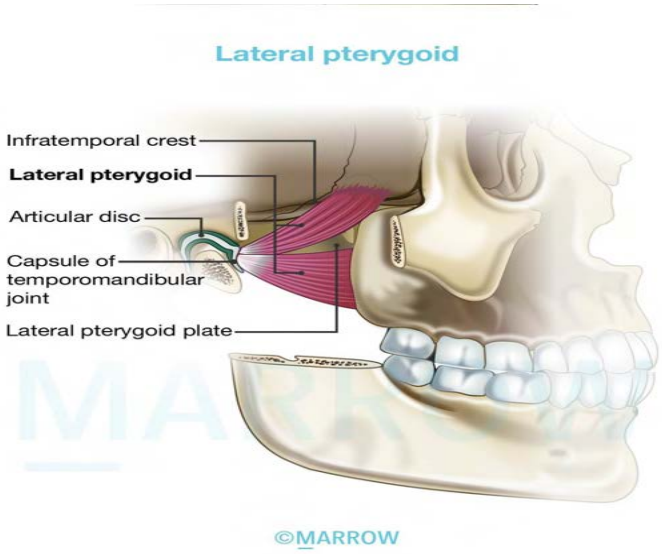
• Nerve supply - Lateral pterygoid nerve which is a branch of the trigeminal nerve.

Other structures marked:

A - Temporalis

C - Masseter

D - Medial pterygoid



Solution to Question 4:

Anterior temporomandibular joint (TMJ) dislocation occurs due to the excessive contraction of the lateral pterygoid. It is associated with the extreme opening of mouth such as yawning, laughing, vomiting or dental treatment.

Some fibres of the upper head of the lateral pterygoid are inserted into the capsule of the TMJ and to the anterior and medial borders of the articular disc. Hence, its contraction can exert forward traction on the disc, allowing for jaw protrusion and in extreme cases, the anterior displacement of the TMJ.

Superior and posterior dislocations of TMJ are rare and is associated with high-energy trauma.

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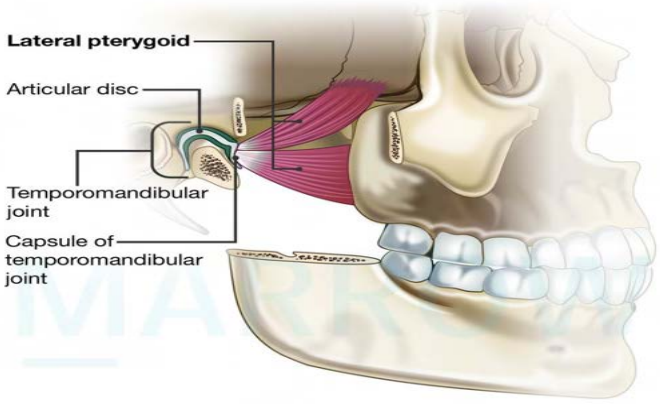
Lateral pterygoid



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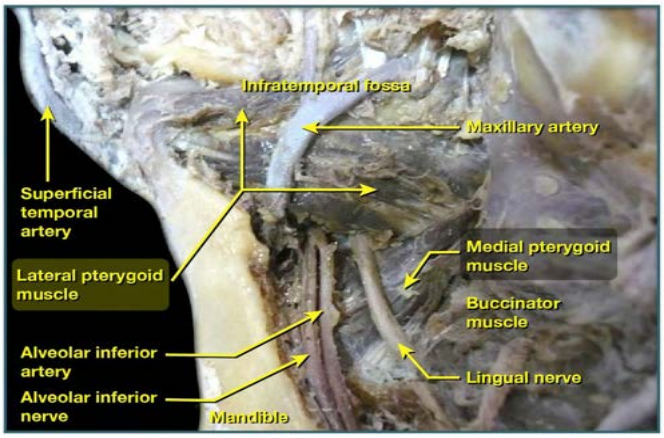
Medial and lateral pterygoid muscles



Solution to Question 5:

The given clinical scenario with a history of chickenpox and lesions over the face is suggestive of herpes zoster ophthalmicus. The cranial nerve involved is the trigeminal nerve. Motor innervation is exclusively carried by mandibular division, not the maxillary division.

The trigeminal nerve (CNV) is the largest cranial nerve. It is a predominantly sensory nerve with motor components.

The nerve divides into three divisions:

• Ophthalmic nerve - V1

• Maxillary nerve - V2

• Mandibular nerve - V3

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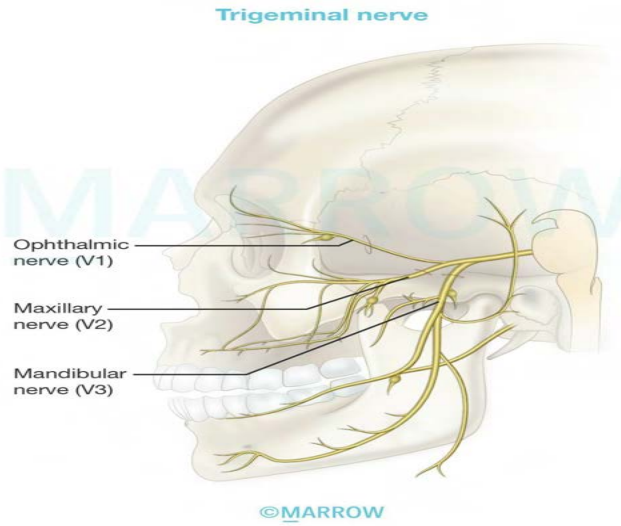
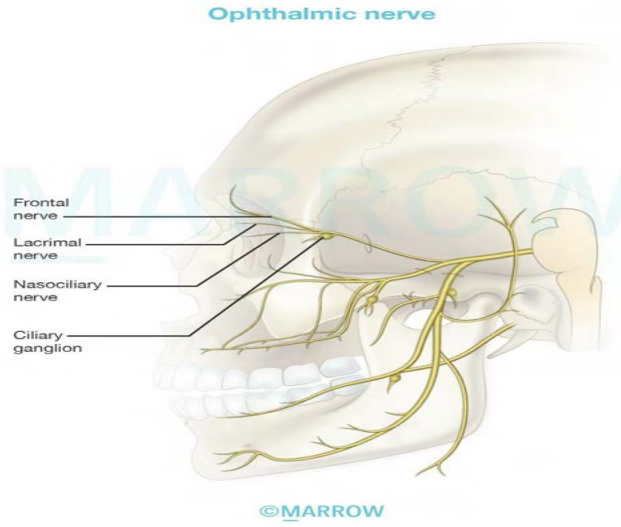


Ophthalmic nerve:

It provides sensory innervation to the scalp, cornea, conjunctiva, iris, upper eyelid, lacrimal gland, and the skin and mucus membranes of paranasal sinuses.

It is the branch that is affected in herpes zoster ophthalmicus. After an attack of chickenpox, the virus travels to the trigeminal ganglion and lies dormant there. Reactivation causes typical manifestations such as skin and eyelid involvement, keratitis, uveitis, and conjunctivitis.



Maxillary nerve:

It provides sensory innervation to the lower eyelid, cheeks, maxillary sinus, nasal cavity, lateral nose, upper lip, palate, teeth, gingiva.

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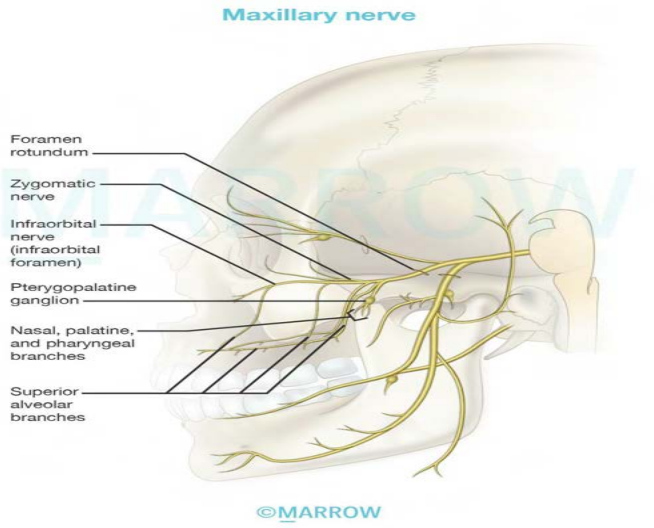
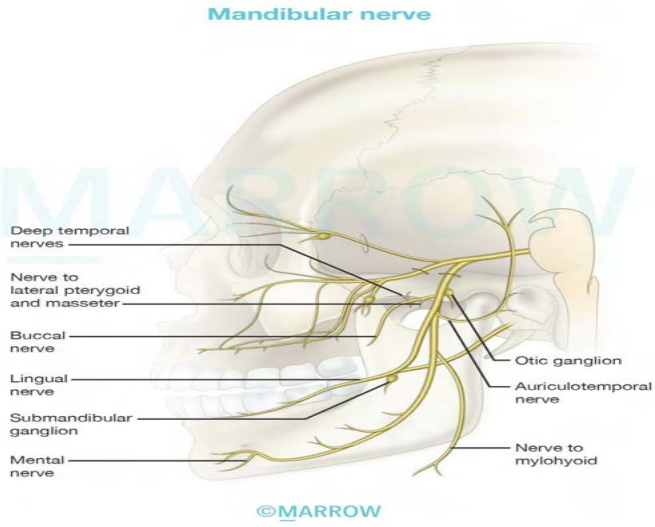


Mandibular nerve:

It provides sensory innervation to the dura mater of middle cranial fossa, mucus membranes in the mouth, parts of pinna, tympanic membrane, mylohyoid, anterior belly of digastric and anterior 2/3rds of the tongue.

It also provides exclusive motor innervation to the muscles of mastication, tensor veli palatini, and tensor tympani.



Solution to Question 6:

The site marked X is the mandibular foramen which contains the inferior alveolar nerve, a branch of the mandibular nerve. All the muscles mentioned above are supplied by the trunk of mandibular nerve except the lateral pterygoid. The lateral pterygoid is supplied by the anterior

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division of mandibular nerve.

Solution to Question 7:

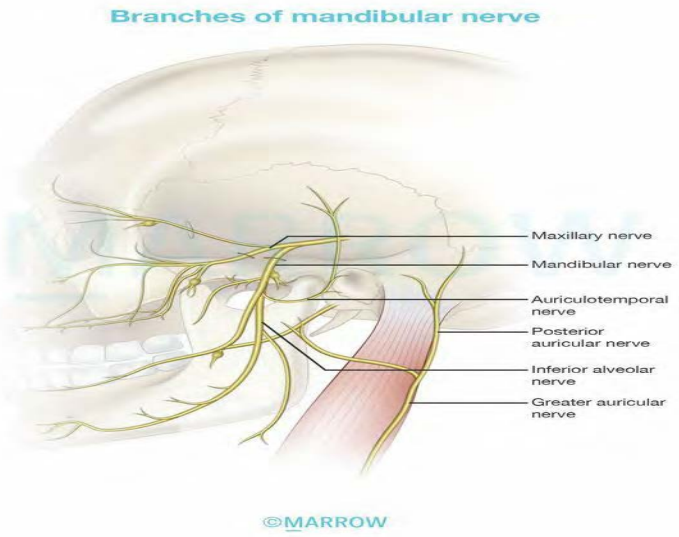
The given case scenario is suggestive of Frey's syndrome which involves the auriculotemporal nerve, marked as 2.

Other structures marked are:

1 - Maxillary nerve

3 - Posterior auricular nerve

4 - Inferior alveolar nerve



The auriculotemporal nerve is identified by its two roots which encircle the middle meningeal artery. It is a branch from the posterior division of the mandibular nerve. It gives cutaneous innervation to the tragus and the adjoining part of the auricle and carries postganglionic secretomotor fibers to the parotid gland.

Frey's syndrome is caused due to aberrant regeneration of the postganglionic parasympathetic nerve fibers of the auriculotemporal nerve. The nerve fibres regenerate into the nearby sweat glands. It can occur following parotid surgery, or any trauma where there is an injury to the parotid capsule. This results in sweating, warmth, and redness of the face during the salivary stimulation by the smell or taste of food. Hence, Frey's syndrome is also known as gustatory sweating or auriculotemporal syndrome.

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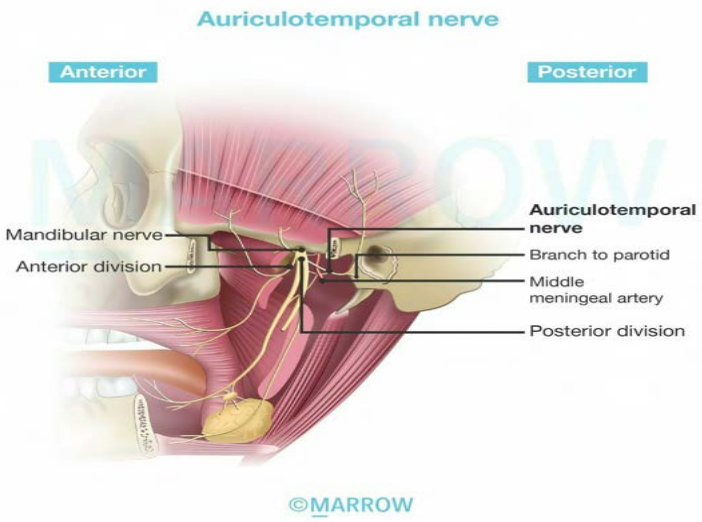

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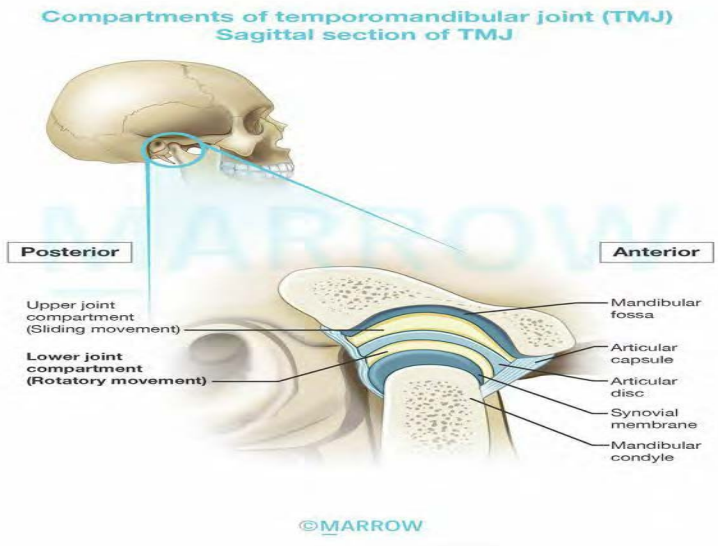
Solution to Question 8:

Rotatory movements of the jaw take place in the joint space below the articular disc of the temporomandibular joint.

The temporomandibular joint is adapted to accommodate both sliding and rotation movement in a sagittal plane.

The capsular ligament that surrounds the upper joint compartment is loose and hence allows the sliding or translation movements.

The capsular ligament that surrounds the lower joint compartment is tight and hence allows only the rotatory movements.



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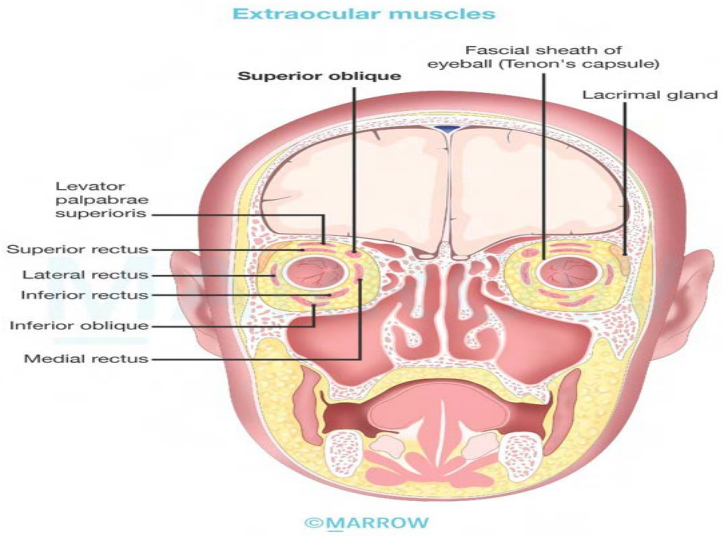
Solution to Question 9:

The structure marked in the image is the superior oblique muscle. It is supplied by the trochlear nerve (CN IV).

The superior oblique muscle helps in looking downwards and inwards. In cases of palsy of the trochlear nerve, the muscle is paralysed and the patient is unable to perform the same movement.



There are seven extraocular muscles present in the eye. They are:

- Levator palpebrae superioris - Which elevates the upper eyelids
- Four recti muscles - Superior, inferior, medial, and lateral recti
- Two obliques - Superior and inferior oblique

The muscles originate from the back of the orbit in a common tendinous ring called the annulus of Zinn and are inserted into the sclera.

All the extraocular muscles are innervated by the oculomotor (III) nerve except:

- Lateral rectus which is supplied by abducens (VI) nerve
- Superior oblique which is supplied by trochlear (IV) nerve

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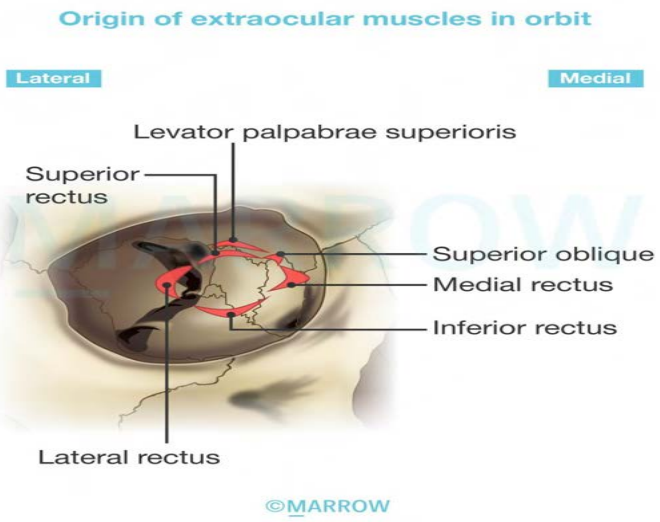

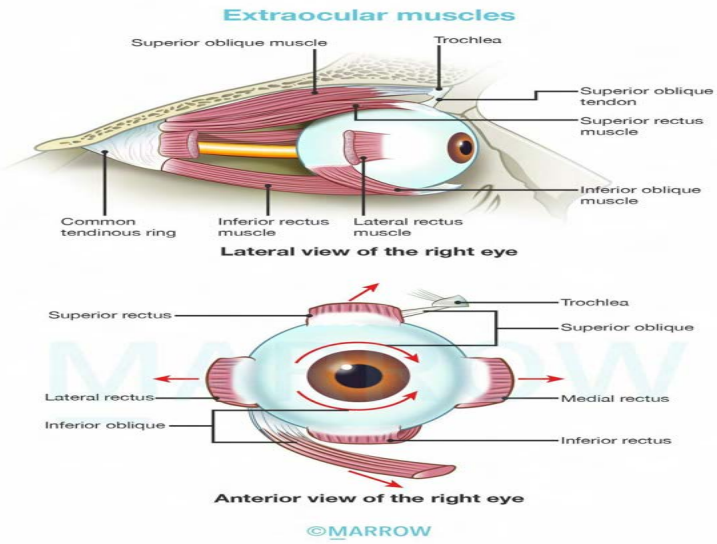

Solution to Question 10:

In the given case, the medial rectus muscle is paralyzed on the right side. This leads to unopposed action of the lateral rectus, causing the eyeball to move outwards. The medial rectus, inferior rectus and inferior oblique are supplied by the inferior division of the oculomotor nerve (CN III)

Course of the oculomotor nerve:

• The oculomotor nerve arises from the midbrain and emerges, by passing medial to the crus cerebri.

• It passes along the lateral wall of the cavernous sinus and divides into superior and inferior divisions. The two divisions enter the orbit through the superior orbital fissure and innervate the extraocular muscles:

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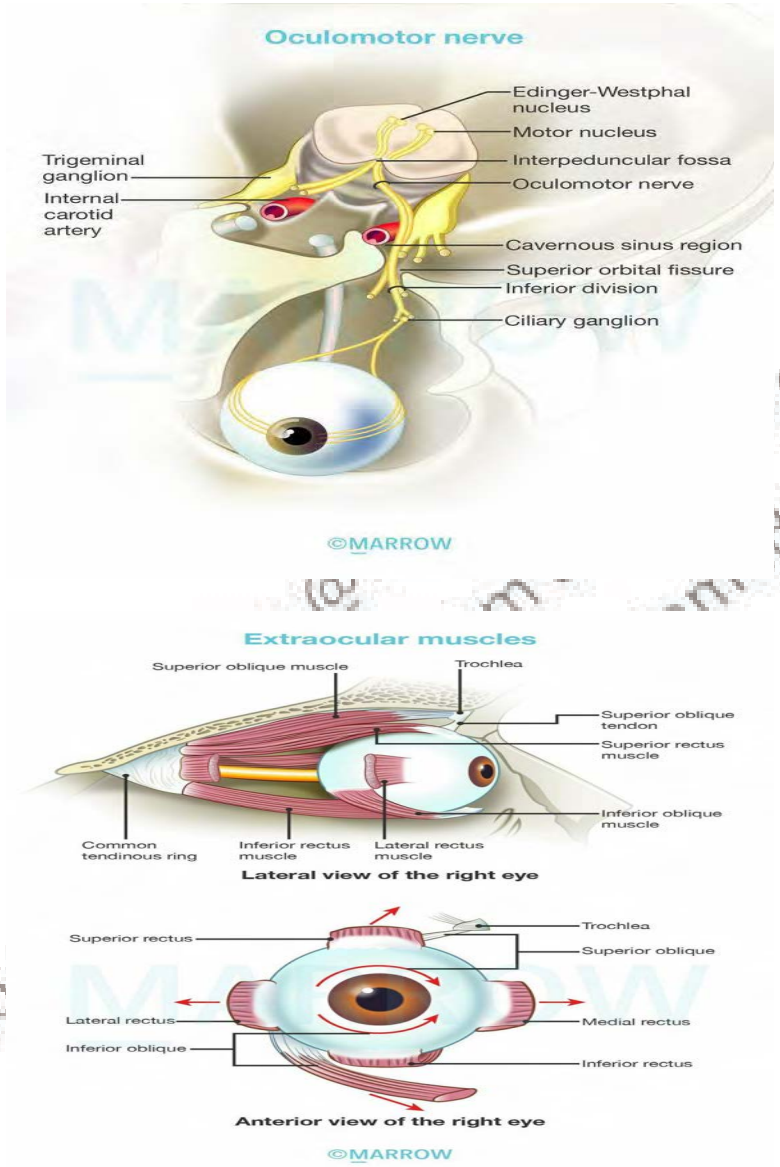
• Superior division - superior rectus and levator palpebrae superioris muscles.

• Inferior division - the inferior rectus, medial rectus, and inferior oblique muscles.



Solution to Question 11:

The structure marked in the image is the oculomotor nerve and it does not supply the superior oblique muscle. Superior oblique muscle is supplied by the trochlear nerve.

All the extraocular muscles are innervated by the oculomotor (III) nerve except:

• Lateral rectus which is supplied by abducens (VI) nerve

• Superior oblique which is supplied by trochlear (IV) nerve

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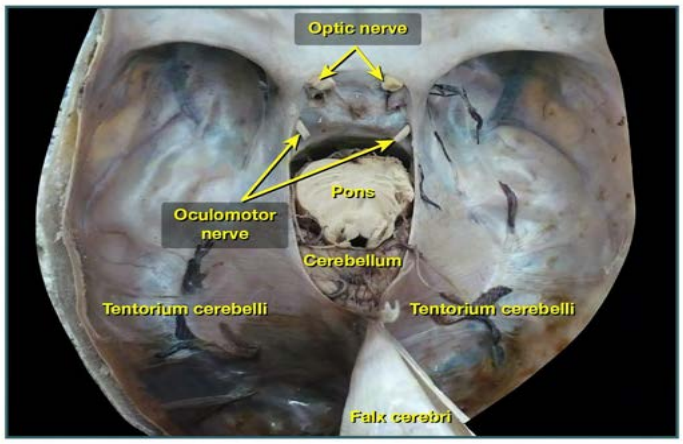
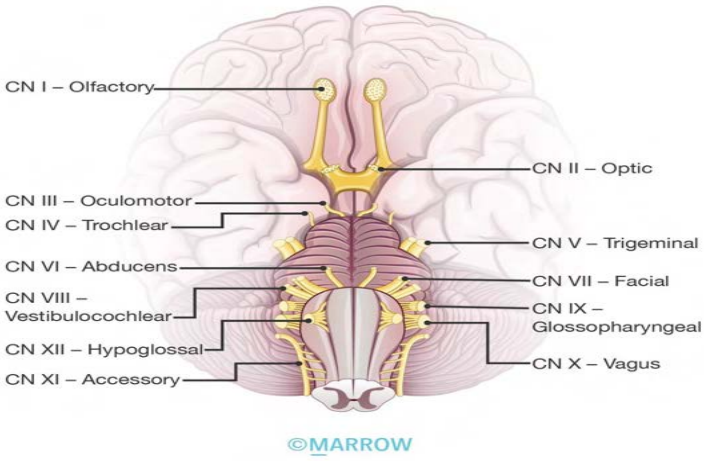
Optic and Oculomotor nerves



Origin of cranial nerves at the base of the brain



Solution to Question 12:

The given scenario is suggestive of injury to the nerve to stapedius which is a branch of the VIIth cranial nerve (facial nerve). During surgery involving the parotid and mandibular region, injury to the facial nerve can damage the nerve to stapedius, hence causing stapedial paralysis which leads to hyperacusis.

The tensor tympani and the stapedius are the muscles of the middle ear and they are innervated by branches of V and VII cranial nerves respectively. Both these muscles contract in response to loud noises and thereby dampen sound. The tensor tympani increases the tension of the tympanic membrane and reduces the force of vibration. Stapedius pulls the stapes posteriorly and reduces the oscillations.

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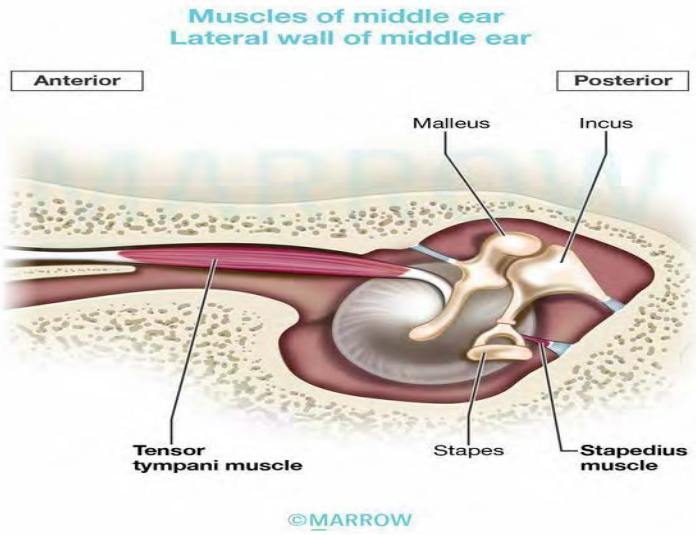
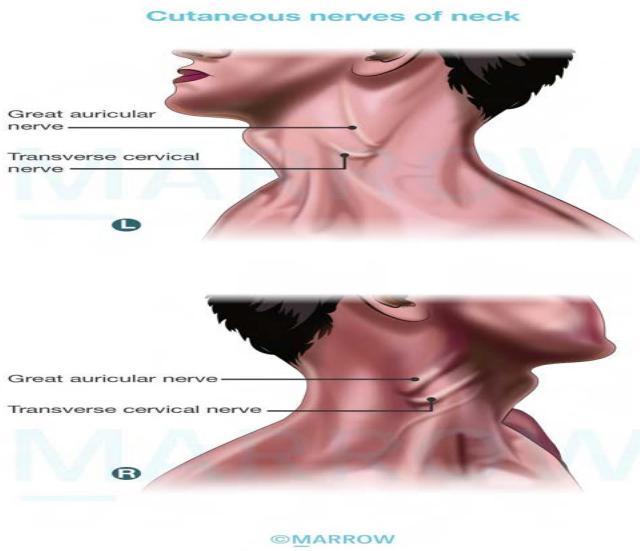
Paralysis of one or both of these muscles causes increased sensitivity to the sounds, a condition known as hyperacusis.



Solution to Question 13:

The thickened nerve marked with the arrow in the above image is the great auricular nerve and the thickened nerve visible below the great auricular nerve is the transverse cervical nerve.

Nerve thickening in this case is likely to be due to leprosy.



Great auricular nerve:

It is the largest ascending branch of cervical plexus and arises from the second and the third cervical spinal nerves.

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It winds over the posterior border of the sternocleidomastoid muscle and ascends upwards. On reaching the parotid gland it divides into the anterior and posterior branches:

• Anterior branch - supplies the facial skin over the parotid gland and joins the facial nerve in the gland.

• Posterior branch - supplies the skin over the mastoid process, posteroinferior part of the auricle, lobule, and concha.

Clinical considerations:

• Leprosy - Nerve thickening is present. The nerve is palpable over the upper part of the sternocleidomastoid muscle. (as seen in the above image)

• Frey's syndrome - An aberrant connection between the auriculotemporal nerve and great auricular nerve causes gustatory sweating.

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Solution to Question 14:

The sternohyoid muscle marked as '3' is not a hybrid muscle. It is innervated only by the anterior rami of spinal nerves C1-C3 (via the ansa cervicalis)

Hybrid muscles are the muscles that are supplied by two different nerves with different root values.

Other muscles in the given image are:

A - Trapezius

B - Sternocleidomastoid

D - Digastric muscle (anterior belly)

Hybrid muscles of head and neck:

• Digastric - Anterior belly is supplied by the nerve to the mylohyoid and posterior belly is supplied by the facial nerve.

• Trapezius and sternocleidomastoid (SCM) - Motor supply is by the spinal accessory nerve and the proprioception is by ventral rami of cervical nerves (C_2, C_3 for SCM and C_3, C_4 for trapezius).

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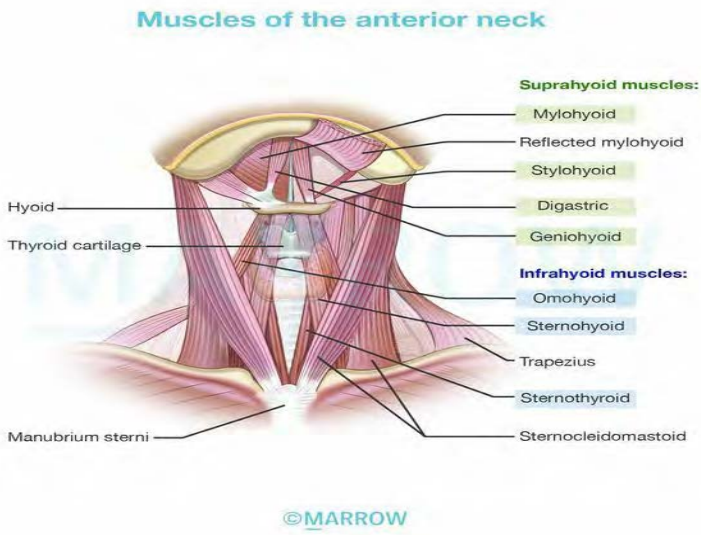

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Solution to Question 15:

The bifurcation of the common carotid artery is at the level of the upper border of thyroid cartilage (C3-C4 junction). Carotid body tumors present at the bifurcation of the CCA and cause the external carotid artery (ECA) and internal carotid artery (ICA) to spread out, or splay, which is called 'Lyre sign' as seen on carotid angiography.

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The course of the common carotid artery (CCA):

- The right and the left common carotid arteries differ in their origin:
- The right CCA arises from the brachiocephalic artery
- The left CCA arises directly from the arch of the aorta.

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• In the neck, it is enclosed within the carotid sheath along with the internal jugular vein and vagus nerve.

• It ascends upwards up to the upper border of the thyroid cartilage (C3-4 junction) and divides into internal and external carotid arteries

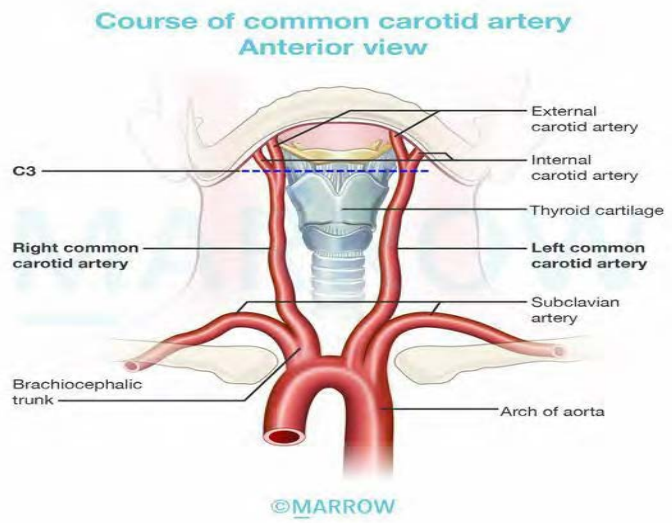
Clinical significance of carotid bifurcation:

• Chassaignac/carotid tubercle/transverse process of C6 vertebra: The pulsations of the common carotid artery can be felt by compressing the artery against this tubercle.

• Site of carotid body tumor

• The most common site for carotid atherosclerosis. It can lead to stroke or transient ischaemic attack (TIA).

• In carotid endarterectomy, the presence of high bifurcation predisposes to injury to the cranial nerves, commonly the hypoglossal nerve or marginal mandibular nerve. In such patients, carotid stenting is usually preferred to carotid endarterectomy.



Solution to Question 16:

The only branch of the external carotid artery which is given from its medial side is ascending pharyngeal artery.

The external carotid artery is a branch of the common carotid artery which begins at the upper border of the thyroid cartilage at the level between third and fourth cervical vertebrae.

Branches of the external carotid artery are:

• Superior thyroid artery

• Ascending pharyngeal artery

• Lingual artery

• Facial artery

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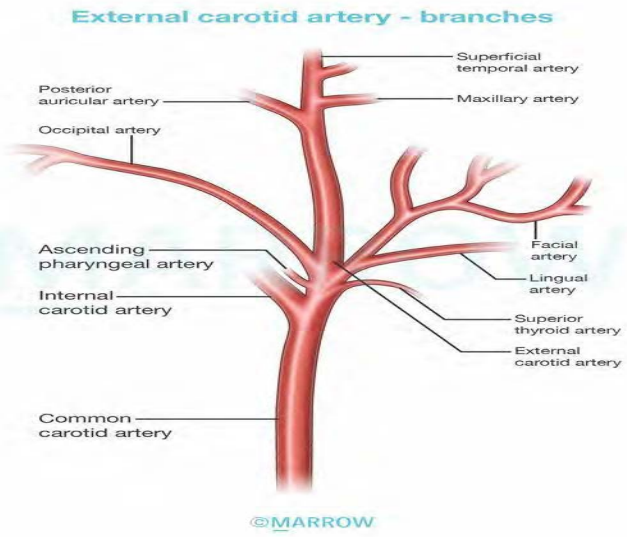
• Occipital artery

• Posterior auricular artery

• Maxillary artery and superficial temporal artery (terminal branches)



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Solution to Question 17:

The internal carotid artery does not give any branch in the cervical region.

The internal carotid artery is a terminal branch of the common carotid artery which begins at the level of the upper border of thyroid cartilage.

Solution to Question 18:

Cavernous sinus thrombosis may lead to the narrowing of the cavernous part of the internal carotid artery (ICA), because the cavernous sinus is closely related to it. The ophthalmic artery will not be involved here, as it is a branch of the cerebral part of the ICA.

Branches of cavernous part of the internal carotid artery:

• Meningeal artery

• Inferior hypophyseal arteries

• Cavernous branch (supplies trigeminal ganglion)

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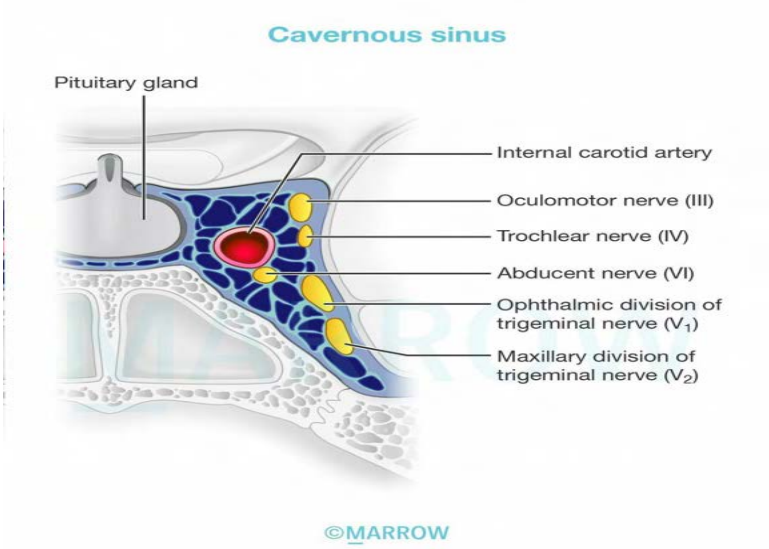

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Solution to Question 19:

The dorsal nasal artery will not be affected in this case, as is not a branch of the facial artery. It is a branch of the ophthalmic artery which is a branch of the ICA.

The facial artery is a branch of the external carotid artery which arises in the carotid triangle, above the origin of the lingual artery. In runs upwards in the neck and curves around the anteroinferior border of the masseter to enter the face.

Branches of facial artery in the neck	Branches of facial artery in the face
Ascending palatine artery	Premasseteric artery
Tonsillar branch	Superior and inferior labial arteries
Submental artery	Lateral nasal artery
Branches to submandibular gland	Angular artery

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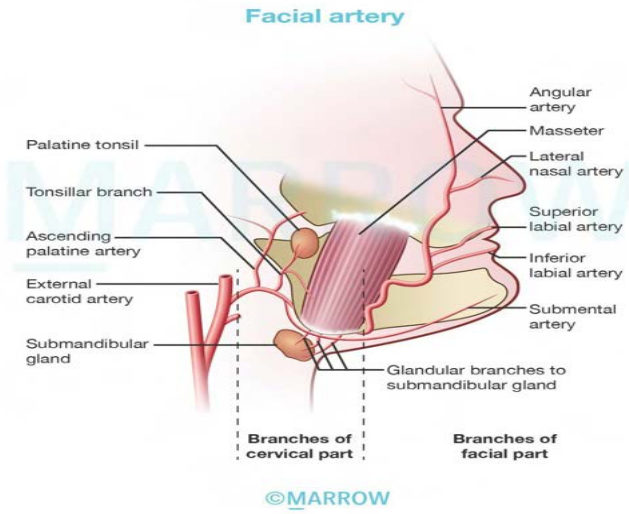
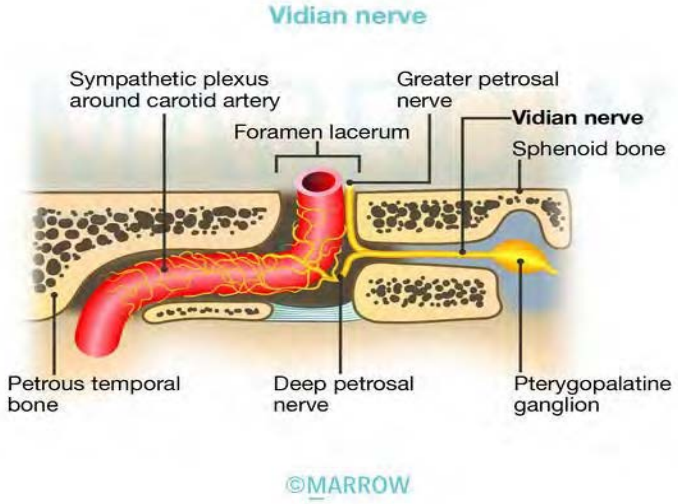


Solution to Question 20:

The involvement of the pterygoid canal can injure the vidian nerve, which is formed by:

• Postganglionic sympathetic fibres of the deep petrosal nerve

• Preganglionic parasympathetic fibres of the greater petrosal nerve



Pterygoid canal (Vidian canal):

• The pterygoid canal, also known as the Vidian canal, is a foramen in the base of the skull, located in the pterygoid process of the sphenoid bone, superior to the pterygoid plates, and inferomedial to the foramen rotundum. It transmits the Vidian artery and Vidian nerve from the middle cranial fossa to the pterygopalatine fossa

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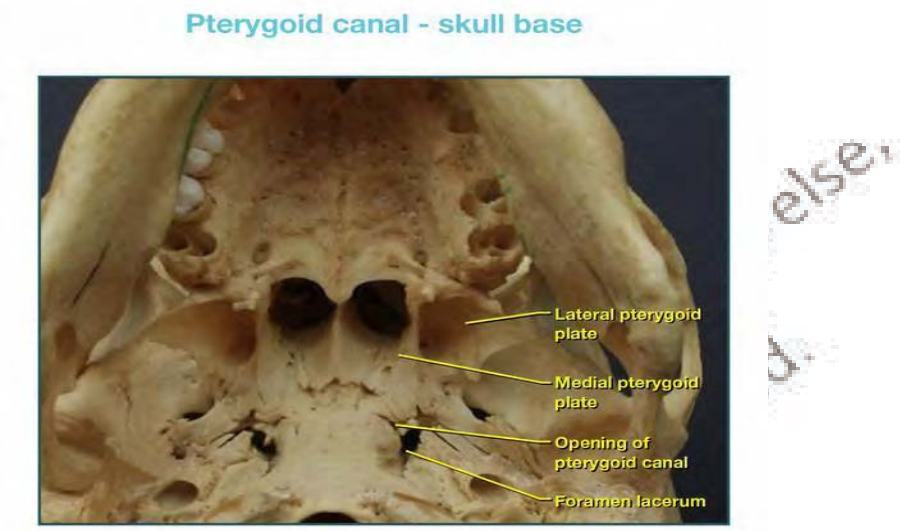
• It transmits the artery, nerve, and vein of the pterygoid canal (Vidian nerve and Vidian artery) into the pterygopalatine fossa.

• The vidian nerve contains the preganglionic fibers of the pterygopalatine ganglion, which provide the secretomotor supply to the nasal mucous glands. Hence vidian neurectomy is indicated in vasomotor rhinitis and intractable rhinnorrhea which is refractory to other treatments.



Solution to Question 21:

The structure marked A is the pterygoid canal. The artery of the pterygoid canal is a branch of pterygopalatine part of the maxillary artery.

Pterygopalatine branches of maxillary artery are (mnemonic PIGPAS):

• Posterior superior alveolar artery

• Infraorbital artery

• Greater palatine artery

• Pharyngeal artery

• Artery of pterygoid canal

• Sphenopalatine artery

Solution to Question 22:

The given image shows distention of the external jugular vein. Its formative tributaries are the posterior auricular vein and retromandibular vein (posterior division).

Venous drainage of the face and scalp:

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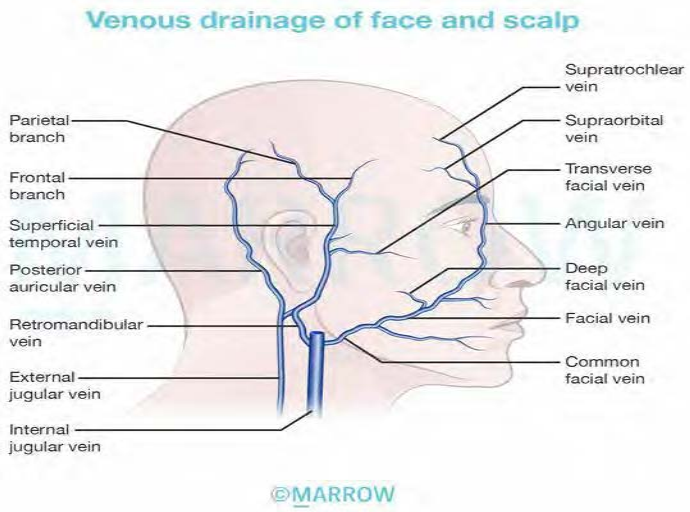
The blood from the face and scalp is mainly drained by the facial vein and retromandibular vein.

• The supratrochlear and the supraorbital veins join at the medial angle of the eye to form the angular vein, which continues down as facial vein.

• The superficial temporal vein joins the maxillary vein to form the retromandibular vein. The retromandibular vein divides into anterior and posterior divisions.

• The anterior division of the retromandibular vein joins the facial vein to form the common facial vein, which drains into the internal jugular vein.

• The posterior division of the retromandibular vein joins with the posterior auricular vein to form the external jugular vein. The external jugular vein then drains into the subclavian vein.



Solution to Question 23:

The triangular area from the corners of the mouth to the bridge of the nose, including the nose and maxilla is considered as the danger triangle of the face or dangerous area of the face.

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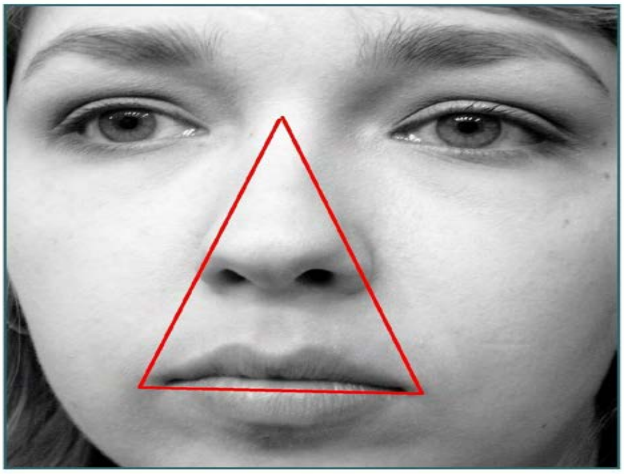
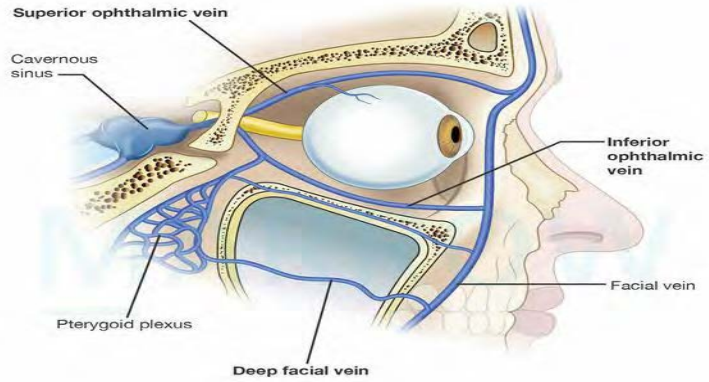
Danger triangle of the face



The blood from these area drains through the facial vein. The facial vein is valveless and connects with the cavernous sinus through the superior ophthalmic vein and with the pterygoid venous plexus through the inferior ophthalmic and deep facial veins. Hence any infection of the face may spread to the cavernous sinus and pterygoid venous plexus and lead to cavernous sinus thrombophlebitis.

Communication between facial vein and cavernous sinus



Solution to Question 24:

The correct pair of lymph nodes and levels among the following options are level 6- Hyoid to clavicle.

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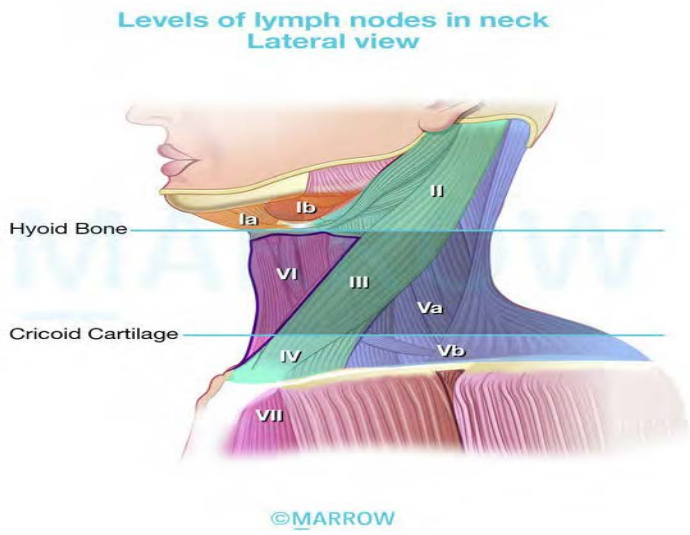

Levels of lymph nodes

Level	Lymph node
1a	Submental
1b	Submandibular
2	Upper jugular
3	Middle jugular
4	Lower jugular
5	Posterior triangle
6	Anterior group
7	Mediastinal

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Glands of the Head and Neck

Question 1:

A surgeon approaches the anteromedial surface of the parotid gland while performing a radical parotidectomy. Which of the following structures is related to it?

a) Mastoid process

b) Medial pterygoid muscle

c) Superficial parotid lymph nodes

d) Styloid process

Question 2:

Which of the following statements is false about the parotid gland?

a) Covered with deep fascia

b) Contains retromandibular vein

c) Develops from ectoderm

d) Parotid nodes lie behind the gland

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Question 3:

A radiologist is performing an ultrasound of the parotid gland in a case of parotid abscess. Which of the following structures will he not visualize within the gland?

a) External carotid artery

b) Facial artery

c) Transverse facial artery

d) Retromandibular vein

Question 4:

Which of the following statements is incorrect regarding the location of the otic ganglion?

a) Anterior to middle meningeal artery

b) Lateral to tensor veli palatini

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c) Lateral to mandibular nerve

d) Inferior to foramen ovale

Question 5:

Match the following with the structures they supply.

a) A-2, B- 4, C-3, D-1

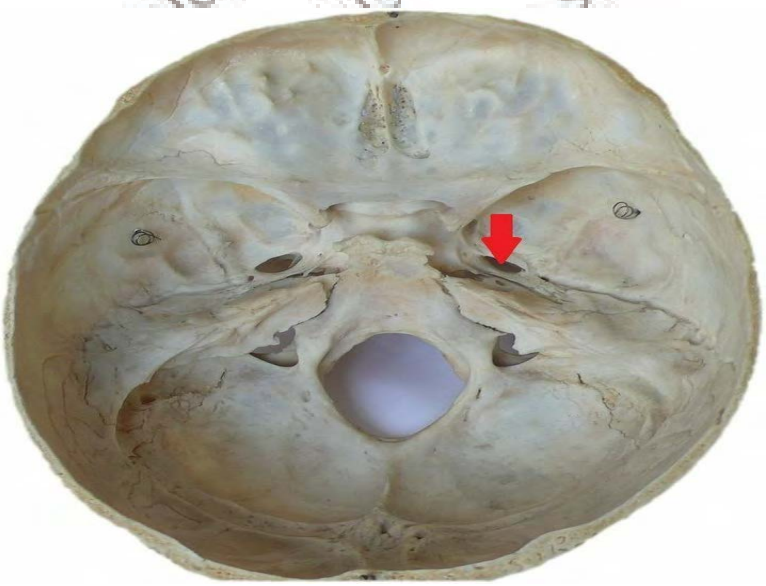
b) A-3, B-1, C-4, D-2

c) A-3, B-4, C-1, D-2

d) A-2, B-4, C-1, D-3

Question 6:

Where does the nerve passing through the marked foramen derive its parasympathetic preganglionic fibres from?



a) Jacobson's nerve

b) Nervus cochlearis

c) Nervus intermedius

d) Chorda tympani

Question 7:

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A medical student skipped breakfast to be able to attend his morning class. He is currently thinking about having food and coffee after class, and notices increased salivary secretion. The nerve fibres to the parotid gland responsible for this come from all except:

a) Otic ganglion

b) Greater petrosal nerve

c) Auriculotemporal nerve

d) Tympanic plexus

Question 8:

While performing a parotid sialography, what anatomical landmark would you use to locate the Stensen's duct?

a) 1st upper molar

b) 2nd upper molar

c) 1st lower molar

d) 2nd lower molar

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Question 9:

Where is the accessory parotid gland present?

a) Between the parotid duct and mandible

b) Below the apex of the parotid gland

c) Above the zygomatic arch

d) Between the parotid duct and zygomatic arch

Question 10:

A patient with Frey's syndrome receives a Botox injection into the skin over the parotid region. Which of the following nerves has undergone aberrant innervation in this condition?

a) Facial nerve

b) Glossopharyngeal nerve

c) Auriculotemporal nerve

d) Great auricular nerve

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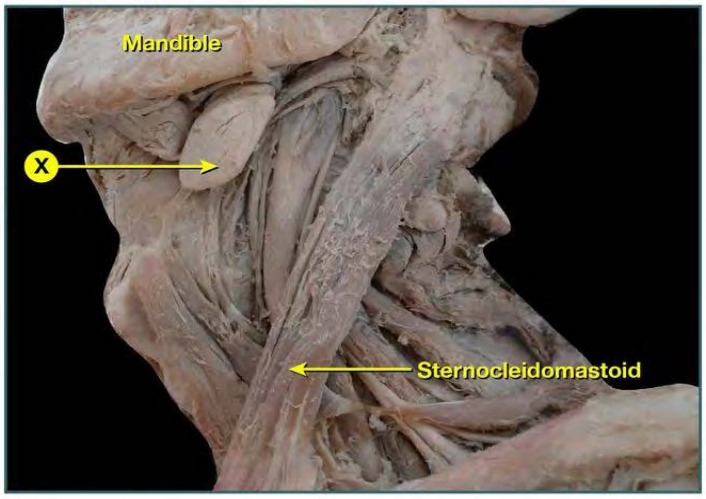
Question 11:

Lobes of the structure marked X are divided by ____



a) Mylohyoid

b) Genioglossus

c) Stylohyoid

d) Styloglossus

Question 12:

Which of the following nerves is susceptible to injury in a patient undergoing a submandibular gland excision?

a) Mandibular nerve

b) Lingual nerve

c) Inferior alveolar nerve

d) Recurrent laryngeal nerve

Question 13:

A 40-year-old man presents with the following finding and is diagnosed with sialadenitis secondary to sialolithiasis. The stone is lodged deep within the gland, hence excision is planned. Which of the following is correct about the surgical anatomy?

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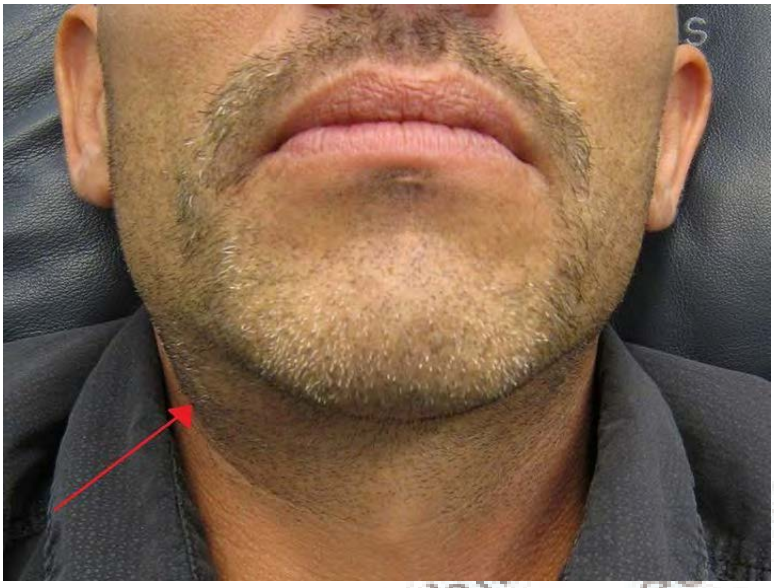

a) The submandibular gland is seen to wrap around the posterior border of mylohyoid

b) Facial artery is related to the deep part of the gland

c) The hypoglossal nerve loops under the submandibular duct

d) Damage to the lingual nerve will cause loss of sensation to the posterior 1/3rd of the tongue

Question 14:

Where do the preganglionic fibers to the submandibular ganglion arise from?

a) Superior salivatory nucleus

b) Inferior salivatory nucleus

c) Nucleus of tractus solitarius

d) Nucleus ambiguus

Question 15:

What is the extent of the thyroid gland?

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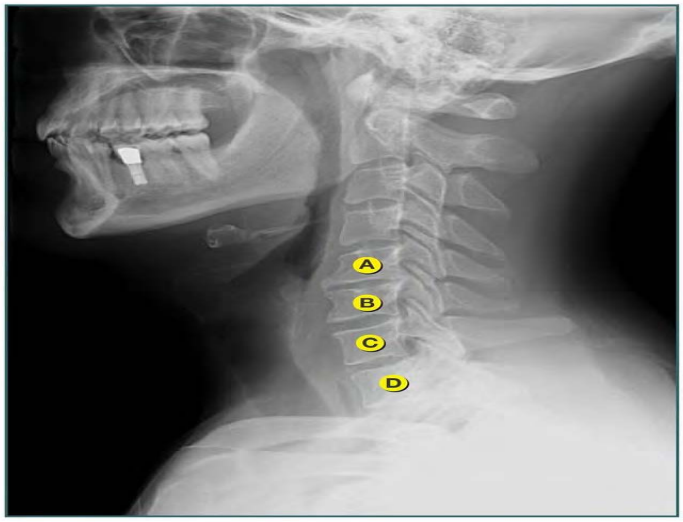


a) B to D

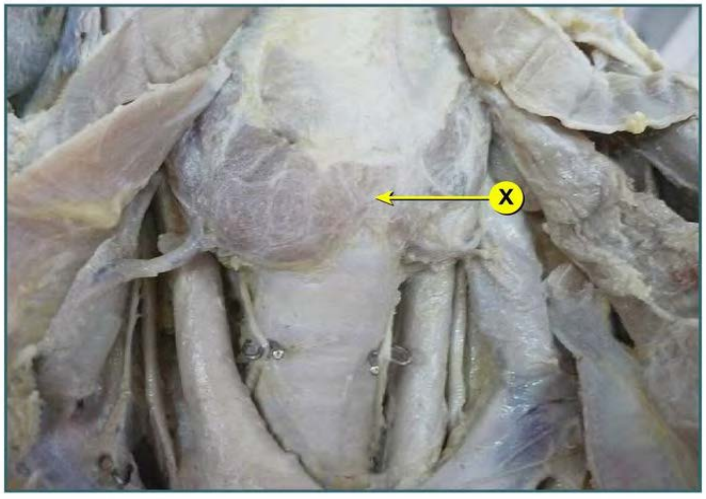
b) A to C

c) A to D

d) C to D

Question 16:

What does the area marked X overlie?



a) 3rd, 4th and 5th tracheal cartilage

b) 1st and 2nd tracheal cartilage

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c) 2nd, 3rd, and 4th tracheal cartilage

d) 3rd and 4th tracheal cartilage

Question 17:

You are an intern, scrubbed in on a thyroidectomy. You observe that the operating surgeon ligates the inferior thyroid artery close to the gland. This is done to prevent injury to which of the following structures?

a) Superior laryngeal nerve

b) Recurrent laryngeal nerve

c) Glossopharyngeal nerve

d) External laryngeal nerve

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Question 18:

Inferior thyroid artery is a branch of _____

a) Thyrocervical trunk

b) External carotid artery

c) Internal carotid artery

d) Lingual artery

Question 19:

A 62-year-old woman underwent a thyroidectomy for a multinodular goiter. After coming out of anesthesia, the patient reports weakness of the right side of the body and is unable to speak. CT-brain showed multiple scattered air bubbles in the left hemisphere. Intraoperative injury to which of the following structures can lead to this condition?

a) Superior or middle thyroid vein

b) Middle or inferior thyroid vein

c) Superior or inferior thyroid vein

d) Superior or inferior thyroid artery

Question 20:

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You are examining a case of goitre and observe that it moves with deglutition. The movement occurs due to the attachment of the thyroid gland by Berry's ligament, to which of the following structures?

a) Hyoid bone

b) Cricoid cartilage

c) Tracheal rings

d) Thyroid cartilage

Question 21:

A 28-year-old male was rushed to the ER after a road traffic accident. He has extensive trauma to the neck, and an emergency mid-line tracheostomy was performed. All of the following structures are prone to injury except:

a) Isthmus of thyroid

b) Arteria thyroid ima

c) Inferior thyroid artery

d) Inferior thyroid vein

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Question 22:

A 40-year old female underwent total thyroidectomy and on the third postoperative day, the patient complains of numbness in her fingers and perioral area. Which of the following vessels would have been injured during the surgery?

a) Anterior branch of superior thyroid artery

b) Posterior branch of superior thyroid artery

c) Superior branch of inferior thyroid artery

d) Inferior branch of inferior thyroid artery

Question 23:

Which of the following structures prevents the upward extension of thyroid swelling through its attachment to the thyroid cartilage?

a) Pretracheal fascia

b) Sternothyroid

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c) Thyrohyoid membrane

d) Ligament of berry

Question 24:

The newly discovered salivary glands are predominantly present over

a) Soft palate

b) Torus tubarius

c) Posterior ■ rd of the tongue

d) Eustachian tube

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Answer Key

Question No.	Correct Option
1	b
2	d
3	b
4	c
5	c
6	a
7	b
8	b
9	d
10	c
11	a
12	b
13	a
14	a
15	c
16	c
17	b
18	a
19	a
20	b

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21	c
22	c
23	b
24	b

Detailed Explanations

Solution to Question 1:

The anteromedial surface of the parotid gland is related to the medial pterygoid muscle.

The parotid gland is the largest salivary gland. It is usually in the shape of an inverted pyramid and has a superior surface, apex, superficial surface, anteromedial surface, and posteromedial surface.

Relations of the parotid gland:

• Superior surface - the external acoustic meatus and posterior part of the temporomandibular joint.

• Apex - directed downwards and is related to the posterior belly of the digastric and carotid triangle.

• Superficial surface - skin, superficial fascia, greater auricular nerve, parotid lymph nodes, and platysma.

• Anteromedial surface - posteroinferior part of the mandibular ramus, masseter, medial pterygoid, and temporomandibular joint.

• Posteromedial surface i- mastoid process, posterior belly of the digastric, styloid process, and the muscles attached to it.

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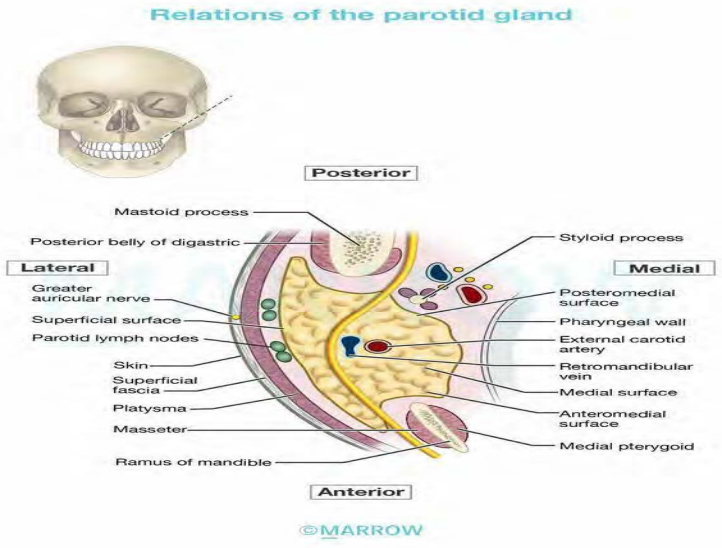

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Solution to Question 2:

The parotid nodes lie on the superficial surface of the parotid gland.

The false capsule which covers the parotid gland is derived from the investing layer of deep cervical fascia.

Structures present in the parotid gland from superficial to deep are the facial nerve, retromandibular vein, and external carotid artery.

The parotid gland is derived from the ectoderm.

Solution to Question 3:

The facial artery is not present within the parotid gland.

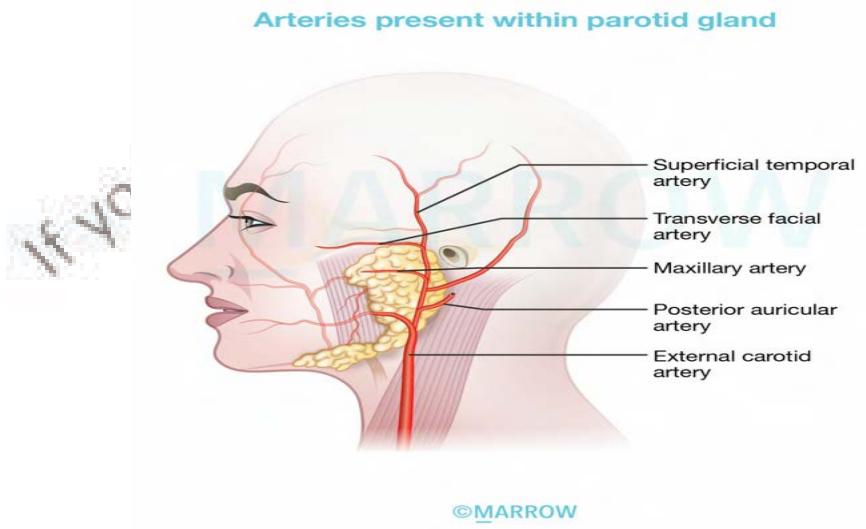
The parotid gland contains:

Arteries:

• External carotid artery, which terminates into the maxillary artery and superficial temporal artery.

• The transverse facial artery, which is a branch of the superficial temporal artery.

Sometimes the external carotid artery may also give posterior auricular artery within the gland.



Veins:

Maxillary vein and superficial temporal vein, which unite to form the retromandibular vein.

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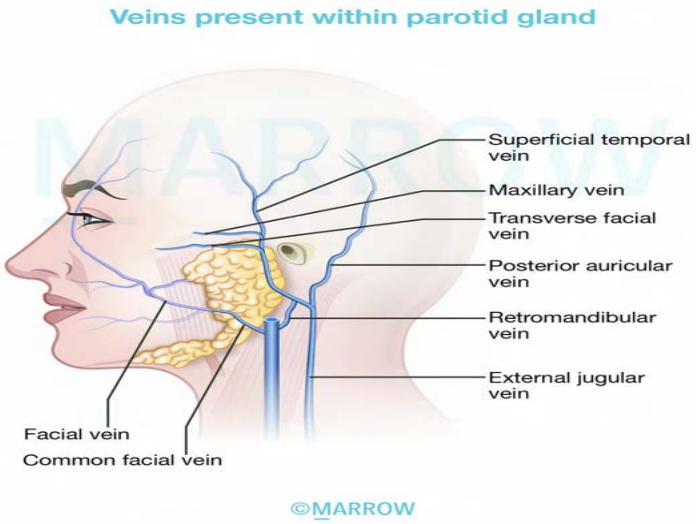
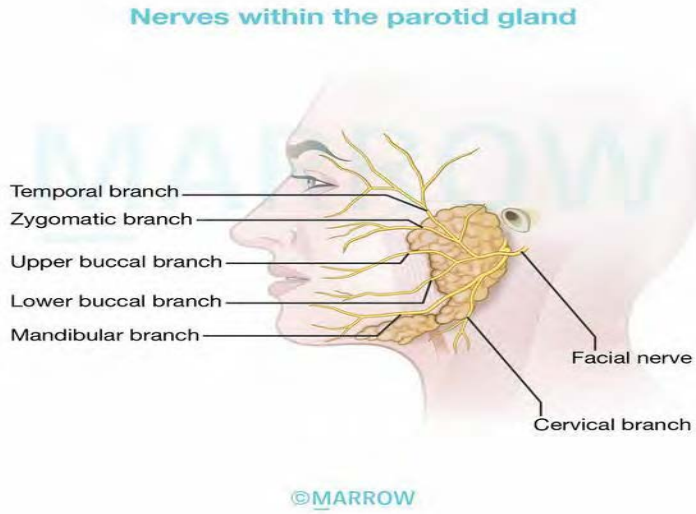


Nerves:

Facial nerve and its branches and parotid lymph nodes



Solution to Question 4:

The secretomotor fibres from glossopharyngeal nerves relay through the otic ganglion before supplying the parotid gland. Otic ganglion is present medial to the mandibular nerve.

Relations of otic ganglion:

- Superiorly - Foramen ovale
- Laterally - Mandibular nerve
- Medially - Tensor veli palatini

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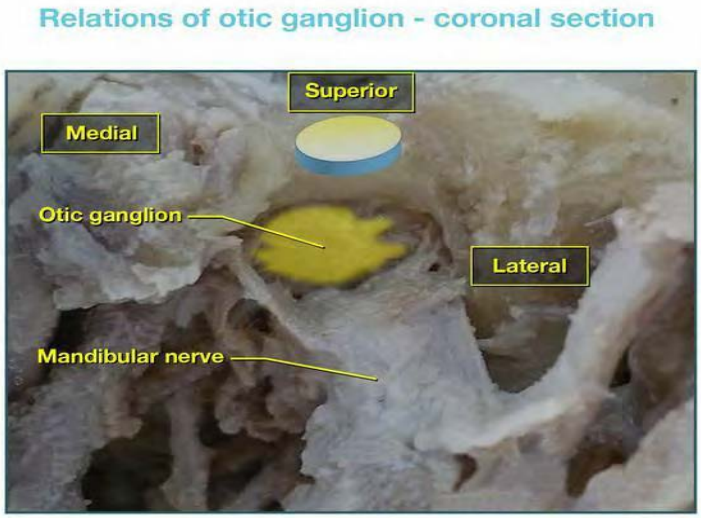
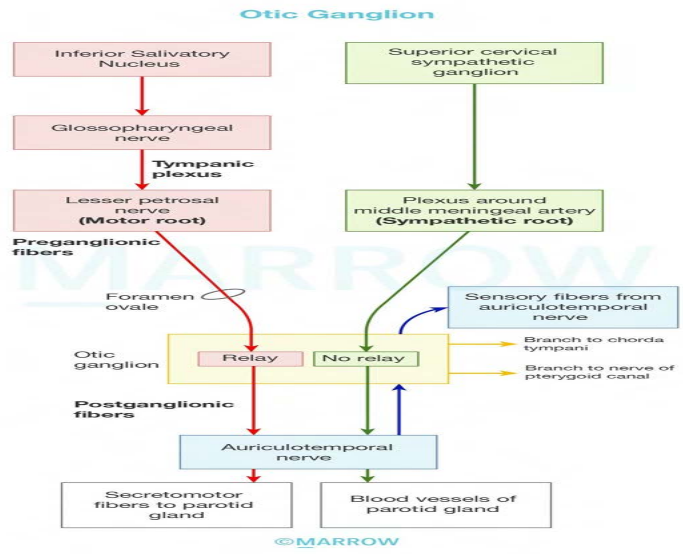
• Posteriorly - Middle meningeal artery



Otic ganglion is a parasympathetic ganglion which supplies secretomotor fibres to the parotid gland and is present below the foramen ovale.

• Preganglionic fibres originate in the inferior salivatory nucleus and pass through the lesser petrosal nerve which is the continuation of the tympanic branch of the glossopharyngeal nerve. They relay in the otic ganglion.

• Postganglionic fibres pass by the communicating branches to the auriculotemporal nerve and supply the parotid gland.



Solution to Question 5:

The otic ganglion supplies the parotid gland.

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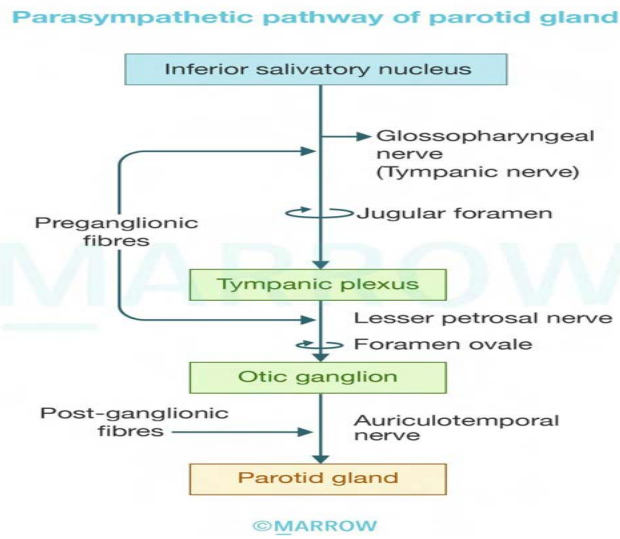
The pterygopalatine ganglion (also known as Meckel's ganglion) supplies the lacrimal glands and palatal glands

The submandibular ganglion supplies the submandibular glands and sublingual glands.

Solution to Question 6:

The given image shows foramen ovale marked. The lesser petrosal nerve passes through this foramen. It derives preganglionic fibres from the tympanic nerve, also known as Jacobson's nerve.



Note: Mandibular division of trigeminal nerve also passes through the foramen ovale. However, it does not have any parasympathetic pre-ganglionic fibres.

Solution to Question 7:

The given case scenario is suggestive of parasympathetic stimulation of the salivary glands, causing the parasympathetic secretomotor fibres to increase salivary secretion.

The parasympathetic fibres to the parotid gland are carried by the lesser petrosal nerve.

Otic ganglion is a parasympathetic ganglion which supplies secretomotor fibres to the parotid gland and is present below the foramen ovale.

• Preganglionic fibres originate in the inferior salivatory nucleus and pass through the lesser petrosal nerve which is the continuation of the tympanic branch of the glossopharyngeal nerve. They relay in the otic ganglion.

• Postganglionic fibres pass by the communicating branches to the auriculotemporal nerve and supply the parotid gland.

The greater petrosal nerve carries secretomotor fibres to the pterygopalatine ganglion and supplies the lacrimal, nasal, and palatine glands.

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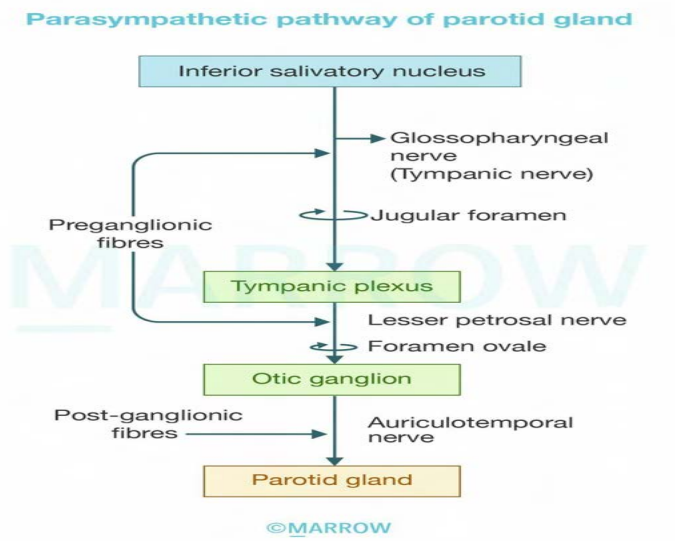

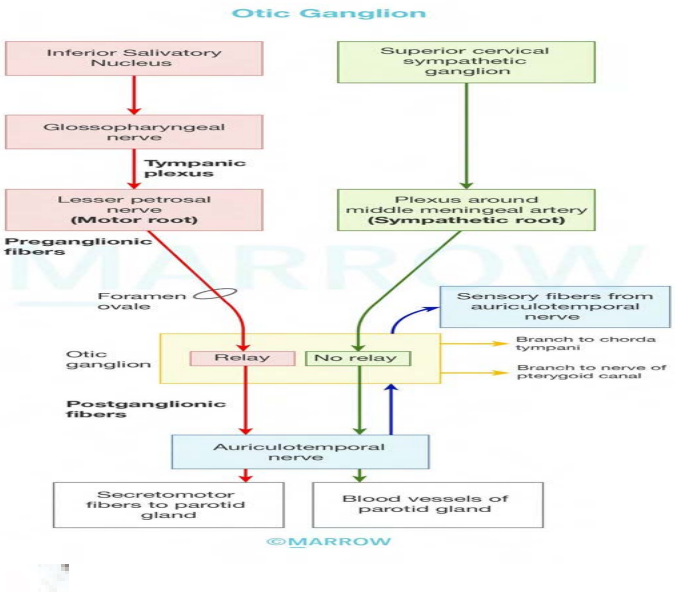

Sympathetic supply to the parotid gland is derived from the plexus around the middle meningeal artery.

Sensory supply to the parotid gland is from the auriculotemporal nerve and to the parotid capsule is from the sensory fibres of greater auricular nerve.

Solution to Question 8:

The parotid duct or the Stensen's duct opens opposite to the 2nd upper molar tooth. It pierces the buccinator at the level of the 3rd upper molar tooth.

Structures pierced by the parotid duct are shown in the image below:

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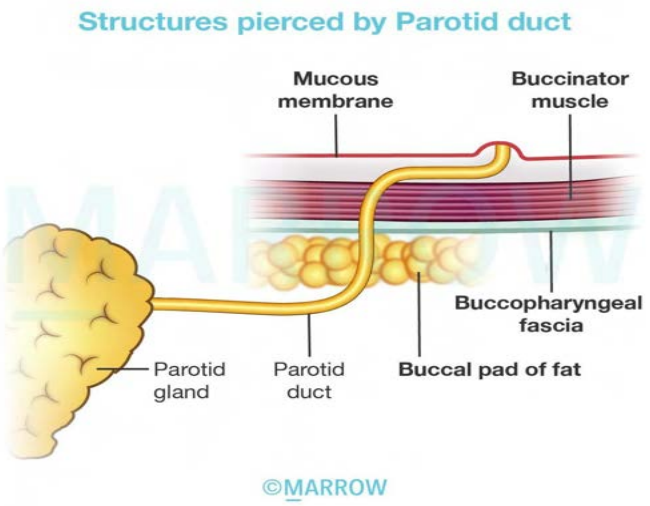

Clinical significance:

Sialolithiasis is the presence of stones in the salivary ducts. It is more commonly seen in the submandibular gland than the parotid gland. Parotid duct stones are usually radiolucent and rarely visible on plain radiography, therefore contrast is given to perform sialography to visualize the stones on X-rays.

Solution to Question 9:

The accessory parotid gland is present between the parotid duct and zygomatic arch.

It is usually a detached part of the parotid gland. They have their own blood supply and a secondary duct that drains into the main parotid duct.

Clinical significance:

• They can be missed during complete parotidectomy.

• They can present as mid-cheek masses.

• The histological characteristics of accessory glands can differ from that of main gland and hence tumors arising from them can show different clinical course.

Solution to Question 10:

Frey's syndrome occurs due to the aberrant innervation of the auriculotemporal nerve. It is also known as gustatory sweating or auriculotemporal syndrome.

It commonly develops after parotid surgery or any trauma where there is an injury to the parotid capsule.

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During the regrowth, an aberrant connection develops between the parasympathetic fibres supplying the parotid gland (auriculotemporal nerve) and the sweat glands.

This results in sweating, warmth, and redness of the face during the salivary stimulation by the smell or taste of food.

Management:

• Antiperspirants - aluminum chloride

• Tympanic neurectomy

• Botulinum toxin injection into the affected skin

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Solution to Question 11:

The structure marked X is the submandibular gland. Lobes of the submandibular gland are divided by the mylohyoid muscle.

The submandibular gland is divided into a larger superficial and smaller deep part by the mylohyoid muscle. They are continuous with each other around the posterior border of the mylohyoid.

Relations of the submandibular gland	
Superficial relations	Deep relations
Facial artery	Deep lingual vein
Facial vein	Sublingual gland
Deep lingual vein	Lingual nerve
Submandibular ganglion	Hypoglossal nerve
Cervical branch of the facial nerve	
Glossopharyngeal nerve	
Lingual nerve	
Hypoglossal nerve	

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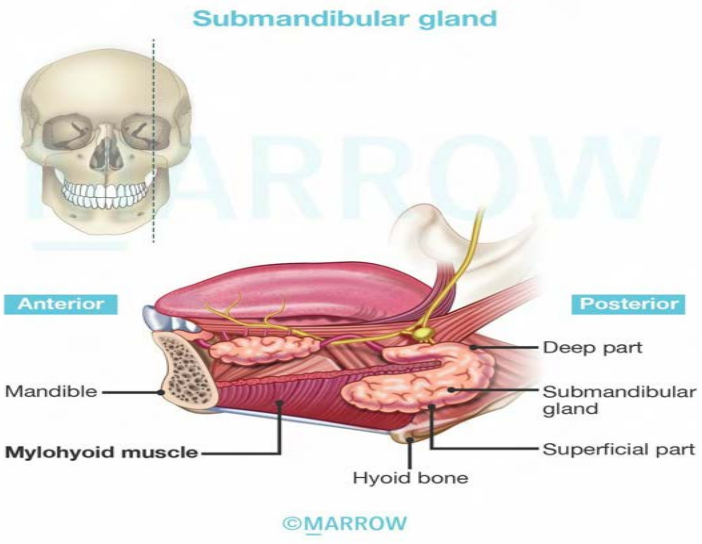
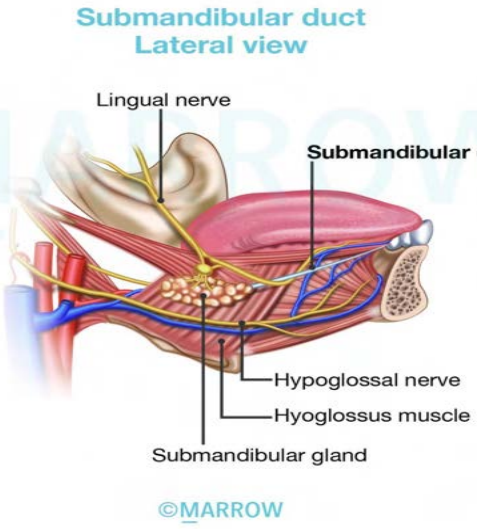


Solution to Question 12:

The lingual nerve is susceptible to injury during excision of the submandibular gland.

Lingual nerve loops around the submandibular duct, and hence is susceptible to injury during the procedures involving the submandibular region.

Superficial to the hyoglossus muscle, the submandibular duct lies between lingual and hypoglossal nerves. As it reaches the anterior border of the hyoglossus, it is crossed by the lingual nerve.



Solution to Question 13:

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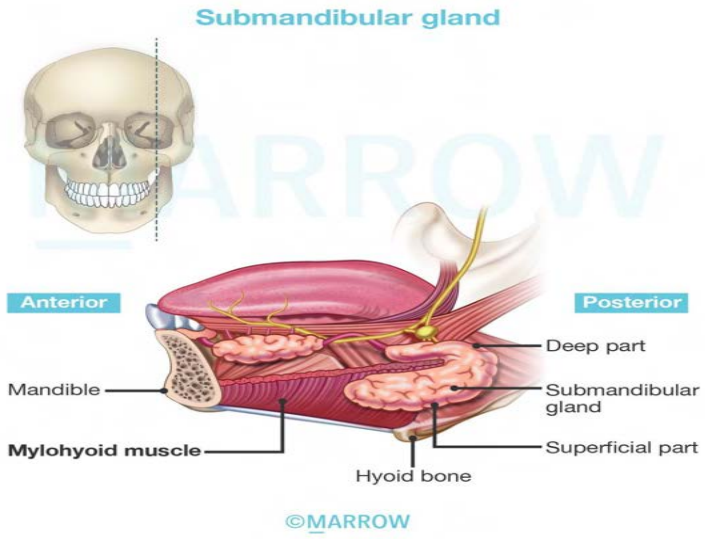
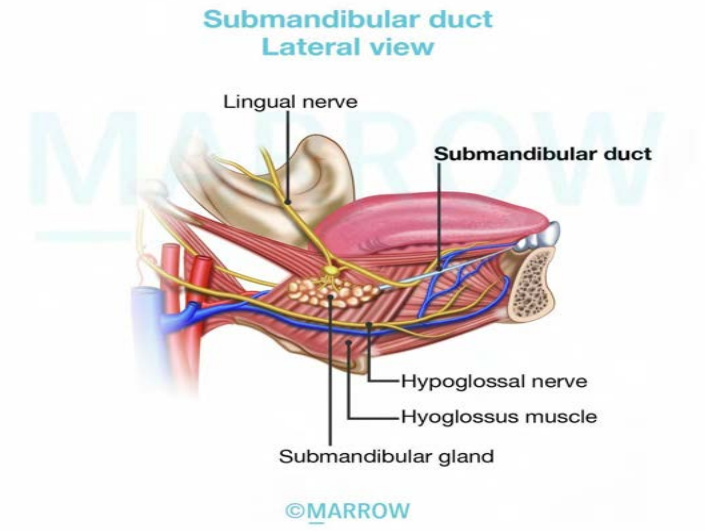
In the given case, the swelling is present in the submandibular region, involving the submandibular gland. The gland is seen to wrap around the posterior border of the mylohyoid.

The submandibular gland is made up of large superficial and smaller deep parts, which are continuous with each other around the posterior border of the mylohyoid.

Option B: The facial artery is related to the superficial part of the gland.

Option C, D: Lingual nerve loops around the submandibular duct. Damage to it causes loss of sensation in the anterior 2/3rd of the tongue.





Solution to Question 14:

Preganglionic fibres to the submandibular ganglion arise from the superior salivatory nucleus..

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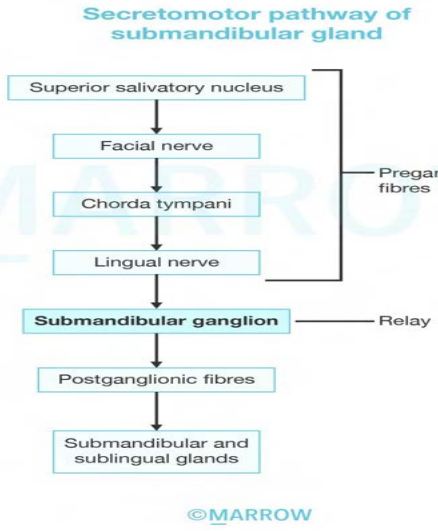

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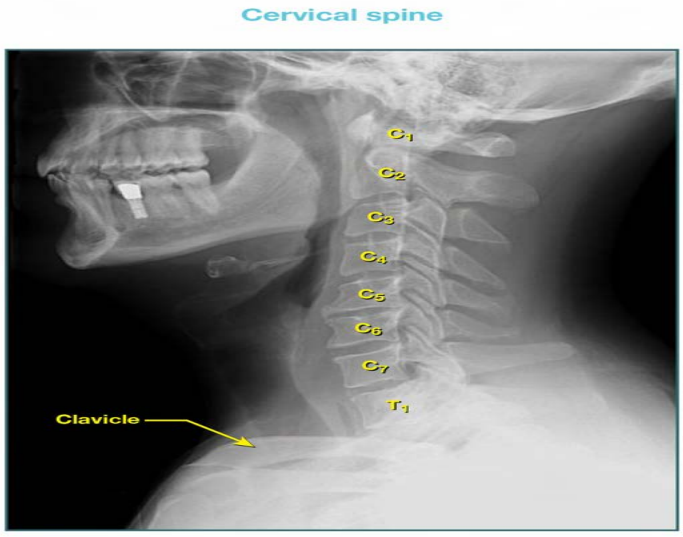
Solution to Question 15:

The extent of the thyroid gland is from vertebral levels A to D in the given image. It extends from vertebral levels C5 to T1.



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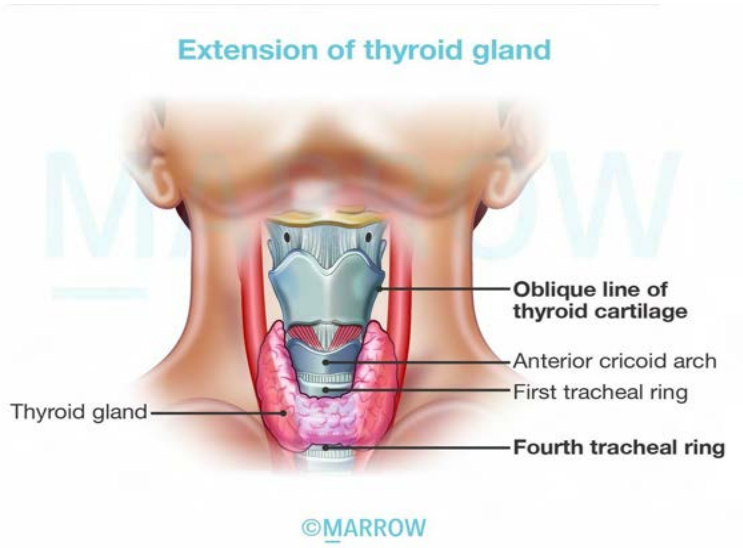

Levels with respect to the tra cheal rings and vertebra	
Lobes of the thyroid gland	Thyroid cartilage to 4thtrach eal ringVertebral level-C5-T1
Isthmus of the thyroid gland	Opposite 2ndand 3rdtracheal rings

Solution to Question 16:

The structure marked X is the isthmus of the thyroid gland. It overlies 2nd, 3rd, and 4th tracheal rings.

Isthmus connects the lower parts of both the lobes of the thyroid gland. It is usually present anterior to the 2nd and 3rd tracheal cartilages, but the position may vary according to its size.

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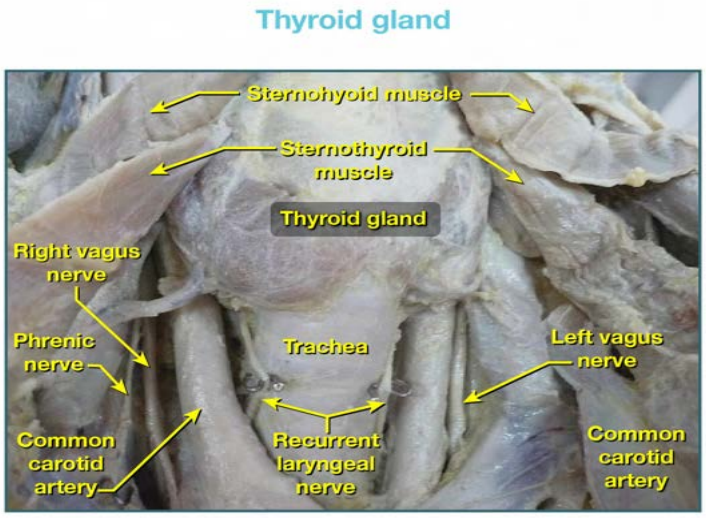

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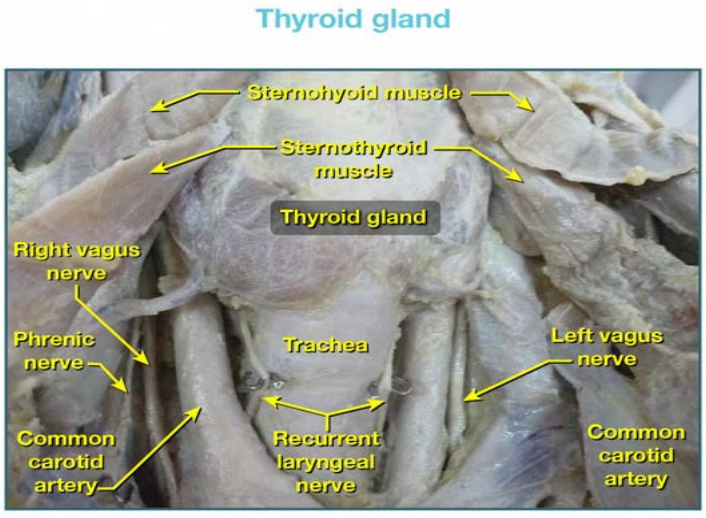
Solution to Question 17:

Recurrent laryngeal nerve is related to the posterior branch of the inferior thyroid artery near the lobes of the thyroid gland. Therefore, during ligation of the artery, it is ligated close to the gland to prevent injury to it.

External laryngeal nerve is related to the superior thyroid artery. Superior thyroid artery pierces the thyroid fascia and supplies the upper part of the gland. The superior thyroid artery is ligated close to the gland to prevent injury to this nerve.



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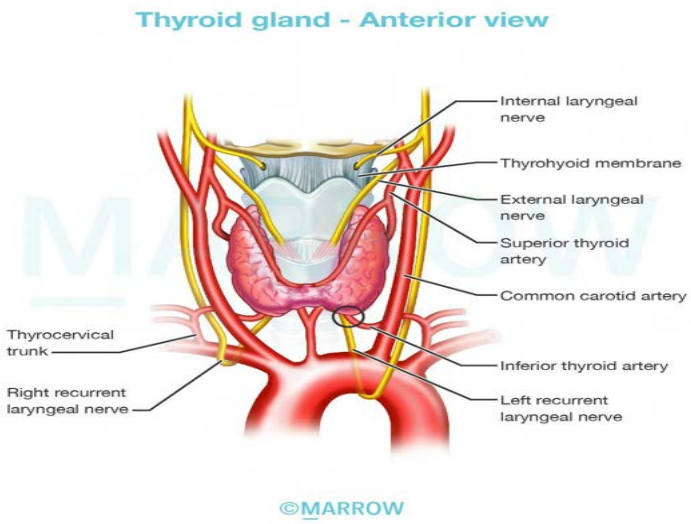

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Solution to Question 18:

Inferior thyroid artery is a branch of the thyrocervical trunk of the subclavian artery.

Solution to Question 19:

The given case scenario is suggestive of cerebral air embolism. Intra-operative injury to the superior or middle thyroid veins causes air to get sucked into them due to the negative venous pressure. The air embolus then travels up through the internal jugular vein into the cerebral venous circulation. Head-down position during surgery prevents air embolism.

Venous drainage of the thyroid gland:

• Superior and middle thyroid veins - drain into the internal jugular vein

• Inferior thyroid vein - drains into the brachiocephalic vein

Solution to Question 20:

The movement of the thyroid gland with deglutition is due to the attachment of Berry's ligament to the cricoid cartilage.

Ligament of Berry:

The pretracheal fascia encloses the thyroid gland to form its false capsule. This capsule is thickened posteriorly and on either side forms a suspensory ligament which is known as ligament of Berry or lateral thyroid ligament. The posteromedial aspects of the lobes of the thyroid are attached to the side of the cricoid cartilage by the ligament of Berry. It also prevents the thyroid gland from sinking into the mediastinum.

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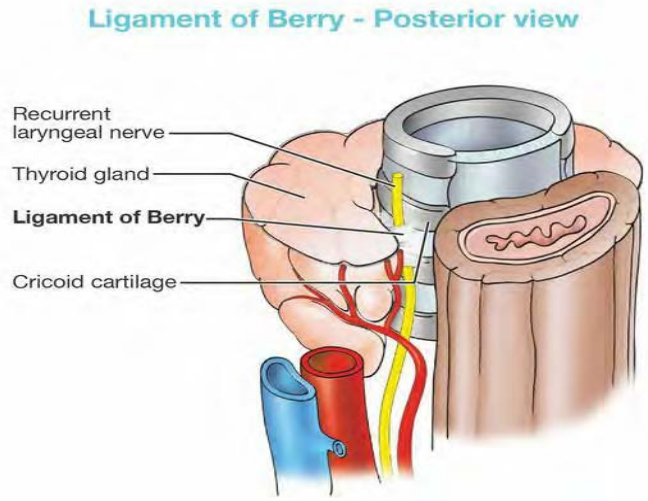

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Solution to Question 21:

The structure that is not damaged during the emergency tracheostomy is the inferior thyroid artery, as it is not a mid-line structure.

Isthmus, arteria thyroid ima, inferior thyroid vein are in the midline and are prone to damage during tracheostomy.

Solution to Question 22:

The above clinical scenario is suggestive of postoperative hypoparathyroidism due to injury to the superior branch of the inferior thyroid artery.

The parathyroid glands are small yellowish-brown structures lying between the posterior border of the thyroid gland and its capsule. There are

• Two superior parathyroid glands

• Two inferior parathyroid glands

These are supplied by the superior branch of the inferior thyroid artery. They secrete parathormone which helps in the regulation of the serum calcium, by the release of calcium from bones.

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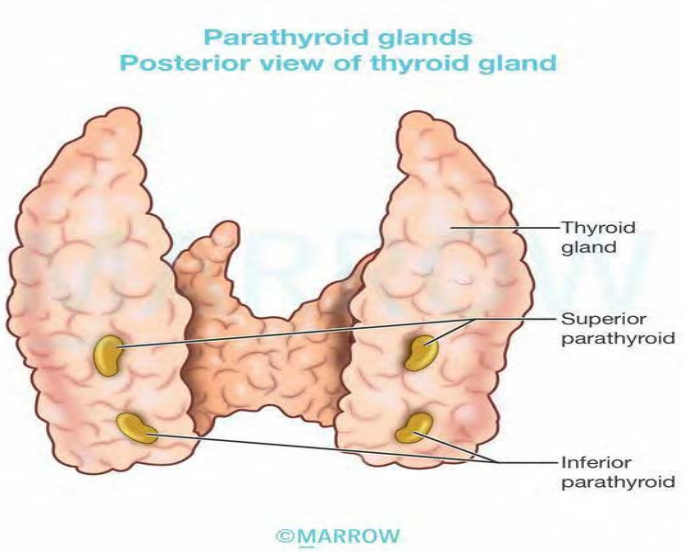


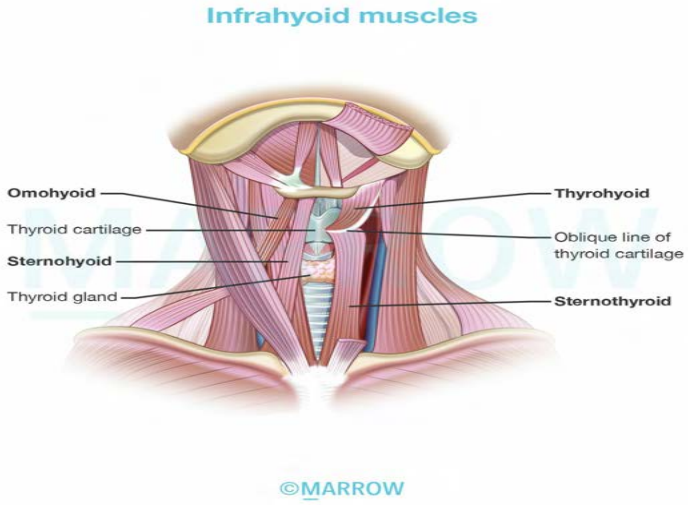
Solution to Question 23:

Sternothyroid and sternohyoid prevent the upward extension of the thyroid swelling through its attachment to the thyroid cartilage.

Pretracheal fascia encloses the thyroid gland and is attached to the larynx. This attachment is responsible for the movement of the enlarged thyroid gland on deglutition.

The thyrohyoid membrane is a fibro-elastic ligament, which arises from the superior margin of the thyroid cartilage, and gets attached to the hyoid bone. It facilitates the upward movement of the larynx during swallowing.

The ligament of Berry, also called the suspensory ligament extends from the cricoid cartilage to the thyroid. Its attachment prevents the thyroid gland from sinking down into the mediastinum.



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Solution to Question 24:

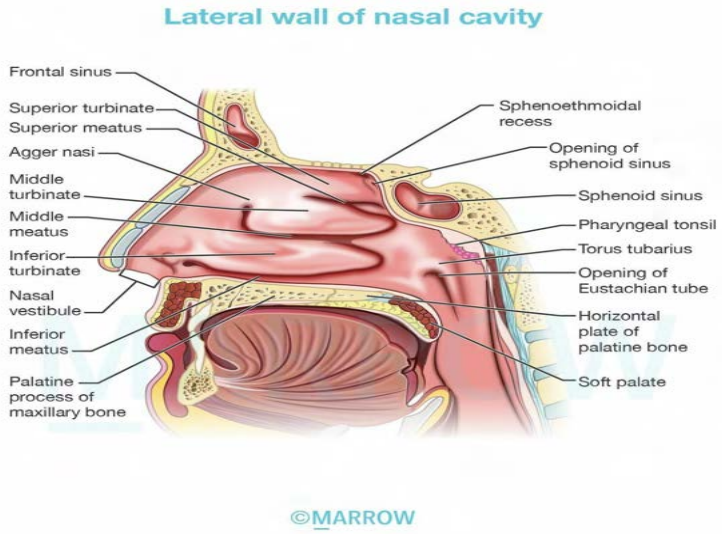
The newly discovered salivary glands are predominantly present over torus tubarius. Torus tubarius is the anatomical structure formed by the cartilage that supports the entrance of the auditory tube.

The proposed name of these newly identified glands is tubarial salivary glands. These glands extend caudally to the pharyngeal wall and cranially to Rosenmuller's fossa.

Positron emission tomography/computed tomography with radio-labeled ligands to the prostate-specific membrane antigen (PSMA PET/CT) can visualize these salivary glands with high sensitivity and specificity.

Clinical significance:

It has been reported that radiotherapy over the location of these glands has led to xerostomia and dysphagia. Sparing these glands, thus, might improve the quality of life of patients receiving radiotherapy.



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Tongue and Palate

Question 1:

Which of the following demarcates the anterior 2/3rds of the tongue from the posterior 1/3rd?

a) Sigmoid sulcus

b) Gingival sulcus

c) Terminal sulcus

d) Median sulcus

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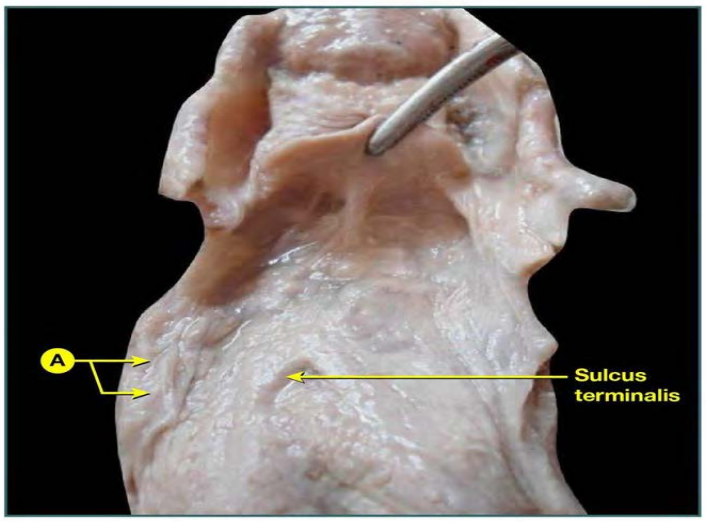
Question 2:

Identify the papillae marked A in the given image.



a) Filiform papillae

b) Fungiform papillae

c) Foliate papillae

d) Circumvallate papillae

Question 3:

All the following muscles of the tongue are derived from occipital myotomes except _____.

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a) Genioglossus

b) Palatoglossus

c) Styloglossus

d) Superior longitudinal muscle

Question 4:

While examining the hypoglossal nerve in a stroke patient, you observe the following finding. Which of the following muscles is likely to be paralyzed?

a) Left styloglossus

b) Right styloglossus

c) Right genioglossus

d) Left genioglossus

Question 5:

A patient who underwent skull base surgery developed drooping of the left side of his face and loss of taste sensation in the anterior two-thirds of the tongue. However, the general sensation over the tongue is intact. Which of the following nerves is likely to be injured?

a) Glossopharyngeal nerve

b) Chorda tympani

c) Hypoglossal nerve

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d) Lingual nerve

Question 6:

While testing the taste sensation in a stroke patient, you place a few drops of sugar water over the circumvallate papillae. Which of the following nerves will carry the taste pathway here?

a) Chorda tympani

b) Greater petrosal nerve

c) Internal laryngeal nerve

d) Glossopharyngeal nerve

Question 7:

A patient presents with a painful aphthous ulcer at the tip of the tongue. Which of the following nerves gives rise to the branch carrying this sensation?

a) Glossopharyngeal nerve

b) Chorda tympani nerve

c) Mandibular nerve

d) Vagus nerve

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Question 8:

A 50-year-old man with a history of tobacco chewing presented with a painless ulcer over the tip of the tongue. Wedge biopsy revealed squamous cell carcinoma. Which of the following lymph nodes would you first biopsy?

a) Submandibular lymph nodes

b) Submental lymph nodes

c) Deep cervical lymph nodes

d) Jugulo-omohyoid lymph nodes

Question 9:

A patient with long-standing erythroplakia now presents with the following finding. Which of the following lymph nodes would be involved first in this patient?

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a) Submental lymph nodes

b) Deep cervical lymph nodes

c) Bilateral submandibular lymph nodes

d) Unilateral submandibular lymph nodes

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Question 10:

You notice the following finding while administering OPV for a child. Which of the following nerves does not provide sensory supply to the structure involved?

a) Facial nerve

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b) Hypoglossal nerve

c) Glossopharyngeal nerve

d) Maxillary nerve

Question 11:

The sensory fibers from the taste buds in the hard and soft palate travel along the ____.

a) Facial Nerve

b) Trigeminal nerve

c) Glossopharyngeal nerve

d) Vagus nerve

Question 12:

Which of the following does not supply the palate?

a) Tonsillar branch of facial artery

b) Ascending palatine artery

c) Descending palatine artery

d) Ascending pharyngeal artery

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Answer Key

Question No.	Correct Option
1	c
2	c
3	b
4	d
5	b
6	d
7	c
8	b
9	d
10	b

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11	b
12	a

Detailed Explanations

Solution to Question 1:

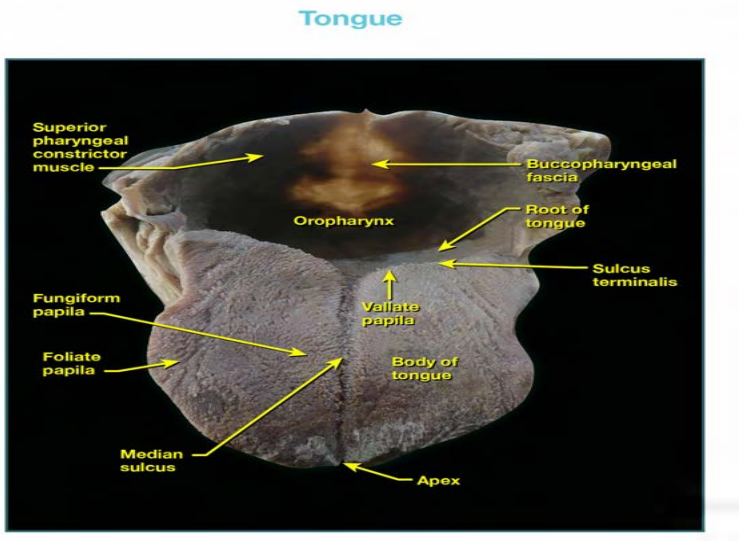
The anterior 2/3rds of the tongue is demarcated from the posterior 1/3rd by the terminal sulcus, also known as the sulcus terminalis.

Sulcus terminalis divides the tongue into anterior and posterior parts. The anterior or the oral part faces superiorly and the posterior or the pharyngeal part faces posteriorly.

Option A: Sigmoid sulcus is present on the mastoid surface of the temporal bone

Option B: Gingival sulcus is present between the tooth and the surrounding gingival tissue

Option D: Median sulcus is the central sulcus present on the tongue



Solution to Question 2:

The structure marked A shows the foliate papillae which lie bilaterally on either side of the tongue near the sulcus terminalis.

Location of papillae in the tongue:

• Filiform papillae - They are minute cylindrical or conical projections that are mainly present on the dorsal part of the anterior 2/3rd of the tongue.

• Fungiform papillae - They are large, rounded and red in colour and are mainly present on the lingual margins and also on the dorsal surface of the tongue.

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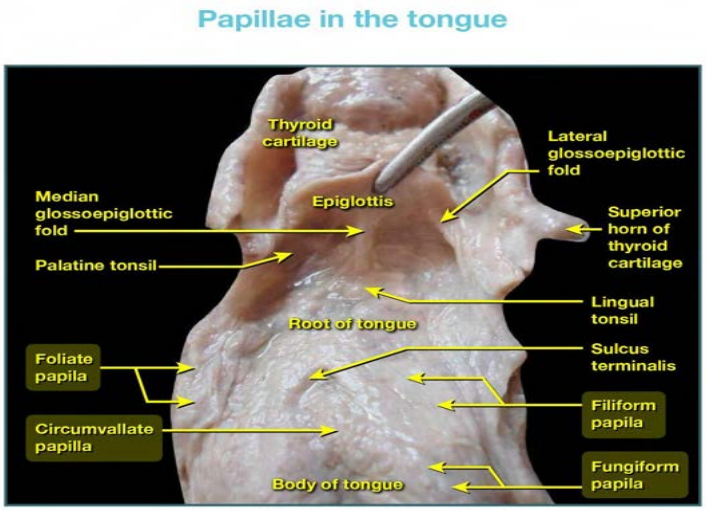
• Foliate papillae - They are red, leaf-like mucosal ridges that are present bilaterally in two zones at the sides of the tongue near the sulcus terminalis.

• Circumvallate papillae - They are large cylindrical structures that are around 8-12 in number. They are arranged in a V-shaped row immediately in front of the sulcus terminalis (not on the sides of the tongue).



Solution to Question 3:

All the muscles of the tongue are derived from occipital myotomes except palatoglossus. It is derived from the fourth pharyngeal arch.

Hence all the muscles of the tongue are supplied by the hypoglossal nerve except the palatoglossus muscle which is supplied by the pharyngeal plexus.

Solution to Question 4:

The given image shows tongue deviation to the left, and the left genioglossus muscle is paralyzed in the above given clinical scenario.

Actions of genioglossus muscle:

• When both the right and left genioglossi contract, they protrude the anterior part of the tongue out of the mouth in the midline. When only one muscle contracts, it protrudes and pushes the tongue to the opposite side.

• It depresses the central part of the tongue.

• It is supplied by the hypoglossal nerve.

In conditions affecting the hypoglossal nerve, the genioglossus muscle on that side is paralyzed. In such cases, when the patient protrudes the tongue, it deviates towards the affected side due to the

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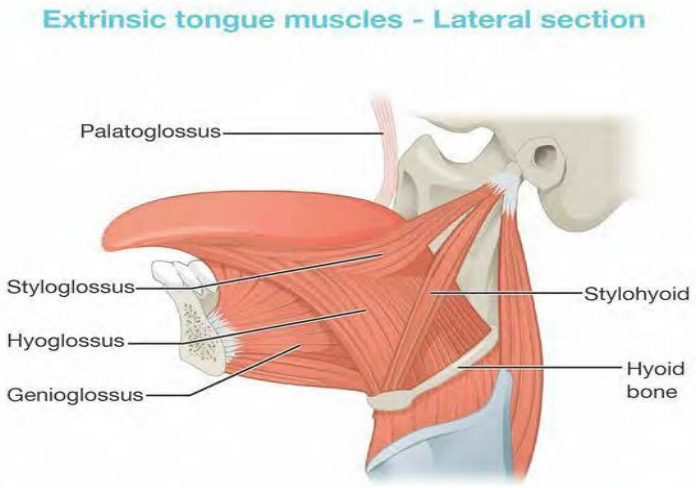
muscle contraction on the normal side.



The genioglossi are attached to the genial tubercle present on the mandible. This prevents the tongue from falling backwards and obstructing respiration. Hence this muscle is known as the safety muscle of the tongue.

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Solution to Question 5:

The given case scenario is suggestive of damage to the facial nerve above the level of the stylomastoid foramen, resulting in injury to chorda tympani nerve.

Taste sensation from the anterior 2/3rd of the tongue is carried by chorda tympani nerve, whereas general sensation is carried by the lingual nerve.

Solution to Question 6:

The taste pathway for circumvallate papillae of the tongue goes through the glossopharyngeal nerve.

Taste sensation from the anterior 2/3rd of the tongue except the circumvallate papillae is carried by the chorda tympani branch of the facial nerve.

Areas innervated by glossopharyngeal nerve:

- The circumvallate papillae
- Posterior 1/3rd of the tongue
- Palatoglossal arches
- The oropharynx

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Taste buds in the extreme posterior part of the tongue and epiglottis receive fibres from the internal laryngeal branch of the vagus.

Solution to Question 7:

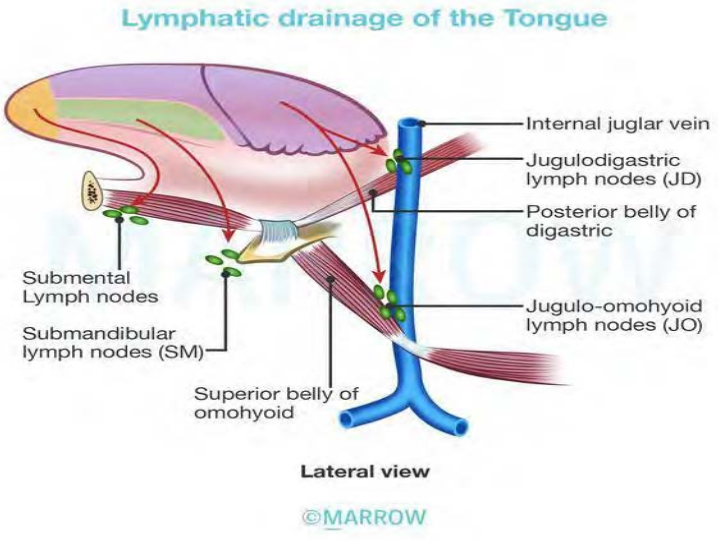
Pain sensation at the tip of the tongue is carried by the lingual nerve which is a branch of the mandibular nerve.

Solution to Question 8:

The submental lymph node will be biopsied first as it is the sentinel lymph node. The sentinel node is the first node that the tumor site drains into.

In squamous cell carcinoma of the tongue, submental lymph nodes are involved in lesions of the tip and submandibular lymph nodes are involved in lesions of the sides of the tongue. Bilateral neck lymph node spread is common due to the crossing of lymph vessels in the tongue.

Lymphatic drainage of the to ngue	Area	Lymph nodes
Marginal	Tipof the tongue	Bilateral submental nodes
Lateralmargin of the tongue	Unilateralsubmandibularnod es	
Central	Central part of the anterior 2/ 3rd of the tongue	Bilateraljugulodigastric and j ugulo-omohyoidnodes
Dorsal	Posterior 1/3rd of the tongue and circumvallate papillae	Bilateraljugulodigastricandju gulo-omohyoidnodes



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Solution to Question 9:

The given image shows carcinoma of the tongue involving the marginal part of the anterior 2/3rd of the tongue. Lymphatics from this region drain to unilateral submandibular lymph nodes.

All lymphatics from the tongue ultimately drain into deep cervical nodes along the internal jugular vein. Hence jugulo-omohyoid nodes are known as the lymph nodes of the tongue.

Solution to Question 10:

The given image shows a cleft palate. The sensory supply to the palate is not provided by the hypoglossal nerve. It is a pure motor nerve.

General sensation from most of the soft palate is carried by:

• Lesser palatine nerve (a branch of the maxillary nerve)

• Pharyngeal branches of the glossopharyngeal nerve

• Plexus around the tonsil (formed by tonsillar branches of the glossopharyngeal and lesser palatine nerves)

Taste sensation from the oral surface of the soft palate is carried by the lesser palatine nerve. The taste fibers initially travel in the greater petrosal nerve (a branch of the facial nerve) and pass through the pterygopalatine ganglion without synapsing.

All the muscles of the soft palate are supplied by the pharyngeal plexus (CN X), except for tensor veli palatini, which is supplied by the mandibular nerve.

The hard palate is supplied by the greater palatine and nasopalatine branches of the pterygopalatine ganglion.

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Solution to Question 11:

The sensory fibers from the taste buds in the hard and soft palate travel along the trigeminal nerve.

The taste sensation from taste buds in the oral surface of the soft palate is carried by the lesser palatine nerve.

The taste fibers initially travel in the greater petrosal nerve (a branch of the facial nerve) and pass through the pterygopalatine ganglion without synapsing.

Solution to Question 12:

The tonsillar branch of facial artery supplies the palatine tonsil and not the palate.

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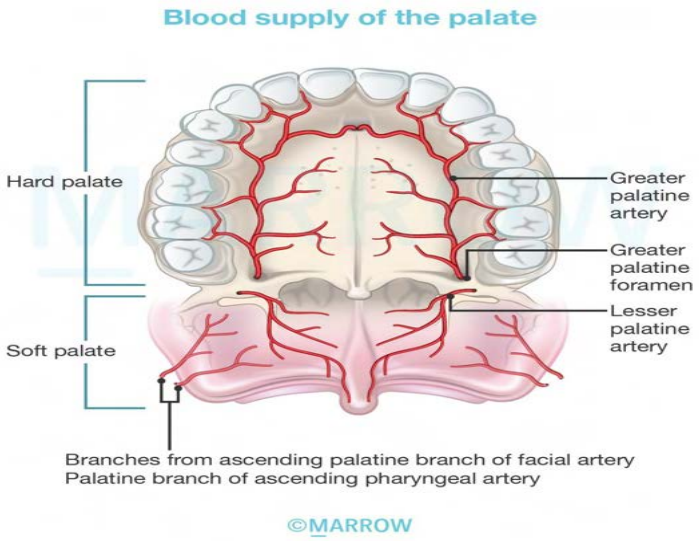
Blood supply of the palate:

• Hard palate - greater (descending) palatine artery which is a branch of the third part of the maxillary artery.

• Soft palate - ascending palatine branch of the facial artery, ascending pharyngeal artery, and lesser palatine arteries.



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Pharynx

Question 1:

At what vertebral level is the lower border of the pharynx?

a) C1

b) C2

c) C4

d) C6

Question 2:

You are an ENT resident performing endoscopy of the nasopharynx in a patient with suspected nasopharyngeal carcinoma. Which of the following structures would you not expect to find here?

a) Piriform fossa

b) Passavant's ridge

c) Opening of eustachian tube

d) Torus tubarius

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Question 3:

Which of the following structures forms the Passavant's ridge?

a) Levator veli palatini and superior constrictor

b) Palatopharyngeus and superior constrictor

c) Palatoglossus and middle constrictor

d) Palatoglossus and superior constrictor

Question 4:

A 9-year-old girl with pharyngitis complains of pain and blocked sensation in her right ear. Where does the involved structure open in the nasopharynx?

a) Behind middle turbinate

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b) Behind posterior end of inferior turbinate

c) Anterior to inferior turbinate

d) Between middle and inferior turbinate

Question 5:

The following image shows the oropharynx in a 16-year-old girl who came with complaints of a sore throat and fever. Which of the following structures will you not see in this region?

a) Palatopharyngeal folds

b) Palatine tonsils

c) Passavant's ridge

d) Palatoglossal folds

Question 6:

You are an ENT resident performing indirect laryngoscopy to visualize the hypopharynx in a patient with suspected glottic carcinoma. Which of the following structures will you not see here?

a) Piriform fossa

b) Post cricoid region

c) Valleculae

d) Posterior pharyngeal wall

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Question 7:

Where is the sinus of Morgagni present?

a) Between middle constrictor and inferior constrictor

b) Between superior constrictor and middle constrictor

c) Between skull and superior constrictor

d) Below inferior constrictor

Question 8:

A 46-year-old male presented with dysphagia and regurgitation. Barium swallow showed the following picture. Weakness of which of the following muscles predisposes to the given condition■?

a) Superior constrictor

b) Inferior constrictor

c) Middle constrictor

d) Palatopharyngeus

Question 9:

Which of the following muscles is not supplied by the pharyngeal plexus?

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a) Palatoglossus

b) Stylopharyngeus

c) Middle constrictor

d) Levator veli palatini

Answer Key

Question No.	Correct Option
1	d
2	a
3	b
4	b
5	c
6	c
7	c
8	b
9	b

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Detailed Explanations

Solution to Question 1:

The lower border of the pharynx is at the level of the sixth or seventh cervical vertebrae.

The pharynx extends from the cranial base to the lower border of the cricoid cartilage (at the level of the sixth or seventh cervical vertebra). It is divided into the nasopharynx, oropharynx, and laryngopharynx.

Solution to Question 2:

Piriform fossa is a structure present in the laryngopharynx and not the nasopharynx.

The nasopharynx is present above the soft palate and is made up of the roof, floor, posterior wall, and two lateral walls. Important structures seen in the nasopharynx are:

• Pharyngeal opening of the eustachian tube

• Torus tubarius- tubal elevation which is present behind the opening of the eustachian tube.

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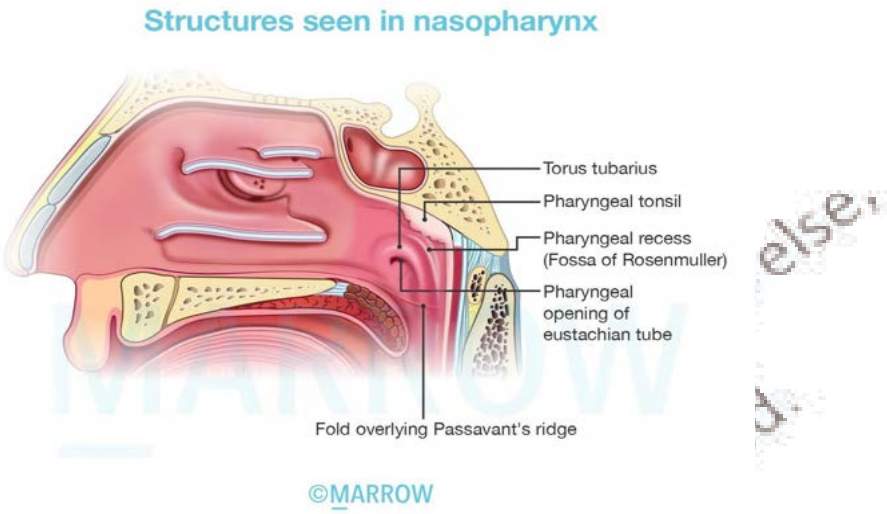
• Fossa of Rosenmuller- A lateral pharyngeal recess that is present behind the torus tubarius. It is the most common site for nasopharyngeal carcinoma

• Pharyngeal tonsil which is present in the roof and posterior wall

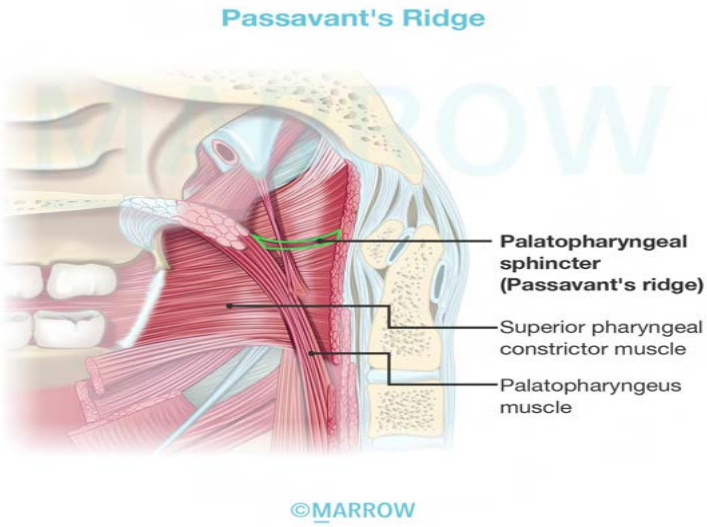
• Passavant's ridge.



Solution to Question 3:

Passavant's ridge is formed by palatopharyngeus and superior constrictor muscles.

Some fibers of the palatopharyngeus muscle pass deep to the mucous membrane of the pharynx and form an internal sphincter to the superior constrictor. These muscles contract and cause a ridge on the posterior wall of the nasopharynx which is known as Passavant's ridge.



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Solution to Question 4:

The given case scenario is suggestive of a middle ear infection i.e., otitis media as a complication of pharyngitis. This is due to the spread of the infection via the eustachian tube. It opens approximately behind the posterior end of the inferior turbinate, in the lateral wall of the nasopharynx.

The eustachian tube connects the nasopharynx and the tympanic cavity in the middle ear. It is usually collapsed and opens during activities such as yawning or swallowing. Its function is to maintain the pressure in the middle ear cavity and drain any secretions from the middle ear.

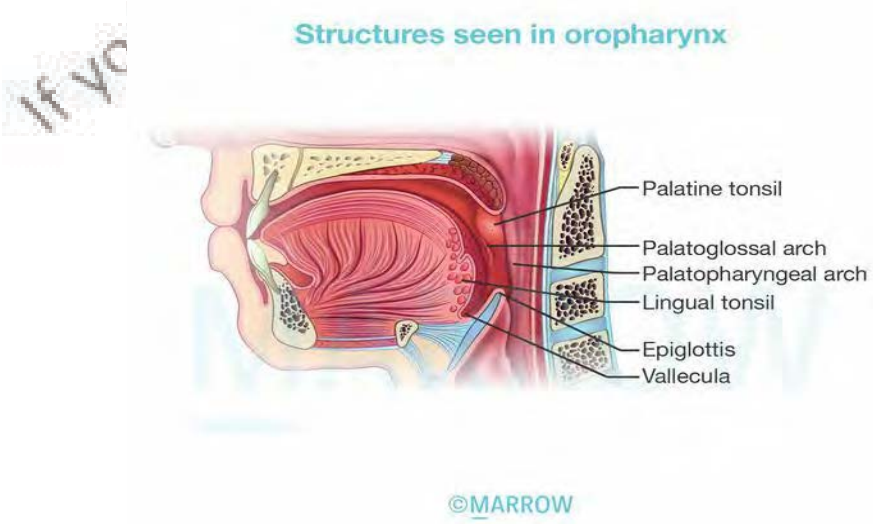
Solution to Question 5:

The given image shows purulent inflammation of the tonsils and the case scenario is suggestive of acute tonsillitis. Passavant's ridge is not seen in the oropharynx as it is present on the posterior wall of the nasopharynx.

The oropharynx extends from below the soft palate to the upper border of the epiglottis.

Structures seen in the oropharynx:

- Palatoglossal folds
- Palatopharyngeal folds
- Palatine tonsils - between the palatoglossal and palatopharyngeal folds
- Lingual tonsils
- Valleculae - mucosal pouches between the tongue and the epiglottis.



Solution to Question 6:

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Valleculae will not be seen here as they are a part of the oropharynx.

Hypopharynx/Laryngopharynx:

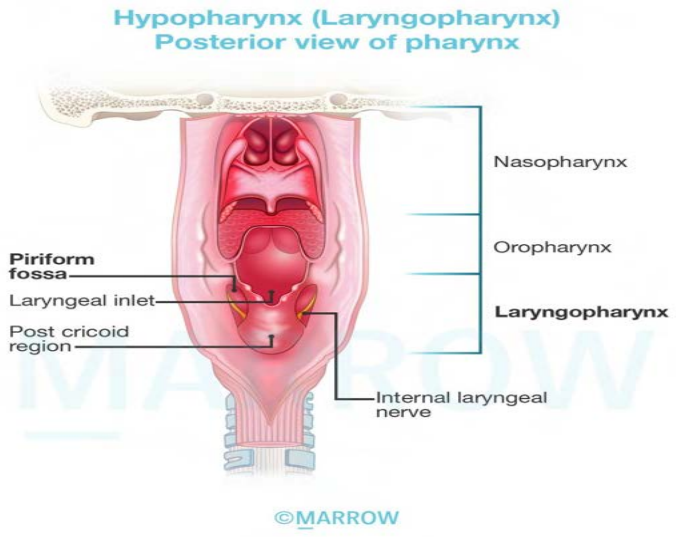
• It extends from the superior border of the epiglottis to the inferior border of the cricoid cartilage.

• It is separated from the oropharynx by the lateral glossoepiglottic folds.

• The anterior wall is made by the parts of the laryngeal inlet, and posterior surfaces of the arytenoid and cricoid cartilages.

Pyriform fossae are present between the aryepiglottic folds medially and thyroid cartilage, thyrohyoid membrane laterally. They serve as channels that direct the solid and liquid food from the oral cavity into the esophagus.

Clinical significance: Branches of the internal laryngeal nerve lie beneath the mucous membrane of the piriform fossa. Hence this site can be used for infiltrating the local anesthetics.



Solution to Question 7:

Sinus of Morgagni is a gap present between the base of the skull and the upper border of superior constrictor muscle.

Structures passing through the sinus of Morgagni are as follows:

• Palatine branch of ascending pharyngeal artery

• Ascending palatine artery

• Levator veli palatini muscle

• Eustachian tube

Note: Sinus of Morgagni syndrome/Trotter's triad is seen in nasopharyngeal carcinoma which spreads laterally to involve the sinus of Morgagni. It is characterized by:

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• Conductive hearing loss

• Ipsilateral immobility of the palate

• Neuralgic pain.

Solution to Question 8:

The given clinical scenario with a pulsion diverticulum on the barium swallow is suggestive of Zenker's diverticulum. It originates through Killian's dehiscence, which is a site of weakness present in the inferior constrictor muscle.

The inferior constrictor muscle is made up of 2 parts:

• Upper part - thyropharyngeus, made of oblique fibres.

• Lower part - cricopharyngeus, made of transverse fibres.

Between the two muscles, there is a potential gap which is called the pharyngeal dimple or Killian's dehiscence.

Another site of weakness in the pharyngeal wall is the Laimer's triangle, which is present between the cricopharyngeus and the longitudinal muscle of the oesophagus.

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Solution to Question 9:

Stylopharyngeus is not supplied by the pharyngeal plexus. It is supplied by the glossopharyngeal nerve.

The pharyngeal plexus is formed by the pharyngeal branches of the glossopharyngeal nerve and the vagus nerve with contributions from the superior cervical sympathetic ganglion. It supplies:

• All muscles of the soft palate

• Except tensor veli palatini - supplied by the mandibular nerve

• All the muscles of the pharynx

• Except stylopharyngeus - supplied by the glossopharyngeal nerve.

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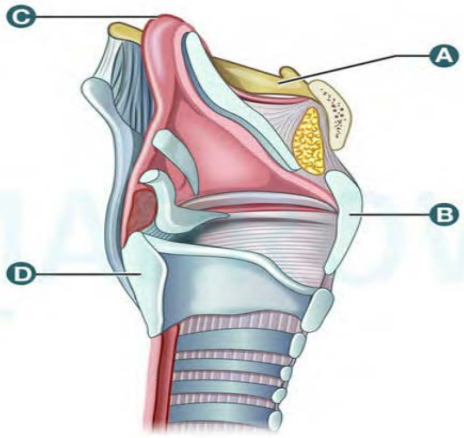
Larynx

Question 1:

Which of the following marked structures does not form part of the laryngeal skeleton?



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a) A

b) B

c) C

d) D

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Question 2:

Which of the following laryngeal cartilages is not paired?

a) Arytenoid

b) Corniculate

c) Cricoid

d) Cuneiform

Question 3:

Which of the following cartilages form a complete ring?

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a) Thyroid cartilage

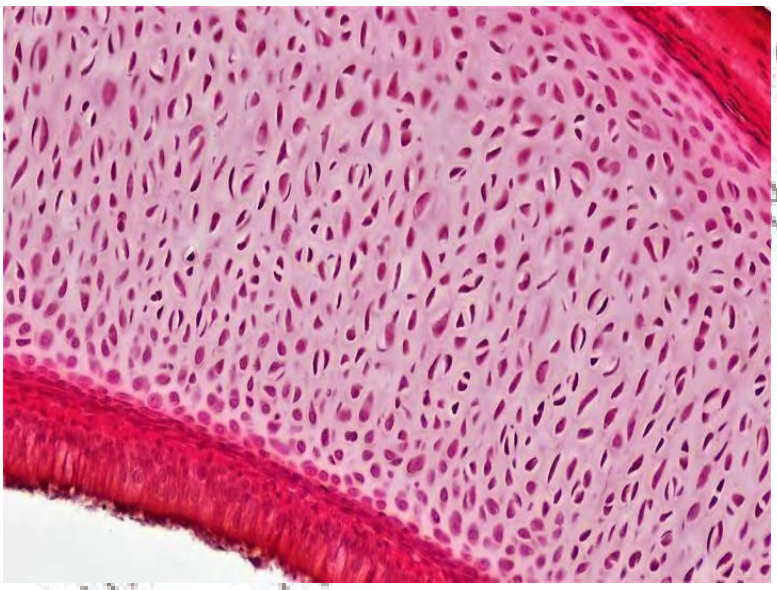
b) Cricoid cartilage

c) Cuneiform cartilage

d) Epiglottis

Question 4:

Which of the following will you not list as an example of this type of cartilage?



a) Cricoid

b) Thyroid

c) Base of arytenoid

d) Apex of arytenoid

Question 5:

All of the following ligaments are components of the external laryngeal membrane except _____.

a) Cricothyroid

b) Thyrohyoid

c) Cricotracheal

d) Hyoepiglottic

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Question 6:

Which of the following statement is true regarding the laryngeal cavity?

a) Laryngeal ventricle is between laryngeal inlet and vestibular folds

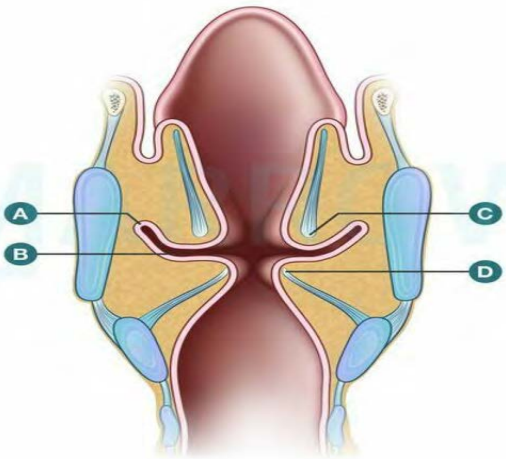
b) Vocal cords are lined by pseudostratified ciliated columnar epithelium

c) Rima glottidis is present between the vocal folds

d) Ventricle is a pouch from the anterior end of the saccule

Question 7:

A trumpet player presented with hoarseness of voice, cough, and a reducible neck swelling. The neck swelling increases in size on performing the Valsalva maneuver. Which of the following regions would you expect to find a defect in?



a) C

b) D

c) A

d) B

Question 8:

You are an ENT resident consulting on a famous metal singer, who presented with complaints of hoarseness of voice. You perform laryngoscopy and ask him to phonate. You notice that he is using his false vocal cords to generate a classic 'death growl'. Which of the following

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structures form the ligament enclosed in these vocal cords?

a) Upper free margin of cricothyroid ligament

b) Lower free margin of quadrangular membrane

c) Upper free margin of quadrangular membrane

d) Upper free margin of conus elasticus

Question 9:

Which among the following is a tensor of vocal cords?

a) Cricothyroid

b) Lateral cricoarytenoid

c) Thyroarytenoids

d) Posterior cricoarytenoids

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Question 10:

On direct laryngoscopy, you observe the following structures. Which of the following statements is incorrect about the muscles acting on it?

a) Thyroarytenoid causes abduction

b) Lateral cricoarytenoid causes adduction

c) Posterior cricoarytenoid causes abduction

d) Cricothyroid is a tensor

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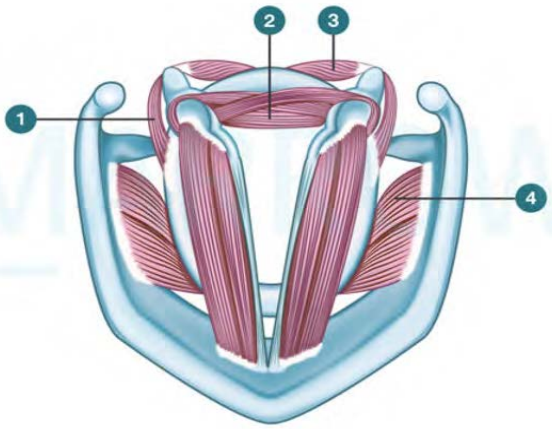
Question 11:

A patient with bronchogenic carcinoma presents to your OPD complaining of hoarseness of voice. On laryngoscopy, you ask him to phonate and notice that the left vocal cord does not abduct. Which of the following muscles is involved?



©MARROW

a) 1

b) 2

c) 3

d) 4

Question 12:

Which of the following statements is correct about the sensory innervation of the larynx?

a) Above the level of vocal cords - Superior laryngeal nerve

b) Above the level of vocal cords - Recurrent laryngeal nerve

c) Below the level of vocal cords - Internal laryngeal nerve

d) Below the level of vocal cords - External laryngeal nerve

Question 13:

Which among the following is false about larynx?

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a) 9 cartilages: 3 paired, 3 unpaired

b) Extends from C3-C6 vertebrae

c) External laryngeal nerve supplies all larynx muscles except cricothyroid

d) Cricothyroid is a tensor of vocal cord

Question 14:

While performing total thyroidectomy, a nerve coursing along the superior thyroid artery is injured. Which of the following is a probable consequence?

a) Loss of sensation above the vocal cords

b) Loss of sensation below the vocal cords

c) Paralysis of lateral cricoarytenoid muscle

d) Paralysis of cricothyroid muscle

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Question 15:

A surgeon is performing a thyroidectomy for a patient with a multinodular goiter. Damage to which structure is most likely to cause vocal cord paralysis?

a) Recurrent laryngeal nerve

b) External laryngeal nerve

c) Internal laryngeal nerve

d) Superior laryngeal nerve

Question 16:

A chronic smoker presented with a supraglottic growth, which was later found to be squamous cell carcinoma. How will this spread to the pre-epiglottic space?

a) Lymphatic spread

b) Perforations in the epiglottis

c) Hematogeneous spread

d) Through the para-glottic space

Question 17:

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All of the following statements are true except:

a) Vagus nerve emerges via the intermediate compartment of jugular foramen

b) Galen's anastomosis refers to anastomosis between the internal laryngeal nerve and recurrent laryngeal nerve

c) Internal laryngeal nerve is accompanied by superior thyroid vessels

d) Right reccurent laryngeal nerve winds around the 1st part of subclavian artery

Answer Key

Question No.	Correct Option
1	a
2	c
3	b
4	d
5	a
6	c
7	c
8	b
9	a
10	a
11	c
12	a
13	c
14	d
15	a
16	b
17	c

Detailed Explanations

Solution to Question 1:

The structure marked as 'A', is the hyoid bone, which is not a part of the laryngeal skeleton.

The structures marked in the image are:

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• Hyoid bone

• Thyroid cartilage

• Epiglottis

• Cricoid cartilage

The laryngeal skeleton is formed by a series of cartilages that are connected by ligaments and fibrous membranes:

• The thyroid, cricoid, and the greater part of the arytenoid cartilages consist of hyaline cartilage.

• The corniculate, cuneiform, tritiate, and epiglottic cartilages and the apices of the arytenoid cartilage consist of elastic cartilage.

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Solution to Question 2:

Cricoid is not a paired cartilage.

Solution to Question 3:

Cricoid cartilage forms a complete ring around the airway and this is the only laryngeal cartilage to do so.

Clinical significance:

• Sellick's maneuver - Cricoid pressure is applied to occlude the esophagus without occluding the airway. It prevents regurgitation of gastric contents during intubation and rapid induction of anesthesia.

• The cricoid cartilage is the narrowest part of the pediatric airway.

Solution to Question 4:

The given image shows the histology of hyaline cartilage. Apex of arytenoid is made up of elastic cartilage, not hyaline cartilage.

Solution to Question 5:

Cricothyroid is the component of the intrinsic laryngeal membrane of the larynx.

The cricothyroid ligament is present between the cricoid and thyroid cartilage of the larynx. It consists of three parts: the right and the left lateral parts and the thickened median portion. The lateral parts are called conus elasticus and the median thickened part is called the median or the anterior cricothyroid ligament.

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The extrinsic ligaments and membranes of the larynx are:

• Thyrohyoid membrane

• Hyoepiglottic ligament

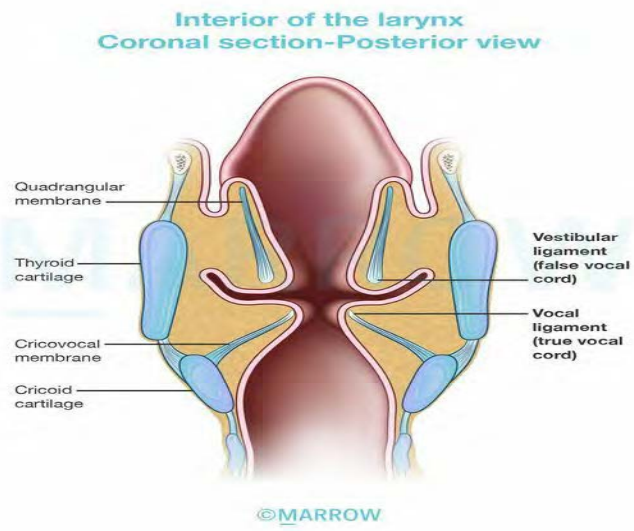
• Cricotracheal ligament

The intrinsic ligaments and membranes of the larynx are:

• Quadrangular membrane - present between the epiglottis and the arytenoid cartilage

• Cricothyroid membrane

• Thyroepiglottic ligament.



Solution to Question 6:

Rima glottidis is present between the vocal folds of the larynx.

The cavity of the larynx can be divided into upper, middle, and lower parts.

Upper part:

• It extends from the laryngeal inlet to the vestibular folds.

• The laryngeal inlet is made of the upper edge of the epiglottis, aryepiglottic fold, arytenoids, and posterior commissure.

• The vestibule is the region between the laryngeal inlet and the vestibular folds.

Middle part:

• It extends from rima vestibuli to the rima glottidis.

• Rima vestibuli is the aperture between the two vestibular folds.

• Rima glottidis is the aperture between the two vocal folds.

• Ventricle is the space bounded by rima vestibuli above and rima glottidis below.

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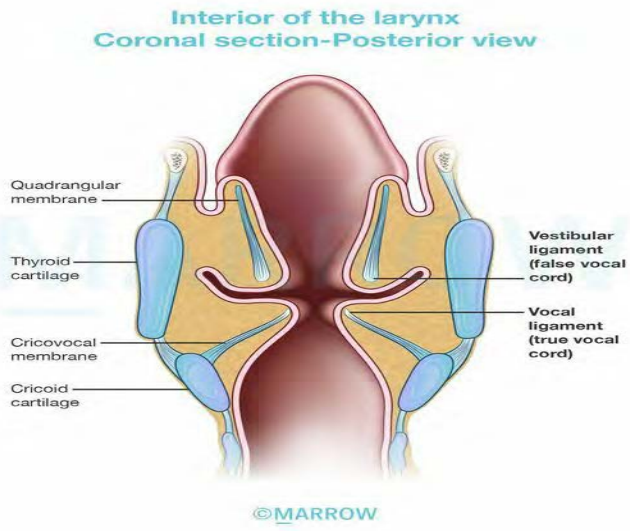
• Saccule is a pouch from the anterior end of the ventricle. It contains mucous glands.

Lower part:

• The lower part is also called the infraglottic cavity or subglottic cavity and extends from the vocal cords to the lower border of the cricoid cartilage.



The larynx is covered by the pseudostratified ciliated columnar epithelium except at three sites where it is covered by non-keratinized stratified squamous epithelium. These are:

• Vocal folds

• Lingual surface of epiglottis

• Upper part of aryepiglottic folds

Solution to Question 7:

The given case scenario is suggestive of laryngocele. The defect is present in the saccule, represented by the area marked A in the above diagram.

The structures marked are:

B. Ventricle

C. Vestibular ligament

D. Vocal ligament

The saccule is a pouch that ascends forwards from the anterior end of the ventricle, between the vestibular fold and thyroid cartilage.

It is conical in shape and contains around 60 and 70 mucous glands, sited in the submucosa.

It is separated from the thyroid cartilage by the thyroepiglotticus muscle which compresses the saccule. On compression, the secretions of the saccule are released into the vocal cords (which lack mucous glands) to lubricate and protect them from desiccation and infection.

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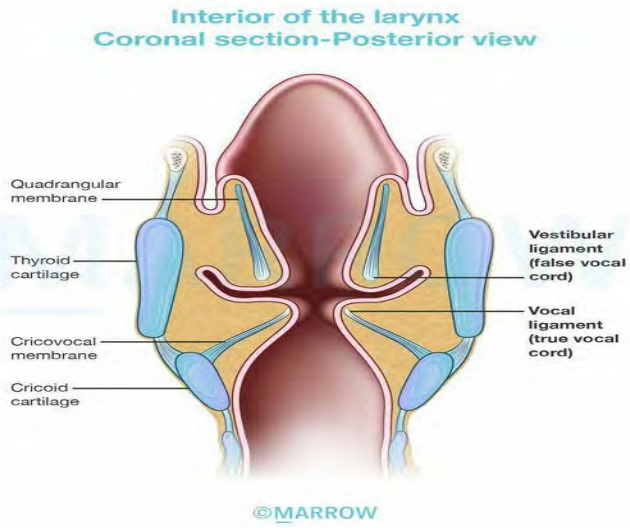
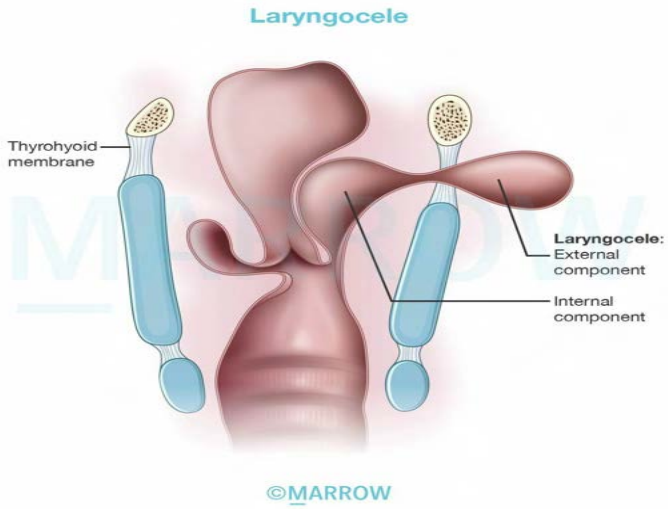


Clinical significance:

Laryngocele is an air-filled cystic swelling due to dilatation of the saccule. It is seen in trumpet players, glass-blowers, or weight lifters due to raised trans-glottic air pressure. It can be internal, external, or combined.

External laryngocele presents as a reducible swelling in the neck which increases in size on coughing or performing Valsalva maneuver.

Internal laryngocele is managed by marsupialization and surgical excision through an external neck incision done for external laryngocele.



Solution to Question 8:

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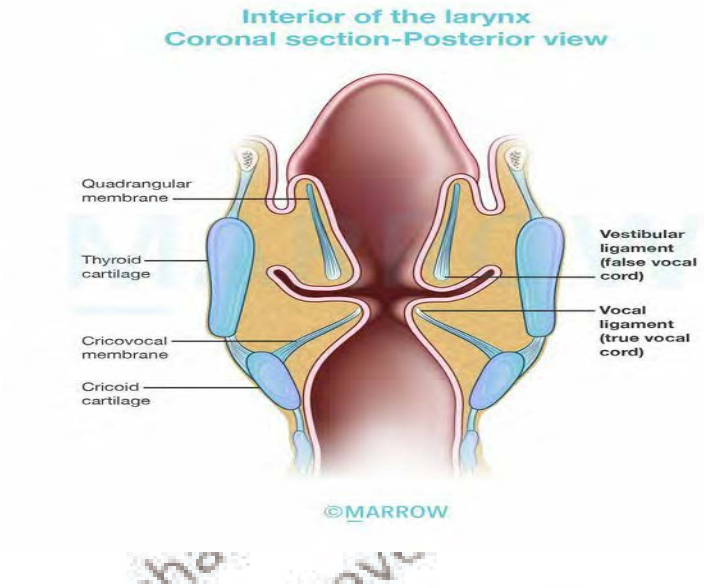
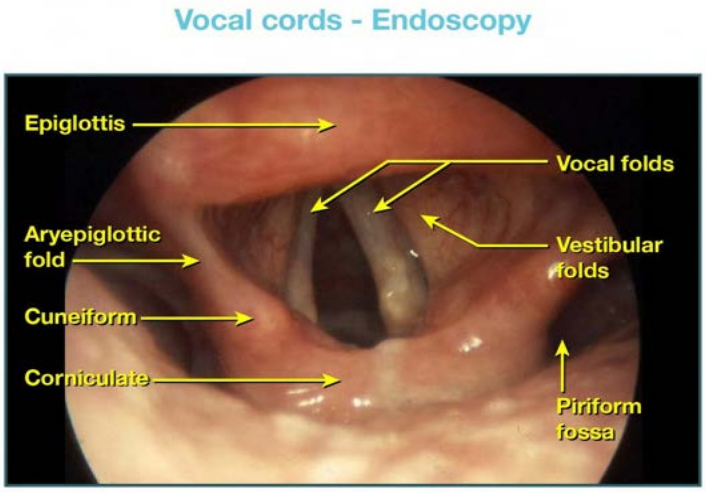
The vestibular ligament is enclosed within the false vocal cords. The lower free margin of the quadrangular membrane is thickened to form the vestibular ligament.

False vocal cords: These are formed by the vestibular folds. They contain the vestibular ligament, a few fibers of thyroarytenoideus muscle, and mucous glands.

True vocal cords: They extend from the middle of the thyroid angle to the vocal processes of arytenoids. They contain the vocal ligament and subepithelial connective tissue.

The upper free margin of the cricovocal ligament/cricothyroid membrane/conus elasticus is thickened to form the vocal ligament.





Solution to Question 9:

Cricothyroid is a tensor of vocal cords.

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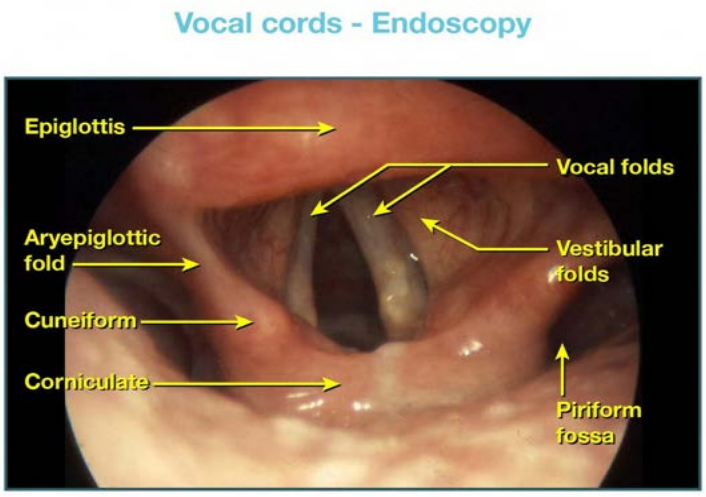
Solution to Question 10:

The given image shows an endoscopic view of the vocal cords.

Thyroarytenoid muscles cause relaxation of the vocal cords and closure of the rima glottidis.



Solution to Question 11:

The given case scenario is of unilateral vocal cord palsy secondary to bronchogenic carcinoma. The posterior cricoarytenoids are involved here (marked as 3), as they are paralyzed since the tumor invades unilateral recurrent laryngeal nerve.

Other structures:

1. Lateral cricoarytenoid muscle - closes the ligamentous part of rima glottidis

2. Transverse arytenoid muscle - closes the inter cartilaginous part of the rima glottidis

4. Cricothyroid muscle - it is a tensor of the vocal cord.

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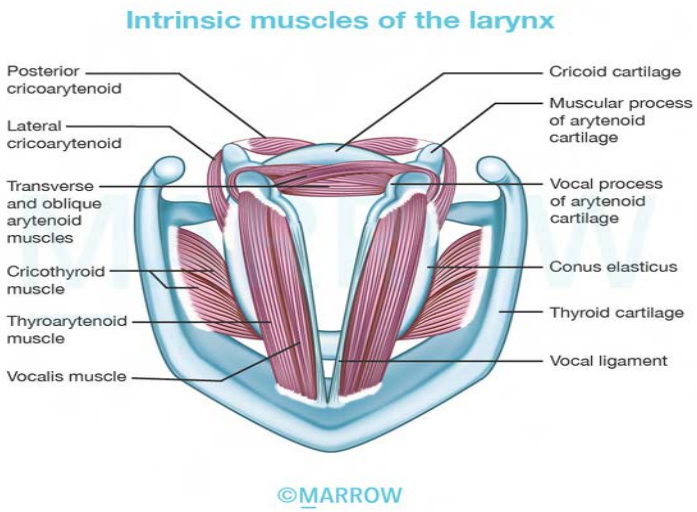

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Solution to Question 12:

The nerve supply of larynx above the level of vocal cords is by internal laryngeal nerve which is a branch of the superior laryngeal nerve.

• Sensory innervation of the larynx above the level of vocal cords is by the internal laryngeal nerve.

• Sensory innervation of the larynx below the level of vocal cords is by the recurrent laryngeal nerve.

• At the level of vocal cords, it is supplied both by the internal laryngeal and recurrent laryngeal nerves.

All the intrinsic muscles of the larynx are supplied by the recurrent laryngeal nerve except for cricothyroid, which is supplied by the external laryngeal nerve.

Solution to Question 13:

The external laryngeal nerve supplies the cricothyroid muscle. All other intrinsic muscles of the larynx are supplied by the recurrent laryngeal nerve.

The larynx contains three paired cartilages (arytenoid, corniculate, cuneiform) and three unpaired cartilages (epiglottis, thyroid, and cricoid).

Sometimes the triticeal cartilage (TC) may be present. This is a small, oval-shaped cartilage found within the lateral border of the thyrohyoid membrane between the greater horn of the hyoid bone and the superior horn of the thyroid cartilage (SHTC). The TC is not a constant structure; it may be present unilaterally, bilaterally, or absent.

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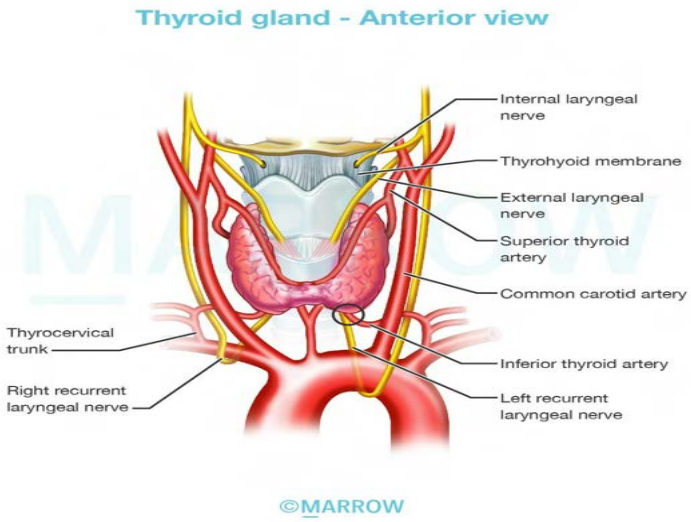
Solution to Question 14:

The nerve which is closely related to the course of the superior thyroid artery is the external laryngeal nerve. Injury to this nerve causes paralysis of the cricothyroid muscle. It is the main tensor of the vocal cord and paralysis of this muscle leads to the decreased pitch of voice.

The internal laryngeal nerve pierces the thyrohyoid membrane at a higher level than the superior thyroid artery. Hence this nerve is not injured and the sensation above the level of vocal cords is preserved.

Except for the cricothyroid, other intrinsic muscles of the larynx are supplied by the recurrent laryngeal nerve. Hence they are not paralyzed in the above clinical scenario.



Solution to Question 15:

Injury to the recurrent laryngeal nerve will cause vocal cord paralysis.

All the intrinsic muscles of the larynx except for the cricothyroid are supplied by the recurrent laryngeal nerve. Cricothyroid is supplied by the external laryngeal nerve which is a branch of the superior laryngeal nerve.

Since most of the laryngeal muscles are supplied by the recurrent laryngeal nerve, the most appropriate answer would be recurrent laryngeal nerve.

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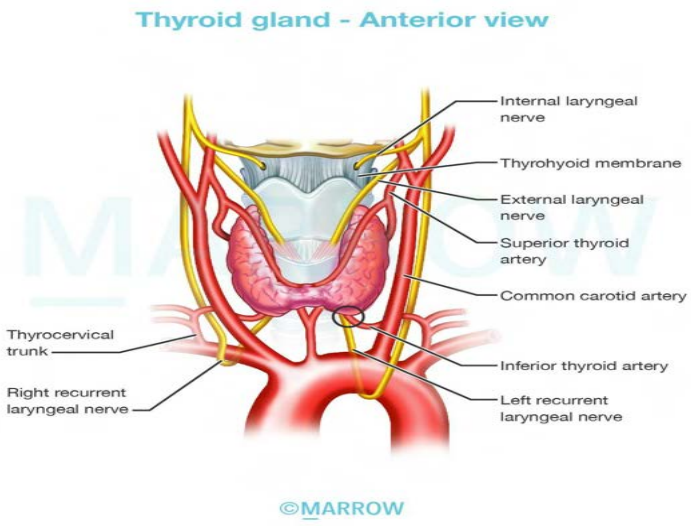

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Solution to Question 16:

Supraglottic tumors spread to the pre-epiglottic space via the perforations in the epiglottic cartilage.

Pre-epiglottic space: It lies anterior to the epiglottis. Its relations are as follows:

• Superior - Hyoepiglottic membrane median hyoepiglottic ligament

• Inferior - Thyroepiglottic ligament

• Anterior - Thyrohyoid membrane and median thyrohyoid ligament

• Posterior - Epiglottis

• Lateral - Greater cornua of the hyoid bone in the upper part, continuous with the paraglottic space in the lower part.

The laryngeal tumors can spread to the pre-epiglottic space through the multiple perforations present in the epiglottis.

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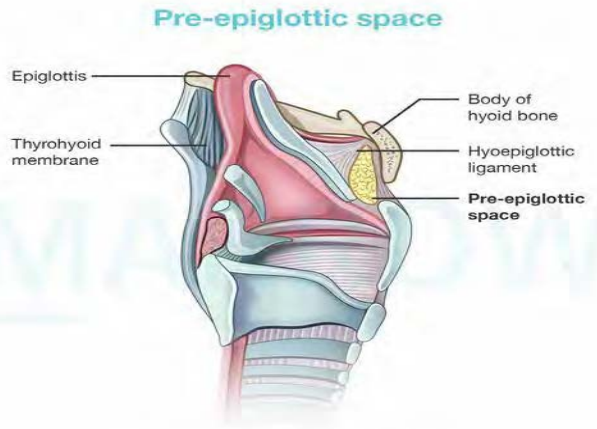
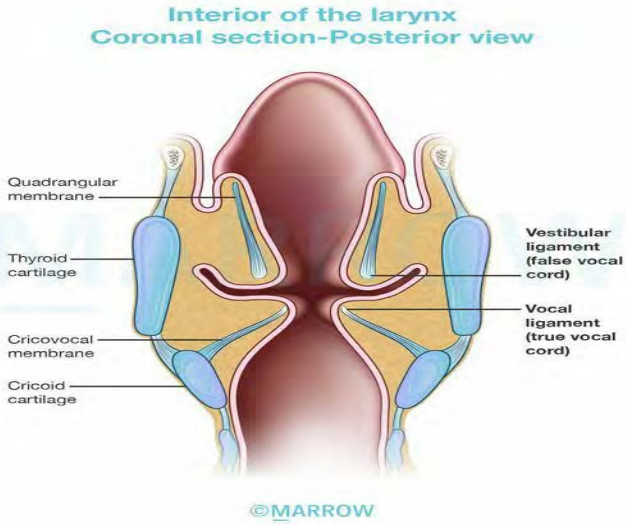


Para-glottic space: This space contains the laryngeal nerve. Its relations are:

- Superior - Para-glottic space is continuous with the pre-epiglottic space.
- Inferior- Cricothyroid joint
- Posterior- Piriform fossa
- Lateral - Thyroid cartilage and thyrohyoid membrane
- Medial- Quadrangular membrane in the upper part and conus elasticus in the lower part.



Solution to Question 17:

The internal laryngeal nerve is accompanied by the superior laryngeal vessels, not the superior thyroid vessels. Along with superior laryngeal vessels, it pierces the thyrohyoid membrane.

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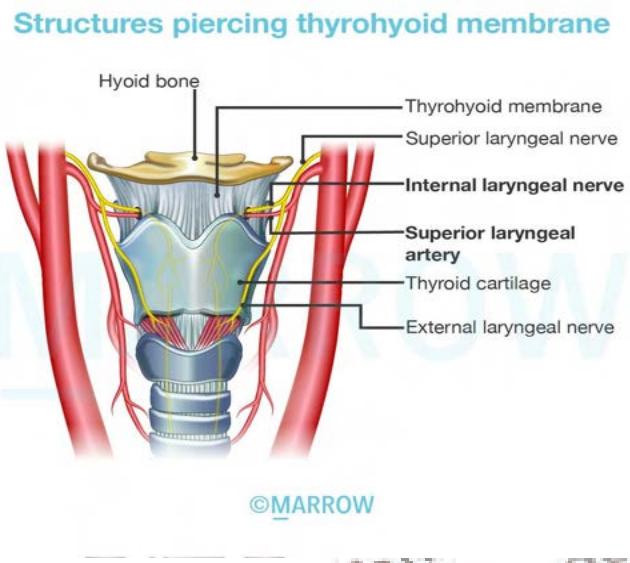

The vagus nerve arises as several rootlets from the medulla which unite to form a single nerve and emerges via the intermediate compartment of the jugular foramen.

Galen's anastomosis is the connecting branch between the inferior laryngeal nerve (a branch of the recurrent laryngeal nerve) and the internal laryngeal nerve (a branch of the superior laryngeal nerve).

Right recurrent laryngeal nerve winds around the lower and posterior part of 1st part of the right subclavian artery and left recurrent laryngeal nerve winds around the arch of the aorta.

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Upper Limb Bones and Joints

Question 1:

Which is the first bone to ossify in the human body?

a) Humerus

b) Clavicle

c) Scapula

d) Lunate

Question 2:

Which of the following is false about clavicle?

a) Ossify partly in membrane and partly in cartilage

b) Transmits part of the weight of upper limb to the axial skeleton

c) It is subcutaneous throughout its length

d) Fractures typically occur at the junction of medial 1/3rd and lateral 2/3rd

Question 3:

Which ligament transmits the weight of the upper limb to the axial skeleton?

a) 1,3 and 5

b) 1 and 3 only

c) 2 and 3 only

d) 2, 4 and 5

Question 4:

In a patient with a coracoid fracture, the action of which of the following muscle is not hindered?

a) Coracobrachialis

b) Short head of biceps

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c) Pectoralis minor

d) Long head of triceps

Question 5:

A 16-year-old athlete was diagnosed with an isolated avulsion fracture of the lesser tubercle of the humerus. The forceful contraction of which of the following muscles■ causes this fracture?

a) Teres minor

b) Subscapularis

c) Supraspinatus

d) Infraspinatus

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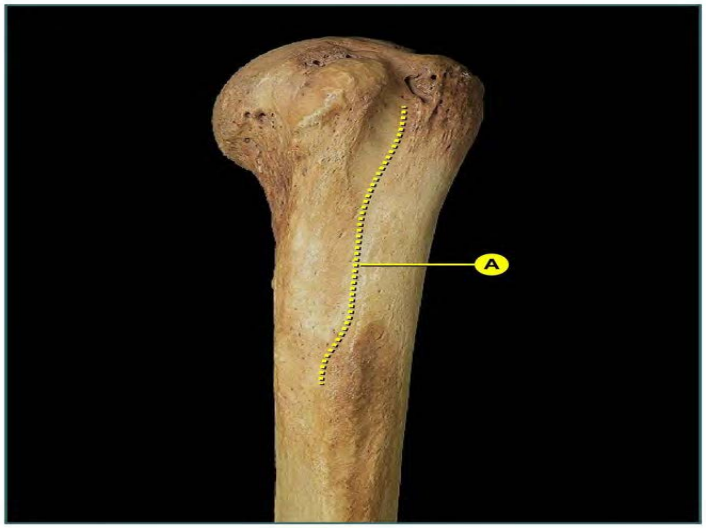
Question 6:

Which muscle is attached to the floor of the structure marked A?



a) Latissimus dorsi

b) Teres major

c) Long head of biceps

d) Pectoralis major

Question 7:

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Which of the following types of joints is incorrectly matched?

a) Acromioclavicular joint – Plane synovial joint

b) Wrist joint - Condyloid joint

c) Sternoclavicular joint – Hinge joint

d) Intercarpal and midcarpal joint – Plane synovial joint

Question 8:

A 25-year-old man comes with sudden pain in his right shoulder. He complains that he is not able to move his right arm. After evaluation, a diagnosis of shoulder dislocation was made. Which of the following statements is false regarding this joint?

a) The glenohumeral joint is the most frequently dislocated joint in the body

b) As mobility of the joint increases, stability also increases

c) The shoulder joint dislocation is rare in children

d) Anterior dislocation is more common than a posterior dislocation

Question 9:

A 17-year-old boy presented with instability of the shoulder joint following sports trauma. Injury to all of the following structures may cause this condition except:

a) Teres major

b) Supraspinatus

c) Tendon of long head of biceps

d) Coracoacromial ligament

Question 10:

In a patient with shoulder dislocation, which of the following muscle action is not hindered?

a) Teres major

b) Pectoralis minor

c) Subscapularis

d) Deltoid

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Question 11:

Which movement range is increased at the glenohumeral joint due to the lateral rotation of the humerus?

a) Adduction

b) Abduction

c) Flexion

d) Extension

Question 12:

A normal scapulohumeral rhythm is in the ratio of _____

a) 1:1

b) 1:2

c) 2:1

d) 3:1

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Question 13:

Which of the following structure is intracapsular?

a) Short head of biceps brachii

b) Medial head of triceps brachii

c) Long head of triceps brachii

d) Long head of biceps brachii

Question 14:

Which of the following muscles form the border of rotator interval?

a) Supraspinatus and subscapularis

b) Supraspinatus and infraspinatus

c) Infraspinatus and teres minor

d) Teres minor and subscapularis

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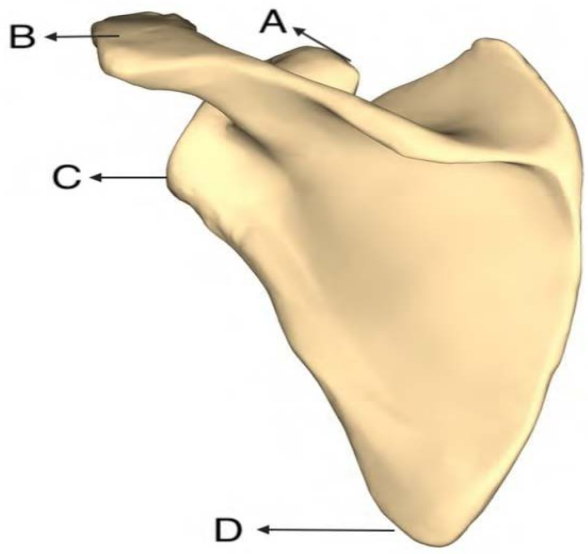
Question 15:

Which of the following structures of the scapula is palpable in the infraclavicular fossa?



a) A

b) B

c) C

d) D

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Question 16:

Movements of pronation and supination occurs in all of the following joints except:

a) Superior radioulnar joint

b) Wrist joint

c) Inferior radioulnar joint

d) Humeroradial joint

Question 17:

During an intracapsular arthroscopy, which of the following structure cannot be seen?

a) Coronoid fossa

b) Radial fossa

c) Olecranon fossa

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d) Lateral epicondyle

Question 18:

What is the normal approximate carrying angle?

a) 0 deg

b) 20 deg

c) 17 deg

d) 23 deg

Question 19:

The middle radioulnar joint is an example of a:

a) Plane synovial

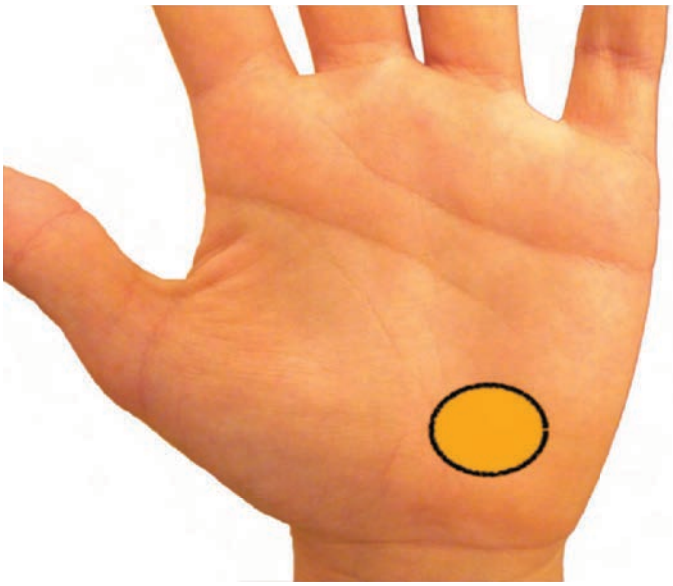
b) Primary cartilaginous

c) Secondary cartilaginous

d) Fibrous joint

Question 20:

A golfer hurt himself after he accidentally hit the ground while taking a shot. He has tenderness in the area shown in the image below. On examination, he has pain radiating to his ring and little finger. Which of the following bones is most likely to be fractured?



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a) Triquetrum

b) Pisiform

c) Hook of Hamate

d) Trapezoid

Question 21:

A child falls from his bicycle and injures his hand. On X-ray, a fracture of the first metacarpal bone is noticed. Where is the epiphysis of the affected bone?

a) At the base

b) At the neck

c) At the head

d) In the shaft

Question 22:

All of the following take part in the formation of the wrist joint, except:

a) Scaphoid

b) Triquetrum

c) Distal end of radius

d) Distal end of ulna

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Answer Key

Question No.	Correct Option
1	b
2	d
3	a
4	d
5	b
6	a
7	c

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8	b
9	a
10	b
11	b
12	c
13	d
14	a
15	a
16	b
17	d
18	c
19	d
20	c
21	a
22	d

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Detailed Explanations

Solution to Question 1:

The clavicle is the first bone to ossify in the human body. It occurs by the 5th- 6th weeks of intrauterine life.

The clavicle is a band of condensed mesenchyme in the early embryonic phase.

At the terminal ends of this band, early cartilage transformation (pre-cartilage) takes place. Intramembranous centers of ossification appear and fuse in the mesenchyme between them. Hence, it ossifies partly in the membrane and partly in cartilage.

Solution to Question 2:

Fractures of the clavicle typically occur at the junction of the medial 3/5 th and lateral 2/5 th.

Middle-third or midshaft region of the clavicle is the most common site for a fracture, especially the junction of medial 3/5 th and lateral 2/5 th.

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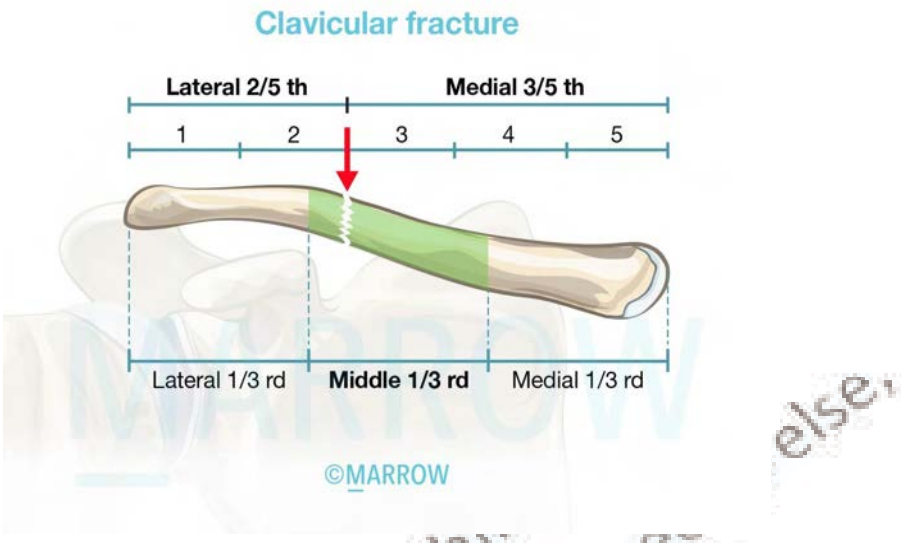

It is the junction where the 2 primary ossification centers meet. It is also where the transition from antecurve to retro curve begins and is prone to be at high risk for fractures.

The fracture causes the upward displacement of the proximal fragment (sternocleidomastoid) and downward displacement of the distal fragment (pectoralis major and gravity).

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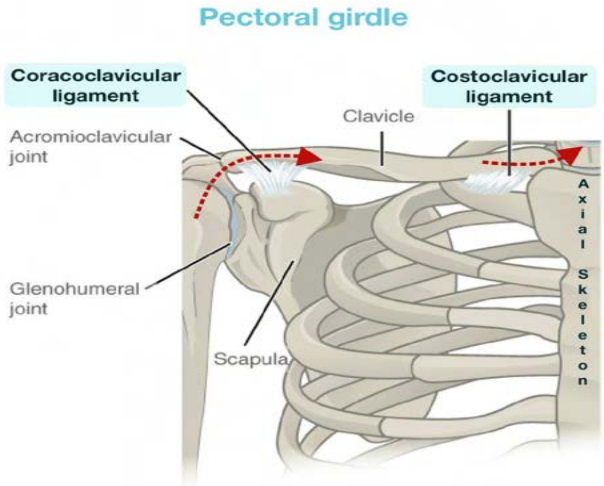
Solution to Question 3:

The weight of the upper limb is transmitted to the axial skeleton by coracoclavicular and costoclavicular ligament.

The weight of the upper limb is transmitted as follows:

Upper limb ⇒ coracoclavicular ligament ⇒ clavicle ⇒ costoclavicular ligament ⇒ axial skeleton (sternum and 1st rib) Manubrium sterni ⇒ Sternoclavicular ligament ⇒ clavicle.



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Note:

• Costoclavicular ligament: Transmits weight of the upper limb to the axial skeleton via the clavicle.

• Coracoclavicular ligament: Transmits weight of the upper limb to the clavicle.

• Sternoclavicular ligament : Transmits weight of the upper limb to axial skeleton via clavicle (inferomedially)

Solution to Question 4:

In a patient with a coracoid fracture, the action of the long head of triceps muscle is not hindered. It attaches to the infraglenoid tubercle on the lateral border of the scapula and not the coracoid process.

Coracoid process attachements:

• Origin: 2 muscles - Coracobrachialis (medially) and short head of biceps (laterally)

• Insertion: 1 muscle - Pectoralis minor

• 3 ligaments:

• Coracoacromial

• Coracoclavicular

• Coracohumeral

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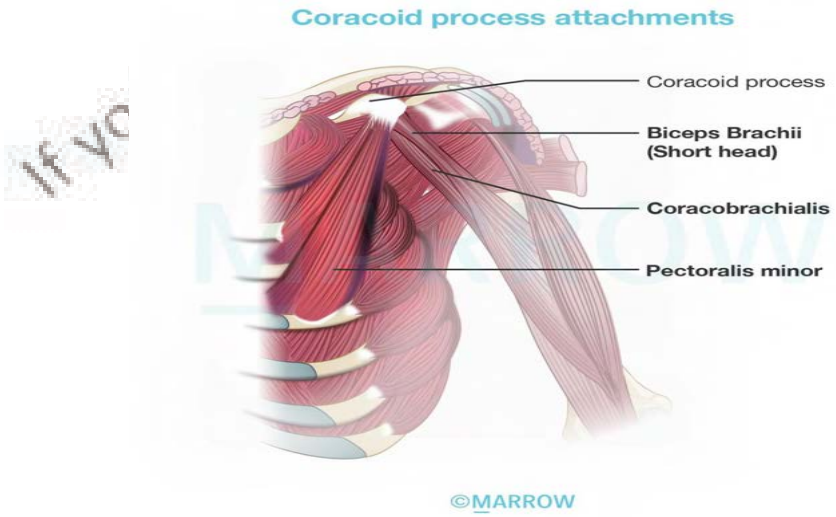

Solution to Question 5:

In the given scenario, forceful contraction of the subscapularis muscle has caused the isolated avulsion fracture of the lesser tubercle of the humerus.

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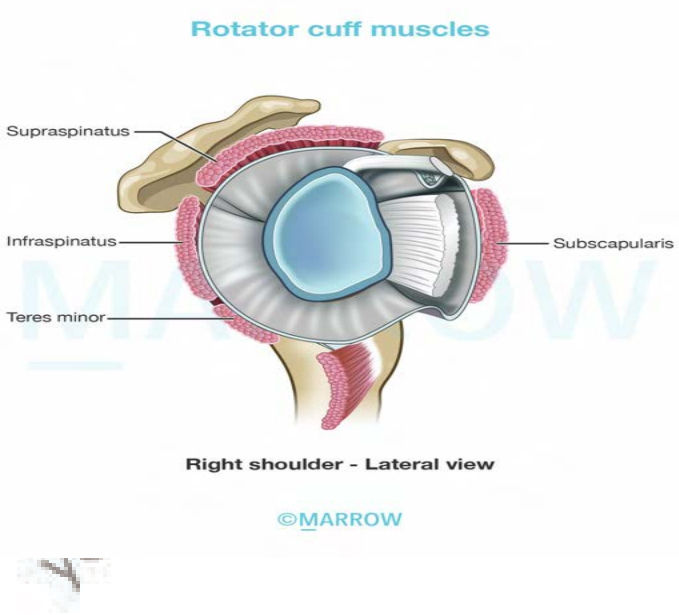
The subscapularis muscle is inserted on the lesser tubercle of the humerus. Forceful contraction of subscapularis muscle to resist the abduction and external rotation of the shoulder may cause the isolated avulsion fracture of the lesser tubercle.

Rotator cuff muscles

Muscle	Insertion
S: Supraspinatus	Greater tubercle
I: Infraspinatus	
T: Teres Minor	
S: Subscapularis	Lesser tubercle



Solution to Question 6:

The structure marked A is the intertubercular sulcus (bicipital groove) and the latissimus dorsi is attached to its floor.

The intertubercular sulcus (bicipital groove) lies between the greater and lesser tubercles.

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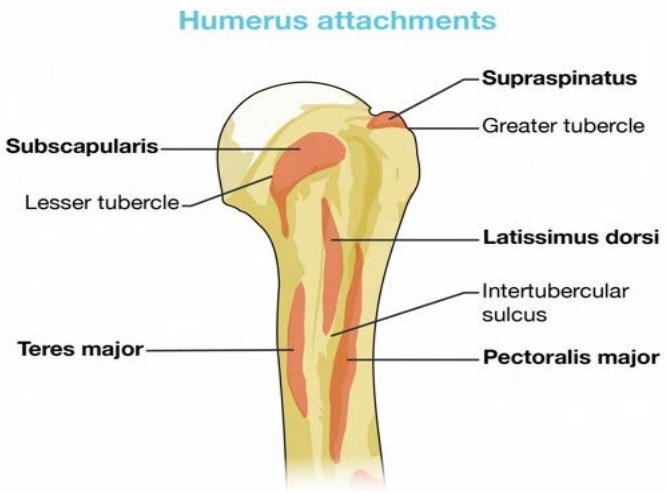

The attachments of bicipital groove are as follows:

• Lateral lip: Pectoralis major

• Medial lip: Teres major

• Floor: Latissimus dorsi

The contents of the sulcus are as follows:

• Long head of the biceps

• ascending branch from the anterior circumflex humeral artery

MEMORY TIP:

Remember 'Lady between two majors': The lady (latissimsus dorsi), in the intertubercular sulcus, lies between the pectoralis major laterally, and teres major medially.

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Solution to Question 7:

The sternoclavicular joint is a synovial sellar (saddle, or hyperbolic paraboloid) joint, and not a hinge joint.

It is the only skeletal articulation between the upper limb and the axial skeleton.

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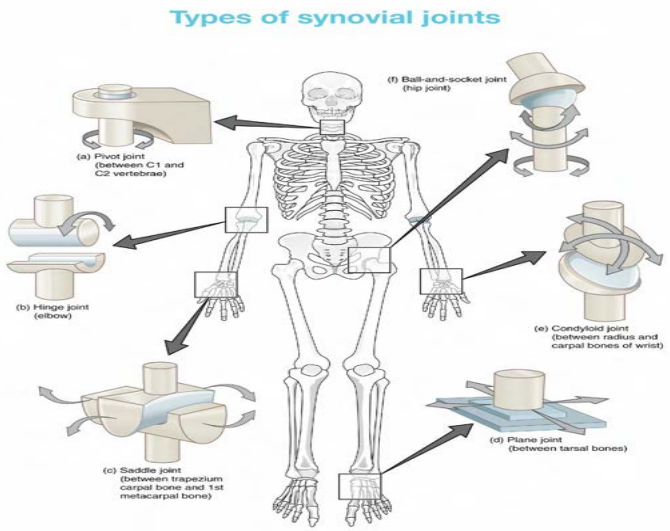

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Solution to Question 8:

As mobility increases, stability is lost in a joint. The glenohumeral joint is the most mobile joint in the body and is very unstable.

The glenohumeral joint is the most frequently dislocated joint in the body. The shoulder dislocation occurs more commonly in adults and is rare in children. Anterior dislocation is much more common than a posterior dislocation.

Solution to Question 9:

Teres major has no role in maintaining the stability of the shoulder joint.

The shoulder joint is a ball and socket joint. Since the head of the humerus is larger than the glenoid cavity, it is often prone to displacement. However, the stability of the shoulder joint is provided by the following:

• Rotator cuff: It is formed by blending of tendons of 4 muscles (SITS)-

• Supraspinatus

• Infraspinatus

• Teres minor

• Subscapularis

• Tendon of the long head of biceps: It passes over the head of the humerus and prevents upward displacement.

• Coracoacromial ligament

Degeneration or tear of the above structures leads to instability of the shoulder joint.

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The shoulder joint is least protected inferiorly. The capsule is loose and only one muscle crosses the joint inferiorly, i.e. long head of triceps.

Solution to Question 10:

Pectoralis minor has no action at the shoulder joint.

Its origin is from 3,4,5 ribs near the costochondral junction and inserts at the medial border and the upper surface of the coracoid process. The pectoralis minor is an accessory muscle of inspiration, which stabilizes the scapula by pulling it anteriorly and inferiorly.

Movements at the shoulder joint:

Movement	Prime Movers	Synergists
Flexion	Pectoralis majorDeltoid	Coracobracialis
Extension	Deltoid (Spinal part)	Teres majorLatissmus dorsiTriceps brachii (Long head)
Abduction	Deltoid	Supraspinatus
Adduction	Pectoralis majorLatissmus dorsi	Teres majorTriceps brachii (Long head)
Medial rotation	Subscapularis	Pectoralis majorDeltoidLatissmus dorsiTeres major
Lateral rotation	Infraspinatus	Teres minorDeltoid

Solution to Question 11:

Lateral rotation of the humerus increases the range of abduction.

When the arm is abducted without rotation, the greater tubercle comes in contact with the coracoacromial arch, preventing further abduction.

If the arm is then laterally rotated 180°, the tubercles are rotated posteriorly and the more articular surface becomes available to continue elevation. Hence, the range of abduction is increased.

Solution to Question 12:

A normal scapulohumeral rhythm is in the ratio of 2:1.

Scapulohumeral rhythm is the ratio of the glenohumeral movement to the scapulothoracic movement during arm elevation.

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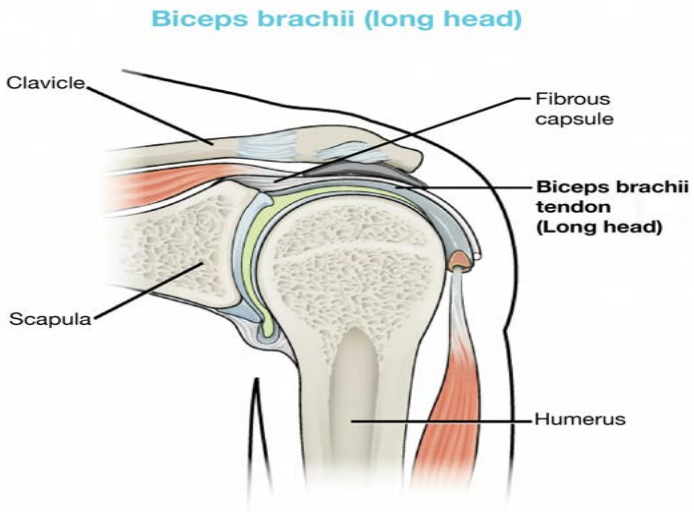
For instance, if the arm is abducted to a 90° angle, the glenohumeral elevation is 60° and the scapulothoracic rotation is 30°. Thus, the humerus and scapula move in a 2:1 ratio.

Solution to Question 13:

The long head of biceps is intracapsular.



The fibrous capsule which envelopes the shoulder joint is attached medially to the glenoid neck at a variable distance from the glenoid labrum. The capsule includes the supraglenoid tubercle, to which the long head of the biceps attaches, and which is therefore intracapsular.

Solution to Question 14:

Rotator interval is an area between the supraspinatus and subscapularis.

The rotator interval is a medially-based, triangular area that is not covered by the capsule.

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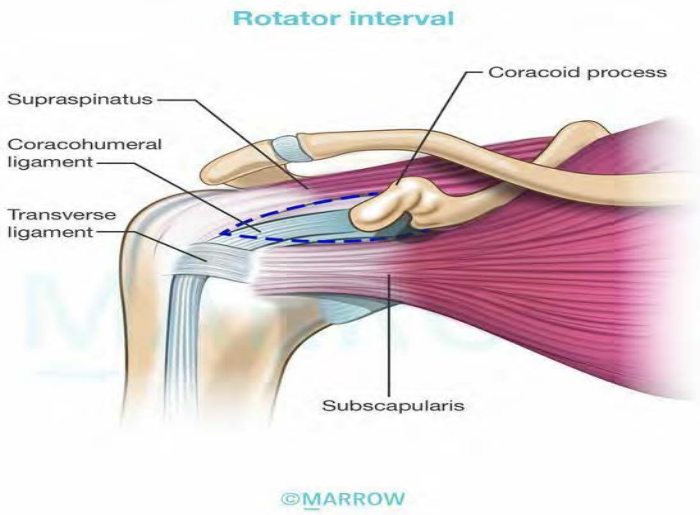

It is present between the superior edge of the subscapularis and the anterior edge of the supraspinatus with the coracoid as the medial boundary of the interval. It is reinforced by the coracohumeral ligament, the superior glenohumeral ligament, and fibers from the supraspinatus tendon laterally.

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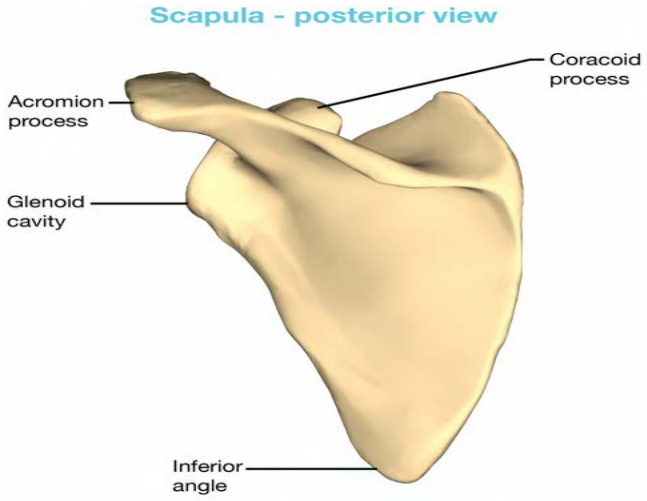
Solution to Question 15:

The part of the scapula marked as "A" in this image is palpable and it is the coracoid process.

The apex of the coracoid process lies approximately 2.5cm below the clavicle, immediately lateral to the infraclavicular fossa (deltopectoral triangle). Hence, the coracoid process can be palpated below the clavicle.



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Solution to Question 16:

Prono-supination movements do not happen at the radiocarpal (wrist) joint.

Supination and pronation mainly occur at 3 joints:

• Humeroradial

• Superior radioulnar joints

• Inferior radioulnar joints

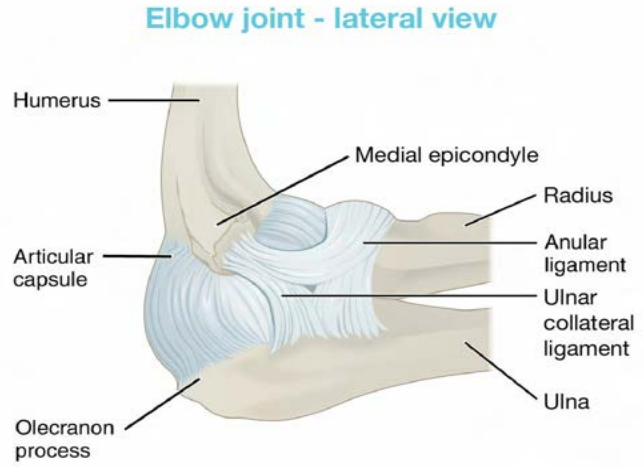
The middle radioulnar joint is a syndesmosis (fibrous) joint that mainly helps bind the radius and ulna together. It also helps in weight transmission from radius towards ulna.

Solution to Question 17:

During the intracapsular arthroscopy, the lateral epicondyle is not seen since it is extracapsular.

The capsular ligament of the elbow joint is attached anteriorly just above the coronoid and radial fossa and posteriorly above the olecranon fossa.

Note: Medial epicondyle is also extracapsular.



Solution to Question 18:

The average carrying angle is approximately 17°.

The carrying angle is the angle defined by the border of the fully supinated forearm and the long axis of the humerus when the elbow is fully extended.

It is usually 10°-15° in males and more than 15° in females. The absolute angle varies from individual to individual and also increases as age increases.

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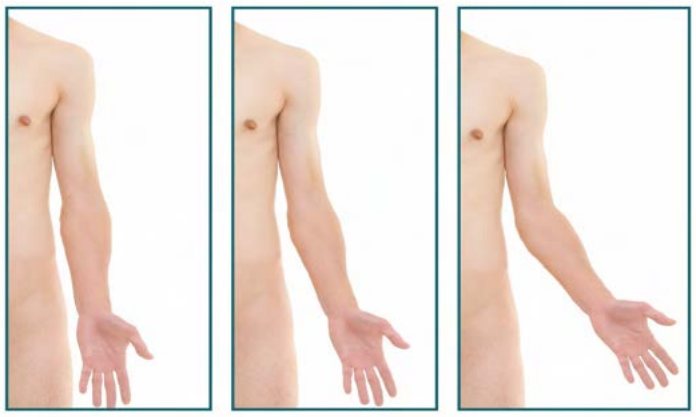
In clinics, it's necessary to see the carrying angle of the contralateral side instead of just on a single side. But anything between 5 to 15 degrees is considered normal. The carrying angle is used to identify varus or valgus in the elbow joint. It decreases in cubitus varus and increases in cubitus valgus.

Carrying angle of elbow

Cubitus varus and cubitus valgus



Solution to Question 19:

The middle radioulnar joint is an example of a fibrous joint (syndesmosis).

The radius and ulna are united with each other by three joints:

- Proximal (superior) radioulnar joint
- Middle radioulnar joint
- Distal (inferior) radioulnar joint

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Proximal and distal radioulnar joints are uniaxial pivot joints (synovial) and are involved in pronation and supination movements of the forearm.

The middle radioulnar joint is a fibrous joint (syndesmosis). The radius and ulna, in the middle, are connected by two syndesmoses namely:

• The oblique cord - extends from the lateral side of the ulnar tuberosity to the radius, distal to the radial tuberosity.

• Interosseous membrane - a broad, thin collagenous structure, which runs perpendicular to the oblique cord. It extends distomedially between the interosseous borders of the radius and ulna.

Based on the structure, joints are classified into three types:

• Fibrous joints

• Sutures

• Syndesmosis

• Gomphosis

• Cartilaginous joints

• Primary cartilaginous joints or synchondrosis

• Secondary cartilaginous joints or symphysis

• Synovial joints

• Ball-and-socket or spheroidal joints

• Sellar or saddle joints

• Condylar or bicondylar joints

• Ellipsoid joints

• Hinge joints

• Pivot or trochoid joints

• Plane joints

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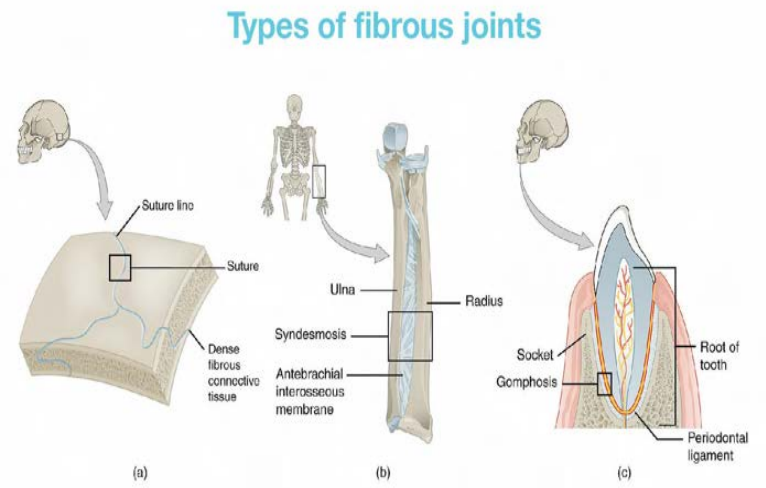

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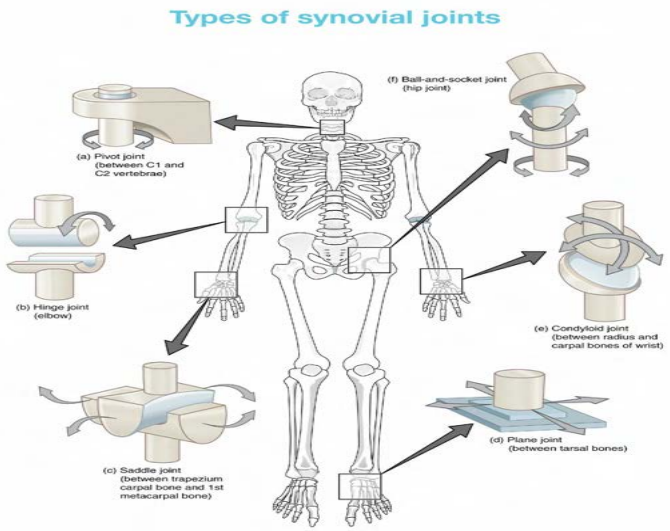

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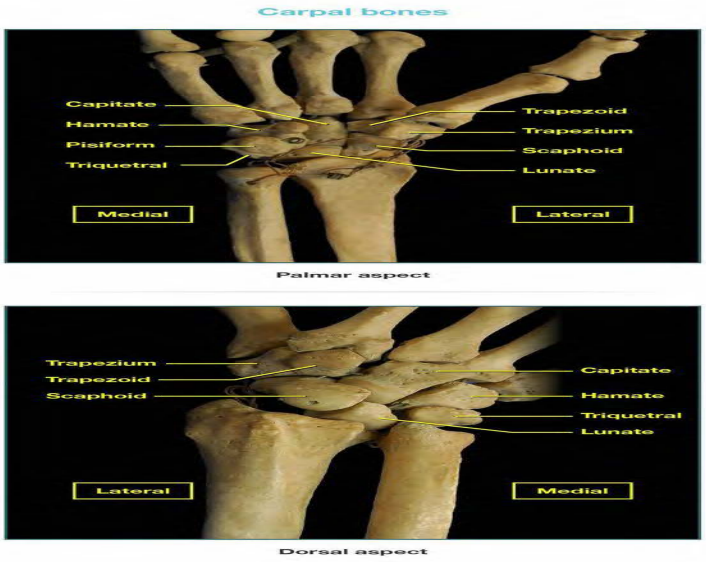
Solution to Question 20:

In the above scenario, the area of tenderness and the pain in the ring and little finger are suggestive of the hook of hamate fracture. The pain in the ring and little finger is related to the close proximity of the ulnar nerve which could get affected due to a fracture of hook of hamate.

The hamate is cuneiform and bears an unciform hamulus (hook) that projects from the distal part of its rough palmar surface.



Mnemonic for Carpal Bones -

She(S) - Scaphoid

Looks(L) - Lunate

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Too(T) - Triquetral

Pretty(P) - Pisiform

Try (T) - Trapezium

To(T) - Trapezoid

Catch(C) - Capitate

Her(H) - Hamate

Solution to Question 21:

The epiphysis of the first metacarpal is present at the base. All the other metacarpals have epiphysis at the head.

Features of the first metacarpal:

• Epiphysis at the head is an aberrant epiphysis

• It is the shortest and stoutest of all metacarpals

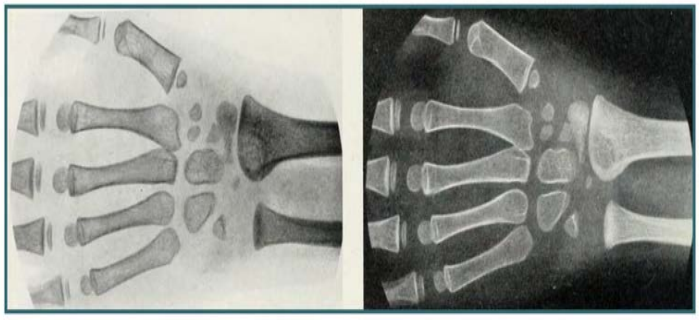
• The palmar (medial) surface is longitudinally concave and divided by a ridge into a larger lateral (anterior) and smaller medial (posterior) part

• The base has a convexo-concave articular surface to make a saddle synovial joint with trapezium

The first metacarpal fracture at the base of the thumb is called Bennett's fracture. It is an intraarticular fracture that separates the palmar ulnar aspect of the base of the first metacarpal from the rest of the first metacarpal.

The image below shows a radiograph of a hand at 2.5 years (dorsopalmar projection). Note the early stages of ossification in the epiphyses at the proximal ends (base) of the phalanges and first metacarpal; the distal ends of the remaining metacarpals and radius.

Hand at 2.5 years (dorsopalmar projection)



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Solution to Question 22:

The distal end of the ulna does not take part in the formation of the radiocarpal joint.

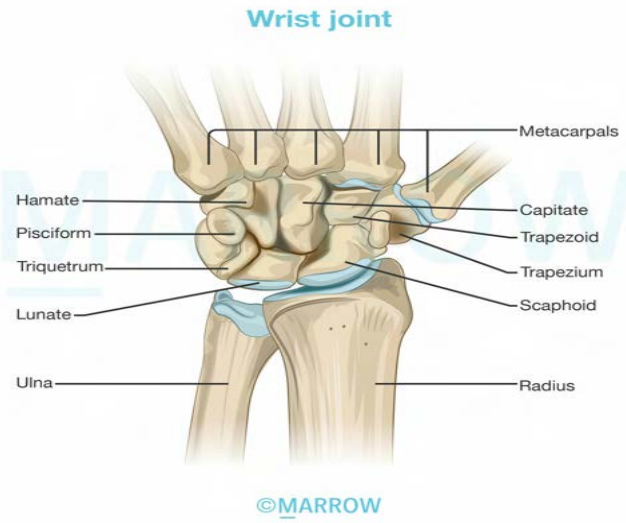
The radiocarpal joint (Wrist joint) is a synovial, biaxial, and ellipsoid joint formed by the articulation of:

• The distal end of the radius

• Articular disc of the triangular fibrocartilage

• Scaphoid, lunate and triquetrum

In the neutral position of the wrist, only the scaphoid and lunate are in contact with the radius and articular disc; the triquetrum comes into apposition with the disc only in full adduction of the wrist joint.



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Fossae and Spaces of the Upper Limb

Question 1:

A 68-year-old woman sustained a fracture of the proximal humerus and injured the axillary artery. She began bleeding into the fascia around it. Where is this fascia derived from?

a) Prevertebral fascia

b) Clavipectoral fascia

c) Investing layer of deep cervical fascia

d) Superficial cervical fascia

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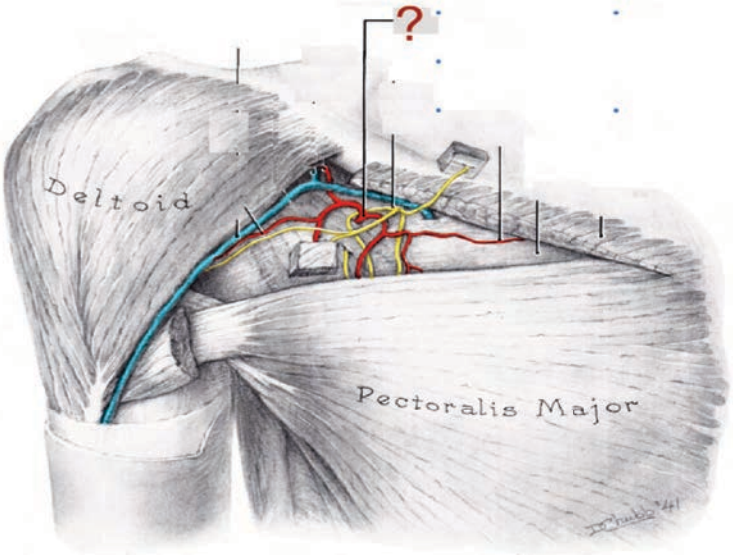
Question 2:

Identify the structure labelled in the diagram below.



a) Axillary artery

b) Thoraco acromial artery

c) Lateral thoracic artery

d) Subscapular artery

Question 3:

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A patient presents with severe radicular pain of the upper extremity due to compression of the radial nerve in a space around the shoulder joint. Which of the following is false regarding this space?

a) Superior border is by teres major

b) It contains the circumflex scapular vessels

c) Lateral border is by shaft of humerus

d) Medial border is by long head of triceps

Question 4:

A 52-year-old woman presented with weakness of shoulder movements. Investigations revealed quadrangular space syndrome. Which of the following nerve is likely to be affected?

a) Musculocutaneous nerve

b) Suprascapular nerve

c) Radial nerve

d) Axillary nerve

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Question 5:

Which of the following is not a content of cubital fossa?

a) Median nerve

b) Bicipital aponeurosis

c) Brachial artery

d) Radial nerve

Question 6:

A patient presented with tenderness in the region shown below following a fall onto an outstretched hand. Which of the following forms the roof of this region?

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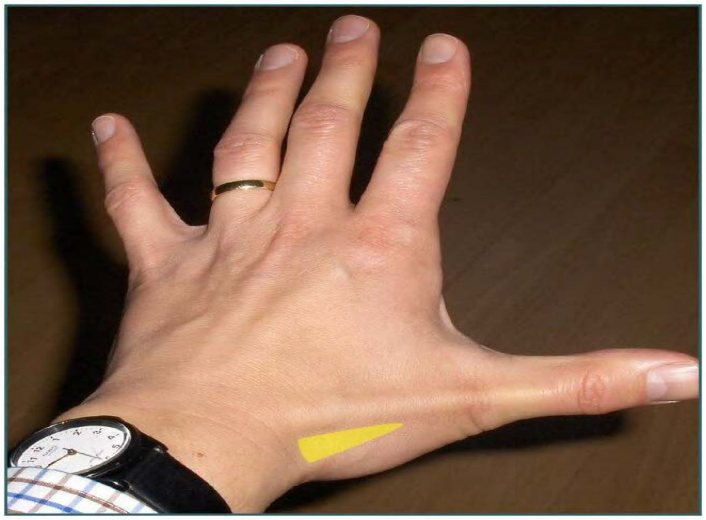

a) Radial artery

b) Basilic vein

c) Superficial branch of radial nerve

d) Superficial branch of ulnar nerve

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Question 7:

Which of the following forms the lateral boundary of the anatomical snuff box?

a) Extensor pollicis brevis and abductor pollicis longus

b) Extensor pollicis longus and abductor pollicis brevis

c) Extensor pollicis longus and extensor pollicis brevis

d) Abductor pollicis longus and abductor pollicis brevis

Question 8:

A 56-year-old woman presents with tingling and numbness in her hands. The symptoms get worse at night and when she's at work using her computer. The affected structure contains all of the following except:

a) Flexor digitorum profundus

b) Flexor digitorum superficialis tendon

c) Flexor pollicis longus tendon

d) Flexor carpi ulnaris tendon

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Question 9:

Which among the following is false regarding flexor retinaculum or transverse carpal ligament?

a) It is medially attached to pisiform and hook of hamate

b) It is laterally attached to scaphoid and trapezium

c) It splits into a medial superficial slip and a lateral deep slip

d) Flexor carpi radialis is the only content in the medial slip

Question 10:

Which of the following is not present in the fourth compartment of the extensor retinaculum?

a) Anterior interosseous artery

b) Posterior interosseous nerve

c) Extensor indices

d) Extensor pollicis longus

Question 11:

Which of the following is false about dorsal digital expansion?

a) Base of the expansion is at the MCP

b) Wing tendons refer to the attachment of extensor digitorum

c) The central slip of the extensor tendon is attached to the base of middle phalanx

d) The collateral slips are attached to the base of distal phalanx

Question 12:

A patient presents with pain in one of her fingers. Kanavel's sign is positive. Which of the following is the most likely diagnosis?

a) Tenosynovitis

b) Dupuytren's contracture

c) Carpal tunnel syndrome

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d) Trigger finger

Question 13:

An infection of the finger as in the image below is most likely to spread to which of the following spaces?

a) Radial bursa

b) Ulnar bursa

c) Mid palmar space

d) Thenar space

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Question 14:

Which of the following is not the content of the mid-palmar space?

a) Flexor digitorum profundus of 4th finger

b) Flexor digitorum profundus of 3rd finger

c) 2nd lumbrical

d) 1st lumbrical

Question 15:

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A patient with the following infection in the finger requires incision and drainage as it can lead to all of the following except:

a) Necrosis of the whole of phalanx

b) Osteomyelitis

c) Flexor tenosynovitis

d) Septic arthritis of the distal interphalangeal joint

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Answer Key

Question No.	Correct Option
1	a
2	b
3	b
4	d
5	b
6	c
7	a
8	d
9	d
10	d
11	b

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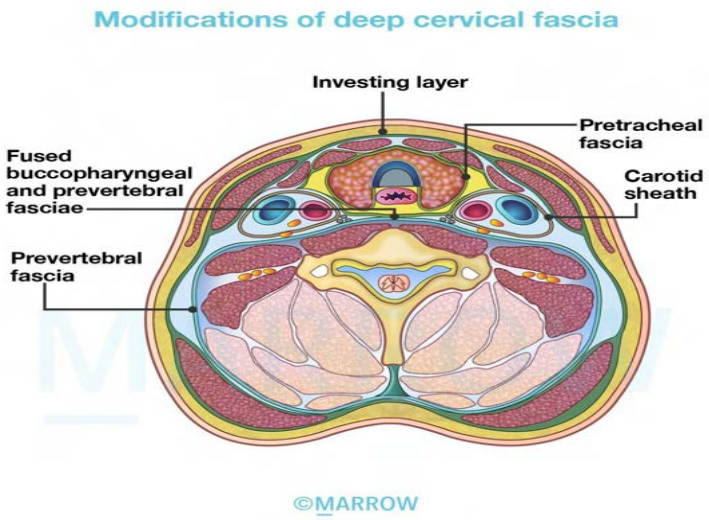
12	a
13	c
14	d
15	a

Detailed Explanations

Solution to Question 1:

The fascia around the axillary vessels and brachial plexus is called the axillary sheath. It is derived from the prevertebral fascia.



Clinical correlation:

• In a brachial plexus nerve block, the axillary sheath localizes the anesthetic solution to the nerve plexus.

• Chronic retropharyngeal abscess in TB may spread to the axilla or to the superior mediastinum. But it never spreads to the posterior mediastinum because prevertebral fascia fuses to restrict the spread.

Solution to Question 2:

Structure labelled in the picture is artery piercing the clavipectoral fascia called thoracoacromial artery.

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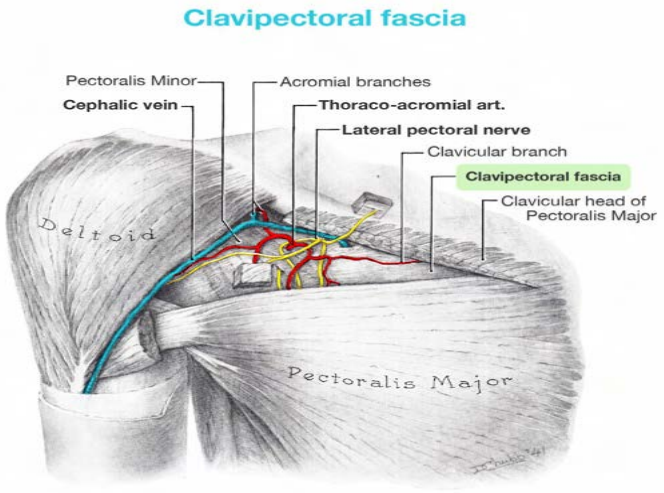

Clavipectoral fascia envelops the subclavius and pectoralis minor. Medially it forms the costocoracoid ligament. Laterally it is connected to the axillary fascia by suspensory ligament of axilla (Gerdy's ligament). The structures piercing clavipectoral fascia are:

- 1 vein: Cephalic vein
- 1 artery: Thoracoacromial artery (associated veins and lymphatics)
- 1 nerve: Lateral pectoral nerve.

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Solution to Question 3:

The space around the shoulder joint where the radial nerve may be compressed is the triangular interval. It contains the profunda brachii vessels.

Solution to Question 4:

The axillary nerve is likely to be affected as it is one of the contents of the quadrangular space.

Quadrangular space syndrome is a condition is caused by hypertrophy or fibrosis of the quadrangular space muscles which impinge on the axillary nerve. Patients present with weakness of the shoulder movements.

Solution to Question 5:

Bicipital aponeurosis is not a content, it forms the roof of cubital fossa. Biceps tendon is a content of cubital fossa.

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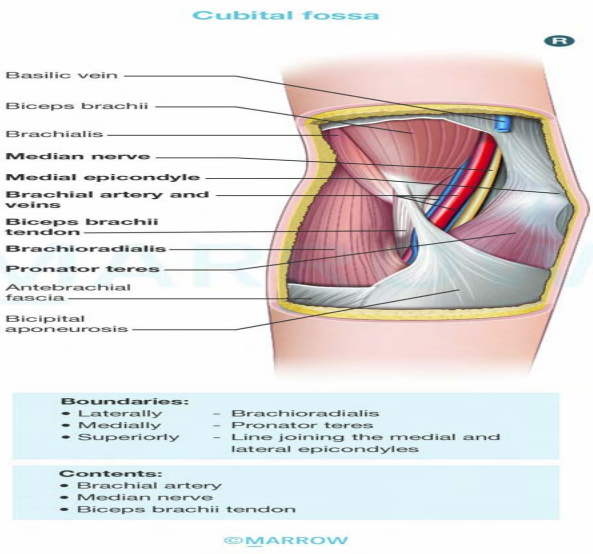

Note - The Radial nerve is given as content of the cubital fossa in some books, in others, it's excluded as a content of cubital fossa due to its extreme lateral position.

Solution to Question 6:

The marked region is the anatomical snuffbox. The superficial branch of radial nerve forms the roof of the anatomical snuffbox. Tenderness in this region is suggestive of a scaphoid fracture, a common injury after a fall on an outstretched hand.

Anatomical snuffbox boundaries:

Lateral wall:

• Abductor pollicis longus (APL),

• Extensor pollicis brevis (EPB)

Medial wall:

• Extensor pollicis longus (EPL).

Roof:

• Cephalic vein

• Superficial branch of radial nerve

Floor:

• Radial styloid, Scaphoid, Trapezium, and 1st Metacarpal.

Only content: Radial artery

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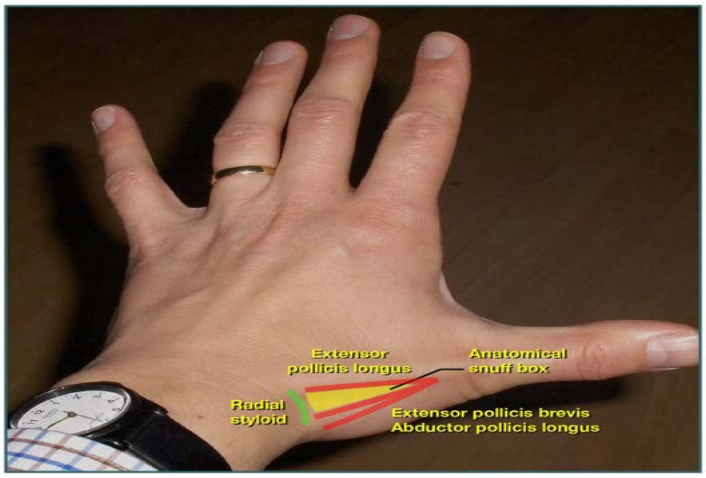
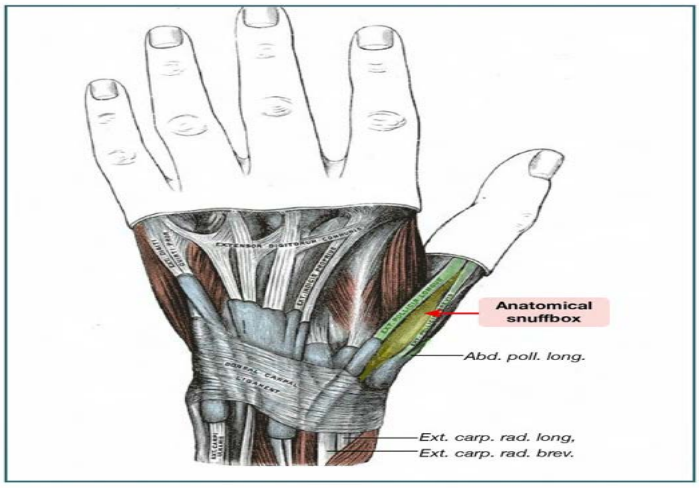
Anatomical Snuff Box



Anatomical snuffbox



Solution to Question 7:

The lateral boundary of the anatomical snuff box is formed by extensor pollicis brevis and abductor pollicis longus.

Boundaries of the anatomical snuffbox:

• Lateral wall:

• Abductor pollicis longus (APL)

• Extensor pollicis brevis (EPB)

• Medial wall:

• Extensor pollicis longus (EPL)

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• Roof:

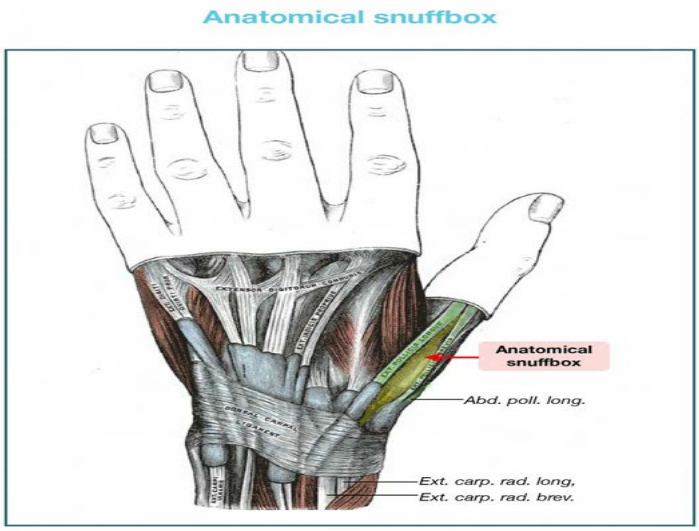
• Cephalic vein

• Superficial branch of the radial nerve

• Floor:

• Radial styloid, scaphoid, trapezium, and 1st metacarpal

Only content: Radial artery



Solution to Question 8:

The given clinical scenario is suggestive of carpal tunnel syndrome. The carpal tunnel does not contain flexor carpi ulnaris tendon (FCU).

Carpal tunnel contents (10 structures): Also can be taken as 4 structures only if FDP and FDS are counted as 2 structures.

• Flexor digitorum profundus (FDP-4 tendons).

• Flexor digitorum superficialis (FDS-4 tendons).

• Flexor pollicis longus (FPL-1 tendon).

• Median nerve between tendons of FDP and FDS.

Superficial to the carpal tunnel and the flexor retinaculum, the ulnar artery and ulnar nerve pass through the ulnar tunnel or Guyon's canal.

Solution to Question 9:

Flexor carpi radialis is the only content in the lateral slip, not medial slip.

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Flexor retinaculum (carpal tunnel): 10 structures in total.

• 4 tendons of flexor digitorum superficialis (FDS), 4 tendons of flexor digitorum profundus (FDP), both in a common synovial sheath (in ulnar bursa).

• 1 Median nerve

• 1 Flexor pollicis longus (FPL) with its synovial sheath (in radial bursa).

Medial superficial slip of flexor retinaculum (called volar carpal ligament):

• Volar carpal ligament forms the "Guyon's canal"

• Guyon's canal contains ulnar nerve and vessels.

Lateral deep slip of flexor retinaculum:

• Flexor carpi radialis (FCR) tendon is the only content.

Flexor retinaculum has 4 attachments:

• Medially:

• Pisiform

• Hook of the hamate

• Laterally:

• Tubercles of scaphoid

• Trapezium

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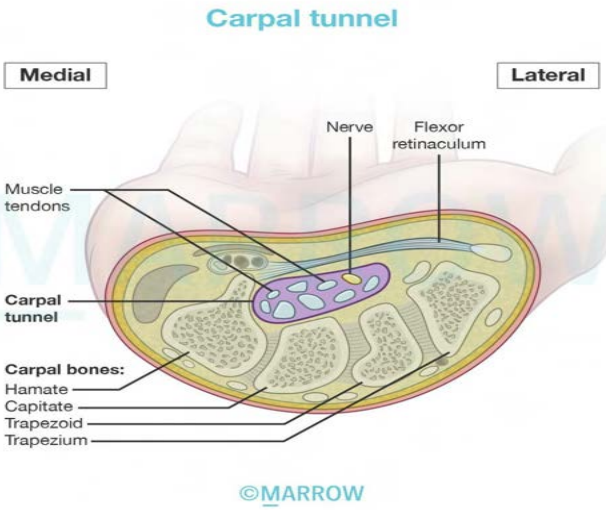

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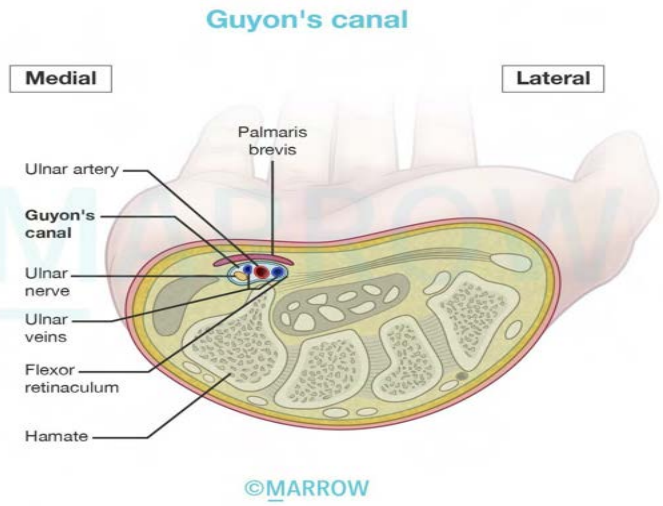

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Solution to Question 10:

Extensor pollicis longus is not present in the fourth compartment of the extensor retinaculum. Posterior interosseous nerve and anterior interosseous artery are present in the fourth compartment.

Extensor retinaculum attachments:

- Medially - Pisiform and triquetral.
- Laterally - Anterior border of the radius.

Solution to Question 11:

Wing tendons refer to the insertion of lumbricals and interossei to the corners of the dorsal digital expansion or simply extensor expansion.

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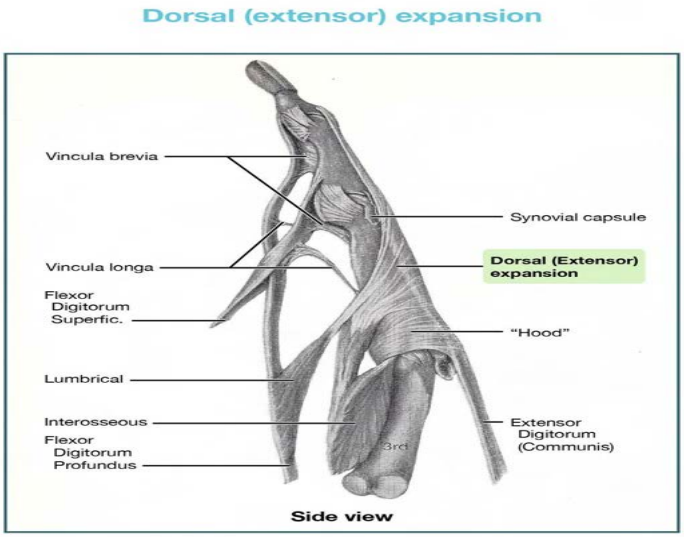

Dorsal digital expansion/ Extensor expansion:

• Formation: By extensor tendons expanding "extensor expansion"

• Location: Back of digits "dorsal digital expansion"

• Extensors making the expansion: ED, EPL (extensor digitorum and extensor pollicis longus)

• Muscles joining the expansion: EDM, EI, EPB (extensor digiti minimi, extensor indicis, and extensor pollicis brevis)

Extensor expansion triangular hood attachments: (The shape of expansion)

• Apex: Distal phalanx

• Central region: Middle phalanx (in the thumb, attached to proximal phalanx)

• Corner of the base: Sides of MCP joint (in the thumb, attached to muscles)

• Extensor hood: Lumbrical, interossei, and extensor digitorum muscles (in the thumb, the adductor pollicis and abductor pollicis brevis muscles)

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Solution to Question 12:

Kanavel's sign is suggestive of tenosynovitis.

Clinically, it can distinguish infectious tenosynovitis from superficial or localized abcess.

Kanavel's sign has the following effects -

• Tenderness over affected tendon

• Fusiform swelling over affected tendon

• The affected finger is in slight flexion

• Pain on passive extension of the affected finger

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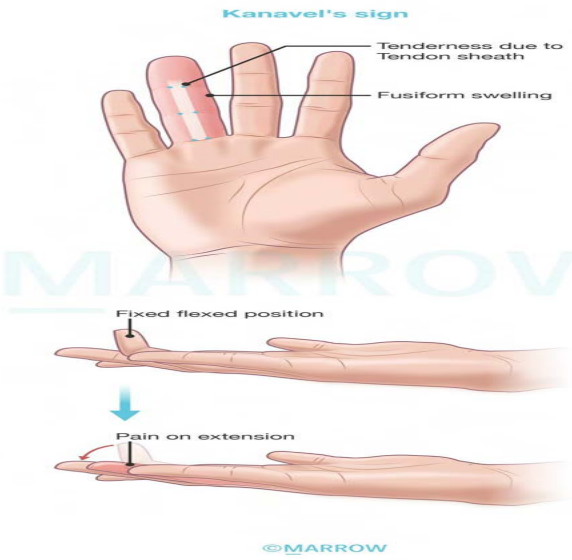

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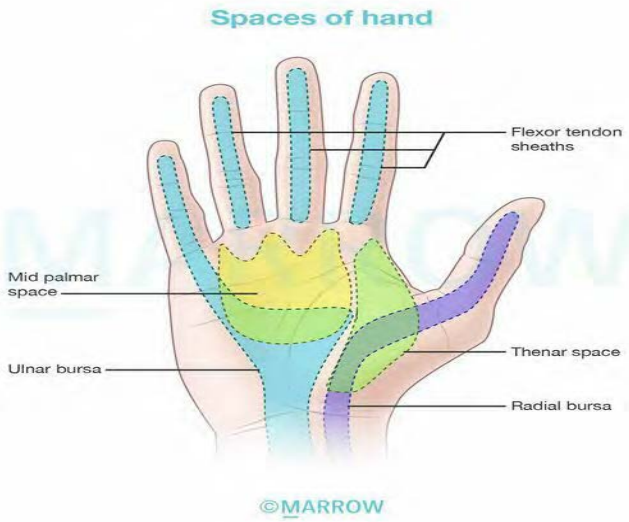
Solution to Question 13:

The given image shows an infection, paronychia, of the middle finger. It can spread into the mid-palmar space.

Infections of the:

- Ring and middle finger spread into the mid-palmar space
- Index finger to thenar space
- Little finger spread to ulnar bursa and mid palmar space.



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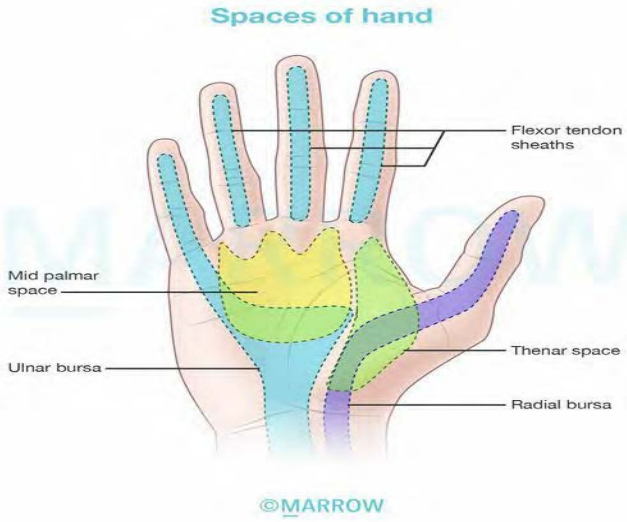
Solution to Question 14:

The 1st lumbrical is not a content of the mid-palmar space.

The 1st lumbrical is related to the FDP (flexor digitorum profundus) tendon of the index (2nd finger). Thus, it lies in the thenar space.

The 2nd, 3rd, and 4th lumbricals are related to the FDP of the middle (3rd finger), ring (4th finger), and little (5th finger) respectively. Thus, they lie in the mid-palmar space.



Solution to Question 15:

The given image shows an infection of the pulp space of the finger or whitlow. It requires incision and drainage because when neglected, whitlow can lead to necrosis of the distal 4/5th of the terminal phalanx. It does not cause necrosis of the entire phalanx because the proximal 1/5th escapes as in this part the artery does not cross the fibrous septa.

The pulp space of fingers contains subcutaneous fat arranged in tight compartments. These compartments are formed by fibrous septa extending from the skin to the periosteum of the terminal phalanx.

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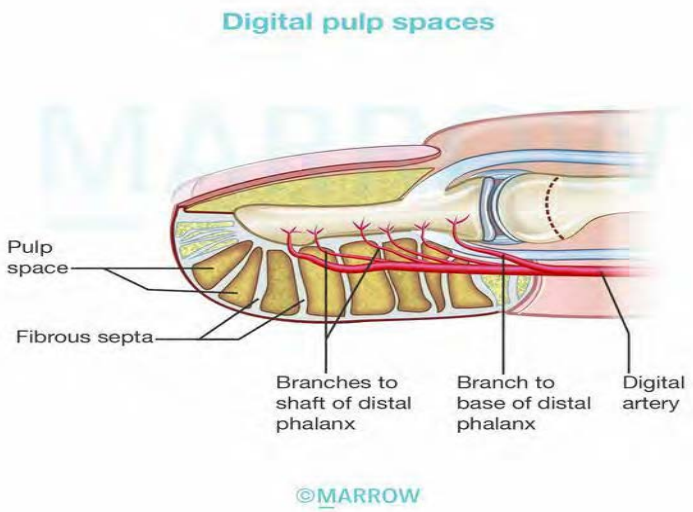

Whitlow or pulp space infections are treated by a lateral incision and drainage. Its complications are:

- Ischemic necrosis of the distal 4/5th of terminal phalanx due to vessel occlusion.
- Osteomyelitis
- Flexor tenosynovitis
- Septic arthritis of DIP (distal interphalangeal joint)

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Breast

Question 1:

Which of the following statement is incorrect regarding the mammary glands?

a) It is a modified sweat gland

b) It lies on the deep pectoral fascia

c) It is supplied by internal thoracic artery

d) Nipple is supplied by the 6th intercostal nerve

Question 2:

After a detailed evaluation, a woman is found to have a breast lump extending into the axillary tail of Spence. Through which of the following foramina do the affected structure passes?

a) Foramen of Winslow

b) Quadrangular space

c) Foramen of Langer

d) Triangular space

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Question 3:

Which of the following does not provide direct blood supply to the breast tissue?

a) Internal thoracic artery

b) Thoraco acromial artery

c) Lateral thoracic artery

d) Axillary artery

Question 4:

Which of the following statement about breast tissue is false?

a) Fibrous stroma is absent beneath the areola

b) Alveolar epithelium is columnar in the resting phase

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c) 15-20 lactiferous ducts open in the nipple

d) Myoepitheliocytes facilitates the passage of the milk along the ducts

Question 5:

The secretion of breast milk is _____

a) Apocrine + Eccrine

b) Merocrine + Holocrine

c) Apocrine + Merocrine

d) Eccrine + Holocrine

Question 6:

A 58-year-old woman was diagnosed with a malignant tumor in the superolateral quadrant of the breast. A blue dye was injected to map the sentinel lymph node for evaluation of metastasis. Which of the following lymph nodes would most likely be removed for biopsy?

a) Anterior axillary

b) Posterior axillary

c) Supraclavicular

d) Internal mammary

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Question 7:

A 40-year-old woman with breast cancer presents to the OPD with the given finding on her right breast. What is the likely cause of this finding?

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a) Skin metastasis of the tumor

b) Adherence of sub-dermal lymphatics

c) Blockade of sub-dermal lymphatics

d) Infiltration of the ligament of Cooper

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Answer Key

Question No.	Correct Option
1	d
2	c
3	d
4	b
5	c
6	a
7	c

Detailed Explanations

Solution to Question 1:

The nipple is supplied by the anterior branch of the lateral cutaneous branch of T4 (4th intercostal nerve).

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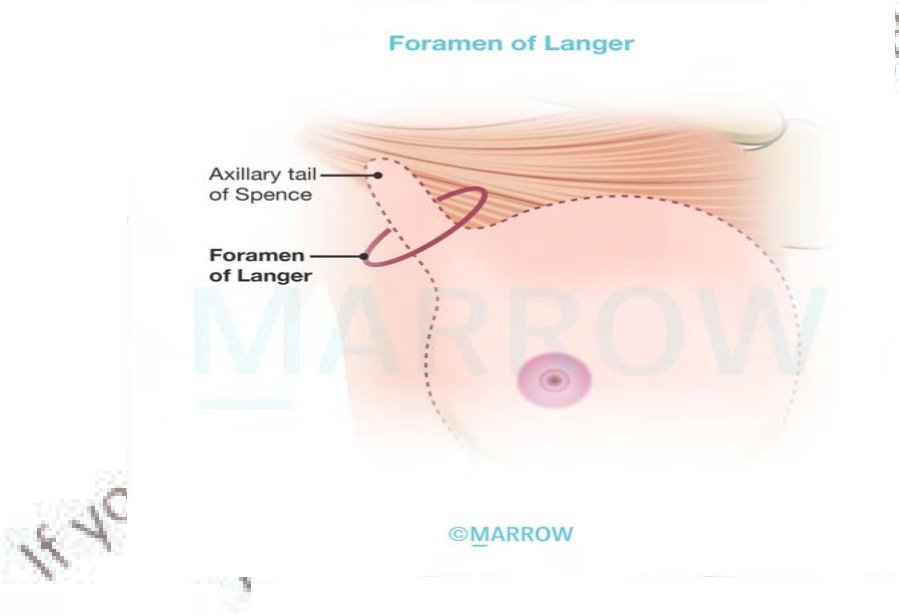
The breast is innervated by anterior and lateral branches of the 4th to 6th intercostal nerves (sensory and sympathetic efferent).

The breast (mammary gland) is a modified sweat gland. It lies on the deep pectoral fascia overlying the pectoralis major muscle. It is supplied by the internal thoracic artery, lateral thoracic artery, and lateral branches of posterior intercostal arteries.

Solution to Question 2:

The axillary tail of Spence is the axillary process of the mammary gland. It passes through the foramen of Langer.

Foramen of Langer is an opening in the deep fascia through which the superolateral quadrant is prolonged towards the axilla. It lies along the inferolateral edge of the pectoralis major and may extend through the deep fascia up to the apex of the axilla.



Solution to Question 3:

The blood supply of the breast does not include the axillary artery.

The blood supply of the breast: 4 major sources

Artery	Area supplied
Lateral thoracicartery	Lateral
Medial mammary branches of internal thoracicartery	Medial

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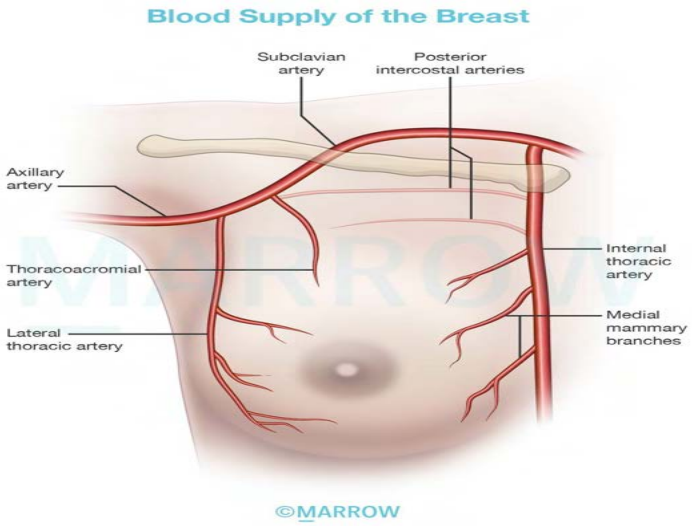
Artery	Area supplied
Pectoral branches of theacromiothoracicandSuperior thoracicarteries	Superior
2ndto 4thposterior intercostalarteries	Base



The veins of the breast correspond with the arteries, draining into the axillary and internal thoracic veins.

Note: The left internal mammary artery (left internal thoracic artery) is the preferred vessel for coronary artery bypass grafting (CABG) because it has superior short- and long-term patency rates compared to saphenous vein grafts.

Solution to Question 4:

Alveolar epithelium is cuboidal in the resting phase, and columnar during lactation.

The fibrous stroma forms septa (suspensory ligaments of Cooper) which anchor the skin and gland to the pectoral fascia. It forms the major part of the gland but is absent beneath the areola and nipple.

In the development of breasts, the thoracic ectodermal ingrowths branch into 15–20 solid buds of ectoderm that will become the lactiferous ducts and their associated lobes of alveoli in the fully formed.

Contraction of myoepitheliocytes facilitates the passage of the milk along the ducts. The lactiferous ducts are arranged in a radial fashion and converge towards the nipple and form lactiferous sinuses.

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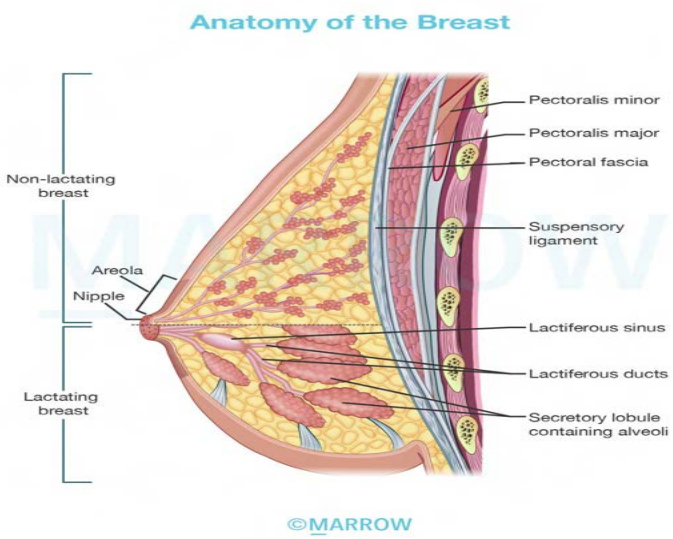

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Solution to Question 5:

Mammary gland cells secrete milk protein casein by merocrine secretion. Milk lipid is secreted by apocrine secretion.

Types of glands:

• Exocrine

• Endocrine

Exocrine glands: The secretions are initially packaged into membrane-bound vesicles. These are then conveyed to the cell surface.

• Merocrine: It is the most common type. Vesicles fuse with the plasma membrane and secrete on the surface. e.g. sweat glands, protein in mammary gland, pancreas, salivary gland.

• Apocrine: Apical portion is pinched off for secretion. e.g. milk fat in the mammary gland, atypical sweat glands, ceruminous glands, glands of Moll.

• Holocrine: Entire gland disintegrates to liberate secretion. e.g. sebaceous gland.

• Eccrine: Active transportation from plasma as exudate. E.g., previously sweat gland was eccrine, now moved under merocrine.

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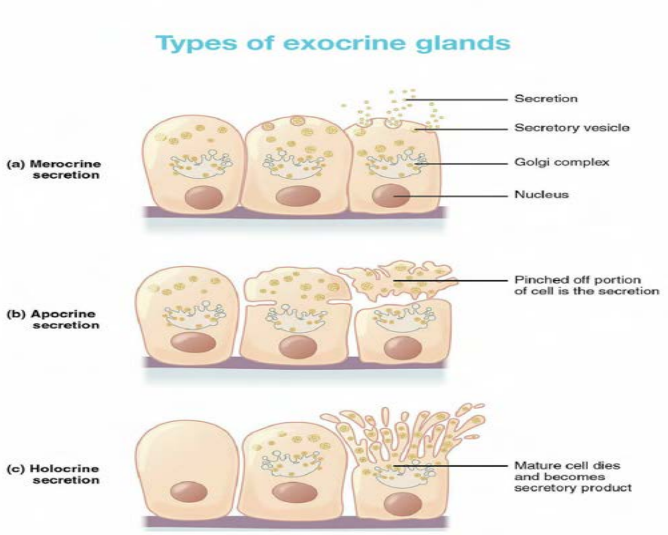

Endocrine glands: Direct secretion into connective tissue interstitium and then into the circulation.

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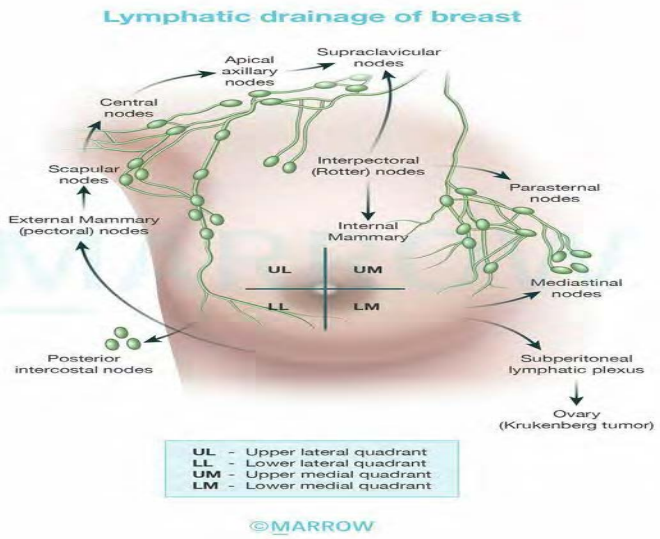
Solution to Question 6:

Lymphatics from the upper outer quadrant of the breast drain first into the anterior axillary lymph nodes (sentinel nodes).

A sentinel node is the first lymph node that receives lymphatic drainage from the tumor. It is identified so that it can be removed during the surgery. The lymph node is sent for histopathological analysis to detect metastasis.

The axillary nodes receive more than 75% of the lymph from the breast.



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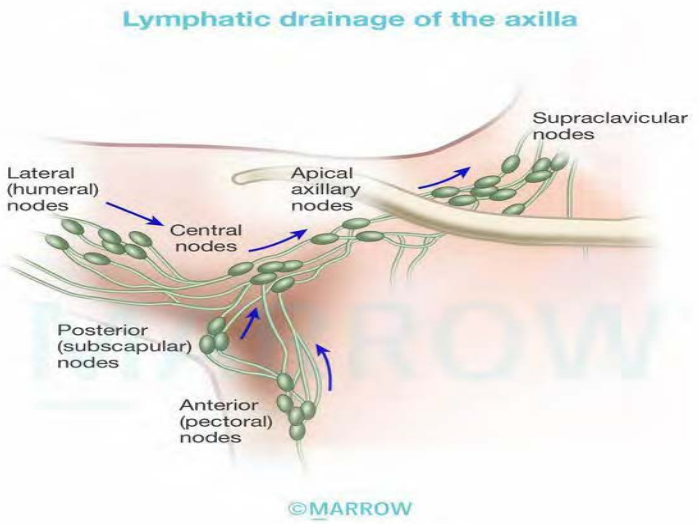

Surgical classification of nodes:

Nodes are described in relation to pectoralis minor:

• Level 1 (Low nodes) - below pectoralis minor

• Level 2 (Middle nodes) - behind the muscle

• Level 3 (Apical/upper nodes) - between the upper border of the pectoralis minor and the lower border of the clavicle

There may be nodes between pectoralis minor and major; this interpectoral group of nodes is also known as Rotter's nodes.

Solution to Question 7:

The given image shows the peau d'orange appearance of the breast. It occurs due to the blockade of sub-dermal lymphatics. It is one of the most conspicuous signs of breast cancer.

The lymphatic blockade gives rise to edema in the breast. However, the swelling is restricted wherever the skin is tethered to the ligaments of Cooper. This deepens the openings of the sweat glands and hair follicles, giving rise to the typical orange peel appearance.

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Brachial Plexus and Nerves

Question 1:

A 48-year-old construction worker presented with complaints of unilateral loss of sweating on the face. He had a history of trauma to his back 1 month ago. Examination revealed the following findings. What is the likely site of the lesion?

a) Grey ramus of T1

b) White ramus of T1

c) Grey ramus of C8

d) White ramus of C8

Question 2:

Which of the following structures of brachial plexus do not give branches?

a) Roots

b) Cords

c) Trunks

d) Divisions

Question 3:

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Which of the following statements about brachial plexus is false?

a) Nerve to subclavius arises from superior trunk

b) Arterial supply to brachial plexus is from branches of common carotid arteries

c) Radial nerve is the largest branch of the entire brachial plexus

d) C4 contributes to brachial plexus occasionally

Question 4:

An infraclavicular block was given in a patient with distal humerus fracture for open reduction and internal fixation. Which of the following branches of brachial plexus would likely be anesthetized?

a) Nerve to Subclavius

b) Dorsal scapular nerve

c) Nerve to serratus anterior

d) Thoracodorsal nerve

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Question 5:

A neonate is being examined after delivery. The delivery was complicated by shoulder dystocia which led to the injury of the upper trunk of the brachial plexus. Which of the following deformities is least likely to be seen in this neonate?

a) Extension at elbow joint

b) Pronation at radio-ulnar joint

c) Abduction and medial rotation at shoulder joint

d) Sensory loss along the outer aspect of the arm

Question 6:

A medical student receives a booster dose of Hepatitis B vaccination. A few hours later, she develops weakness in the abduction and lateral rotation of that arm. Which nerve is most likely to have been injured?

a) Surgeon's nerve

b) Labourer's nerve

c) Nerve of Bell

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d) Musician's nerve

Question 7:

Which of the following nerves is not directly related to humerus?

a) Axillary nerve

b) Median nerve

c) Ulnar nerve

d) Radial nerve

Question 8:

Which of the following will you test in patients with median nerve injury at the wrist?

a) Contraction of flexor pollicis brevis

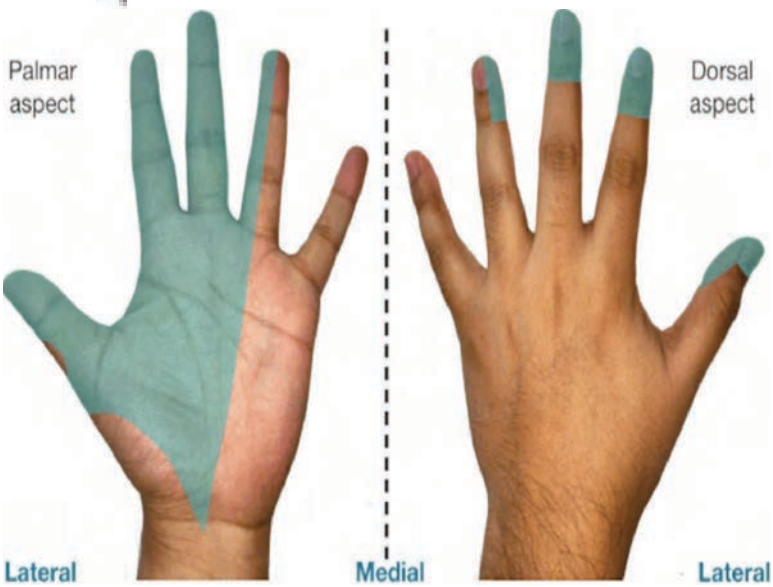
b) Loss of sensation of the palm

c) Contraction of abductor pollicis brevis

d) Loss of sensation on the ring finger

Question 9:

A 56-year-old man presented with a loss of sensation over the hand as marked in the given image. Which of the following statements is true regarding the affected nerve?



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a) It innervates adductor pollicis

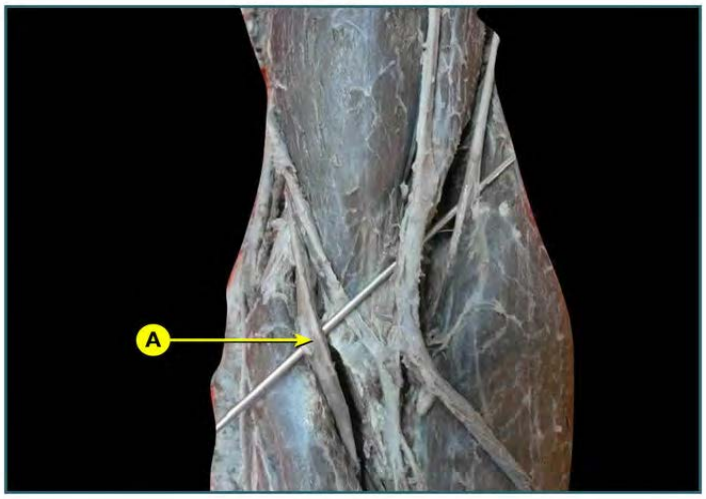
b) It innervates medial half of flexor digitorum profundus

c) Ape thumb deformity can be seen irrespective of site of lesion

d) Wrist drop can be seen if the lesion is above the elbow

Question 10:

Lesion of the structure marked 'A' causes:



a) Loss of sensation of the nail of index finger

b) Hypothenar muscles wasting

c) Loss of sensation at the tip of radial tubercle

d) Loss of sensation of the 4th interdigital cleft

Question 11:

Which of the following muscles are likely to be affected in patients with ulnar nerve injury at the elbow?

a) Flexor digitorum superficialis

b) Palmaris longus muscle

c) Pronator teres

d) Palmar interossei

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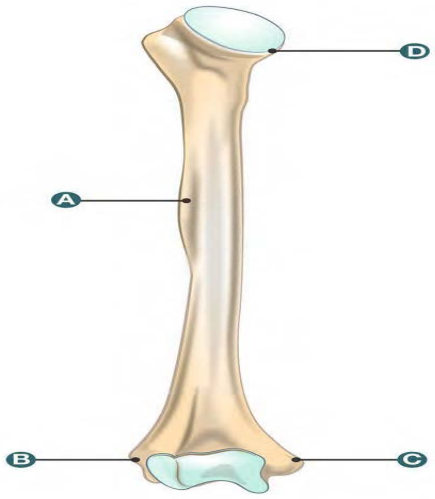
Question 12:

A patient came with complaints of inability to move his 4th and 5th digit, cannot hold a pen and he was not able to hold a paper between fingers. Which of the following sites given below is the probable cause of injury to the nerve in question?



a) A

b) B

c) C

d) D

Question 13:

Which of the following is injured in a patient presenting with atrophy of hypothenar eminence and numbness in the palmar aspect of the little finger?

a) Deep branch of ulnar nerve

b) Ulnar nerve before it's division into superficial and deep branch

c) Palmar cutaneous branch of ulnar nerve

d) Superficial terminal branch of ulnar nerve

Question 14:

A patient is unable to hold a piece of paper between his thumb and index finger firmly following a cut wound over the hypothenar eminence. Which of the following nerves is likely

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to be damaged?

a) Superficial terminal branch of ulnar nerve

b) Deep branch of ulnar nerve

c) Deep branch of radial nerve

d) Deep branch of median nerve

Question 15:

A 25-year-old man presented with displaced fracture of distal humerus. Which of the following signs would indicate that the ulnar nerve is injured at this site?

a) Total claw hand

b) Paralysis of all interossei

c) Complete paralysis of flexor digitorum profundus

d) Paralysis of all lumbricals

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Question 16:

Which of the following digits can be used to test radial nerve, ulnar nerve, and median nerve?

a) Ring finger

b) Index finger

c) Little finger

d) Thumb

Question 17:

A 30-year-old woman presents with paresthesias in the lower lateral part of the arm. Branch of which of the following nerve is affected here?

a) Axillary nerve

b) Radial nerve

c) Median nerve

d) Ulnar nerve

Question 18:

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A patient with radial head fracture presents with an inability to extend the metacarpophalangeal joint. On examination, wrist extension is normal with no sensory impairment. Which of the following is the probable cause?

a) Injury to the radial nerve just below the spiral groove

b) Injury to the anterior interosseous nerve

c) Injury to the posterior interosseous nerve

d) Injury to the common extensor origin

Question 19:

A 40-year-old man has a C6, C7 nerve root injury due to disc herniation. Sensations of which part of the upper limb will be lost?

a) Thumb and index finger

b) Little finger

c) Upper medial part of arm

d) Upper medial side of forearm

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Question 20:

You are testing the deep tendon reflexes in a patient with Guillan-Barre syndrome. Which spinal segment is tested predominantly by a tap on the triceps tendon?

a) C6

b) C7

c) C5

d) C8

Question 21:

Which of the following statements regarding the radial nerve is true?

a) It leaves the axilla by passing through the quadrangular space

b) Lateral head of triceps is paralyzed in a lesion of radial nerve in lower spiral groove

c) Anconeus is supplied by a branch arising in the axilla

d) In the arm it travels along the brachial artery

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Question 22:

Which of the following statements is false regarding carpal tunnel syndrome?

a) Rheumatoid arthritis is a cause

b) Pain and paresthesia are worse at night time

c) Paresthesia over the skin of thenar eminence is prominent

d) No artery passes through the tunnel

Question 23:

Which of the following structure is not likely to be injured in a wrist slash injury over the radial side of the left wrist?

a) Radial artery

b) Radial nerve

c) Flexor carpi radialis

d) Palmaris longus tendon

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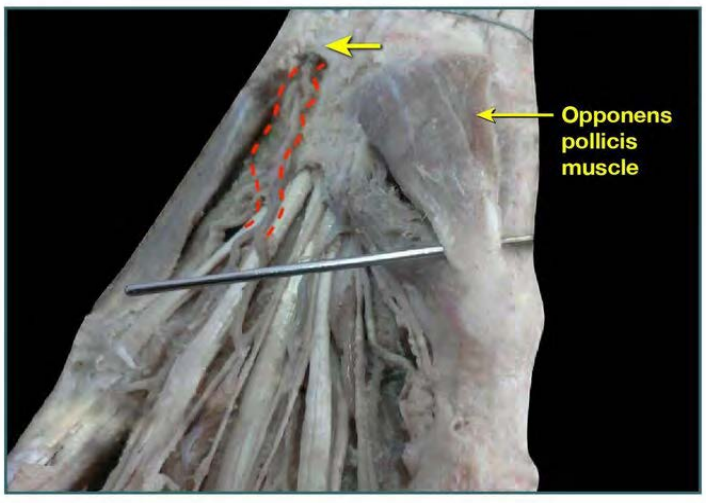
Question 24:

Which of the following forms the roof of the structure marked in the given image?



a) Pisiform bone, flexor carpi ulnaris and abductor digiti minimi

b) Flexor retinaculum and pisohamate ligaments

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c) Hook of hamate, extrinsic flexor tendons, the transverse carpal ligaments

d) Palmar carpal ligament and palmaris brevis

Question 25:

A 13-year-old boy presents with injury to the medial epicondyle of the humerus. Which of the following is least likely to be seen?

a) Weakness of the ulnar deviation and flexion

b) Complete paralysis of the IIIrd and IVth digits

c) Atrophy of the hypothenar eminence

d) Decreased sensation of the hypothenar eminence

Question 26:

You are suspecting injury to the long thoracic nerve in a patient who underwent radical mastectomy. Which of the following tasks will you ask the patient to perform to test the integrity of the nerve?

a) Shrug the shoulders

b) Raise the arm above the head on the affected side

c) Touch the opposite shoulder

d) Lift a heavy object from ground

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Question 27:

Till which point does the anterior axial line extend?

a) Shoulder

b) Elbow

c) Wrist

d) Knuckle

Question 28:

What is the deformity seen in patients with 'main en griffe'?

a) Extension at metacarpophalengeal joint and flexion at interphalengeal joint

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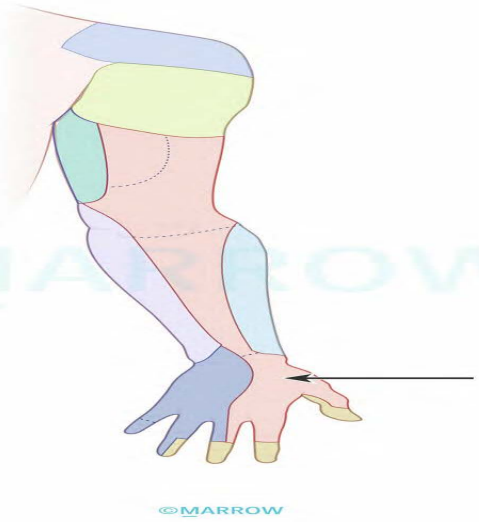
b) Extension at both metacarpophalengeal and interphalengeal joints

c) Flexion at both metacarpophalengeal and interphalengeal joints

d) Flexion at metacarphophalengeal joint and extension at interphalengeal joint

Question 29:

Nerve supply of the area marked by arrow in the image is:



a) Radial nerve

b) Posterior interosseus nerve

c) Median nerve

d) Ulnar nerve

Question 30:

True regarding the lesion of the structure marked by the arrow is:

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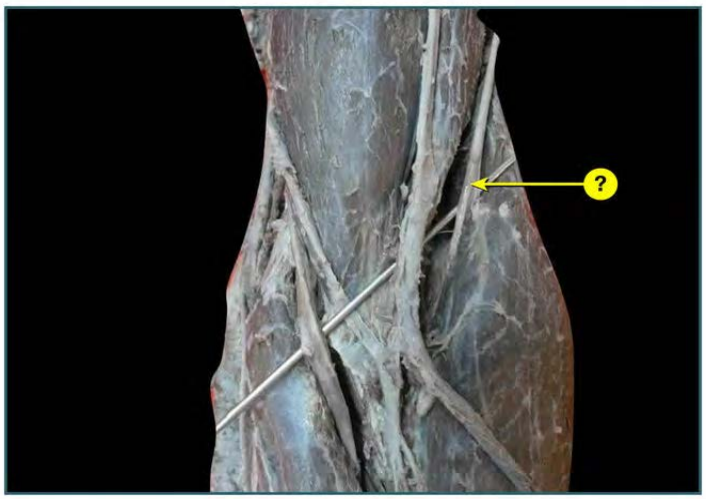

a) Ape thumb deformity

b) Claw hand

c) Claudication

d) Wrist drop

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Question 31:

A patient is unable to abduct his arm. Which of the following root values is likely to be affected?

a) C_4

b) C_5

c) C_6

d) C_7

Answer Key

Question No.	Correct Option
1	b
2	d
3	b
4	d

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5	c
6	a
7	b
8	c
9	c
10	a
11	d
12	c
13	b
14	b
15	b
16	d
17	b
18	c
19	a
20	b
21	b
22	c
23	b
24	d
25	b
26	b
27	c
28	a
29	a
30	d
31	b

Detailed Explanations

Solution to Question 1:

The given clinical scenario is suggestive of Horner's or Bernard-Horner's syndrome. It can be caused by the lesion of the white ramus of T1.

Horner's syndrome is characterized by a constricted pupil (miosis), drooping of the upper eyelid (ptosis), and an absence of sweating of the face (anhidrosis). It occurs due to the disruption of the sympathetic nerve supply.

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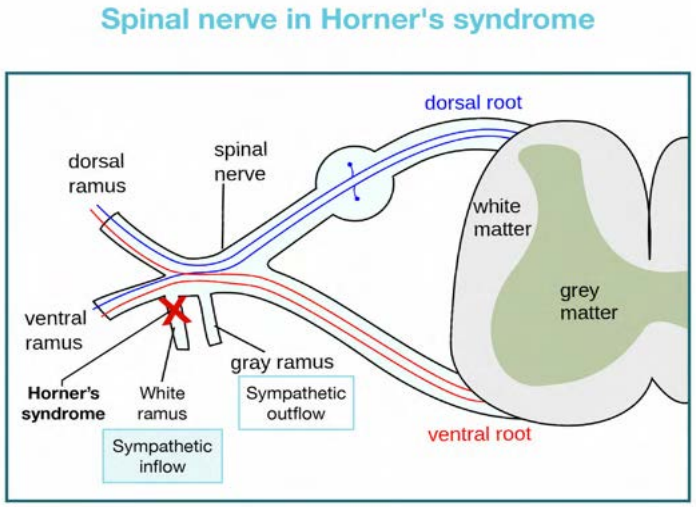
In the autonomic nervous system, the sympathetic plexus is thoracolumbar and the parasympathetic plexus is craniosacral.

The sympathetic plexus is formed along the side of the spinal cord by white ramus inflow (preganglionic nerve fibers) and gray ramus outflow (postganglionic) and it extends from T1-L2.

In Horner's syndrome, since the sympathetic inflow is disrupted, the white ramus of the spinal cord is affected as shown below.



The difference between the sympathetic and parasympathetic ganglions are tabulated below.

	Sympathetic ganglions	Parasympathetic ganglions
Location	Closer to the spinal cord	Closer to the organ
Pre-ganglionic fibers	Short	Long
Post-ganglionic fibers	Long	Short

Solution to Question 2:

The divisions in the brachial plexus do not give any branches.

However, the roots, trunks, and cords of the brachial plexus give out direct branches.

Solution to Question 3:

Arterial supply to brachial plexus is from branches of subclavian and vertebral arteries, and not from carotid arteries.

The upper/superior trunk of the brachial plexus gives two branches:

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• Suprascapular nerve (C5, C6)

• Nerve to the subclavius (C5, C6)

Radial nerve (C5, C6, C7, C8, T1) is the largest branch of the brachial plexus. It originates as the terminal branch of the posterior cord of the plexus.

Brachial plexus variations can be 2 types:

• C4 pre-fixed brachial plexus

• T2 post-fixed brachial plexus

Solution to Question 4:

The thoracodorsal nerve would be anesthetized in the infraclavicular nerve block as it is an infraclavicular branch of the brachial plexus. It arises from the posterior cord (C6-C8).

Branches of the brachial plexus that arise from the roots and trunk are supraclavicular branches. They include:

• Dorsal scapular nerve (C5)

• Long thoracic nerve of Bell (C5-C7)

• Suprascapular nerve (C5, C6)

• Nerve to Subclavius (C5, C6)

All the other branches of the brachial plexus that arise from the cords are infraclavicular branches.

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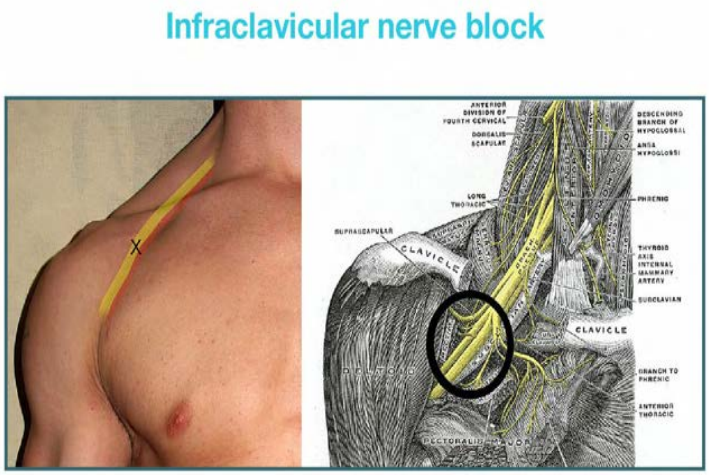

Solution to Question 5:

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In the given clinical scenario, upper cervical trunk injury causes Erb's or Erb-Duchene palsy. This palsy involves adduction and medial rotation at the shoulder, and not abduction.

The most common cause of Erb's palsy is the undue separation of head and neck i.e. fall on shoulder and birth injuries. The stretching causes damage to the upper trunk (C_5, C6). Hence, the affected nerves include:

• Suprascapular nerve

• Axillary nerve

• Musculocutaneous nerve

• Radial nerve

Erb's palsy has a typical presentation of a policeman's tip or waiter's tip hand deformity. It includes the following features:

• Arm is adducted and medially rotated at the shoulder joint

• Elbow joint is extended

• Radioulnar joint is pronated

• Sensory loss along the outer aspect of the arm

The given image below shows classic deformity seen in Erb's palsy.

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Solution to Question 6:

The axillary nerve or surgeon's nerve is frequently injured during inadvertent intramuscular (IM) injections.

The course of axillary nerve:

• It is a branch of the posterior cord of the brachial plexus in the axilla

• It exits the axilla through the quadrangular space to enter the arm

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• In the arm, it winds around the surgical neck of the humerus and gives cutaneous supply to the lower part of the deltoid (upper lateral cutaneous nerve of the arm)

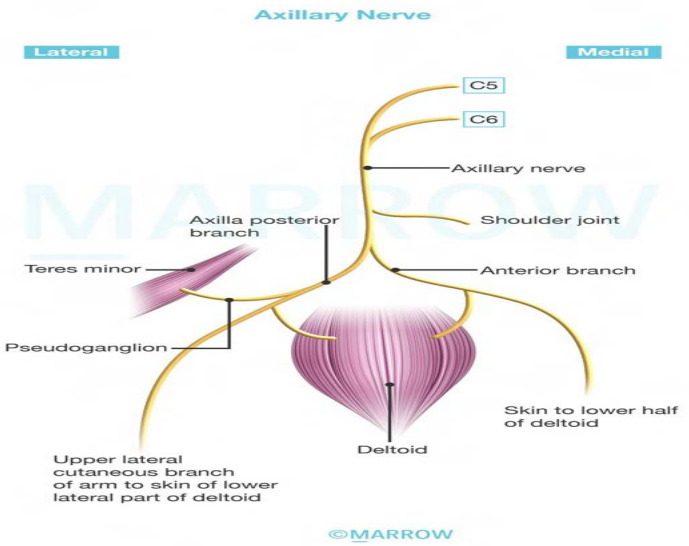
Injuries to the axillary nerve can be caused by:

• Fracture of surgical neck of humerus

• Inferior dislocation of the humerus

• Inadvertent IM injection

Test for axillary nerve involves testing sensations of skin over the lower part of the deltoid. In the case of axillary nerve lesions, there is a loss of sensations over this region. It is called regimental badge anesthesia.



Named nerves of the upper limb are:

• Laborer's nerve - median nerve

• Musician's nerve - ulnar nerve

• Surgeon's nerve - axillary nerve

• Nerve of Bell - long thoracic nerve

Solution to Question 7:

The median nerve is not directly related to the humerus.

Nerves related to the humerus:

• Axillary nerve is at the surgical neck

• Ulnar nerve is at the medial epicondyle

• Radial nerve is at the spiral groove of the shaft of the humerus.

Median nerve course:

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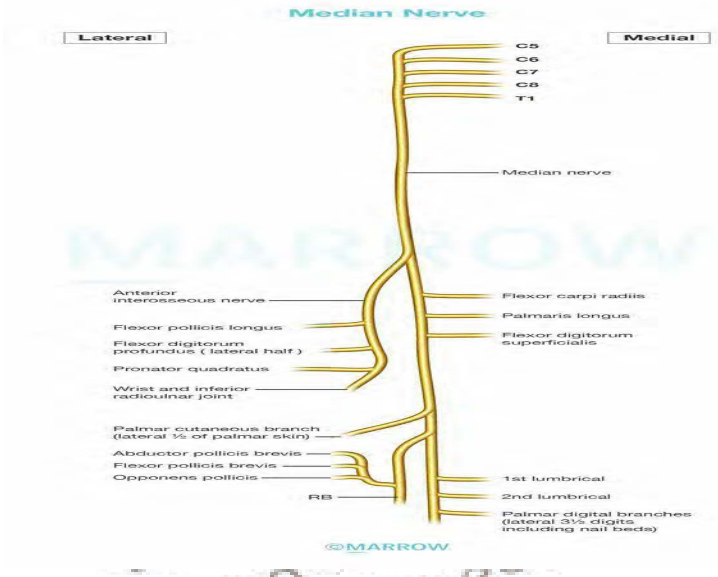
• Origin: Lateral and medial cords of the brachial plexus

• Axilla and arm: No muscle supply from the median nerve

• Forearm (flexor compartment): It supplies most superficial flexors. It leaves the cubital fossa between the 2 heads of Pronator teres and gives off the anterior interosseous nerve

• Before entering deep into the flexor retinaculum gives off a palmar cutaneous branch. At the distal end of the flexor retinaculum, it divides into a recurrent branch and palmar digital nerves



Solution to Question 8:

Injury to the median nerve at the wrist is tested by contraction of the abductor pollicis brevis. Loss of thumb mobility and opposition (abductor pollicis brevis) is tested by pen test.

Option A: Paralysis of flexor pollicis brevis can occur in median nerve injury at the arm and elbow. Benediction hand sign (attempt to make a fist gives pointed index and middle finger) and Ochsner's clasping test (attempt to clasp both hands show pointing index finger) are used to test such injuries.

The images below show the Benediction hand sign and Ochsner's clasping test.

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Benediction hand sign

Ochsner's clasping test

Option B: The lateral 1/2 of the palm is supplied by the palmar cutaneous branch of the median nerve. It is usually spared in median nerve injury to the wrist as it does not pass through the carpal tunnel.

Option D: The loss of sensation over ring finger cannot be tested for median nerve injury as it supplies:

• Lateral half of palmar aspect

• Medial half of distal 1/3 of dorsal aspect

Note: Out of three muscles in the thenar eminence only abductor pollicis brevis and opponens pollicis can be tested for isolated action. Flexor pollicis brevis cannot be tested for isolated action.

Solution to Question 9:

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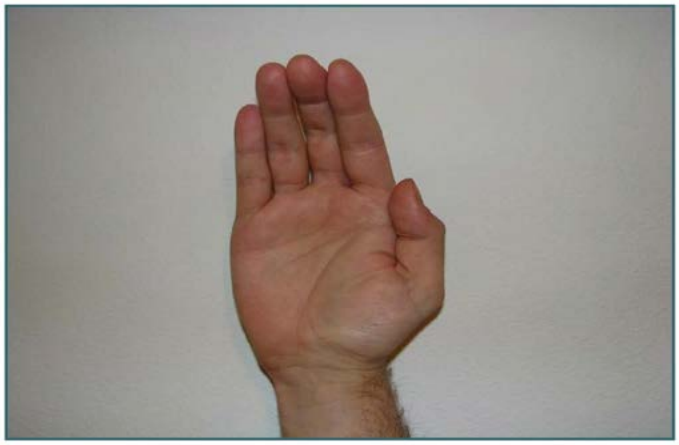
The nerve supply of the region marked in the image is the median nerve. The ape-thumb deformity is seen in the median nerve lesion irrespective of the site of the lesion, as it is a defect of the end of the nerve. It is caused by non-use atrophy of the muscles of the thenar eminence (except adductor pollicis).

Ape-thumb deformity



Median nerve supply:

The sensory nerve supply to hand by median nerve is given below.

Branch	Muscles/ region
Median nerve	Superficial flexors (pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum superficialis)Exceptions: flexor carpi ulnaris, medial half of flexor digitorum profundus
Anterior interosseous nerve	2 ½ muscles:Flexor pollicis longus, pronator quadratus, lateral half of FDP (medial half by ulnar nerve)
Recurrent branch	Thenarmuscles(except adductor pollicis)
Palmar cutaneous branch	Lateral 2/3rd of palm
Palmar digital nerves	Lateral 2 lumbricalsSkin over the lateral 3 ½ digits

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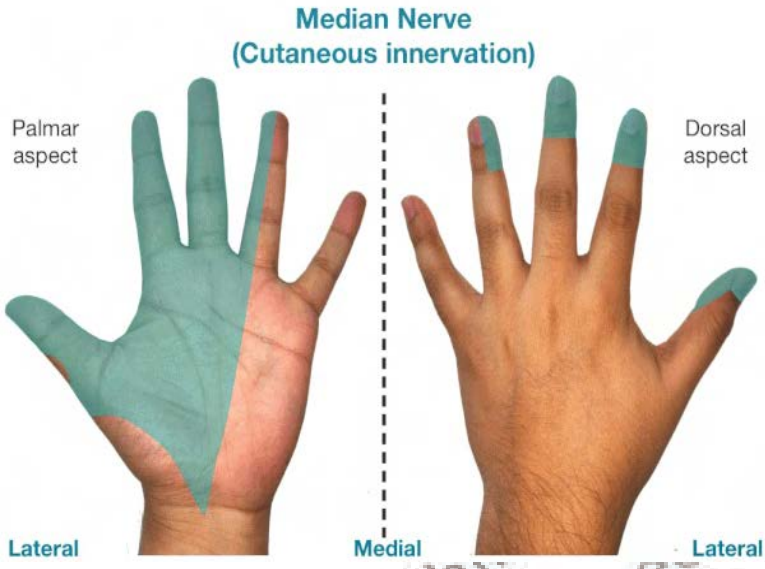

Option A: Adductor pollicis is innervated by the ulnar nerve.

Option B: Median nerve innervates lateral half of flexor digitorum profundus. Ulnar nerve innervates medial half of flexor digitorum profundus.

Option D: Wrist drop is seen in radial nerve palsy.

Note: Thenar muscles include abductor pollicis, adductor pollicis, opponens pollicis, and flexor pollicis brevis. Adductor pollicis is called the graveyard of the ulnar nerve because after supplying all other muscles medially it ends laterally in adductor pollicis.

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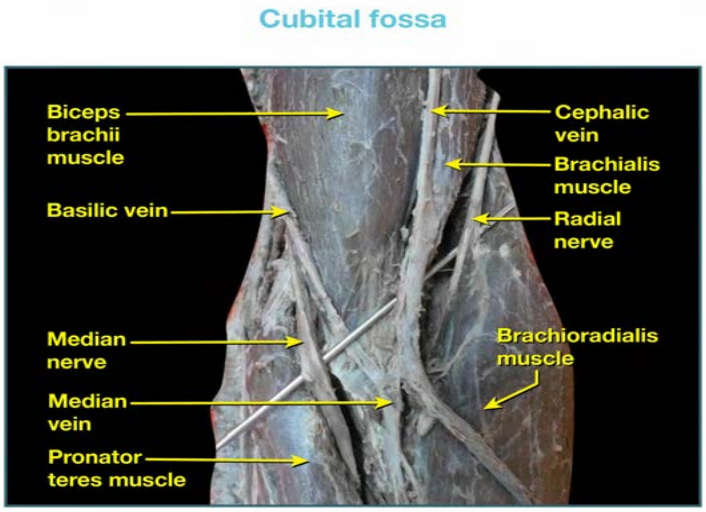
Solution to Question 10:

The structure marked 'A' in the diagram is median nerve in the cubital fossa. A lesion of the median nerve causes loss of sensation of the nail of the index finger.



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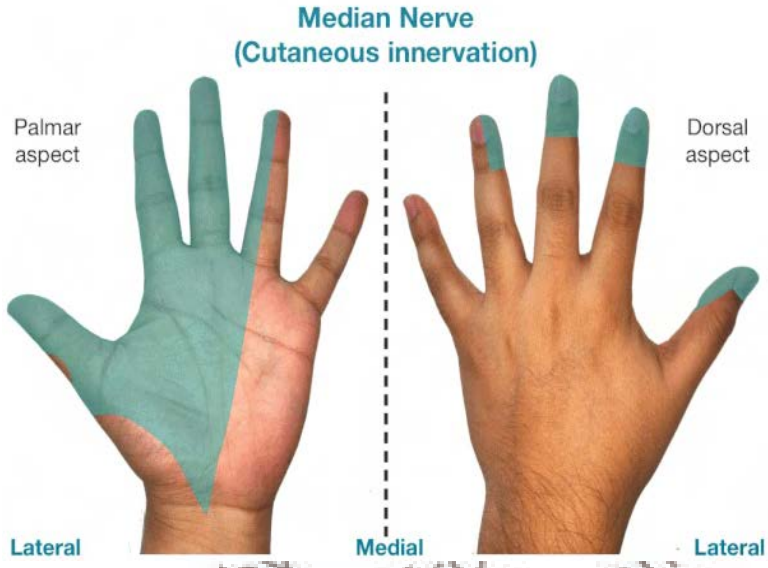
Median nerve cutaneous supply:

• Lateral 2/3rd of the palm by superficial cutaneous branch

• Lateral 3½ fingers (palmar aspect and dorsal aspect of nailbeds) by palmar digital nerves



Contents of cubital fossa: (From medial to lateral) - "MBBR"

• Median nerve

• Brachial artery

• Biceps brachii tendon

• Radial nerve

Solution to Question 11:

The ulnar nerve supplies the palmar interossei.

The course of the ulnar nerve:

• A branch of the medial cord of the brachial plexus

• No muscle supply in the axilla and arm

• Up to midarm, it passes medial to the brachial artery

• After midarm, it inclines posteromedially to perforate the medial intermuscular septum and passes through a fibrous canal called arcade of Struthers (not to be confused with supinator arch or arcade of Frohse which is over radial nerve deep branch).

• In the upper forearm, it passes between the 2 heads of FCU and gives off some branches

• In the distal forearm, it gives off a dorsal cutaneous branch

• In the wrist, it passes superficial to flexor retinaculum but under a fascial band lateral to pisiform called Guyon's ulnar tunnel

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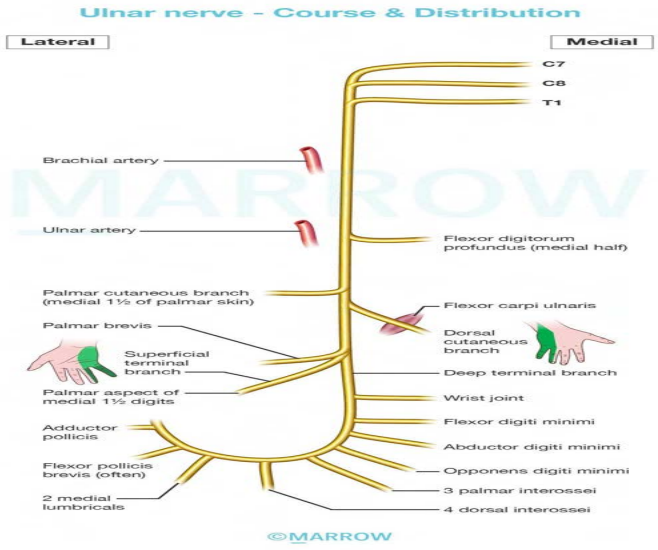
• Distal to pisiform it gives 2 terminal branches. One superficial terminal and another deep terminal



Ulnar nerve supply:

The image given below shows the cutaneous innervation of the hand by the ulnar nerve.

Branches	Muscles/ region
Upper forearm branches	Flexor carpi ulnarisMedial half of flexor digitorum profundus
Dorsal cutaneous branch (distal forearm)	Dorsum of medial 1/3 of hand and medial 1 1/2 fingers
Palmar cutaneous branch (near the wrist)	Hypothenar eminence
Superficial terminal branch	Palmaris brevisPalmar surface of medial 1 1/2 fingers
Deep terminal branch	All intrinsic muscles of the hand (except first 2 lumbricals and thenar eminence)

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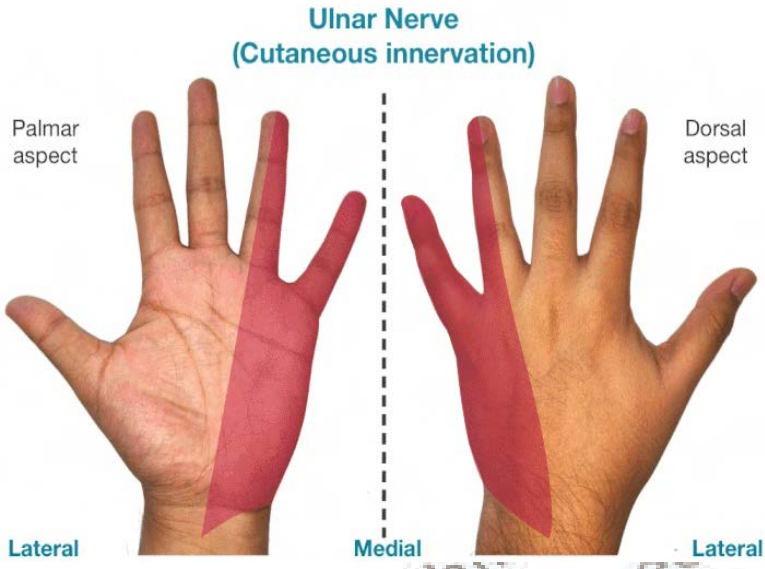

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Solution to Question 12:

The given clinical situation suggests an ulnar nerve injury. The most likely site of injury would thus be medial epicondyle (marked as C).

Tests for ulnar nerve lesions are as follows:

- Card test positive
- Claw hand deformity
- Froment's sign positive
- Wartenberg sign
- Palmaris brevis sign

Positive card test is due to weakness of palmar interrosei, causing loss of adduction. As a result, the patient is unable to hold the card firmly between his or her fingers.

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Option A: It is the radial groove where radial nerve runs along with profunda brachii artery.

Option D: It is the neck of humerus where axillary nerve runs around.

Option B: It is the lateral epicondyle. Fracture of this part may lead to tardy ulnar nerve palsy, but incidence is less.

Solution to Question 13:

The given clinical scenario is suggestive of an injury to the ulnar nerve lesion before its division into a superficial and deep branch, as the function of both branches is affected.

The ulnar nerve after passing distal to pisiform bone gives 2 terminal branches:

• Superficial branch which supplies

• Palmaris brevis

• Skin on the palmar surface of medial 1½ fingers

• Deep branch runs within the concavity of deep palmar arch. It supplies all intrinsic muscles of the hand (except first 2 lumbricals and thenar muscles)

Injury to the ulnar nerve:

Given below is the Froment test used to test adductor pollicis.

Site of injury	High lesion(Elbow)	Low lesion(Wrist)
Causes	Fracture/dislocation of theme dial epicondyleCubital tunnel syndromeCompression betw een the two heads of FCUTar dy ulnar nerve palsy (Valgus deformity)	Wrist laceration/ slashingGuy on's canalsyndrome

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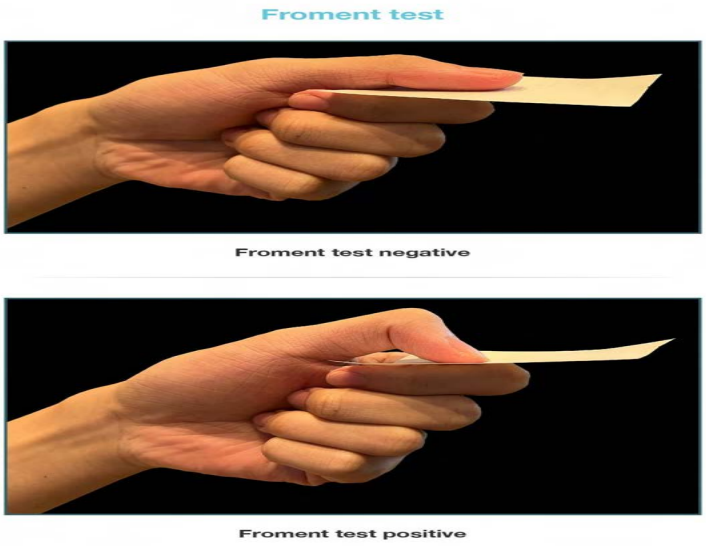
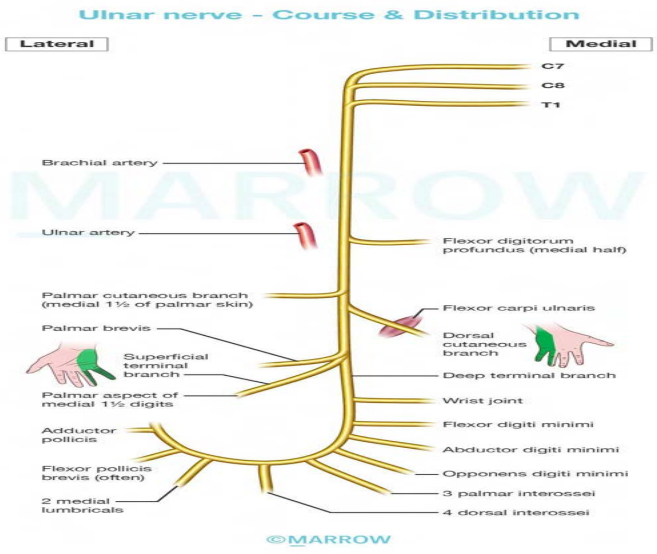
Site of injury	High lesion(Elbow)	Low lesion(Wrist)
Motor loss	Claw-handdeformityHypothenar & interosseous wastingLoss of:• Abduction & adduction of fingers(Card test- Positive)• Adduction of thumb(Froment sign-Positive)• Flexion of MCP jointsWeakness of wrist flexion (radial deviation)	Claw-handdeformity(more pronounced)Hypothenar & interosseous wastingLoss of:• Abduction & adduction of fingers(Card test- Positive)• Adduction of thumb(Froment sign-Positive)
Sensory loss	Over dorso-ulnar aspect of the palm	Over palmar aspect of themedial 11/2fingers



Given below is the course of the ulnar nerve.



Note: Wartenberg's sign is used to assess the weakness of palmar interossei.

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Solution to Question 14:

Loss of adduction points toward the deep ulnar nerve injury. The hypothenar injury could have caused downstream loss of innervation of the deep ulnar nerve which innervates adductor pollicis in thenar eminence.

The course of deep ulnar nerve:

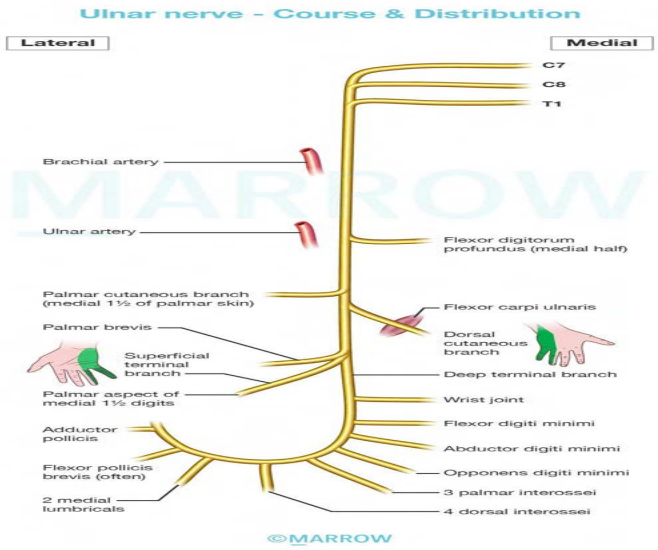
• At its origin, it innervates the hypothenar muscles.

• As it crosses the deep part of the hand, it innervates all the interosseous muscles and the third and fourth lumbricals.

• It ends by innervating the adductor pollicis and the medial (deep) head of the flexor pollicis brevis.

• It also sends articular filaments to the wrist joint following Hilton's law.

Given below is the course of the ulnar nerve.



Solution to Question 15:

Paralysis of all interossei is seen in injury to the ulnar nerve in the elbow.

All interossei (dorsal and palmar) are supplied by ulnar nerve.

• Dorsal Interossei - Abduction (DAB)

• Palmar Interossei - Adduction (PAD)

Note: Median nerve and ulnar nerve injury lead to a total claw hand.

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Solution to Question 16:

The radial nerve, ulnar nerve, and median nerve can be tested using the thumb.

The muscles of thumb that are affected in the different nerve injuries are:

Nerve injury	Thumb muscle affected	Thumb movement lost
Median nerve	Opponens pollicis	Thumb opposition
Ulnar nerve	Adductor pollicisPalmar interossei	Adduction of thumb
Radial nerve	Abductor pollicis longus (APL)Extensor pollicis brevis (EPB)Extensor pollicis longus (EPL)	Thumb extension

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Solution to Question 17:

The lower lateral part of the arm is innervated by the lower lateral cutaneous nerve of the arm. It is one of the 5 branches of the radial nerve in the spiral groove.

The course of the radial nerve:

• It is the largest branch of the brachial plexus (C5, 6, 7,8, T1).

• It leaves the axilla by passing through the lower triangular space.

• It enters the arm and runs along the radial groove with profunda brachii artery. It gives the following branches:

• Lower lateral cutaneous nerve of arm

• Posterior cutaneous nerve of forearm

• Branch to lateral head of triceps

• Branch to medial head of triceps

• Branch to anconeus

• In the forearm, it divides in to 2 branches superficial (sensory) and deep (motor) branch at the cubital fossa.

• Superficial branch crosses the tendon of brachioradialis and goes posterior to supply dorsum of the hand.

• Deep branch/ posterior interroseous nerve pierces the supinator and supplies the extensors in the forearm.

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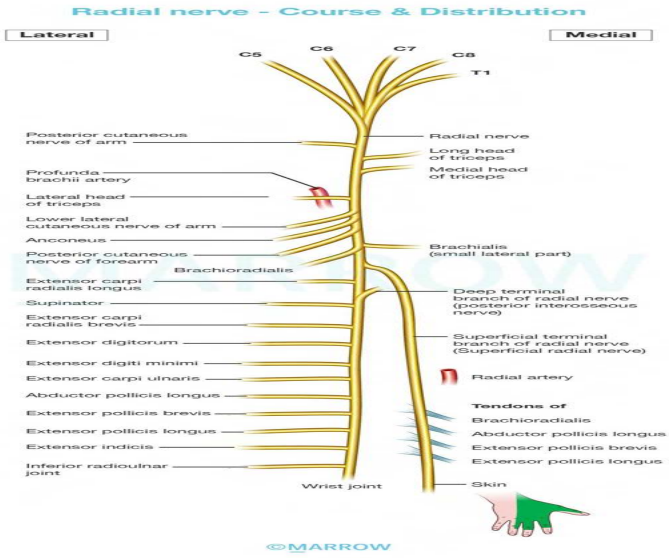

Solution to Question 18:

In the given clinical scenario, there is a likely injury to the posterior interosseous nerve.

It is prone to be injured in radial head fractures as the nerve winds around the radial neck to go into the posterior compartment of the forearm. There is no cutaneous sensory loss in lesions confined to the posterior interosseous nerve.

The radial nerve divides into 2 branches, namely superficial (sensory) and deep (motor) branches at the cubital fossa.

Deep radial nerve after supplying extensor carpi radialis brevis (ECRB) and supinator, continues as posterior interosseous nerve (PIN). From the posterior compartment, the supinator muscle wraps around the upper 1/3rd of the radius to reach the anterior compartment.

PIN arches and winds around the radial neck along with the supinator muscle, into the posterior compartment of the forearm. Hence, it is in close relation with the radial head and neck, and the supinator arch or arcade of Froese.

There is no cutaneous innervation by the posterior interosseous nerve.

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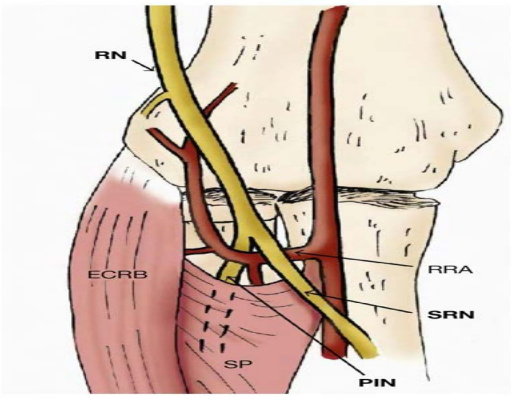
Placement of nerves around the elbow



PIN	-	Posterior interosseous nerve
RN	-	Radial nerve
SRN	-	Superficial radial nerve
RRA	-	Radial recurrent artery
ECRB	-	Extensor carpi radialis brevis
SP	-	Supinator muscle

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Solution to Question 19:

Sensations over the thumb and index finger are lost in C6, C7 nerve root injuries.

The palmar pad of the thumb is innervated by C6 and the pad of the index finger is innervated by C7.

Solution to Question 20:

A tap on the tendon of the triceps posterior to the elbow mainly tests for C7.

A tap on the tendon of the biceps in the cubital fossa tests mainly for spinal cord level C6.

Solution to Question 21:

The lateral head of the triceps is paralyzed in a lesion of the radial nerve in the lower spiral groove.

Spiral groove injuries could be upper or lower (proximal or distal). The following muscles are affected:

• Lateral head of triceps - as branching happens in the lower spiral groove

• Anconeus - as branching happens from the upper spiral groove

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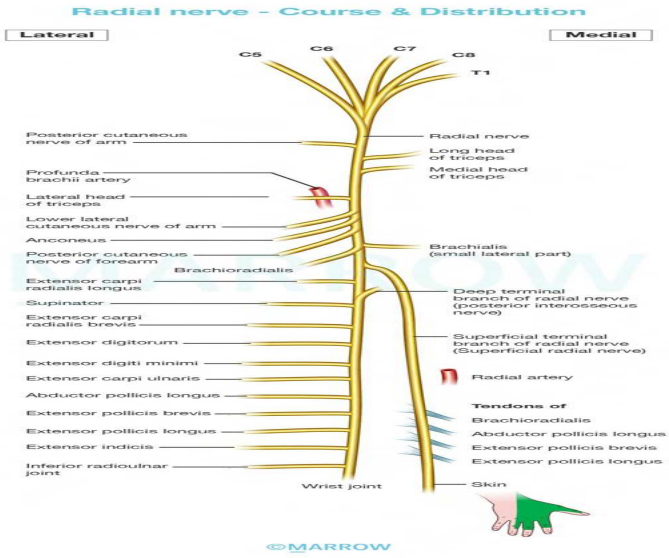

Option A: Radial nerve branches from the posterior cord of the brachial plexus. It leaves the axilla by passing through the lower triangular space.

Option C: Anconeus is supplied by a branch arising in the spiral groove.

Option D: In the arm, it runs along the radial groove with the profunda brachii artery.

Solution to Question 22:

Paresthesia over the skin of thenar eminence is not seen in carpal tunnel syndrome. As the median nerve gives off the palmar cutaneous branch, that supplies the thenar eminence before it enters the carpal tunnel.

Carpal tunnel syndrome is due to compression of the median nerve due to:

• Reduced size of the osseofibrous carpal tunnel

• Inflammation or thickening of the synovial sheaths of the flexors tendons (tenosynovitis) due to stress injury (eg., occupational)

• Inflammation of the flexor retinaculum

• Arthritic changes in the carpal bones (particularly rheumatoid arthritis)

The pain and paresthesia are worse at night and on gripping objects.

Structures passing through the carpal tunnel:

• Tendons of FDS (flexor digitorum superficialis), FDP (flexor digitorum profundus), FPL (flexor pollicis long)

• Median nerve

No artery passes through the carpal tunnel.

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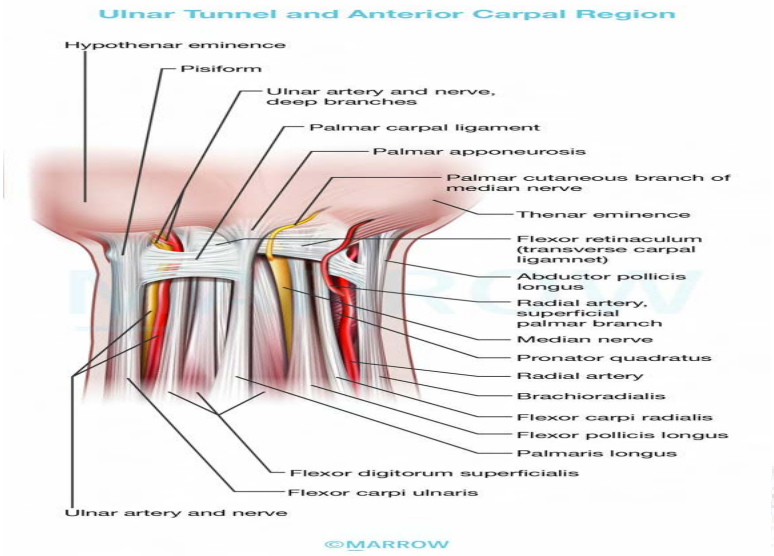

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Solution to Question 23:

The median nerve is likely to be injured in case of deep laceration of the radial side of the wrist, whereas the radial nerve is least likely to be injured.

Wrist slash injuries:

A deep laceration on the radial side of the wrist may injure the following structures:

- Radial artery
- Median nerve
- Flexor carpi radialis tendon
- Palmaris longus tendon

A deep laceration on the ulnar side of the wrist may injure the following structures:

- Ulnar artery
- Ulnar nerve
- Flexor carpi ulnaris tendon

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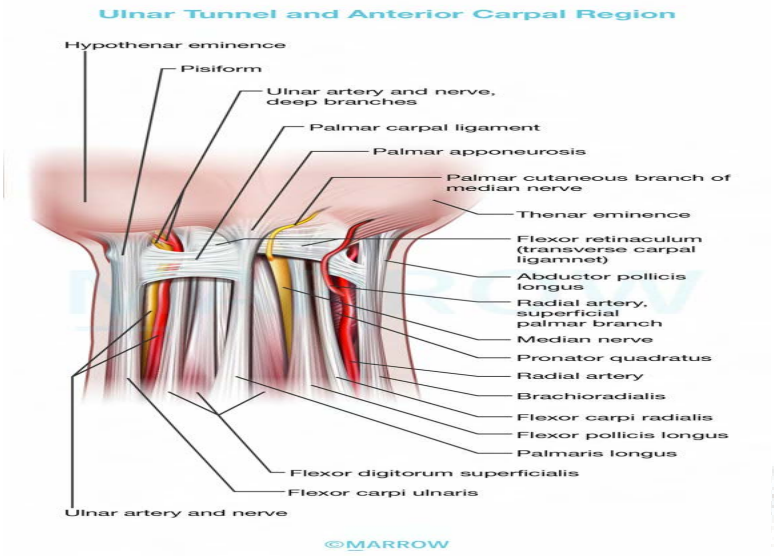

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Solution to Question 24:

The structure marked in the image is the Guyon's canal. The roof of Guyon's canal is formed by the palmar carpal ligament and palmaris brevis.

Guyon's canal is a 4 cm long canal formed by splitting of the flexor retinaculum along the anteromedial side of the wrist.

Boundaries:

- Ulnar/Medial side - Pisiform bone, flexor carpi ulnaris, and abductor digiti minimi
- Lateral - Hook of hamate, extrinsic flexor tendons, and the transverse carpal ligaments
- Floor - Flexor retinaculum and pisohamate ligaments
- Roof - Palmar carpal ligament and palmaris brevis

Contents:

- Ulnar nerve
- Ulnar artery

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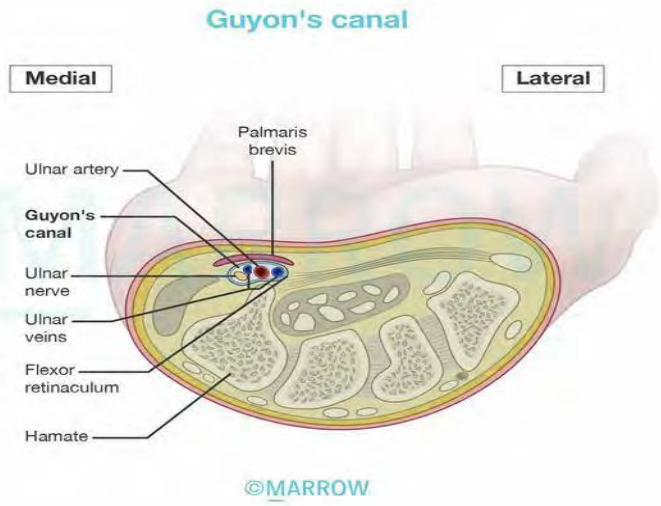

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Solution to Question 25:

Injury to the medial epicondyle injures the ulnar nerve. Since flexor digitorum superficialis (supplied by median nerve) and extensor digitorum (supplied by the radial nerve) are still functional, complete paralysis of the third and fourth digits is not seen.

Injury to the medial epicondyle damages the ulnar nerve. This causes:

- Paralysis of:
- Flexor carpi ulnaris (FCU) - loss of ulnar deviation
- Medial half of flexor digitorum profundus (FDP) - loss of distal interphalangeal joint flexion
- Hypothenar paralysis - lead to atrophy
- Sensory loss over medial 1/3 of hand and medial 1 1/2 fingers

Solution to Question 26:

Injury to the long thoracic nerve during radical mastectomy paralyzes the serratus anterior muscle. This can be tested by raising the arm above the head on the affected side.

Shrugging of the shoulders is mainly carried out by the trapezius, which is supplied by the spinal accessory nerve. This muscle works with the serratus anterior for overhead abduction.

Pectoralis major, supplied mainly by medial and lateral pectoral nerves, causes flexion at the shoulder joint. It is involved in touching the opposite shoulder.

Solution to Question 27:

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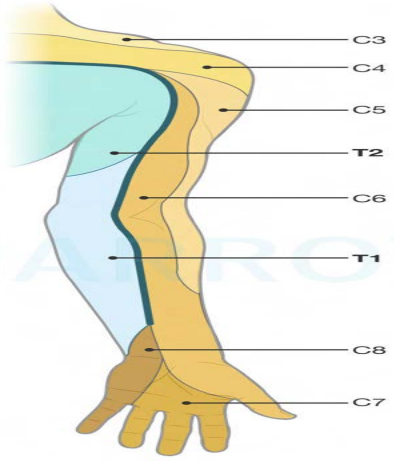
The anterior axial line extends till the wrist joint.

The axial line is the junction between two dermatomes supplied by discontinuous spinal nerves.

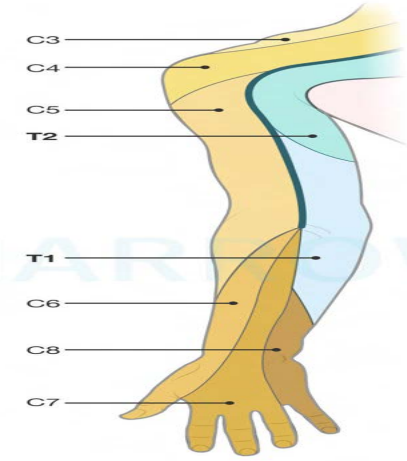
• The anterior axial line starts from the sternal angle (second rib) and extends to the wrist joint level.

• The posterior axial line begins at the shoulder and reaches the elbow joint level.

The images given below show the dermatomes of the upper limb with a dark green line indicating the axial line.



Dermatomes in the Upper Limb
Anterior aspect
©MARROW



Dermatomes in the Upper Limb
Posterior aspect
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Solution to Question 28:

Extension at the metacarpophalangeal joint and flexion at interphalangeal joints due to ulnar nerve injury produces claw hand (main en griffe).

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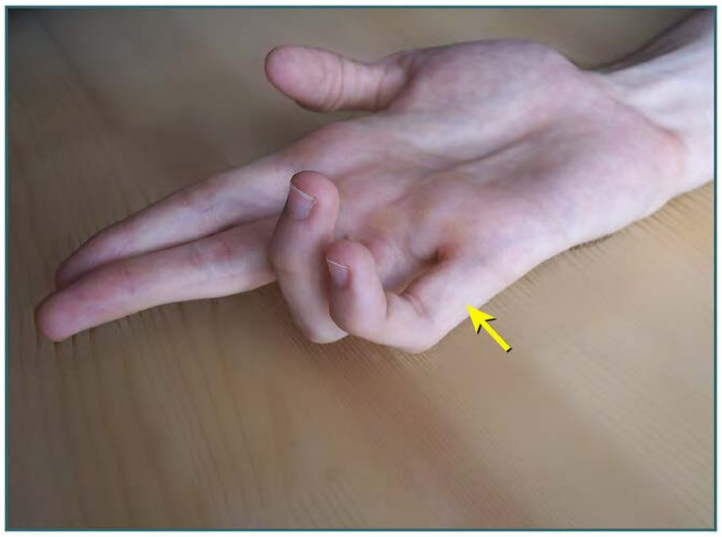
The ulnar nerve supplies medial two lumbricals in the hand. The lumbricals have a combined action on metacarpophalangeal (MCP) joint flexion and interphalangeal (IP) joint extension (glass holding posture).

In ulnar nerve injury, since the medial lumbricals are not functional, the forearm muscles are unopposed. MCP joint goes into hyperextension (unopposed activity of extensor digitorum, posterior forearm) and IP joints go into flexion (unopposed activity of flexor digitorum muscles, anterior forearm) and they bring about the claw hand deformity.

The image given below shows the ulnar claw hand (main en griffe). Note the hyperextension at MCP joints and flexion at IP joints.



Signs	Ulnar claw	Hand of Benediction
Clinical presentation		
Seen on	Extending fingers/ at rest	Making a fist
Nerve affected	Distal ulnar nerve	Proximal median nerve

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Solution to Question 29:

The area marked in the image is supplied by radial nerve.

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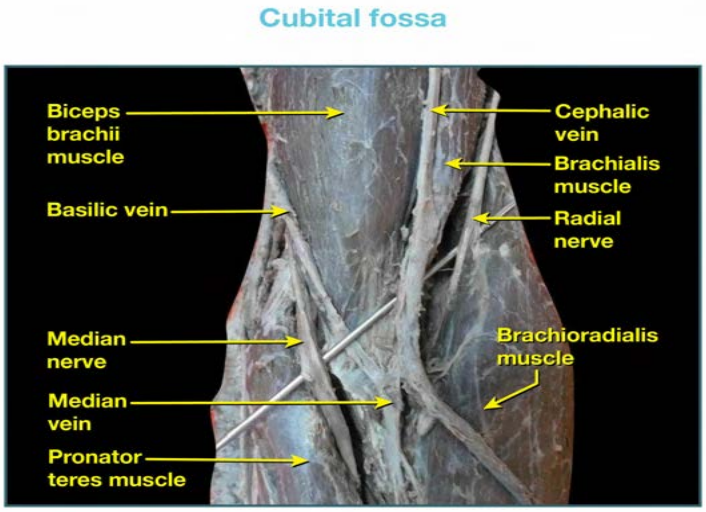
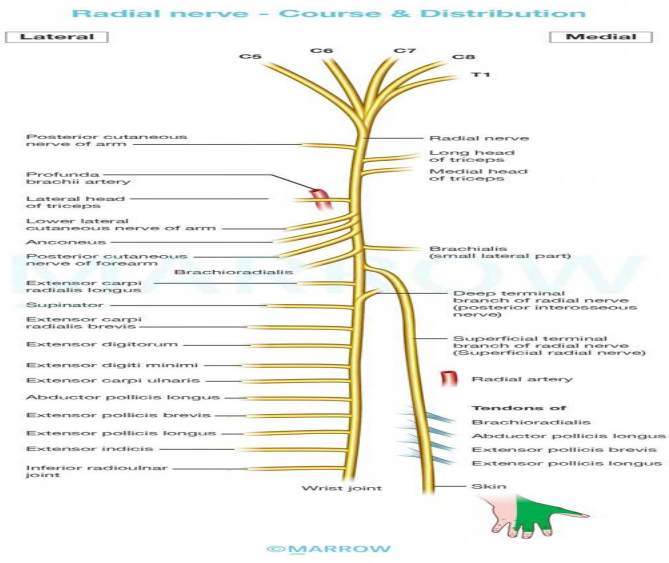
Solution to Question 30:

The structure marked in the image is the radial nerve demonstrated in the cubital fossa. A lesion of the radial nerve leads to a wrist drop.





Ape thumb deformity is seen in a lesion of the median nerve.

Claw hand deformity is seen in a lesion of the ulnar nerve.

Solution to Question 31:

The inability to abduct the arm is most likely due to a lesion of the C5 root.

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The deltoid muscle is the main muscle involved in the abduction of the arm. It is innervated by the C5 root of the axillary nerve. So, a lesion involving the C5 causes inability to abduct the arm.

The table below shows the movements and muscles tested to determine the location of the lesion in the upper limb.

Arm movement	Muscle	Root	Nerve
Shoulder abduction	Deltoid	C5	Axillary
Elbow extension	Triceps	C7	Radial
Elbow flexion	BicepsBrachioradialis	C5/6 C6	MusculocutaneousRadial
Radial wrist extensor	Extensor carpi radialis longus	C6	Radial
Finger extensors	Extensor digitorum	C7	Posterior interosseus
Finger flexors	Flexor pollicis longus and flexor digitorum profundus, indexFlexor digitorum profundus, ring and little	C8C8	Anterior interosseousUlnar
Finger abduction	First dorsal interosseusAbductor pollicis brevis	T1T1	UlnarMedian

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Muscles - Upper Limb

Question 1:

A 22-year-old presented with pain and stiffness in the neck following a blow with a hockey stick. On examination, the right shoulder is drooping. Which of the following muscles is likely to be paralyzed?

a) Trapezius

b) Deltoid

c) Latissimus dorsi

d) Serratus anterior

Question 2:

All the following nerves can cause winging of the scapula if injured, except:

a) Dorsal scapular nerve

b) Spinal accessory nerve

c) Long thoracic nerve

d) Thoracodorsal nerve

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Question 3:

A 32-year-old male was brought to the emergency department after being injured in mob violence. The patient had a penetrating injury in the right shoulder region by a sharp glass piece. On examination, there was drooping of the right shoulder associated with winging of the scapula. Which of the following nerves is likely to be injured?

a) Long thoracic nerve

b) Thoracodorsal nerve

c) Spinal accessory nerve

d) Dorsal scapular nerve

Question 4:

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Which of the following muscles will not be involved in a patient with full-thickness rotator cuff tear?

a) Teres minor

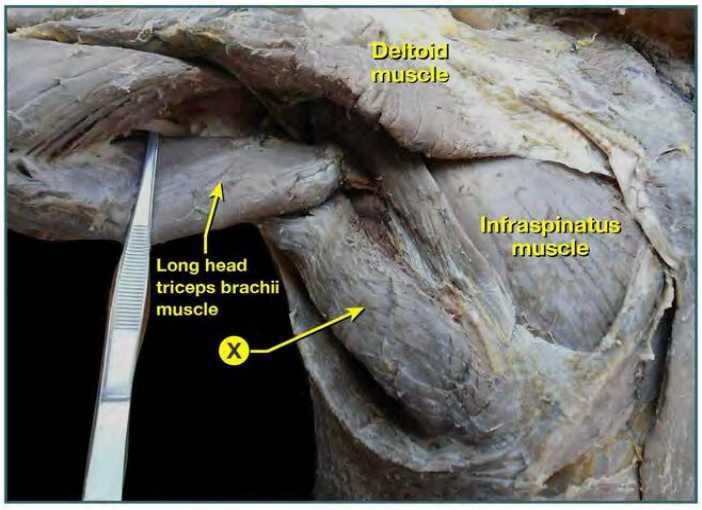
b) Teres major

c) Infraspinatus

d) Subscapularis

Question 5:

What is the nerve supply to the muscle marked in the diagram below?



a) Axillary nerve

b) Lower subscapular nerve

c) Supra scapular nerve

d) Radial nerve

Question 6:

Following radical mastectomy, the patient is unable to extend, adduct, and internally rotate the arm. Innervation to which of the following muscles is likely to be damaged?

a) Deltoid

b) Teres minor

c) Latissimus dorsi

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d) Pectoralis major

Question 7:

Which of the following muscles is not involved in the overhead abduction of the arm?

a) Serratus anterior

b) Deltoid

c) Trapezius

d) Pectoralis major

Question 8:

A 38-year-old man had recently joined a gym to improve his physical health. He attempted to lift a 30 Kg dumbbell but developed sudden pain in his right arm. He came to the casualty with an abnormal bulge over his arm as shown in the image below. Which of the following tendons is most likely to be injured?

a) Brachialis tendon

b) Distal tendon of biceps

c) Proximal tendon of biceps

d) Long belly of biceps

Question 9:

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Which of the following muscles cross both the shoulder and elbow joint?

a) Brachialis and biceps brachii

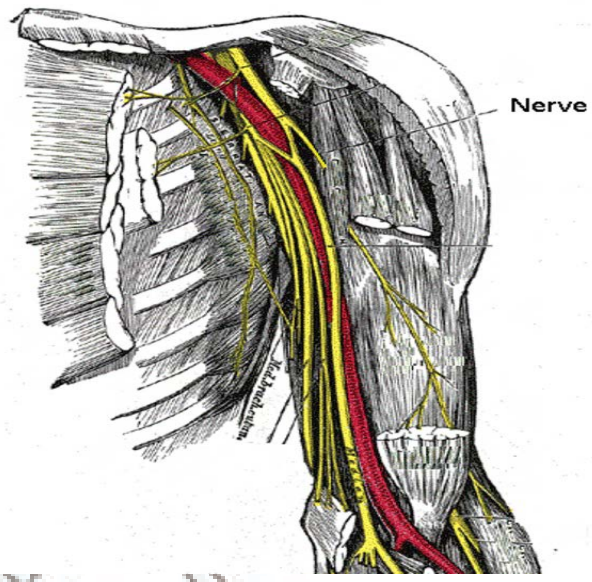
b) Coracobrachialis and biceps brachii

c) Long head of triceps and brachialis

d) Long head of triceps and biceps brachii

Question 10:

The structure pierced by the nerve in the diagram below is:



a) Short head of biceps

b) Long head of biceps

c) Coracobrachialis

d) Medial head of triceps

Question 11:

Which muscle is attached to the area marked in the diagram below?

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a) Biceps brachii

b) Brachialis

c) Brachioradialis

d) Long head of triceps

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Question 12:

Which of the following is not a composite muscle?

a) Brachialis

b) Flexor pollicis brevis

c) Trapezius

d) Flexor digitorum superficialis

Question 13:

All of the following muscles are innervated by the posterior interosseous nerve except:

a) Extensor carpi ulnaris

b) Extensor carpi radialis longus

c) Extensor digitorum

d) Extensor digiti minimi

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Question 14:

Which of the following is most likely to be affected in a patient with acute compartment syndrome of the anterior forearm?

a) Flexor carpi ulnaris

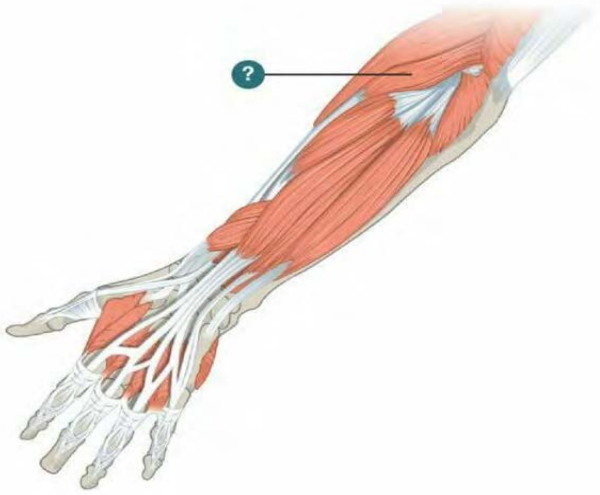
b) Flexor pollicis longus

c) Flexor carpi radialis

d) Palmaris Longus

Question 15:

The arrow in the image denotes which of the following muscles?



a) Extensor carpi radialis longus

b) Brachioradialis

c) Supinator

d) Flexor carpi radialis brevis

Question 16:

Which of the following muscle is unipennate?

a) 1st dorsal interossei

b) 4th dorsal interossei

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c) 3rd lumbricals

d) 2nd palmar interossei

Question 17:

A patient with hand weakness is being evaluated as shown below. The muscle being tested here does not have an attachment on which metacarpal?

a) 4th metacarpal

b) 2nd metacarpal

c) 3rd metacarpal

d) 5th metacarpal

Question 18:

What is the function of the muscle marked as A in the image below, at the metacarpophalangeal joint?

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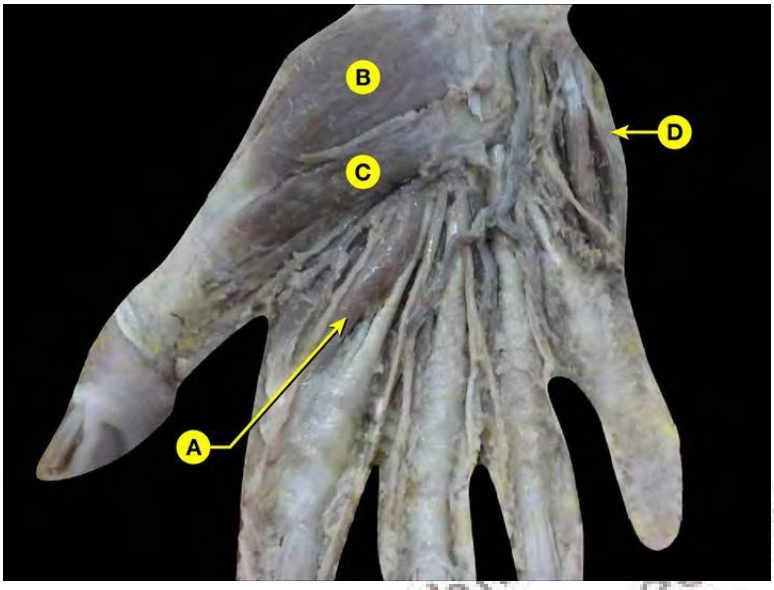

a) Flexion

b) Extension

c) Adduction

d) Abduction

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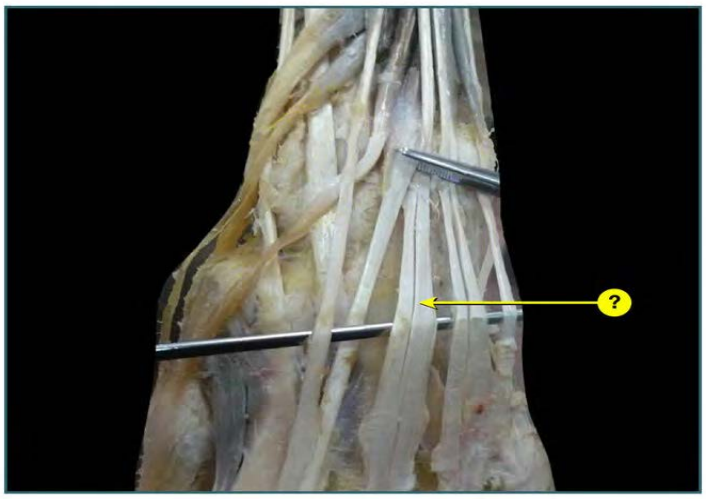
Question 19:

All of the following form the marked structure except:



a) 2nd Dorsal interossei

b) Lumbricals

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c) Extensor digitorum

d) 2nd Palmar interossei

Question 20:

A patient presented with the extension of MCP joint and flexion of IP joints. Which muscle is affected?

a) Extensor digitorum

b) Interossei and lumbricals

c) Abductor pollicis

d) Abductor pollicis brevis

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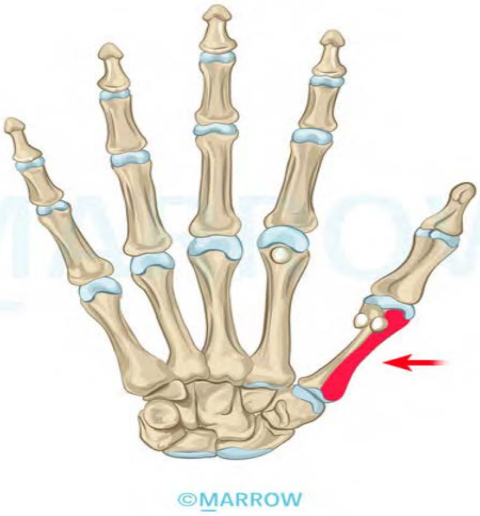
Question 21:

Which of the following muscles is attached to the area marked in the image below?



a) Abductor pollicis longus

b) Palmar interossei

c) Opponens pollicis

d) Flexor pollicis brevis

Question 22:

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Power grip of hand is a function of:

a) Long flexors

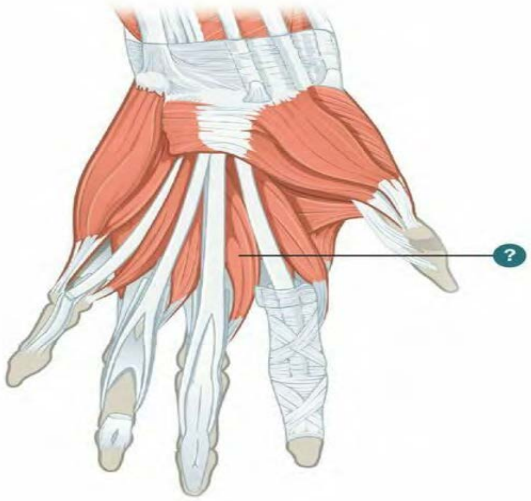
b) Short flexors

c) Palmaris brevis

d) Lumbricals

Question 23:

What is the nerve supply of the structure marked in the image below?



a) Posterior interosseus nerve

b) Median nerve

c) Anterior interosseus nerve

d) Ulnar nerve

Answer Key

Question No.	Correct Option
1	a
2	d
3	c

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4	b
5	b
6	c
7	d
8	c
9	d
10	c
11	a
12	d
13	b
14	b
15	a
16	d
17	c
18	a
19	d
20	b
21	c
22	a
23	b

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Detailed Explanations

Solution to Question 1:

The drooping of the shoulder is due to the paralysis of the trapezius muscle.

The trapezius is innervated by the spinal accessory nerve (CN XI). It causes:

• Retraction of scapula

• Shrugging of the shoulder

• Overhead abduction (along with serratus anterior)

Paralysis of the trapezius causes drooping of the shoulder and slight winging of the scapula (the superior angle of the scapula becomes more prominent).

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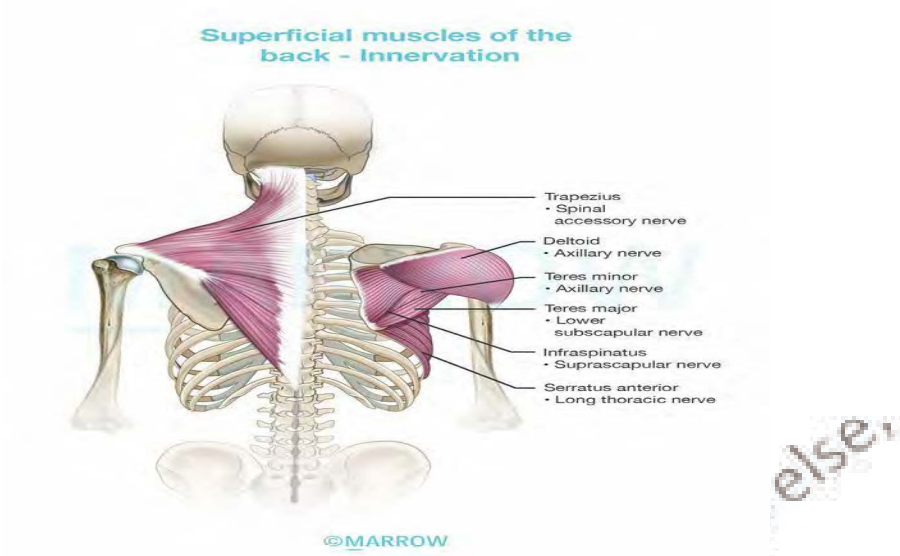

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Solution to Question 2:

The thoracodorsal nerve does not cause winging of the scapula. It supplies latissimus dorsi muscle and if injured, the patient will not be able to extend, adduct, or medially rotate the arm.

Nerves causing winging of scapula:

Nerves	Muscles	Type of winging
Spinal accessory nerve	Trapezius and sternocleidomastoid	The superior angle of the scapula becomes more prominent (lateral winging)
Long thoracic nerve	Serratus anterior	The scapula is pulled upwards and towards the spine by the unopposed action of the trapezius (medial winging)
Dorsal scapular nerve	Levator scapulae, rhomboid major, and rhomboid minor	Similar to serratus anterior but mild winging

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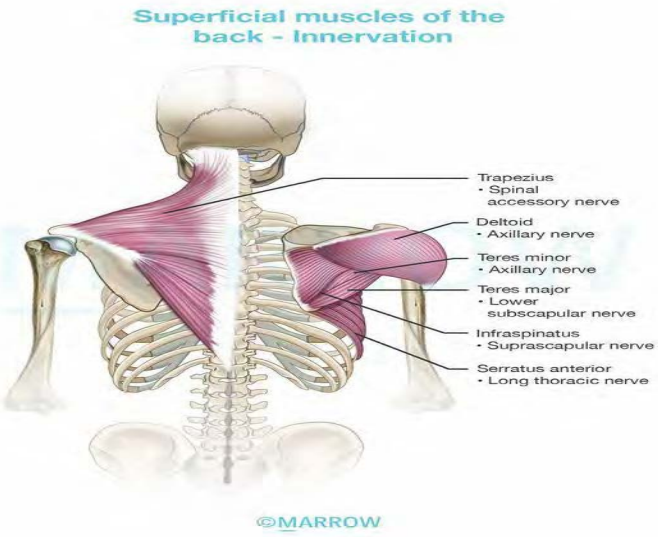

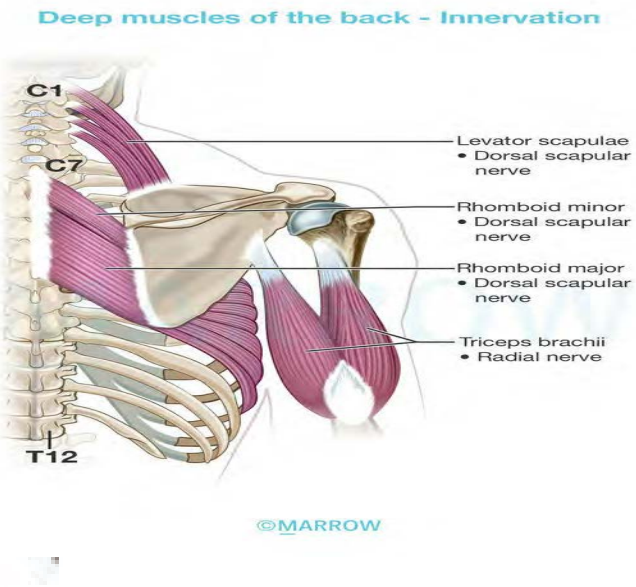

Solution to Question 3:

Injury to the spinal accessory nerve can cause both drooping of the shoulder and winging of the scapula.

The trapezius is innervated by the spinal accessory nerve (CN XI). It causes:

• Retraction of scapula

• Shrugging of the shoulder

• Overhead abduction (along with serratus anterior)

Nerves causing winging of the scapula:

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Nerves	Muscles	Type of winging
Spinal accessory nerve	Trapezius and sternocleidomastoid	The superior angle of the scapula becomes more prominent (lateral winging)
Long thoracic nerve	Serratus anterior	The scapula is pulled upwards and towards the spine by the unopposed action of the trapezius (medial winging)
Dorsal scapular nerve	Levator scapulae, rhomboid major, and rhomboid minor	Similar to serratus anterior but mild winging

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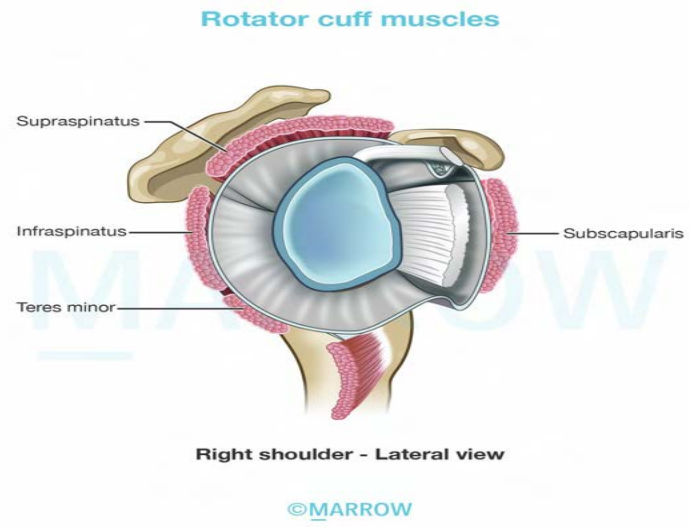
Solution to Question 4:

Tere major is not involved in a patient with rotator cuff tear.

The rotator cuff is a group of 4 muscles (SITS) that stabilizes the shoulder joint:



Solution to Question 5:

The muscle marked in the image is the teres major and it is supplied by the lower subscapular nerve.

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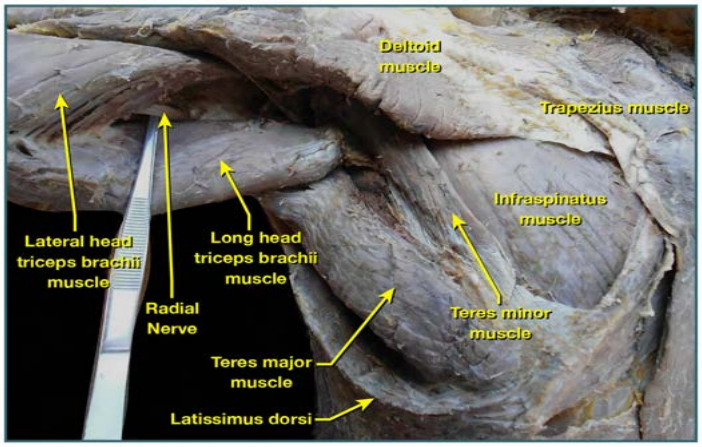
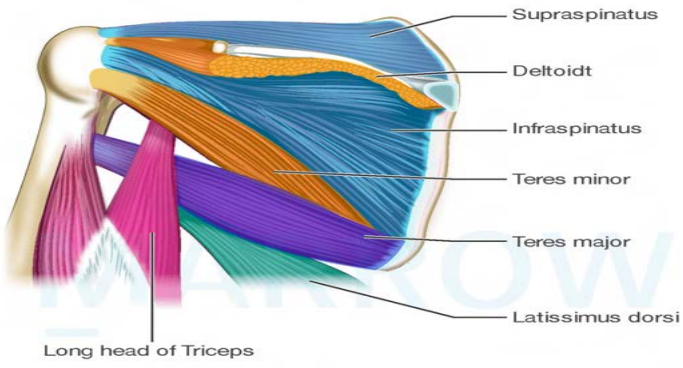
Upper limb muscles



Muscles and nerve innervation around shoulder



©MARROW

Solution to Question 6:

In the above scenario, innervation to latissimus dorsi is most likely to be damaged.

Latissimus dorsi is innervated by the thoracodorsal nerve, which could be injured during radical mastectomy. It has the following actions on the arm:

- Extension
- Adduction
- Medial rotation

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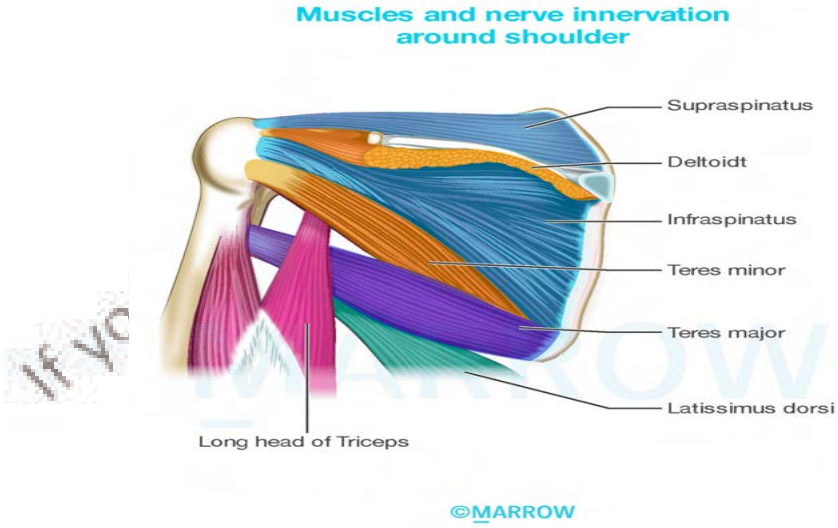
Muscles	Actions
Supraspinatus	Steadies the head of the hum erus during movements, abd uction of shoulder joint from 0-15°
Deltoid	Abduction, anterior fibers - fl exors and medial rotators, po sterior fibers - extensors and lateral rotators
Infraspinatus	Lateral rotator of the arm
Teres minor	Lateral rotator of the arm
Teres major	Adduction and medial rotatio n of the arm
Latissimus Dorsi	Adduction, medial rotation, a nd extension of the arm
The long head of the triceps	Extension of elbow joint
Pectoralis major	Adduction, medial rotation, a nd flexion of the arm



Solution to Question 7:

Pectoralis major is mainly involved in adduction and medial rotation of the arm and is not involved in the abduction of the arm.

Glenohumeral abduction is about 120° or more. The glenohumeral arthrodesis restricts the abduction at about 45°. Further abduction occurs at the sterno and acromioclavicular articulations, and contralateral vertebral flexion.

Muscles involved in the abduction of the shoulder:

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• The first 15° of abduction is initiated by the supraspinatus muscle.

• 15° to 90° of abduction is carried out mainly by the middle fibers of the deltoid muscle.

• Abduction of the arm, beyond 90°, is carried out by the movement of the shoulder girdle caused by the action of trapezius and serratus anterior.

Solution to Question 8:

The above image shows the Popeye sign, which is seen in the proximal biceps tendon rupture.

Popeye sign is seen on flexing the elbow. An extremely prominent bulge of the muscle belly occurs as its unrestrained fibers contract.

The proximal biceps tendon makes up 90-97% of all biceps tendon ruptures. In isolation, it has little effect on the upper limb function but produces a characteristic deformity called the Popeye sign.

Note:

The 4 most common areas of tendon rupture include quadriceps, achilles, rotator cuff (most commonly supraspinatus), and biceps.

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Solution to Question 9:

The long head of triceps and biceps brachii cross both shoulder and elbow joints, hence acting on both joints.

Muscles	Origin	Insertion	Innervation
Anterior compartment			
Coracobrachialis	Coracoid Process of scapula	The medial side of midshaft of humerus	Musculocutaneous nerve
Brachialis	Distal half of anterior aspect of humerus	Ulnar tuberosity	Musculocutaneous and radial nerve
Biceps Brachii	Short head: Coracoid processLong head: Supraglenoid tubercle	Radial tuberosity	Musculocutaneous nerve
Posterior compartment			
Triceps brachii	Long head: Infraglenoid tubercleMedial and Lateral heads: Posterior surface of Humerus	Olecranon process of ulna	Radial nerve

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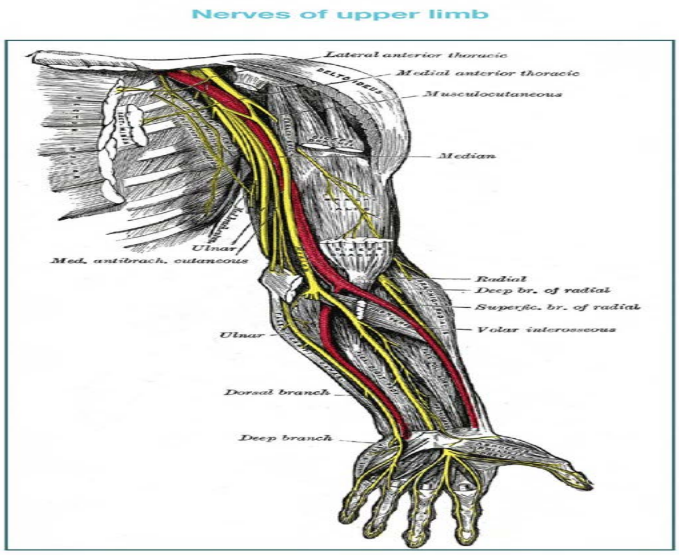
Solution to Question 10:

The nerve shown in the image is the musculocutaneous nerve. It penetrates and innervates the coracobrachialis.

In the axilla, the medial surface of the coracobrachialis is pierced by the musculocutaneous nerve, which innervates it and then passes through the muscle to enter the arm. Then innervates all the muscles of the anterior compartment of the arm (i.e. biceps brachii, and brachialis)



Solution to Question 11:

The image above shows the radius, identified by the radial head at the elbow joint. The arrow points to a raised area, which is the radial tuberosity. Biceps brachii is attached to the radial tuberosity.

The short head of the biceps brachii originates from the apex of the coracoid process and the long head arises from the supraglenoid tubercle of the scapula. Both the tendons end in a flattened tendon and are attached to the radial tuberosity. The nerve supply is by the musculocutaneous nerve (C5, C6).

Solution to Question 12:

Flexor digitorum superficialis (FDS) is not a composite muscle.

A composite muscle is innervated by more than 1 nerve. Since FDS is supplied by the median nerve (C8, T1) only, it is not a composite muscle.

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Muscle	Innervation
Subscapularis	Upper and lower subscapular nerves
P. Major	Medial and lateral pectoral n erves
Trapezius	Motor: Spinal accessory nerv eProprioception: C3, C4
Brachialis	Motor: Musculocutaneous ne rveProprioception: Radial ne rve
Flexor digitorum profund us	Medial half ulnar nerveLater al half anterior interosseous nerve
Flexor pollicis brevis	Superficial head: Median ner veDeep head: Deep branch of ulnar nerve

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Solution to Question 13:

Extensor carpi radialis longus (ECRL) and brachioradialis are supplied by the radial nerve (C6 and C7) before its division into superficial and deep branches in the lateral wall of the cubital fossa.

The deep branch of the radial nerve after penetrating the supinator is called the posterior interosseous nerve, which innervates all extrinsic wrist extensors except ECRL.

Muscles in the anterior compartment of the forearm:

Muscles	Innervation
Superficial layer	
Flexor carpi ulnaris (FCU)	Ulnar nerve
Palmaris longusFlexor carpi r adialis (FCR)Pronator teres	Median nerve
Intermediate layer	
Flexor digitorum superficialis	Median nerve
Deep layer	
Flexor digitorum profundus (FDP)	Lateral half: Anterior interos seous nerveMedial half: Ulna r nerve
Flexor pollicis longus (FPL)P ronator quadratus	Anterior interosseous nerve

Muscles of the posterior compartment of the forearm

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Muscles	Innervation
Superficial	
BrachioradialisExtensor carpi radialis longus (ECRL)	Radial nerve before division
Extensor carpi radialis brevis (ECRB)	Radial nerve deep branch before penetrating supinator
Extensor digitorumExtensor digiti minimiExtensor carpi ulnaris	Posterior interosseous nerve
Anconeus	Radial nerve
Deep	
SupinatorAbductor pollicis longus (APL)Extensor pollicis brevis (EPB)Extensor pollicis longus (EPL)Extensor indicis	Posterior interosseous nerve

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Solution to Question 14:

Flexor pollicis longus (FPL) is most likely to be affected in a patient with acute compartment syndrome of the anterior forearm as it is present in the deep layer.

Muscles in the anterior compartment of the forearm:

Muscles	Innervation
Superficial layer	
Flexor carpi ulnaris (FCU)	Ulnar nerve
Palmaris longusFlexor carpi radialis (FCR)Pronator teres	Median nerve
Intermediate layer	
Flexor digitorum superficialis	Median nerve
Deep layer	
Flexor digitorum profundus (FDP)	Lateral half: Anterior interosseous nerveMedial half: Ulnar nerve
Flexor pollicis longus (FPL)Pronator quadratus	Anterior interosseous nerve

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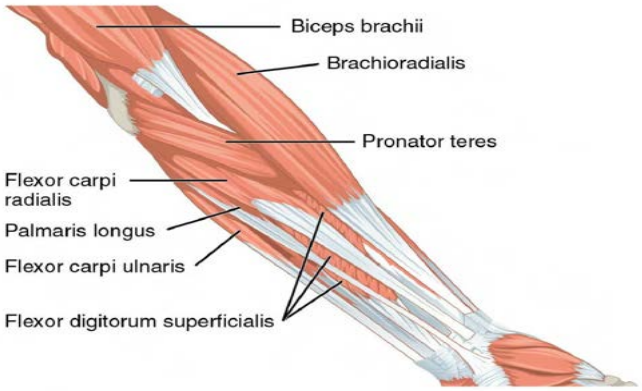
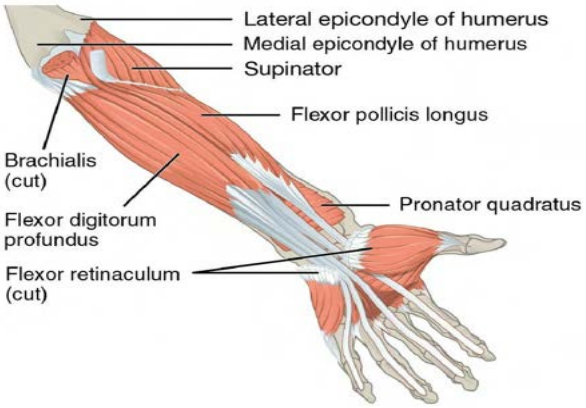
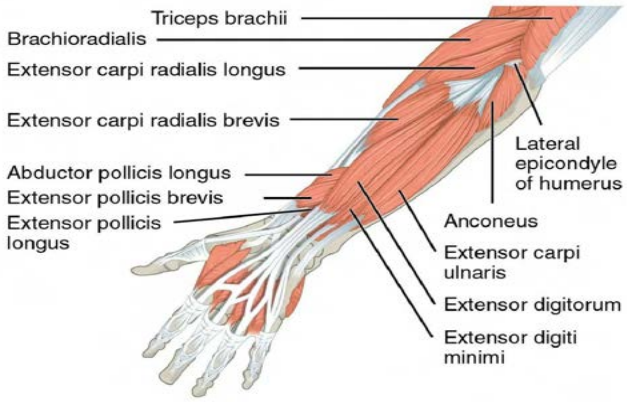
Left forearm superficial muscles (palmar view)



Left forearm deep muscles (palmar view)



Left forearm superficial muscles (dorsal view)



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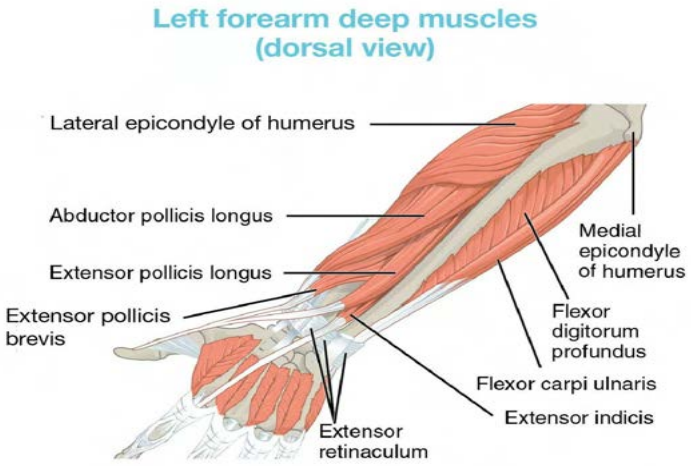

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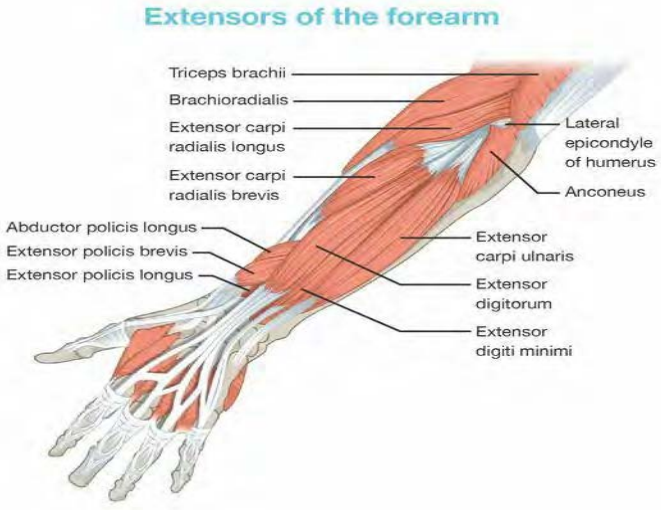
Solution to Question 15:

The arrow shows extensor carpi radialis longus.

It originates from the distal third of the lateral supracondylar ridge of the humerus and inserts at the second metacarpal (radial side). It is innervated by the radial nerve, C6, and C7.

The vascular supply is by radial recurrent artery and it is responsible for the extension and abduction of the wrist joint.



Solution to Question 16:

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Palmar interossei is a unipennate muscle.

A muscle with a central tendon towards which the fibers converge on either side is called the bipennate muscle.

• Bipennate -

• Medial 2 lumbricals

• Dorsal interossei

• Unipennate -

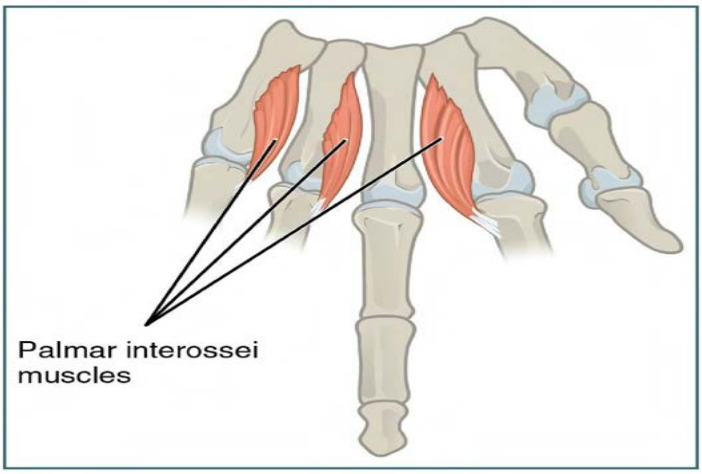
• Lateral 2 lumbricals

• Palmar interossei

Overview of Muscles of the hand:

Intrinsic muscles	Extrinsic muscles
Adductor PollicisPalmaris Br evisInterosseiLumbricalsthen arHypothenar	Originate in the forearm, ins ert in the hand
Precision grip to execute prec ision movements	Power grip for forceful grip w ith hand

Interossei muscles of left hand (palmar view)



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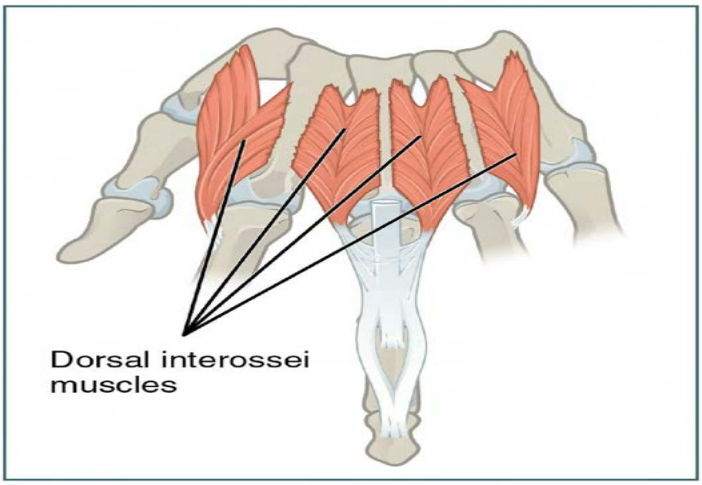
Interossei muscles of left hand (dorsal view)



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Solution to Question 17:

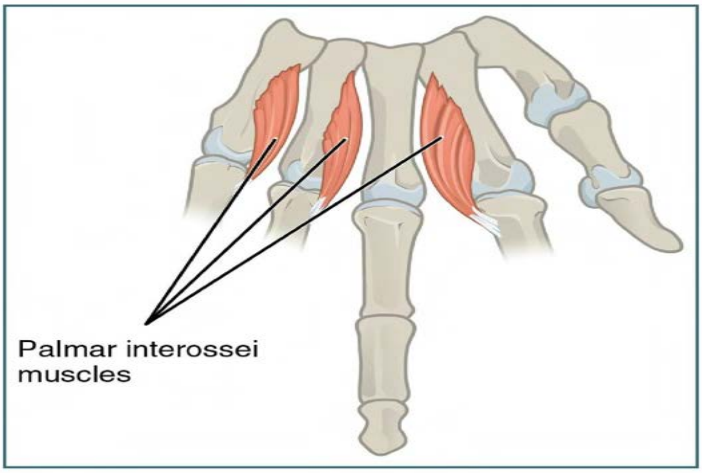
The test being performed in the above-shown image is the card test for the palmar interossei muscle. The 3rd metacarpal (middle finger) has no palmar interosseous attachment.

Palmar interossei lie on the palmar surface of the metacarpals. There are 3 palmar interossei:

- 2nd metacarpal (Ulnar side)
- 4th metacarpal (Radial side)
- 5th metacarpal (Radial side)

Note: There may be 4 interossei in some people.

Interossei muscles of left hand (palmar view)



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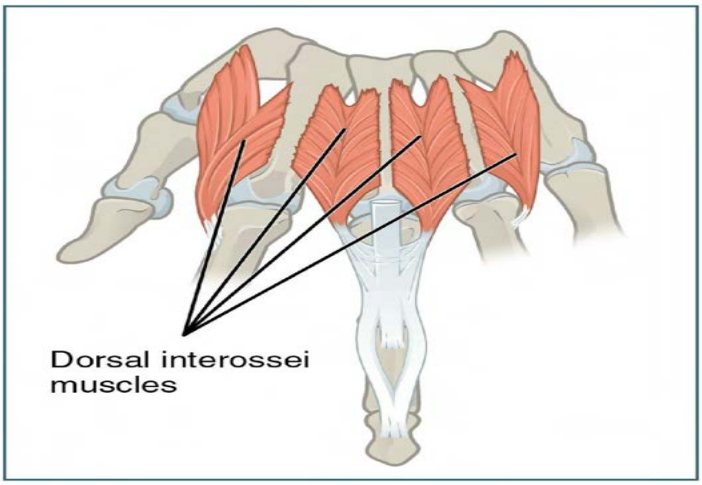
Interossei muscles of left hand (dorsal view)



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Solution to Question 18:

The muscle marked 'A' is lumbricals and they cause flexion at the metacarpophalangeal joints.

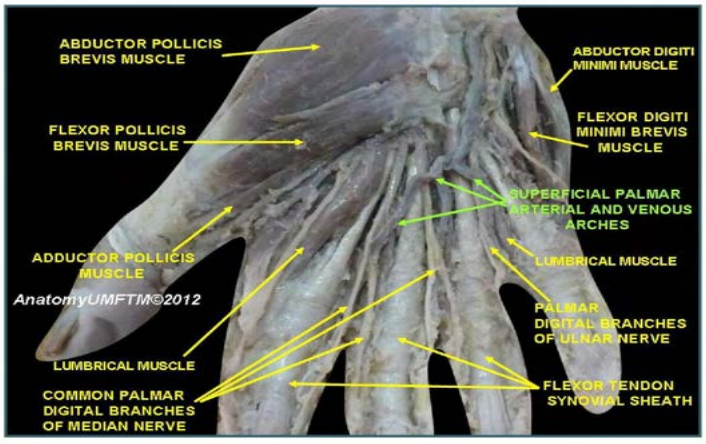
Lumbricals are intrinsic muscles of the hand that flex the metacarpophalangeal joints (MCP) and extend the interphalangeal joints (PIP & DIP).

They originate from flexor digitorum profundus.

• The lateral two are unipennate, supplied by the median nerve.

• The medial two are bipinnate, supplied by the ulnar nerve.

Superficial muscles of the hand



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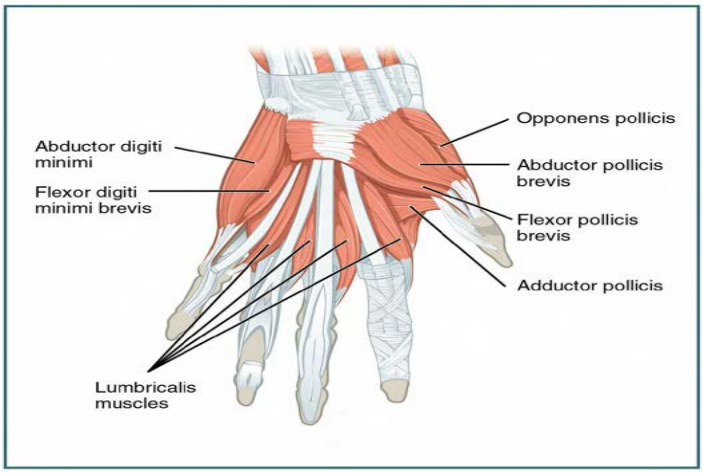
Superficial muscles of the hand (palmar view)



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Solution to Question 19:

The structure marked in the image is the dorsal digital expansion of the middle finger. Palmar interossei do not attach to the middle finger and therefore it does not contribute to the dorsal digital expansion of the middle finger.

Palmar interossei are unipennate muscles originating from their own metacarpal bone. Their function is adduction. The middle finger does not need adduction and hence does not have palmar interossei.

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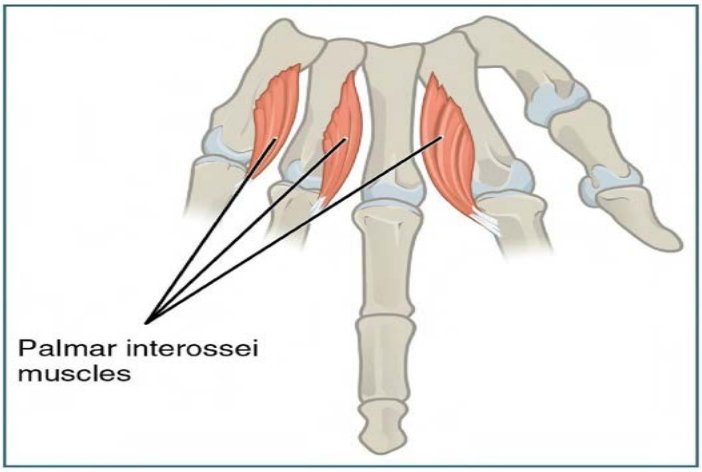
Interossei muscles of left hand (palmar view)



Dorsal interossei are bipennate muscles originating from the adjacent metacarpal bone. They attach to the middle three fingers on both sides and do not attach on the thumb and little finger. Their function is abduction. The thumb and little finger have other muscles for abduction.

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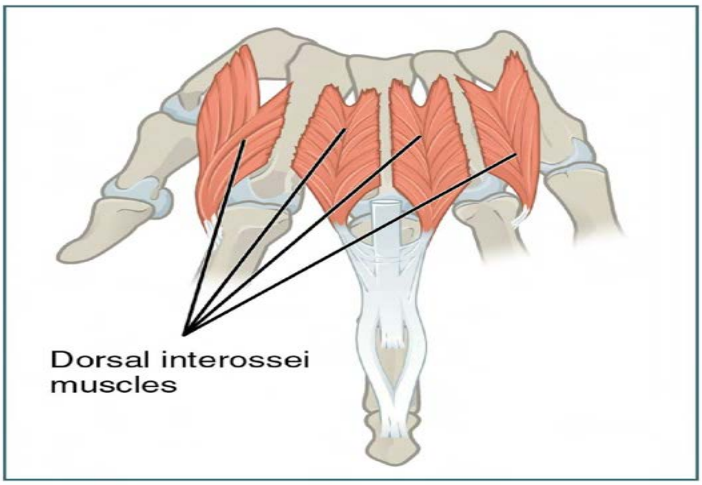
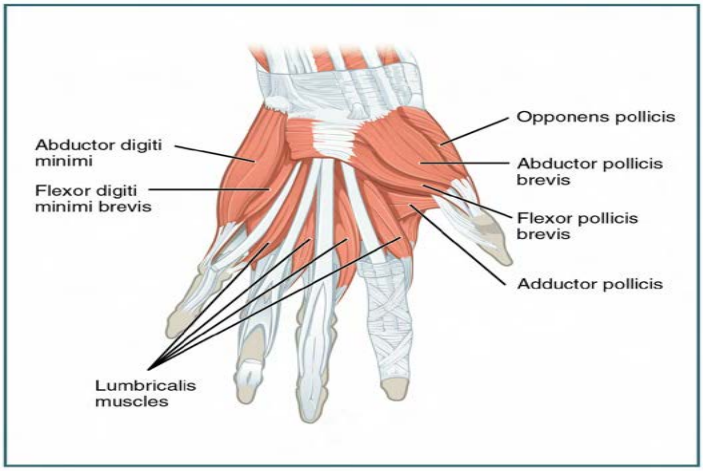
Interossei muscles of left hand (dorsal view)



The lateral 2 lumbricals are unipennate and medial 2 lumbricals are bipennate. Their function is flexion at metacarpophalangeal joints.

Superficial muscles of the hand (palmar view)



Solution to Question 20:

The lumbricals and interossei muscles are affected.

The lumbricals and interossei muscles through their attachments to the dorsal digital expansions, cause:

• Flexion of the metacarpophalangeal (MCP) joints

• Extension of the interphalangeal (IP) joints

In cases of ulnar nerve injury, these muscles may get atrophied leading to the extension of MCP joints and flexion of IP joints.

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Note: The ulnar nerve innervates all the intrinsic muscles of the hand, except for

- First and second lumbrical
- Abductor pollicis brevis
- Opponens pollicis
- Part of flexor pollicis brevis

Solution to Question 21:

The area marked in the image is the palmar aspect of the first metacarpal. The opponens pollicis muscle is inserted at this site.

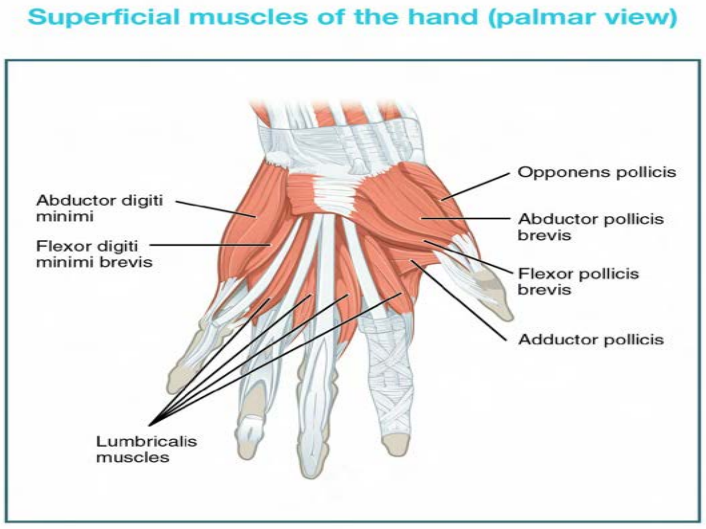
Opponens pollicis:

Origin: Tubercle of the trapezium and flexor retinaculum

Insertion: Whole length of the lateral border and adjoining lateral half of the palmar aspect of the first metacarpal.

Action: Flexes the metacarpal bone of the thumb.

The image below shows various intrinsic muscles of the hand.



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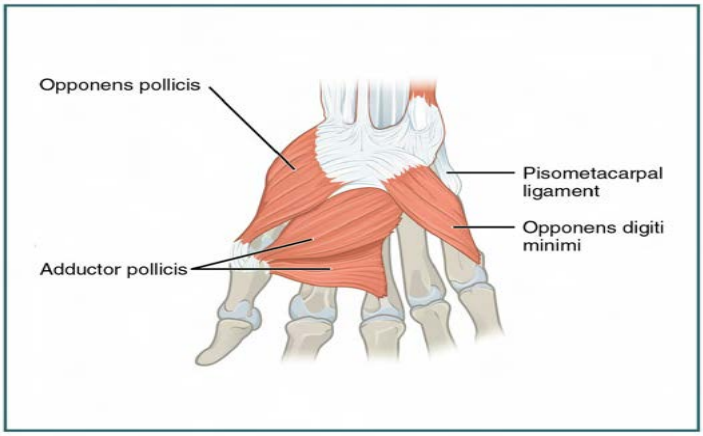
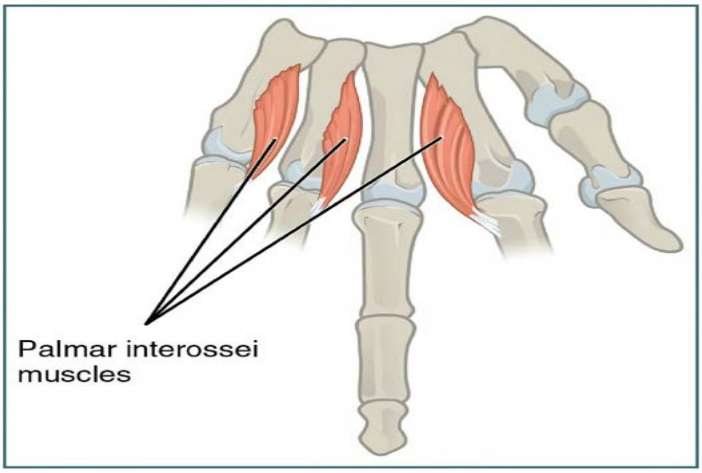
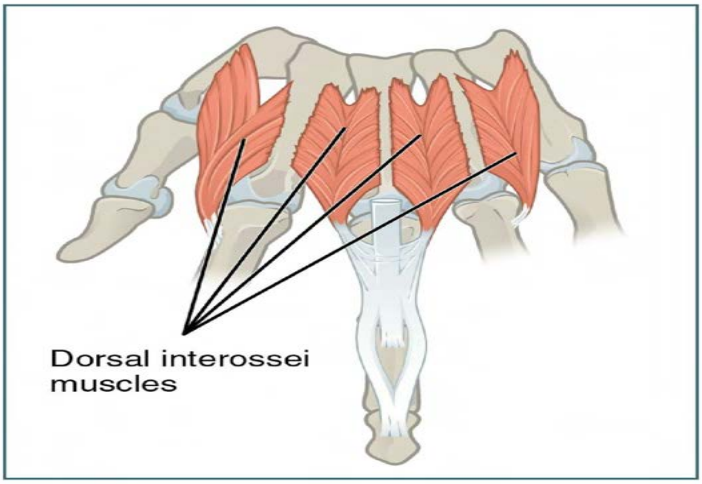
Deep muscles of the hand (palmar view)



Interossei muscles of left hand (palmar view)



Interossei muscles of left hand (dorsal view)



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Solution to Question 22:

Power grip is by extrinsic muscles of the hand (long flexors).

Extrinsic muscles of the hand originate in the forearm and insert in the hand i.e. long flexors.

Precision grip is a function of the intrinsic muscles of the hand.

Intrinsic muscles of the hand originate and insert in the hand.

- Adductor pollicis
- Palmaris brevis
- Interossei, lumbricals
- Thenar, hypothenar

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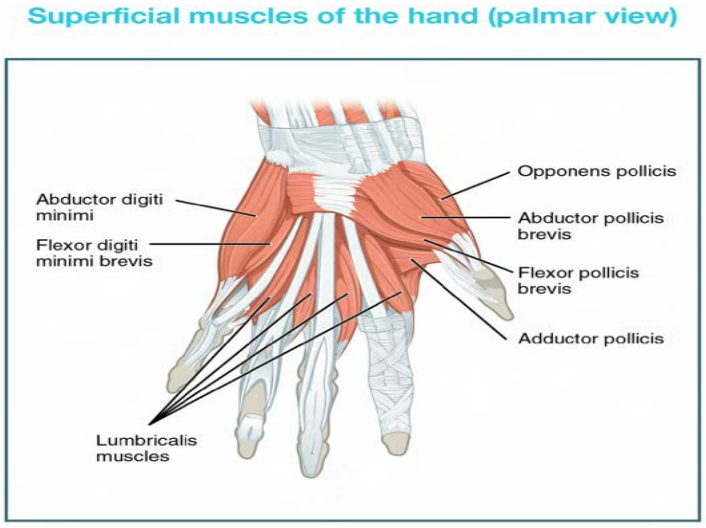
Solution to Question 23:

The marked structure is second lumbrical which is supplied by the median nerve.

The lateral two lumbricals are supplied by the median nerve and the medial two are supplied by the ulnar nerve. Function of these muscles is flexion at the metacarpophalangeal joints and extension at both the interphalangeal joints.



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Vessels-Upper limb

Question 1:

Which of the following is not a branch of the 1st part of the subclavian artery?

a) Vertebral artery

b) Internal thoracic artery

c) Thyrocervical trunk

d) Costocervical trunk

Question 2:

Which of the following muscle divides the axillary artery into 3 parts?

a) Pectoralis major

b) Teres major

c) Pectoralis minor

d) Teres minor

Question 3:

A patient with anterior dislocation of the shoulder joint is found to have compression of the axillary artery. However, the blood supply of the arm seems to be non-compromised. Anastomoses between which of the following vessels maintain this circulation?

a) 3rd part of subclavian and 3rd part of axillary artery

b) 1st part of subclavian and 1st part of axillary artery

c) 3rd part of subclavian and 1st part of axillary artery

d) 1st part of subclavian and 3rd part of axillary artery

Question 4:

A 57-year-old man presents with pain, numbness, and fatigue of the right arm. Angiography reveals decreased flow through the vessels anastomosing near the surgical neck of the humerus. The pathology is likely to be present in which of the following arteries?

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a) 1st part of axillary artery

b) 1st part of subclavian artery

c) 3rd part of axillary artery

d) 3rd part of subclavian artery

Question 5:

Angiography of the upper limb vessels in a patient shows a blockage in the brachial artery. All of the following vessels will have decreased flow, except:

a) Profunda brachii artery

b) Superior ulnar collateral artery

c) Inferior ulnar collateral artery

d) Anterior circumflex humeral artery

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Question 6:

The interosseous recurrent artery is a branch of which of the following arteries?

a) Anterior Interosseous artery

b) Posterior Interosseous artery

c) Common Interosseous artery

d) Radial artery

Question 7:

Which of the following structures pass through the opening marked in the diagram below?

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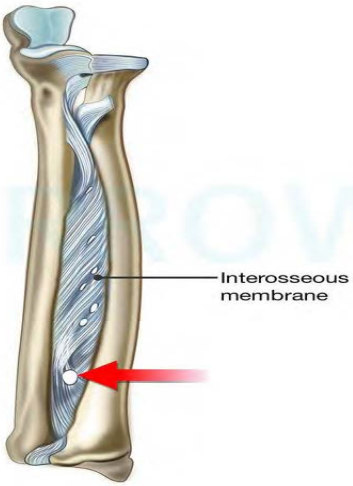


a) Posterior interosseous artery

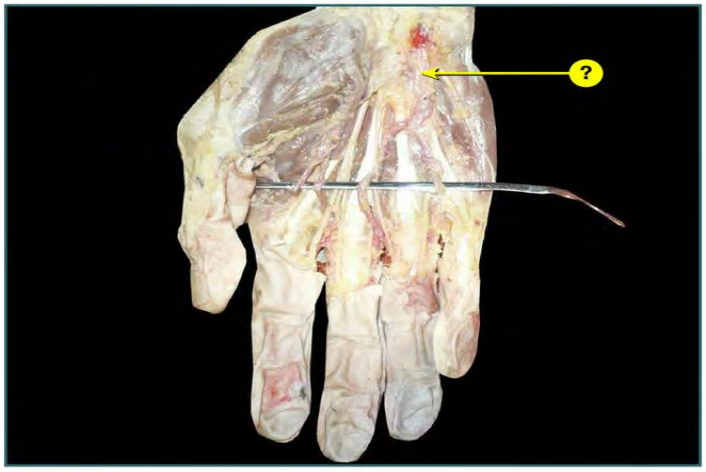
b) Deep branch of radial nerve

c) Anterior interosseous artery

d) Recurrent interosseous artery

Question 8:

Identify the structure marked in the image given below:



a) Ulnar nerve

b) Ulnar artery

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c) Superficial radial artery

d) Median nerve

Question 9:

An intern was asked to collect a sample for arterial blood gas analysis. Before puncturing the artery, she performed a modified Allen's test to assess the circulation. However, the test result was negative. What is the inference?

a) Radial circulation is inadequate, hence, ulnar artery should be punctured

b) Radial circulation is inadequate, hence, ulnar artery should not be punctured

c) Ulnar circulation is inadequate, hence, radial artery should be punctured

d) Ulnar circulation is inadequate, hence, radial artery should not be punctured

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Question 10:

A 52-year-old man with end-stage renal disease was planning to undergo hemodialysis. An arteriovenous fistula was created on his forearm. This procedure is done mainly to achieve a minimum venous flow rate of:

a) 50 ml/min

b) 600 ml/min

c) 750 ml/min

d) 250 ml/min

Question 11:

Palmar venous network in the palm of hand gives rise to which of the following veins?

a) Cephalic vein

b) Basilic vein

c) Median antebrachial vein

d) Median cubital vein

Question 12:

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You are asked to send a blood sample for complete blood count analysis of a clinically anemic patient. Sampling from which of the following vein is preferred?

a) Cephalic vein

b) Antecubital vein

c) Basilic vein

d) Brachial vein

Question 13:

A patient is diagnosed with superficial thrombophlebitis of the cephalic vein. This vein drains into which of the following vessels?

a) Brachial vein

b) Subclavian vein

c) Axillary vein

d) Basilic vein

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Question 14:

Which of the following is a pre-axial vein?

a) Cephalic vein

b) Basilic vein

c) Axillary vein

d) Subclavian vein

Question 15:

A 40-year-old woman with breast carcinoma was planned for a mastectomy. During the procedure, a blue dye was injected to map the flow of lymphatic drainage in the axillary lymph nodes. Which of the following will receive lymphatic drainage from the rest of the axillary lymph node groups?

a) Central

b) Apical

c) Lateral

d) Posterior

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Question 16:

Which of the following statements regarding axillary lymph nodes is false?

a) Posterior group lies along subscapular vessels

b) Lateral group lies along lateral thoracic vessels

c) Apical group lies along axillary vessels

d) Axillary lymph nodes drains trunk above the umbilicus

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Answer Key

Question No.	Correct Option
1	d
2	c
3	d
4	c
5	d
6	b
7	c
8	b
9	d
10	d
11	c
12	b
13	c
14	a
15	b
16	b

Detailed Explanations

Solution to Question 1:

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The costocervical trunk is not a branch of the 1st part of the subclavian artery. It is a branch of the 2nd part.

Scalenus anterior divides the subclavian artery into 3 parts:

	Branches
1stpart	Vertebral artery(Largest branch)Internal thoracic arterySuperior epigastric arteryMusculophrenic arteryThyrocervical trunkSuprascapular arteryInferior thyroid arteryTransverse cervical artery
2ndpart	Costocervical trunk
3rdpart	Dorsal scapular artery

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Solution to Question 2:

The axillary artery is divided into 3 parts by the pectoralis minor muscle.

The axillary artery is the continuation of the subclavian artery. It extends from the outer border of the 1st rib to the lower border of teres major.

Pectoralis minor divides the artery into 3 parts:

After passing the lower margin of the teres major, it becomes the brachial artery.

Part	Relation to Pectoralis minor	Branches
1st part	Lies proximally	Superior thoracic artery
2nd part	Lies posteriorly	Thoracoacromial trunk
3rd part	Lies laterally	Subscapular arteryAnterior circumflex humeral arteryPosterior circumflex humeral artery

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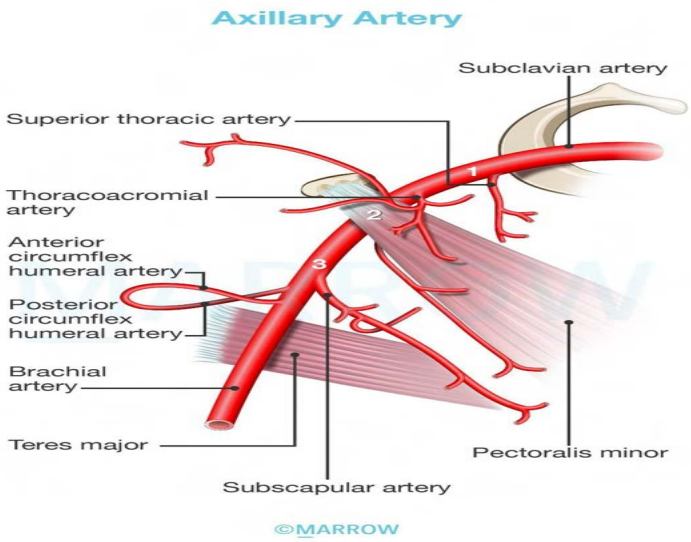

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Solution to Question 3:

Anastomosis around the scapula maintains circulation to the upper limb if the blood supply is interrupted (fractures or dislocation of the shoulder joint). Anastomosis occurs between the 1st part of the subclavian artery and the 3rd part of the axillary artery. These arteries also anastomose with intercostal arteries.

The axial artery of the upper limb is the subclavian artery.

Anastomosis around the scapula:

Level of anastomosis	Arteries involved	Branch of
Body of Scapula	Suprascapular artery	Thyrocervical trunk
Deep branch of transverse ce rvical artery	Thyrocervical trunk	
Circumflex scapular artery	Subscapular artery	
Inferior angle of scapula	Deep branch of transverse ce rvical artery	Thyrocervical trunk
Subscapular artery	3rd part axillary artery	
Acromion process	Thoraco-acromial artery (Acr omial branch)	2nd part axillary artery
Suprascapular artery (Acromi al branch)	Thyrocervical trunk	
Posterior circumflex humeral artery (Acromial branch)	3rd part axillary artery	

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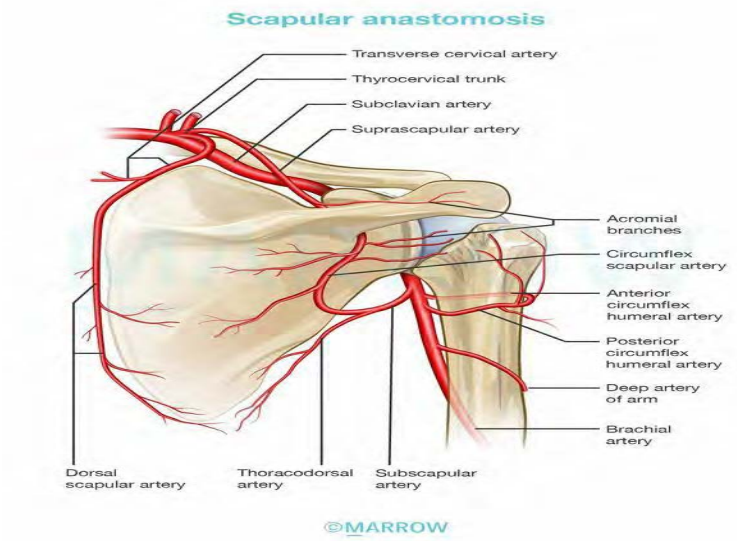

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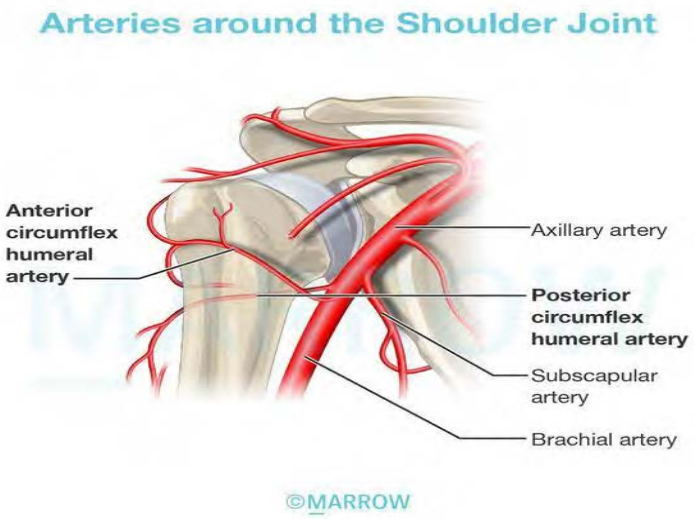
Solution to Question 4:

The branches of the third part of the axillary artery supply the surgical neck of the humerus. Thrombus in this part will cause decreased supply in its branches - the anterior and posterior circumflex humeral arteries.

Branches of 3rd part of the axillary artery are:

- Anterior circumflex humeral arteries
- Posterior circumflex humeral arteries
- Subscapular artery (not involved in the anastomosis)



Fracture of the surgical neck is the commonest site among all proximal humerus fractures due to its inherent weakness. Fracture at this site may cause injury to the posterior circumflex humeral

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artery and the axillary nerve that accompanies it.

Positional compression of the axillary artery is seen in athletes who are involved with throwing movement, as in baseball players. Repeated movement of the humerus may cause compression of the distal part of the axillary artery. This may lead to thrombosis or aneurysm resulting in arm ischemia.

Solution to Question 5:

The anterior circumflex humeral artery is a branch of the axillary artery. Hence, it is unlikely to have a decreased flow due to blockage in the brachial artery.

The brachial artery has 3 branches:

• Profunda brachii (accompanies radial nerve in the spiral groove) gives off nutrient artery to the humerus and an ascending branch which anastomoses with posterior circumflex humeral artery. It then divides into:

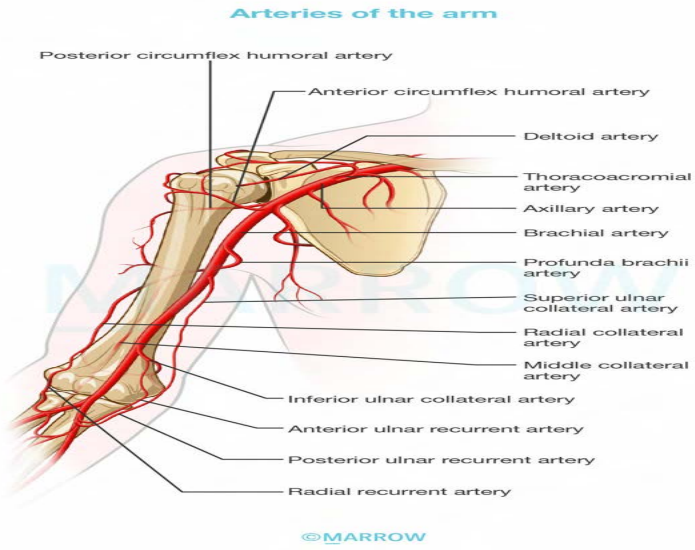
• Anterior descending artery (Radial collateral artery)

• Posterior descending artery (Middle collateral artery)

• Superior ulnar collateral artery (accompanies ulnar nerve)

• Inferior ulnar collateral (supratrochlear) artery

The image given below shows branches of the brachial artery.



Solution to Question 6:

The interosseous recurrent artery is a branch of the posterior interosseous artery.

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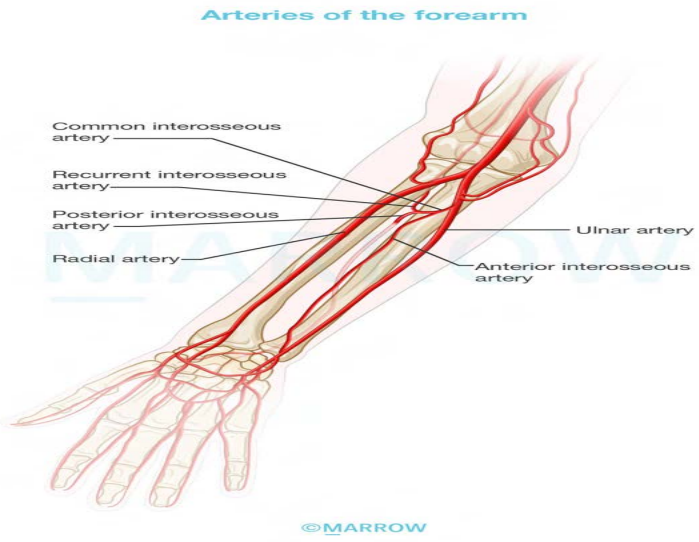
The posterior interosseous artery originates from the common interosseous branch of the ulnar artery. It contributes a branch, the recurrent interosseous artery to the vascular network around the elbow joint.



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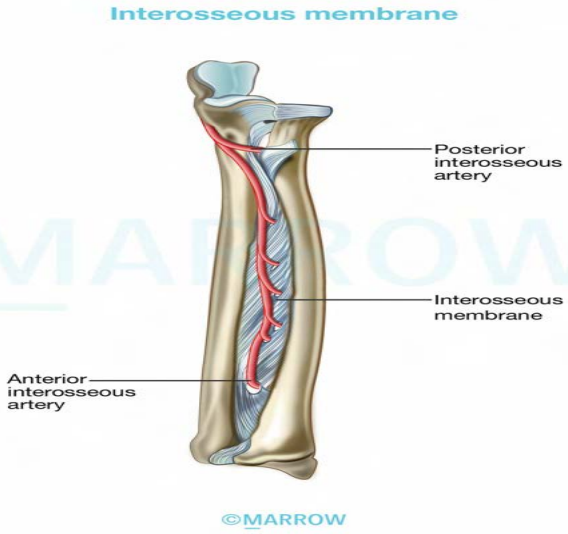
Solution to Question 7:

The anterior interosseous artery passes through the opening in the interosseous membrane.

The anterior interosseous artery passes distally along the anterior aspect of the interosseous membrane and supplies muscles of the deep compartment of the forearm, radius, and ulna.

Perforating the interosseous membrane in the distal forearm, the anterior interosseous artery terminates by joining the posterior interosseous artery.

The image given below shows anterior interosseous artery.



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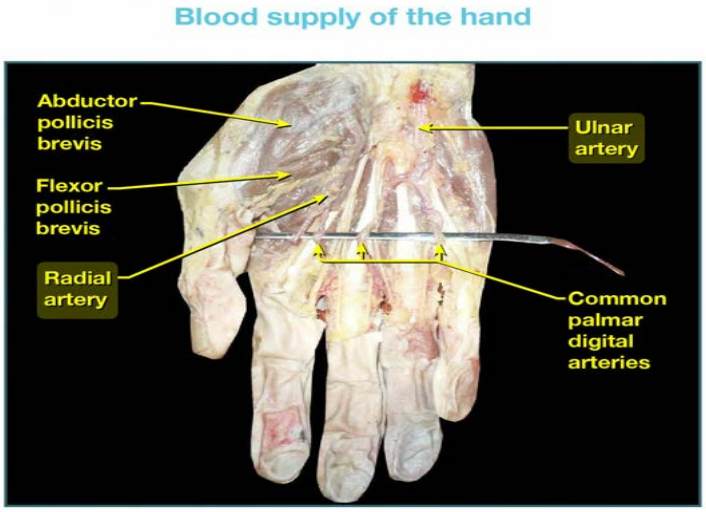
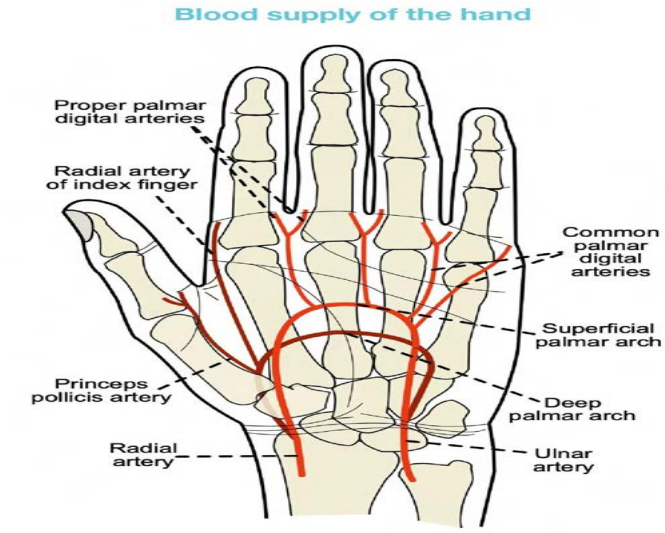
Solution to Question 8:

The structure marked in the image is the ulnar artery, seen contributing to the superficial palmar arch.

It passes deep to the Guyon's canal in the wrist and contributes to the superficial and deep palmar arch.





Solution to Question 9:

A negative result of the modified Allens test implies that the ulnar circulation is inadequate, hence, the radial artery should not be punctured. In such cases, the modified Allen's test is

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performed on the other hand, which is likely to have a normal circulation.

The integrity of the arcuate system of the hand is assessed by modified Allen's test which is performed routinely before instrumentation of the radial artery.

The test determines the integrity between superficial and deep palmar arches and the patency of the radial and ulnar arteries at the wrist. Each one of the arteries is compressed at a time. The individual artery which is sufficient to maintain the arterial supply to the hand in isolation is noted.

Procedure:

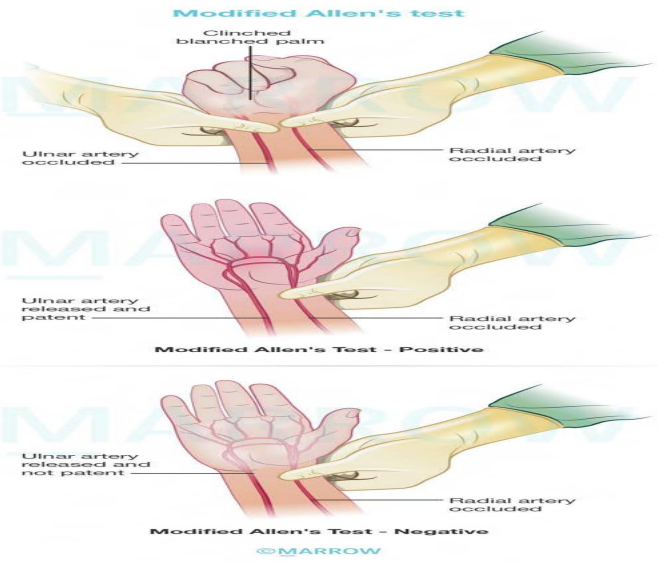
• The patient makes a tight fist, examiner digitally compresses both ulnar and radial arteries.

• The patient opens the fist to reveal the pale palm.

• Ulnar artery compression is removed, palm turns red including the thumb zone (positive modified Allen's test).

• If blood fails to return to the palm including the thumb zone, it reveals the anastomosis between the 2 palmar arches is inadequate (negative modified Allen's test).

If the hand does not flush within 5–15 seconds (modified Allen's test negative), it indicates that ulnar circulation is inadequate or nonexistent. In this situation, the radial artery supplying arterial blood to that hand should not be punctured.



Solution to Question 10:

The process of dialysis occurs over many hours and requires considerable flow rates of 250-500 mL/minute.

As no vein in the peripheral limbs has such high flow, a surgical procedure (AV fistulas) is necessary to create such a system.

Two types of arteriovenous fistulas:

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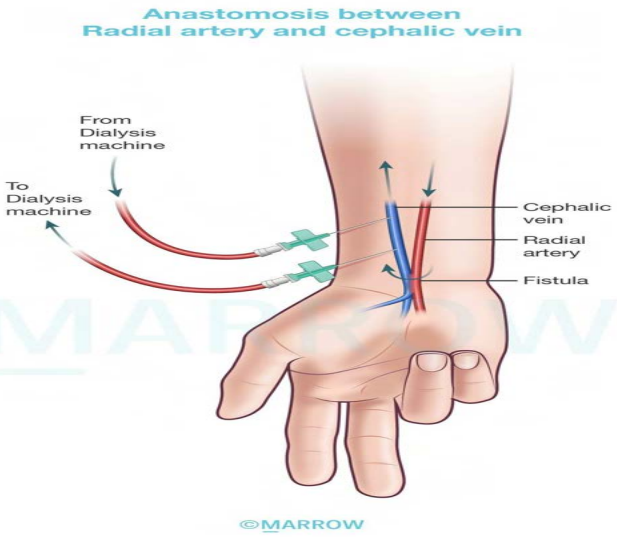
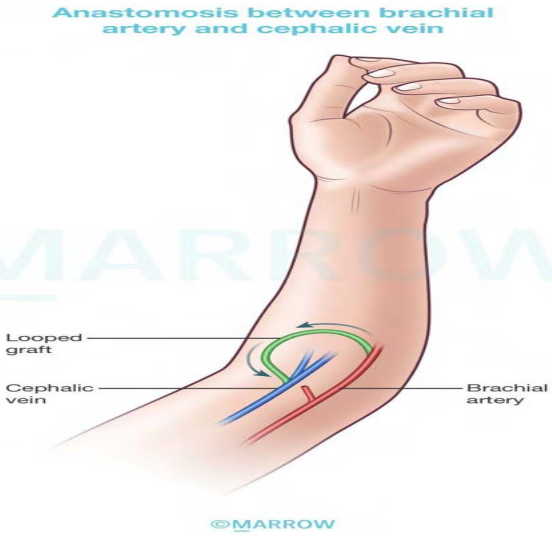
• The radial artery is anastomosed to the cephalic vein in the wrist (most common)

• The brachial artery is anastomosed to the cephalic vein at the elbow

The following image shows radiocephalic and brachiocephalic fistula respectively.





Solution to Question 11:

The palmar venous network in the palm of the hand gives rise to the median antebrachial vein.

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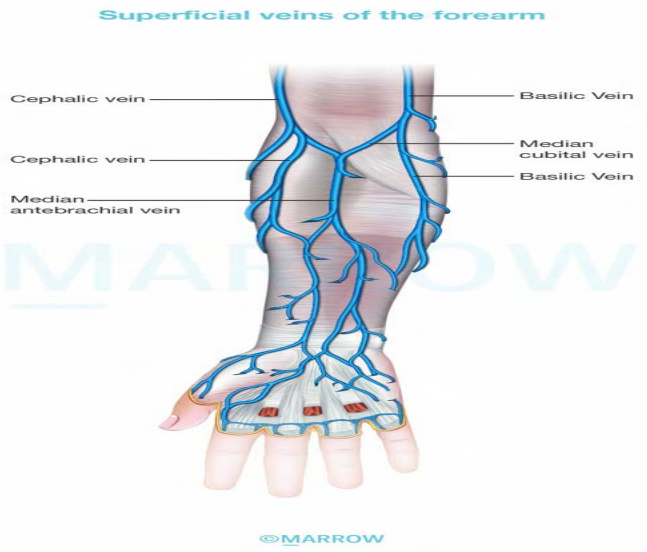
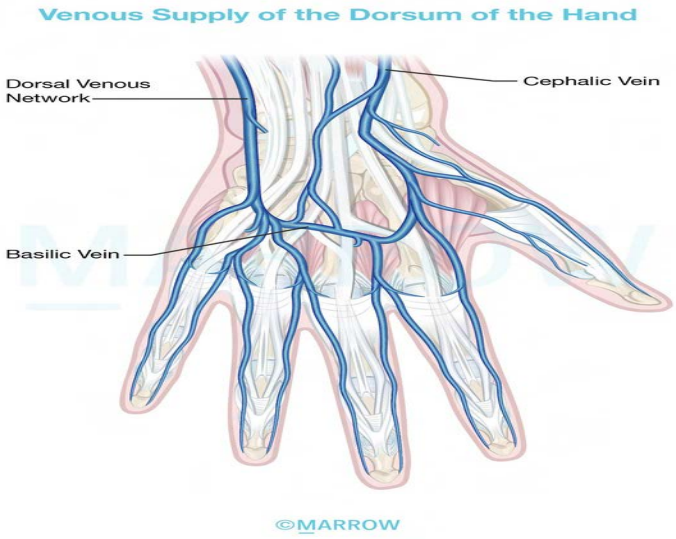


The median antebrachial vein is a superficial vein of the anterior forearm. It drains the superficial structures of the forearm and wrist. It ascends to the cubital fossa where it drains into the medial cephalic and median basilic veins in an inverted Y-shaped configuration.

The dorsal venous network on the dorsum of the hand gives rise to cephalic and basilic veins as shown below.



Solution to Question 12:

The antecubital vein (median cubital vein) is usually the vein preferred for direct blood investigations.

The median cubital vein connects the cephalic vein to the basilic vein at the roof of the cubital fossa. It lies superficial to bicipital aponeurosis and hence is easily accessible. It is used for IV

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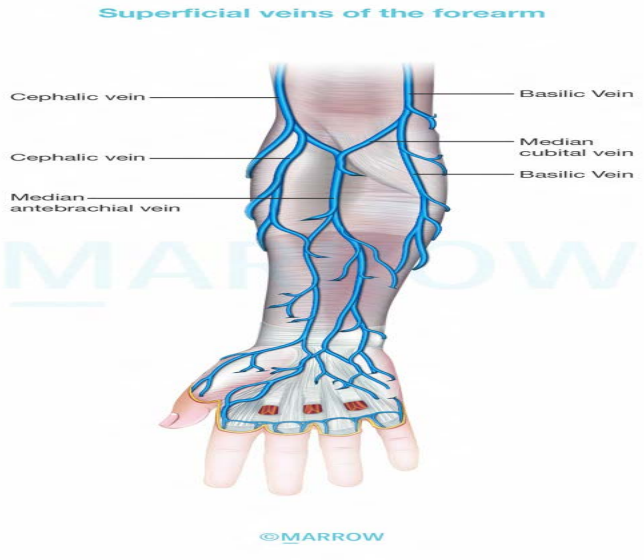
injections, blood transfusions, and blood withdrawal.



Option A: The cephalic vein begins as a radial continuation of the dorsal venous arch, runs on the roof of the anatomical snuffbox. It ends in the axillary vein. It is connected to the basilic vein by the median cubital vein. It is the preferred site for short-term IV cannula.

Option C: The basilic vein drains the ulnar end of the dorsal venous arch, passing on the medial aspect of the forearm. It pierces deep fascia at the elbow and joins venae comitantes of brachial artery forming the axillary vein, at the lower border of teres major.

Option D: The brachial vein is a deep vein of the forearm which lies on either side of the brachial artery. It is formed by joining the venae comitantes of radial and ulnar arteries. It joins the axillary vein at the lower border of the teres major.

Solution to Question 13:

The cephalic vein drains into the axillary vein.

The blood in the cephalic vein is drained to the axillary vein by 2 routes:

• Directly after piercing clavipectoral fascia i.e., Cephalic vein ⇒ Axillary vein

• Some amount of venous blood is drained into the basilic vein through the median cubital vein i.e., Cephalic vein ⇒ Median cubital vein ⇒ Basilic vein ⇒ Axillary vein

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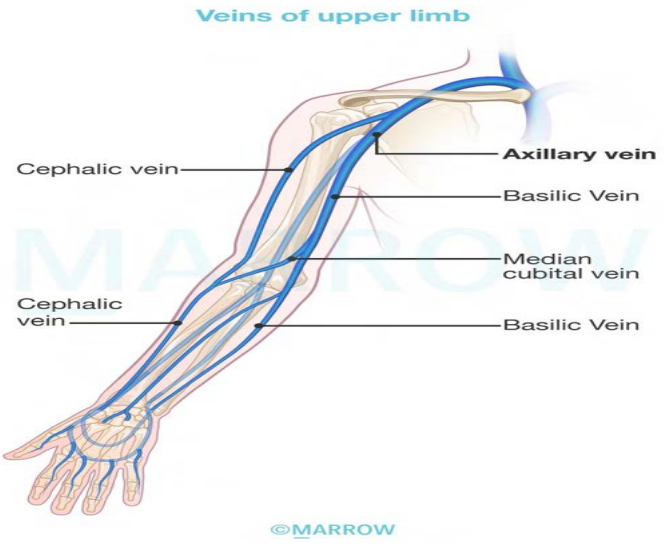

Solution to Question 14:

The cephalic vein is a preaxial vein.

The pre-axial and post-axial borders are decided on the basis of their placement, with respect to the axis of the limb.

In the upper limb, the pre-axial vein of the dorsal venous arch becomes the cephalic vein and the postaxial vein becomes the basilic vein.

	Pre-axial border	Post-axial border
Embryo	Cranially-placed limb border	Caudally-placed limb border
Adults	Upper limb:Outerborder (radial aspect)•Cephalic veinLower limb: Inner border• Greater saphenous vein	Upper limb:Innerborder (ular aspect)•Basilic veinLower limb: Outer border• Lesser saphenous vein

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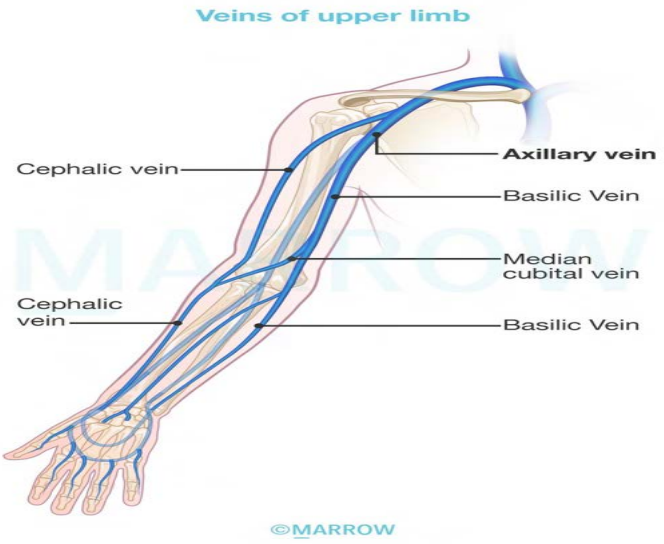

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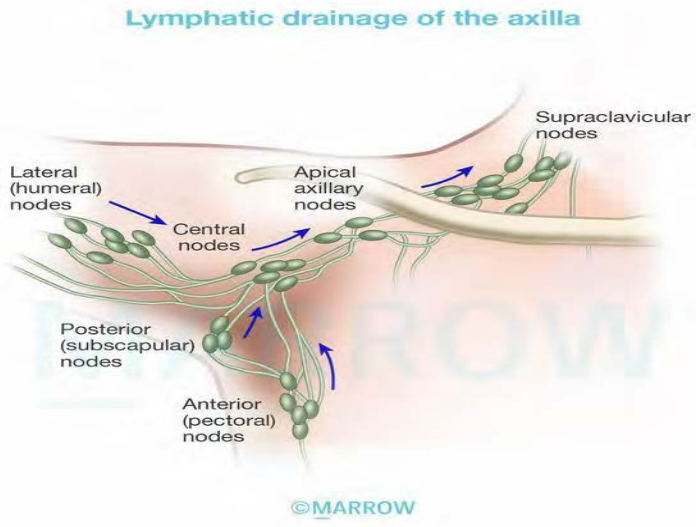
Solution to Question 15:

The apical group of lymph nodes receives lymphatic drainage from the rest of the axillary lymph node groups. Hence, they are known as terminal axillary lymph nodes.

The lymphatic drainage of axillary nodes is given below:

Anterior, posterior and lateral groups ⇒ Central group ⇒ Apical group

The apical group then drains into the supraclavicular lymph nodes.



Solution to Question 16:

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The lateral group of axillary nodes lies posteromedial to the axillary vein. The anterior group of axillary nodes lies near the lateral thoracic vessels.

Axillary lymph nodes collectively drain the entire upper limb, breast, and trunk above the umbilicus.

Axillary nodes can be divided into 5 groups namely:

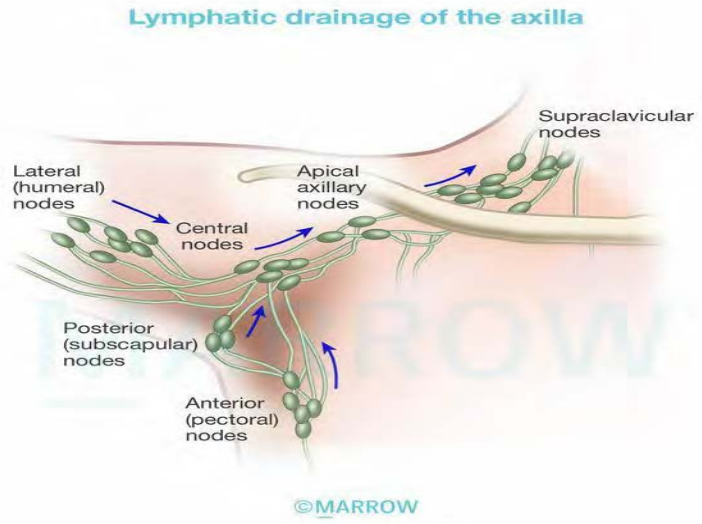
• Lateral/ humeral

• Anterior/ pectoral

• Posterior/ subscapular

• Central

• Apical



	Location	Afferents	Efferents
Humeral/ Lateral group	Posteromedial toaxillary vein	Whole limb except vessels accompanying cephalic veins	• Central nodes• Apical nodes• Inferior deep cervical nodes
Pectoral/ Anterior group	Alonglateral thoracic vessels	Skin and muscles of supra-umbilical anterolateral body wall and breast	• Central nodes• Apical nodes
Subscapular/ Posterior group	Along thesubscapular vessels	Skin and muscles of the inferior posterior region of the neck, dorsal aspect of the trunk up to iliac crest	• Central nodes• Apical nodes
Central group	Embedded in theaxillary pad of fat	All preceding groups	• Apical group

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	Location	Afferents	Efferents
Apical group	Deep to clavipectoral fascia, along theaxillary vessels	Those accompanying cephalic vein	Unite as subclavian trunk, right trunk drains into Jugulo-subclavian venous junction and left trunk ends in thoracic duct

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General Anatomy of Thorax

Question 1:

Which of the following is a false rib?

a) 1st rib

b) 6th rib

c) 7th rib

d) 8th rib

Question 2:

Which of the following joints is not formed by direct articulation with ribs?

a) Costovertebral joint

b) Costochondral joint

c) Costotransverse joint

d) Costosternal joint

Question 3:

What type of joint is the first sternocostal joint?

a) Synchondrosis

b) Synarthrosis

c) Synovial joint

d) Syndesmosis joint

Question 4:

The joint between the attachment of the 8th and 9th rib to the 7th rib is a:

a) Fibrocartilaginous joint

b) Symphyseal joint

c) Synovial joint

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d) Fibrous joint

Question 5:

Which of the following does not provide articulations to ribs?

a) Vertebral bodies

b) Intervertebral disc

c) Spinous process of vertebra

d) Transverse process of vertebra

Question 6:

Which of the following ribs is atypical and doesn't articulate with the vertebra at 3 sites?

a) 1st rib

b) 2nd rib

c) 6th rib

d) 8th rib

Question 7:

A 47-year-old smoker presented with cough, chest pain, dyspnea, and right shoulder pain. Chest X-ray revealed homogeneous opacity at the lung apex and destruction of the first rib. Which of the following is not compressed?

a) Superior intercostal artery

b) Thoracic duct

c) First posterior intercostal vein

d) Sympathetic trunk

Question 8:

Which of the following structures passes through the marked area in the diagram below?

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a) 1st thoracic nerve

b) Subclavian artery

c) Internal thoracic artery

d) Subclavian vein

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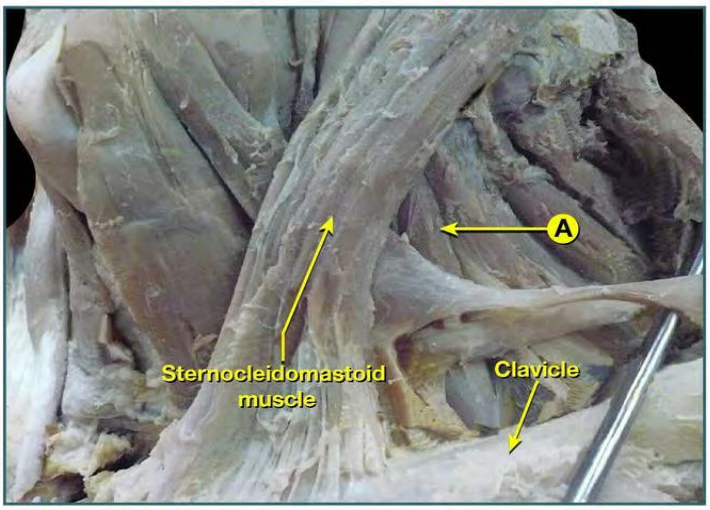
Question 9:

The image given below shows structures in the posterior triangle of the neck. Where does the structure marked A attach?



a) 1st rib - Scalene tubercle

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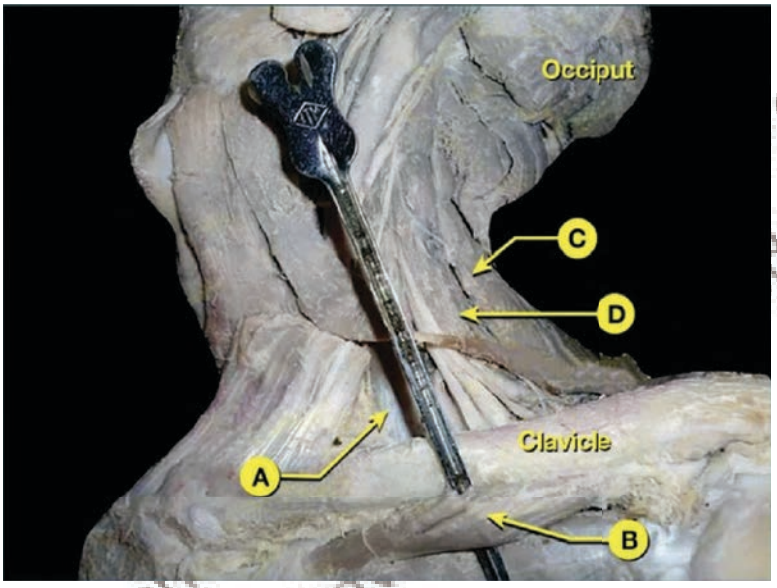
b) 1st rib - Tuberculum sellae

c) 2nd rib - Scalene tubercle

d) 2nd rib - Chassaignac tubercle

Question 10:

Which of the following muscles seen below does not attach to the first rib?



a) A

b) B

c) C

d) D

Question 11:

The relationship of the components of the neurovascular bundle from below upwards in intercostal space is _____

a) Vein-artery-nerve

b) Artery-nerve-vein

c) Vein-nerve-artery

d) Nerve-artery-vein

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Question 12:

In the costal groove of which of the following ribs is the classic arrangement of vein-artery-nerve is not seen?

a) 1

b) 2

c) 11

d) 12

Question 13:

What does the tip of the T3 spinous process correspond to?

a) Lower extent of ligamentum nuchae

b) Superior angle of scapula

c) Root of the spine of scapula

d) Inferior angle of scapula

Question 14:

Which among the following is incorrect regarding Sibsons's fascia?

a) Attached to the inner border of 2nd rib

b) Covers apical part of lung

c) Part of scalenus minimus muscle

d) Vessels pass above the fascia

Question 15:

On the ides of March, Julius Caesar was stabbed 23 times. One such stab wound was present in the left supraclavicular fossa, piercing his left lung. Which of the following provides the vertebral attachment to the fascia present here?

a) C1

b) C2

c) C5

d) C7

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Answer Key

Question No.	Correct Option
1	d
2	d
3	b
4	c
5	c
6	a
7	b
8	d
9	a
10	c
11	d
12	a
13	c
14	a
15	d

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Detailed Explanations

Solution to Question 1:

The 8th rib is the false rib because it does not articulate with the sternum anteriorly.

- First 7 ribs are true ribs as they are attached anteriorly to the sternum by costal cartilages.
- Ribs 8-10 are false ribs as they join the superjacent costal cartilage.
- Ribs 11 and 12 are floating ribs as they float freely without costal attachment.

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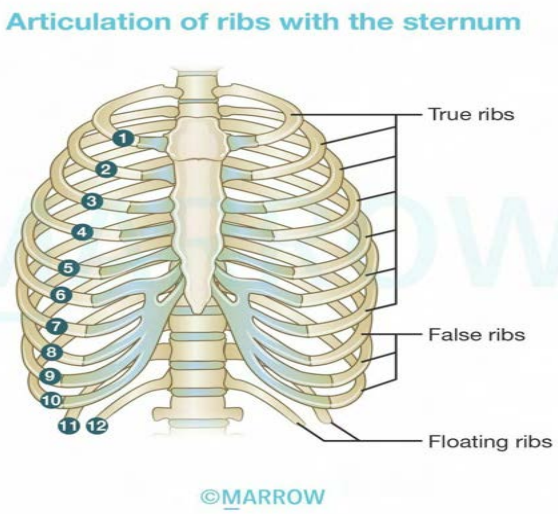

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Solution to Question 2:

The costosternal joint is not formed by direct articulation with ribs. The costosternal joint is formed by the articulation of the lateral sternal border with the costal cartilages of the ribs.

Solution to Question 3:

The first sternocostal joint is a type of synarthrosis.

Joints are classified in 2 ways:

Classification 1 is based on the type of motion (functional):

• Synarthrosis - no movement (first sternocostal joint)

• Amphiarthrosis - some movement (pubic symphysis)

• Diarthrosis - full movement (elbow/shoulder/ankle)

Classification 2 is based on the structure of joint:

1. Fibrous

• Sutures (joints between skull bones)

• Syndesmoses (distal tibiofibular joint)

• Gomphose (joint between teeth and teeth sockets in mandibular/maxillary bone)

2. Cartilaginous

• Synchondrosis - primary cartilaginous (costochondral joints)

• Symphysis - secondary cartilaginous (manubriosternal and xiphisternal joints)

3. Synovial (elbow, knee, hip etc.)

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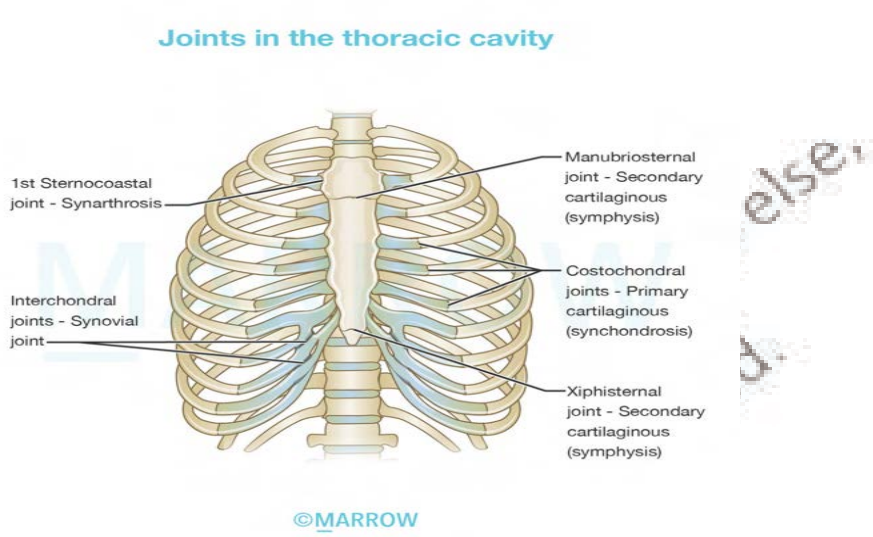
• the presence of these help the thoracic cavity expand during inspiration. E.g.:

• Interchondral joint

• Sternocostal joint

• Costovertebral joint

• Costotransverse joint



Solution to Question 4:

The interchondral joint between the attachment of the 8th and 9th rib with the 7th rib is a synovial joint.

Joints in the thoracic cavity are of the following types:

• Synarthrosis - structures are connected by a fibrous band of tissue. E.g, 1st sternocostal joint

• Synchondrosis - primary cartilaginous joints. E.g., costochondral joints

• Symphysis - secondary cartilaginous joints. E.g. manubriosternal and xiphisternal joints

• Synovial joints - the presence of these help the thoracic cavity expand during inspiration. E.g.:

• Interchondral joint

• Sternocostal joint

• Costovertebral joint

• Costotransverse joint

Note:

The interchondral joint between the 9th and 10th cartilages is never synovial and sometimes absent.

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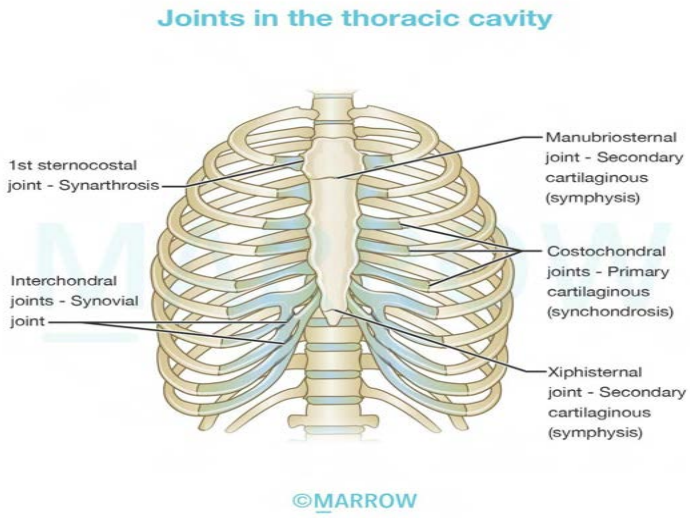

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Solution to Question 5:

The spinous processes of vertebrae do not provide articulation to ribs.

Note:

Two facets on head of the ribs are separated by a transverse crest which is attached to the intervertebral disc above it.

Solution to Question 6:

1st rib is an atypical rib and does not articulate at 3 sites with a vertebra. It has 2 articulations as follows:

• Circular facet on the head of the rib with the body of the first thoracic vertebra

• Tubercle of the rib to the transverse process of the corresponding vertebra

Ribs are divided based on anatomical features as typical and atypical.

Typical ribs:

Ribs 3 to 9 are typical. A typical rib is curved, and has a shaft with anterior and posterior ends:

• The anterior end has costal cartilage

• The posterior end has a head, neck, and a tubercle and articulates with the vertebra at 3 sites as follows:

• The head has 2 facets and articulates with the vertebra at 2 sites

• The tubercle has articular and nonarticular surfaces. The articular surface articulates with the transverse process

Atypical ribs:

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Ribs 1, 2, 10, 11, and 12 are atypical.

• 1st rib - it is flat. The head has only a single articular facet. The superior surface has a scalene tubercle.

• 2nd rib - the external surface of the shaft has a rough area, where the serratus anterior attaches.

• 10th rib - the head has a single facet.

• 11th and 12th ribs - the head has 1 large facet. They don't have necks or tubercles.

Solution to Question 7:

The given case scenario and chest X-ray features are suggestive of a tumor at the apex of the right lung, also called Pancoast tumor. The thoracic duct does not lie between the 1st rib and the apex of the lung, so it will not be compressed. The thoracic duct crosses from right to left in the mediastinum at the level of T5 and ascends upwards to drain into the venous system.

The structures present between the 1st rib and apex of the lung (medial to lateral) can be remembered using the mnemonic SVAN:

• Sympathetic trunk

• Vein - Posterior intercostal

• Artery - Superior intercostal

• Nerve - T1 nerve

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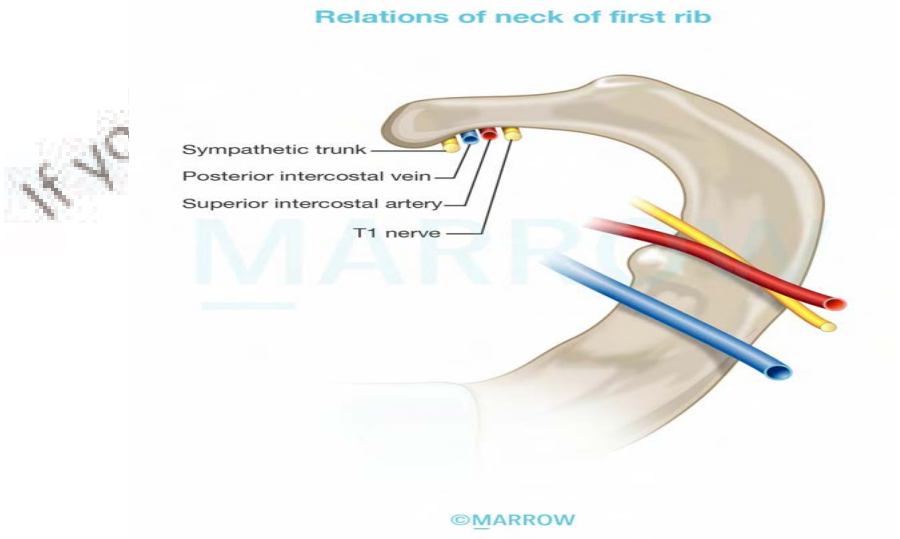

Clinical significance:

Pancoast tumors can cause destruction of the first rib by mass effect. Given below is an X-ray image of a Pancoast tumor (marked as P).

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Pancoast tumor

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Solution to Question 8:

The marked area is the groove anterior to the scalene tubercle on the first rib. The subclavian vein passes through this.

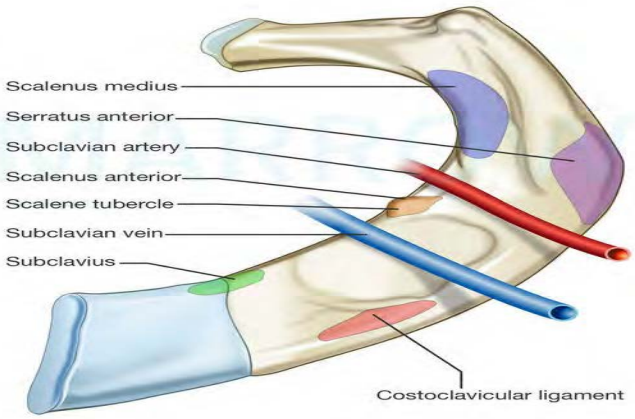
It is structures passing through the grooves around the scalene tubercle are:

• Anterior groove - Subclavian vein.

• Posterior groove - Subclavian artery and lower trunk of brachial plexus.

The image below shows the relations of the first rib

First rib: Superior view



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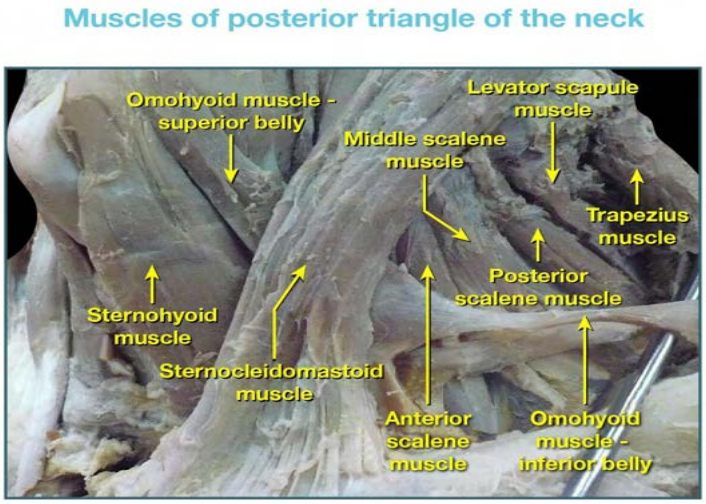
Solution to Question 9:

The structure marked A is the scalenus anterior. It attaches on the first rib on its scalene tubercle.



The scalene tubercle is a small projection on the medial (inner) border of the 1st rib, between two grooves.

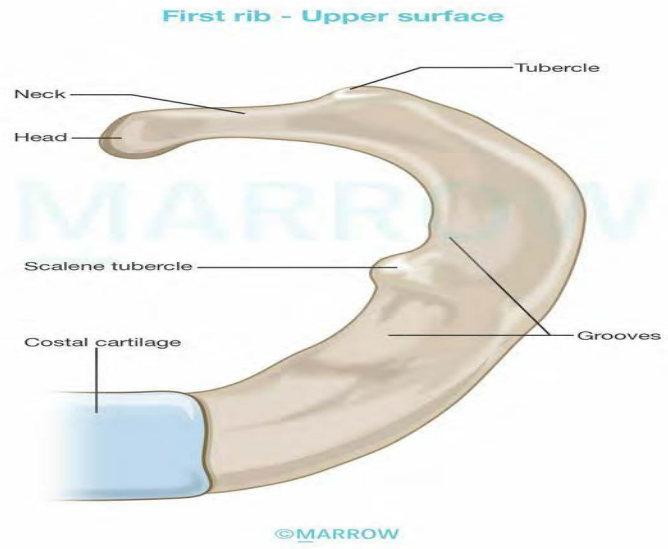
Structures passing through these grooves are

• Anterior groove - Subclavian vein.

• Posterior groove - Subclavian artery and lower trunk of brachial plexus.

Option B: The tuberculum sellae is a part of the sphenoid bone and is present within the sella turcica

Option D: The Chassaignac tubercle or carotid tubercle is present on the transverse process of C6. The carotid pulsations are palpated by pressing against this.



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Solution to Question 10:

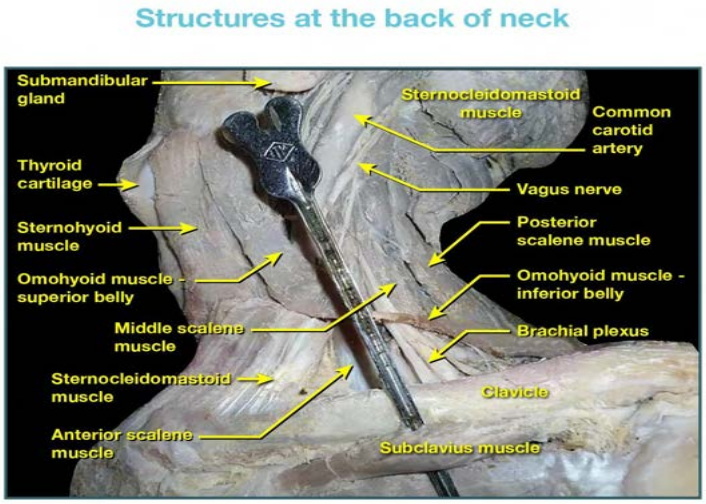
In the given image, the scalenus posterior marked as C has no attachment on the first rib. It attaches to the second rib.

Other structures marked are:

A - Scalenus anterior

B - Subclavius

D - Scalenus medius



The attachments on the 1st rib are:

- Subclavius
- Scalenus anterior
- Scalenus medius
- First digitation of serratus anterior
- Suprapleural membrane
- Costoclavicular ligament

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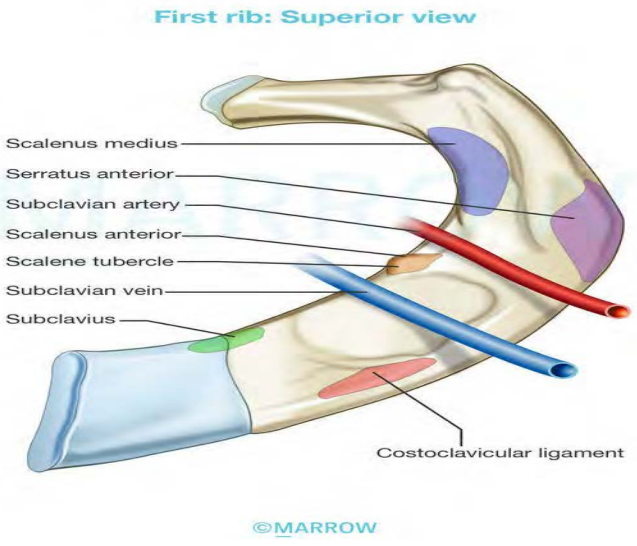

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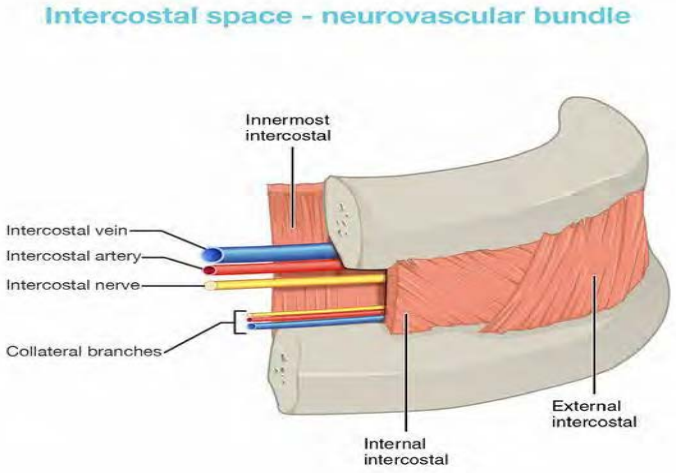
Solution to Question 11:

The arrangement of the components of the neurovascular bundle in the intercostal space from below upwards is nerve-artery-vein.

The arrangement can be remembered from above downwards with the mnemonic VAN: vein-artery-nerve.



Solution to Question 12:

The classic vein-artery-nerve arrangement is not seen in the 1st rib.

In the first rib, the arrangement of structures seen medial to lateral are as follows: SVAN

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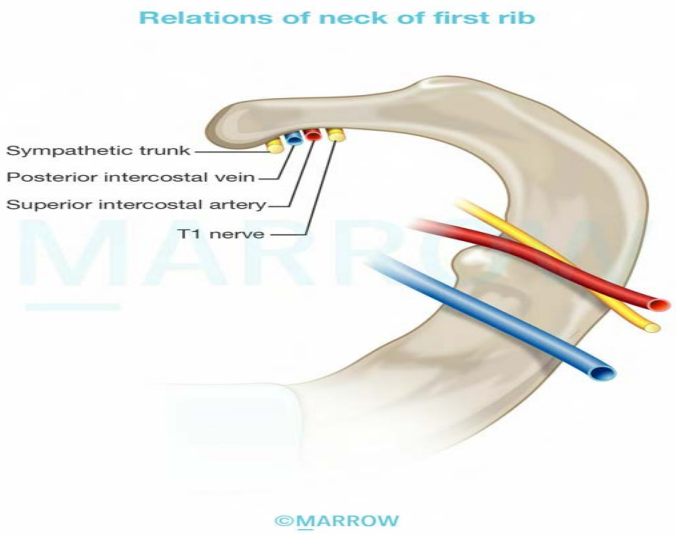
• Sympathetic trunk

• Vein (intercostal)

• Artery (superior intercostal)

• Nerve (T1 nerve)



Solution to Question 13:

The tip of the T3 spinous process corresponds to the root of the spine of the scapula

Other important surface markings of scapula:

• Superior angle of scapula: at the level of 2nd rib and vertebra T2.

• Inferior angle of scapula: opposite the T7 vertebral spinous process.

Solution to Question 14:

Sibson's fascia is attached to the inner border of the 1st rib, not the 2nd rib.

Sibson's fascia (suprapleural membrane) serves as a plane of separation between the lower neck and the thorax and covers the apical part of the lung. It is attached to the inner border of the 1st rib and posteriorly to the anterior border of the transverse process of the C7 vertebra. It is strengthened by a few spreading muscular fibers derived from the scalene muscles. The subclavian vessels lie on top of it.

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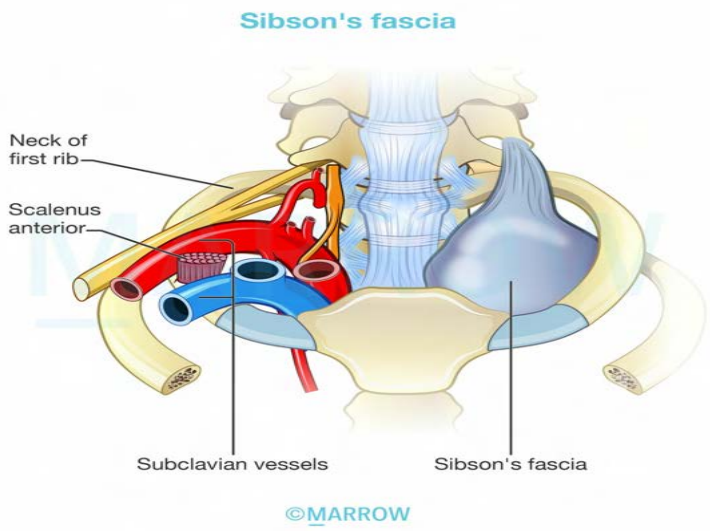

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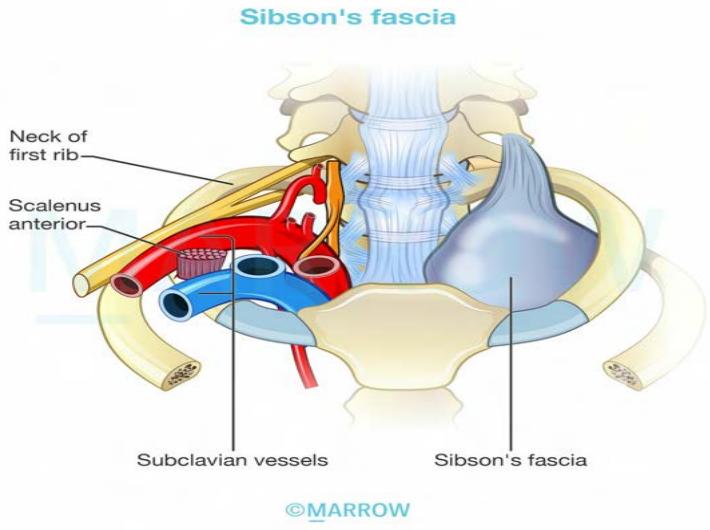
Solution to Question 15:

The stab injury penetrated the apex of the lung. It is covered by Sibson's fascia, also known as the suprapleural membrane. Attachment of Sibson's fascia is at vertebra C7.

Sibson's fascia is attached:

- Anteriorly to the inner border of the first rib
- Posteriorly to the anterior border of the transverse process of the C7 vertebra.



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Thoracic Wall

Question 1:

What is the intercostal nerve a branch of?

a) Dorsal rami of cervical spinal nerves

b) Dorsal rami of thoracic spinal nerves

c) Ventral rami of thoracic spinal nerves

d) Ventral rami of cervical spinal nerves

Question 2:

A patient with a history of slip and fall developed fracture of the thoracic spine. On neurological examination, there's a loss of sensation over the xiphoid process. Which of the following spinal nerves involves this region?

a) T4

b) T6

c) T9

d) T10

Question 3:

The given image shows the posterior thoracic wall. Which of the following statements is false about the structure marked A within the intercostal space?

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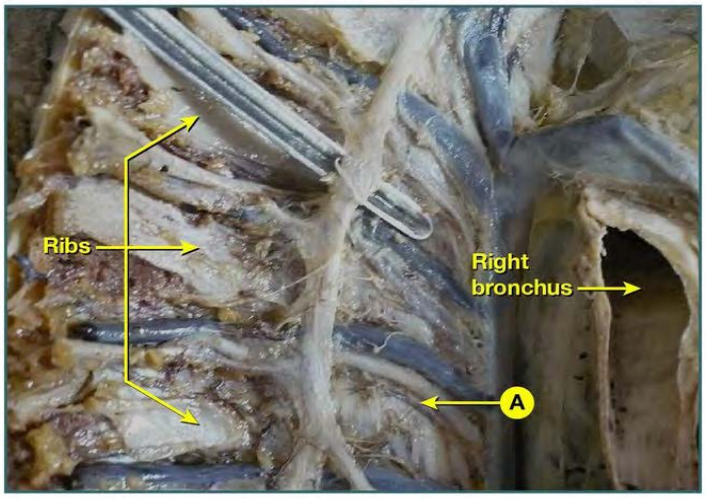

a) It is located below the intercostal artery

b) Derivatives from T4 and T5 are typical in type

c) They lie between external intercostal and internal intercostal muscle

d) Derivatives from T7 to T11 supply the abdominal wall

Question 4:

What forms the subcostal nerve?

a) Dorsal ramus of T6

b) Dorsal ramus of T12

c) Ventral ramus of T6

d) Ventral ramus of T12

Question 5:

A patient who underwent right-sided mastectomy is now complaining of pain over the axilla and medial aspect of the right upper arm. What is the nerve involved a branch of?

a) 1st intercostal nerve

b) 2nd intercostal nerve

c) 3rd intercostal nerve

d) Upper trunk of brachial plexus

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Question 6:

A patient diagnosed with empyema was planned for intercostal drainage tube insertion. During the procedure, which of the following muscles is not pierced?

a) External intercostal

b) Internal intercostal

c) Innermost intercostal

d) Transversus thoracis

Question 7:

Which of the following is true about the left phrenic nerve?

a) Arise from dorsal rami of C2, C3, and C4

b) Descends in the left pleural space

c) Supplies the parietal peritoneum on the diaphragm

d) Passes through the vena caval opening in the diaphragm

Question 8:

A patient with pericarditis is complaining of pain in the left shoulder and neck. Through which of the following nerves is this sensation carried?

a) Deep cardiac plexus

b) Superficial cardiac plexus

c) Phrenic nerve

d) Subcostal nerve

Question 9:

A 50-year-old woman presented with chest pain, dyspnea, and weight loss. Chest X-ray showed an elevated right dome of the diaphragm. CT revealed a tumor invading the right lung surface anterior to the hilum. Which of the following nerves is most likely to be involved by the tumor?

a) Recurrent laryngeal nerve

b) Intercostal nerve

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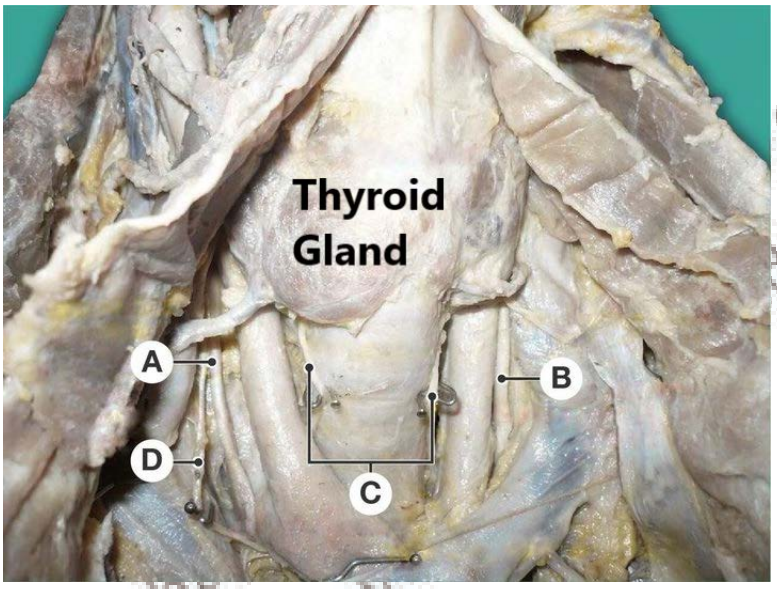
c) Vagus nerve

d) Phrenic nerve

Question 10:

A patient presented with paradoxical respiration. Which of the following nerves is most likely to be affected?



a) A

b) B

c) C

d) D

Question 11:

A fluoroscopic examination is being performed in a patient with suspected phrenic nerve palsy. On asking the patient to inspire, you observe the following in the diaphragm. Which of the following statements is correct about the course of the nerve involved?

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a) It runs anterior to scalenus anterior

b) It lies posterior to brachial plexus

c) It lies posterior to subclavian artery

d) It runs behind the left hilum

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Question 12:

What is the superior intercostal artery a branch of?

a) Costocervical trunk

b) Dorsal scapular artery

c) Thyrocervical trunk

d) Internal thoracic artery

Question 13:

Which of the following is true about the anterior intercostal arteries?

a) They are present in the 1st to 12th intercostal spaces

b) The upper 9 intercostal spaces have 2 anterior intercostal arteries

c) They are branches of the external thoracic artery

d) They anastomose with internal thoracic artery

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Question 14:

A 20-year-old male was brought to the emergency department after he suffered a stab wound in the anterior chest wall. CT-scan revealed arterial extravasation from injury to the internal thoracic artery. The condition causes a decrease in blood supply through all of the following blood vessels, except:

a) Superior epigastric

b) Musculophrenic

c) Anterior intercostal

d) Posterior intercostal

Question 15:

Rib notching was observed on chest X-ray, in a patient with Turner's syndrome due to enlargement of arteries in the inferior rib margin. Which of the following is incorrect about these arteries?

a) They supply the intercostal space up to the costo-chondral junction

b) First two pairs arise from branches of the thyrocervical trunk

c) Arteries on the right are longer than the corresponding ones on the left

d) There are 11 pairs of posterior intercostal arteries

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Question 16:

In the post-ductal coarctation of the aorta, blood flow to the lower limbs is maintained by increased blood flow through which of the following?

a) Inferior phrenic and pericardiophrenic artery

b) Intercostal and superior epigastric artery

c) Subcostal and umbilical artery

d) Vertebral and anterior spinal artery

Question 17:

Which of the following is not a tributary of left superior intercostal vein?

a) Left 3rd posterior intercostal vein

b) Left 2nd posterior intercostal vein

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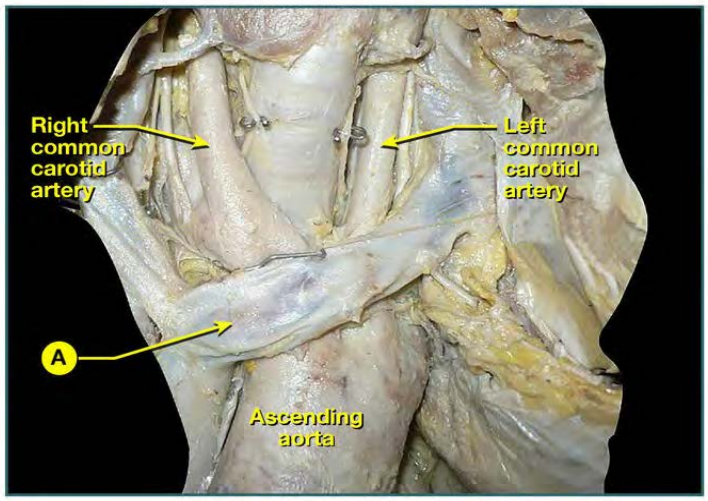
c) Left 1st posterior intercostal vein

d) Left 4th posterior intercostal vein

Question 18:

Which of the following veins drain into the structures marked A?



a) Hemiazygous vein

b) Superior thyroid veins

c) Right superior intercostal vein

d) Left superior intercostal vein

Question 19:

In a patient with inferior vena caval obstruction, which of the following collaterals do not help drain the blood?

a) Superior epigastric and inferior epigastric vein

b) Superficial epigastric and iliolumbar vein

c) Azygous and hemiazygous veins

d) Vertebral venous plexus

Question 20:

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A 2-year-old girl playing with small magnets suddenly develops breathlessness. Chest X-ray shows an inhaled foreign body in one of the bronchi. Where does the vein supplying the most likely site of obstruction drain into?

a) Right subclavian vein

b) Right brachiocephalic vein

c) Azygous vein

d) Accessory hemiazygous vein

Question 21:

At what level does the hemizygous vein cross from the left to the right side?

a) T8

b) T10

c) T12

d) T6

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Answer Key

Question No.	Correct Option
1	c
2	b
3	c
4	d
5	b
6	d
7	c
8	c
9	d
10	d
11	a
12	a
13	b
14	d

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15	b
16	b
17	c
18	d
19	b
20	c
21	a

Detailed Explanations

Solution to Question 1:

The intercostal nerve is a branch of ventral rami (anterior) of thoracic spinal nerves.

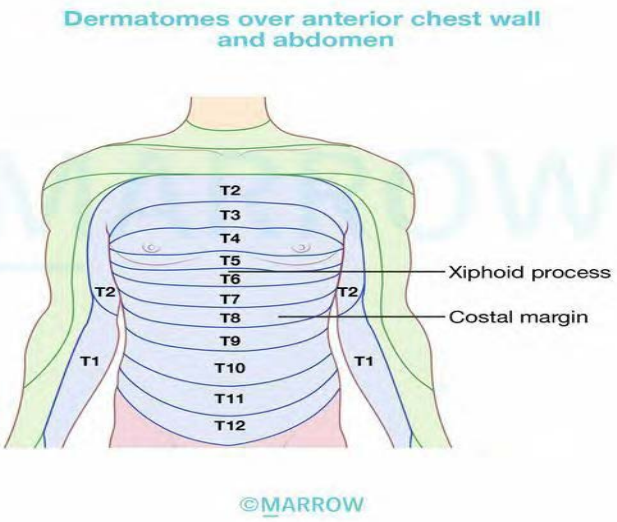
Intercostal nerves are distributed primarily to the thoracic and abdominal walls:

• The 1st thoracic nerve with a variable proportion of the 2nd passes into the brachial plexus.

• The 3rd,4th,5th,6th supply only the thoracic wall,

• The 7th,8th,9th,10,11th supply both thoracic and abdominal walls.

• The subcostal nerve supplies the abdominal wall and the gluteal skin.



Solution to Question 2:

Thoracic spinal nerve, T6 is involved here as it supplies the skin over the xiphoid process.

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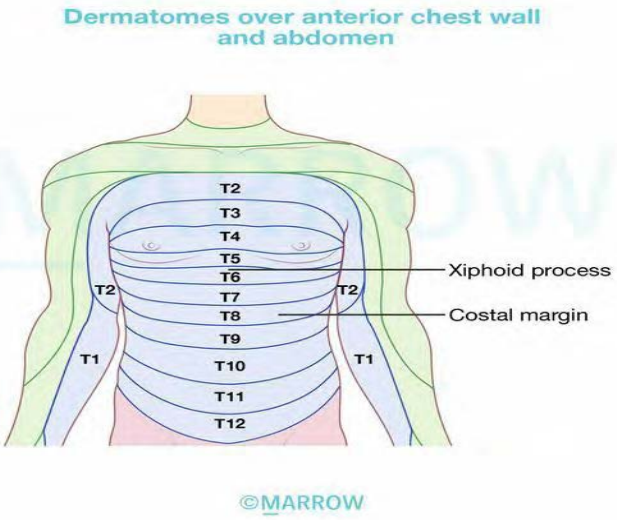
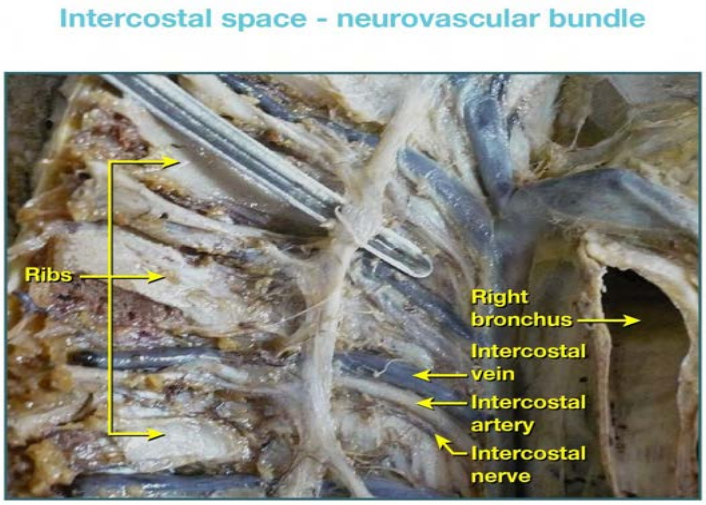
The anterior chest wall is innervated by the lateral and anterior cutaneous branches of the intercostal nerves.

Intercostal nerves T7 to T11 and the subcostal nerve T12 supply the skin and muscle of the abdominal wall. In addition, T5 and T6 supply the upper parts of the external oblique muscle of the abdominal wall. The highest thoracic dermatome on the anterior chest wall is T2.



Solution to Question 3:

The structure marked A is the intercostal nerve. It doesn't lie between external and internal intercostal muscles, but lies between the internal and innermost intercostal muscles.



Intercostal nerves are derived from the ventral rami of the thoracic vertebrae - T1 to T11. They lie between the internal intercostal and innermost intercostal muscles.

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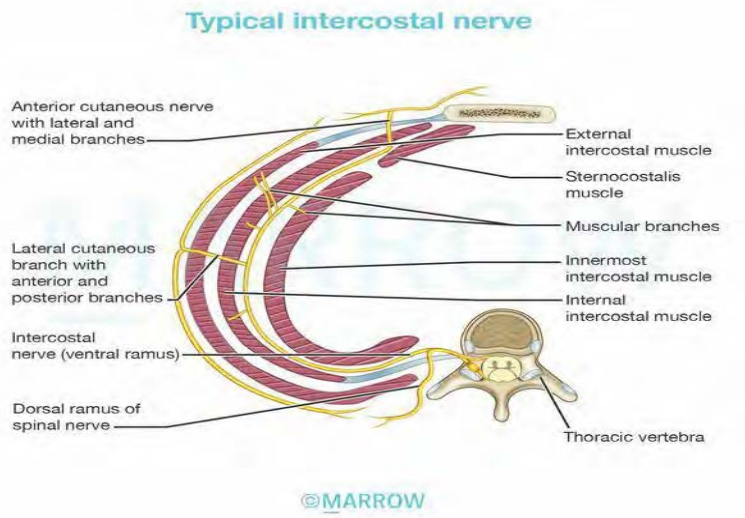
Typical intercostal nerves are those that only supply only the thoracic wall, e.g, 3rd to 6th intercostal nerves. All the other intercostal nerves supply other regions as follows:

• Upper two intercostal nerves - supply upper limb

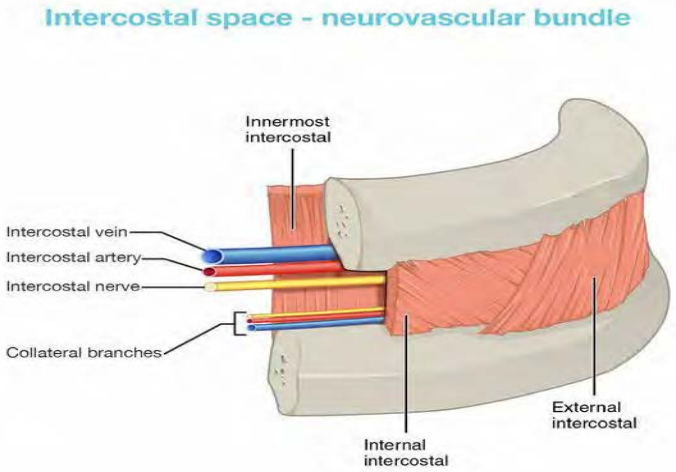
• 1st intercostal nerve - does not have the lateral and anterior cutaneous branches.

• 2nd intercostal nerve - gives off the intercostobrachial nerve

• 7th to 11th intercostal nerves - supply abdominal wall, hence they are called thoracoabdominal nerves.



In each intercostal space, the arrangement of the structures superior to inferior is vein, artery, nerve (VAN). In the 1st intercostal space, the neurovascular bundle lies superiorly, and the arrangement from medial to lateral is the Sympathetic trunk, intercostal Vein, superior intercostal Artery, intercostal Nerve. (SVAN).



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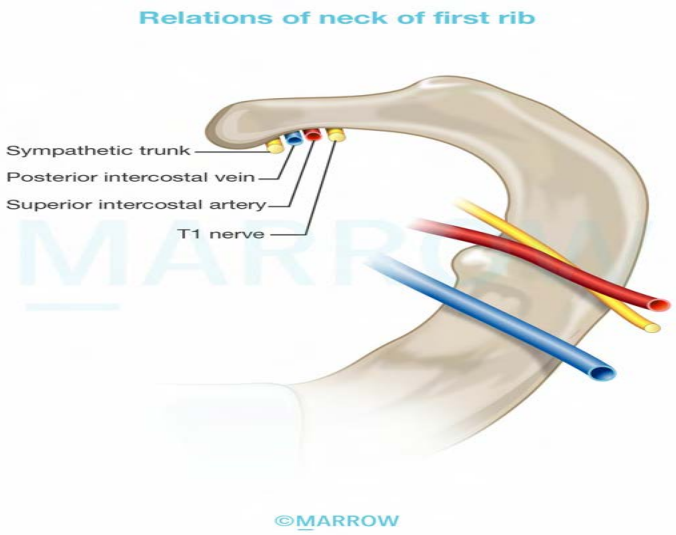

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Solution to Question 4:

The subcostal nerve is formed by the ventral ramus of T12.

It supplies the abdominal wall and gluteal skin and gives a branch to pyramidalis.

Solution to Question 5:

The given case scenario is suggestive of iatrogenic injury to the intercostobrachial nerve. It is a branch of the 2nd intercostal nerve.

It is the lateral cutaneous branch of the 2nd intercostal nerve and supplies the skin of the axilla and upper part of the medial aspect of the arm.

Clinical significance:

• Common site of injury during surgeries such as mastectomy, axillary nerve blocks, and other axillary surgeries.

• Source of referred cardiac pain.

Solution to Question 6:

Intercostal drainage tubes are placed in the mid-axillary line, and transversus thoracis is not pierced as it lies anteriorly, not in the mid-axillary line.

Transversus thoracis muscle:

• Also known as triangularis sternae or sternocostalis.

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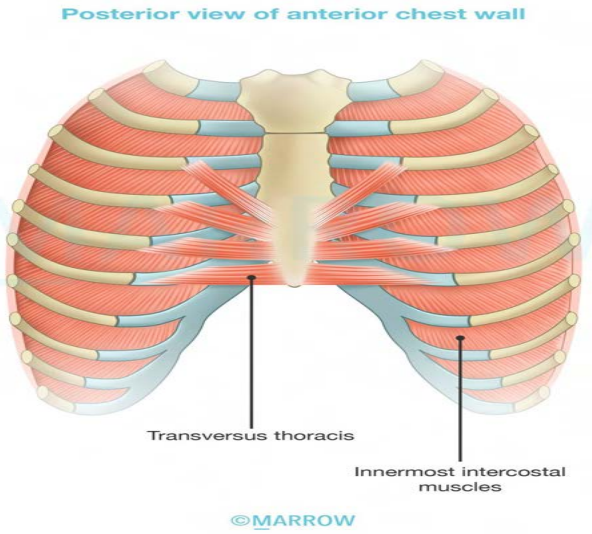
• Origin - lower third of the posterior surface of the sternum, xiphoid process, and costal cartilages of lower 3-4 true ribs.

• Insertion - into the cartilage of the 2nd to 6th ribs.



The innermost muscular plane has three named muscles:

• Innermost intercostals are at the sides of the rib cage.

• Subcostalis are at the back

• Transversus thoracis at the anterior part of the thoracic rib cage.

Solution to Question 7:

The left phrenic nerve supplies sensory fibers to the parietal peritoneum covering the diaphragm, and the mediastinal and diaphragmatic pleura on the left side.

The phrenic nerve is a mixed nerve derived mostly from the C4 ramus and also receives contributions from the C3 and C5 ventral rami. It is formed at the lateral border of scalenus anterior.

It descends anterior to the pulmonary hilum and lies between the mediastinal pleura and fibrous pericardium. It passes through the muscular part of the diaphragm just anterior to the central tendon. The right phrenic nerve passes through the vena caval opening.

Both right and left phrenic nerves supply:

• Motor fibers to the muscular diaphragm - respective crura of the diaphragm

• Sensory fibers to the mediastinal pleura, fibrous and serous pericardium, and diaphragmatic peritoneum.

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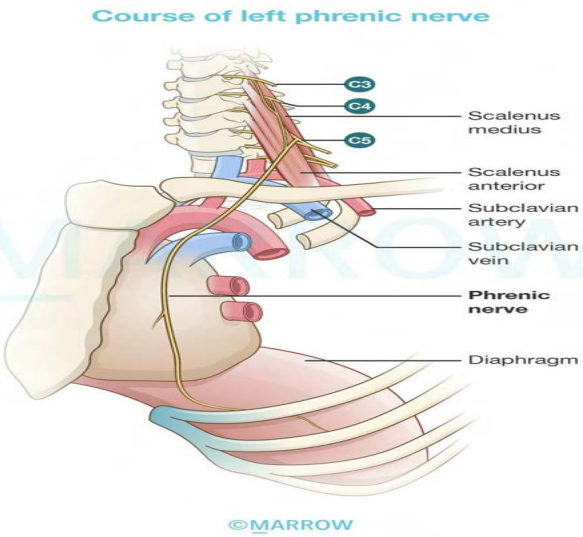

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Solution to Question 8:

The pain of pericarditis is carried by the phrenic nerve.

The somatic sensation from the pericardium is carried by the somatic afferent fibres of the phrenic nerve. The pericardial pain may be referred to the supraclavicular region of the shoulder or lateral neck area (dermatomes C_3, C_4, and C_5).

Solution to Question 9:

The right phrenic nerve is involved by the tumor as it passes anterior to the hilum of the lung.

The phrenic nerve provides the sole motor supply to the diaphragm. Normally, the diaphragm flattens when it contracts. Involvement of the phrenic nerve causes elevation of the respective dome of the diaphragm.

Options A, C - Vagus nerve passes posterior to the hilum of the lung. The recurrent laryngeal nerve arises from the vagus nerve before this.

Option B - The intercostal nerve lies in the intercostal space and is not related to the hilum of the lungs.

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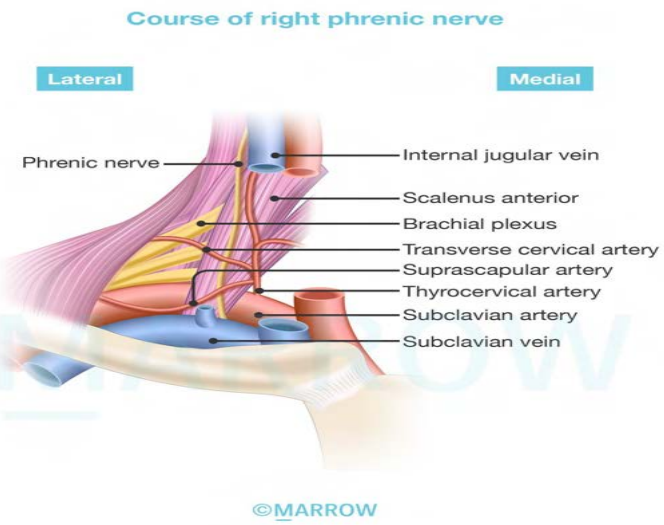

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Solution to Question 10:

Paradoxical respiration occurs due to the damage of the phrenic nerve, which is marked as D, in the given image.

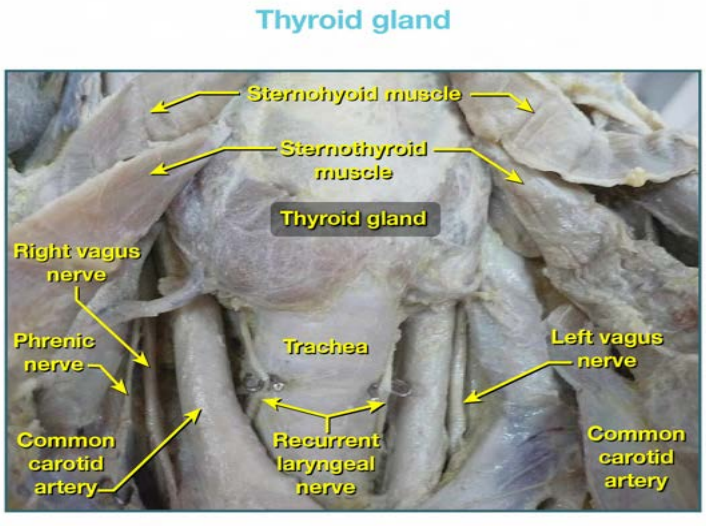
The structures marked in the image are:

A. Right vagus nerve

B. Left vagus nerve

C. Recurrent laryngeal nerve

D. Right phrenic nerve



Paradoxical movements in the chest are as follows:

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• Paradoxical respiration - the abnormal movement of the chest wall or abdominal wall, where they move in during inspiration instead of moving out. It is seen in flail chest.

• Paradoxical movement of the diaphragm - normally, the diaphragm moves down during inspiration. However, in cases of phrenic nerve palsy, the affected side of the diaphragm moves upward (paradoxical respiration) due to diaphragmatic paralysis. The gold standard investigation to detect this is the electrical or magnetic stimulation of the phrenic nerve with a recording of the compound muscle action potential and/or the transdiaphragmatic pressure. This can be observed on ultrasound or fluoroscopy.

Solution to Question 11:

The given case scenario and paradoxical elevation of the left dome of the diaphragm on inspiration are suggestive of left phrenic nerve palsy. The left phrenic nerve runs anterior to the scalenus anterior.

The course of the left phrenic nerve:

Cervical region - both phrenic nerves pass,

• Anterior to scalenus anterior muscle

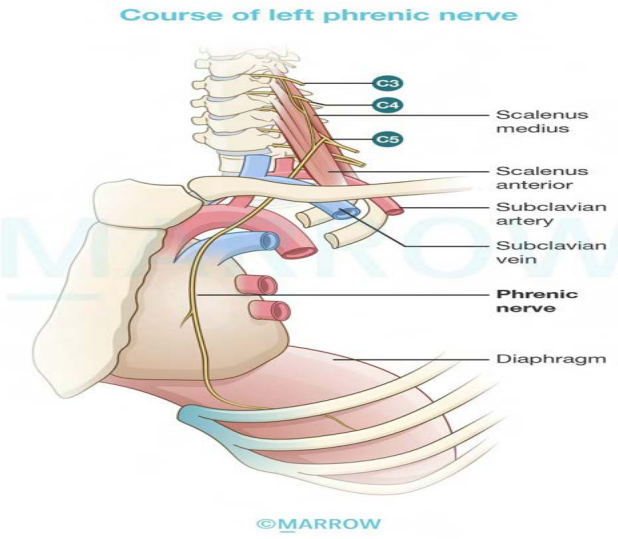
• Posterior to sternocleidomastoid and inferior belly of omohyoid

• Posterior to internal jugular vein, transverse cervical artery, and suprascapular artery

• Posterior to the thoracic duct on the left

Root of the neck - It lies medial to the trunks of the brachial plexus in the neck. At the root of the neck, it runs anterior to the second part of the subclavian artery and posterior to the subclavian vein.

Thorax - The phrenic nerve enters the thorax by crossing medially in front of the internal thoracic artery. Within the thorax, the phrenic nerve descends anterior to the pulmonary hilum between the fibrous pericardium and mediastinal pleura, accompanied by the pericardiacophrenic vessels.



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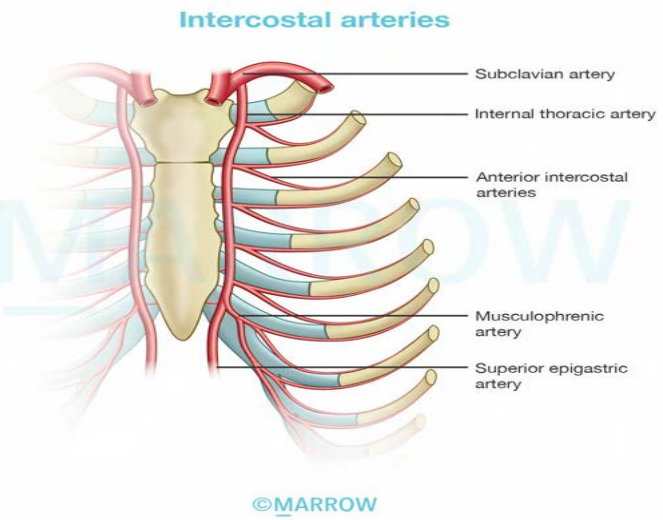
Solution to Question 12:

Superior intercostal artery is a branch of the costocervical trunk.

It descends in front of the neck of the first 2 ribs and gives rise to the first two posterior intercostal arteries.

The artery is not constant and is more common on the right. When it is absent, it is replaced by a direct branch from the aorta.



Solution to Question 13:

Each of the upper 9 intercostal spaces has 2 anterior intercostal arteries and 1 posterior intercostal artery.

The 10th and 11th intercostal spaces have no anterior intercostal artery and 1 posterior intercostal artery.

Anterior intercostal arteries arise from the following:

• Internal thoracic artery - Upper 6 spaces

• Musculophrenic artery - 7th to 9th spaces

Anterior intercostal arteries anastomose with the respective posterior intercostal arteries and their collaterals. They are shorter than the posterior intercostal arteries.

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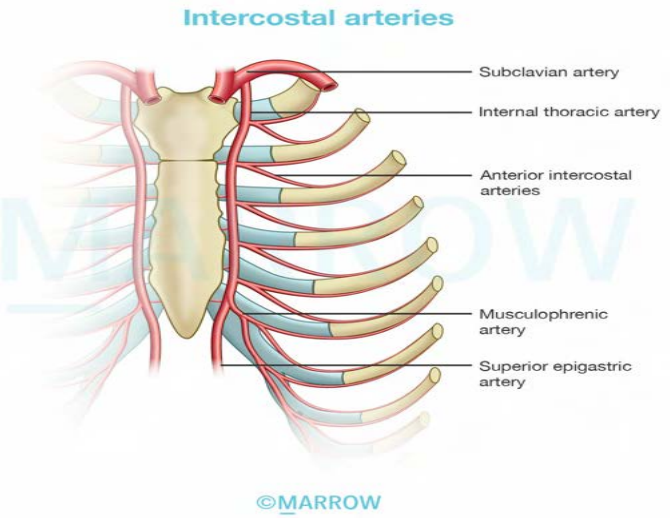

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Solution to Question 14:

Posterior intercostal arteries are not branches of the internal thoracic artery, hence there would be no decrease in blood supply through these arteries.

Branches of the internal thoracic artery:

- Terminal branches at the level of the 6th intercostal space:
- Superior epigastric artery
- Musculophrenic artery
- Sternal branches to:
- Transversus thoracis muscle
- Periosteum of the posterior sternal surface
- Sternal red bone marrow
- Anterior intercostal arteries for the first 6 intercostal spaces.
- Perforating branches that pierce and supply pectoralis major and then become direct cutaneous vessels that supply the skin.

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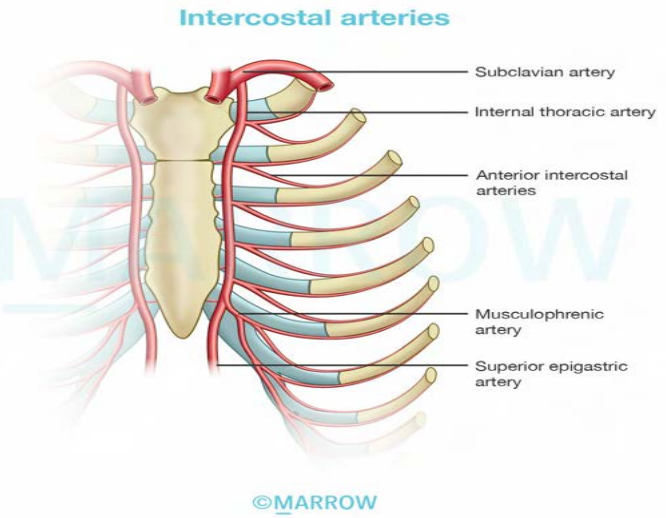

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Solution to Question 15:

Rib notching occurs due to enlargement of the posterior intercostal arteries. This is seen in coarctation of aorta.

There are 11 pairs of posterior intercostal arteries, and these supply up to the costochondral junction. The first 2 pairs are branches of the superior intercostal artery, a branch of the costocervical trunk. They are distributed to upper 2 intercostal spaces. The lower 9 pairs are branches of the descending thoracic aorta, which lies to the left of the vertebral column. Hence, the right posterior intercostal arteries are longer than those on the left.

Clinical significance:

Coarctation of the aorta is a congenital heart disease, causing narrowing of the aorta. Chest x-ray shows rib notching and enlargement of left subclavian artery.

Solution to Question 16:

The blood flow to the lower limb is maintained by intercostal and superior epigastric arteries.

In the post-ductal coarctation of the aorta, an extensive collateral circulation develops from the following sources:

• Axillary artery - The branches involved are:

• Thoraco-acromial

• Lateral thoracic

• Subscapular

• Subclavian artery - The enlarged branches are:

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• Suprascapular

• Costocervical trunk (1st and 2nd posterior intercostals)

• Internal thoracic arteries

• Costocervical trunk

• Posterior intercostal arteries

• Inferior epigastric arteries

The internal thoracic arteries give rise to:

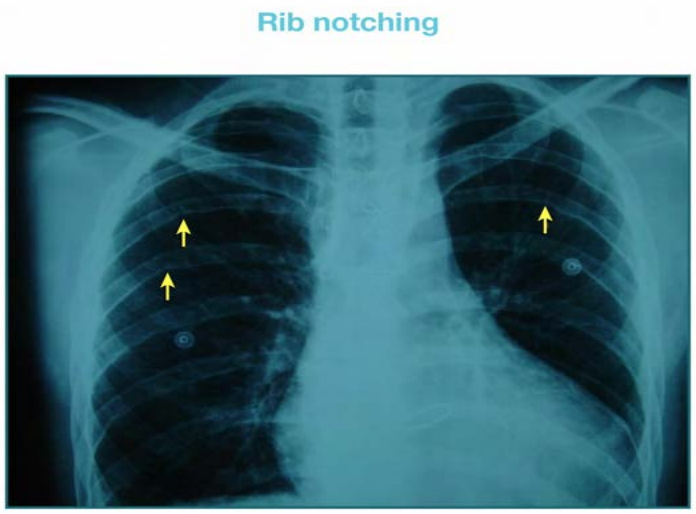
• Anterior intercostal arteries that carry blood to the posterior intercostals (3rd-6th) and thence into the descending aorta

• Superior epigastric arteries that anastomoses with the inferior epigastric (in the rectus sheath) and sends blood into the external iliac artery and thence towards the lower limb.

High vascularity is observed in the anterior thoracic wall as well as over the posterior thoracic wall especially in the interscapular area.

The scapular anastomosis is opened up and both scapulae become pulsatile.

Radiographic evidence of "rib notching" is seen in the inferior margins of the rib due to greatly enlarged posterior intercostal arteries. Also, the radiographic shadow of the enlarged left subclavian artery is quite evident clinically.



Lower limb may be supplied by the channels:

• Arch of aorta—subclavian artery—internal thoracic artery—superior epigastric artery—inferior epigastric artery—iliac artery—pelvis and lower limb.

• Arch of aorta—subclavian artery—internal thoracic artery—anterior intercostal artery—posterior intercostal artery—descending thoracic aorta—thorax, abdomen, pelvis, lower limb.

• Arch of aorta—subclavian artery—vertebral artery—anterior spinal artery—segmental artery—thoracic and abdominal aorta—thorax—abdomen, pelvis, lower limb.

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Solution to Question 17:

The left first posterior intercostal vein is not a tributary of the left superior intercostal vein.

On both sides, the first posterior intercostal vein drains into the brachiocephalic or vertebral vein.

On the right side:

• The 2nd, 3rd, and often the 4th posterior intercostal veins form the right superior intercostal vein, which drains into the arch of the azygos vein.

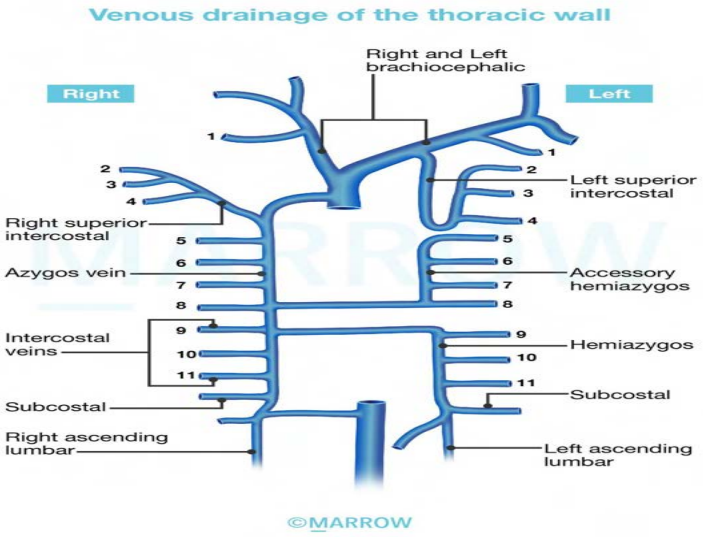
• The lower spaces drain directly into the azygos vein.

On the left side:

• The 2nd, 3rd and sometimes 4th posterior intercostal veins form left superior intercostal vein which drains into the left brachiocephalic vein.

• The 4th or 5th to 8th posterior intercostal veins drain into the accessory hemiazygos vein.

• The 9th to 11th posterior intercostal veins drain into the hemiazygos vein.



Solution to Question 18:

The structures marked A are the right and left brachiocephalic veins. The left superior intercostal vein drains into the left brachiocephalic vein.

Tributaries of the brachiocephalic vein:

• Left and right internal thoracic veins

• Left and right inferior thyroid veins

• Left superior intercostal vein drains into the left brachiocephalic vein.

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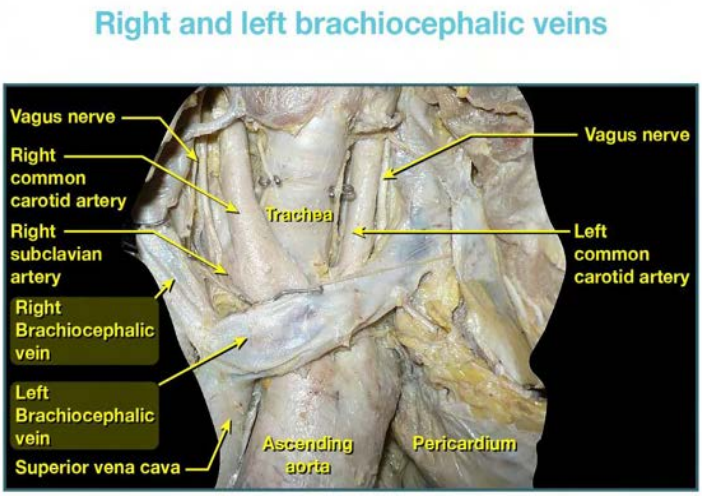
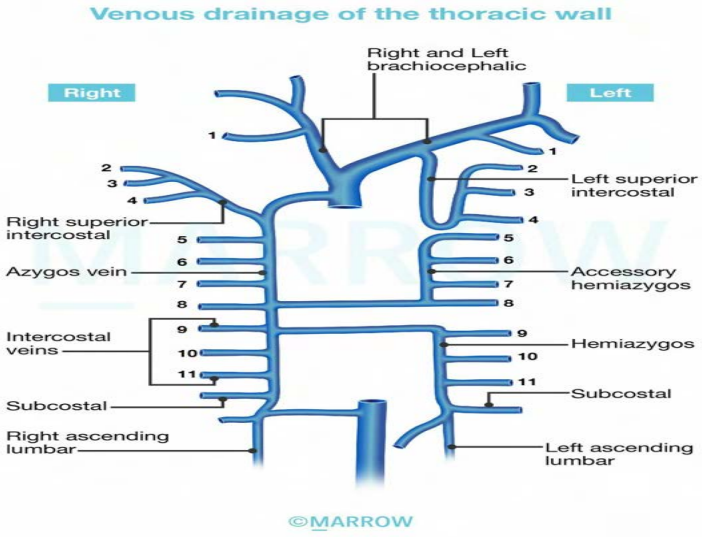
The right superior intercostal vein drains into the azygos vein.

Hemizygous vein drains into the azygous vein. (Option A)

Superior thyroid veins drain directly into internal jugular veins. (Option B)

Right superior intercostal vein drains into the azygous vein. (Option C)





Solution to Question 19:

Superficial epigastric and iliolumbar veins do not help to drain the blood in inferior vena caval (IVC) obstruction as they drain into the IVC itself. Iliolumbar veins drain directly into the IVC and superficial epigastric vein drains via the femoral vein.

In IVC obstruction, the collateral channels open up to drain the blood from the lower limb into the superior vena cava (SVC) and then to the heart.

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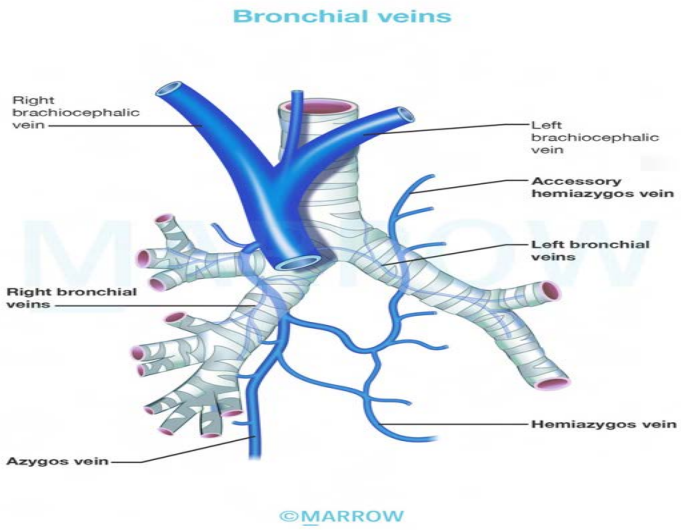
The main collateral channels are via azygous and hemizygous veins and vertebral venous plexuses. They communicate with the common iliac veins by the ascending lumbar veins and tributaries of the inferior vena cava. Additionally, blood is also drained by inferior epigastric veins > superior epigastric veins > internal thoracic veins > brachiocephalic veins > superior vena cava.

Solution to Question 20:

In the given case scenario of an inhaled foreign body, it is most likely to lodge into the right bronchus. The right bronchial veins drain to the azygos vein.

Left bronchial veins drain into the accessory hemiazygos vein or left superior intercostal vein.



Clinical significance:

The right principal bronchus is wider, shorter, and more vertical. This is why an inhaled foreign body is more likely to lodge there. Also, the tracheal bifurcation directs the foreign body to the right lung

Solution to Question 21:

The hemiazygos vein crosses from the left to the right side at the level of T8 vertebrae.

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Mediastinum

Question 1:

The mediastinum is divided into superior and inferior by a line joining sternal angle to the _____

a) T3-T4 intervertebral disc

b) T2-T3 intervertebral disc

c) T5-T6 intervertebral disc

d) T4-T5 intervertebral disc

Question 2:

Which of the following regions does the trachea lie in?

a) Superior mediastinum

b) Anterior mediastinum

c) Middle mediastinum

d) Posterior mediastinum

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Question 3:

A patient with myasthenia gravis was suspected to have a thymoma and a lateral chest X-ray was ordered to confirm the diagnosis. Which of the following regions will you expect to find a mass in?

a) Superior mediastinum

b) Middle mediastinum

c) Posterior mediastinum

d) Inferior mediastinum

Question 4:

Which of the following structures is present in the posterior mediastinum?

a) Thymus

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b) Ascending aorta

c) Esophagus

d) Tracheal bifurcation

Question 5:

Match the following structures and their locations.

a) A-1 , B-3 , C-4, D-2

b) A-2 , B-3 , C-4, D-1

c) A-2 , B-3 , C-1, D-4

d) A-3 , B-2, C-4, D-1

Question 6:

Which of the following statements is correct about the mediastinum?

a) Heart enclosed in the pericardium occupies the middle mediastinum

b) Thymus remnants may be present in the middle mediastinum

c) Posterior boundary of posterior mediastinum corresponds to T1-T4 vertebrae

d) Lower border of anterior mediastinum extends more inferiorly than posterior mediastinum

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Question 7:

A 60-year-old woman was diagnosed with papillary carcinoma thyroid. CT cuts from the middle mediastinum showed metastatic deposits. In this section, which of the following structures will not be visualized?

a) Superior vena cava

b) Ascending aorta

c) Pericardiophrenic veins

d) Left recurrent laryngeal nerve

Question 8:

Which of the following structures do not pass through the superior thoracic aperture?

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a) Right recurrent laryngeal nerve

b) Left common carotid artery

c) Left sympathetic trunk

d) Thoracic duct

Question 9:

A patient with lung cancer was found to have the following finding on his anterior abdominal wall. On examination, you observe that the blood flow in these blood vessels is completely downwards. CT chest showed obstruction of a thoracic vessel. Which of the following is false about the same?

a) Opens into the right atrium

b) Pierces the pericardium at 3rd costal cartilage

c) Enters the heart at the level of 4th intercostal space

d) Receives azygous vein below sternal angle

Question 10:

The thoracic duct usually originates at the level of:

a) L1 vertebra

b) T7 vertebra

c) L4 vertebra

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d) T11 vertebra

Question 11:

The thoracic duct receives tributaries from all of the following except:

a) Bilateral ascending lumbar trunk

b) Bilateral descending lumbar trunk

c) Left upper intercostal duct

d) Right bronchomediastinal lymphatic trunk

Question 12:

A patient with gastric cancer and Virchow's node developed a left-sided pleural effusion. An intercostal chest tube was inserted, and the following fluid was drained. Where does the structure affected in this case normally drain into?

a) Junction of superior vena cava and left brachiocephalic veins

b) Junction of left jugular and left subclavian veins

c) Directly into coronary sinus

d) Azygos vein

Question 13:

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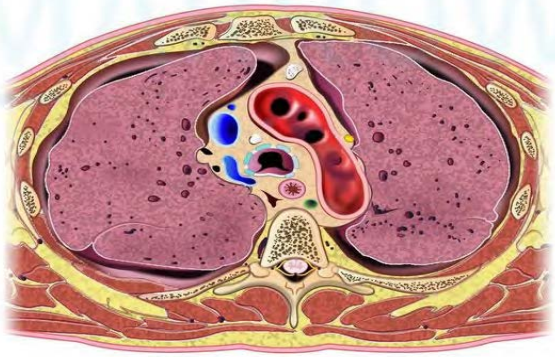
Identify the level of the cross-section shown in the image below.



a) T1 - T2

b) T2 - T3

c) T3 - T4

d) T4 - T5

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Answer Key

Question No.	Correct Option
1	d
2	a
3	a
4	c
5	b
6	a
7	d
8	a
9	b
10	a
11	d
12	b

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13	c

Detailed Explanations

Solution to Question 1:

The mediastinum is divided into superior and inferior by a line joining sternal angle to the T4-T5 intervertebral disc.

The sternal angle lies between the T4 vertebra and the upper half of the T5 vertebra in the majority of adults.

Sternal plane:

• Extent:

• Anteriorly - Manubriosternal joint (sternal angle or angle of Louis) at second costal cartilage.

• Posteriorly- intervertebral disc between the T4-T5 vertebrae

• Separates superior mediastinum from the inferior mediastinum.

• Anatomical landmark for:

• Superior limits of the pericardium

• Bifurcation of the pulmonary trunk

• Origin of the aortic arch

• The site where the superior vena cava penetrates the pericardium to enter the right atrium

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Solution to Question 2:

The trachea lies in the superior mediastinum.

Solution to Question 3:

Thymomas are tumors of the thymus gland and are associated with myasthenia gravis.
The thymus occupies the superior and anterior mediastinum.

Solution to Question 4:

The esophagus is present in the posterior mediastinum. The esophagus enters the superior mediastinum and lies between the trachea anteriorly and the vertebrae posteriorly. Inferiorly, it continues into the posterior mediastinum, passes through the diaphragm, and opens into the stomach.

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Option A - The thymus is present in the superior and anterior mediastinum.

Option B - The ascending aorta is present in the middle mediastinum.

Option D - The tracheal bifurcation is present in the middle mediastinum.

Solution to Question 5:

The correctly matched structures are -

	Structure		Location
A.	Left subclavian artery	2.	Superior mediastinum
B.	Hemiazygos vein	3.	Posterior mediastinum
C.	Phrenic nerve	4.	Middle mediastinum
D.	Sternopericardial ligaments	1.	Anterior mediastinum

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Solution to Question 6:

The heart enclosed in the pericardium occupies the middle mediastinum.

The middle mediastinum is the broadest part of the inferior mediastinum and contains the pericardium, heart, tracheal bifurcation, and corresponding vessels and nerves.

Option B: The thymus or its remnants are present in the superior and anterior mediastinum.

Option C: The posterior mediastinum is bounded:

• Anteriorly by

• Tracheal bifurcation

• Pericardium

• Pulmonary vessels

• Posteriorly by

• Bodies of T5-T12 vertebrae

• Anteroinferiorly by

• Arched posterior 1/3rd of the central portion of the diaphragm

Option D: The lower border of the posterior mediastinum extends more inferiorly as compared to the anterior mediastinum.

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Solution to Question 7:

The left recurrent laryngeal nerve will not be visualized in this section, as it is not present in the middle mediastinum. It is located in the superior mediastinum.

Solution to Question 8:

The right recurrent laryngeal nerve does not pass through the superior thoracic aperture, but the left recurrent laryngeal nerve does. The right recurrent laryngeal nerve hooks around the right subclavian artery in the neck region and ascends up in the tracheoesophageal groove to supply the larynx.

Structures passing through the superior thoracic aperture/thoracic inlet are:

- Viscera:
- Esophagus
- Trachea
- Lung apices with pleura
- Thymic remnants
- Large vessels:
- Brachiocephalic artery
- Right and left brachiocephalic vein
- Left common carotid artery
- Small vessels:
- Right and left internal thoracic arteries
- Right and left superior intercostal arteries
- Right and left first intercostal veins
- Inferior thyroid veins
- Nerves:
- Left recurrent laryngeal nerve
- Right and left phrenic nerves
- Right and left vagus nerves
- Right and left sympathetic trunks
- Right and left first thoracic nerves
- Muscles:
- Sternohyoid
- Sternothyroid
- Longus colli

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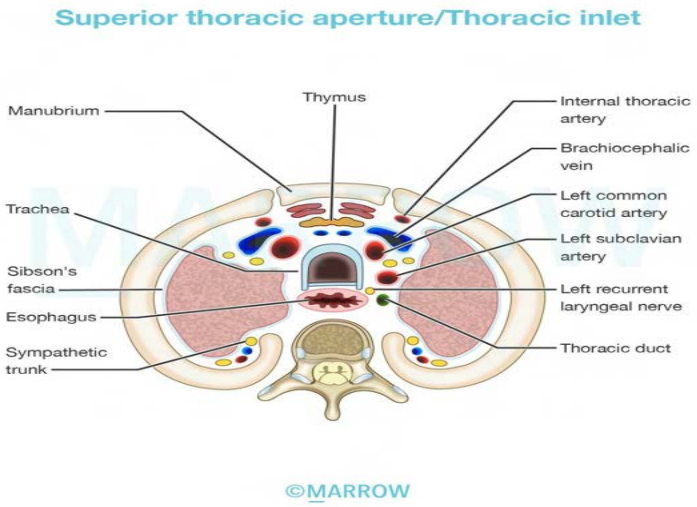
• Thoracic duct

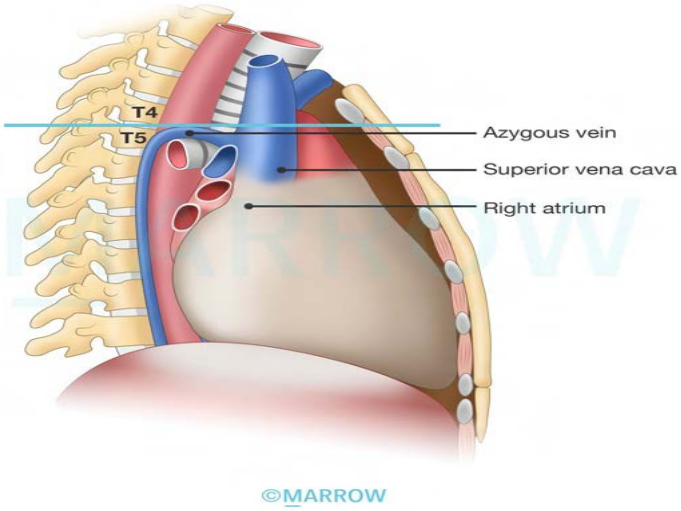


Solution to Question 9:

The given clinical scenario is suggestive of obstruction of the superior vena cava. It does not pierce the pericardium at the level of 3rd costal cartilage.

The superior vena cava pierces the pericardium opposite 2nd costal cartilage (angle of Louis/sternal angle), at the level of T4-T5 intervertebral disc. It also receives the azygous vein about 2 cm below the sternal plane at the level of T5 vertebra.

It enters the right atrium at the level of the 4th intercostal space.



Superior vena cava syndrome:

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Obstruction of superior vena cava due to metastatic cancers (eg. lung cancer, breast cancer, etc.) can result in reduced venous return from head and neck and upper extremities. It presents with swelling of the neck and face, dyspnea, headache, dizziness, and hemoptysis. Symptoms are aggravated by bending forwards.

On examination, the following may be seen

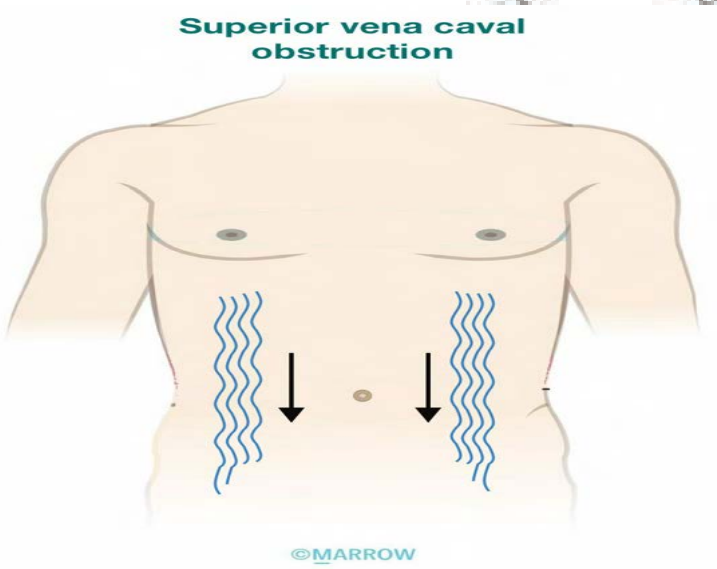
• Dilated neck veins

• Proptosis

• Papilledema

• Increased collateral veins on the anterior chest wall - flow is completely downward

CT-chest shows an absence or reduction of the opacification of the central veins and the presence of prominent collateral venous circulation.



Solution to Question 10:

The thoracic duct usually originates at the level of the L1 vertebra.

The thoracic duct usually originates anterior to L1 or L2 vertebra. It is formed when the intestinal and two lumbar lymph trunks join to form cisterna chyli which continues as the thoracic duct.

Course: It passes through the aortic hiatus of the diaphragm and enters the posterior mediastinum lying to the right between the aorta and the azygos vein up till T4-T5 vertebra. It then crosses over to the left side posterior to the esophagus. It continues upwards in the superior mediastinum and arches over the subclavian artery and descends anteriorly to drain into the confluence of the left jugular vein and left subclavian vein.

It receives lymph from both halves of the body below the diaphragm and only the left half of the head and neck, upper limb, and thorax.

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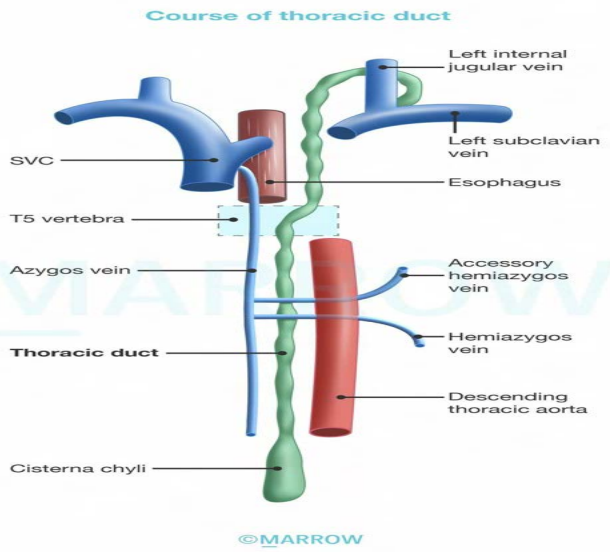

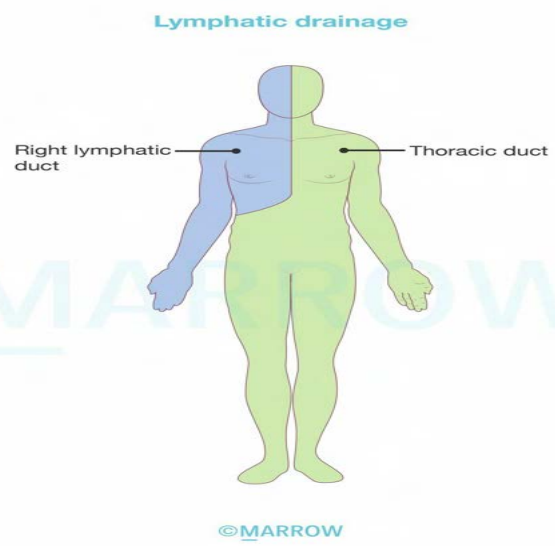

Solution to Question 11:

The thoracic duct does not receive a tributary from the right bronchomediastinal trunk. It receives a tributary from the left bronchomediastinal trunk.

The right lymphatic duct receives lymphatic drainage from the right half of the body above the diaphragm from:

• The right half of head and neck via the jugular trunk

• The right half of thoracic cavity via right bronchomediastinal trunk

• Right upper limb via subclavian trunk

Clinical relevance:

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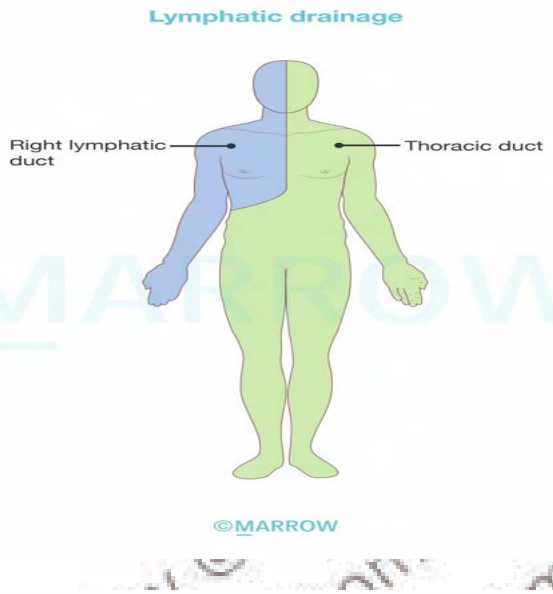
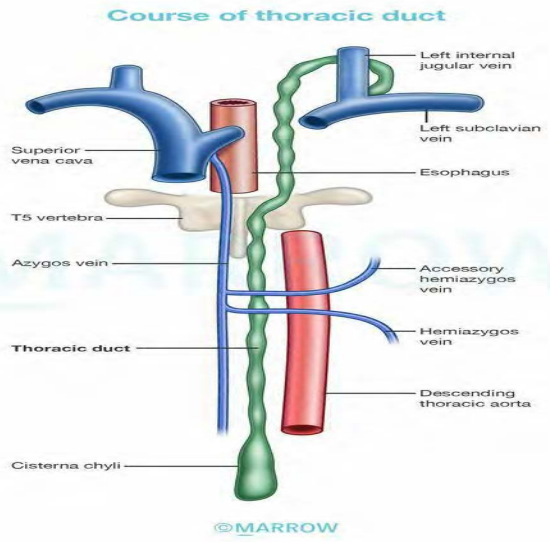
Chylothorax refers to the condition in which, there is an accumulation of lymphatic fluid in the pleural cavity. Depending on whether the obstruction of the thoracic duct is below or above the level of the fifth thoracic vertebra the pleural effusion is either right or left-sided, respectively.





Solution to Question 12:

The structure affected in this case is the thoracic duct. It drains into the junction of the left jugular and left subclavian veins.

The given image shows chyle, and the case scenario is suggestive of chylothorax secondary to obstruction of the thoracic duct by Virchow's node.

Clinical note:

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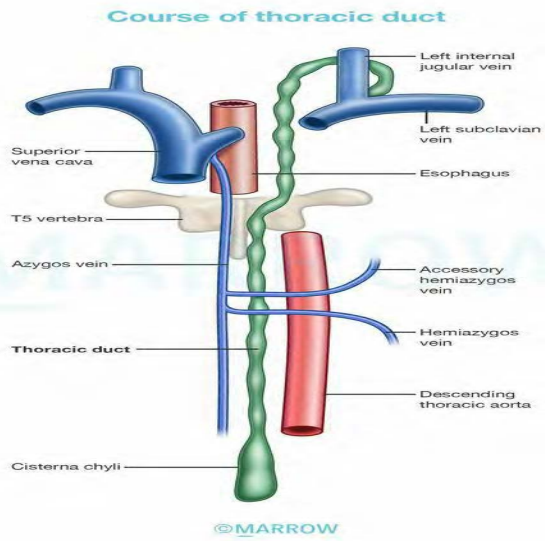
In gastric cancer, metastasis to the left supraclavicular lymph node causes its enlargement, and it is known as Virchow's node. The Virchow's node is closely related to the thoracic duct at the site where it drains into the venous system, therefore its enlargement can mechanically obstruct the thoracic duct.



Solution to Question 13:

The cross-section shown in the image is at the level of T3-T4.

The cross-section shows a large vascular opening of the arch of the aorta, along with three small openings corresponding to the brachiocephalic trunk, left common carotid artery and left subclavian artery. This suggests that the section was taken at the level between T3 and T4.

Options A, B: In cross-sections at the levels of T1-T2 and T2-T3, only the small vascular openings of the branches arising from the arch of aorta would be visible.

Option D: In cross-section at the level of T4-T5, where, the arch of the aorta begins and ends, bifurcation of the pulmonary trunk is visible.

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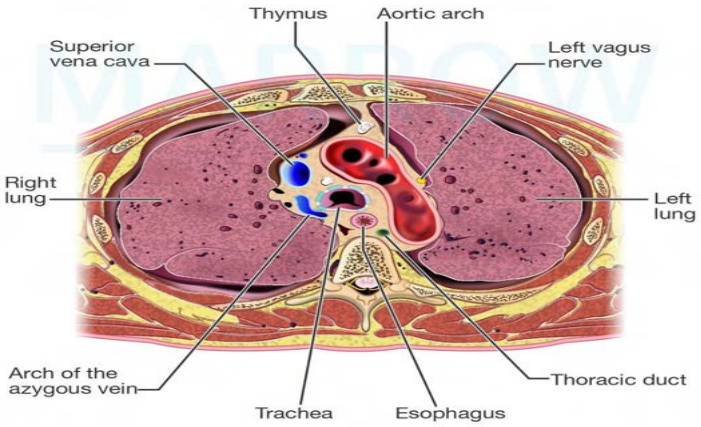
Axial section of the thorax at T3 - T4



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Diaphragm

Question 1:

Which of the following does not supply the diaphragm?

a) Musculophrenic artery

b) Inferior phrenic artery

c) Pericardiophrenic artery

d) Middle phrenic artery

Question 2:

The structure passing through the central tendon of the diaphragm is:

a) Oesophagus

b) Aorta

c) Inferior vena cava

d) Sympathetic Chain

Question 3:

A cardiothoracic surgeon performing a heart transplant accidentally damages the right phrenic nerve. Where does this structure pass through?

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a) 1

b) 2

c) 3

d) 4

Question 4:

Which of the following structures passes through the area marked A in the given diagram?

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a) Right phrenic nerve

b) Sympathetic trunk

c) Vagus nerve

d) Splanchnic nerves

Question 5:

A gasteroenterologist is performing an esophagoscopy in a patient with severe acid reflux. At which level will he encounter its diaphragmatic constriction?

a) T8

b) T9

c) T10

d) T12

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Question 6:

A vascular surgeon is operating on a case of aortic dissection of the thoracic aorta. He suspects that the dissection has extended into the abdominal aorta, and approaches the aortic hiatus of the diaphragm to localize the extension. Which of the following structures will be present here?

a) Left gastric vein and thoracic duct

b) Right vagus nerve and thoracic duct

c) Azygous vein and thoracic duct

d) Left vagus nerve and thoracic duct

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Question 7:

Which of the following does not pass through the structure marked A?

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a) Aorta

b) Azygous vein

c) Thoracic duct

d) Vagal trunk

Question 8:

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A patient with advanced esophageal cancer in the lower third of the esophagus is undergoing transhiatal esophagectomy. The surgeon enlarges the esophageal hiatus with four fingers. All of the following structures are likely to be injured, except:

a) Left gastric artery branch

b) Right vagus nerve

c) Left vagus nerve

d) Left phrenic nerve

Question 9:

All of the structures pass posterior to the crus of diaphragm except ____

a) Aorta

b) Azygous vein

c) Thoracic duct

d) Greater splanchnic nerve

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Answer Key

Question No.	Correct Option
1	d
2	c
3	c
4	b
5	c
6	c
7	d
8	d
9	d

Detailed Explanations

Solution to Question 1:

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The diaphragm is not supplied by the middle phrenic artery

The blood supply of diaphragm is via (Mnemonic - Simple):

• Superior phrenic arteries

• Inferior phrenic arteries

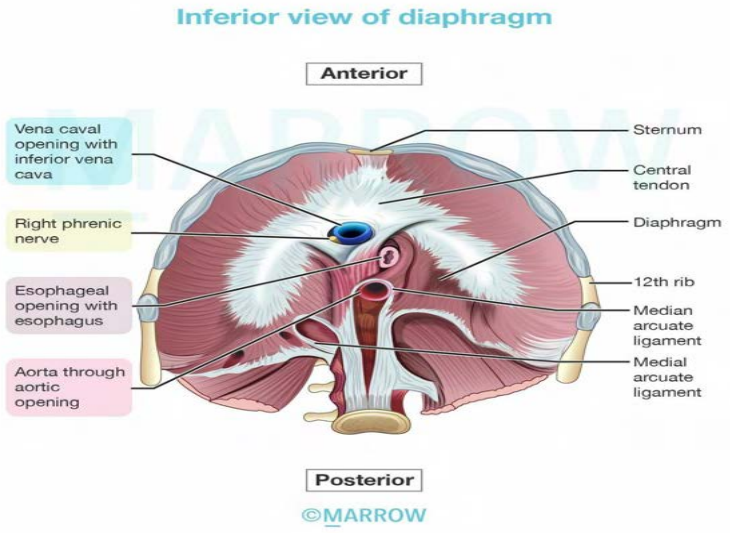
• Musculophrenic arteries

• Pericardiophrenic arteries

• Lower 5 intercostal and subcostal arteries

Solution to Question 2:

The inferior vena cava passes through the central tendon of the diaphragm.



Solution to Question 3:

The right phrenic nerve passes through the central tendon of the diaphragm, either by the caval hiatus (labeled 3) or just lateral to it.

Other structures:

• 1 - Medial arcuate ligament

• 2 - Aortic opening

• 4 - Esophageal opening

The left phrenic nerve passes through the muscular part of the diaphragm anterior to the central tendon, just lateral to the left cardiac surface and more anterior than the right phrenic nerve.

Clinical significance:

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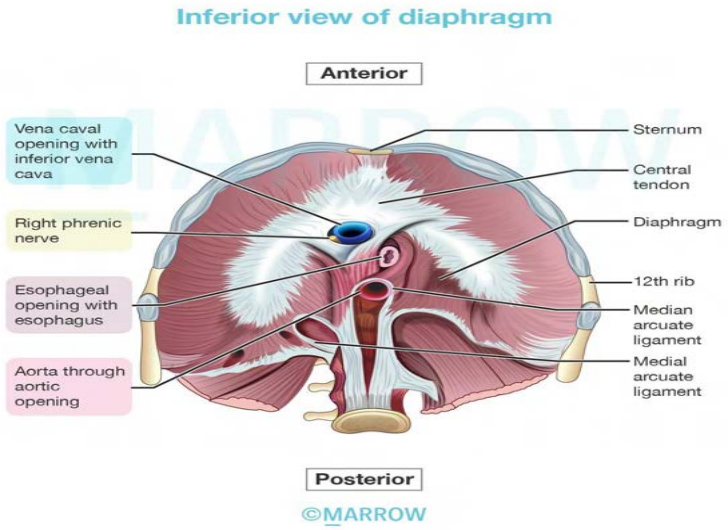
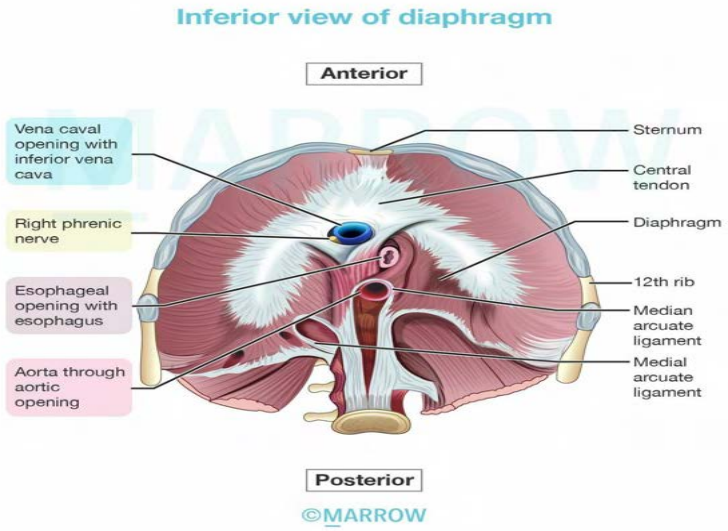
Phrenic nerve injury can occur due to cardiothoracic surgery and can present as diaphragmatic paralysis. On chest X-ray, it appears as elevation of hemidiaphragm.



Solution to Question 4:

The area marked A represents the medial arcuate ligament. The thoracic sympathetic trunk passes posterior to it and becomes the lumbar sympathetic trunk.



Solution to Question 5:

The esophageal hiatus is located at the level of the T10 vertebra, and it forms a normal constriction of the esophagus. It transmits the following:

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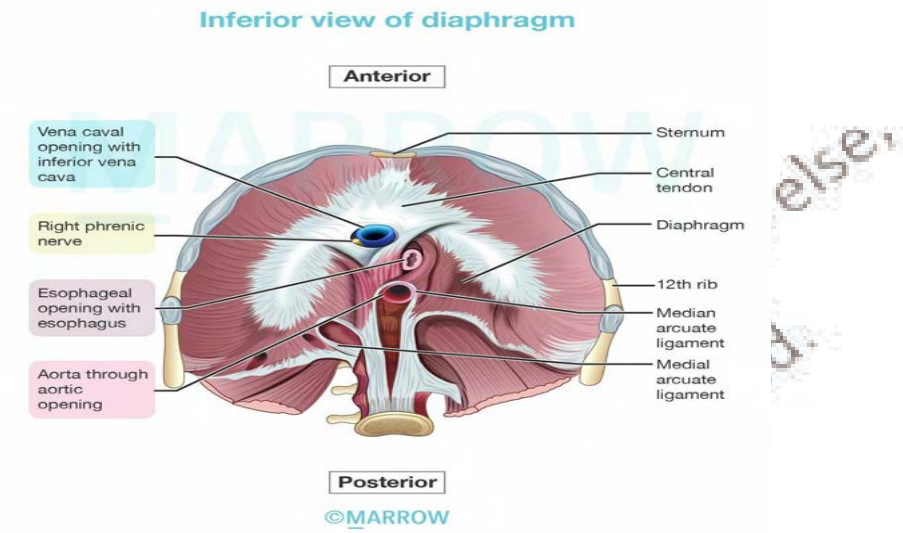
• Esophagus

• Vagal trunks

• Gastric nerves

• Esophageal branches of the left gastric vessels and

• Some lymphatic vessels



Clinical significance:

Anatomical constrictions of the esophagus are important landmarks in esophagoscopy. These are 4 in number and located at a distance from the upper incisors as follows:

• 15cm - Cricopharyngeus muscle

• 22.5cm - Aortic arch

• 27.5cm - Left bronchus

• 37.5cm - Diaphragmatic opening

Solution to Question 6:

The azygous vein and the thoracic duct are present at the aortic hiatus. These are transmitted along with the thoracic aorta.

Clinical significance:

Aortic dissection occurs when there's an intimal tear in the aorta. It presents with tearing interscapular pain and extension of dissection into the abdominal aorta can present with abdominal pain. CT/MRI are the investigations of choice. Aortic dissections are classified using the DeBakey and Stanford systems. Depending on the classification, aortic dissections are managed with aggressive antihypertensive therapy or immediate surgical intervention (open/endovascular).

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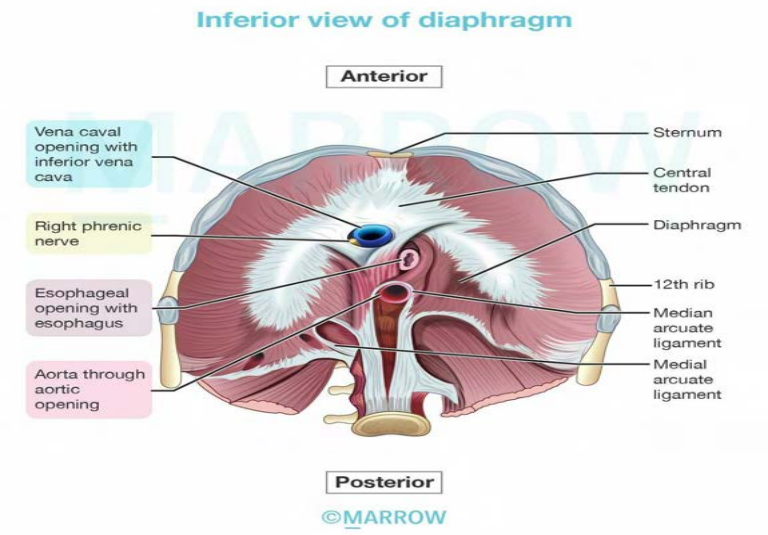
Solution to Question 7:

The structure marked A is the aortic opening of the diaphragm.

The vagal trunk does not pass through the aortic opening of the diaphragm. It passes through the esophageal opening at the level of T10 vertebra.



Solution to Question 8:

The left phrenic nerve is unlikely to be injured as does not pass through any specific opening in the diaphragm. It passes through the muscular part of the diaphragm anterior to the central tendon, just lateral to the left cardiac surface and more anterior than the right phrenic nerve.

Structures passing through the esophageal hiatus are:

• Esophagus

• Vagal trunks

• Gastric nerves

• Esophageal branches of the left gastric vessels

• Some lymphatic vessels

Clinical significance:

In carcinoma esophagus involving the lower third, the Orringer approach or transhiatal esophagectomy is done. The stomach and lower part of esophagus are mobilised via laparotomy and the upper part is mobilized via the left side of the neck. Blunt dissection is done at the hiatus to approach the thorax from the abdomen. Other alternatives to this procedure are robotic and thoracoscopic techniques

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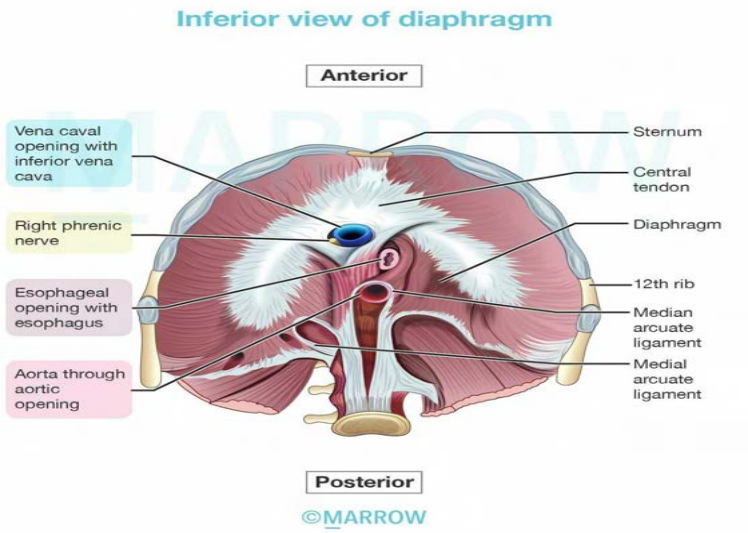
Solution to Question 9:

The greater splanchnic nerve usually pierces through the crus of the diaphragm to enter the thorax and does not pass posterior to the crus of the diaphragm.

The aortic hiatus is present posterior to the crus of the diaphragm, hence the following structures are likely to be damaged-

- Aorta
- Thoracic duct
- Azygous vein



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Heart

Question 1:

Which of the following represents the surface marking of the aortic valve?

a) Sternal end of left third costal cartilage

b) Sternal end of the right third costal cartilage

c) Beside the sternum in the left third intercostal space

d) Beside the sternum in right third intercostal space

Question 2:

What is the surface marking of the mitral valve?

a) Behind the sternum end of the left 4th costal cartilage

b) Behind the sternal end of the right 4th costal cartilage

c) Left 4th intercostal space in midclavicular line

d) Left 3rd intercostal space in midclavicular line

Question 3:

A patient developed hoarseness due to left recurrent laryngeal nerve weakness. TTE revealed compression of the nerve by the enlarged base of the heart. Which of the following chambers is likely to be dilated?

a) Right atrium

b) Left atrium

c) Right ventricle

d) Left ventricle

Question 4:

The region marked corresponds to the surface marking for which of the following structures:

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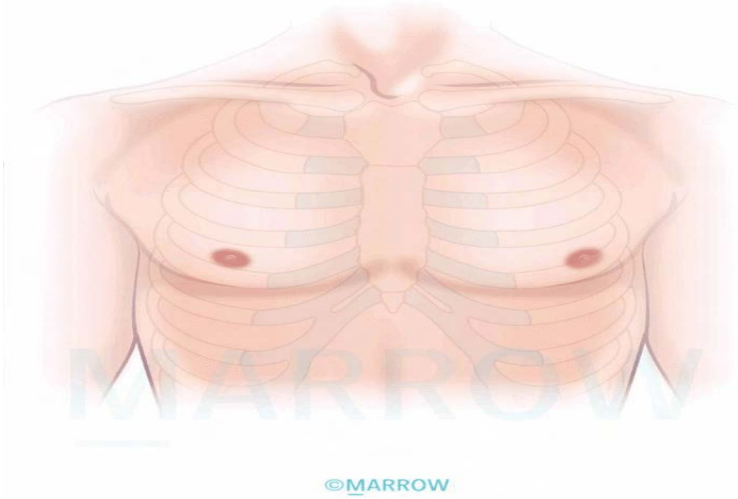

a) Thoracic duct

b) Right atrium

c) Inferomedial bronchopulmonary segments

d) Hilum

Question 5:

A 30-year-old man was brought to the emergency department after a car accident. He sustained a severe injury to the anterior chest wall from the impact caused by the steering wheel. X-ray revealed fracture of the body of the sternum. Which of the following chambers of the heart is most likely to be injured?

a) Left atrium

b) Left ventricle

c) Right ventricle

d) Right atrium

Question 6:

During the post-mortem heart examination of a patient, the resident palpates a muscular ridge, which is the site of origin of pectinate muscles. In which of the following chambers is the resident palpating this structure?

a) Right atrium

b) Left atrium

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c) Right ventricle

d) Left ventricle

Question 7:

The right border of the heart is formed by which of the following structures?

a) Right atrium

b) Right ventricle

c) Superior vena cava

d) Inferior vena cava

Question 8:

While doing the doppler USG of a fetal heart, you note blood flow from the right atrium to the left atrium. After the delivery, the connection eventually closes. What would form the floor of this structure after it closes?

a) Septum primum

b) Septum secundum

c) Endocardial cushions

d) Tricuspid valve orifice

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Question 9:

What is the location of the sinoatrial node?

a) 2,3, and 5

b) 1,2,3 and 4

c) 2 and 5

d) 1,3, and 4

Question 10:

A cardiologist is doing the AV node ablation procedure for AVNRT. While locating the AV node, he would look at all of the following landmarks forming its boundary except:

a) Tendon of Todaro

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b) Septal leaflet of tricuspid valve

c) Posterior leaflet of tricuspid valve

d) Coronary sinus

Question 11:

Which of the following statements is false regarding the SA node?

a) It is located at the right border of ascending aorta

b) It contains specialized nodal cardiac muscle

c) It is supplied by the atrial branches of the right coronary artery

d) Action potential generated here does not have phase 1 or 2

Question 12:

A 40-year-old man underwent coronary artery bypass grafting. During the procedure, the surgeon applied a clamp to the vessel lying anterior to the transverse pericardial sinus. Identify the vessel.

a) Aorta

b) Pulmonary artery

c) Inferior vena cava

d) Superior vena cava

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Question 13:

How many papillary muscles are there in the left ventricle?

a) 2

b) 3

c) 5

d) 8

Question 14:

What are Purkinje fibers?

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a) Modified nerve fibers

b) Modified smooth muscle

c) Modified cardiac muscle

d) Fibrous tissue

Question 15:

A surgeon opens the pericardial sac anteriorly during surgery. He passes a surgical clamp through the transverse sinus. The circulation of blood in which of the following structures is stopped/diverted by his action?

a) Superior and inferior vena cava

b) Aorta and pulmonary veins

c) Aorta and pulmonary trunk

d) SVC and pulmonary veins

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Question 16:

A cardiologist while reviewing a case of MI, notes that the patient has right dominant circulation. Which of the following determines coronary dominance?

a) Posterior interventricular artery

b) Anterior interventricular artery

c) Circumflex artery

d) Right coronary artery

Question 17:

Coronary angiography of a patient revealed posterior interventricular artery branching from the circumflex artery. What would the arterial circulation in this patient be called?

a) Right dominant

b) Left dominant

c) Balanced dominant

d) Codominant

Question 18:

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All of the following are true about the right coronary artery except _____

a) It's diameter is less than left coronary artery

b) It arises from the anterior aortic sinus

c) It gives rise to circumflex coronary branch

d) Right conal artery is it's first branch

Question 19:

A 55-year-old man presented with angina. Coronary angiography revealed a block in the right coronary artery. Blood supply through which of the following arteries would not be affected?

a) Acute marginal

b) Posterior interventricular artery

c) Artery to SA node

d) Circumflex artery

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Question 20:

All of the following supply the marked structure except :

a) Right coronary artery

b) Anterior interventricular artery

c) Marginal artery

d) Diagonal artery

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Question 21:

A patient underwent angioplasty with a Sirolimus-eluting stent in the anterior interventricular artery. This artery is a branch of:

a) Right coronary artery

b) Left coronary artery

c) Circumflex artery

d) Left anterior descending artery

Question 22:

In a patient with STEMI, nuclear stress test revealed poor blood supply to the anterior two-thirds of the interventricular septum. Which of the following blood vessels is most likely to be blocked?

a) Right coronary artery

b) Left coronary artery

c) Posterior interventricular artery

d) Circumflex artery

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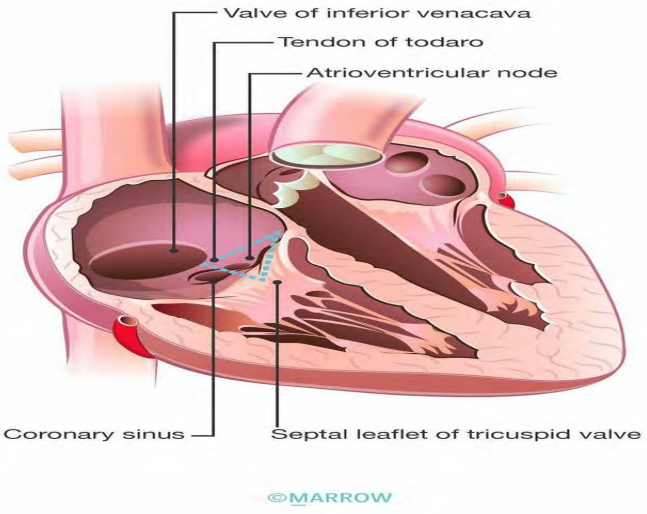
Question 23:

What is the arterial supply of the structure labelled in the picture with the blue dotted line?



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a) Right coronary artery

b) Left coronary artery

c) Left anterior descending artery

d) Artery from the left posterior aortic sinus

Question 24:

A patient with a recent MI underwent coronary angiography, which revealed a block in the anterior interventricular artery. The infarction is likely to be present in which of the following regions of the heart?

a) Posterior part of interventricular septum

b) Anterior wall of the left ventricle

c) Lateral part of the heart

d) Inferior surface of the right ventricle

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Question 25:

Which of the following is not a tributary of the coronary sinus?

a) Posterior cardiac vein

b) Small cardiac vein

c) Anterior cardiac vein

d) Great cardiac vein

Question 26:

Where does the great cardiac vein lie?

a) Anterior part of the coronary sulcus

b) Posterior part of the right coronary sulcus

c) Anterior interventricular groove

d) Posterior interventricular groove

Question 27:

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Which of the following statements is true regarding the coronary sinus?

a) It lies in the anterior part of coronary sulcus

b) It ends in the right atrium

c) It has venae cordis minimae as its tributaries

d) It develops from the right anterior cardinal vein

Question 28:

A 58-year-old man is undergoing coronary artery bypass grafting. The coronary angiography revealed total blockage of the posterior descending artery. While exposing this artery during the procedure, which accompanying vessel is most likely to be injured?

a) Great cardiac vein

b) Posterior vein of left ventricle

c) Small cardiac vein

d) Middle cardiac vein

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Question 29:

Which among the following is wrong about the venous drainage of the heart?

a) Coronary sinus is guarded by the Thebesian valve

b) Middle cardiac vein lies in the posterior atrioventricular groove

c) Great cardiac vein accompanies left anterior descending artery

d) Venae cordis minimae open into all 4 chambers

Question 30:

In a patient with thrombosis of the coronary sinus, which of the following cardiac veins are least likely to get dilated?

a) Middle cardiac vein

b) Small cardiac vein

c) Oblique cardiac vein

d) Anterior cardiac vein

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Question 31:

Which of these veins does not open into the sinus venarum?

a) Superior vena cava

b) Coronary sinus

c) Inferior vena cava

d) Small cardiac vein

Question 32:

Sympathetic innervation of heart is by _____

a) T1-T3

b) T1-T5

c) T3-T7

d) L1-L5

Question 33:

Where is cardiac ganglion situated?

a) Below the arch of aorta

b) Above the arch of aorta

c) Left side of ligamentum arteriosum

d) Posterior to ligamentum arteriosum

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Answer Key

Question No.	Correct Option
1	c
2	a
3	b
4	b
5	c

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6	a
7	a
8	a
9	d
10	c
11	a
12	a
13	a
14	c
15	c
16	a
17	b
18	c
19	d
20	d
21	b
22	b
23	a
24	b
25	c
26	c
27	b
28	d
29	b
30	d
31	d
32	b
33	a

Detailed Explanations

Solution to Question 1:

The surface marking of aortic valve is beside the sternum in the left third intercostal space.

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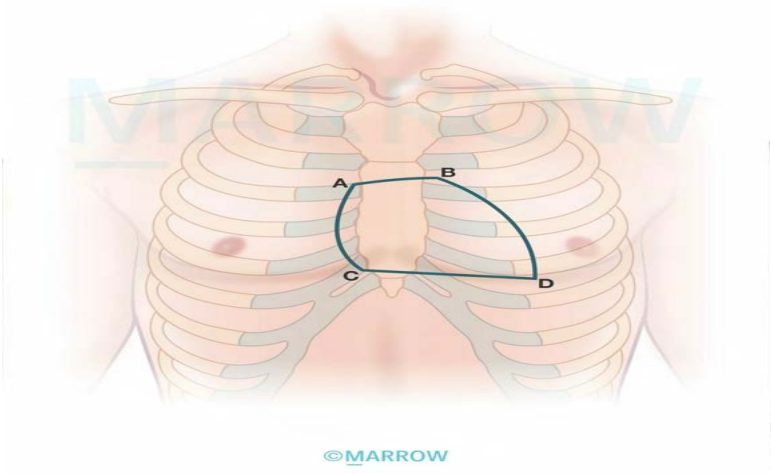
The relation of valves of the heart to the thoracic cage.



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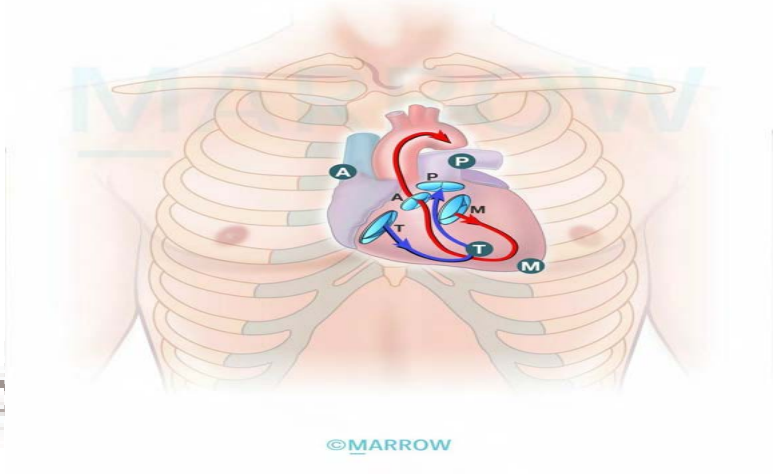
The relation of valves of the heart to the thoracic cage.



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Solution to Question 2:

The orifice of the mitral valve is level with the left half of the sternum opposite the left 4th costal cartilage and is represented by a line approximately 3 cm long and descending to the right.

Solution to Question 3:

The base of the heart is formed mainly by the left atrium. Enlargement of the left atrium can cause hoarseness due to compression of the left recurrent laryngeal nerve.

The base of the heart is a quadrilateral directed posteriorly. It is made of:

• The left atrium mainly

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• Small part of the right atrium

• Proximal parts of superior vena cava, inferior vena cava, and pulmonary veins

The base of the heart lies at the level of T5-T8 vertebrae in the supine position.

The apex of the heart is formed by the left ventricle in the 5th intercostal space.

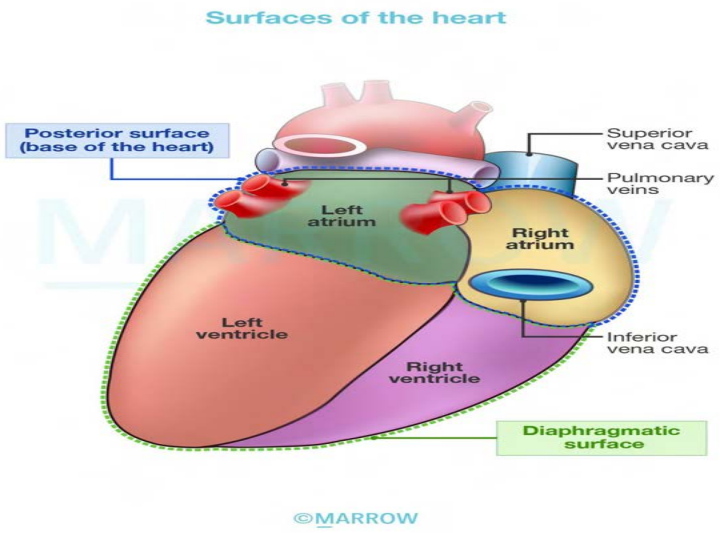
Surfaces of the heart:

• Sternocostal surface - Formed by the right atrium, right and left ventricles

• Diaphragmatic surface - Formed mainly by the left ventricle

• Left surface - Formed mainly of the left ventricle

• Right surface - Formed mainly of the right atrium



Solution to Question 4:

The region marked corresponds to the surface marking for the right atrium.

The costal margin, xiphoid process, and the mid-clavicular line are seen in this image. The examiner draws a laterally convex line that extends from a level below the 2nd costal cartilage (as clued in by the sternal angle) i.e., 3rd costal cartilage to about 3 spaces below i.e., the 6th costal cartilage. This line is about 1.2 cms lateral to the sternal edge. These suggest that the region marked corresponds to the surface marking for the right atrium.

The projection of the cardiac borders, of an average adult, onto the anterior thoracic wall forms a trapezoid. This can be mapped out using the percussion method by looking for cardiac dullness.

The varying heart borders and the corresponding surface markings are as follows:

• Upper border: Slopes gently from the second left costal cartilage to the third right costal cartilage. It corresponds to the left atrium.

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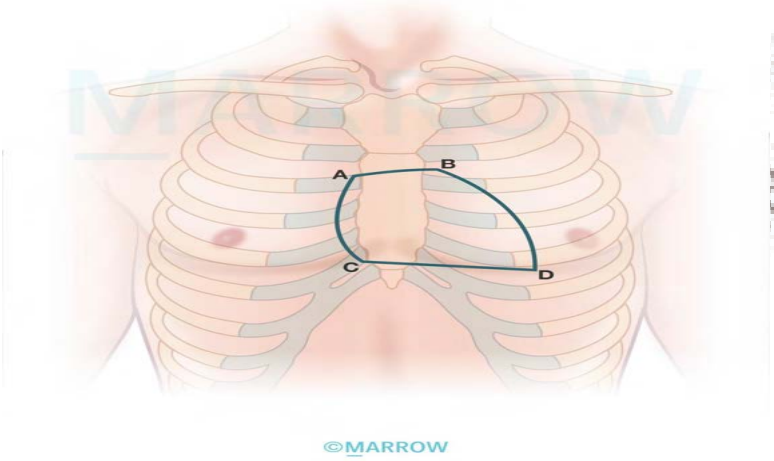
• Right border: Convex to the right and runs from the third to the sixth right costal cartilages, 1–2 cm lateral to the sternal edge. It corresponds to the right atrium.

• Inferior border or acute border: Runs leftwards from the 6th right costal cartilage to the cardiac apex which is located approximately 9 cm lateral to the midline, often in the left 5th intercostal space or level with the 5th or 6th rib. It corresponds to the right ventricle.

• Left border or obtuse border: Convex laterally on the left. It extends superomedially from the cardiac apex to meet the second left costal cartilage about 1 cm from the left sternal edge. It corresponds to the left ventricle.

The relation of valves of the heart to the thoracic cage.



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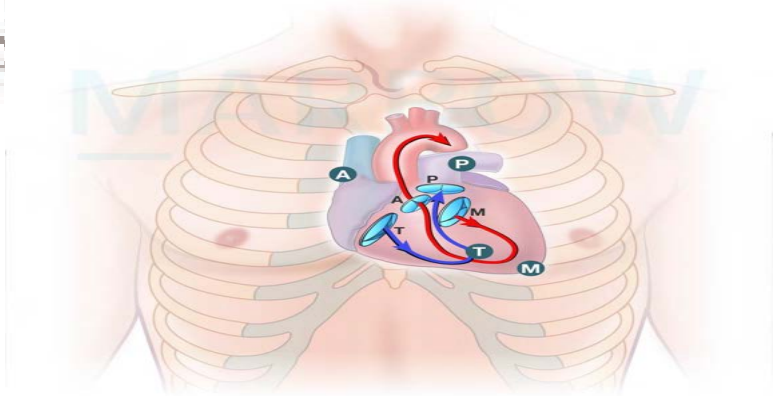
The relation of valves of the heart to the thoracic cage.



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Solution to Question 5:

The area posterior to the sternum is occupied by the right ventricle and hence is most likely to be injured in this case.

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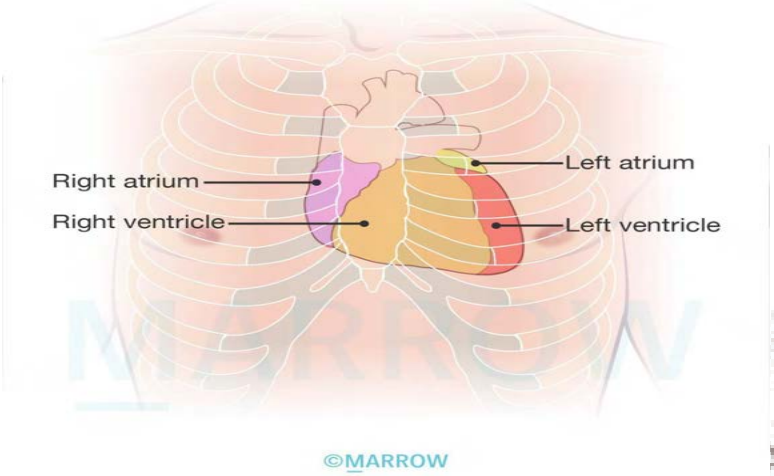
The convex anterosuperior surface of the right ventricle makes up a large part of the sternocostal aspect of the heart, and is separated from the thoracic wall only by the pericardium.



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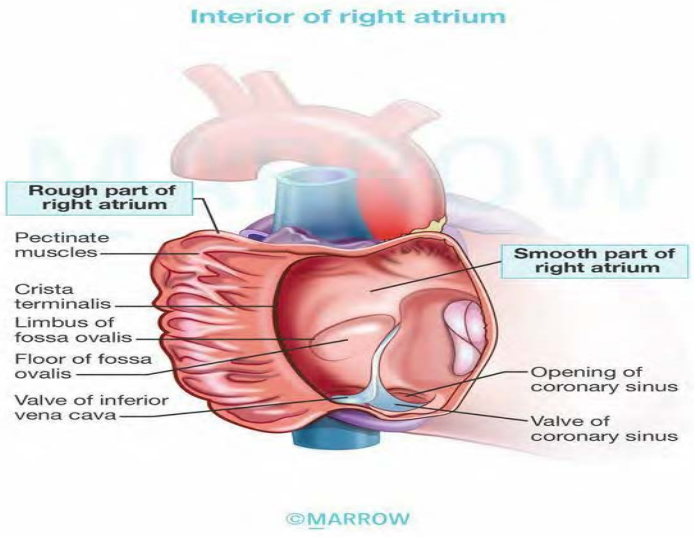
Solution to Question 6:

The structure being palpated by the resident is crista terminalis. It is present in the right atrium.

It is a muscular ridge that runs anteriorly along the atrial wall from the opening of the superior vena cava to the opening of the inferior vena cava. It corresponds externally to sulcus terminalis. It is the site of origin of pectinate muscles.

It divides the right atrium into a smooth posterior part and a rough anterior part. Both the vena cavae empty into the posterior smooth part.



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Solution to Question 7:

The right border of the heart is formed of the right atrium.

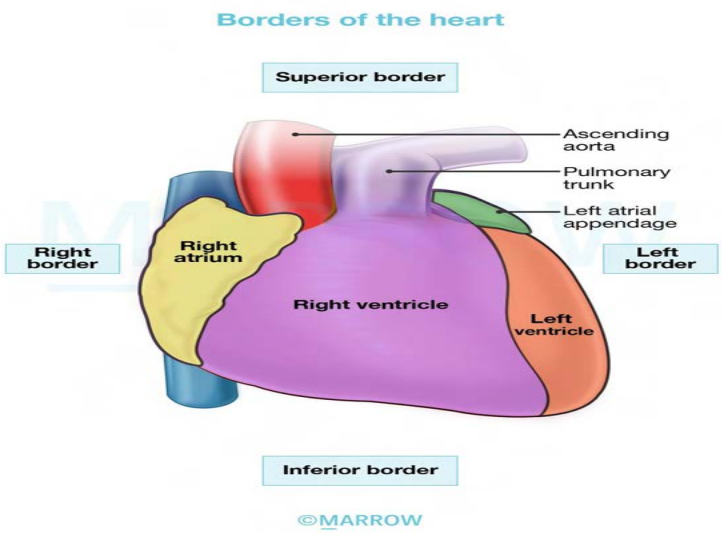
Borders of the heart:

• Right border: Right atrium

• Left border: Left ventricle mainly and to a slight extent by left atrial appendage

• Inferior border: Right ventricle mainly and a small contribution by the left ventricle

• Upper border: Left atrium, ascending aorta, and the pulmonary trunk.



Solution to Question 8:

The structure mentioned here is the foramen ovale through which blood passes from the right atrium to the left atrium as part of fetal circulation. It closes at delivery and later forms fossa ovalis. The floor of the fossa ovalis is formed by the septum primum.

Fossa ovalis is an oval-shaped depression in the septal wall of the right atrium just above the opening of inferior vena cava. Its floor is formed by the remnant of septum primum. The limbus of fossa ovalis is the prominent rim of the depression which represents the remnant of septum secundum.

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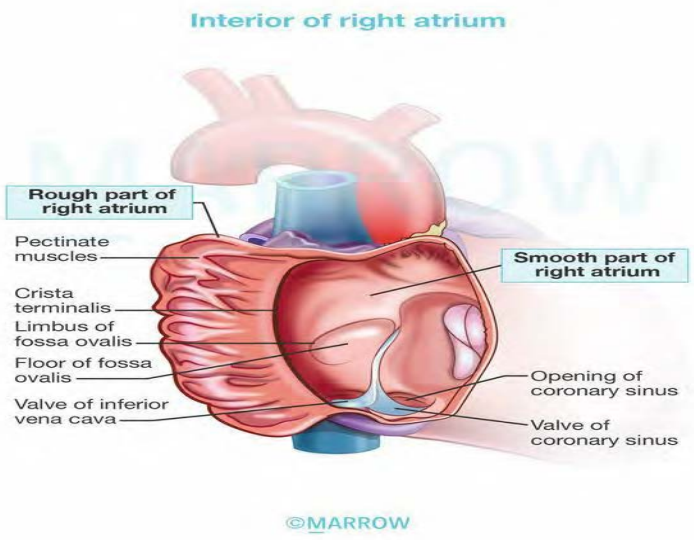

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Solution to Question 9:

The sinoatrial (SA) node is located at the upper part of the crista terminalis, at the junction of the superior vena cava opening to the right atrium. This is also the junction between the parts of the right atrium derived from sinus venosus and primitive atria.

The Atrioventricular (AV) node lies at the lower back section of the interatrial septum near the opening of the coronary sinus. It is located in the center of the Koch triangle.

Solution to Question 10:

The AV node is present in the center of the triangle of Koch. The posterior leaflet of the tricuspid valve does not form its boundary.

The triangle of Koch is found on the smooth posterior wall of the right atrium. It is bound by:

- The coronary sinus
- Tendon of Todaro
- The septal cusp of the tricuspid valve

The triangle of Koch can be seen in the image below bound by the dashed blue lines:

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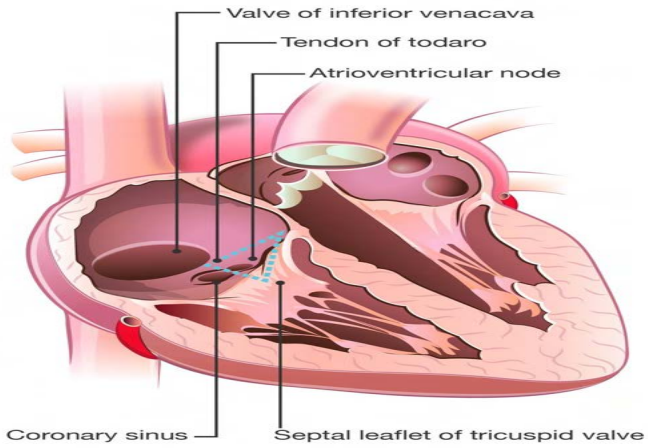

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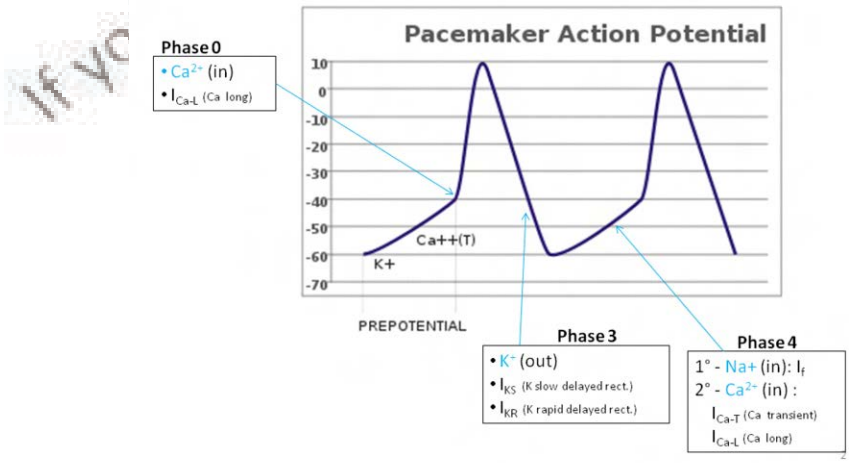
Solution to Question 11:

Sino-atrial (SA) node is not located at the right border of the ascending aorta.

It is located at the opening of the superior vena cava into the right atrium. It is called the 'pacemaker' of the heart. It is supplied by the atrial branches of the right coronary artery. It contains specialized nodal cardiac muscle which spontaneously produces an electrical impulse. The action potential of these cells does not have phase 1 or 2.



Solution to Question 12:

The aorta lies anterior to the transverse pericardial sinus.

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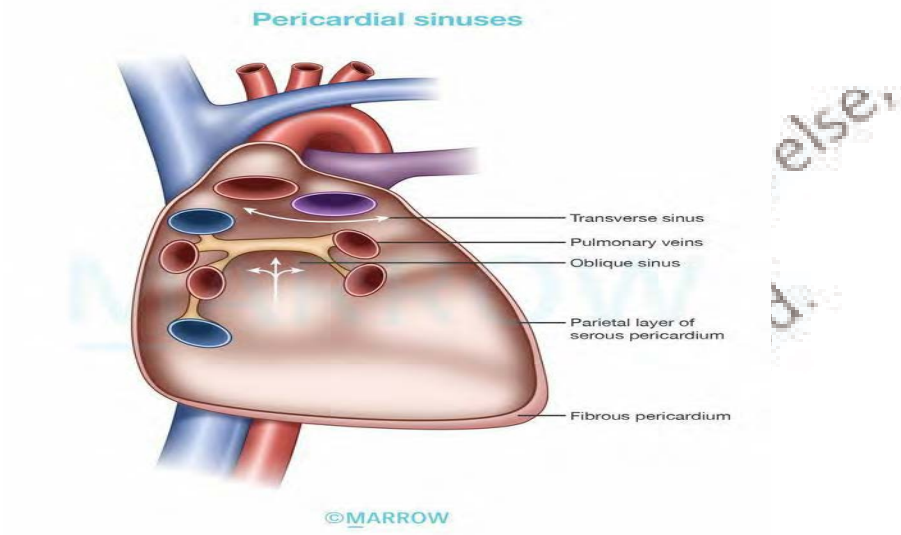
The reflections of the serous pericardium are arranged as two tubes – one enclosing the aorta and the pulmonary trunk and the other enclosing the vena cavae and the four pulmonary veins.

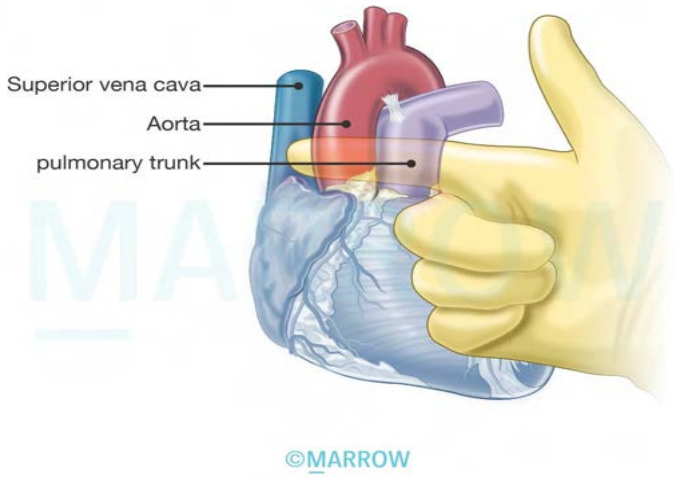
Oblique pericardial sinus: The zone of reflection surrounding the veins is J-shaped and the cul-de-sac formed within the J is the oblique pericardial sinus. This lies posterior to the left atrium.

The image below shows the posterior view of the heart demonstrating the oblique and the transverse sinus.



Transverse pericardial sinus: It is a passage between the two 'tubes'. The aorta and the pulmonary trunk lie anterior and the superior vena cava and the atria lie posterior to it.

The pulmonary trunk divides into the right and left pulmonary arteries above the transverse sinus.



Clinical significance:

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During cardiac surgery, the transverse pericardial sinus allows a surgeon to isolate the pulmonary trunk and ascending aorta and apply a temporary ligature or clamp.

Solution to Question 13:

The left ventricle has 2 papillary muscles.

There are 3 papillary muscles in the right ventricle:

• Anterior,

• Posterior

• Septal muscles

There are 2 papillary muscles in the left ventricle:

• Anterior

• Posterior

Solution to Question 14:

Purkinje fibers are modified cardiac muscles.

The Purkinje network is subendocardial and the muscular excitation proceeds from endocardium to epicardium.

Solution to Question 15:

During surgery, a clamp is passed through the transverse sinus. This stops/diverts the blood flow from the aorta and pulmonary trunk.

The transverse pericardial sinus separates the arterial end of the heart tube from the venous end. Aorta and pulmonary trunk lie anterior to the sinus and the superior vena cava lies posterior to it. Therefore, during surgery, a clamp passed through the transverse sinus stops or diverts the blood flow from the aorta and pulmonary trunk.

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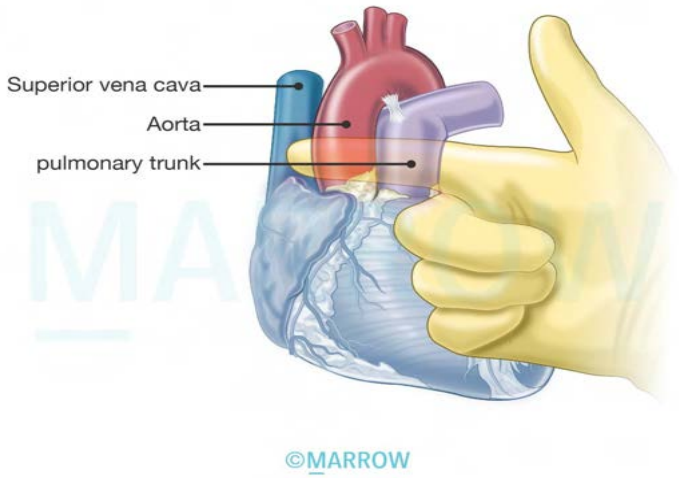

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Solution to Question 16:

Coronary dominance is determined by the posterior interventricular artery (PIVA).

In about 65% of the population, the PIVA is given by the right coronary artery and this is called the right cardiac dominance.

In 10% of the population, it is a branch of the left coronary artery alone, called the left cardiac dominance.

In the remaining 25% population, it is given by both (balanced dominance).

Solution to Question 17:

If the circumflex artery gives off the posterior interventricular artery, then the arterial supply is called left dominant.

In 65% of the population, the posterior interventricular artery (PIVA) is a branch of the right coronary artery and this is called the right dominance.

In 10% of the population, PIVA is given by the circumflex artery (a branch of the left coronary artery) and this is called the left dominance.

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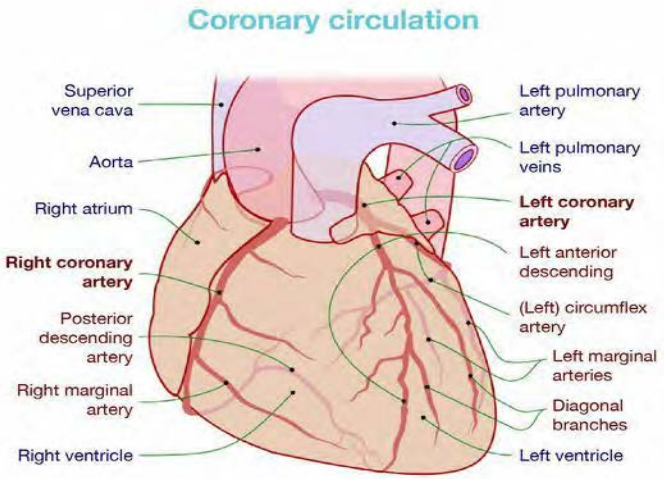

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Solution to Question 18:

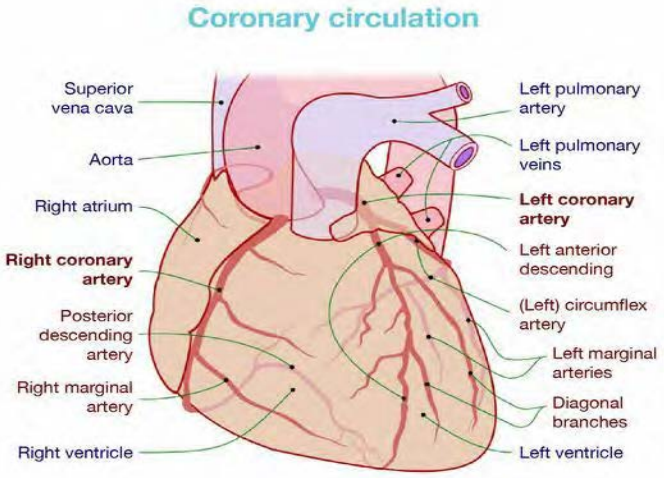
The right coronary artery does not give rise to the circumflex coronary artery.

The right coronary artery arises from the anterior aortic sinus (right coronary sinus) of the ascending aorta. It passes anteriorly and descends vertically in the coronary sulcus between the right atrium and the right ventricle. On reaching the inferior margin, it turns posteriorly and continues in the sulcus onto the diaphragmatic surface and the base of the heart.

The diameter of the right coronary artery is less than that of the left coronary artery.

The right conal artery is, usually the first branch of the right coronary artery.

The circumflex coronary artery is a branch of the left coronary artery and is the exclusive supplier to the right bundle branch.



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Solution to Question 19:

The circumflex artery is a branch of the left coronary artery, not the right coronary artery. Hence, blood supply through the circumflex artery won't be affected.

The branches of the right coronary artery are:

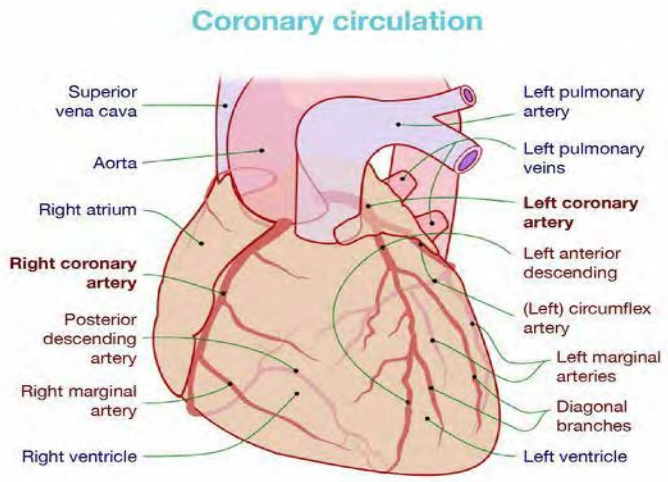
• Right conal artery - first branch of the right coronary artery

• Artery of the SA node

• Acute right marginal artery

• Posterior interventricular artery (in 65% population)

• Atrial and anterior and posterior ventricular branches



Solution to Question 20:

The structure marked is the right ventricle. It is not supplied by the diagonal artery.

The diagonal artery is a branch of the anterior interventricular artery supplying the left ventricle. This is present in about 30-50% of the population.

The right ventricle is mostly supplied by the right coronary artery and its branches such as the marginal artery.

The anterior interventricular artery gives off 1-2 anterior right ventricular branches.

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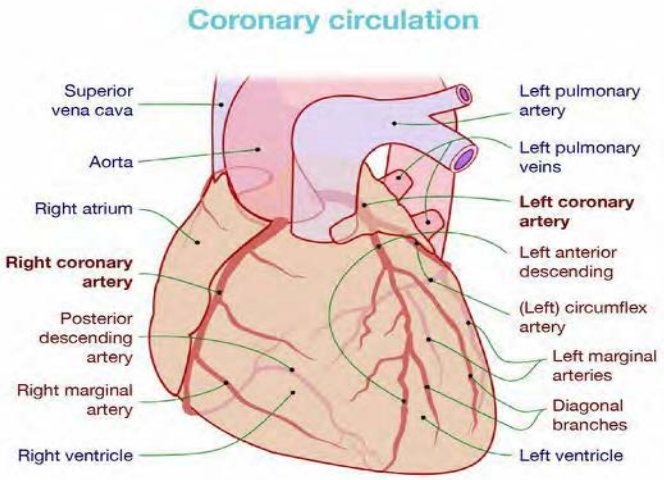

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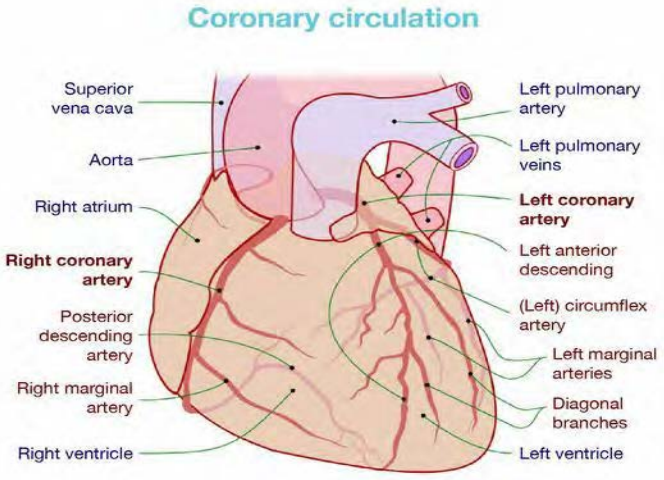
Solution to Question 21:

The anterior interventricular artery is a branch of the left coronary artery.

The left coronary artery arises from the left aortic sinus (left posterior sinus) of the ascending aorta. It passes between the pulmonary trunk and the left auricle and then runs in the coronary sulcus. It divides into its two terminal branches in the coronary sulcus. They are:

• Anterior interventricular branch - also called the left anterior descending artery (LAD).

• Circumflex branch - It gives a left marginal artery also called the obtuse marginal artery supplying the left ventricle.



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Solution to Question 22:

The anterior two-thirds of the interventricular septum is supplied by the left coronary artery. Hence, this artery is most likely blocked.

The right coronary artery distribution supplies:

• Right atrium

• Right ventricle (except a small region to the right of the anterior interventricular groove)

• A variable part of the diaphragmatic aspect of the left ventricle

• Posteroinferior 1/3rd of the interventricular septum

• Part of the left atrium

• The conduction system, as far as the proximal parts of the right and left crura

The left coronary artery distribution supplies:

• Left atrium

• Left ventricle

• A narrow strip of the right ventricle

• The anterior 2/3rd of the interventricular septum

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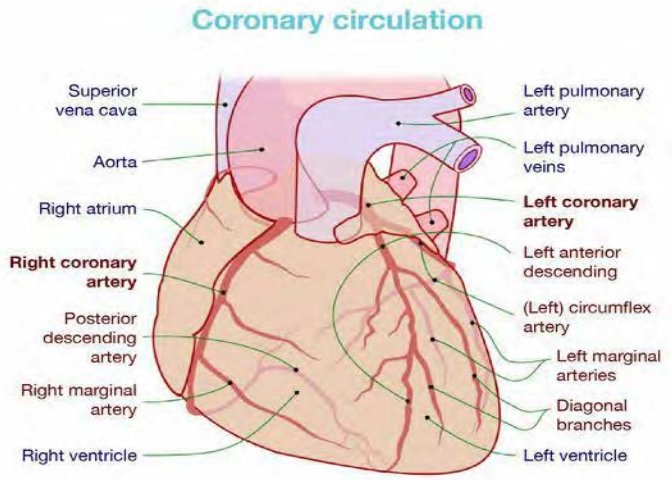

Solution to Question 23:

The image shows a triangle of Koch marked with blue dotted lines. The arterial supply to the triangle of Koch is from the right coronary artery in the majority of the population.

Solution to Question 24:

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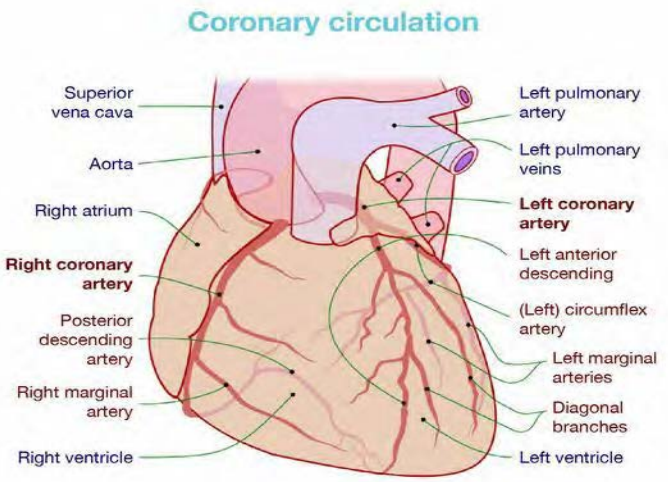
The occlusion of the left anterior descending artery (LAD) will lead to the infarction of the anterior wall of the left ventricle.

The left anterior descending artery also called the anterior interventricular artery supplies the anterior 2/3rd of the interventricular septum and the adjacent anterior wall of the left ventricle.



Options A and D: The posterior interventricular artery supplies the posterior part of the interventricular septum and the inferior part of the right ventricle.

Option C: The left lateral surface of the heart is supplied by the circumflex artery.

Solution to Question 25:

Anterior cardiac vein does not open into the coronary sinus. It drains directly into the right atrium.

Tributaries of coronary sinus include the following:

• Great cardiac vein

• Middle cardiac vein

• Small cardiac vein

• Posterior cardiac vein

• Oblique vein of the left atrium

Thebsian vein/venae cordis minimae, anterior cardiac veins, and the right marginal vein drain directly into the right atrium.

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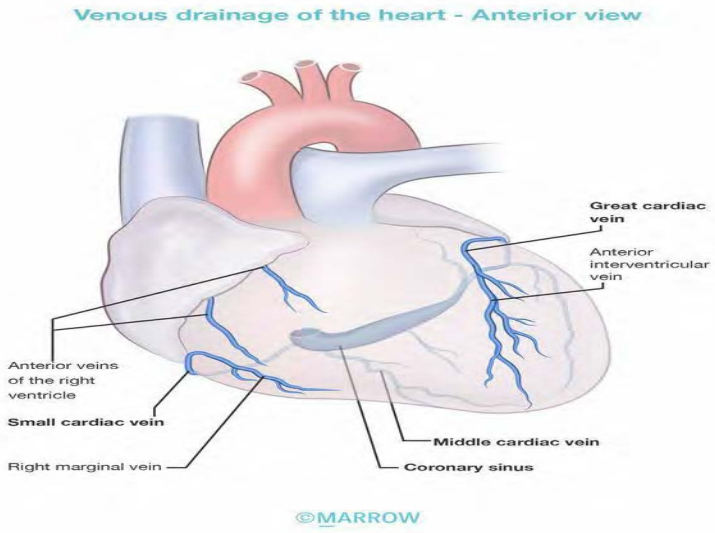

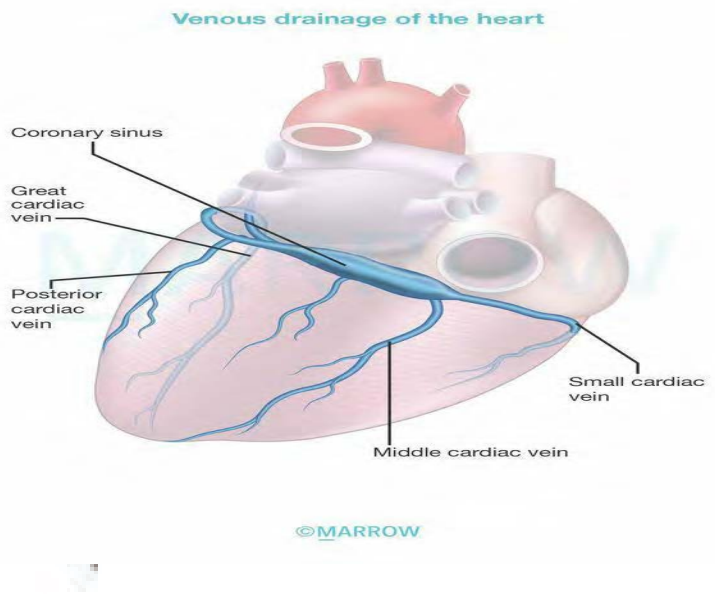

Solution to Question 26:

The great cardiac vein lies in the anterior interventricular sulcus.

The great cardiac vein begins at the cardiac apex, and ascends in the anterior interventricular groove to the atrioventricular groove, which it follows, passing to the left and posteriorly to enter the coronary sinus at its origin.

The great cardiac vein accompanies the anterior interventricular artery (left anterior descending artery).

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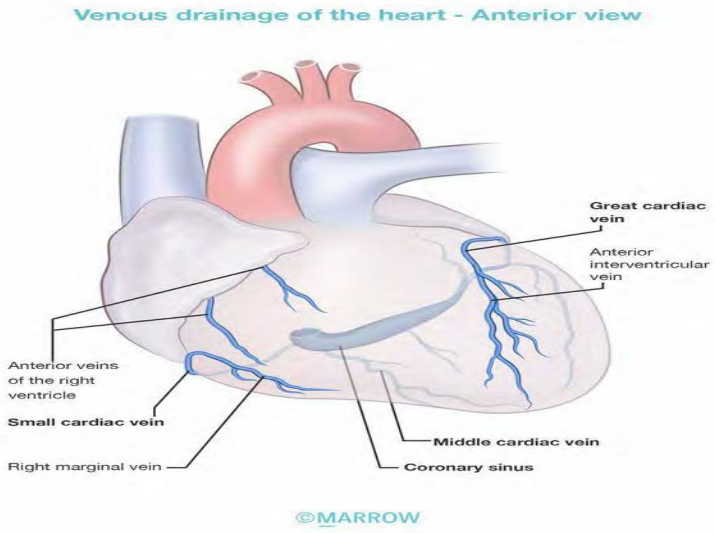

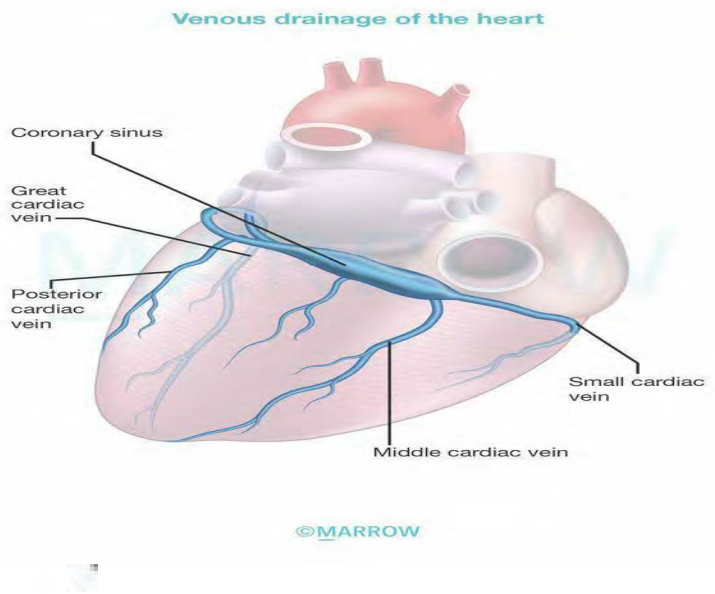

Solution to Question 27:

Coronary sinus ends in the right atrium.

Coronary sinus develops from the left horn of the sinus venosus and lies in the posterior part of the atrioventricular groove. The sinus opens into the right atrium between the opening of the inferior vena cava and the right atrioventricular orifice.

Venae cordis minimae drains directly into the nearest heart chamber (drains into all 4 chambers).

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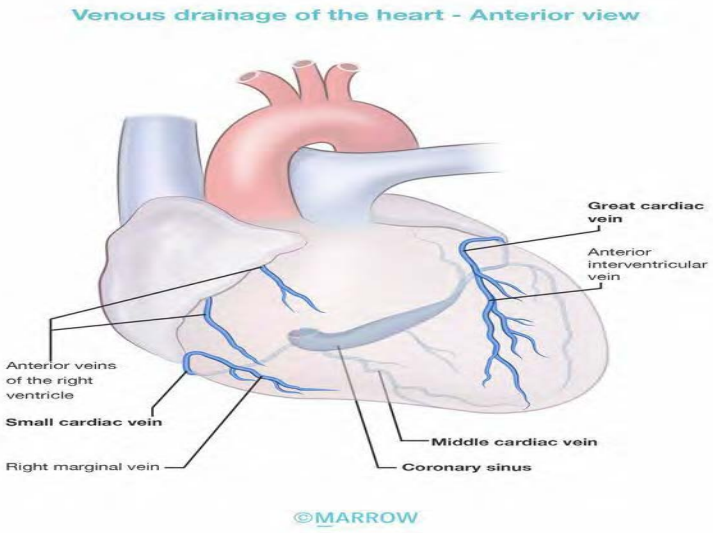

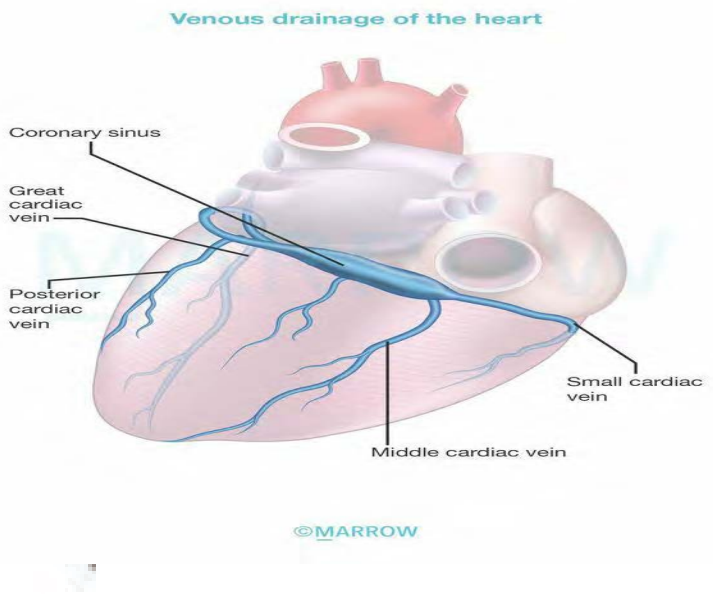

Solution to Question 28:

The middle cardiac vein is present in the posterior interventricular groove accompanying the posterior descending artery, and hence is most likely to be injured in this case.

Solution to Question 29:

The middle cardiac veins lie in the posterior interventricular groove and not the posterior atrioventricular groove.

Option A: The opening of the coronary sinus may be guarded by a semilunar valve of the coronary sinus, the Thebesian valve.

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Option C: The great cardiac vein accompanies the anterior interventricular artery (left anterior descending artery) in the anterior interventricular groove.

Option D: The venae cordis minimae / Thebesian veins open into all cardiac chambers.

Solution to Question 30:

The anterior cardiac vein drains directly into the right atrium and not into the coronary sinus, hence, they might remain normal in coronary sinus thrombosis.

Solution to Question 31:

Small cardiac vein does not open into the sinus venarum. It opens into the coronary sinus.

Superior vena cava, coronary sinus, and the inferior vena cava open into the sinus venarum or the smooth posterior part of the right atrium.

Solution to Question 32:

The sympathetic innervation of the heart is by T1-T5.

The preganglionic sympathetic nerves to the heart arise from T1-T5. Some of these synapse in the upper thoracic sympathetic ganglia and some synapse in the cervical ganglia. The postganglionic fibres from these ganglia form the sympathetic cardiac nerves and innervate the heart.

Solution to Question 33:

The cardiac ganglion of Wrisberg is present in the superficial cardiac plexus immediately below and slightly in front of the arch of aorta to the right of the ligamentum arteriosum.

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Lungs and Pleura

Question 1:

A patient is asked to do incentive spirometry after his surgery. Which of the following muscles would he use while expiring into the device shown?

a) External intercostal

b) Diaphragm

c) Internal intercostal

d) Rhomboids

Question 2:

Which of the following is not an accessory muscle of inspiration?

a) Serratus anterior

b) Serratus posterior

c) Latissimus dorsi

d) Scalene

Question 3:

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Which of the following do not elevate the ribs?

a) Serratus posterior superior

b) Serratus posterior inferior

c) External intercostals

d) Levator costarum

Question 4:

You are interpreting the lateral neck X-ray of a patient who has multiple bruises on his face and neck. To look for tracheal injuries, you will start looking from which level?

a) C4 vertebra

b) C5 verterbra

c) C6 vertebra

d) C7 vertebra

Question 5:

At which vertebral level does the trachea bifurcate?

a) T7

b) T6

c) T5

d) T4

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Question 6:

Left bronchus crosses esophagus at _____

a) 23 cm from upper incisor

b) 15 cm from upper incisor

c) 23 cm from lower incisor

d) 28 cm from upper incisor

Question 7:

You are asked to do thoracentesis for a patient with mild pleural effusion on the left side. You are being cautious while inserting a needle in the left midaxillary line of the patient. You would not insert the needle below which level so as not to damage the surrounding structures?

a) 6th rib

b) 10th rib

c) 8th rib

d) 12th rib

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Question 8:

You are asked to mark the oblique fissure of the lung on a cadaver. Which of the following landmarks will not touch the line while drawing surface markings for this fissure?

a) 6th intercostal space

b) 5th rib

c) 7th rib

d) 4th costal cartilage

Question 9:

A young man is rushed to the emergency department after suffering a stab wound over the chest wall. The entry wound is present on the left side in the mid-clavicular line. The lung is likely to not be injured if the entry wound is below which level?

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a) 12th rib

b) 10th rib

c) 8th rib

d) 6th rib

Question 10:

What does the pleural cupola refer to?

a) Costal part of parietal pleura

b) Mediastinal part of parietal pleura

c) Visceral pleura forming pulmonary septa

d) Cervical part of parietal pleura

Question 11:

A 50-year-old chronic smoker presented with cough, haemoptysis, and unexplained weight loss. CT-scan revealed a ■tumor in the right lung invading the mediastinal pleura. The patient is likely to experience referred pain in which of the following regions?

a) Side of neck

b) Anterolateral thoracic wall

c) Medial part of arm

d) Abdominal wall

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Question 12:

Which of the following structures is related to the mediastinal part of the right lung?

a) Arch of aorta

b) Superior vena cava

c) Pulmonary trunk

d) Ventricle

Question 13:

Which of the following is a posterior relation to the root of the right lung?

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a) Right atrium

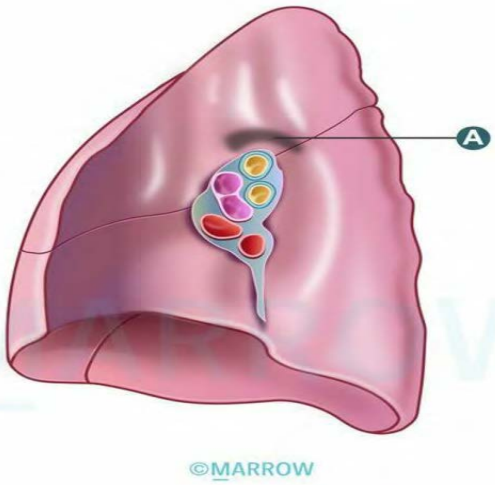
b) Right vagus nerve

c) Superior vena cava

d) Phrenic nerve

Question 14:

Which of the following structures is related to the area marked 'A' in the diagram below?



a) Superior vena cava

b) Arch of Aorta

c) Azygos vein

d) Left brachiocephalic trunk

Question 15:

Which is the most superior structure at the hilum of the left lung?

a) Pulmonary veins

b) Bronchial artery

c) Bronchus

d) Pulmonary artery

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Question 16:

What is the inferior most structure of the right hilum?

a) Right atrium

b) Inferior pulmonary vein

c) Pulmonary artery

d) Inferior bronchial vein

Question 17:

Which is not a lobe of lungs?

a) Superior

b) Inferior

c) Middle

d) Lingula

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Question 18:

How many bronchopulmonary segments are there in the right and left lungs, respectively?

a) 9, 11

b) 11, 9

c) 10, 10

d) 11, 10

Question 19:

A 40-year-old male smoker was diagnosed to have carcinoma of the right lung. Bronchogram showed the presence of a tumor, causing partial occlusion of the eparterial bronchus. Which of the following bronchopulmonary segments are likely to receive decreased airflow■?

a) Anterior, posterior, medial

b) Apical, anterior, posterior

c) Lateral, medial, superior

d) Basal, lateral, medial

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Question 20:

Bronchopulmonary segments are aerated by which of the following bronchi?

a) Secondary bronchi

b) Tertiary bronchi

c) Terminal bronchioles

d) Respiratory bronchioles

Question 21:

Which of the following statements is false regarding the bronchopulmonary segment?

a) It is surgically resectable

b) It is named according to the segmental bronchus supplying it

c) It is drained by independent intrasegmental branch of pulmonary vein

d) It is the largest subdivision of a lobe

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Question 22:

A 2-year-old child is brought to the ED due to choking. Examination showed decreased breath sounds on the right side. An inhaled foreign body lodged in the right bronchus is suspected. Which of the following is not an explanation for this presentation?

a) Right lung is shorter and wider than the left

b) Right principal bronchus is more vertical than the left bronchus

c) Tracheal bifurcation directs the foreign body to the right lung

d) Right inferior lobar bronchus is in continuation with the principal bronchus

Question 23:

Up to which level does the bronchial artery supplies blood to the lungs?

a) Tertiary bronchioles

b) Respiratory bronchioles

c) Alveolar ducts

d) Terminal bronchioles

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Answer Key

Question No.	Correct Option
1	c
2	c
3	b
4	c
5	d
6	d
7	b
8	d
9	d
10	d
11	a
12	b
13	b
14	c
15	d
16	b
17	d
18	c
19	b
20	b
21	c
22	a
23	b

Detailed Explanations

Solution to Question 1:

The internal intercostal muscles are the muscles of expiration.

The device shown in the image is an incentive spirometer. It is a device used to help your lungs recover after surgery or a lung illness.

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Solution to Question 2:

Latissimus dorsi is not an accessory muscle of inspiration. It is an accessory muscle of expiration.

Accessory muscles of inspiration:

• Sternocleidomastoid

• Scalene muscles

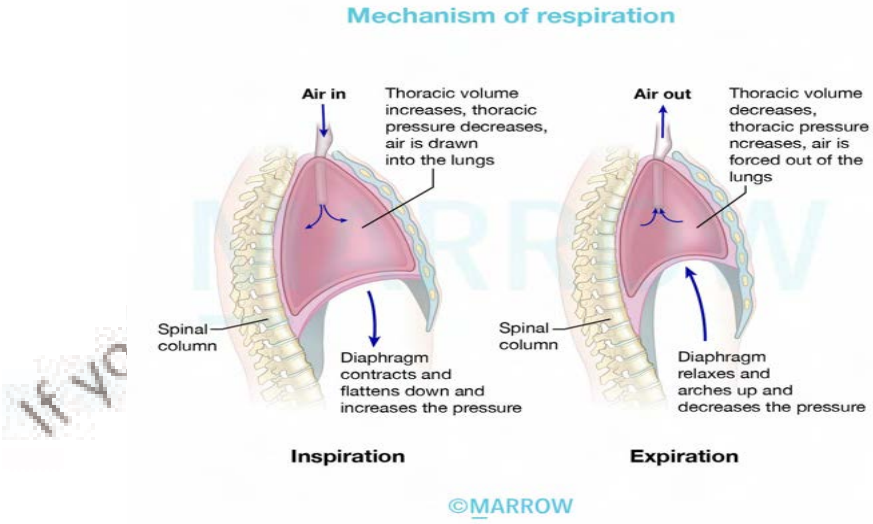
• Serratus posterior and anterior

• Errector spinae

• Pectoralis major and minor

Breathing involves changing the thoracic volume by altering the vertical, transverse, and anteroposterior dimensions of the thorax. The diaphragm is the key muscle in respiration.

Serratus posterior superior elevates the ribs, hence aiding in inspiration. Serratus posterior inferior depresses the ribs. It is a muscle aiding in expiration.



Solution to Question 3:

Serratus posterior inferior does not elevate the ribs.

The muscles of inspiration help increase the diameters of the thoracic cavity by elevating the ribs. Serratus posterior inferior is an accessory muscle of expiration. The muscles of expiration help in the depression of the ribs.

Mnemonic: SIT-Q depressors that work along with anterior abdominals for expiration:

• Serratus posterior inferior

• Internal intercostals

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• Transversus thoracis

• Quadratus lumborum

Solution to Question 4:

The trachea starts at the level of the inferior border of the cricoid cartilage at the level of the C6 vertebra.

Solution to Question 5:

The trachea bifurcates at the lower border of T4 vertebra.

The trachea is 10 - 12 cm long and has 2 parts:

• Upper cervical

• Thoracic(in superior mediastinum)

Note: Although Gray's Anatomy 41st Ed states that the tracheal bifurcation is at T6, we choose to stick with T4 as multiple other textbooks give the answer as T4.

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Solution to Question 6:

The left bronchus crosses the esophagus at 28 cm from the upper incisor teeth.

Normally esophagus shows 4 constrictions at the following levels measured from upper incisors:

• Junction of the esophagus with cricopharynx (15 cm from the incisor teeth)

• Crossed by arch of aorta (23 cm from the incisor teeth)

• Crossed by left bronchus (28 cm from the incisor teeth)

• It pierces the diaphragm (40 cm from the incisor teeth)

Solution to Question 7:

The inferior margin of the pleura in the midaxillary line is at the level of the 10th rib. So, while doing thoracentesis you would not go below this level. It is done in the 8th or 9th intercostal space so as not to damage the surrounding structures.

Solution to Question 8:

The surface marking of the oblique fissure of the lung will not touch 4th costal cartilage.

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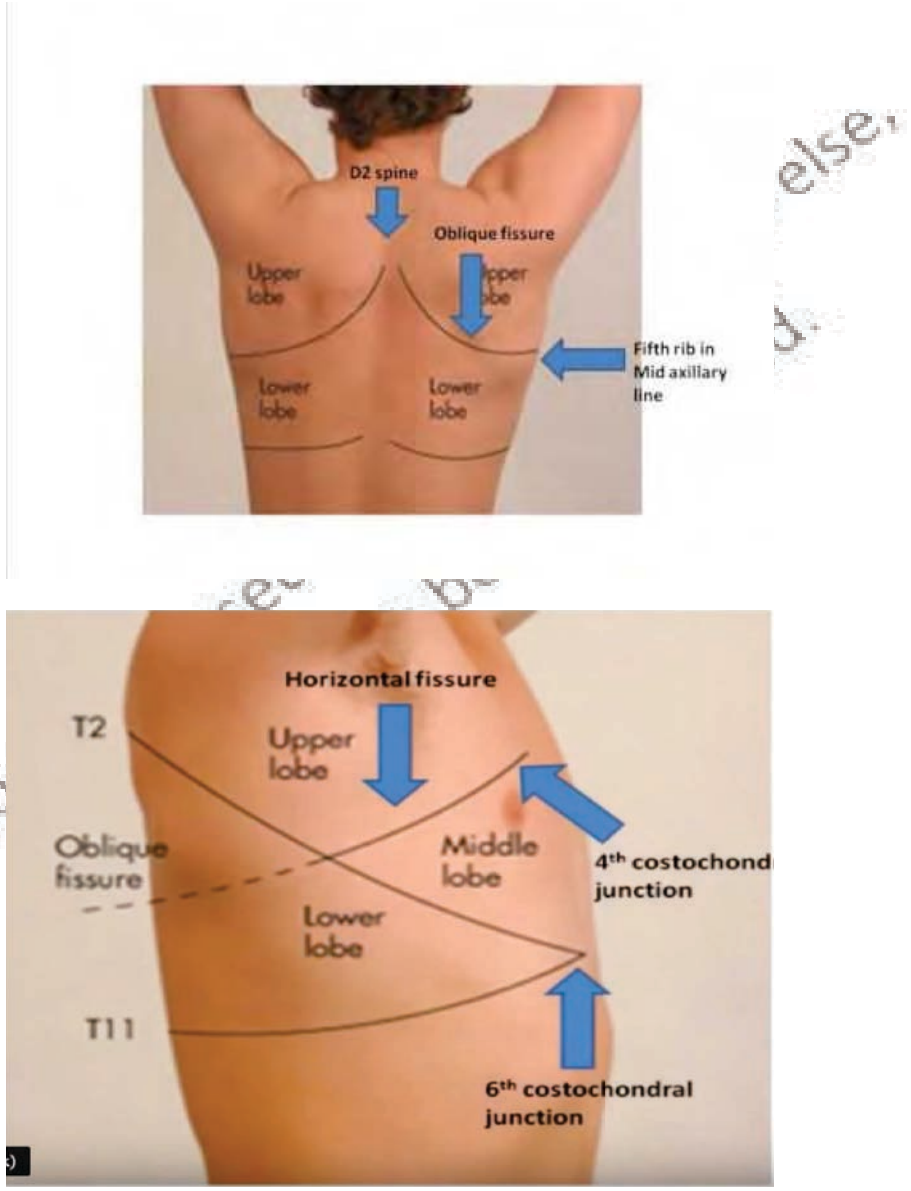
On either side, the upper and lower lobes of the lung are separated by the oblique fissure.

This can be marked by a line that runs anteroinferiorly from the posterior end of the 4th rib (the spinous process of the T3 vertebra), crosses the 5th rib in the midaxillary line, continues inferiorly, crossing either the 6th intercostal space/ 7th rib on the right or the 5th rib/ 5th intercostal space on the left, on both sides at the midclavicular line.

The left oblique fissure is located at a higher level and courses more vertically than the right oblique fissure.



Solution to Question 9:

The lower border of the lung in the midclavicular line is at the level of the 6th rib. Hence, if the entry wound is below this level, the lung is probably not injured.

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Solution to Question 10:

The dome-shaped layer of parietal pleura lining the cervical extension of the pleural cavity is called cervical pleura/pleural cupola/dome of pleura.

Solution to Question 11:

The pain from mediastinal pleura is referred to the side of the neck.

Pleura	Innervation	Pain referred to
Costaland peripheral diaphragmatic pleura	Intercostal nerves	Thoracic or abdominal wall
Mediastinaland Central diaphragmatic pleura	Phrenic nerve (C3, C4, and C5)	Lateral neck and supraclavicular region

Solution to Question 12:

Superior vena cava is related to the mediastinal part of the right lung.

Solution to Question 13:

The vagus nerve is posterior to the root of the lung.

The roots of the lung are at the level of T5-T7 vertebral bodies. The phrenic nerve is anterior to the root of the lung.

Solution to Question 14:

The area marked 'A' is where the azygos vein arches over the hilum of the right lung.

The diagram shown is of the right lung, identified by the presence of hyparterial and eparterial bronchus at the hilum.

Solution to Question 15:

The sequence of structures at the left hilum superior to inferior is: (Mnemonic: 'ABV')

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• Pulmonary artery,

• Principal (hyparterial) bronchus

• Inferior pulmonary vein

The sequence of structures at the right hilum superior to inferior is: (Mnemonic: 'BABV')

• Superior lobar (eparterial) bronchus

• Pulmonary artery

• Principal bronchus

• Inferior pulmonary vein

Solution to Question 16:

The inferior most structure of the right hilum is the inferior pulmonary vein.

The sequence of structures at the right hilum superior to inferior is: (Mnemonic - 'BABV')

• Superior lobar (eparterial) bronchus

• Pulmonary artery

• Principal bronchus

• Inferior pulmonary vein

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Solution to Question 17:

Lingula is not a lobe. It is a small process that is usually present at the lower end of the cardiac notch of the left lung.

The right lung has 3 lobes:

• Superior

• Middle

• Inferior

The left lung has 2 lobes:

• Superior

• Inferior

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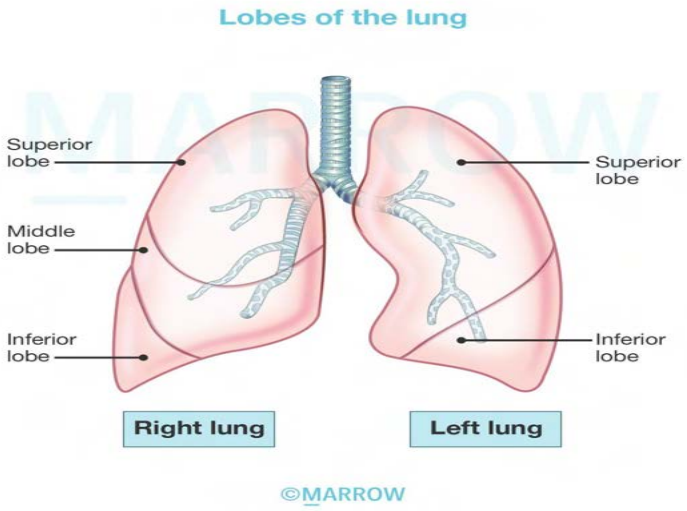

Note: The azygos vein may sometimes course in a more lateral position, within a four-layered pleural septum within the superior lobe, creating an 'azygos lobe'. This is not a true lobe, but a separated portion of the superior lobe that lacks its own bronchi, arteries, or veins.

Solution to Question 18:

Both the lungs have 10 bronchopulmonary segments each.

The functionally independent unit of lung tissue is called a bronchopulmonary segment. Each segment is a separate respiratory unit.

Solution to Question 19:

The eparterial bronchus supplies the right upper lobe, which includes the segments: apical, posterior, and anterior. Hence, these segments will have decreased airflow.

Solution to Question 20:

The bronchopulmonary segments are aerated by tertiary bronchi (3°).

Principal bronchi (1°) ---> lobar bronchi (2° - right into 3, left into 2) ---> segmental bronchi (3°)

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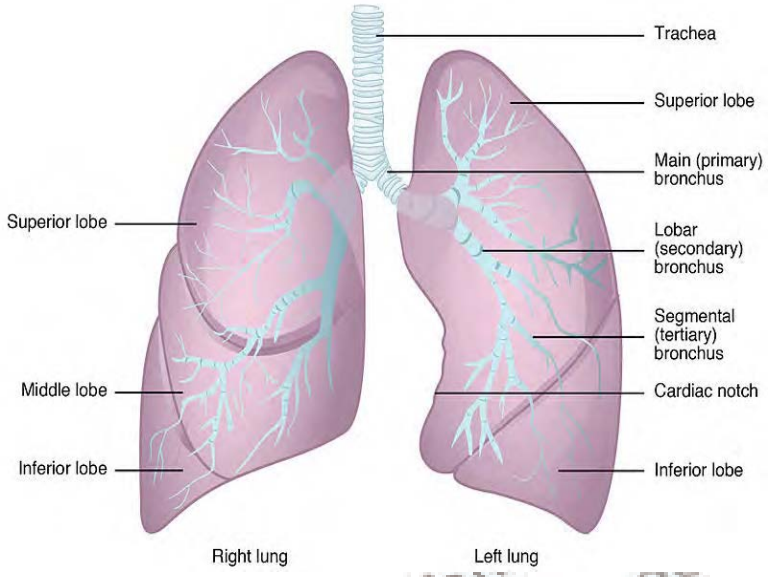

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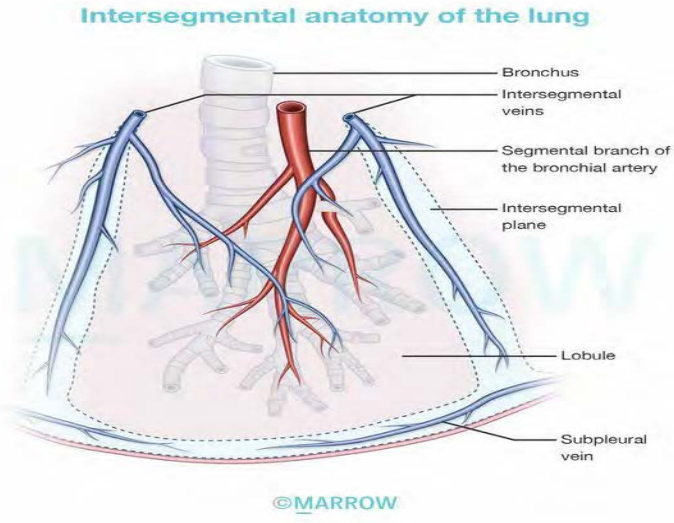
Solution to Question 21:

The bronchopulmonary segments are not drained by an independent branch of the pulmonary vein.

The tributaries of the pulmonary vein tend to pass intersegmentally between and around the margins of segments.

A bronchopulmonary segment is the area of lung supplied by a segmental bronchus and its accompanying pulmonary artery branch and can be resected surgically. It is the largest division of a lobe.



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Solution to Question 22:

The right principal bronchus (not the right lung) is wider, shorter (2.5 cm), and more vertical than the left. The right inferior lobar bronchus is the continuation of the bronchus intermedius which is in the continuation of the right principal bronchus. These differences explain why inhaled foreign bodies enter the right principal bronchus more often than the left.

The left principal bronchus is narrower, longer (5 cm) and less vertical than the right principal bronchus.

Solution to Question 23:

The bronchial artery supplies the lungs up to the respiratory bronchiole.

Bronchial arteries are derived from the descending thoracic aorta either directly or indirectly. They travel and branch with the bronchi, and terminate around the level of the respiratory bronchioles.

Pulmonary arteries alone perfuse the further distal pathways including the alveolar ducts and the alveoli.

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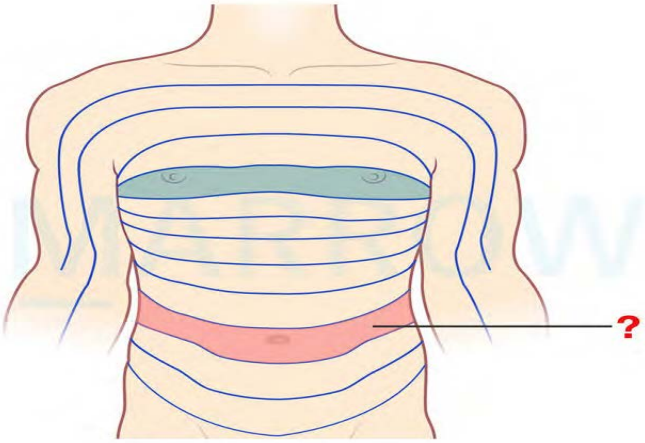
Anterior Abdominal Wall

Question 1:

Area marked in the given image is supplied by dermatome number?



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a) T8

b) T9

c) T10

d) T11

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Question 2:

During the abdominal examination of a patient, you notice the following pattern of subcutaneous venous circulation. In which of the following conditions is this pattern seen?

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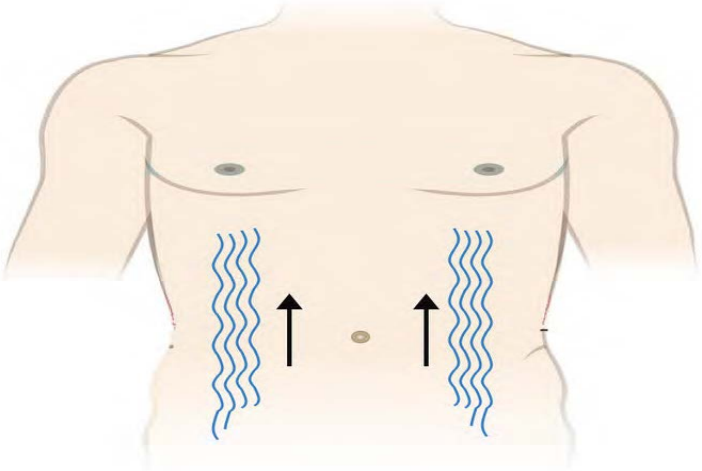


a) Superior vena caval obstruction

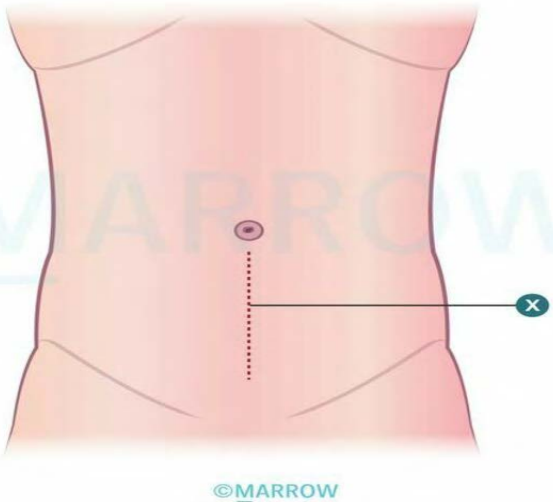
b) Inferior vena caval obstruction

c) Superior mesenteric artery thrombosis

d) Budd-Chiari syndrome

Question 3:

A 25-year-old woman having lower abdominal pain and shock is diagnosed with a ruptured ectopic pregnancy. The gynecologist decides to perform an emergency laparotomy via the incision shown in the image below. Which of these structures is not incised in this approach?



a) Transversalis fascia

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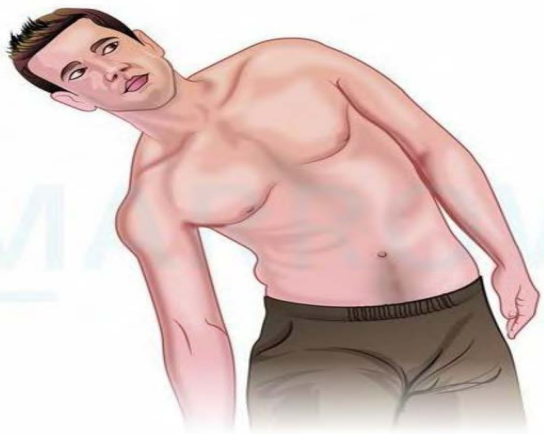
b) Extraperitoneal fat

c) Campers and Scarpa fascia

d) Transversus abdominis muscle

Question 4:

A 70-year-old man complains of weakness of his trunk muscles following a stroke. While examining the patient, you ask him to perform the following movement. Which of the following muscles is/are being tested here?



a) Rectus abdominis

b) Ipsilateral external oblique and contralateral internal oblique

c) Ipsilateral external oblique and internal oblique

d) Ipsilateral transversus abdominis and internal oblique

Question 5:

An anterior abdominal wall nerve block is to be performed for a patient with pain at the appendicectomy incision site. What is the site of injection of the local anesthetic?

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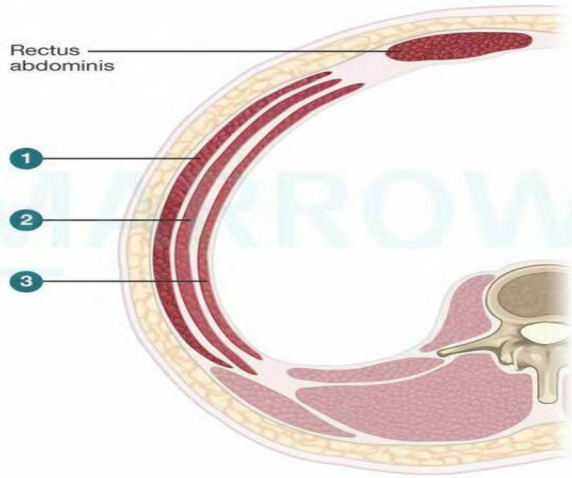

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a) Between 1 and 2

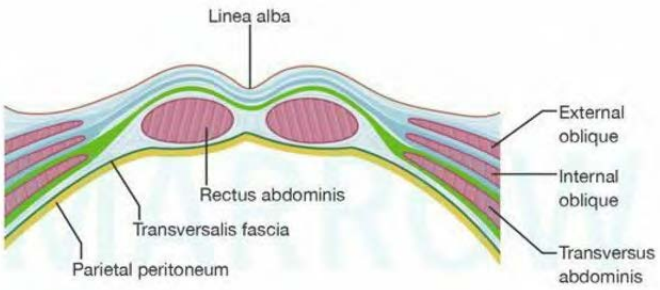
b) Deep to 3

c) Between 2 and 3

d) Superficial to 1

Question 6:

The given image of the rectus sheath represents a section at which of the following levels?



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a) Above the umbilicus

b) Below a point midway between pubic symphysis and umbilicus

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c) Between the umbilicus and arcuate line

d) Below a point midway between xiphisternum and pubic symphysis

Question 7:

In the rectus sheath, with which of the following arteries does the superior epigastric artery anastomose?

a) Branch of internal iliac artery

b) Branch of superficial circumflex iliac artery

c) Branch of femoral artery

d) Branch of external iliac artery

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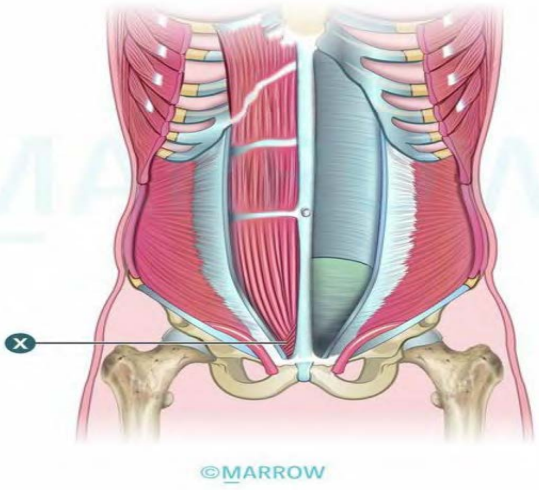
Question 8:

What is the nerve supply for the structure marked X in the below image?



a) Genital branch of genitofemoral nerve

b) Femoral branch of genitofemoral nerve

c) Subcostal nerve

d) T7- T11 intercostal nerves

Question 9:

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Which of the following statements regarding the boundaries of the inguinal canal is false?

a) Anterior wall has external oblique aponeurosis along its entire length

b) Posterior wall has transversalis fascia along its entire length

c) Roof has the internal oblique and transversus abdominis muscle

d) External oblique is present in the anterior wall, roof, and posterior wall

Question 10:

Which of the following statements regarding the contents of the inguinal canal is true?

a) Internal spermatic fascia is derived from the fascia transversalis

b) Ilioinguinal nerve enters the canal at the deep inguinal ring

c) Cremasteric artery is a branch of superior epigastric artery

d) Indirect Inguinal hernias do not occur in women

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Question 11:

A man was brought to the emergency department after he fell into a manhole and injured his perineum. He was unable to pass urine and blood was seen at the tip of the urethra. A diagnosis of bulbar urethral injury was made. Where do you least expect the urine to get collected in this case?

a) Perineum

b) Anterior abdominal wall

c) Medial portion of thigh

d) Root of scrotum

Question 12:

The image below shows the insertion of the transversus abdominis muscle. Identify the conjoint tendon.

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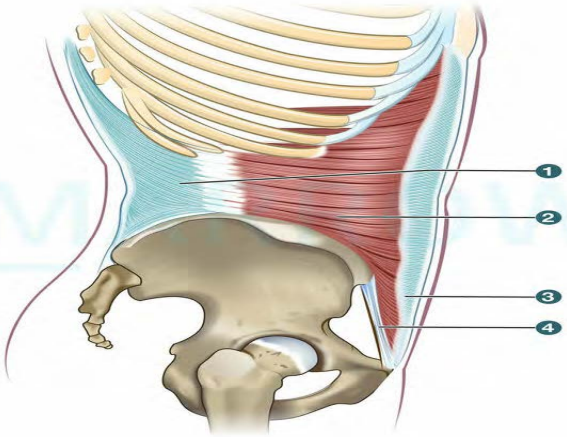

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a) 1

b) 2

c) 3

d) 4

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Answer Key

Question No.	Correct Option
1	c
2	b
3	d
4	c
5	c
6	b
7	d
8	c
9	d
10	a
11	c
12	c

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Detailed Explanations

Solution to Question 1:

The marked dermatome which includes the umbilicus is supplied by T10.

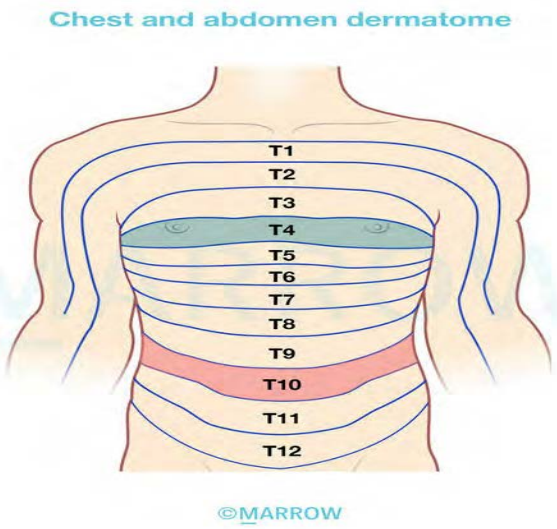
The dermatomal distribution of the abdominal region is as follows:

• T7, T8, T9 - supplies skin from the xiphoid process to just above the umbilicus.

• T10 - supplies skin around the umbilicus.

• T11, T12 - supplies skin below the umbilicus upto the suprapubic region.

• L1 - supplies skin around the genitalia and upper medial thigh.



Solution to Question 2:

The pattern of subcutaneous venous circulation depicted in the image can be seen in cases of inferior vena caval obstruction.

The level of the umbilicus is a watershed area for venous and lymphatic circulation. The systemic veins anastomose with tributaries of portal veins at the umbilicus. Normally, venous blood and lymphatics flow upwards above the plane of the umbilicus and downwards below this plane.

Disease	Pattern of blood flow in anterior abdominal wall veins
Inferior vena cava obstruction	Completely upwards
Superior vena cava obstruction	Completely downwards

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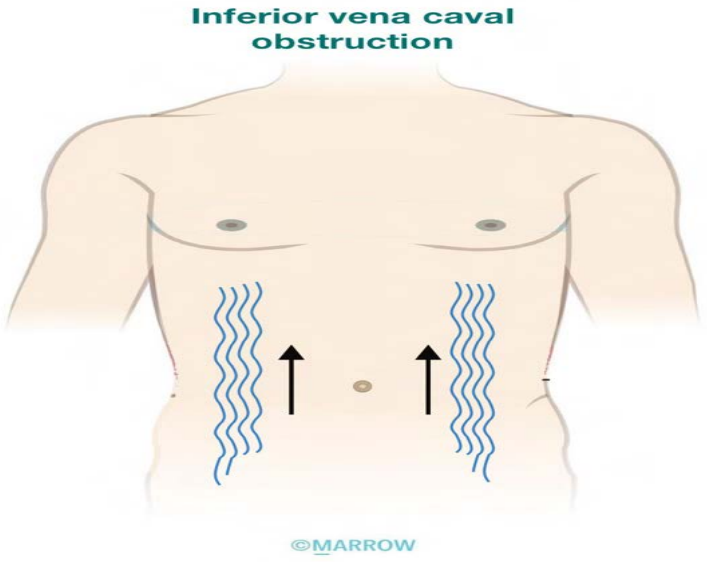
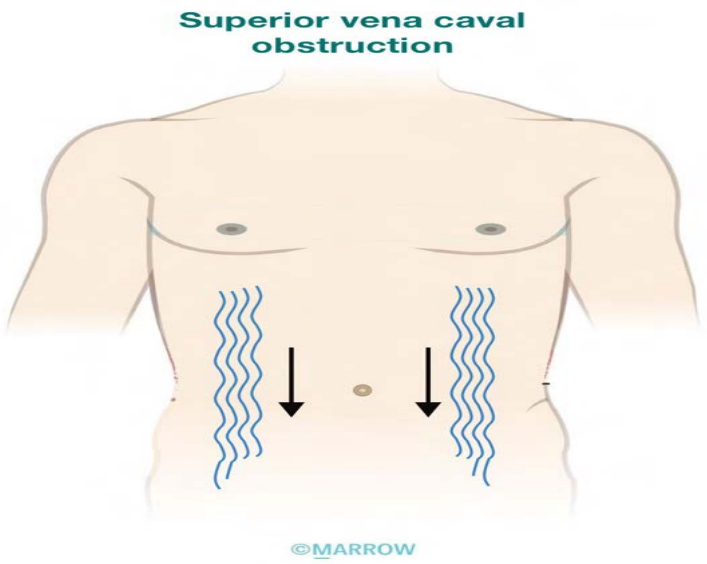
Disease	Pattern of blood flow in anterior abdominal wall veins
Portal hypertension	Radiating away from the umbilicus like a star (caput-medusae)





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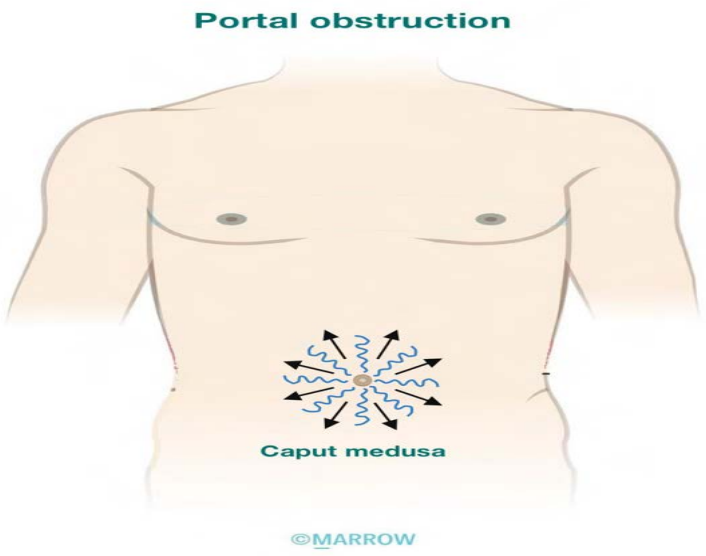

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Solution to Question 3:

The image shows a midline incision used for emergency laparotomy. Transversus abdominis muscle is not incised in this approach.

Layers of the abdomen pierced in the midline approach (from superficial to deep):

- Skin
- Superficial fascia (Campers and Scarpa)
- Linea alba
- Transversalis fascia
- Extraperitoneal fat
- Parietal peritoneum

There are no muscles pierced in this approach.

Layers of the abdomen pierced in the flanks (from superficial to deep):

- Skin
- Superficial fascia (Campers and Scarpa)
- External oblique
- Internal oblique
- Transversus abdominis
- Transversalis fascia
- Extraperitoneal fat
- Parietal peritoneum

These layers are shown in the image below:

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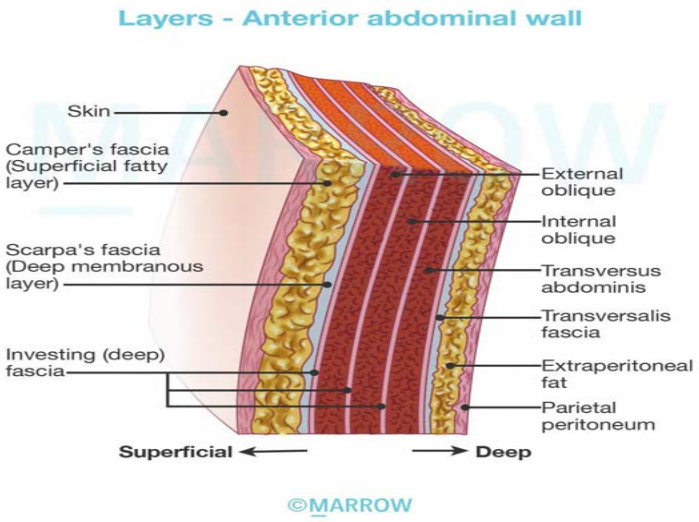

Clinical Note: Umbilical and epigastric hernias can happen due to a congenital or acquired defect in the linea alba such as a midline abdominal incision.

Solution to Question 4:

The given image shows lateral flexion of the trunk being performed, which is done by the ipsilateral external oblique (EO) and internal oblique (IO) muscles.

The anterior abdominal wall comprises of 4 muscles:

- External oblique
- Internal oblique
- Transversus abdominis
- Rectus abdominis

Muscles involved in movements of the trunk include:

Action	Muscles involved
Forward flexion of trunk (lumbar spine)	Rectus abdominis and bilateral IO and EO
Lateral flexion of the trunk	Ipsilateral IO and EO
Rotation of trunk	Ipsilateral IO and contralateral EO
Tensing the linea alba	Pyramidalis
Pulling the testes towards the superficial inguinal ring	Cremaster

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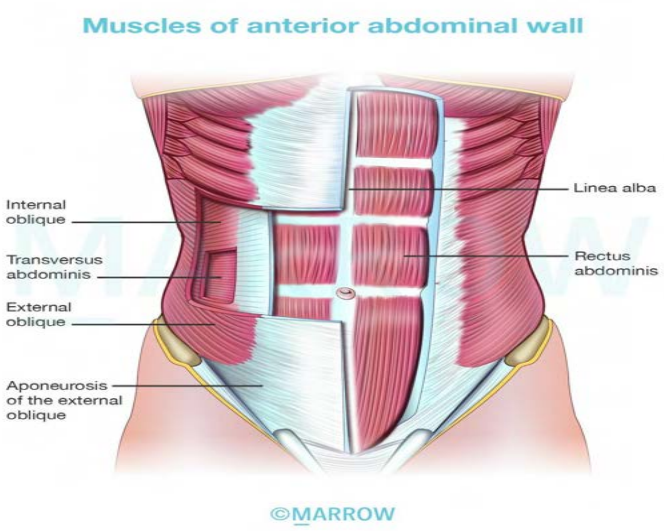

Solution to Question 5:

The local anesthetic is injected between the internal oblique (marked as 2) and transversus abdominis (marked as 3) muscles in the anterior abdominal wall. This is because the neurovascular plane of the abdominal wall lies between these two muscles.

The plane between the internal oblique and transversus abdominis contains:

- Lower 6 thoracic nerves (T7-12)
- Iliohypogastric nerves
- Posterior intercostal and subcostal vessels
- Anastomosis between superior and inferior epigastric arteries

The transversus abdominis plane (TAP) block is a regional anesthetic technique used for abdominal surgeries like open cholecystectomy, open appendicectomy, and hernia surgery. It is also used for postoperative analgesia after these surgeries.

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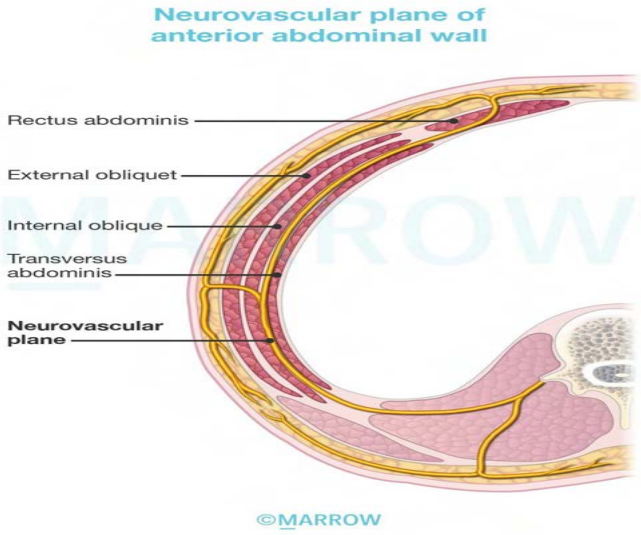

Solution to Question 6:

The given image represents a transverse section through the rectus sheath below the arcuate line. The arcuate line is located midway between the umbilicus and pubic symphysis.

The rectus sheath is formed from the aponeuroses of all three lateral abdominal muscles i.e. external oblique, internal oblique, and transversus abdominis. Each aponeurosis is bilaminar having 2 leaves.

Rectus sheath above the arcuate line:

• Anterior layer is composed of both leaves of the aponeurosis of the external oblique and the anterior leaf of the aponeurosis of the internal oblique.

• Posterior layer is composed of the posterior leaf of the aponeurosis of the internal oblique and both leaves of the aponeurosis of transversus abdominis.

Rectus sheath below the arcuate line

• Anterior layer is formed by the aponeurosis of all three muscles - external oblique, internal oblique, and transversus abdominis.

• Posterior layer is deficient and the rectus abdominis muscle lies directly on the fascia transversalis.

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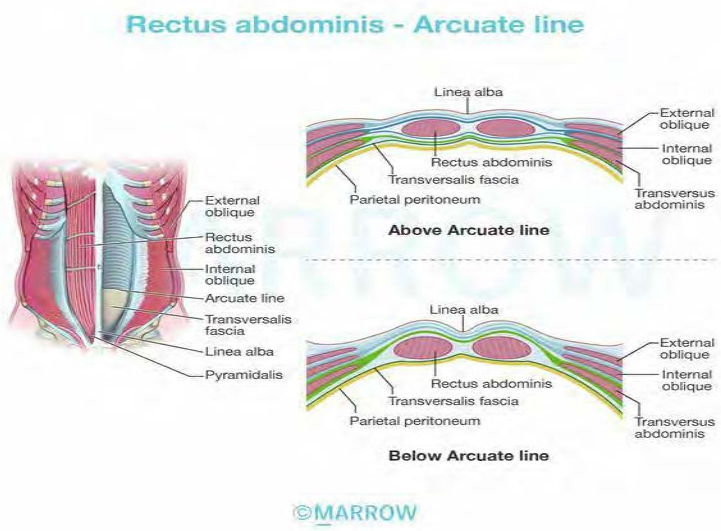
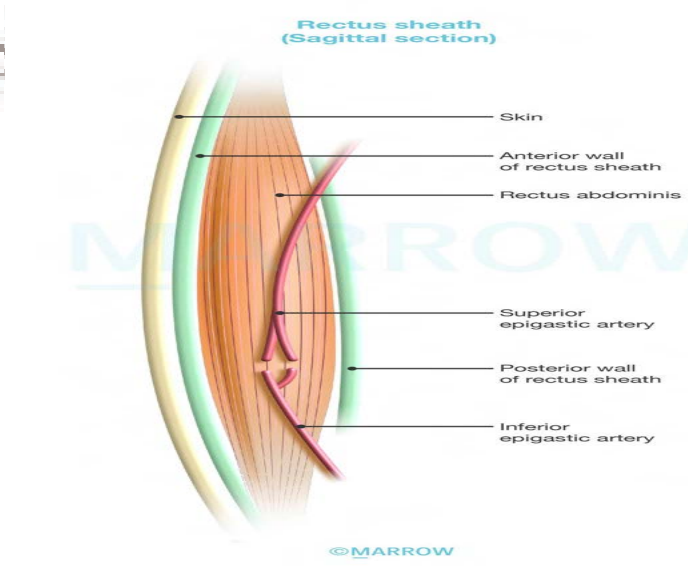


Solution to Question 7:

In the rectus sheath, the superior epigastric artery anastomoses with the inferior epigastric artery, a branch of the external iliac artery.

The superior epigastric artery is a branch of the internal thoracic artery. They anastomose in the rectus sheath above the level of the umbilicus.

The image given below shows the anastomosis between the superior and inferior epigastric artery in the rectus sheath.



Solution to Question 8:

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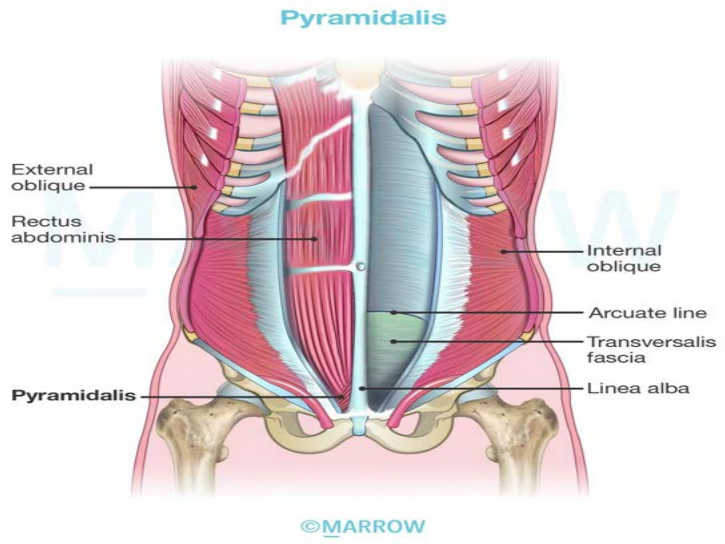
The structure marked in the image is pyramidalis, which is supplied by the subcostal nerve (ventral ramus of T12).

The pyramidalis is a triangle-shaped muscle that runs within the rectus sheath. The base is attached to the anterosuperior margin of the pubis and to the ligamentous fibres in front of the symphysis. The apex is attached to the linea alba.

It gets its nerve supply from the terminal branches of the subcostal nerve (the ventral ramus of T12). In some cases, it may be innervated wholly or partly by fibres from L1 travelling in the subcostal or ilioinguinal nerves.



Solution to Question 9:

The external oblique is present only in the anterior wall of the inguinal canal.

Internal oblique is present in the anterior wall in the lateral one-third (as muscular fibers), roof (as arched fibers), and posterior wall (as part of the conjoint tendon) of the inguinal canal.

Transversus abdominis is present as part of the roof and posterior wall (as the conjoint tendon)

Solution to Question 10:

Internal spermatic fascia is a derivative of fascia transversalis.

External spermatic fascia is derived from external oblique aponeurosis. The cremasteric fascia is derived from internal oblique.

Option B: The ilioinguinal nerve does not enter the inguinal canal at the deep inguinal ring. It enters the inguinal canal by piercing its posterior wall.

Option C: The cremasteric artery is a branch of the inferior epigastric artery.

Option D: Indirect inguinal hernias are seen in both men and women.

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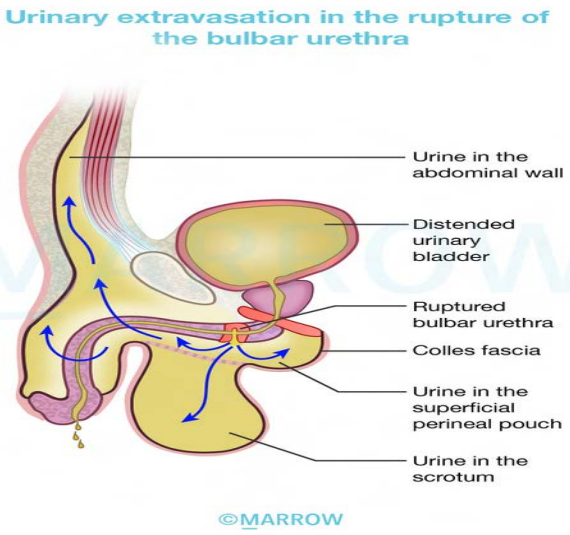
Solution to Question 11:

In bulbar urethral injury, the medial portion of the thigh is the least likely site for the collection of urine.

The rupture of the urethra below the urogenital diaphragm will result in extravasation of urine into the superficial perineal pouch, penis and scrotum in males and labia majora in females, and the anterior abdominal wall.

The superficial fascia of the abdomen is divided below the umbilicus into a superficial fatty layer (fascia of Camper) and a deep membranous layer (fascia of Scarpa). Scarpa's fascia is continuous with the membranous layer of the superficial perineal fascia (Colles' fascia).

Colles' fascia is attached to fascia lata (the deep fascia of the thigh) along the Holden's line that extends from the pubic tubercle laterally for 8 cm. Extravasated fluid cannot pass into the medial thigh below Holden's line due to the firm attachment of Colles' fascia to the fascia lata.



Solution to Question 12:

The structure marked 3 is the conjoint tendon. It is formed from the lower fibers of the internal oblique and the lower part of the aponeurosis of the transversus abdominis. It is attached to the pubic crest and extends to a variable extent along the pectineal line.

Transversus Abdominis muscle:

Origin - from the internal surface of 7th-12th costal cartilages, thoracolumbar fascia, iliac crest, connective tissue deep to lateral third of inguinal ligament.

Insertion - at the linea alba with the aponeurosis of internal oblique, pubic crest, and pecten pubis via the conjoint tendon.

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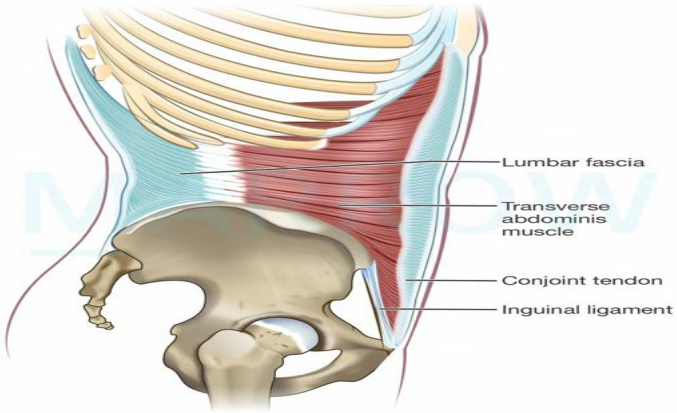
Conjoint tendon Anterior abdominal wall



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Abdominal cavity and Peritoneum

Question 1:

The imaginary plane passing through the bony prominences marked in red in the image below lies at the level of_____.

a) Lower border of L3

b) Upper border of L3

c) Upper border of L5

d) Lower border of L5

Question 2:

Which of the following structures is not present in the plane marked as 1 in the image?

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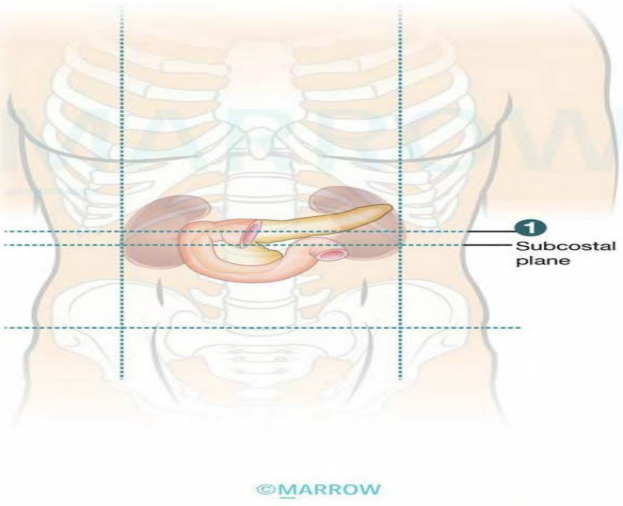

a) 1 and 3

b) 1, 3, and 5

c) 2, 4 and 5

d) 1 and 4

Question 3:

Which level does the structure marked as X in the image lie at?

a) L1

b) L2

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c) T11

d) T12

Question 4:

In a patient with referred back pain, a surgeon suspects the origin of pain to be from a retroperitoneal organ. Which of the following is the likely cause of pain?

a) Jejunum

b) Liver

c) Stomach

d) Pancreas

Question 5:

Which of the following statements regarding the root of the mesentery is false?

a) 1,3, and 4

b) 1,2, and 4

c) 1,3, and 5

d) 1, 2, and 5

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Question 6:

A 60-year-old man presented with bleeding per rectum and weight loss. He underwent an endorectal ultrasound whose findings are given below. A diagnosis of rectal carcinoma was made and the patient was posted for total mesorectal excision. Which of the following is contained in the excised structure?

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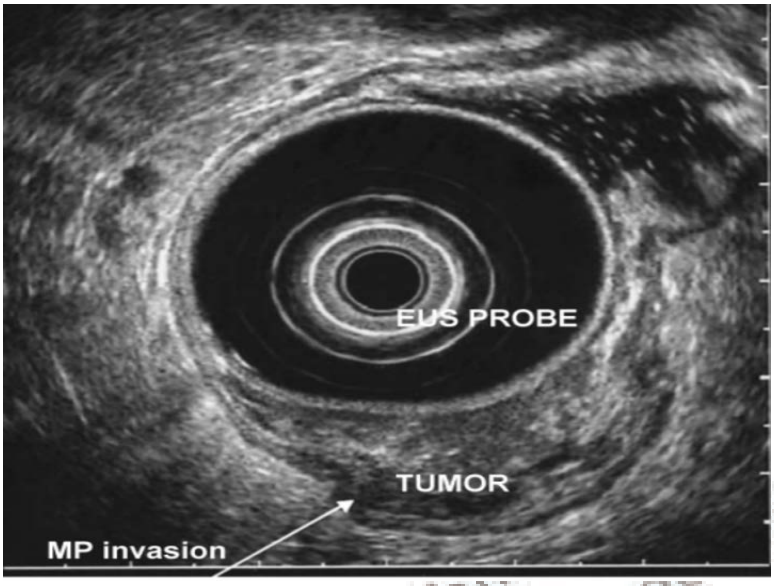

a) Superior mesenteric plexus

b) Superior rectal vein

c) Inferior rectal vein

d) Inferior rectal artery

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Question 7:

Identify the wrongly matched pair.

a) 1

b) 2

c) 3

d) 4

Question 8:

Which of the following is true about the structure marked as X in the image?

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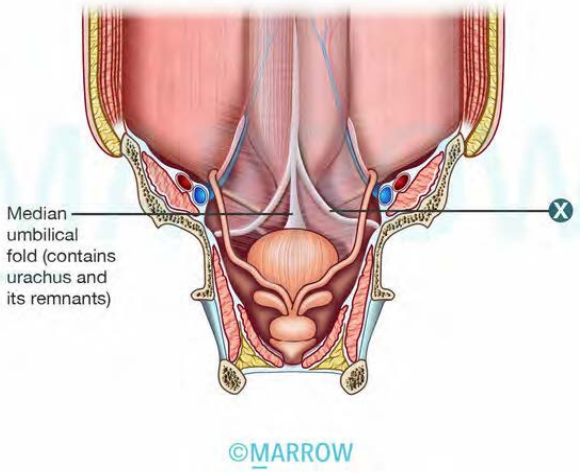

a) Contains the remnant of urachus

b) Overlies the obliterated umbilical arteries

c) Covers the inferior epigastric vessels

d) It passes from external iliac artery to the umbilicus

Question 9:

A 58-year-old woman was undergoing cholecystectomy. During the procedure, the resident accidentally advanced the scissors along the superior border of the epiploic foramen causing injury. Which of the following structures is likely to be injured?

a) Right lobe of liver

b) Quadrate lobe of liver

c) Caudate lobe of liver

d) Fundus of gall bladder

Question 10:

Which of the following duodenal recesses contains the inferior mesenteric vein in its free margin?

a) Superior duodenal recess

b) Paraduodenal recess

c) Inferior duodenal recess

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d) Mesenterico-parietal recess

Question 11:

Where would you expect any intra-abdominal fluid to get collected in a patient lying supine?

a) Right infracolic space

b) Left infracolic space

c) Right subhepatic space

d) Left paraduodenal space

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Answer Key

Question No.	Correct Option
1	c
2	a
3	a
4	d
5	c
6	b
7	d
8	b
9	c
10	b
11	c

Detailed Explanations

Solution to Question 1:

The structures marked in red are the tubercles of the iliac crest. An imaginary line passing through them forms the trans-tubercular plane which lies at the upper border of L5.

The abdomen is divided into 9 regions based on the following:

• Two transverse planes:

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• Subcostal plane which is indicated by a line that joins the lowest point of the costal margin on each side. It corresponds to the level of 10th costal cartilage and lower border of second lumbar vertebra(L2) or upper border of third lumbar vertebra (L3)

• Trans-tubercular plane is indicated by a line that joins the tubercles of the iliac crests. It corresponds to the level of fifth lumbar vertebra (L5).

• Two vertical planes on both sides:

• Right and left lateral planes passing from mid-clavicular point to the mid-inguinal point.

Solution to Question 2:

The structure marked in the image is the transpyloric plane which is present at L1 level. The origin of the celiac trunk (T12) and lower limit of the spinal cord of a newborn (L3) are not present at this level.

The transpyloric plane (Addison's plane) passes midway between the suprasternal notch of the manubrium and the upper border of the pubic symphysis. This approximately corresponds to midway between the xiphisternal joint and the umbilicus. Posteriorly, this plane passes through the lower half of the body of the first lumbar vertebra (lower border of L1).

Structures present in the transpyloric plane:

Organs	Neurovascular structures
Pylorus of stomach	Origin of the superior mesenteric artery
D1 part of the duodenum	Origin of the renal artery
Duodenojejunal flexure	Origin of the portal vein (behind the neck of the pancreas)
Fundus of the gallbladder	Lower limit of the spinal cord in adults
Hilum of the left kidney (right kidney is slightly lower)	Cisterna chyli

Solution to Question 3:

The structure marked in the image is the fundus of the gallbladder. It lies at the level of L1 in the transpyloric plane.

The tip of the ninth costal cartilage in the transpyloric plane, near the junction of the linea semilunaris with the costal margin is used to identify the fundus of the gall bladder.

The transpyloric plane is an imaginary plane that lies midway between the suprasternal notch and the upper border of the pubic symphysis. Posteriorly, this plane intersects the lower half of the body of the first lumbar vertebra. Anteriorly, it intersects the costal margin at the ninth costal cartilage.

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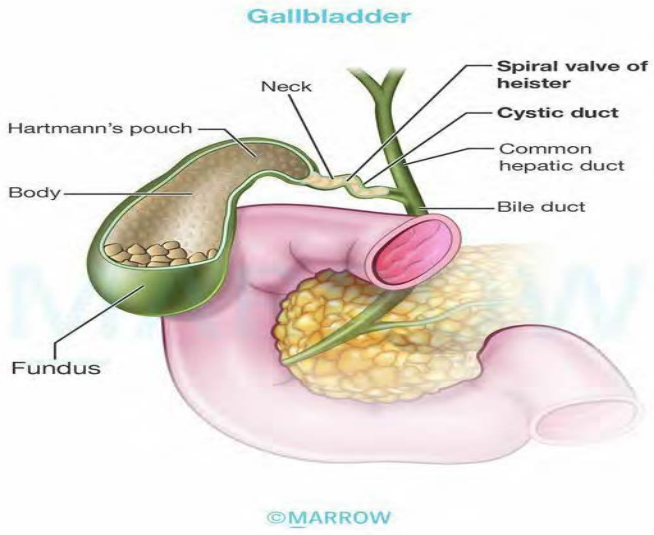

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Solution to Question 4:

The pancreas is a retroperitoneal structure. All the other structures listed are intraperitoneal. Pain originating from retroperitoneal organs are likely to be referred to the back.

Relationship of viscera to the peritoneum:

Intraperitoneal	Retroperitoneal	Partially covered in the perit oneum(considered as retrope ritoneal)
Stomach	Esophagus (abdominal)	Ascending colon
Jejunum and ilium	D2 and D3 duodenum	Descending colon
Transverse and sigmoid colo n	Pancreas	Rectum
Liver and gallbladder	Kidneys, ureters, and adrenal gland	
Spleen	Abdominal aorta and inferior vena cava	
	Celiac plexus	

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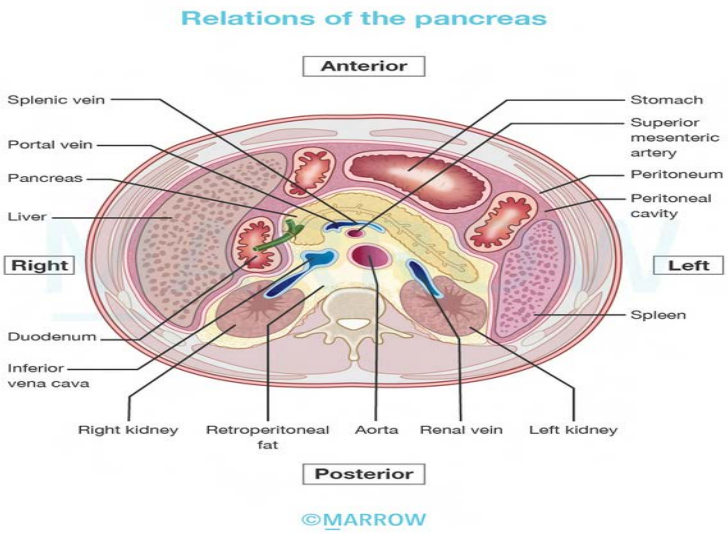

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Solution to Question 5:

The root of the mesentery is approximately 15 cm long. It is crossed by the right ureter and right psoas major and it crosses the midline.

The root of the mesentery is the attachment of the mesentery of the small intestine to the posterior abdominal wall. It runs diagonally from the duodenojejunal flexure on the left side of the L2 vertebral body to the right sacroiliac joint. The length of intestinal attachment of the mesentery measures approximately 5 to 6 meters (same as the length of the small intestine) and it has a breadth (from the root to the intestinal border) of 20 cm.

Structures crossed by the root of the mesentery include:

- Third part of the duodenum
- Abdominal aorta
- Inferior vena cava
- Right ureter
- Right psoas major

Contents of the mesentery include:

- Superior mesenteric vessels (jejunal and ileal branches)
- Nerves related to the superior mesenteric plexus
- Lymphatics and regional lymph nodes
- Connective tissue and fat

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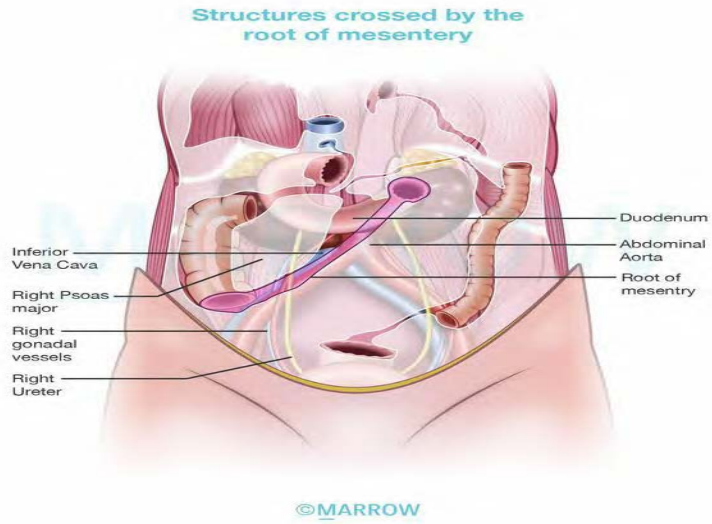

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Solution to Question 6:

The mesorectum is excised in total mesorectal excision. It contains the superior rectal vein.

The rectum has no mesentery attached to it. However, it is surrounded by fat which is enclosed within a fascial envelope known as the mesorectum, which contains:

- Superior rectal artery and its branches
- Superior rectal vein and its tributaries
- Lymphatic vessels and nodes

Anterolaterally, branches of the inferior hypogastric plexus and middle rectal vessels enter the mesorectum covered in a layer of fascia which is known as the lateral rectal ligament.

Total mesrectal excision (TME) is a standard procedure done for rectal cancer. It includes resection of tumor along with the surrounding fatty tissues, blood vessels and lympatics present in the mesorectum.

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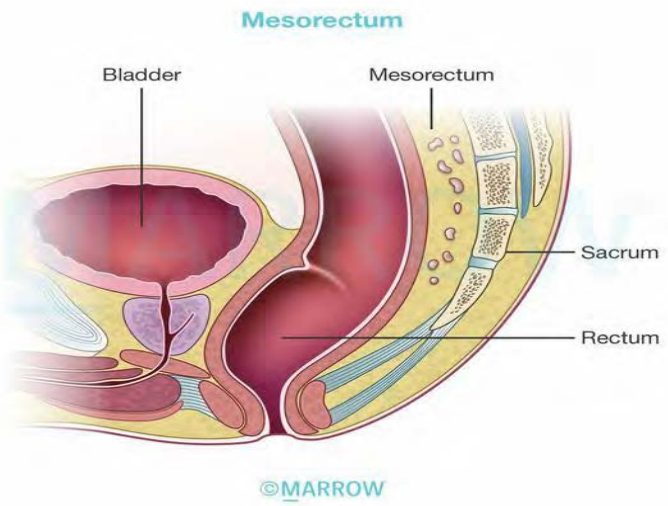

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Solution to Question 7:

The sigmoid mesocolon contains sigmoid vessels and superior rectal vessels.

Solution to Question 8:

The structure marked in the image is the medial umbilical fold. It overlies the obliterated umbilical artery.

The peritoneum of the lower anterior abdominal wall is raised into five folds that diverge as they descend from the umbilicus. These include:

Umbilical folds	Features
Median umbilical fold	Single, present in the midline Extends from the umbilicus t o the apex of the bladderRem nant of the urachus
Medial umbilical folds	Two in numberExtends from the internal iliac artery to the umbilicusOverlies the obliter ated umbilical artery
Lateral umbilical folds	Two in numberOverlies the i nferior epigastric vessels

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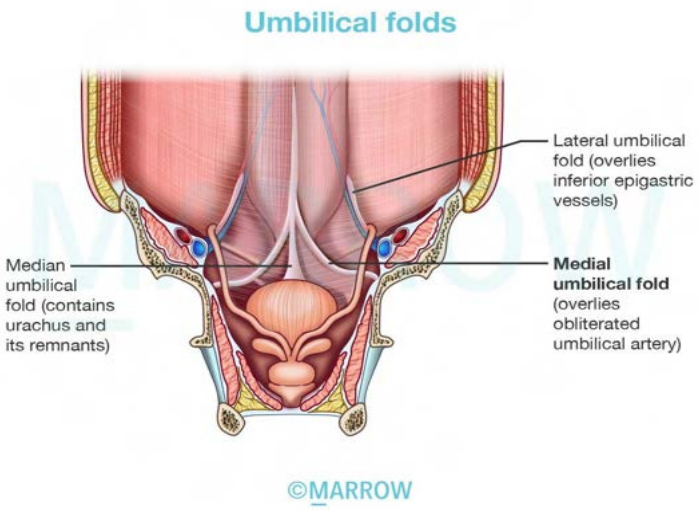
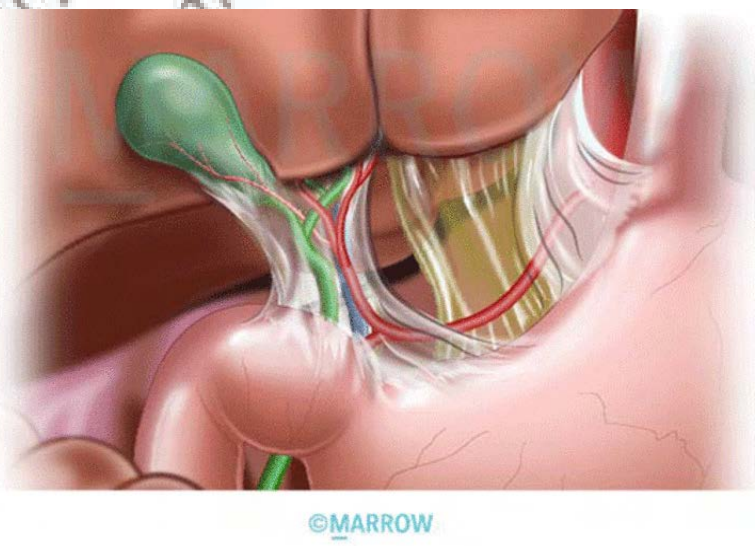


Solution to Question 9:

The superior border of the epiploic foramen (foramen of Winslow) is formed by the caudate lobe of the liver. It is likely to be injured in this case.

Epiploic foramen is a vertical slit of about 3 cm behind the free right border of the lesser omentum. It connects the lesser sac to the greater sac.

Clinical note: Pringle maneuver (as shown below) is a technique where the free margin of the lesser omentum is compressed to obtain rapid control of bleeding from the hepatic artery and portal vein in liver trauma and surgery.



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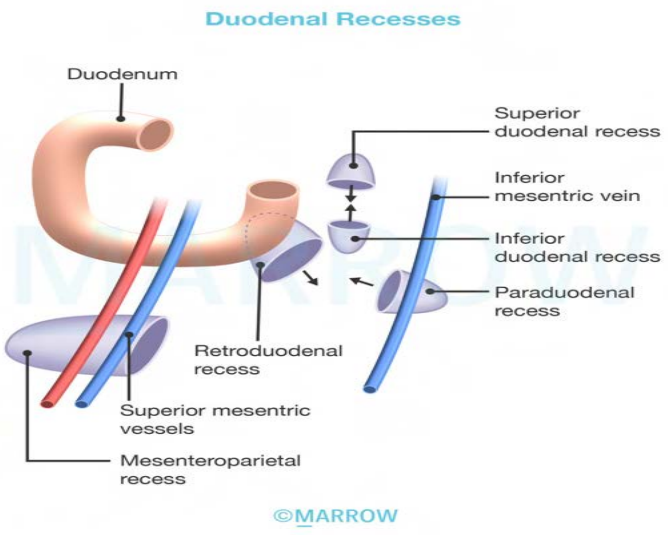
Solution to Question 10:

Paraduodenal recess contains the inferior mesenteric vein in its right free margin.

The fourth part of the duodenum and the duodenojejunal junction has several folds of peritoneum that give rise to many named recesses. They are probably formed during development due to minor aberrations of duodenal rotation and fixation.

The duodenal recesses include:

Recess	Location	Vascular relations
Superior duodenal recess	Directly left of D4Opposite L 2 vertebraBehind the duoden ojejunal fold	Inferior mesenteric vein is di rectly behind the lateral edge of the recess
Inferior duodenal recess	Left of D4 (sometimes behin d)Opposite L3 vertebraBehin d the duodenomesocolic fold	Passes in front of ascending branch of left colic artery and inferior mesenteric vein
Para-duodenal recess	Slightly left and behind D4Be hind falciform fold of periton eum	Right free edge contains infer ior mesentric vein and ascen ding branch of left colic arter y
Retroduodenal recess	Behind D3 and D4Has a wide orifice, with duodeno-parieta l folds on either side	Lies in front of the abdomina l aorta
Mesenterico-parietal recess	Below D3Forms a pocket in t he right upper part of mesent ery	Has a large, left facing orifice behind a fold raised by the s uperior mesenteric artery
Duodenojejunal recess	Below pancreasBetween DJ j unction and root of transvers e mesocolon	Left of the abdominal aorta



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Solution to Question 11:

The most dependent part of the peritoneal cavity in the supine position is the right subhepatic space (hepatorenal pouch of Morison). The intra-abdominal fluid gets collected in this space in the supine position.

It lies between the inferior surface of the right lobe of the liver and the upper pole of the right kidney.

The boundaries of the hepatorenal pouch are as follows:

• Superiorly - inferior layer of the coronary ligament.

• Inferomedially - hepatic flexure, transverse mesocolon, second part of the duodenum, and part of the head of the pancreas.

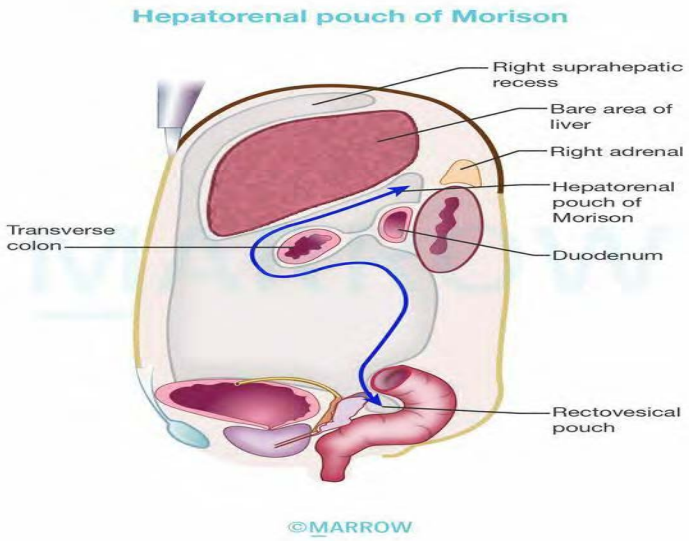
• Laterally - right lateral abdominal wall

• Posteriorly - anterior surface of the upper pole of the right kidney

Note: The most dependent part of the peritoneal cavity in erect posture:

• In males - rectovesical pouch

• In females - rectouterine pouch.



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GI Tract

Question 1:

Which of the following arteries does not contribute to the blood supply of the stomach?

a) Common hepatic artery

b) Splenic artery

c) Gastroduodenal artery

d) Inferior pancreaticoduodenal artery

Question 2:

Ligation of common hepatic artery will impair blood supply in:

a) Right gastric and right gastroepiploic artery

b) Right gastric and left gastric artery

c) Right gastroepiploic and short gastric vessels

d) Right gastric and short gastric vessels

Question 3:

A patient presents with a recurrence of peptic ulcers. He had undergone vagotomy ten years ago for peptic ulcer disease. You suspect this has occurred due to the criminal nerve of Grassi being missed during the previous surgery. Which of the following gives rise to this nerve?

a) Posterior vagus nerve

b) Anterior vagus nerve

c) Greater splanchnic nerve

d) Lesser splanchnic nerve

Question 4:

Which of the following receives the prepyloric vein of Mayo?

a) Right gastroepiploic vein

b) Left gastroepiploic vein

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c) Left gastric vein

d) Right gastric vein

Question 5:

Among the following, which is the final structure to drain lymphatics from the stomach?

a) Coeliac nodes

b) Intestinal lymph trunk

c) Para-aortic nodes

d) Lumbar lymph trunk

Question 6:

A 50-year-old woman presented with abdominal pain, nausea, and bilious vomiting. CT scan revealed obstruction of the third part of the duodenum by a large vessel. Which of the following blood vessels is most likely to cause the compression?

a) Inferior vena cava

b) Right gonadal vessels

c) Superior mesenteric artery

d) Abdominal aorta

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Question 7:

Which of the following arteries does not supply the duodenum?

a) Common hepatic artery

b) Right gastric artery

c) Jejunal artery

d) Splenic artery

Question 8:

In which part of the intestine is the finding given in the image more prominently seen?

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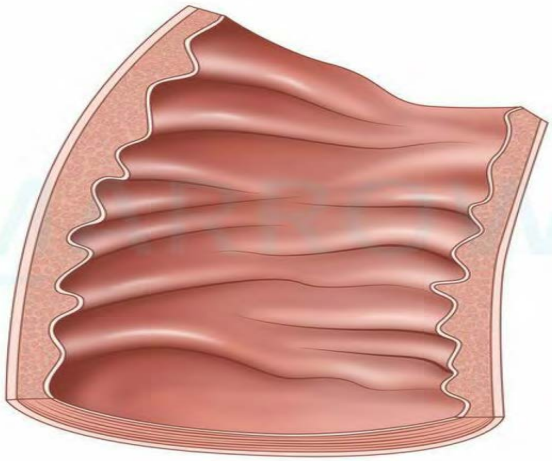

a) Ileum

b) Jejunum

c) Duodenum

d) Ascending colon

Question 9:

Identify the correct match among the following.

a) Peyer's patch - mesenteric border of ileum

b) Meckel's diverticulum - mesenteric border of jejenum

c) Meckel's diverticulum - antimesenteric border of ileum

d) Peyer's patch - antimesenteric border of jejunum

Question 10:

Which of the following is the longest part of the large intestine?

a) Transverse colon

b) Descending colon

c) Ascending colon

d) Sigmoid colon

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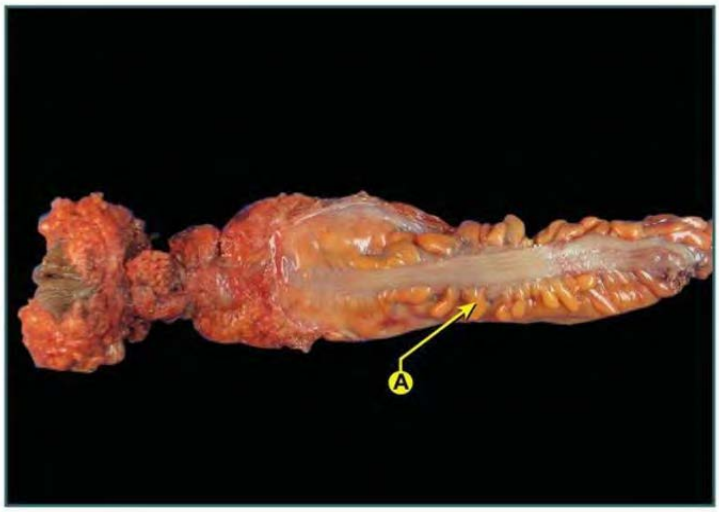
Question 11:

A specimen of the large intestine is given below. In which of the following is the marked structure usually not present?



a) Sigmoid colon

b) Descending colon

c) Transverse colon

d) Caecum

Question 12:

An elderly man with atherosclerosis presented with abdominal pain and blood-stained stools. CECT abdomen is suggestive of ischemic colitis at the splenic flexure involving the marginal artery of Drummond. What are the arteries contributing to the formation of this structure?

a) Right colic and left colic arteries

b) Ileocolic and left colic arteries

c) Left colic and middle colic arteries

d) Left colic and sigmoid arteries

Question 13:

A 10-year-old boy complained of nausea, anorexia and abdominal pain. On examination, tenderness was noted at McBurney's point and ilio-psoas sign was positive. You suspect

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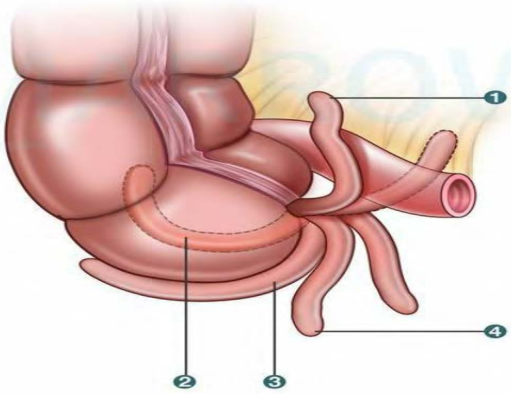
inflammation of the organ shown in the image. What is its most common anatomical position?



a) 1

b) 2

c) 3

d) 4

Question 14:

Which of the following is a content of the lateral rectal ligament?

a) Right superior rectal artery

b) Left superior rectal artery

c) Middle rectal artery

d) Inferior rectal artery

Question 15:

Which of the following statements about the muscles of the anal canal is false?

a) Internal anal sphincter is the thickened terminal part of the inner circular muscle of large intestine

b) The conjoint longitudinal muscle plays an important role in the prevention of haemorrhoids

c) Treitz's muscle is the submucosal muscle of the anal canal that prevents haemorrhoids

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d) The external anal sphincter is the continuation of the outer longitudinal muscle of the rectum

Question 16:

A 60-year-old man presented with a painful mass at the anus associated with bleeding. Examination revealed external haemorrhoids. Which of the following nerves is responsible for carrying the pain sensation?

a) Parasympathetic fibres S2, 3, and 4

b) Pudendal nerve S2, 3, and 4

c) Sympathetic fibres L1 and 2

d) Least splanchnic nerve T12

Question 17:

How many transverse mucosal folds are commonly present in the rectum?

a) 2

b) 3

c) 4

d) 5

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Answer Key

Question No.	Correct Option
1	d
2	a
3	a
4	d
5	b
6	c
7	d
8	b
9	c
10	a

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11	d
12	c
13	b
14	c
15	d
16	b
17	b

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Detailed Explanations

Solution to Question 1:

The inferior pancreaticoduodenal artery does not contribute to the blood supply of the stomach. It is a branch of the superior mesenteric artery. It supplies the duodenum (second and third parts) and the pancreas (head and uncinate process).

The arterial supply of the stomach is contributed exclusively by the celiac trunk through its branches:

• Left gastric artery - supplies the lesser curvature of the stomach

• Splenic artery:

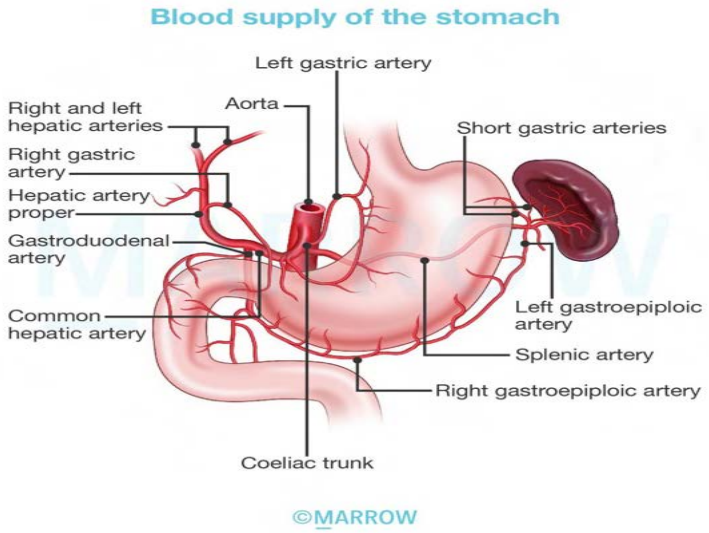
• Short gastric arteries - fundus

• Left gastroepiploic artery - greater curvature

• Common hepatic artery:

• Right gastric artery - lesser curvature

• Gastroduodenal artery - right gastroepiploic artery arises from this and supplies the greater curvature of the stomach.



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Clinical note: The presence of an abnormal, tortuous artery in the submucosa of the lesser curvature is called the Dieulafoy's lesion. As it is superficial, it is more vulnerable to rupture causing significant haemorrhage.

Solution to Question 2:

Ligation of the common hepatic artery will cause impairment in the blood supply through its branches i.e right gastric artery and right gastroepiploic artery.

Blood supply of the stomach:

The arterial supply of the stomach is contributed exclusively by the branches of the celiac trunk. They are:

• Left gastric artery - Supplies the lesser curvature of the stomach

• Splenic artery- This further divides into:

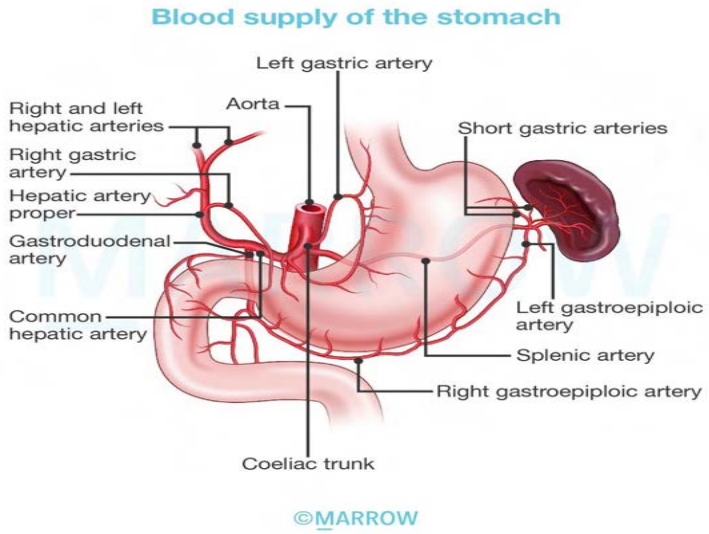
• Short gastric arteries- Supplies the fundus of the stomach

• Left gastroepiploic artery- Supplies the greater curvature of the stomach

• Common hepatic artery, which gives the following branches

• Right gastric artery- Supplies the lesser curvature of the stomach

• Gastroduodenal artery- Right gastroepiploic artery arises from this and supplies the greater curvature of the stomach.



Solution to Question 3:

The posterior vagus nerve gives rise to the criminal nerve of Grassi.

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This nerve supplies the cardia and fundus of the stomach. It is called a criminal nerve because it is often missed during a vagotomy procedure and can result in recurrent peptic ulcer disease.

Nerve supply of the stomach:

The sympathetic supply arises from T5-T12 spinal segments and is distributed to the stomach via the greater and lesser splanchnic nerves and the celiac plexus. They perform the following functions:

• Vasoconstriction

• Constriction of the pyloric sphincter and inhibition of gastric motility

• Carry visceral pain sensations

The parasympathetic supply arises from the right and left vagus nerves. The anterior vagal trunk is formed from the left vagus nerve, whereas the posterior vagal trunk is formed from the right vagus nerve. They perform the following functions:

• Secretomotor to the gastric glands

• Motor to the gastric musculature

• Relaxation of pyloric sphincter and promoting gastric emptying

• Carry sensations such as fullness, nausea, and probably pain.

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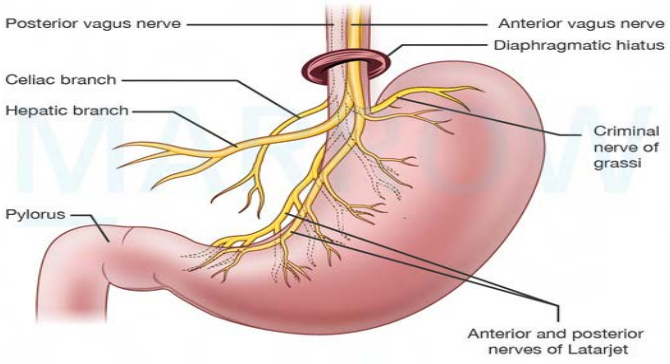
Nerve supply of the stomach



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Solution to Question 4:

The right gastric vein receives the prepyloric vein of Mayo.

The prepyloric vein serves as the guidepost for the surgeons to identify the pylorus of the stomach.

The common pattern of venous drainage of the stomach is as follows:

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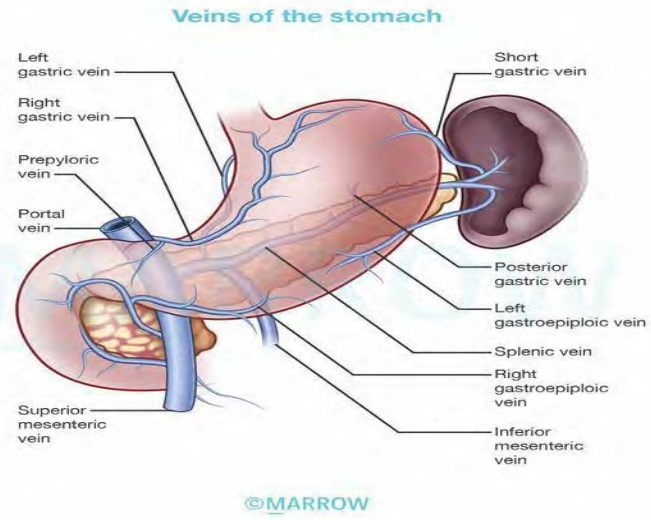
Veins of the stomach	Drains into
Right gastric vein	Portal vein
Left gastric vein	Portal vein
Right gastroepiploic vein	Superior mesenteric vei n
Left gastroepiploic vein	Splenic vein
Short gastric veins	Splenic vein



Solution to Question 5:

Among the given options, the intestinal lymph trunk is the last structure to drain lymphatics from the stomach.

The intestinal lymph trunk is a major lymphatic channel in the abdomen. It receives lymphatics from the pre-aortic group of lymph nodes such as coeliac nodes, superior mesenteric nodes, and inferior mesenteric nodes. The intestinal lymph trunk finally drains into the cisterna chyli.

The lymphatic drainage of the stomach can be divided into four zones as shown in the image below.

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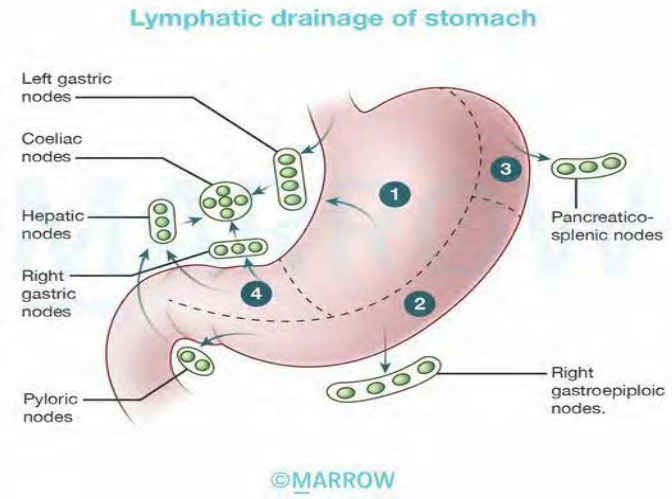

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Solution to Question 6:

The clinical scenario is suggestive of superior mesenteric artery syndrome or Wilkie syndrome. In this condition, the third part of the duodenum is compressed by the superior mesenteric artery causing bowel obstruction.

The mid-portion of the third part of the duodenum lies in the angle between the superior mesenteric artery anteriorly and the abdominal aorta posteriorly.

Parts of the duodenum and their characteristics:

Parts of the duodenum	Extent	Anterior relations	Posterior relations
First(5 cm)	Duodenal end of pylorus to superior duodenal flexure	Quadrate lobe of liver	Gastroduodenal arteryCommon bile ductPortal vein
Second(8 cm)	Superior duodenal flexure to inferior duodenal flexure	Right end of greater omentumOrigin of transverse mesocolonMesentery of upper ascending colon and hepatic flexure	Right psoas majorLateral edge of inferior vena cavaHilum of right kidneyRight renal vessels
Third(10 cm)	Inferior duodenal flexure to ascending portion of the fourth part of duodenum	Transverse mesocolonOrigin of the root of mesenterySuperior mesenteric vessels	Right ureterRight gonadal vesselsInferior vena cavaAbdominal aortaRight Psoas major
Fourth(2.5 cm)	From the left of aorta to duodenojejunal flexure	Transverse colonTransverse mesocolon	Left renal vesselsLeft gonadal vesselsAbdominal aortaLeft psoas majorLeft sympathetic trunk

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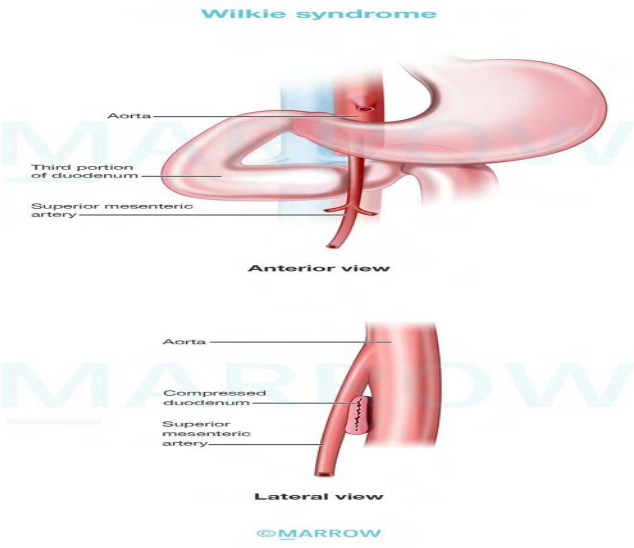

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Solution to Question 7:

The splenic artery does not supply the duodenum.

The major vessels supplying the duodenum are:

• Gastroduodenal artery - branch of the common hepatic artery

• Superior mesenteric artery - anterior branch of the abdominal aorta.

Branches of the gastroduodenal artery supplying the first and second parts of the duodenum and head of the pancreas are:

• Posterior superior pancreaticoduodenal artery

• Anterior superior pancreaticoduodenal artery

• Supraduodenal artery

• Retroduodenal arteries

• Pancreatic branches

Note: The first and second parts of the duodenum also receive minor blood supply from the right gastric artery and the right gastroepiploic artery.

Branches of the superior mesenteric artery supplying the second, third, and fourth parts of the duodenum, and the head and uncinate process of the pancreas are:

• Inferior pancreaticoduodenal artery - anterior and posterior branches supply the second and third parts of the duodenum

• First jejunal artery - supply the fourth part of the duodenum

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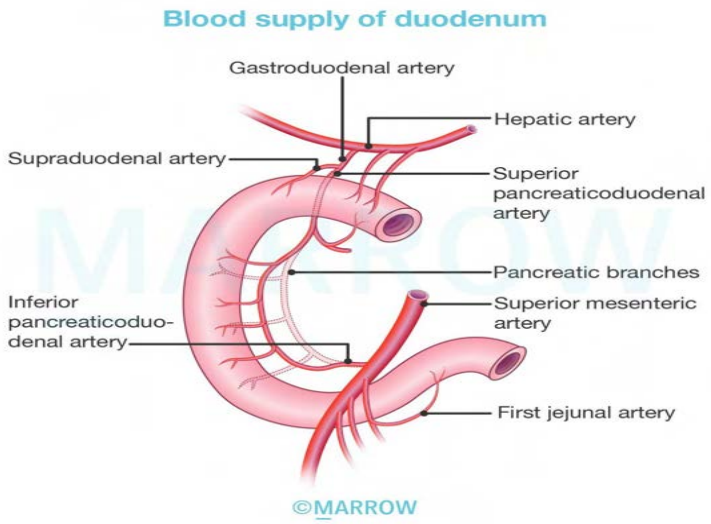

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Solution to Question 8:

The image shows plicae circulares which are also known as valvulae conniventes. They are more prominent in the jejunum.

Plicae circulares are the circular mucosal folds. They frequently branch and stack upon each other, giving the jejunum a characteristic feathery appearance in single contrast radiography.

Solution to Question 9:

Meckel's diverticulum projects from the antimesenteric border of the terminal ileum. It is commonly located 2 feet proximal to the ileocaecal valve.

Peyer's patches are lymphoid aggregates present in the submucosa and are arranged longitudinally along the antimesenteric border of ileum.

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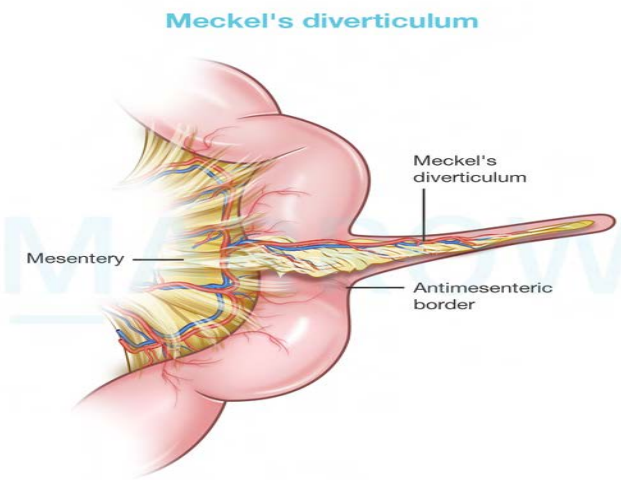

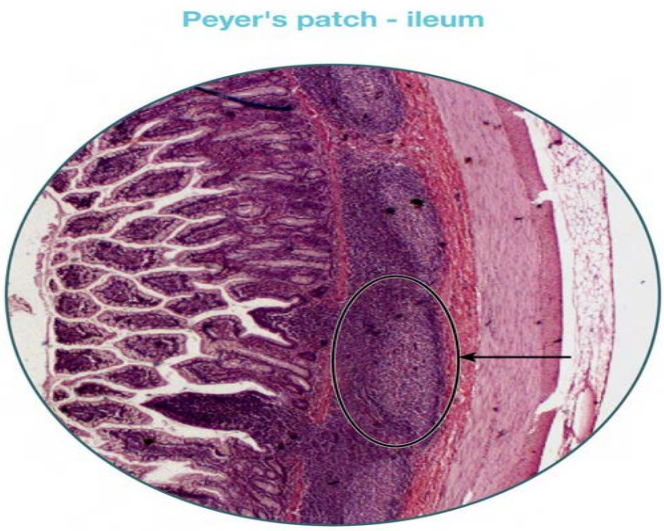

Solution to Question 10:

The transverse colon is the longest part of the large intestine, measuring 50 cm in length on an average. It is intraperitoneal in location and suspended by the transverse mesocolon.

Lengths of various parts of the large intestine are as follows:

Intestinal segment	Approximate length
Caecum	6 cm
Ascending colon	15 to 20 cm
Transverse colon	50 cm

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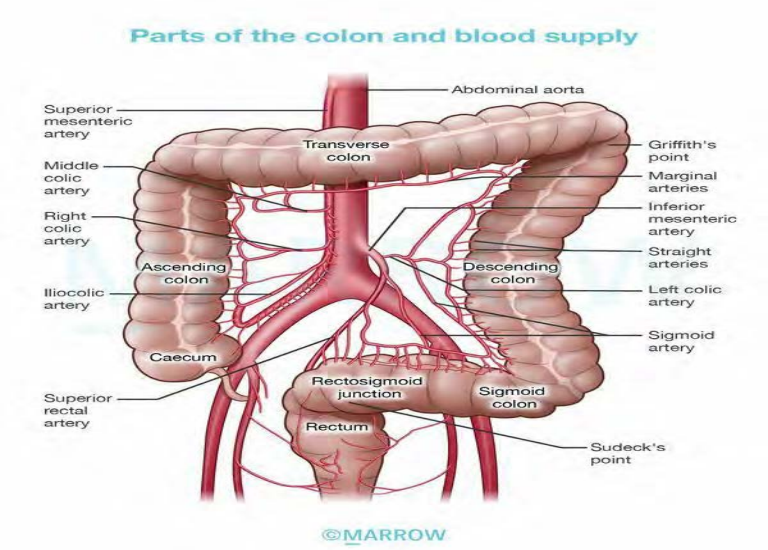
Intestinal segment	Approximate length
Descending colon	25 to 30 cm
Sigmoid colon	37.5 cm
Rectum	15 cm
Anal canal	2 to 5 cm



Solution to Question 11:

The structures marked in the image are appendices epiploicae and they are usually absent in the caecum.

Appendices epiploicae are small fat-filled peritoneal pouches scattered over the surface of the large intestine. They are very abundant on the surface of the sigmoid colon and tend to be absent from caecum, rectum, and appendix.

The below image shows the appendices epiploicae.

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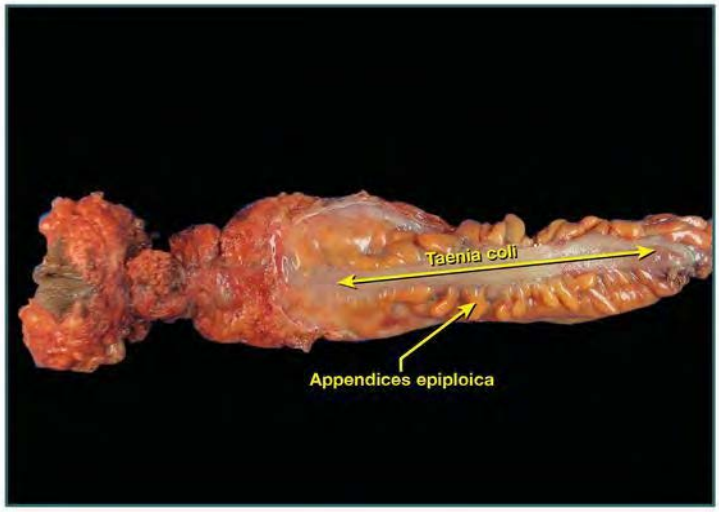

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Solution to Question 12:

The middle and left colic arteries contribute to the formation of the marginal artery of Drummond at the splenic flexure. The splenic flexure (Griffith's point) is a watershed area of the colon which is more prone to ischemia.

The anastomotic vessel that runs in the mesentery along the inner margin of the colon is called the marginal artery of Drummond. From this artery, numerous small branches are given to the large bowel. It is formed by:

- Branches of superior mesenteric artery - middle colic, right colic, and ileocolic arteries
- Branches of inferior mesenteric artery - left colic, sigmoid, and superior rectal arteries

When ischemia occurs at Griffith's point, the blood supply in this region is augmented by another arterial loop called the inner arterial arc (of Riolan). This arc connects the main trunk of the middle colic artery with the ascending branch of the left colic artery.

Note: Sudeck's point is another watershed area present at the rectosigmoid junction. The sigmoid artery anastomoses with the superior rectal artery at this site.

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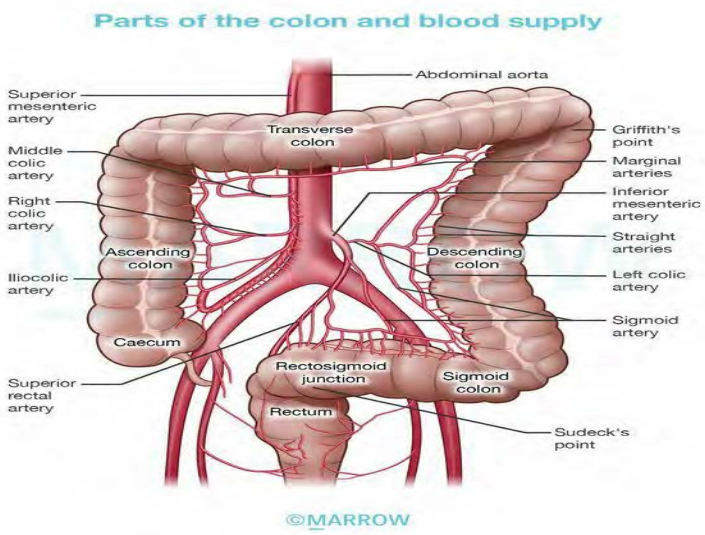

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Solution to Question 13:

The given clinical scenario points towards appendicitis and the most common position of the appendix is retrocaecal. This has been marked as position '2' in the image. This is because the appendix develops during the descent of the colon in embryonic life.

The base of the appendix is fixed and depending on the direction of the tip, the positions of the appendix are as follows:

- Retrocaecal
- Pelvic
- Paracolic
- Subcaecal
- Pre ileal
- Post ileal
- Promonteric

Clinical note:

- Ilio-psoas sign - Pain elicited on extension of the hip, seen in retrocaecal appendicitis.
- Obturator sign - Pain elicited on internal rotation of the hip, seen in pelvic appendicitis.

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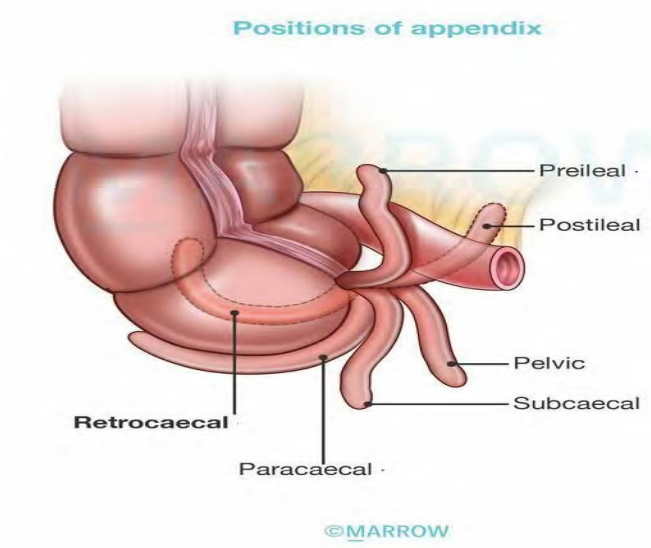

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Solution to Question 14:

The middle rectal artery is a content of the lateral rectal ligament.

The condensation of the endopelvic fascia that surrounds the middle rectal vessels is referred to as the lateral rectal ligament. Branches of the inferior hypogastric plexus also enter the rectum through this ligament.

Blood supply of the rectum:

Artery	Branch of	Location	Parts supplied
Superior rectal artery	Inferior mesenteric artery	Mesorectum	Upper two-thirds of the rect um
Middle rectal artery	Anterior division of the inter nal iliac artery or inferior ve sical artery	Lateral rectal ligament	Middle third of the rectum
Inferior rectal artery	Internal pudendal artery	Ischio-rectal fossa	Distal third of the rectumAn al canal with internal and ex ternal anal sphinctersPerian al skin

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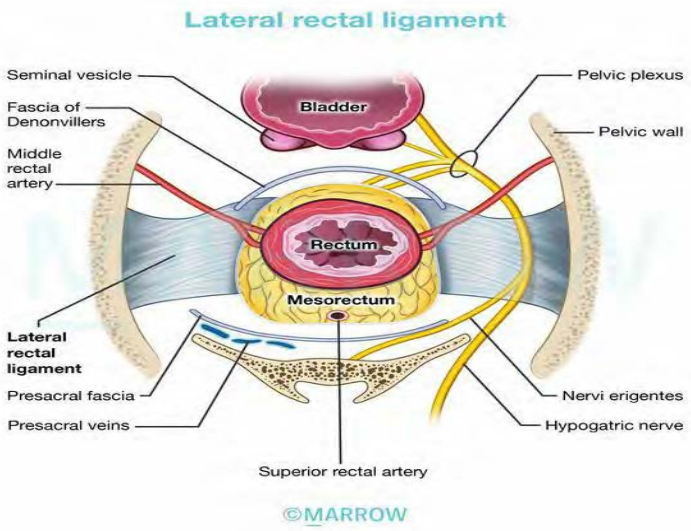

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Solution to Question 15:

The external anal sphincter is made up of striated muscle fibres. It is not a continuation of the outer longitudinal muscle of the rectum

The external anal sphincter is made up of two parts - upper(deep) and lower (subcutaneous or superficial). The pudendal nerve innervates the external anal sphincter and it is under voluntary control.

Muscles of the anal canal:

• External anal sphincter

• Internal anal sphincter: It is the terminal thickened part of the inner circular muscle of the large intestine. It extends from the anorectal junction to the anal verge. It is innervated by the autonomic nervous system: parasympathetic - relaxation; sympathetic - contraction.

• Conjoint longitudinal muscle: It lies between the internal anal sphincter and the external anal sphincter. It is the continuation of the outer longitudinal muscle of the rectum. The muscle fibres distally fan out and traverse the internal and external anal sphincter. It has a protective effect on haemorrhoids. This muscle degenerates as age advances.

• Treitz's muscle: It is the submucosal muscle of the anal canal. It is attached to the conjoint longitudinal muscle by the Park's ligament. It maintains the integrity of the anal cushions and plays an important role in preventing haemorrhoids.

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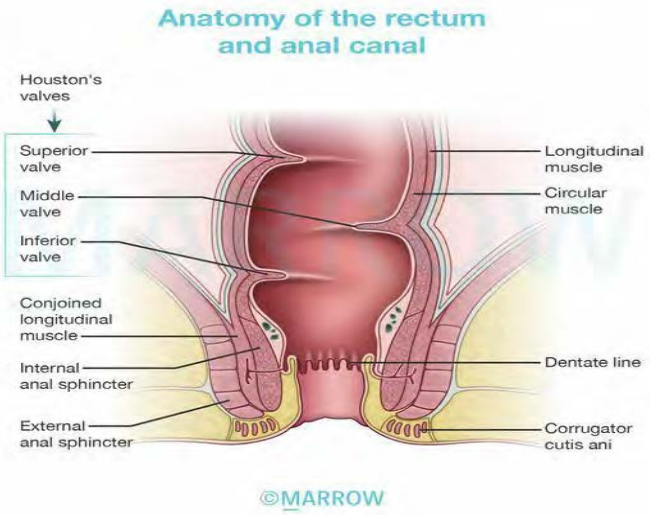
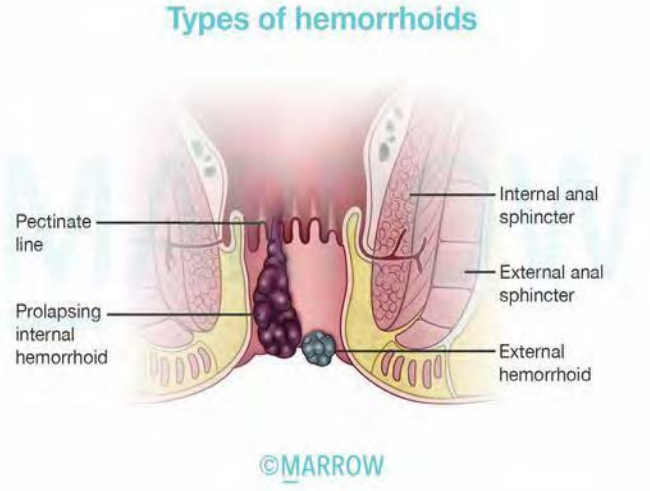


Solution to Question 16:

The nerve mediating pain in external haemorrhoids is pudendal nerve S2, 3, and 4.

Differences between external and internal haemorrhoids:

External haemorrhoids	Internal haemorrhoids
Located distal to the dentate line	Located proximalto the denta te line
Innervated by the inferior rec tal branch of pudendal nerve S2, 3, and 4 (somatic nerve)	Innervated by parasympathet ic fibres S2, 3, and 4, and sy mpathetic fibres L1 and 2
Pain sensitive	Pain insensitive



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Solution to Question 17:

Three transverse mucosal folds (also known as Houston's valves) are commonly present in the rectum.

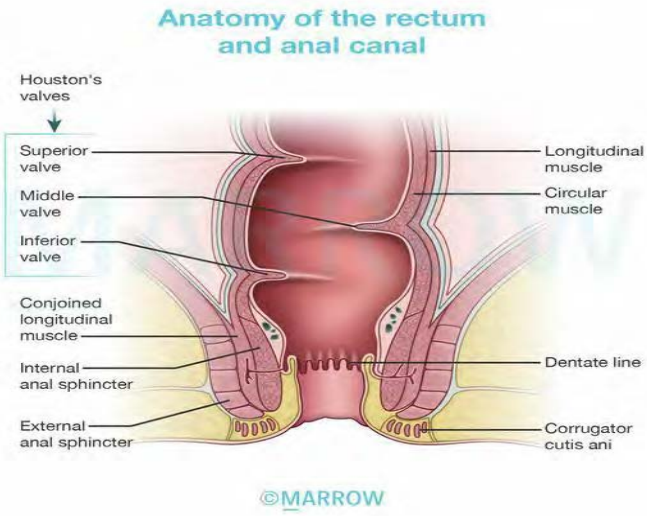
The transverse mucosal folds are permanent and become very prominent on distension of the rectum.

• The superior transverse fold - present at either side of the beginning of the rectum and may occasionally encircle the entire lumen.

• The middle transverse fold - largest and constant fold present above the rectal ampulla. It projects from the anterior and right wall of the rectum.

• The inferior transverse fold - most variable and found on the left side.

Apart from these, the rectal mucosa has several longitudinal folds, which disappear on distension of the rectum.



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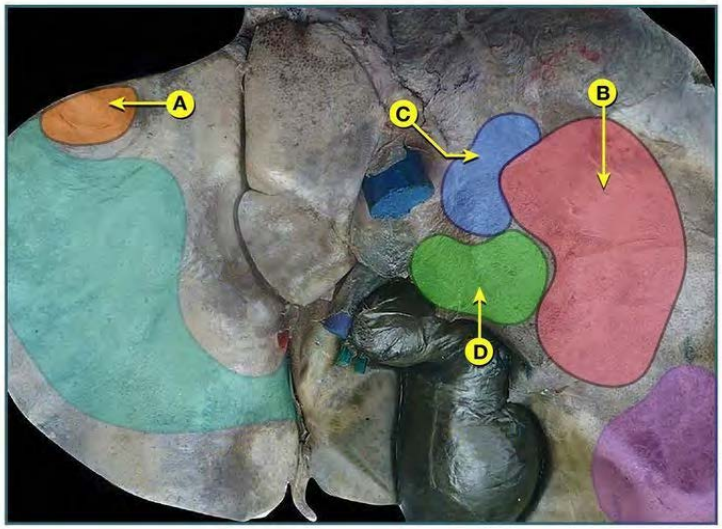
Hepatobiliary system, Spleen & Pancreas

Question 1:

Which of the following is related to the area marked 'A' on the posterior surface of the liver?



a) Aorta

b) Esophagus

c) Duodenum

d) Pylorus

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you may have
else,
d.

Question 2:

A 60-year-old man diagnosed with hepatocellular carcinoma underwent resection of Couinaud's segments II, III, and IV. What is the basis for the division of these segments?

a) Hepatic artery

b) Portal vein

c) Bile ducts

d) Hepatic vein

Question 3:

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Cholecysto-vena caval line separates which of the following?

a) Gallbladder and inferior vena cava

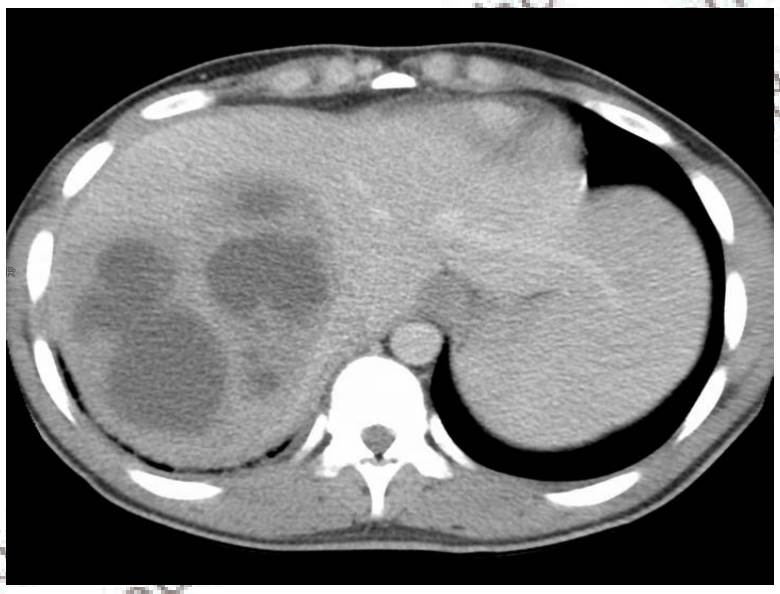
b) Porta hepatis and inferior vena cava

c) Caudate lobe and quadrangular lobe

d) Right and left lobe of liver

Question 4:

The CT abdomen of a patient shows a large abscess in the right part of the liver. Which of the following Couinaud's segments are involved here?



a) V, VI, VII, VIII

b) V, VI, VII

c) IV, V, VI, VII, VIII

d) VI, VII, VIII

Question 5:

Which of the cells marked in the image stores vitamin A in the liver?

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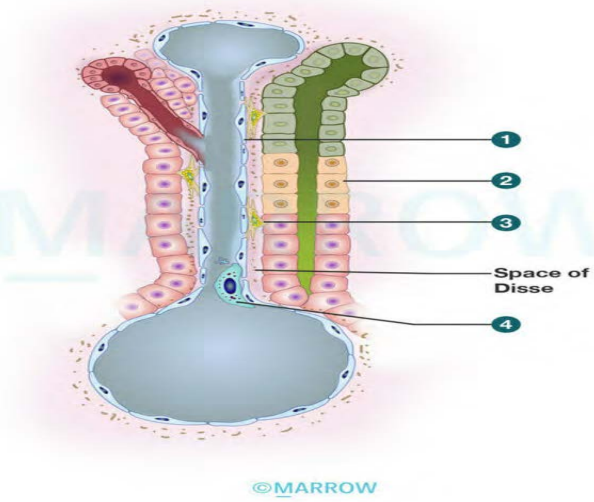

a) 1

b) 2

c) 3

d) 4

Question 6:

Which of the following statements is false regarding the liver?

a) Quadrate lobe is drained by the left hepatic duct

b) Pringle manoeuvre refers to compressing the hepatic pedicle in the free edge of lesser omentum

c) 80% of blood supply is via portal vein

d) Segment IV corresponds to caudate lobe of Liver

Question 7:

The CT abdomen of a patient with Budd-Chiari syndrome shows enlargement of the structure marked X in the image. Identify the structure.

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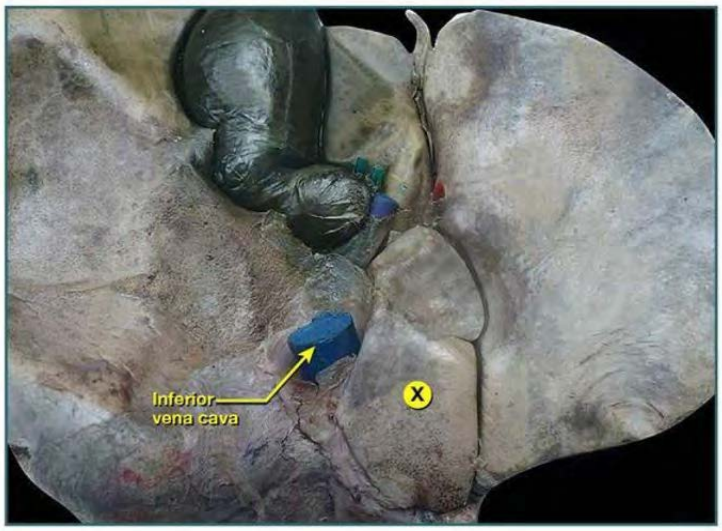

a) Quadrate lobe

b) Caudate lobe

c) Middle lobe

d) Left lobe

Question 8:

A 53-year-old man presented with hematemesis and ascites. Investigations revealed the presence of a tumor at the porta hepatis causing portal hypertension. Which of the following structures is least likely to be involved by the tumor?

a) Hepatic artery

b) Hepatic nervous plexus

c) Hepatic veins

d) Hepatic bile ducts

Question 9:

Which of the following is referred to as Valoean sheath?

a) Fibrous sheath surrounding the gall bladder

b) Fibrous sheath surrounding the splenic vessels at hilum

c) Fibrous sheath surrounding hepatic artery, bile duct and portal vein in each liver segment

d) Fibrous sheath surrounding the pancreatic duct and CBD at the Ampulla of Vater

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Question 10:

Which of the following pouches is seen in the gallbladder?

a) Pouch of Douglas

b) Rathke's pouch

c) Morison's pouch

d) Hartmann's pouch

Question 11:

You are a surgery resident assisting in an open cholecystectomy procedure. The senior resident asks you to ligate the structure marked in the image. Which of the following structures is it a branch of?

a) Proper hepatic artery

b) Right hepatic artery

c) Superior mesenteric artery

d) Common hepatic artery

Question 12:

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A 50-year-old woman was undergoing cholangiography. However, during the procedure, there was difficulty in inserting the catheter through the cystic duct. Which of the following features of the cystic duct is likely to interfere with the passage of the catheter?

a) Presence of Moynihan's hump

b) Presence of anomalous hepatic duct

c) Spiral valves of Heister

d) Tortuosity of cystic duct

Question 13:

Boundaries of Calot triangle are formed by all except:

a) Common hepatic duct

b) Cystic duct

c) Cystic artery

d) Gall bladder

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Question 14:

A 35-year-old man was brought to the emergency department following a road traffic accident. On examination, tachycardia and hypotension were present. e-FAST examination revealed intra-abdominal hemorrhage and X-ray showed fractures of the 10th and 11th ribs on the left side. Which of the following organs is likely to be injured?

a) Pancreas

b) Spleen

c) Left Kidney

d) Liver

Question 15:

Which of the following is related to the area marked on the image of the visceral surface of the spleen?

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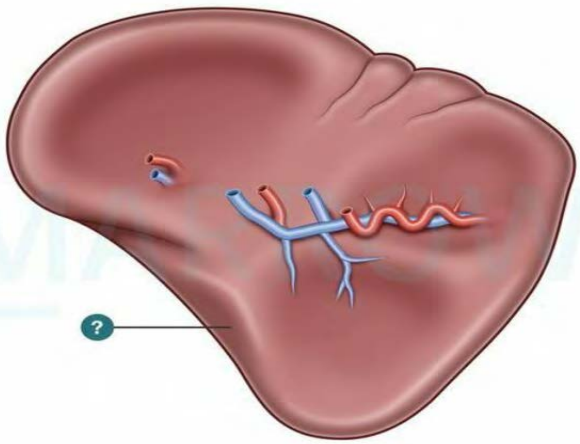

a) Stomach

b) Pancreas

c) Colon

d) Left kidney

Question 16:

A patient with hereditary spherocytosis is set to undergo a splenectomy. During the procedure, which of the following sites is the splenic artery ligated at?

a) Gastrosplenic ligament

b) Splenocolic ligament

c) Splenorenal ligament

d) Phrenicosplenic ligament

Question 17:

On examination of a patient with chronic myeloid leukemia, you find his spleen has enlarged towards the right iliac fossa. Which of the following structures prevents its displacement towards the left iliac fossa?

a) Linorenal ligament

b) Phrenicocolic ligament

c) Upper pole of the left kidney

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d) Gastrosplenic ligament

Question 18:

Which of the following structure is a carcinoma head of the pancreas likely to invade if it extends posteriorly?

a) Right renal vein

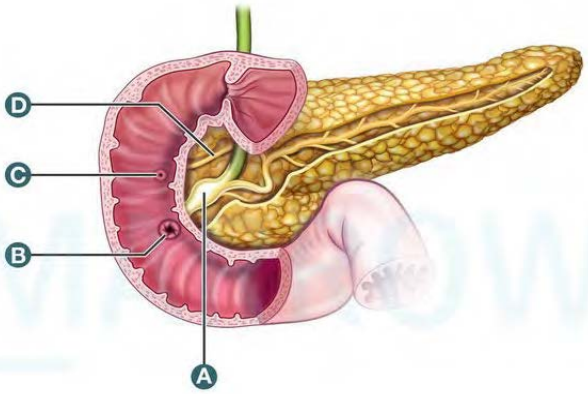
b) Transverse colon

c) Aorta

d) Lesser sac

Question 19:

Identify the Ampulla of Vater in the given image.



©MARROW

a) A

b) B

c) C

d) D

Question 20:

Which of the following parts of the pancreas is devoid of peritoneum?

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a) Tail of the pancreas

b) Entire pancreas

c) Anterior surface

d) Posterior surface

Question 21:

The arterial supply of the pancreas is mainly by branches of_____.

a) Coeliac trunk and splenic artery

b) Right gastric, splenic and right renal arteries

c) Common hepatic, gastroduodenal, and splenic artery

d) Coeliac trunk and superior mesenteric artery

Question 22:

A tumor of the uncinate process of the pancreas affects which of the following vessels?

a) Superior mesenteric artery

b) Portal vein

c) Common hepatic artery

d) Inferior mesenteric artery

Question 23:

Which among the following depicts a pancreas divisum?

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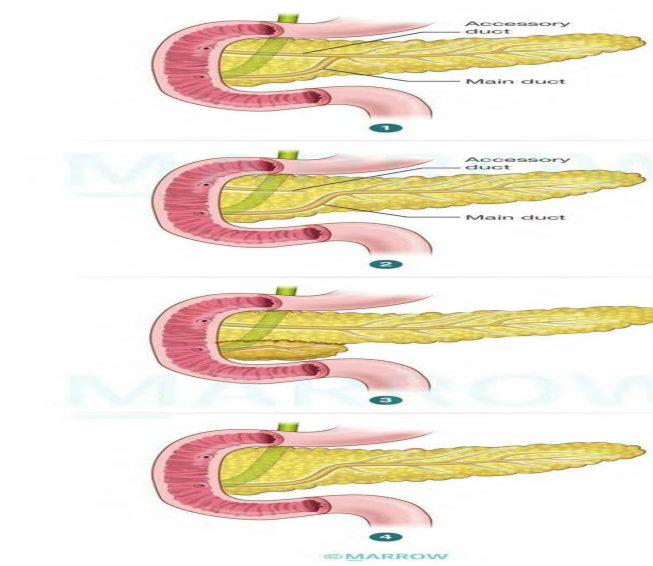

a) 1

b) 2

c) 3

d) 4

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Answer Key

Question No.	Correct Option
1	b
2	b
3	d
4	a
5	c
6	d
7	b
8	c
9	c
10	d
11	b
12	c
13	d
14	b

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15	d
16	c
17	b
18	a
19	a
20	d
21	d
22	a
23	c

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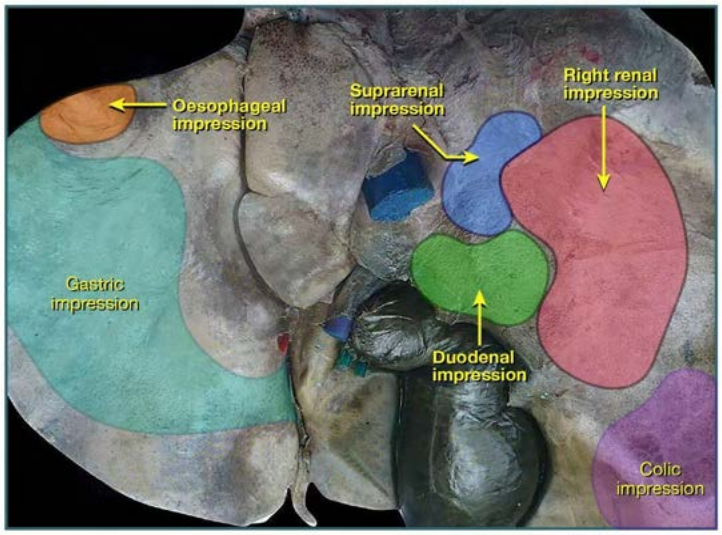
Detailed Explanations

Solution to Question 1:

The area marked 'A' on the posterior surface of the liver is related to the esophagus.

The image given below shows the relations of the posterior surface of the liver.



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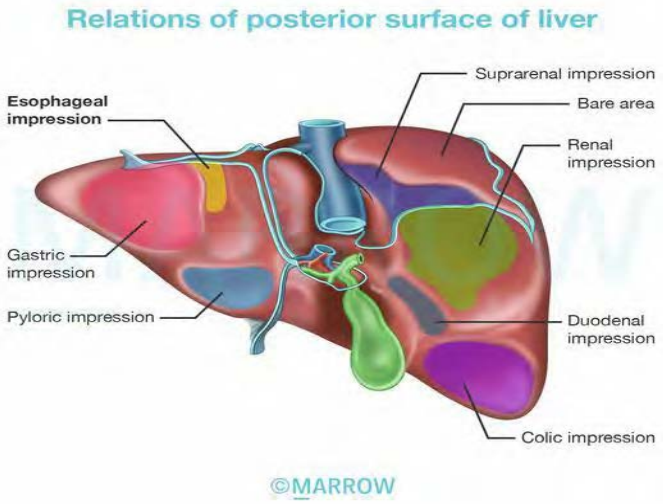

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Solution to Question 2:

Couinaud's segments are divided based on the distribution of the portal vein.

Veins of the liver:

• Portal vein- collects the blood from the gall bladder, pancreas, and spleen, and abdominal part of the alimentary tract. It transfers the blood collected from these organs to the liver.

• Hepatic vein- collects the de-oxygenated blood from the liver. It directly drains into the inferior vena cava and ultimately into the heart.

Note: Left hemihepatectomy involves the resection of segments II, III, and IV. Right hemihepatectomy involves the resection of segments V, VI, VII, and VIII.

Solution to Question 3:

Cholecysto-vena caval line (Cantlie line) separates right and left lobe of the liver.

Cantlie line is an imaginary line that that divides the liver into 2 planes. It extends from the midpoint of the gallbladder fossa at the inferior margin of the liver back to the midpoint of the inferior vena cava (IVC) and contains the middle hepatic vein.

Solution to Question 4:

The right part of the liver includes Couinaud's segments V, VI, VII, and VIII.

The given CT abdomen shows a large cystic lesion in the right lobe, presumed to occur due to appendicitis.

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Solution to Question 5:

Ito cells or hepatic stellate cells which are marked as 3 in the given histological image of the liver store vitamin A. They are present in the space of Disse and are mesenchymal in origin. These cells have 2 states:

• Dormant state- they are mostly dormant . They store the fat-soluble vitamin A in their lipid droplets and are a signi■cant source of growth factors involved in liver homeostasis and regeneration.

• Active state- they get activated as a result of liver injury and replace damaged hepatocytes with collagenous scar tissue leading to hepatic ■brosis. They secrete intralobular matrix components, including collagen type III (reticular) ■bres.

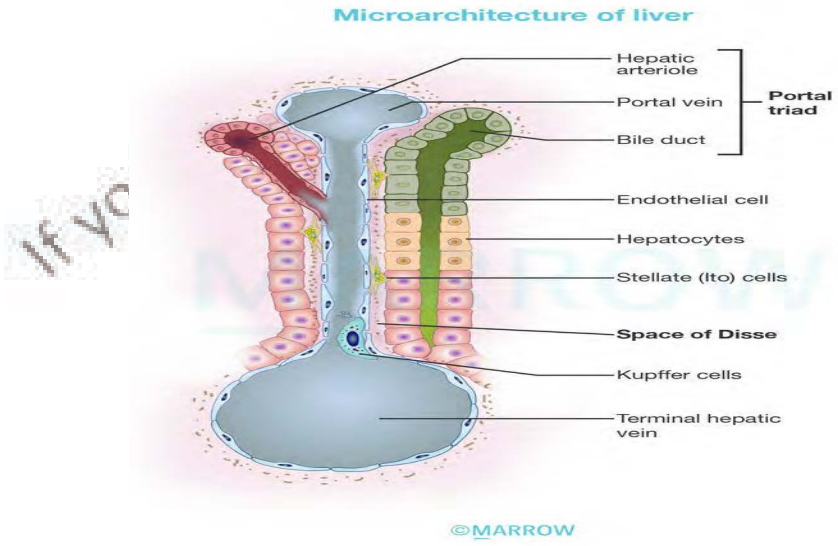
The space of Disse is the area between a hepatocyte and a sinusoid. Other than Ito cells, it also contains:

• Interstitial fluid

• Microvilli of adjacent hepatocytes

• Fine collagen fibers (mostly type III)

Lymph produced in the liver drains via the perisinusoidal space of Disse and periportal clefts of Mall to larger lymphatics.



Solution to Question 6:

Segment IV (left medial sector) corresponds to the quadrate lobe and not the caudate lobe (segment I). It is a part of the physiological left lobe of liver (segments II, III, and IV) and is drained by the left hepatic duct.

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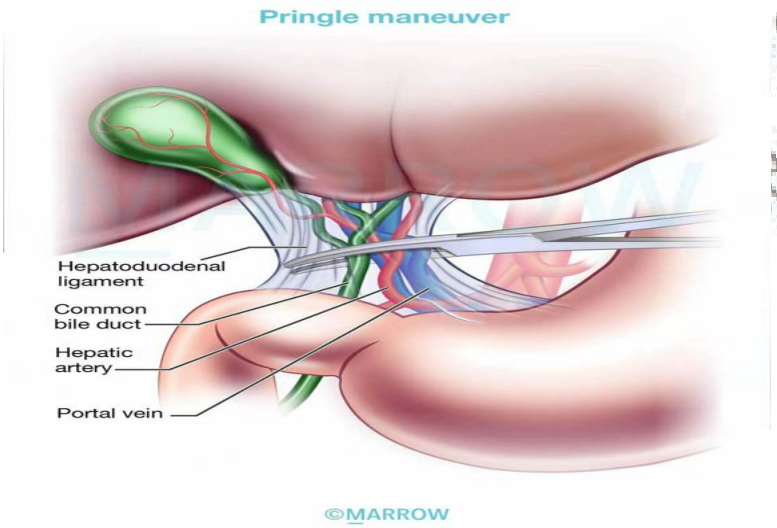
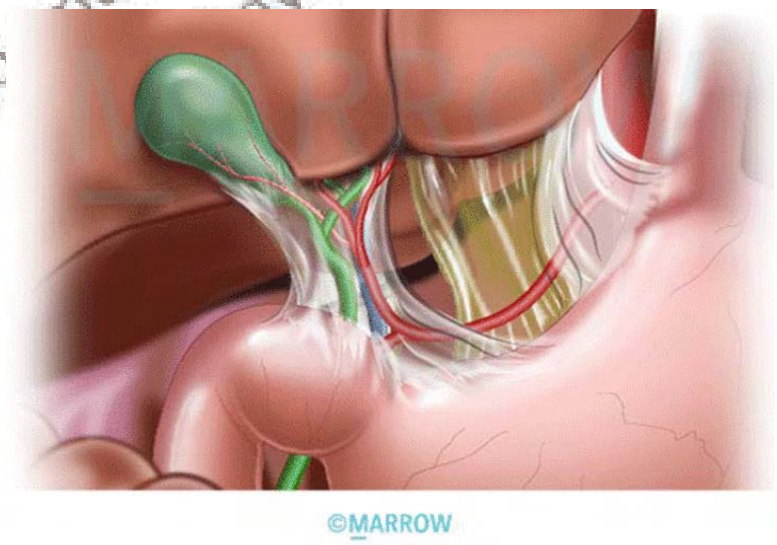
The physiological left lobe is supplied by the left hepatic artery and left branch of the portal vein. The physiological right lobe of the liver (segments V, VI, VII, and VIII) is drained by the right hepatic duct, and supplied by the right hepatic artery and right branch of the portal vein.

80% of blood supply to the liver is through the portal vein whereas 20% is through the hepatic artery.

Pringle's maneuver is compressing the hepatic pedicle at the free edge of the lesser omentum. It is used for rapid control of hemorrhage from the vessels entering the porta hepatis (hepatic pedicle). This is conveniently done by dividing the lesser omentum immediately to the left of these structures and passing a tape around them through the epiploic foramen.

The below image shows the Pringle maneuver.





Solution to Question 7:

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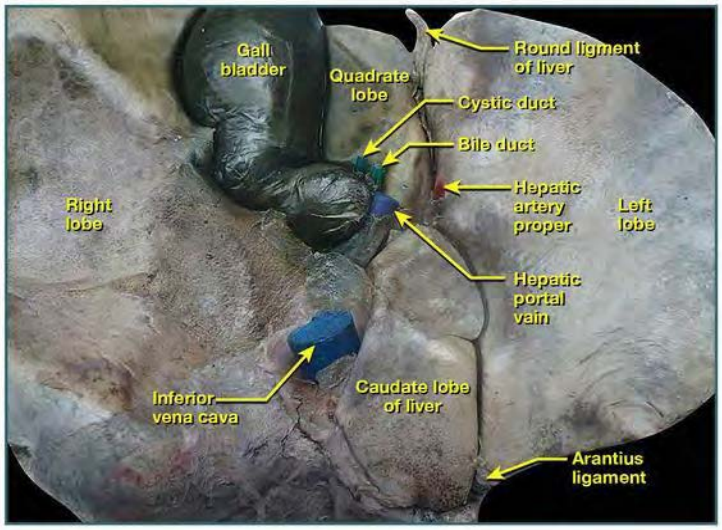
The area marked in the image is the caudate lobe of the liver. Caudate lobe hypertrophy is seen in Budd-Chiari syndrome.

This segment is unique in that it receives blood supply from both the right and left portal veins and hepatic arteries. It directly drains into the inferior vena cava.

It also forms the superior boundary of the epiploic foramen.

The image given below shows the posterior surface of the liver.



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Solution to Question 8:

Hepatic veins do not enter/exit the liver at the porta hepatis and are least likely to be involved by a tumor in that location.

Porta hepatis is a deep, transverse fissure that is situated on the inferior surface of the right lobe of the liver.

Structures entering at porta hepatis:

• Portal vein

• Hepatic artery

• Hepatic nervous plexus

Structures exiting the porta hepatis:

• Right and left hepatic bile ducts

• Lymphatics

The classical feature of portal hypertension are ascites, splenomegaly, esophageal varices and distended veins around the umblicus.

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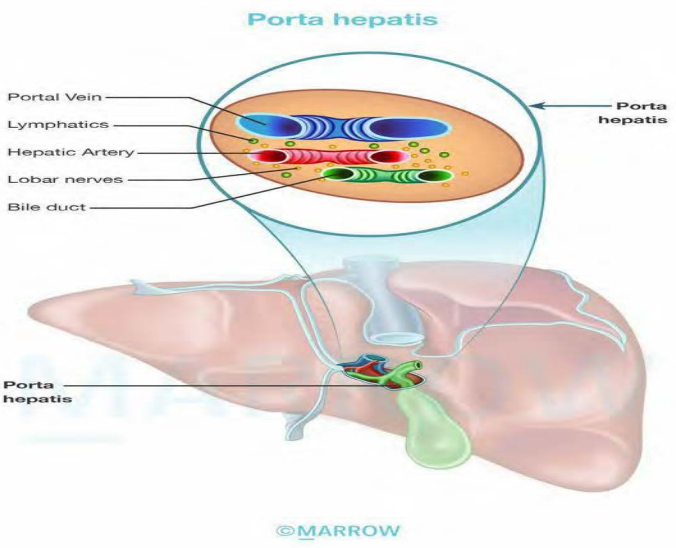
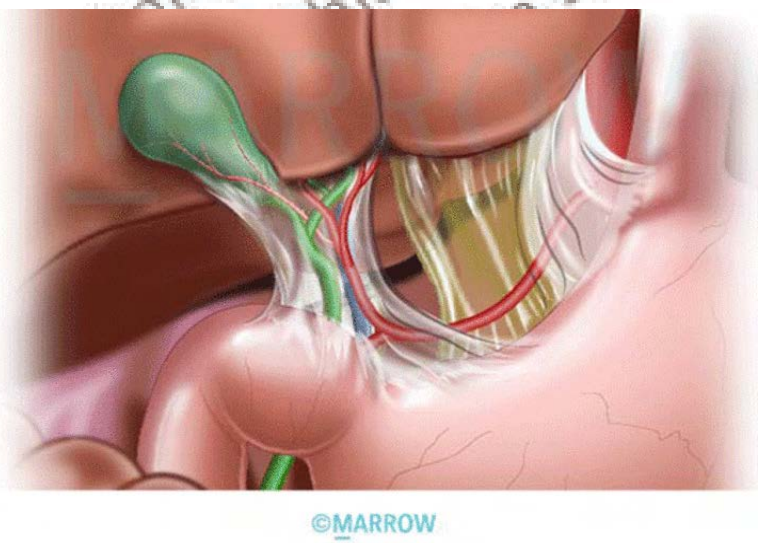


Clinical note:

Pringle maneuver- rapid control of hemorrhage from the vessels entering the porta hepatis can be obtained by compressing them in the free edge of the lesser omentum.

The below image shows Pringle maneuver.



Solution to Question 9:

The fibrous sheath surrounding the hepatic artery, bile duct, and portal vein in each liver segment is referred to as Valoean sheath.

This is an extension of the Glisson's capsule, which becomes condensed as a sheath around the branches of the portal triad structures as they enter the liver parenchyma. This arrangement of sheaths facilitates surgical control of the right and left vasculo-biliary pedicles of the liver.

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Solution to Question 10:

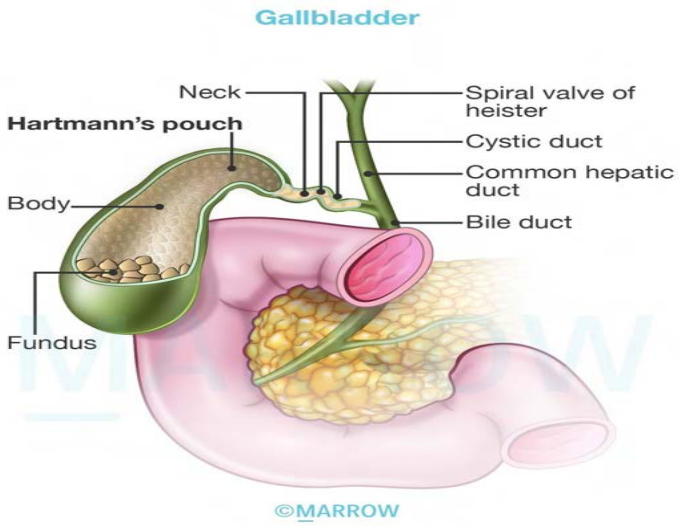
Hartmann's pouch is seen in the gallbladder.

Hartmann's pouch (infundibulum) is an outpouching at the junction of the neck of the gallbladder and the cystic duct. Although it is frequently seen, it is not a constant feature of the gallbladder. It serves as a potential space for the gallstones to get lodged.

Option A: Pouch of Douglas or recto-uterine pouch is the most dependent part of the abdomen in the erect position in females.

Option B: Rathke's pouch is an ectodermal outpouching from the developing pharynx that gives rise to the anterior pituitary.

Option C: Morison's pouch or hepatorenal pouch is the most dependent part of the abdomen in the supine position and pathological fluid may collect here.



Solution to Question 11:

The marked structure in the image is the cystic artery. It is a branch of the right hepatic artery.

The cystic artery is the main source of blood supply to the biliary system. After originating from the right hepatic artery, it passes posterior to the common hepatic duct and superior to the cystic duct at the hepatobiliary triangle. On reaching the superior aspect of the neck of the gallbladder, it divides into a superficial branch and a deep branch.

The images given below show the cystic artery.

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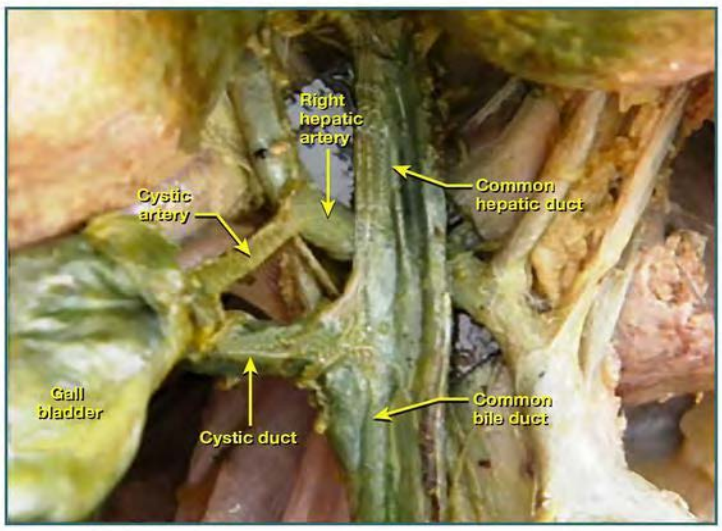

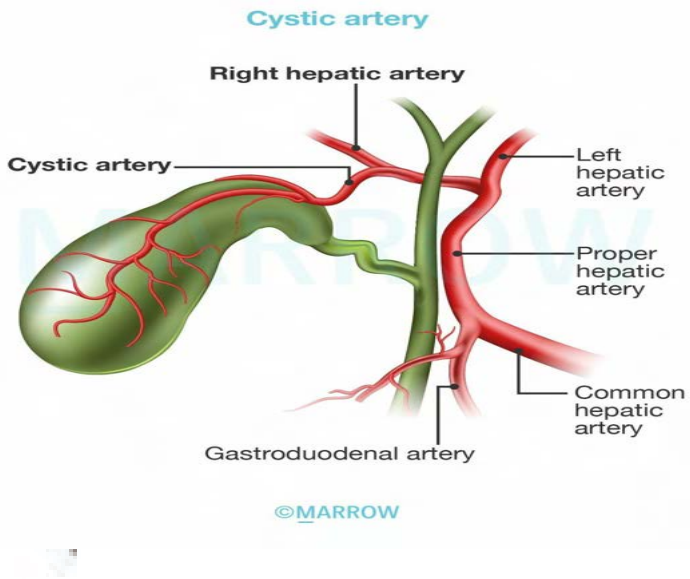

Solution to Question 12:

Spiral valves of Heister are the mucosal folds present in the cystic duct. In most cases, they are responsible for causing difficulty in the passage of catheter through the cystic duct.

The mucosa of the cystic duct forms 2–10 crescentic folds which are spirally arranged to form the spiral valve of Heister, also called spiral folds. These are continuous with those in the neck of the gallbladder. The function of these spiral folds is unknown but they may help to preserve the patency of this narrow, tortuous duct.

The cystic duct drains the gallbladder into the common hepatic duct. It unites with the common hepatic duct to form the common bile duct.

Note: Tortuous course of the right hepatic artery, also known as Moynihan's hump or caterpillar hump, is a rare but important anomaly to be recognized to prevent intraoperative vascular

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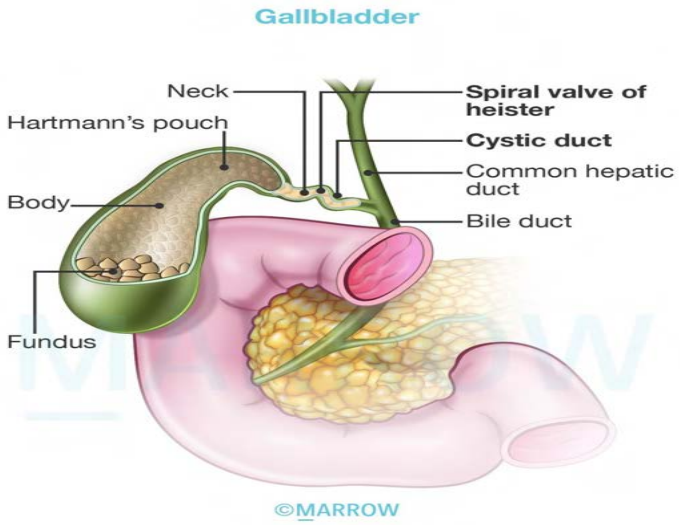
and biliary injuries during surgical procedures involving the liver and biliary apparatus.



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Solution to Question 13:

The gall bladder does not form a boundary of the Calot's triangle.

Calot's triangle is bounded by 3C's:

- Medially – Common hepatic duct
- Inferiorly – Cystic duct
- Superior – Cystic artery

Solution to Question 14:

The given clinical scenario is suggestive of injury to the spleen.

The spleen is a wedge-shaped organ and extends from the 10th rib to the 12th rib in the left hypochondrium. It lies along the long axis of the 11th rib and is likely to be injured in blunt trauma to the abdomen. Laceration of the spleen leads to profuse intra-abdominal bleeding and hypovolemic shock.

It is not palpable in a normal adult. For the spleen to be palpable, it has to become 3 times its normal size.

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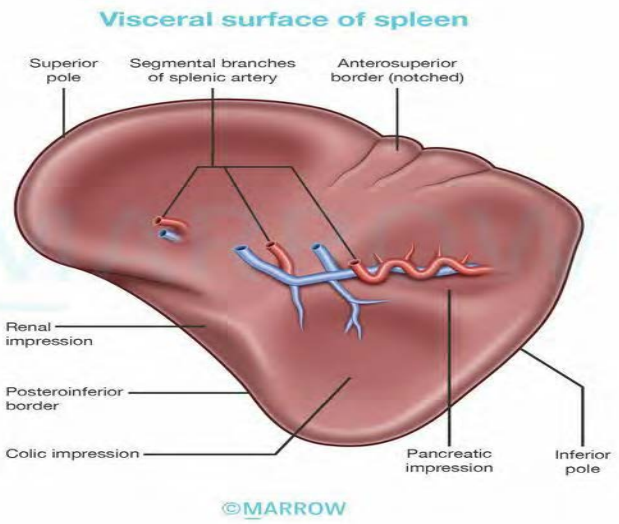

Note: Anatomical variations exist among human beings. Some sources mention that spleen is related to the 9th to 11th ribs; however, Gray's textbook of Anatomy, mentions it as the 10th to 12th ribs.

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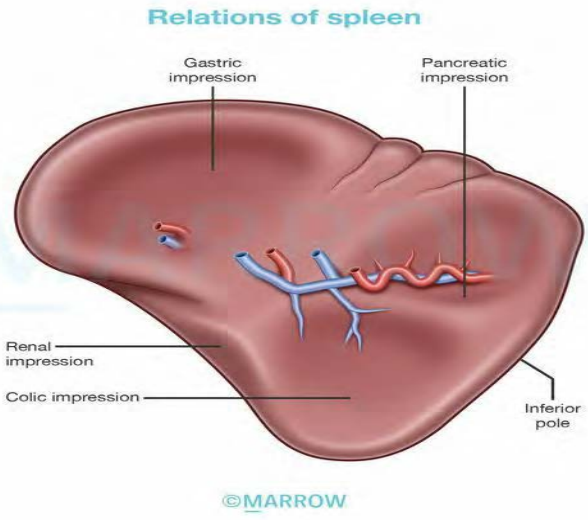
Solution to Question 15:

The area marked on the given image of the visceral surface of the spleen is related to the left kidney.

The various anatomical relations of the visceral surface of the spleen are shown below.



Solution to Question 16:

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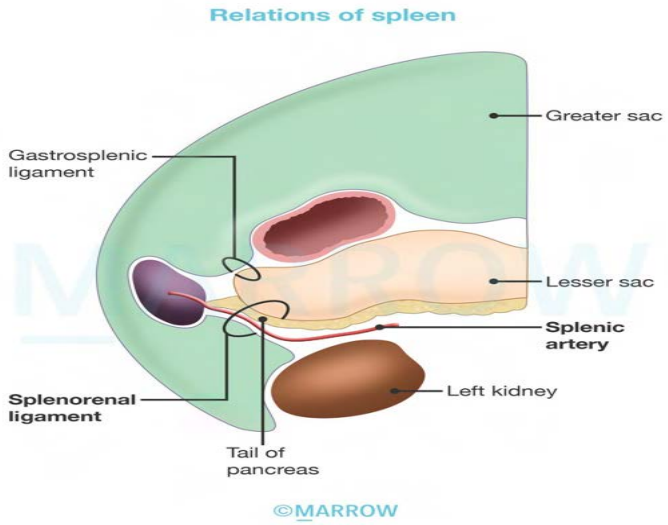
The splenorenal ligament contains the splenic artery. So during splenectomy, it is ligated at the splenorenal ligament.



Splenic ligament	Attachments	Contents
Gastrosplenic ligament	Greater curvature of the stomach to the upper pole of the spleen	Short gastric vesselsLeft gastroepiploic vessels
Phrenicosplenic ligament	Posterior abdominal wall to the upper pole of the spleen	-
Splenorenal(lienorenal) ligament	Hilum of the spleen to the anterior surface of the left kidney	Tail of pancreasSplenic arteryand vein
Phrenicocolic ligament	Diaphragm to the splenic flexure of the colon	-

Solution to Question 17:

The downward displacement of the spleen towards the left iliac fossa is prevented due to the presence of the phrenicocolic ligament. So the spleen usually enlarges towards the right iliac fossa.

The phrenicocolic ligament connects the splenic flexure of the colon to the diaphragm. It is not attached to the spleen. However, it lies below the spleen and supports its lower pole. When the spleen gets enlarged, the phrenicocolic ligament along with the splenic flexure of the colon restricts its downward displacement.

The phrenicocolic ligament functions as a potential barrier to the spread of infection between the left paracolic gutter and the left subphrenic space.

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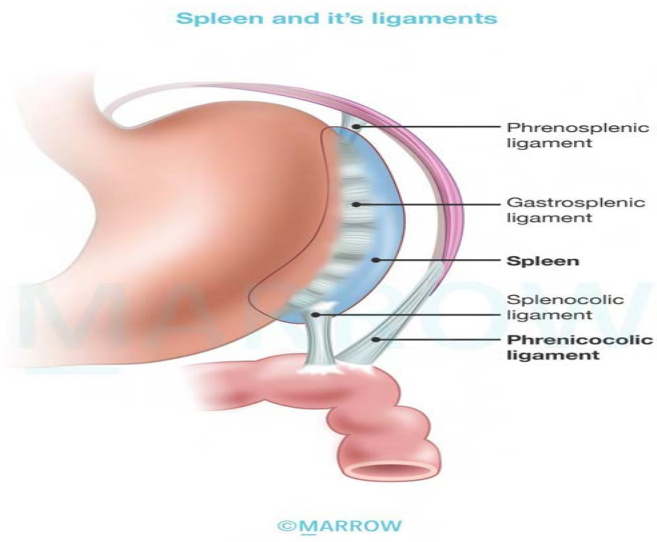

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Solution to Question 18:

The right renal vein forms the posterior relation of the head of the pancreas. So it is invaded by posterior expansion of the carcinoma of the head of the pancreas.

Relations of the head of the pancreas:

- Anterior:
- 1st part of the duodenum
- Origin of the transverse mesocolon
- Posterior:
- Right renal vein
- Right renal artery
- Inferior vena cava
- Common bile duct (which is embedded in the head)
- Right crus of the diaphragm
- Termination of the right gonadal vein

Relations of the neck of the pancreas:

- Anterior:
- Lesser sac
- pylorus
- The anterior superior pancreaticoduodenal branch of the gastroduodenal artery
- Posterior:
- Portal vein

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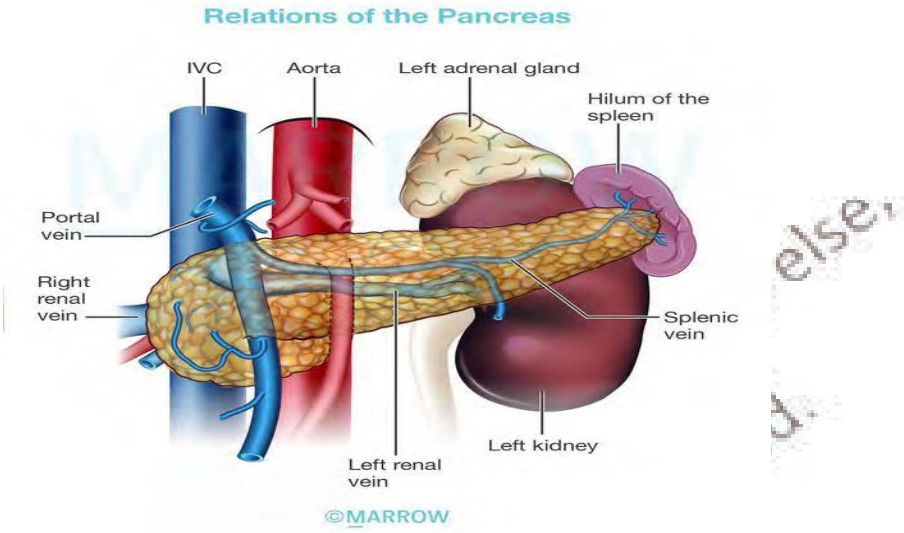
• Superior mesenteric vein

• Inferior mesenteric vein (in 1/3rd individuals)

Clinical note: Cancers arising from the head or neck of the pancreas are difficult to operate on due to the confluence of so many vessels near them. This also makes blood-borne spread faster.

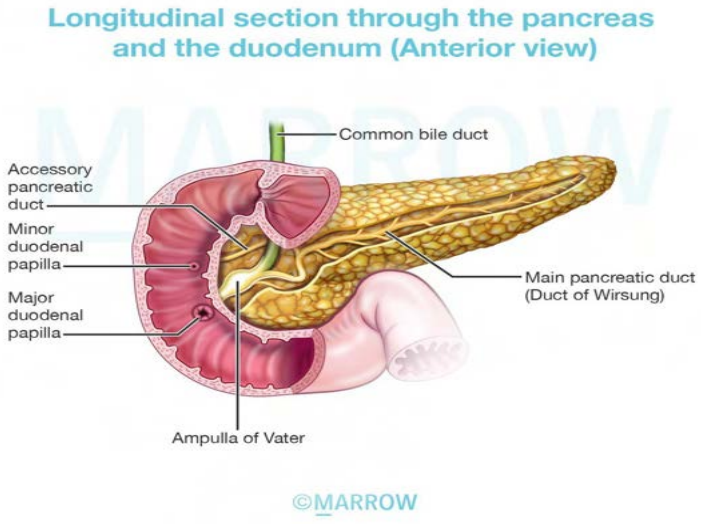


Solution to Question 19:

The structure marked A in the image is the ampulla of Vater.

The bile duct and the pancreatic duct unite to form the hepatopancreatic ampulla (ampulla of Vater) within the second part of the duodenum, which opens at the major duodenal papilla.

Sometimes an accessory pancreatic duct is present, and opens into the minor duodenal papilla. It is about 2 cm proximal to the major duodenal papilla in the second part of the duodenum.



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Clinical Note:

• Familial adenomatous polyposis [APC gene defect] is associated with carcinoma of the Ampulla of Vater.

• Duodenal villous adenomas are commonly found around the ampulla of Vater and they are premalignant.

• Duodenal injuries with tissue loss distal to the major duodenal papilla and proximal to the superior mesenteric vessels are best treated by Roux-en-Y duodenojejunostomy.

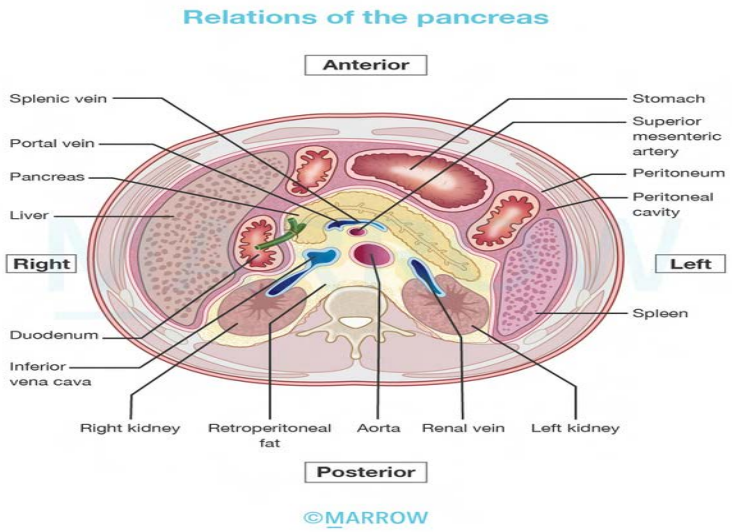
Solution to Question 20:

The entire posterior surface of the pancreas is devoid of the peritoneum.

The posterior surface of the pancreas lies over the fascia of Toldt in front of the aorta. The splenic vein traverses directly on this surface.

Only parts of the uncinate process (where the superior mesenteric vessels descend on it) are also devoid of the peritoneum. The entire anterior surface of the body is covered by peritoneum and the tail lies between the layers of the splenorenal ligament, which is formed from the peritoneum.

Note that the pancreas is a retroperitoneal organ(except for the tail), in that it is not enveloped with the peritoneum but the anterior surface is in contact with the peritoneum.



Solution to Question 21:

The arterial supply of the pancreas is mainly by branches of the coeliac trunk and the superior mesenteric artery.

Arterial supply of the pancreas:

• Head and uncinate process

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• Anterior and posterior superior pancreatoduodenal arteries [branches of the gastroduodenal artery, which is a branch of the celiac trunk]

• Anterior and posterior inferior pancreaticoduodenal arteries [branches of the inferior pancreaticoduodenal artery, which is a branch of the superior mesenteric artery]

• Body and tail [branches of the splenic artery, which is a branch of the celiac trunk]

• Dorsal pancreatic artery

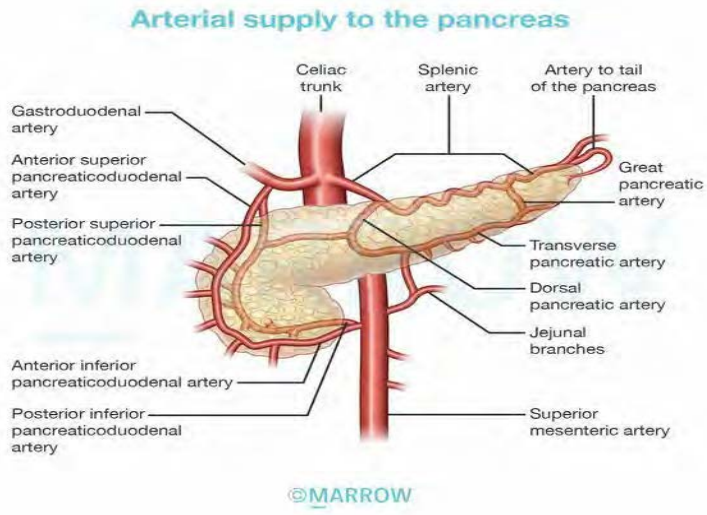
• Great pancreatic artery

• Artery to the tail of the pancreas

Options A and C: While all the given branches of the coeliac trunk do supply the pancreas, these options do not include branches from the superior mesenteric artery. So, option D is more complete and thus it is the better option.

Option B: Right gastric and right renal arteries do not supply the pancreas.

The image given below shows the blood supply of the pancreas.



Solution to Question 22:

A tumor of the uncinate process of pancreas affects the superior mesenteric artery.

The superior mesenteric artery arises from the abdominal aorta. It lies first behind the body of the pancreas and then in front of the uncinate process.

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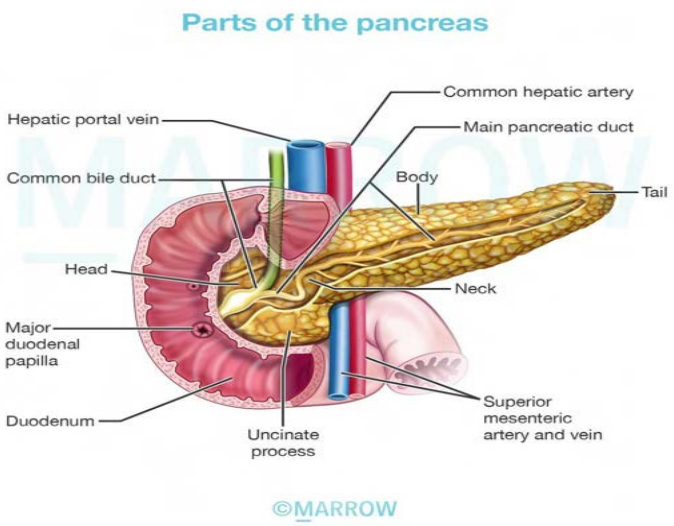

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Relations of the other parts of pancreas:

Head of pancreas:

- Anterior:
- 1st part of the duodenum
- Origin of the transverse mesocolon
- Posterior:
- Right renal vein
- Right renal artery
- Inferior vena cava
- Common bile duct (which is embedded in the head)
- Right crus of the diaphragm
- Termination of the right gonadal vein

Neck of the pancreas:

- Anterior:
- Lesser sac
- pylorus
- The anterior superior pancreaticoduodenal branch of the gastroduodenal artery
- Posterior:
- Portal vein
- Superior mesenteric vein
- Inferior mesenteric vein (in 1/3rd individuals)

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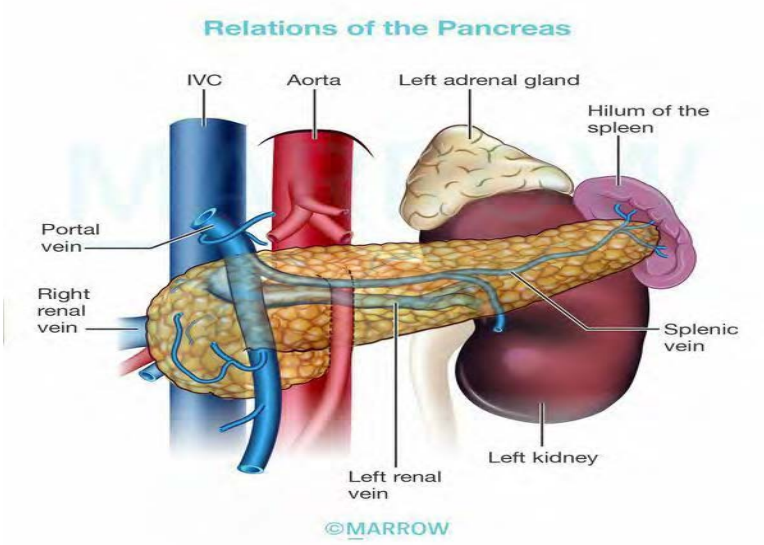

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Solution to Question 23:

Pancreas divisum has been depicted in the image marked 3.

The pancreas has two ducts which normally fuse during embryologic development:

• The accessory (dorsal) pancreatic duct (of Santorini) drains the upper part of the anterior portion of the pancreatic head.

• The main pancreatic duct (of Wirsung) usually runs within the substance of the gland from left to right.

When the ventral and dorsal ducts fail to fuse together, it results in pancreas divisum. In this condition, the majority of the pancreas drains via a dominant dorsal duct that enters the duodenum at the minor papilla. A short ventral duct, along with the bile duct, drains into the major duodenal papilla. Therefore, the major drainage of the pancreas is done by the dorsal duct which opens up into the minor papilla.

Patients with this condition are usually asymptomatic, however, 25-38% of these patients experience recurrent pancreatitis that may further progress to chronic pancreatitis.

Image A: Normal pancreatic ducts with communication between main and accessory ducts.

Image B: Normal pancreatic ducts and no communication between main and accessory ducts.

Image D: Absence of accessory pancreatic duct.

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KUB & Adrenal Gland

Question 1:

A patient with right flank pain and fever has renal angle tenderness on examination. Which of the following forms the boundaries of this angle?

a) Lower border of 11th rib and medial border of erector spinae

b) Lower border of 12th rib and medial border of erector spinae

c) Lower border of 11th rib and lateral border of erector spinae

d) Lower border of 12th rib and lateral border of erector spinae

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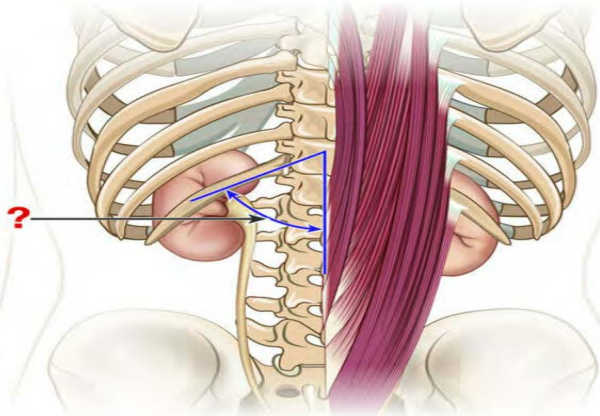
Question 2:

Identify the angle shown in the image below.



a) Renal angle

b) Costovertebral angle

c) Lumbar angle

d) Pyelovertebral angle

Question 3:

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Arrange the coverings of the kidney from within outwards:

a) 1 - 4 - 2 - 3

b) 1 - 3 - 2 - 4

c) 2 - 3 - 1 - 4

d) 2 - 4 - 1 - 3

Question 4:

Which of the following fascia attaches the perirenal fascia to the peritoneum?

a) Gerota's fascia

b) Lateroconal fascia

c) Thoracolumbar fascia

d) Treitz's fascia

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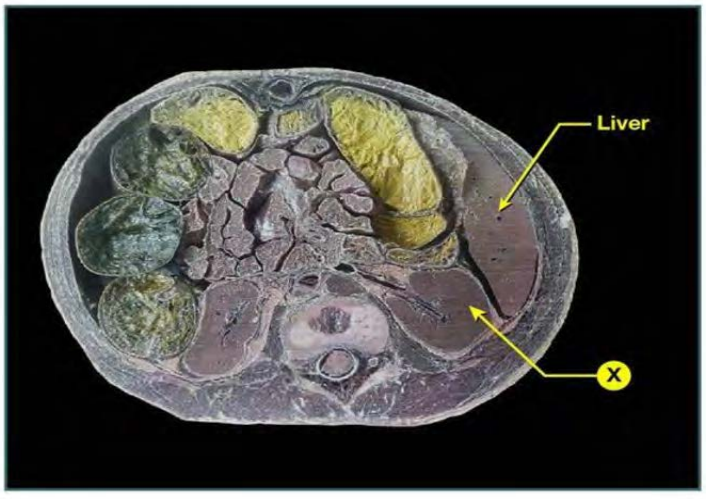
Question 5:

Which of the following structures does not form an anterior relationship with the marked structure?



a) Descending part of the duodenum

b) Pylorus of the stomach

c) Coils of small intestines

d) Adrenal gland

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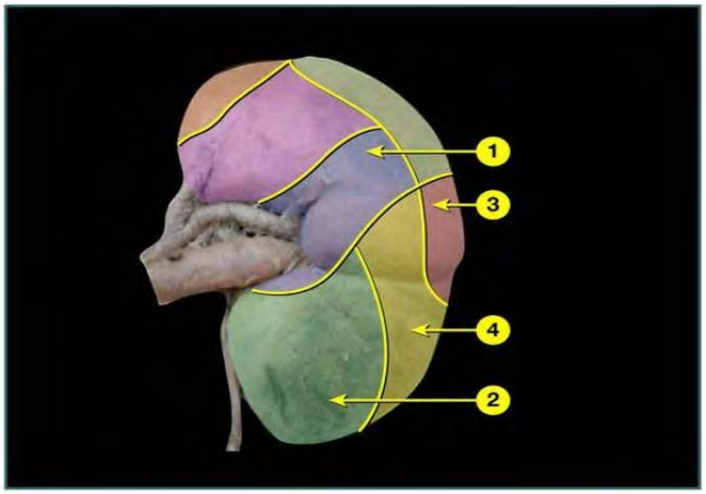
Question 6:

Which of the following areas of the left kidney is separated from its relation by a peritoneal layer?



a) 1

b) 2

c) 3

d) 4

Question 7:

Which of the following is related to the marked area in the image?

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else,

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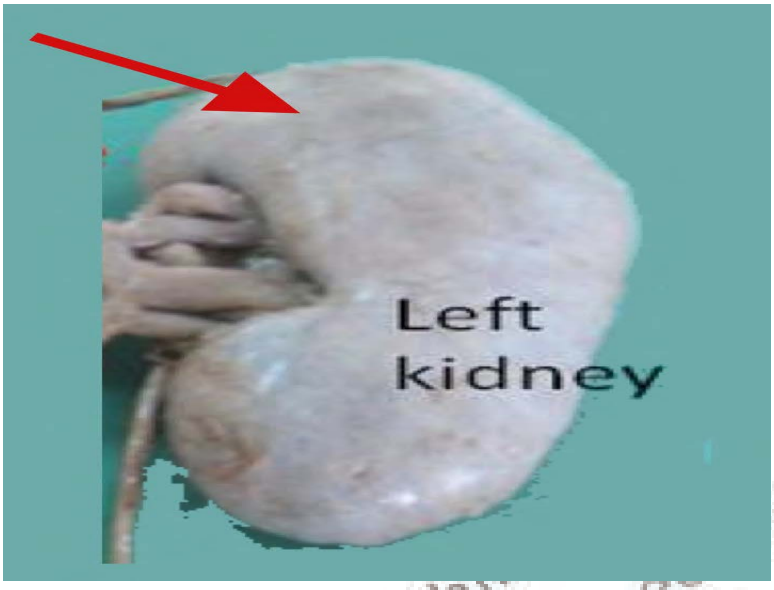

a) Stomach

b) Spleen

c) 2nd part of duodenum

d) Pancreas

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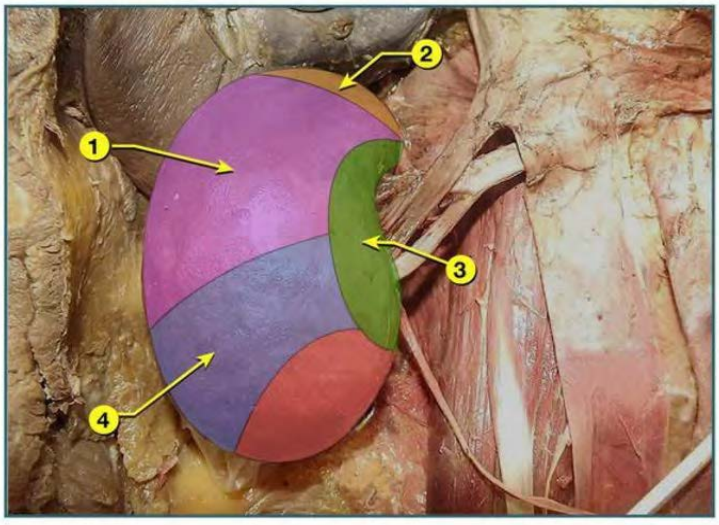
Question 8:

Which of the following areas of the anterior surface of the right kidney is separated by a layer of peritoneum?



a) 1

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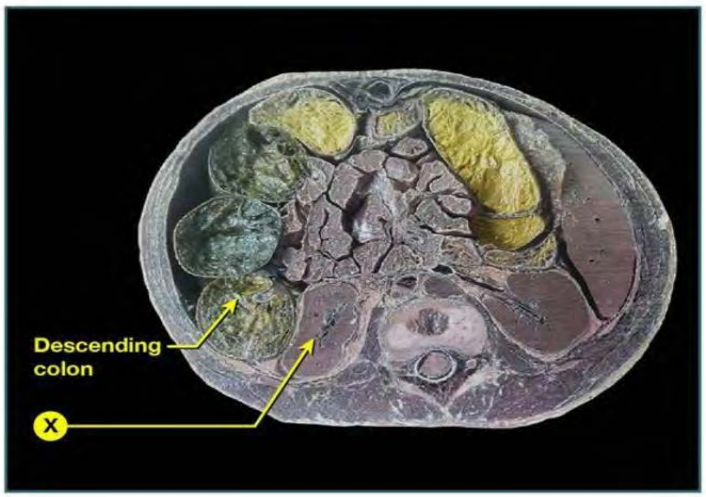
b) 2

c) 3

d) 4

Question 9:

Which of the following is not a posterior relation of the marked structure?



a) Psoas major

b) Medial arcuate ligament

c) Sympathetic chain

d) Ilioinguinal nerve

Question 10:

What is the correct arrangement of the structures in the marked area from anterior to posterior?

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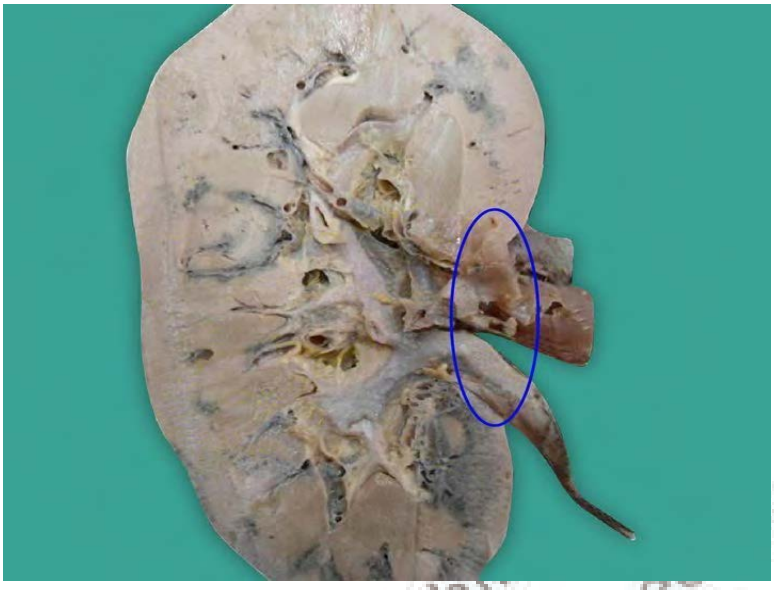

a) Renal artery, renal vein, renal pelvis

b) Renal vein, renal artery, renal pelvis

c) Renal pelvis, renal artery, renal vein

d) Renal vein, renal pelvis, renal artery

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Question 11:

What is the structure into which the renal papillae open?

a) Cortex

b) Pyramid

c) Minor calyces

d) Major calyces

Question 12:

Which of the following contributes to the nerve supply of the kidney?

a) Inferior hypogastric plexus

b) Coeliac plexus

c) Inferior mesenteric plexus

d) Superior hypogastric plexus

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Question 13:

A 20-year-old man presented with left flank pain, varicocele, hematuria, and headache. On examination, BP was 170/100 mm Hg. CT abdomen was done and a diagnosis of Nutcracker syndrome was made. What is the cause?

a) Compression of left renal vein between abdominal aorta and superior mesenteric artery

b) Compression of left renal vein between inferior vena cava and superior mesenteric vein

c) Compression of right renal vein between abdominal aorta and superior mesenteric artery

d) Compression of right renal vein between inferior vena cava and superior mesenteric vein

Question 14:

A 56-year-old male was brought to the emergency department with severe pain in the left flank region. CT-examination revealed occlusion of the left renal vein. The condition would impede the blood flow through all of the following veins except:

a) Left adrenal vein

b) Left testicular vein

c) Left diaphragmatic vein

d) Left subcostal vein

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Question 15:

Which of the following structures does not cross the midline?

a) Left gonadal vein

b) Left renal vein

c) Accessory hemiazygous vein

d) Root of the mesentery

Question 16:

A 42-year-old man presented with severe pain in the lower back radiating to the pubic symphysis. Ultrasonography revealed a stone in the left ureter, measuring 3 mm in size. The stone is most likely to be lodged in which of the following sites?

a) Pelvi-ureteric junction

b) At pelvic brim

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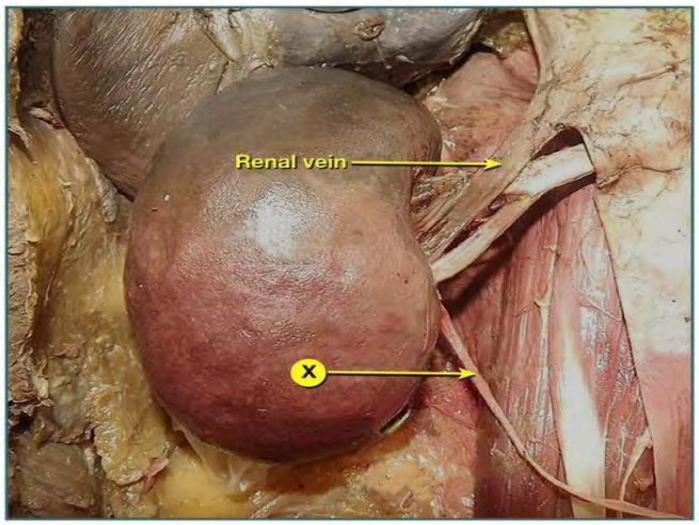
c) Vesicoureteric junction

d) At vas deferens

Question 17:

Which of the following structure is not a posterior relation of the structure marked as X?



a) Common iliac artery

b) Quadratus lumborum

c) Psoas major

d) Genitofemoral nerve

Question 18:

Which of the following arteries does not supply the ureters?

a) Uterine artery

b) Gonadal artery

c) Common Iliac artery

d) Superior mesenteric artery

Question 19:

Which of the following arteries does not supply the marked structure?

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a) Abdominal aorta

b) Gonadal artery

c) Inferior phrenic artery

d) Superior mesenteric artery

Question 20:

Where does the right main adrenal vein drain into?

a) Right renal vein

b) Inferior vena cava

c) Second right lumbar vein

d) Right gonadal vein

Question 21:

During the cystoscopic evaluation of a patient with hematuria, where will you find the Mercier's bar?

a) Between two ureteric orifices

b) Between uvula vesicae and ureteric orifice

c) Between verumontanum and ureteric orifice

d) Between internal and external urethral orifice

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Question 22:

Which of the following lobes of the prostate forms the uvula vesicae?

a) Anterior

b) Posterior

c) Median

d) Lateral

Question 23:

Where does the internal urethral orifice lie at birth?

a) At the level of the umblicus

b) At the level of the lower border of symphysis pubis

c) At the level of the perineal body

d) At the level of the upper border of symphysis pubis

Question 24:

Which of the following structures is innervated by the neurons present in Onuf's nucleus?

a) Detrusor muscle

b) Trigone

c) Internal urethral sphincter

d) External urethral sphincter

Question 25:

What is the number of arterial segments in the kidney?

a) 3

b) 4

c) 5

d) 6

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Answer Key

Question No.	Correct Option
1	d
2	b
3	d
4	b
5	b
6	b
7	a
8	a
9	c
10	b
11	c
12	b
13	a
14	d
15	a
16	c
17	b
18	d
19	d
20	b
21	a
22	c
23	d
24	d
25	c

Detailed Explanations

Solution to Question 1:

The given clinical scenario and the renal angle tenderness are suggestive of acute pyelonephritis. The renal angle is formed by the lower border of the 12th rib and the lateral border of the erector spinae.

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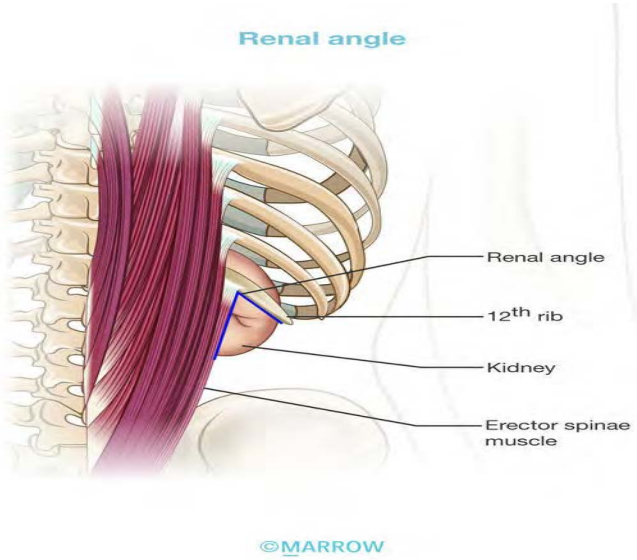
The lower pole of the kidney occupies this angle. Tenderness in this angle is usually suggestive of infection in and around the kidney or renal stones.



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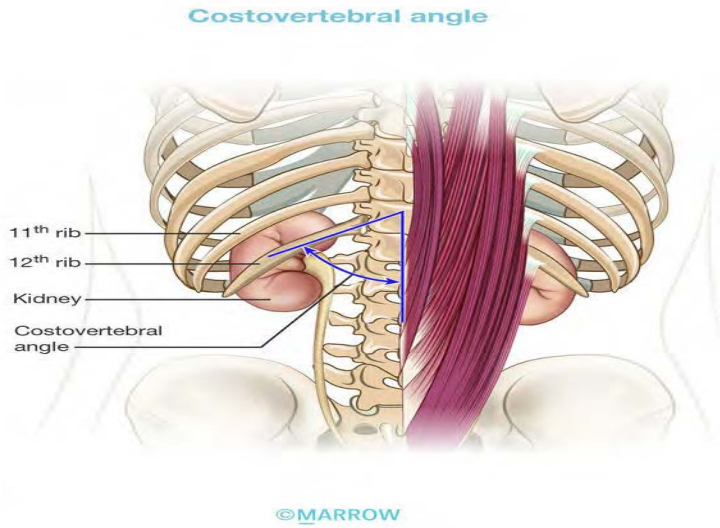
Solution to Question 2:

The angle shown in the image is the costovertebral angle, formed between the lower border of the 12th rib and the vertebral column.

Causes for pain/tenderness at the costovertebral angle include:

- Nephrolithiasis
- Pelviureteric junction obstruction
- Pyelonephritis
- Hemorrhagic fever with renal syndrome (HFRS) - caused by Hantavirus.



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Solution to Question 3:

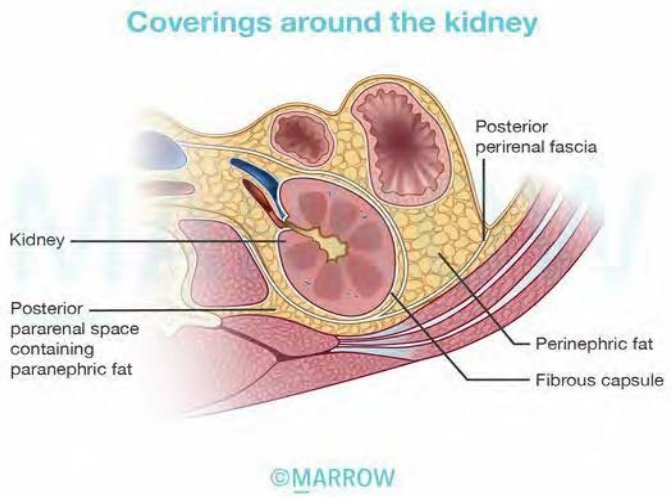
The 4 coverings of the kidney from within outwards are as follows:

• True or fibrous capsule - formed by the collagen-rich connective tissue.

• Perinephric fat or adipose capsule - consists of fat and occupies the space between the fibrous capsule and the renal fascia.

• Renal fascia

• Paranephric fat - occupies the space between the renal fascia and the anterior layer of the thoracolumbar fascia.



Solution to Question 4:

The lateroconal fascia attaches the perirenal fascia to the peritoneum. It extends from the lateral margin of perirenal fascia and attaches to the parietal peritoneum.

Option A: Gerota's fascia is the perirenal fascia. The kidney and the suprarenal gland are enclosed within anterior and posterior lamina of the perirenal fascia. The anterior lamina of the perirenal fascia blends with the connective tissue surrounding the great vessels behind the duodenum and pancreas. The posterior lamina continues as the lateroconal fascia.

Option C: Thoracolumbar fascia is a complex arrangement of multiple fascial layers in the thoracolumbar region. This fascia encloses the paraspinal muscles, quadratus lumborum muscle and the lattisimus dorsi muscle.

Option D: Treitz's fascia has been used to refer to the fusion fascia behind the head of pancreas.

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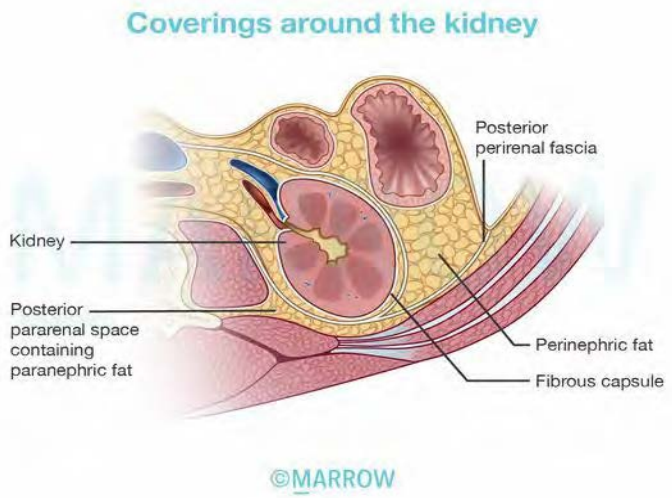

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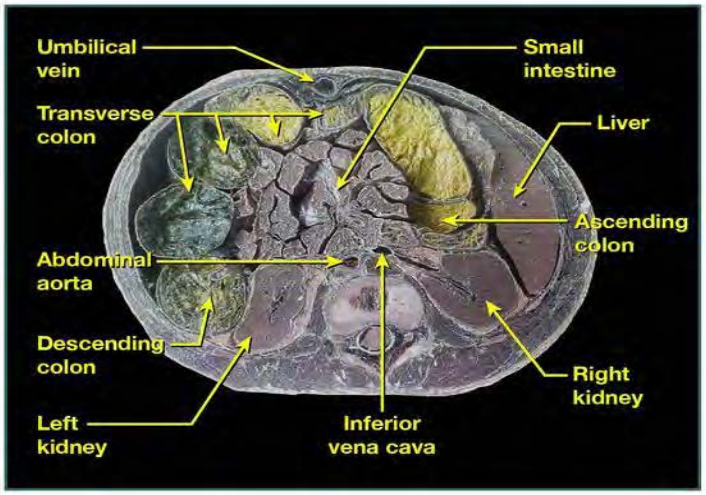
Solution to Question 5:

The marked structure in the image is the right kidney. The pylorus of the stomach is not related to the anterior surface of the right kidney.

The anterior relations of the right kidney:

The below image shows the cross-section of the abdomen at the level of kidney.

Intraperitoneal	Right lobe of liverSmall intestine
Retroperitoneal	Right suprarenal gland2ndpart of duoednumHepatic flexure of colon



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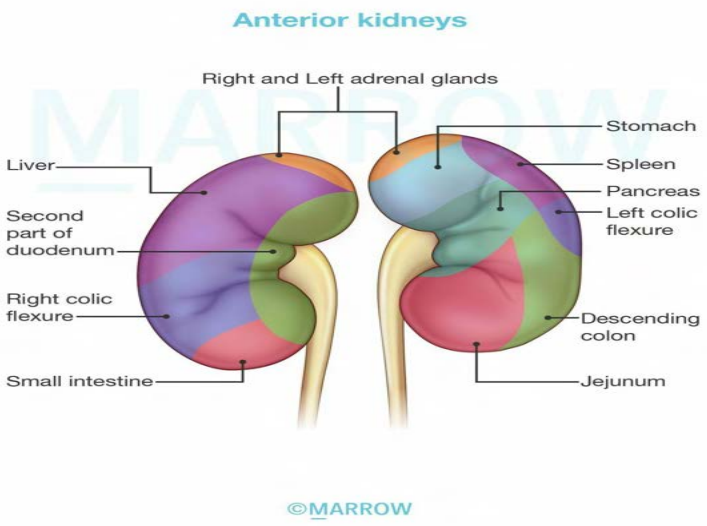

Solution to Question 6:

The anterior surface of the left kidney in relation with the jejunal loops (marked as 2) is separated from the structure by a peritoneal layer.

As the kidneys are located retroperitoneally, intraperitoneal anterior relations are separated from it by a peritoneal layer.

The anterior relations of the left kidney include:

Intraperitoneal	StomachJejunumSpleen
Retroperitoneal	Left suprarenal glandPancreasSplenic vesselsSplenic flexure and beginning of descending colon

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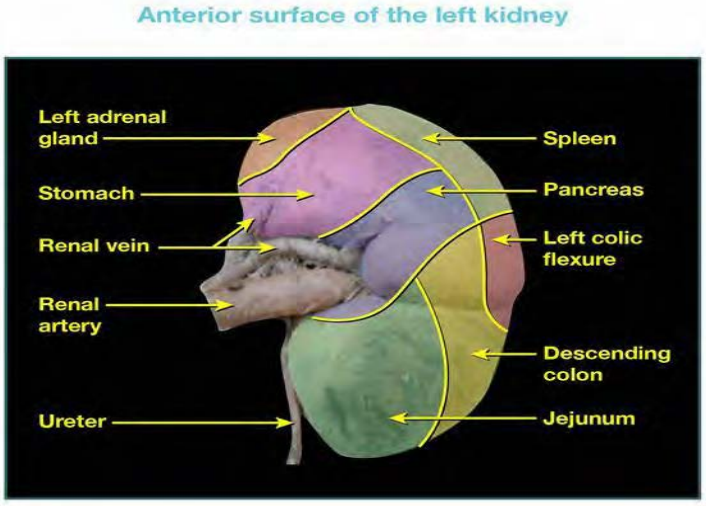

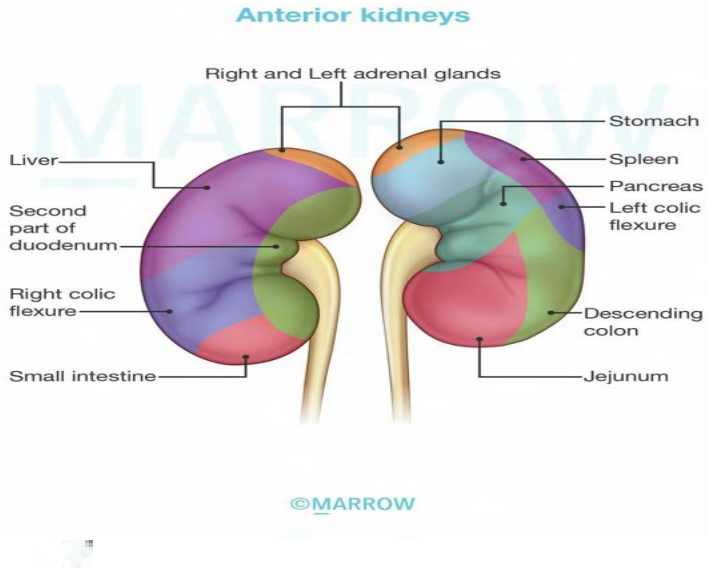

Solution to Question 7:

The marked area in the image of the left kidney is related to the stomach.

The anterior relations of the right kidney:

The anterior relations of the left kidney:

The posterior relations of the kidneys:

• One vessel - subcostal vessels

• Two ligaments - medial and lateral arcuate ligaments

• Three nerves - subcostal, iliohypogastric, and ilioinguinal nerves

• Four muscles - diaphragm, psoas major, quadratus lumborum, and transverse abdominis.

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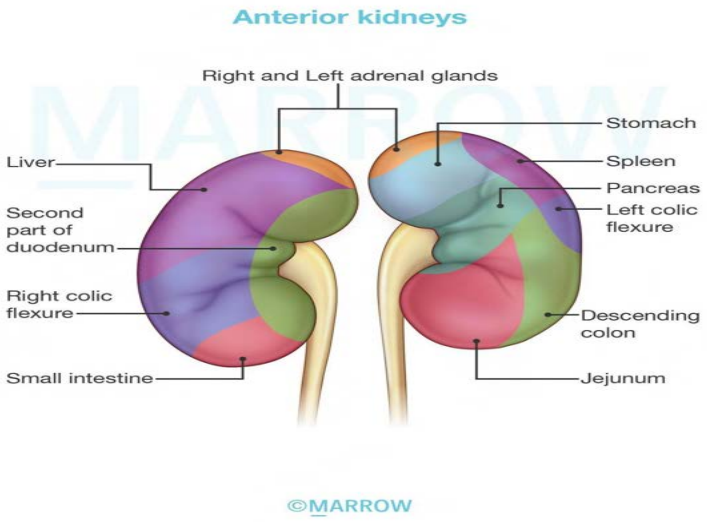
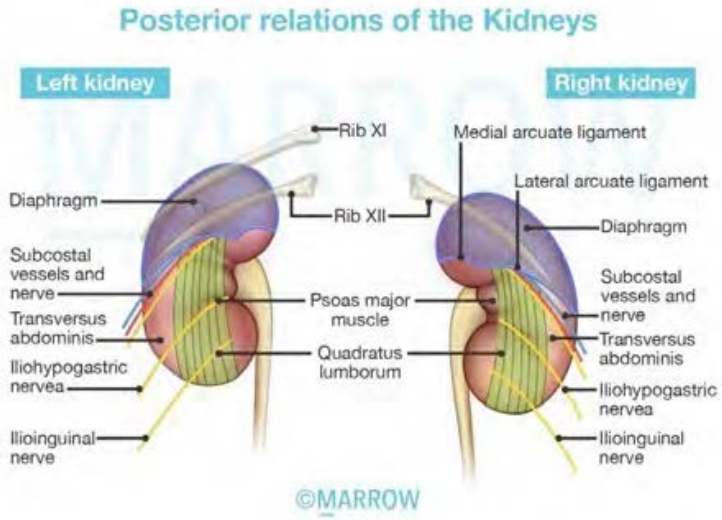
• The right kidney is related to the 12th rib and the left kidney is related to the 11th and 12th ribs

Intraperitoneal	Right lobe of liverSmall intestine
Retroperitoneal	Right suprarenal gland2ndpart of duoednumHepatic flexure of colon

Intraperitoneal	StomachJejunumSpleen
Retroperitoneal	Left suprarenal glandPancreassSplenic vesselsSplenic flexure and beginning of descending colon





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Solution to Question 8:

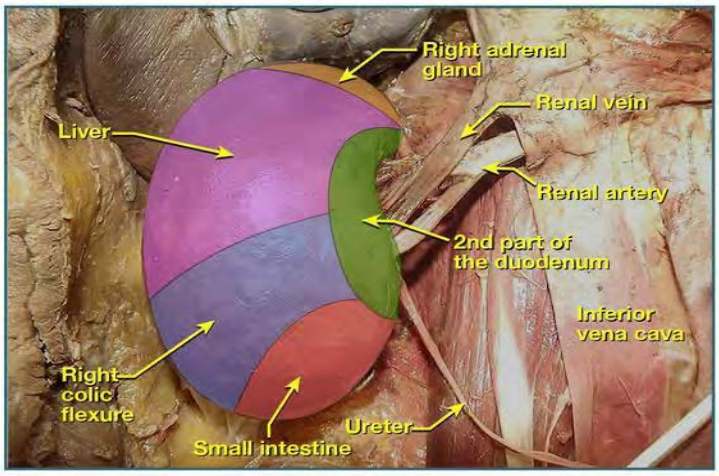
The anterior surface of the right kidney related to the right lobe of the liver (marked as 1) is separated by a layer of peritoneum.

As the kidneys are located retroperitoneally, intraperitoneal anterior relations are separated from it by a peritoneal layer.

The anterior relations of the right kidney:

Intraperitoneal	Right lobe of liverSmall intestine
Retroperitoneal	Right suprarenal gland2ndpart of duoednumHepatic flexure of colon

Anterior surface of the right kidney



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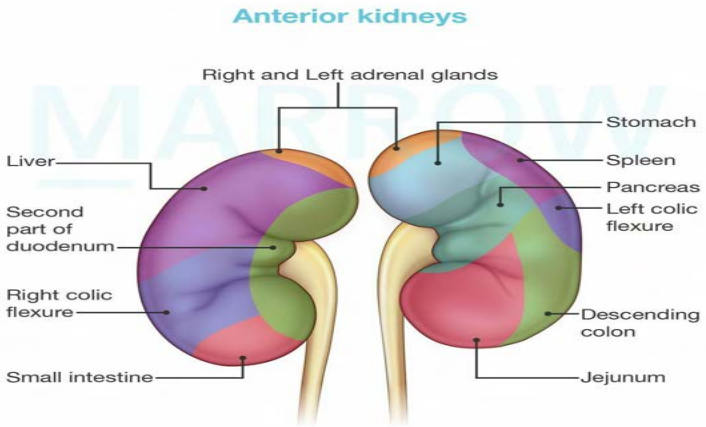

MARROW
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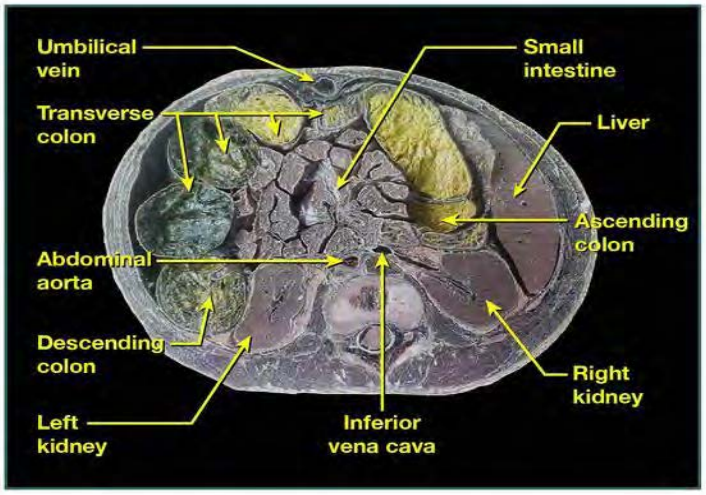
Solution to Question 9:

The marked structure in the given image is the left kidney. The sympathetic chain is not a posterior relation of the left kidney.

The posterior relations of the kidneys are as follows:

- One vessel - subcostal vessels
- Two ligaments - medial and lateral arcuate ligaments
- Three nerves - subcostal, iliohypogastric, and ilioinguinal nerves
- Four muscles - diaphragm, psoas major, quadratus lumborum, and transverse abdominis.
- The right kidney is related to the 12th rib and the left kidney is related to the 11th and 12th ribs

The below image shows the cross section of the abdomen at the level of kidney.



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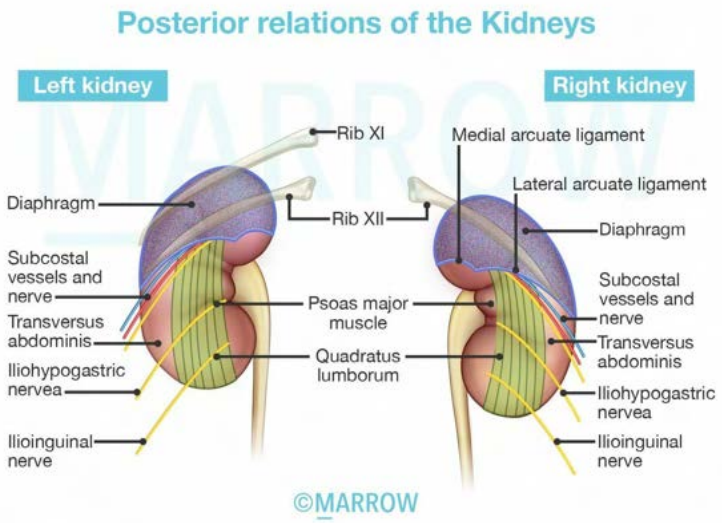
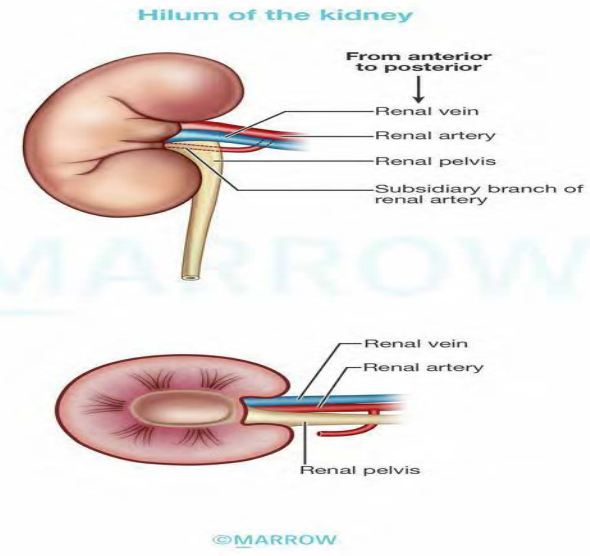


Solution to Question 10:

The marked area is the hilum of the kidney. It contains the following structures from anterior to posterior:

- Renal vein
- Renal artery
- Renal pelvis



Solution to Question 11:

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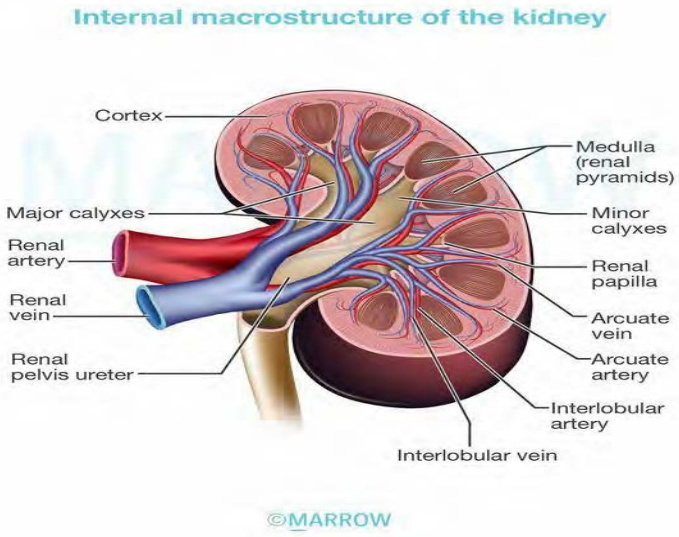
The renal papillae open into the minor calyces.

The papilla is the conical apex of a renal pyramid, where the urine from the collecting ducts enters into the minor calyces. The minor calyces unite to form the major calyces, which further unite to form the renal pelvis.

The kidney is divided into an outer cortex and an inner medulla. The renal medulla contains many striated and conical pyramids. The base of the pyramid is peripherally located, whereas the apex is directed towards the renal sinus (hilum). The renal cortex is subcapsular and arches over the bases of the pyramids. It extends between the pyramids towards the renal sinus as renal columns.



Solution to Question 12:

The coeliac plexus contributes to the nerve supply of the kidneys.

Nerve supply of the kidney:

• Coeliac ganglion and plexus

• Aorticorenal ganglion

• Lowest thoracic splanchnic nerve

• First lumbar splanchnic nerve

• Aortic plexus

The rami from these structures form a dense network of autonomic plexus around the renal artery called the renal plexus. They control the blood flow between the cortex and medulla.

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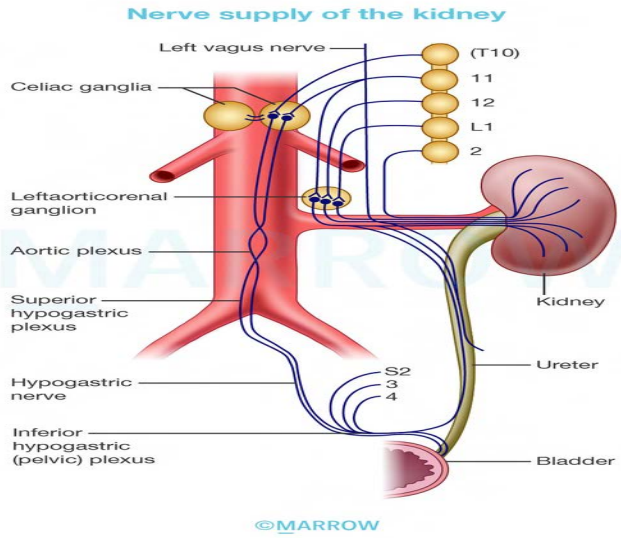

Solution to Question 13:

The most likely cause is compression of the left renal vein between the abdominal aorta and superior mesenteric artery. This manifests as nutcracker syndrome.

Nutcracker syndrome is characterized by left renal vein hypertension, which occurs due to the compression of the left renal vein between the abdominal aorta and the superior mesenteric artery. This is because the left renal vein is posterior and inferior to the superior mesenteric artery.

The left renal vein is longer than the right renal vein. It runs anterior to the aorta just below the origin of the superior mesenteric artery and drains into the inferior vena cava after crossing the midline.

Note: The left kidney is preferred in donor nephrectomy than the right because of the long course of the left renal vein.

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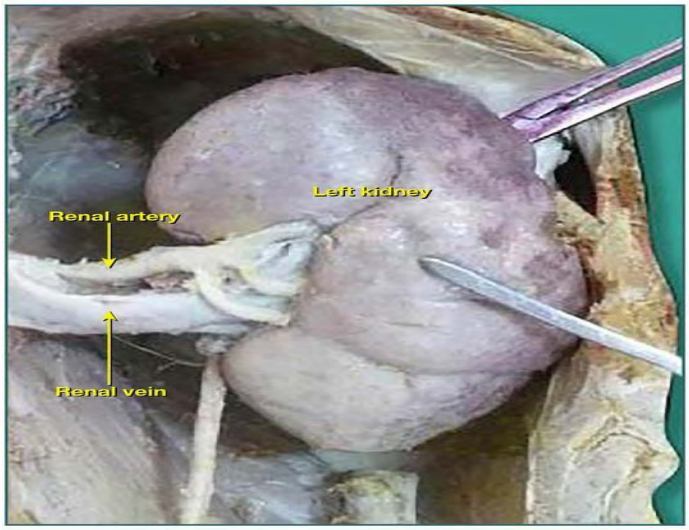

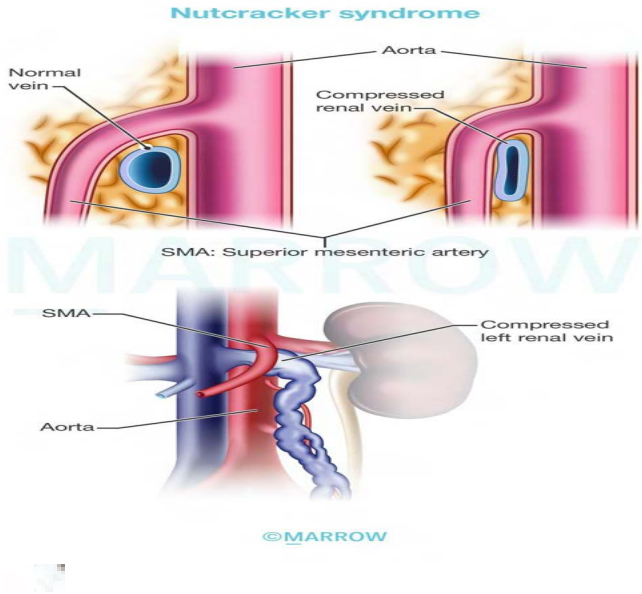

Solution to Question 14:

The left subcostal vein does not drain into the left renal vein. It drains into the hemiazygos vein. So the occlusion of the left renal vein does not impede the blood flow in the left subcostal vein.

Veins that commonly drain into the left renal vein (which in turn drains into the IVC) are:

- Left inferior phrenic (diaphragmatic) vein,
- Left suprarenal (adrenal) vein,
- Left gonadal vein

On the right side, all the above veins drain into the inferior vena cava directly.

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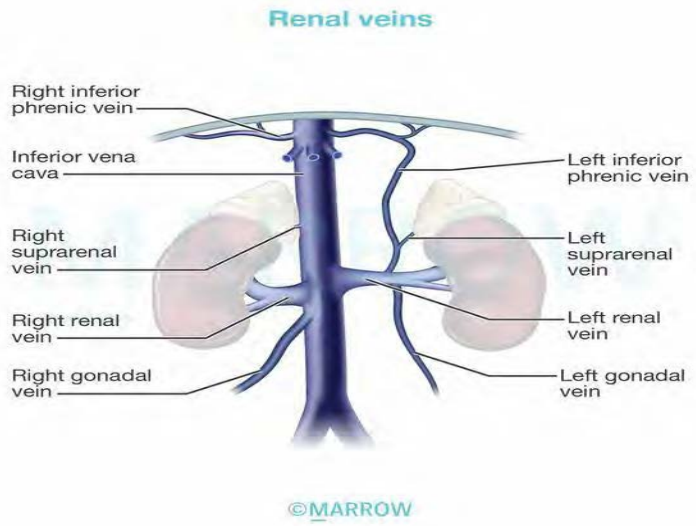
Apart from the veins described above, the first and second left lumbar veins and hemiazygos vein may drain into the left renal vein.



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Solution to Question 15:

The left gonadal vein does not cross the midline. It is formed from the pampiniform plexus of veins and drains into the left renal vein.

The left renal vein is longer than the right renal vein and it crosses the midline anterior to the aorta. It drains directly into the inferior vena cava. The right renal vein does not cross the midline.

The accessory hemiazygous vein at T7 vertebral level crosses the midline to drain into the azygous vein.

The root of the mesentery extends across a line from the duodenojejunal flexure on the left side to the sacroiliac joint on the right side. This spans a length of 15 cm and crosses the midline in its course.

Solution to Question 16:

Vesicoureteric junction is the narrowest part of the ureter. This is the reason why stones as small as 2 to 3 mm get arrested in the vesicoureteric junction.

The ureter is constricted at 5 places:

- Pelvi-ureteric junction
- Brim of the lesser pelvis (as it crosses the common iliac artery)
- Point of crossing of the ureter by ductus deferens or broad ligament of the uterus.
- Vesico-ureteric junction

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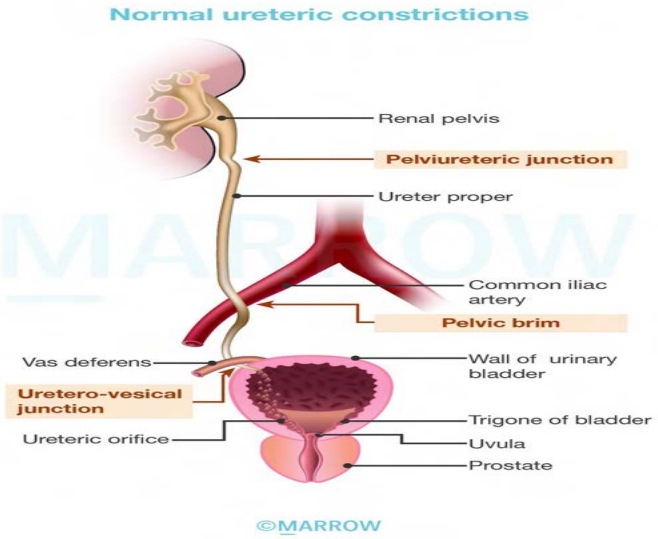
• Opening in the lateral angle of the trigone

These are regarded as surgical constrictions of the ureter.

However, only 1, 2, and 4 are the anatomical constrictions of the ureter.



Solution to Question 17:

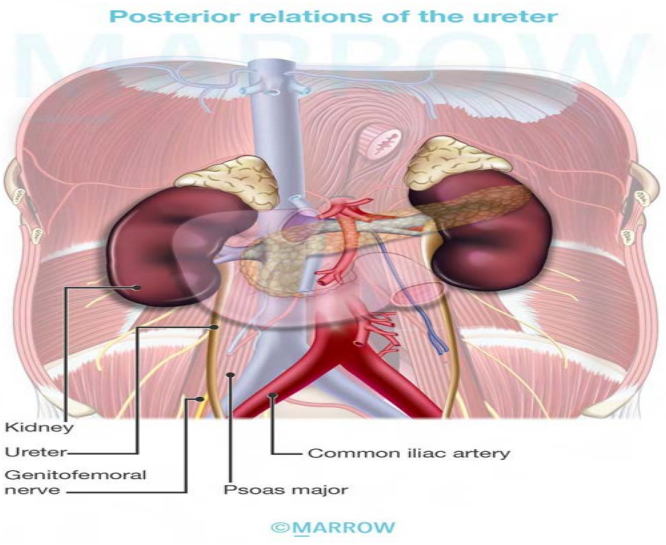
The structure marked in the image is the ureter. Quadratus lumborum is not a posterior relation of the ureter.

Posterior relations of the ureter in the abdominal cavity are:

• Psoas major

• Genitofemoral nerve

• End of the common iliac artery or beginning of the external iliac artery



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Solution to Question 18:

The superior mesenteric artery does not supply the ureters.

The ureter receives its blood supply from the following arteries:

• Renal artery

• Gonadal artery

• Common iliac artery

• Internal iliac artery

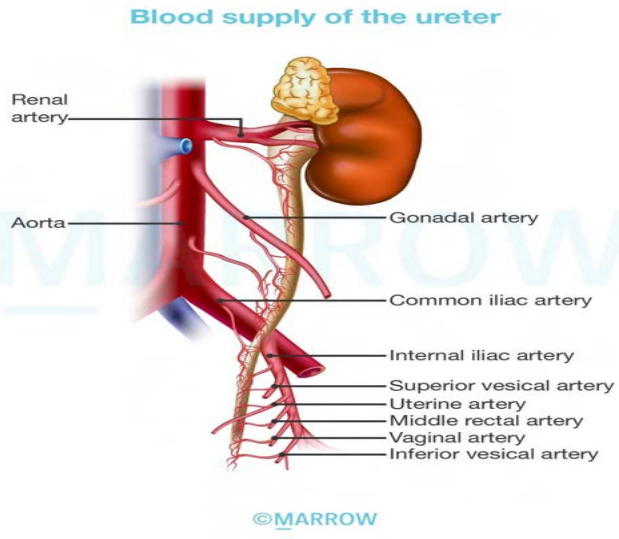
• Vesical artery

• Uterine artery

• Abdominal aorta

Among these branches, the branch from the renal artery and the branch from the inferior vesical artery are always constant.

Clinical note: The branch of the renal artery that supplies the ureter must be carefully preserved in renal transplantation to maintain good vascularity of the ureters.



Solution to Question 19:

The structure marked in the CT abdomen is the left adrenal gland. The superior mesenteric artery does not supply the suprarenal or adrenal gland.

The adrenal gland receives its arterial supply from the superior, middle, and inferior suprarenal arteries. These arteries have some variations in their origin as follows:

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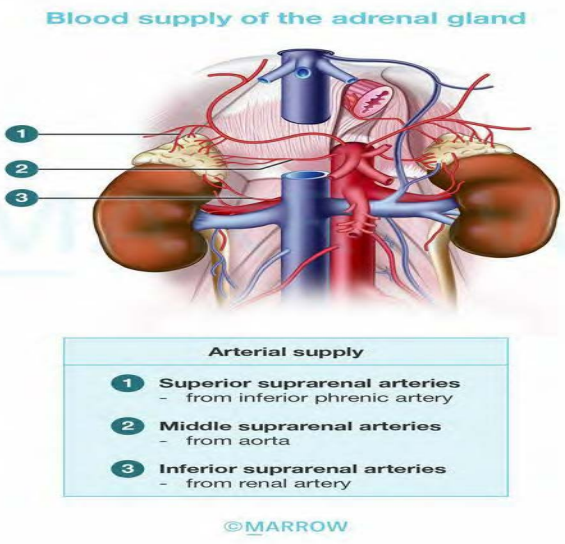
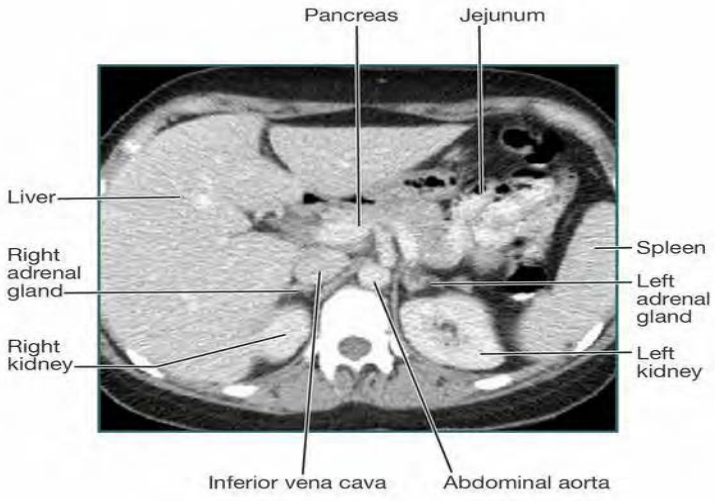
Artery	Usual origin	Variation in origin
Superior suprarenal	Inferior phrenic artery	Abdominal aorta
Middle suprarenal	Abdominal aorta (as lateral b ranches)	Inferior phrenic arteryRenal artery
Inferior suprarenal (major bl ood supply)	Renal artery	Abdominal aortaGonadal art ery



The below CT abdomen shows the right and left adrenal gland.



Solution to Question 20:

The right main adrenal vein usually drains into the inferior vena cava.

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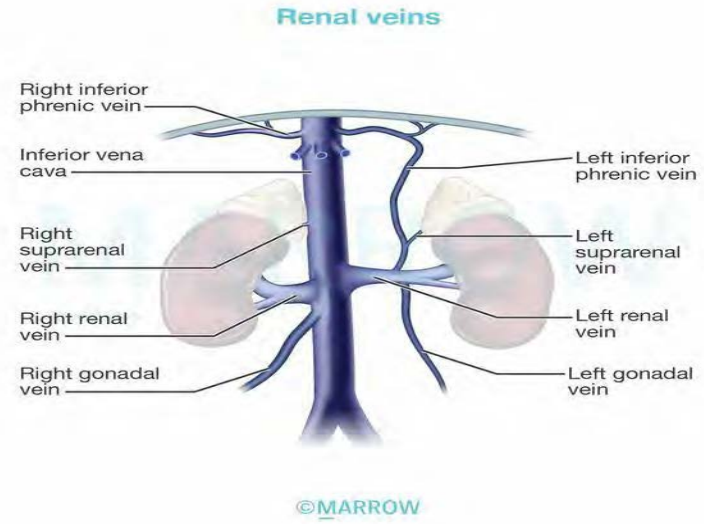
The left main adrenal vein usually drains into the left renal vein. Variations are common on the right side, where the right adrenal vein may drain into the right inferior phrenic vein.



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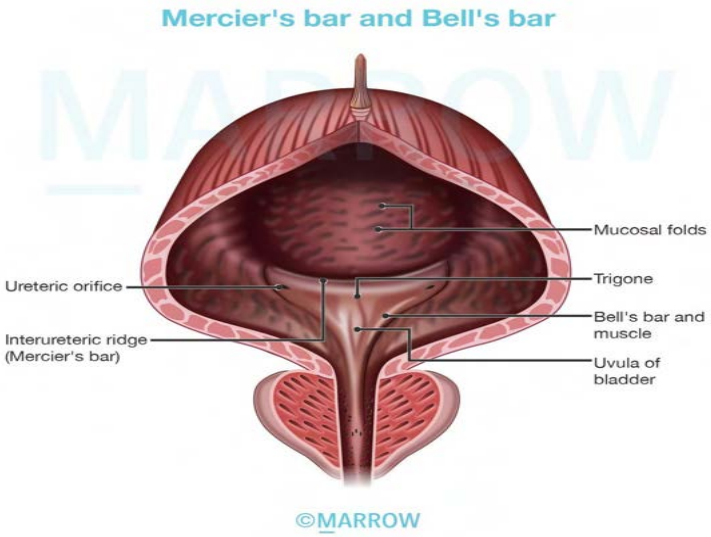
Solution to Question 21:

The Mercier's bar (interureteric bar or interureteric ridge) is a curved fold of mucous membrane between the two ureteric orifices inside the bladder.

This fold of mucous membrane is formed by the thickening of the superior border of the trigone muscle. In cystoscopy, the interureteric ridge appears as a pale band and acts as a guide to the ureteric orifices.

The mucosal fold running from the uvula vesicae to the ureteric orifice is called the Bell's bar. This fold forms the lateral borders of the trigone. It contains a band of muscle fibres called the Bell's muscle.



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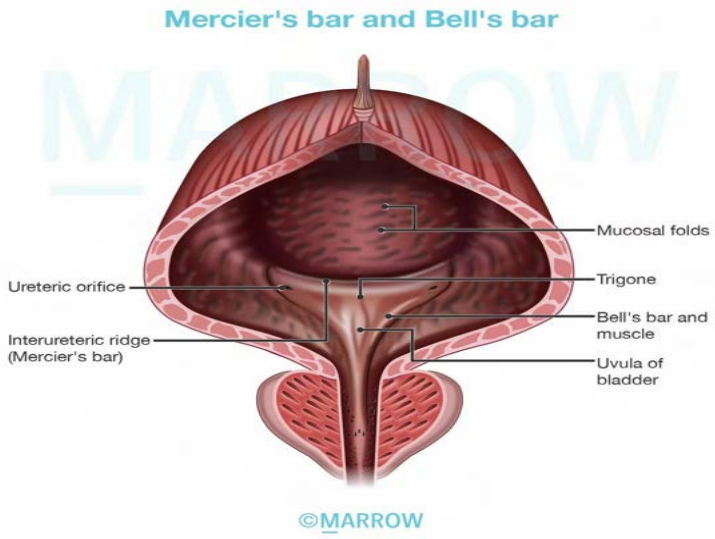
Solution to Question 22:

The median lobe of the prostate forms the uvula vesicae.

Uvula vesicae is an elevation in the mucous membrane of the urinary bladder, behind the internal urethral orifice. It is often enlarged in benign prostatic hypertrophy.



Solution to Question 23:

The internal urethral orifice lies at the level of the upper border of the pubic symphysis at birth.

At birth, the bladder is an abdominal organ. But as the child grows, the blader descends, and near puberty, it becomes a pelvic organ.

In an adult, the internal urethral orifice lies 3–4 cm behind the lower part of the pubic symphysis. It corresponds to the bladder neck.

Clinical note: As the bladder lies above the symphysis pubis, we can safely perform suprapubic needle punctures to obtain urine samples in children. But in adults, this can only be done if the bladder is fully distended.

Solution to Question 24:

The external urethral sphincter is innervated by the neurons present in Onuf's nucleus.

The neurons present in the lamina IX of the grey matter in spinal segments S2, S3, and S4 constitute Onuf's nucleus. These neurons contract the external urethral sphincter.

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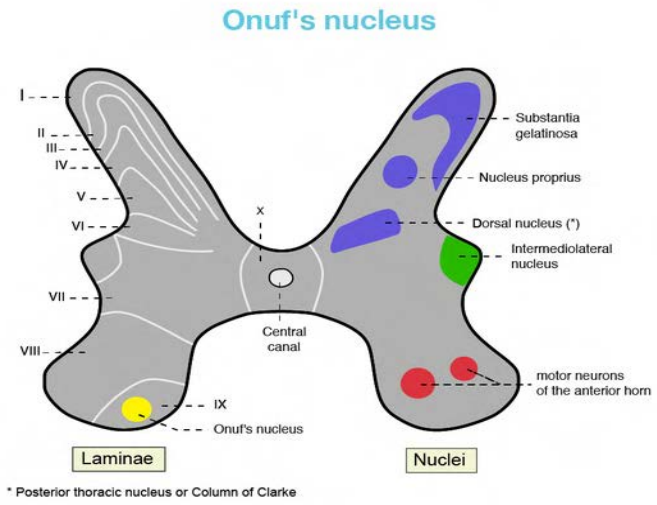
The external urethral sphincter is made up of skeletal muscle fibers. In the contracted state, they are responsible for the maintenance of urinary continence. Just before the onset of voiding the sphincter is relaxed. This happens because the neurons in the Onuf's nucleus are centrally inhibited by the brain.

The below image shows Onuf's nucleus located in the lamina IX.



Nerve supply of the bladder:

Parasympathetic supply	Sympathetic supply
From S2, S3, and S4 spinal s egments	From T10, T11, T12, L1, and L2 spinal segments
Richly innervate the fundus o f the bladderSparsely innerva te the bladder neck	Richly innervate the smooth muscles around the bladder neckSparsely innervate the fu ndus of the bladder
They contract the urinary bla dder and aids in the micturiti on	They contract the internal ur ethral sphincter and aids in t he filling of the urinary bladd er

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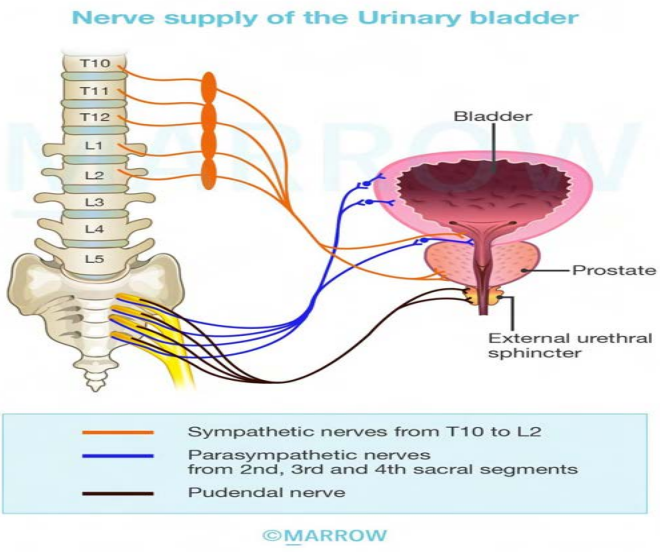

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Solution to Question 25:

There are five arterial segments in the kidney:

- Apical
- Superior
- Middle
- Inferior
- Posterior

Blood supply of the kidney: The renal artery is a direct lateral branch of the abdominal aorta. Near the hilum of the kidney, the renal artery is divided into anterior and posterior divisions. These divisions are further divided into five segmental arteries (four anterior and one posterior). The segmental arteries further branch out in a hierarchy to form different arteries. Finally, the renal vein is formed which joins the inferior vena cava.

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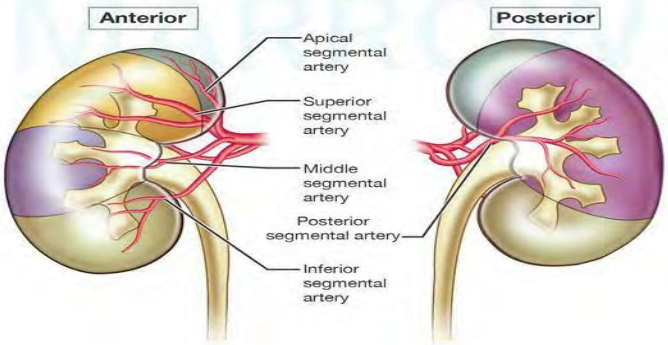
Segmental arteries of the kidney



Right kidney

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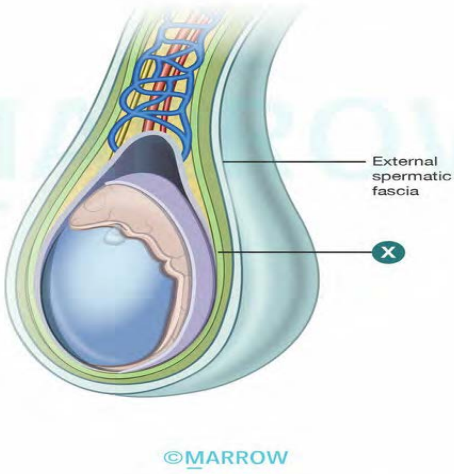
Internal and external genitalia

Question 1:

Which of the following forms the marked structure?



a) External oblique aponeurosis

b) Muscle fibres of internal oblique

c) Fascia transversalis

d) Colle's fascia

Question 2:

Which of the following structures of the inguinal canal lies outside the internal spermatic fascia?

a) Pampiniform plexus of veins

b) Testicular artery

c) Testicular nerve plexus

d) Ilioinguinal nerve

Question 3:

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Which of the following arteries gives rise to the cremasteric artery?

a) Internal pudendal artery

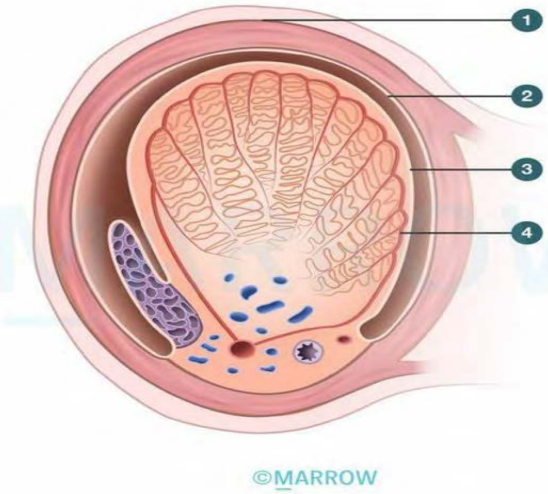
b) External pudendal artery

c) Inferior epigastric artery

d) Obturator artery

Question 4:

A middle-aged man presents with right scrotal swelling and pain. On examination, transillumination is positive, and cough impulse is absent. His condition is due to the accumulation of fluid in which layer of the testis?



a) 1

b) 2

c) 3

d) 4

Question 5:

A 34-year-old man underwent surgery for an indirect inguinal hernia. During the procedure, the surgeon accidentally injured a nerve which has led to decreased sensation over the anterior one-third region of the scrotum and anteromedial region of the thigh. Which of the following nerves is most likely to be injured?

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a) Perineal nerve

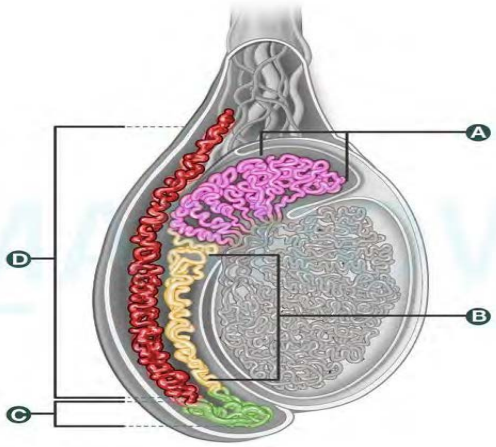
b) Posterior cutaneous nerve of thigh

c) Iliohypogastric nerve

d) Genitofemoral nerve

Question 6:

Which part of the epididymis contains sperms with low amplitude and high-frequency tail movements?



a) C

b) B

c) A

d) D

Question 7:

A 50-year-old man was admitted to the emergency department with pain over the flank, associated with pain in the scrotum. On examination, you note a left-sided varicocele. CT scan revealed venous occlusion. Which of the following veins are most likely to be occluded?

a) Left suprarenal vein

b) Superior mesenteric vein

c) Left renal vein

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d) Inferior venacava

Question 8:

Which of the following zones of the prostate primarily encircles the ejaculatory duct?

a) Fibromuscular zone

b) Transitional zone

c) Central zone

d) Peripheral zone

Question 9:

Which of the following statements is false about the prostate?

a) 2 and 4

b) 2 and 5

c) 1, 3 and 5

d) 1, 2 and 5

Question 10:

Which of the following statements is false about seminal vesicles?

a) It is lined by pseudo-stratified columnar epithelium

b) It is supplied by inferior vesical artery

c) It acts as a storehouse for sperms

d) The secretions are alkaline

Question 11:

Which of the following arteries gives rise to helicine arteries of the penis?

a) Dorsal artery of the penis

b) Deep artery of the penis

c) Bulbourethral artery

d) Perineal artery

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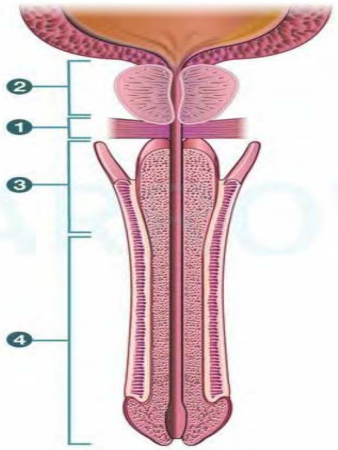
Question 12:

Which part of the male urethra appears stellate in the transverse section?



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a) 1

b) 2

c) 3

d) 4

Question 13:

Which of the following is the periurethral gland in males?

a) Cowper's glands

b) Bartholin's glands

c) Skene's glands

d) Littre glands

Question 14:

A patient presented with an enlarged inguinal lymph node. The most likely primary cause is

a) Testicular cancer

b) Anal cancer

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c) Sigmoid colon cancer

d) Prostate cancer

Question 15:

Which of the following structures form the angle of anteversion?

a) Uterus and bladder

b) Uterus and cervix

c) Cervix and vagina

d) Cervix and bladder

Question 16:

A 24-year-old primipara was brought to the ER with lower abdominal pain 6 hours after delivering her baby. On examination, pallor and cold clammy skin were present. Pulse was feeble and BP was 70/50 mm Hg. A bedside ultrasound revealed a broad ligament hematoma. Which of the following is not a content of the involved structure?

a) Round ligament

b) Fallopian tubes

c) Lymph nodes

d) Ovaries

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Question 17:

Which of the following ligaments attaches the ovary to the lateral angle of the uterus?

a) Round ligament

b) Suspensory ligament

c) Mesovarium

d) Ovarian ligament

Question 18:

A 45-year woman presented with abdominal pain, distension, anorexia, and weight loss. Ultrasound abdomen revealed a unilocular cyst with a solid component arising from the right

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ovary. CA-125 level is elevated. The tumor spreads to which of the following lymph nodes?

a) External iliac nodes

b) Internal iliac nodes

c) Obturator nodes

d) Para-aortic nodes

Question 19:

The lining epithelium of the fallopian tube is similar to which of the following?

a) Epithelium of stomach

b) Epithelium of trachea

c) Epithelium of bronchioles

d) Epithelium of proximal convoluted tubule

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Question 20:

Which of the following ligaments extends from the cervix and vagina to the lateral pelvic wall?

a) Broad ligament

b) Pubocervical ligament

c) Round ligament

d) Cardinal ligament

Question 21:

Which of the following structures is not related to the posterior surface of the vagina?

a) Rectovaginal septum

b) Recto uterine pouch

c) Waldeyer's fascia

d) Perineal body

Question 22:

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Which of the following gives rise to azygous arteries of the vagina?

a) Internal iliac artery

b) Obturator artery

c) External iliac artery

d) Median sacral artery

Answer Key

Question No.	Correct Option
1	c
2	d
3	c
4	b
5	d
6	a
7	c
8	c
9	d
10	c
11	b
12	a
13	d
14	b
15	c
16	d
17	d
18	d
19	c
20	d
21	c
22	a

Detailed Explanations

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Solution to Question 1:

Fascia transversalis forms the internal spermatic fascia.

Solution to Question 2:

The ilioinguinal nerve lies outside the internal spermatic fascia of the spermatic cord.

Ilioinguinal nerve is not the content of the spermatic cord but it is the content of the inguinal canal. The ilioinguinal nerve lies inferior to the cord in the inguinal canal. It provides innervation to the groin and medial aspect of the thigh, the upper part of the scrotum, and the penile root. It may be commonly injured during open hernia repair.

The spermatic cord is a structure that passes through the inguinal canal in males. The inguinal canal is a natural passageway between the muscle layers of the anterior abdominal wall in the region of the groin. It transmits the spermatic cord in males, the round ligament of the uterus in females, and the ilioinguinal nerve in both sexes.

The contents of the spermatic cord include:

- Cremaster muscle fibers
- Testicular artery and pampiniform plexus of veins
- Genital branch of the genitofemoral nerve
- Vas deferens
- Cremasteric vessels
- Lymphatics
- Processus vaginalis

Coverings of the spermatic cord from inside to outside are:

- Internal spermatic fascia from fascia transversalis
- Cremasteric fascia
- External spermatic fascia from external oblique aponeurosis

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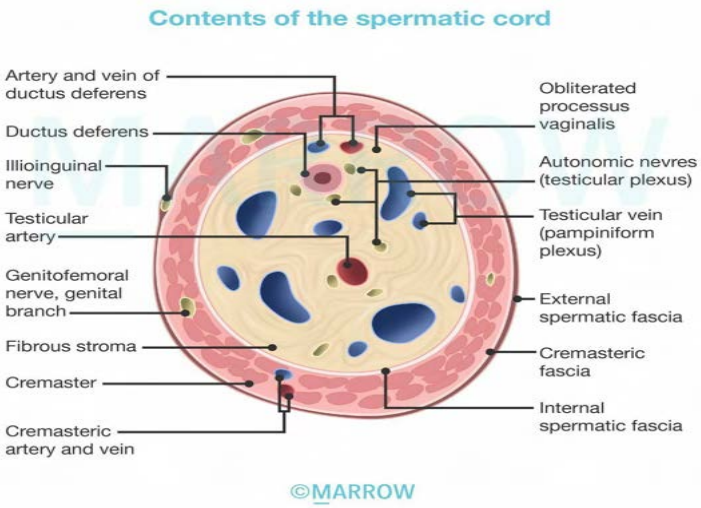

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Solution to Question 3:

The inferior epigastric artery, a branch of the external iliac artery gives rise to the cremasteric artery.

The cremasteric artery travels along with the spermatic cord to supply the cremaster muscle and other coverings of the cord.

When the testicular artery is interrupted, there will be formation of collaterals from the cremasteric and deferential arteries. This will prevent the ischemia of the testis.

Note: The Fowler-Stephens orchidopexy done for undescended abdominal testis is based on this collateral formation. In the first stage, testicular vessels are clipped laparoscopically to promote the collateral formation along the vas deferens. In the second stage, the testis along with collaterals and vas deferens are mobilized to the scrotum.

Solution to Question 4:

The given clinical scenario is a hydrocele. It is due to the accumulation of fluid in the tunica vaginalis of the testis that is derived from the peritoneum.

Clinical note: When the part of processus vaginalis between the internal inguinal ring and testis fails to obliterate, it forms a communication between the abdominal cavity and scrotum. This results in the formation of congenital inguinal hernia and congenital hydrocele.

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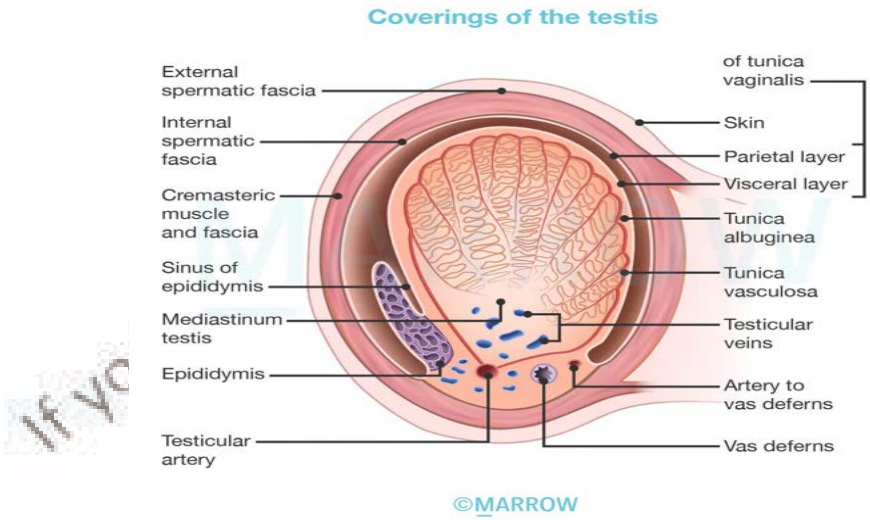
Layersof the testicular capsule	Features
Tunica vaginalis	OutermostlayerDerived from processes vaginalis (embryological extension of peritoneum)Contains parietal and visceral layer with a potential space in between
Tunica albuginea	Intermediatetough layer made up of collagen fibersNumerous fibrous septa extend into the testis to form mediastinum testisBlood vessels, nerves, and testicular duct traverses the testicular capsule via the mediastinum testis
Tunica vasculosa	InnermostlayerContains plexus of blood vessels and loose connective tissue



Solution to Question 5:

The genitofemoral nerve is likely to be injured. The genital branch of the genitofemoral nerve innervates the anterior one-third of the scrotum, and the femoral branch innervates the anteromedial region of the thigh.

Clinical note: Considering the root values of the nerves supplying the scrotum, the spinal block should be given above the level of L1 to anesthetise it.

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Part of the scrotum	Nerve supply	Root value
Anterior one-third	Ilioinguinal nerveGenital branch of genitofemoral nerve	L1
Posterior two-third	Perineal branch of the posterior cutaneous nerve of thighPosterior scrotal branches of the perineal nerve	S3

Solution to Question 6:

The tail of the epididymis (marked as C) contains sperms with low amplitude and high-frequency tail movements.

The motility of sperm plays an important role in the process of fertilization. Sperms acquire their motility and maturation in the epididymis.

The epididymis has the following three parts:

Clinical note: Cystic degeneration of epididymis can result in epididymal cysts.

Head of the epididymis	Tail of the epididymis
High amplitude and low-frequency tail movements	Low amplitude and high-frequency tail movements
Responsible for thesubtle motionof the sperms	Responsible for therapid forward progressionand aids infertilization

Parts of the epididymis	Features
Head	Receives the immature spermatozoa from the superior pole of the testis through the efferent ducts
Body	Efferent ducts from the head open into the tubules of the epididymisThese tubules coalesce forming a single, highly coiled tubuleThe wall of the body contains smooth muscles which propel the sperms towards the tail during ejaculation
Tail	The coiled tubule passes through the tail and continues as the vas deferens

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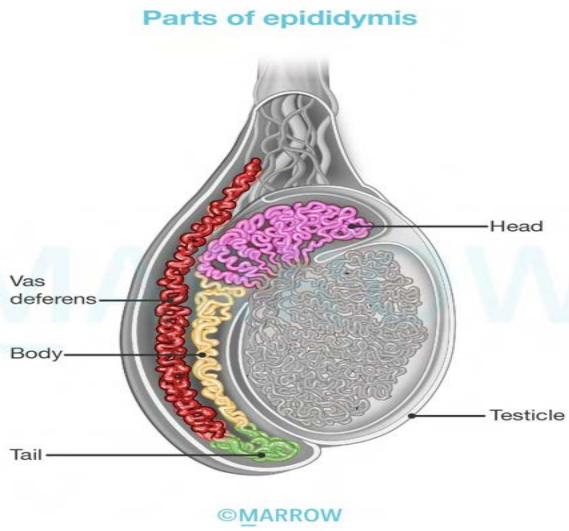

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Solution to Question 7:

The left renal vein is likely to be occluded in this case. The left testicular vein drains into the left renal vein. Occlusion of the left renal vein impedes the blood flow in the left testicular veins. As a result, the veins become swollen and cause pain on the affected side.

Venous drainage of the testis:

The pampiniform plexus of veins arising from the testes ascend through the inguinal canal and abdomen. They coalesce to form the testicular veins during their course.

- The left testicular vein drains into the left renal vein at a right angle.
- The right testicular vein drains into the inferior vena cava at an acute angle.

Clinical note: Varicose dilatation of the veins draining the testis is called varicocele. 90% of the varicocele occurs on the left side and mostly this is due to the absence or incompetence of valves in the testicular vein.

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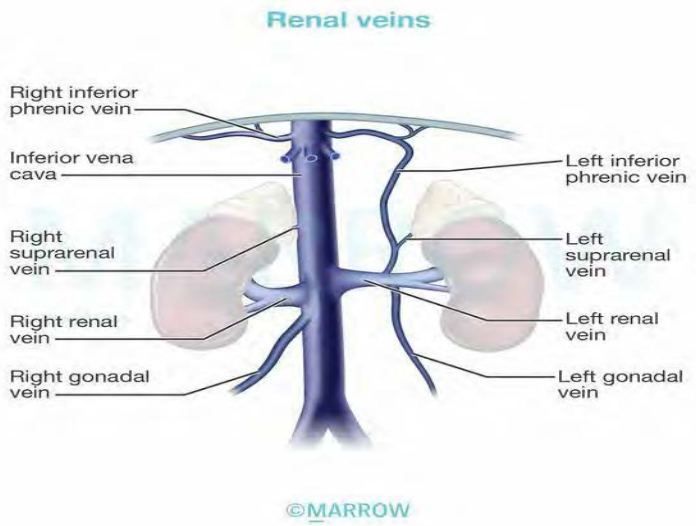

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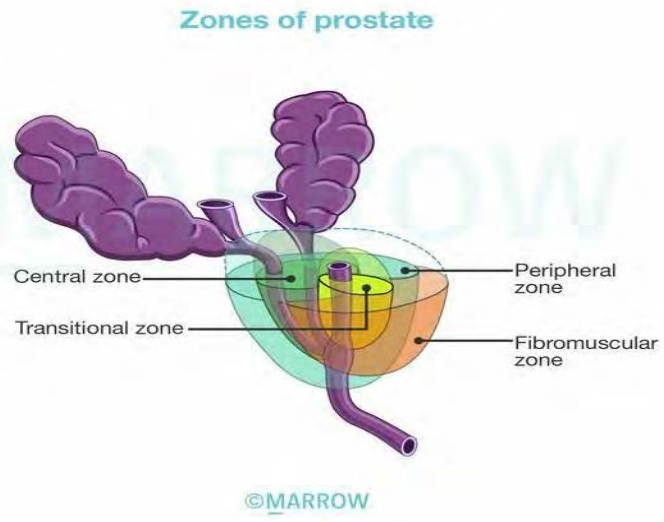
Solution to Question 8:

The central zone of the prostate primarily surrounds the ejaculatory ducts.

The prostate has three distinct zones as follows:

Zone	Structures enclosed	Clinical significance
Transitional zone	Urethra	Most common site for benign prostatic hyperplasia (BPH)
Central zone	Ejaculatory ducts	Rarely diseased
Peripheral zone	Central and transitional zone sPre-prostatic urethra	Most common site for prostatic carcinoma



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Note: Some regard fibromuscular stroma as a zone, but as per Gray's anatomy, 41e, there are only three distinct zones in the glandular prostate.

Solution to Question 9:

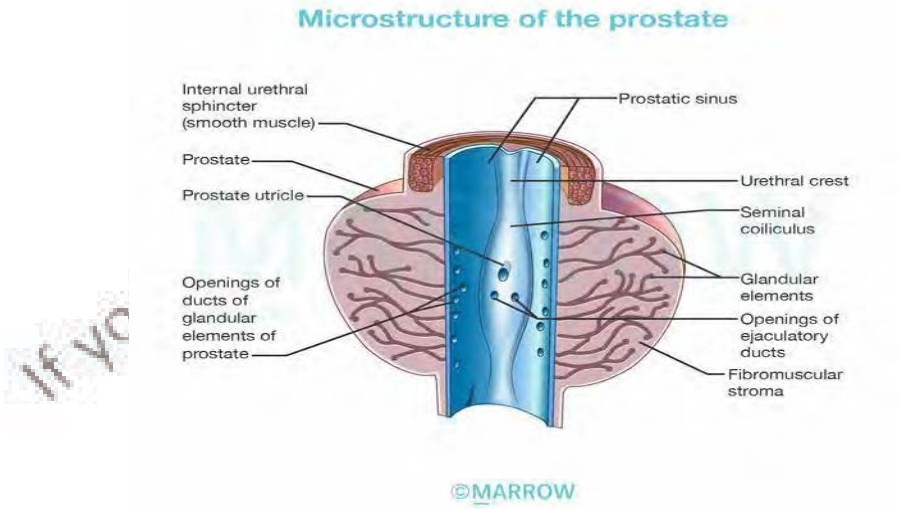
Statements 1, 2 and 5 are false.

The prostatic ducts open into the prostatic sinus in the prostatic urethra. The urethral crest is a midline ridge in the posterior wall of the prostatic urethra. The shallow depressions on either side of the ridge are called prostatic sinuses.

The glandular part of the prostate contains numerous follicles separated by fibromuscular stroma. These follicles are lined by single-layered or pseudostratified columnar epithelium.

Small eosinophilic colloid amyloid bodies called corpora amylacea are frequently seen within a follicle.

The ducts of the prostate follicles are lined by bilayered epithelium (basal cuboidal and apical columnar). The secretions of the prostate are acidic and contain acid phosphatase, amylase, prostate-specific antigen (PSA), fibrinolysis, and zinc.



Solution to Question 10:

Seminal vesicles do not store sperms.

Seminal vesicles are paired accessory glandular structures of the male reproductive system located at the base of the prostate. The duct of the seminal vesicle joins with vas deferens to form the ejaculatory duct. The mucosa of the seminal vesicle is highly folded and is lined by pseudostratified columnar epithelium.

They secrete white-yellow viscous fluid and contribute to at least two-thirds of the volume of the semen. Secretions are rich in fructose, coagulation proteins, and prostaglandins. They are alkaline

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and play an important role in the motility and metabolism of the sperms.

The vesiculo-deferential artery, a branch of the umbilical artery is the primary arterial supply of the seminal vesicles. Additional blood supply is from the inferior vesical artery. Venous drainage is by the vesiculo-deferential veins and inferior vesical plexus. Lymphatic drainage is to the internal iliac nodes

Solution to Question 11:

The deep artery of the penis (cavernosal artery) gives rise to helicine arteries of the penis. They open up into the sinusoidal space of the corpora cavernosa and supply it.

Blood supply of the penis:

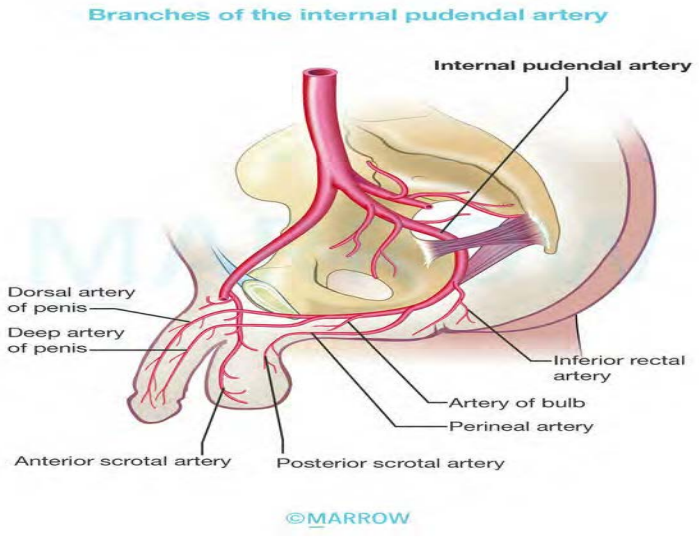
• The external pudendal artery supplies the skin of the penis.

• The internal pudendal artery gives the following two branches:

• Perineal artery - supplies the ischiocavernosus, bulbospongiosus and posterior scrotal surface.

• Common penile artery - divides into the following three branches and supplies the shaft of the penis.

Branches of the common pen ile artery	Structures supplied
Bulbourethral artery	Bulb of the penisCorpus spon giosum with the urethraGlan s penis
Deep artery of the penis (cav ernosal artery)	Corpora cavernosa
Dorsal artery of the penis	Glans penisCorpus spongiosu m (through the circumferenti al branches)



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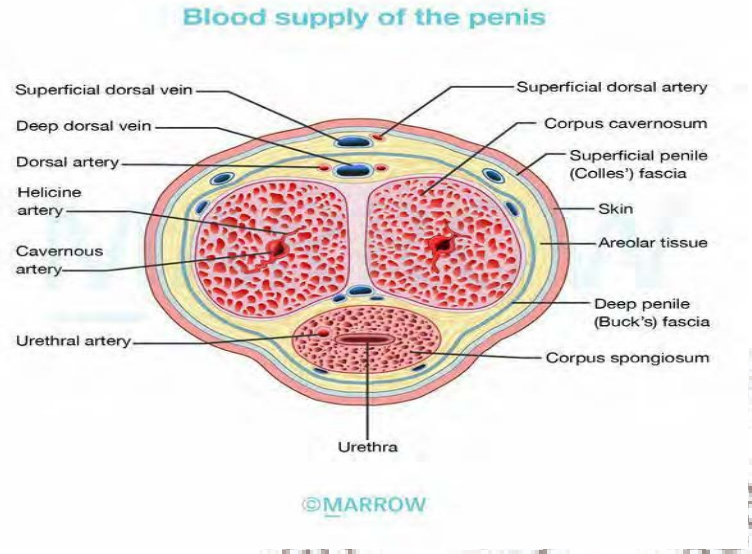
The below image shows a cross-section of the shaft of the penis and the arteries supplying them.



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Solution to Question 12:

The membranous part (marked as 1) of the male urethra appears stellate in the transverse section.

Parts of the urethra	Extent	Appearance in transverse section	Structures opening	Lining epithelium	Clinical/anatomical significance
Pre-prostatic urethra(1 cm)	From the base of the bladder to prostate	Stellate	Small periurethral glands	Transitional epithelium	-
Prostatic urethra(3 to 4 cm)	Enclosed within the prostate	Crescentic	Prostatic ducts Ejaculatory duct	Transitional (till the opening of the ejaculatory duct)Pseudostratified or stratified columnar below the opening of ejaculatory duct	Verumontanum is used as a surgical landmark for the urethral sphincter during TURP
Membranous urethra(2 to 2.5 cm)	From the prostate to the bulb of the penis	Stellate	-	Pseudostratified or stratified columnar	External urethral sphincter encircles the membranous urethra
Bulbar urethra	Enclosed within the bulb (root) of the penis	Transverse	Ducts of bulbourethral (Cowper's) glands	Pseudostratified or stratified columnar	-

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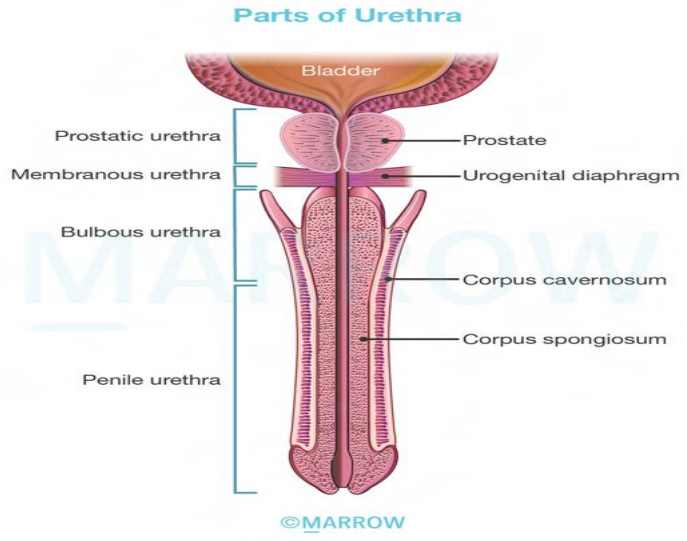
Parts of the urethra	Extent	Appearance in transverse section	Structures opening	Lining epithelium	Clinical/anatomical significance
Penile urethra(15 cm - bulbar and penile)	Enclosed within the penile shaft	Transverse	Ducts of the Littre glands	Distal end has stratified squamous epithelium	-



Solution to Question 13:

Littre glands are the periurethral glands in males. These glands are numerous in the penile urethra. They secrete mucus prior to ejaculation which helps in lubrication.

Option A: Cowper's glands are the bulbourethral glands found in males. They are located lateral to the membranous urethra and opens via a duct into the bulbar urethra by piercing the perineal membrane. Their function is to secrete mucin during sexual arousal.

Option C: Skene's glands are the paraurethral glands found in females. These open on either side of the urethra. They are considered homologous to the male prostate.

Option B: Bartholin's glands are known as the greater vestibular glands in females. These glands are located in the posterior part of the vestibule and open through a duct into the vaginal orifice. They secrete mucus during sexual arousal for lubrication.

Clinical note: Since all these glands open via a duct into the orifices, any obstruction in the duct can result in cyst formation. They can get infected and necessitate removal.

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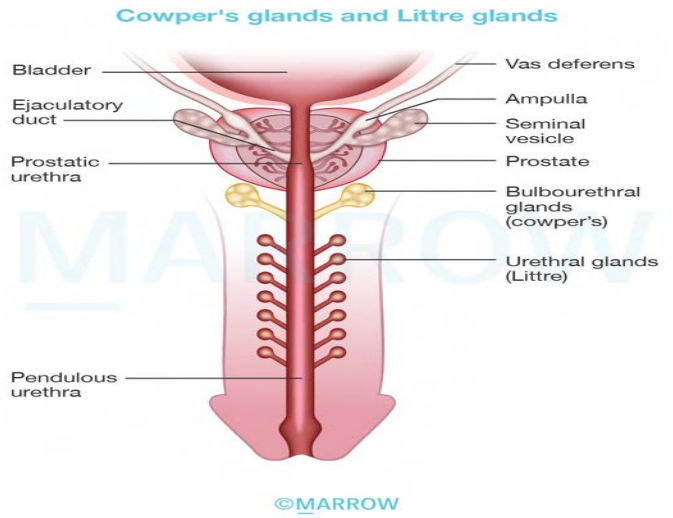

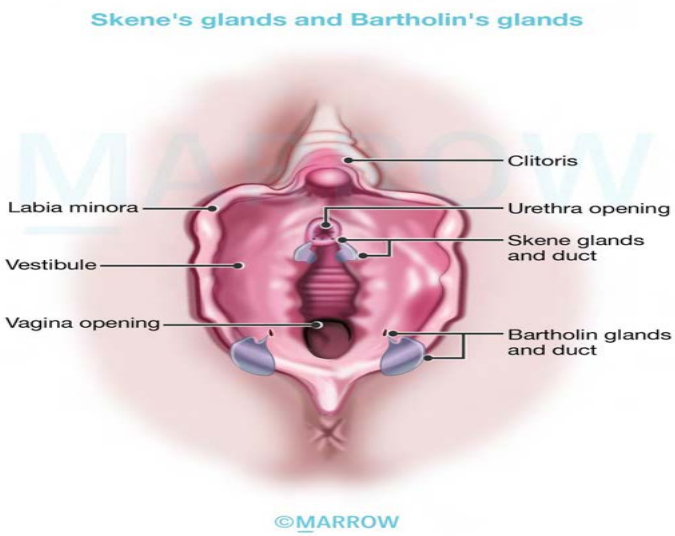

Solution to Question 14:

The most likely primary cause of an enlarged inguinal lymph node is anal cancer.

Lymphatics from the anal canal distal to the dentate line (anal margin) drains into the inguinal lymph nodes. Hence, anal cancer arising distal to dentate line can cause enlarged inguinal lymph nodes. Lymphatics proximal to the dentate line (anal canal) drains into internal iliac lymph nodes through superior rectal lymphatics.

Option A: In testicular cancer, lymphatic spread occurs to the paraaortic lymph nodes.

Option C: In sigmoid colon cancer, lymphatic spread occurs to the regional lymph node and then to the central lymph node.

Option D: In prostate cancer, lymphatic spread occurs to the:

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• Lymph nodes beside the internal iliac vein and in the hollow of the sacrum

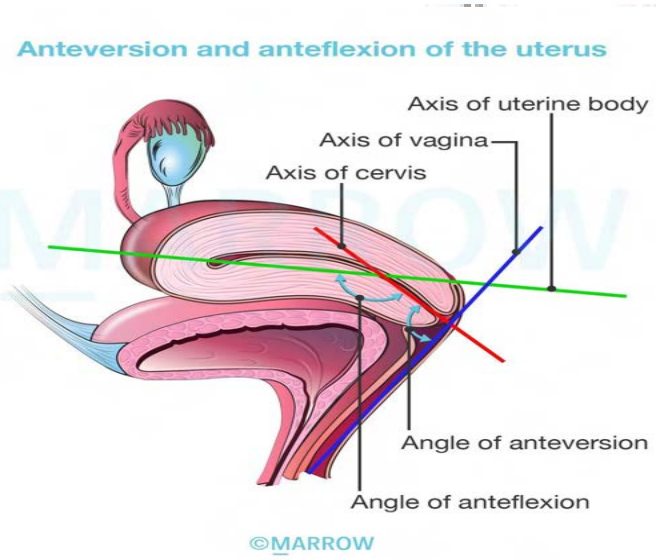
• External iliac lymph nodes.

Solution to Question 15:

The angle of anteversion is formed between the long axis of the cervix and the long axis of the vagina.

The angle of anteflexion which is formed by the body of the uterus and the long axis of the cervix.

When the whole of the uterus leans backwards at an angle to the vagina, it is called retroversion. If the uterus angles backwards in relation to cervix it is called retroflexion.



Solution to Question 16:

The ovaries are not the contents of the broad ligament.

Ovaries are suspended in the pelvic cavity by the mesovarium. It attaches only the hilum of the ovary to the posterior surface of the broad ligament. The majority of the ovarian surface is covered by a single layer of cuboidal epithelium which imparts a dull white color to the ovaries.

Solution to Question 17:

The ovarian ligament (ligament of the ovary) attaches the inferomedial extremity of the ovary to the lateral angle of the uterus.

Other ligamentous supports of the ovaries:

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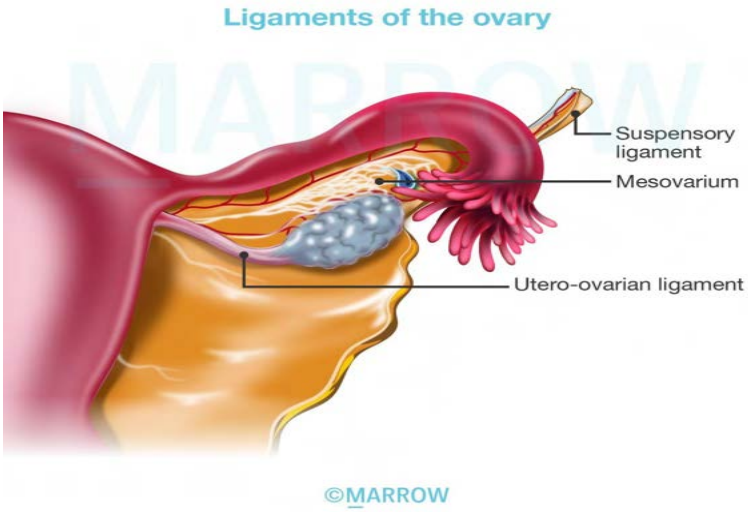
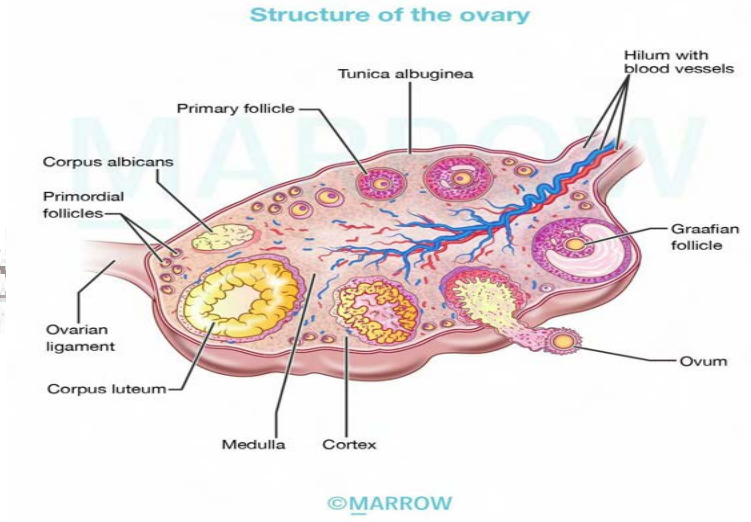
• Infundibulo pelvic ligament (suspensory ligament) - attaches the lateral surface of the ovary to the peritoneum lining the lateral pelvic wall. It contains the ovarian vessels and nerves.

• Mesovarium - a short peritoneal fold that attaches the ovary to the back of the broad ligament. This carries blood vessels and nerves to the hilum of the ovary.





Solution to Question 18:

The given clinical scenario is suggestive of serous cystadenocarcinoma of the ovary. It spreads to the para-aortic nodes as the ovary is drained by them alongside the origin of the ovarian arteries.

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Lymphatic drainage of the female reproductive tract	
Vulva	Skin of labia, clitoris, and perineum - Superficial inguinal nodesClitoris - Deep inguinal (Cloquet's) node, internal iliac nodes
Vagina	Upper vagina - Internal and External Iliac nodesMiddle vagina - Internal Iliac nodesLower vagina (below hymen) - Superficial Inguinal nodes
Cervix	External iliac, internal iliac and obturator nodes
Uterus	Fundus -Para-aortic nodesIsthmus of the tube and round ligament - Superficial inguinal lymph nodesBody -External iliac, internal iliac and obturator nodes
Fallopian Tubes	Para-aortic, internal iliac, and superficial inguinal nodes(via round ligament)
Ovaries	Para-aortic lymph nodes

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Solution to Question 19:

The lining epithelium of the fallopian tube is a single layer of ciliated columnar epithelium. It is similar to the epithelium of the bronchioles.

The ciliated epithelial cells are predominant in the distal part of the fallopian tube. There is an increase in the height and number of cilia in these cells during the estrogenic phase of the menstrual cycle.

Other cells in the fallopian tube epithelium include:

• Secretory or peg cells - maximally located in the proximal portion of the tube. These cells are active around the time of ovulation, and their secretions help in the capacitation of sperms.

• Intraepithelial lymphocytes - may present occasionally.

Option A: Epithelium of stomach - simple columnar

Option B: Epithelium of trachea - Pseudostratified ciliated columnar

Option D: Epithelium of proximal convoluted tubule - cuboidal with microvilli.

Solution to Question 20:

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The cardinal ligament (transverse cervical ligament or ligament of Mackenrodt) extends from the side of the cervix and lateral fornix of the vagina to the pelvic wall.

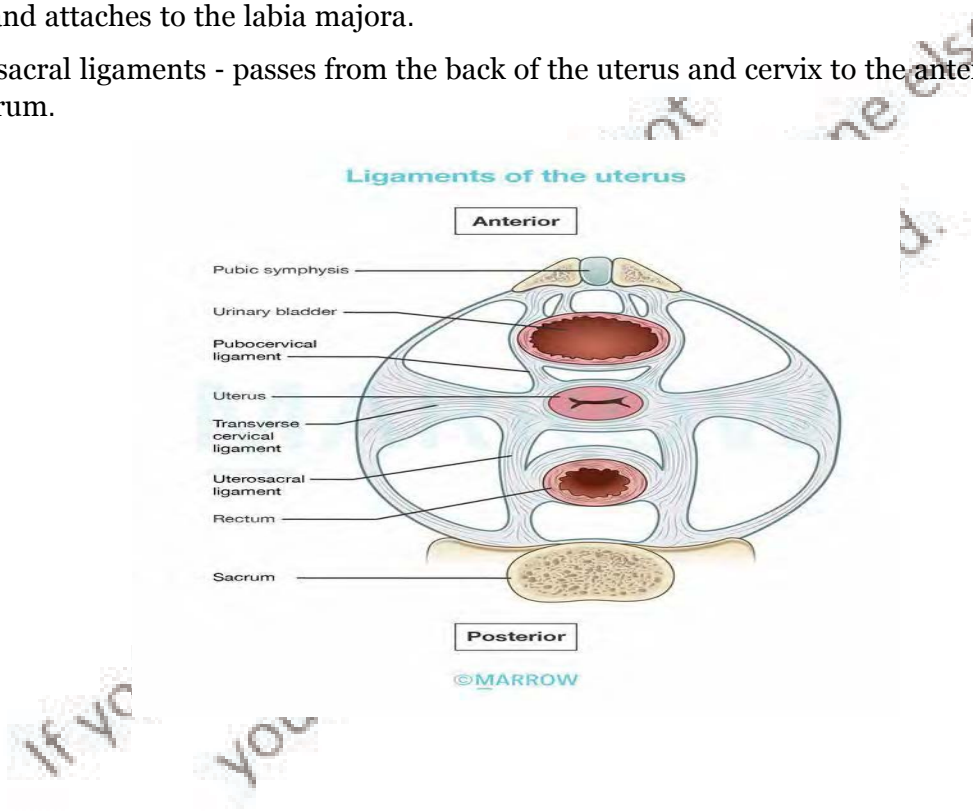
Other ligaments of the uterus:

• Broad ligament - peritoneal fold covering the ovaries and fallopian tubes. It has three parts named after the structures it covers, i.e., mesosalpinx, mesovarium, and mesometrium (largest part).

• Pubocervical ligament - attaches the anterior aspect of the cervix and upper vagina to the posterior aspect of the pubic bones.

• Round ligaments - arises from the lateral cornua of the uterus, passes through the inguinal canal, and attaches to the labia majora.

• Uterosacral ligaments - passes from the back of the uterus and cervix to the anterior surface of the sacrum.



Solution to Question 21:

Waldeyer's fascia (presacral fascia) forms the posterior relationship of the rectum and is not related to the vagina. It lines the anterior surface of the sacrum.

Relations of the vagina:

Parts of vagina	Anterior relation	Posterior relation	Lateral relation
Upper third	Bladder	Peritoneum of the rectouterine pouch	Levator aniTransverse cervical ligamentPubocervical ligamentUterosacral ligamentUreter and uterine artery (related to the lateral fornix)
Middle third	Bladder	Rectovaginal fascia/septum	Pubovaginalis muscle

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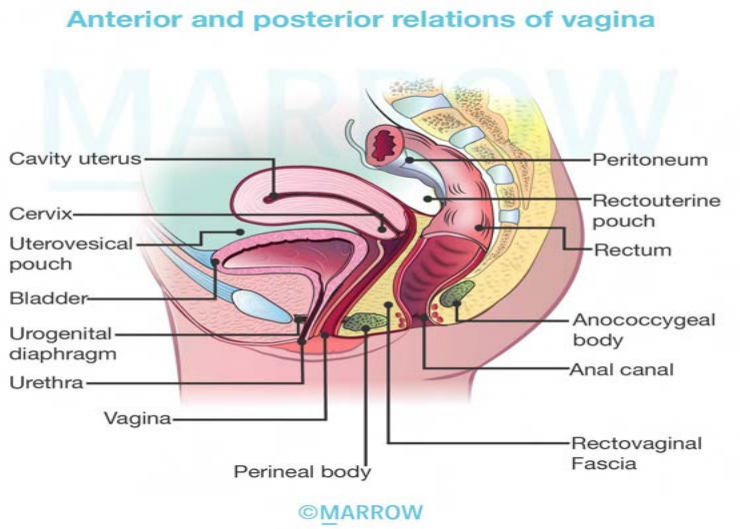
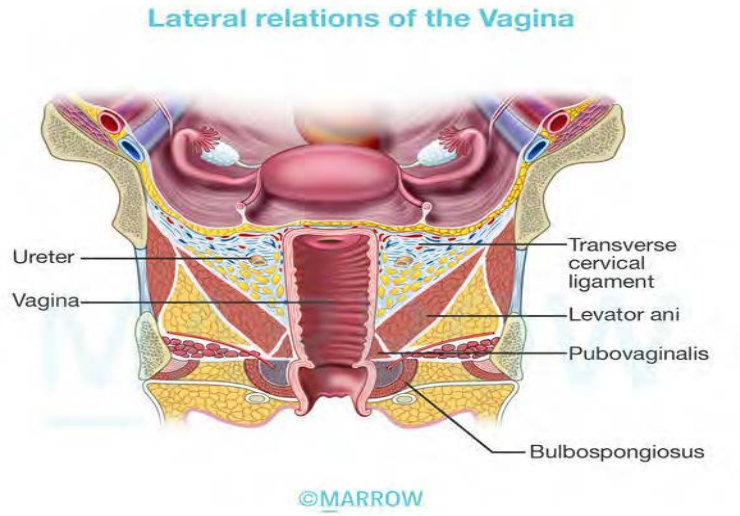
Parts of vagina	Anterior relation	Posterior relation	Lateral relation
Lower third	Urethra	Perineal body	Bulbospongiosus





Solution to Question 22:

The internal iliac artery gives rise to the azygous arteries of the vagina.

The azygous arteries are longitudinal median vessels and run on the anterior and posterior surfaces of the vagina. The vagina also receives blood supply from the uterine, internal pudendal, and middle rectal branches of the internal iliac artery.

Blood supply of the female reproductive system:

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Structure	Arterial supply	Venous drainage
Vulva	Superficial and deep external pudendal arteries of the femoral arteryInternal pudendal artery (inferior part of the vulva)	Via external pudendal veins to the long saphenous vein
Clitoris	Branches of the internal pudendal artery	Via deep dorsal veins into the internal pudendal veinVia superficial dorsal veins into the external pudendal and long saphenous veins
Vagina	Azygous arteries of the vagina from the internal iliac artery	Via vaginal vein into the internal iliac vein
Uterus	Uterine artery from the anterior division of the internal iliac artery	Via uterine veins into the internal iliac vein
Fallopian tube	Medial two-third - uterine arteryLateral one-third - ovarian artery	Medial two-third - via uterine plexus into the internal iliac veinLateral one third - via the pampiniform plexus into the IVC on the right and the renal vein on the left
Ovary	Ovarian artery (direct branch of the abdominal aorta)	Ovarian veins emerge as a pampiniform plexus and form the ovarian veins draining into the IVC on the right, and the renal vein on the left side.

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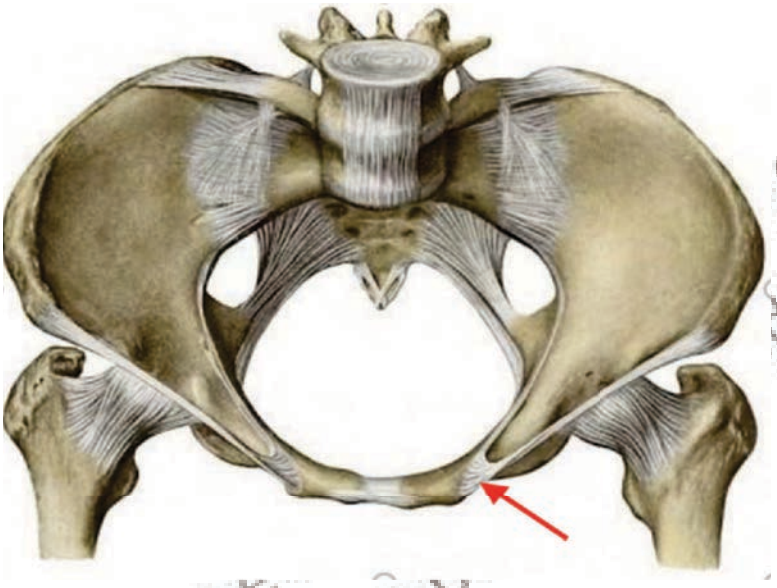
Pelvis & Perineum

Question 1:

Identify the structure marked in the image below.



a) Poupart's ligament

b) Lacunar ligament

c) Cooper's ligament

d) Conjoint tendon

Question 2:

Which of the following statements is true about the iliopubic tract?

a) It is a thickening of the lumbar fascia

b) It lies anterior to the Poupart's ligament

c) It inserts into the pubic tubercle in front of the conjoint tendon

d) Its fibers fan out with fascia iliaca laterally

Question 3:

Which of the following does not form the bony pelvis?

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a) Pubis

b) Ilium

c) L_5

d) Coccyx

Question 4:

A 33-year-old primigravida presented at term with non-engagement of the fetal head. She is suspected to have cephalopelvic disproportion at the level of inlet. Which of the following does not form the boundary of the involved structure?

a) Sacral promontory

b) Ischial tuberosity

c) Pecten Pubis

d) Pubic symphysis

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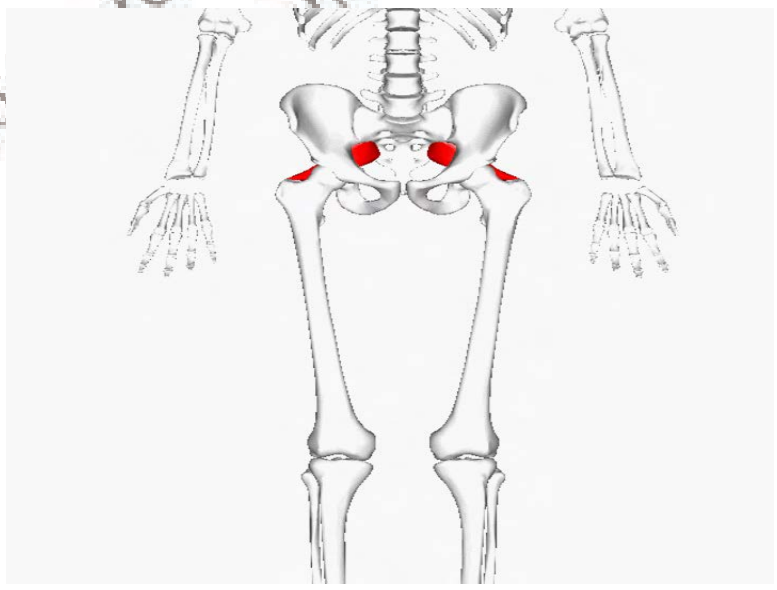
Question 5:

A patient with sciatica was found to have inflammation of the muscle marked below. Identify it.



a) Piriformis

b) Gamellus superior

c) Gluteus minimus

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d) Quadratus femoris

Question 6:

Which of the following forms the anterolateral wall of the true pelvis?

a) Obturator externus

b) Piriformis

c) Obturator internus

d) Levator ani

Question 7:

An elderly woman presented with the following finding. Weakness of which of the following muscles could not have led to this condition?

a) Puborectalis

b) Pubococcygeus

c) Ischiococcygeus

d) Iliococcygeus

Question 8:

Which of the following is false about the levator ani?

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a) Contraction leads to occlusion of the vaginal canal

b) Puborectalis and pubococcygeus creates the anorectal angle

c) Helps in maintaining rectal tone

d) Arises from the condensation of the piriformis fascia

Question 9:

During the evaluation of a patient with erectile dysfunction, his internal pudendal artery was found to be stenosed. Which of the following■ vessels is this a branch of?

a) Anterior division of internal iliac artery

b) Posterior division of internal iliac artery

c) External iliac artery

d) Iliolumbar artery

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Question 10:

While examining a patient with a direct inguinal hernia, you note that the sac protrudes through the Hesselbach's triangle. Where does the structure forming its lateral boundary originate from?

a) Anterior trunk of the internal iliac artery

b) Posterior trunk of the internal iliac artery

c) External iliac artery

d) Femoral artery

Question 11:

Which of the following is a tributary of the common iliac vein?

a) Middle rectal vein

b) Superior gluteal vein

c) Inferior gluteal vein

d) Median sacral vein

Question 12:

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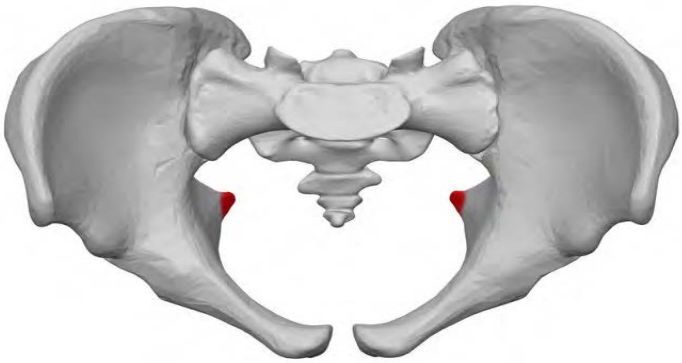
Which of the following structures given below is related to the structure highlighted (red) in the image?



a) Pudendal nerve

b) Sciatic nerve

c) Obturator nerve

d) Femoral nerve

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Question 13:

Which of the following does not form an anatomical boundary of the perineum?

a) Arcuate ligament of pubis

b) Sacrotuberous ligaments

c) Sacrospinous ligaments

d) Coccyx

Question 14:

A line between which of the following structures divides the perineum into anterior and posterior triangles?

a) Right and left ischial spines

b) Symphysis pubis and sacral promontory

c) Right and left ischial tuberosities

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d) Symphysis pubis and coccyx

Question 15:

A 30-year-old man with a history of blunt trauma to the pelvis was diagnosed with urethral rupture. Imaging revealed extravasation of the urine into the superficial perineal pouch. The attachment of which ■of the following fascia prevents extravasation into the thigh and anal triangle?

a) Fatty layer of Camper

b) Membranous layer of Scarpa

c) Buck's fascia

d) Colle's fascia

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Question 16:

Which of the following is not a content of the superficial perineal pouch?

a) Root of penis

b) Bulbospongiosus muscle

c) Great vestibular glands

d) Bulbourethral glands

Question 17:

Which of the following is not a content of the deep perineal pouch?

a) Dorsal nerve of penis

b) Bulbourethral gland

c) Root of penis

d) Sphincter urethrae

Question 18:

Which of the following muscles is not involved in the formation of the perineal body?

a) Bulbospongiosus muscle

b) Superficial transverse perineal muscles

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c) Deep transverse perineal muscles

d) Internal anal sphincter muscle

Question 19:

A surgeon is dissecting the ischioanal fossa in a patient with anal cancer. Which of the following statements is correct about its boundaries?

a) Posterior boundary is the perineal membrane

b) Anterior boundary is the sacrotuberous ligament

c) Lateral boundary is the obturator internus

d) Medial boundary is the gluteus maximus

Question 20:

The fascia of which of the following muscles is involved in the formation of the Alcock's canal?

a) Levator ani

b) Obturator internus

c) External anal sphincter

d) Gluteus minimus

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Answer Key

Question No.	Correct Option
1	b
2	d
3	c
4	b
5	a
6	c
7	c
8	d
9	a

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10	c
11	d
12	a
13	c
14	c
15	d
16	d
17	c
18	d
19	c
20	b

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Detailed Explanations

Solution to Question 1:

The structure marked is the lacunar ligament.

Lacunar (Gimbernat's) ligament - It is a thick triangular band of tissue formed from fibres of the medial end of the inguinal ligament and fascia lata. It forms the medial wall of the femoral canal. The apex of the triangle is attached to the pubic tubercle.

Inguinal (Poupart's) ligament - The thick external oblique aponeurosis stretched between ASIS (anterior superior iliac spine) and pubic tubercle.

Pectineal (Astley-Cooper's) ligament - A strong fibrous band that extends laterally along the pectineal line from the pectineal attachment of the lacunar ligament.

Conjoint tendon - It is a condensation of tissue that runs through the lateral edge of the lower rectus sheath. It is formed from the common aponeurosis of the internal oblique muscle and transverse abdominis muscle. The fibers turn inferiorly and insert into the crest of the pubis at the pectineal line immediately deep to the superficial inguinal ring.

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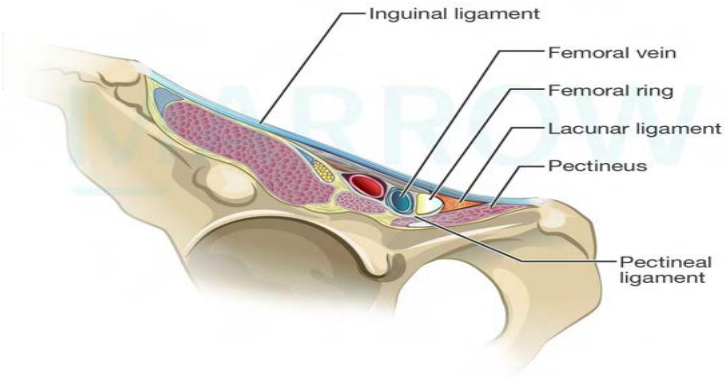
Inguinal ligament and associated structures



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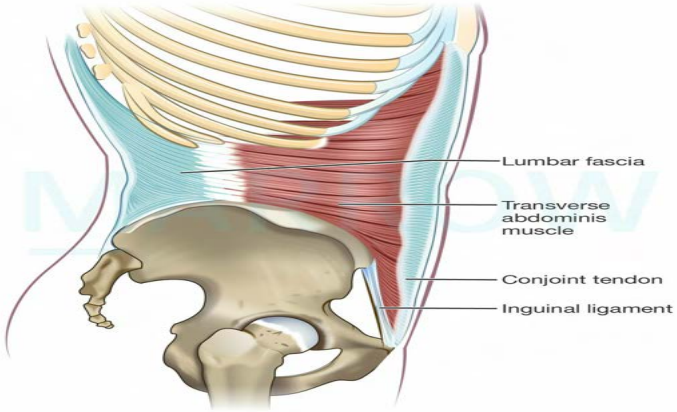
Conjoint tendon Anterior abdominal wall



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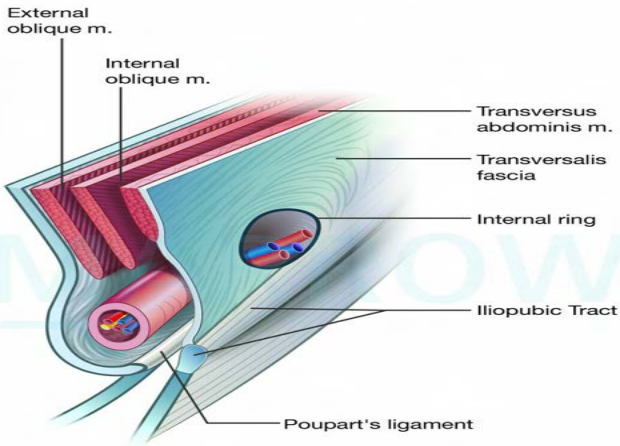
Iliopubic Tract



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Solution to Question 2:

The fibers of the iliopubic tract fan out with fascia iliaca laterally.

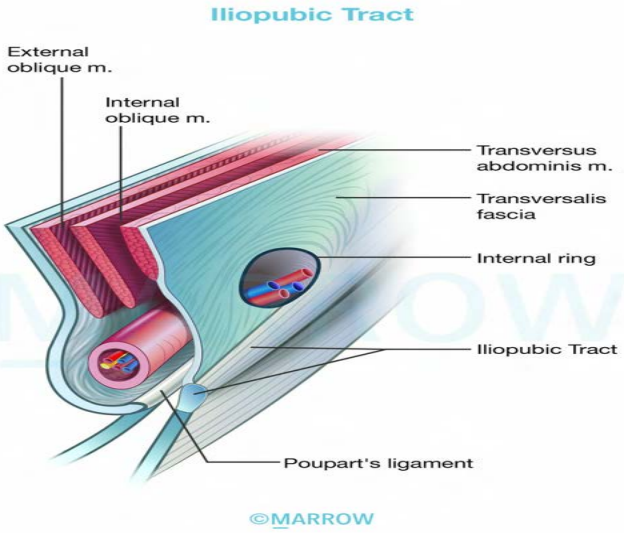
The iliopubic tract is a thickening of the transversalis fascia lying immediately posterior to the inguinal (Poupart's) ligament. It extends from the anterior superior iliac spine (ASIS) superolaterally and arches across the front of the femoral sheath.

Attachments:

• Medially, its fibres insert by a broad attachment into the pubic tubercle and pectineal line, behind the conjoint tendon.

• Laterally, its fibres fan out within the fascia transversalis and fascia iliaca without bony attachment to the iliac spines.

Clinical note: It is considered as an important landmark in laparoscopic hernia surgeries.



Solution to Question 3:

The L5 lumbar vertebra does not form the bony pelvis.

The bony pelvis consists of four bones:

• two hip bones

• sacrum

• coccyx

The articulations of these bones form four joints which are:

• Two sacroiliac joints – Between the ilium of the hip bones, and the sacrum.

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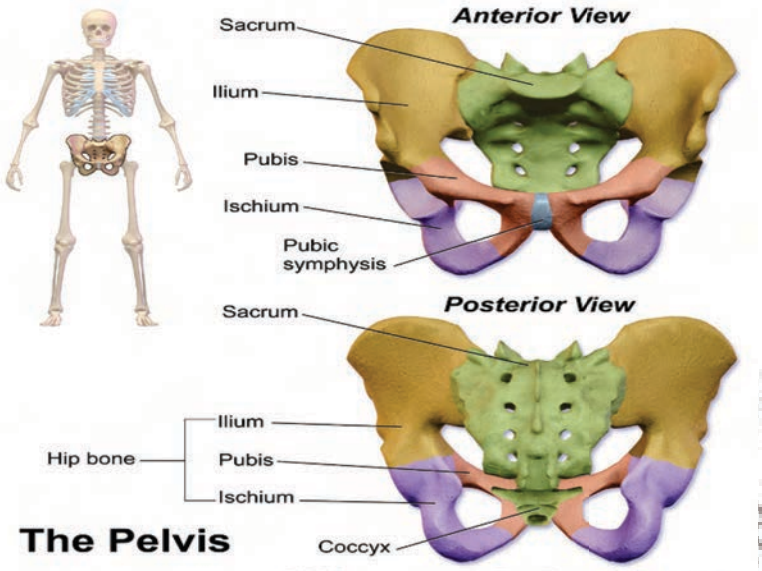
• Sacrococcygeal symphysis – Between the sacrum and the coccyx.

• Pubic symphysis – Between the pubis bodies of the two hip bones.



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Solution to Question 4:

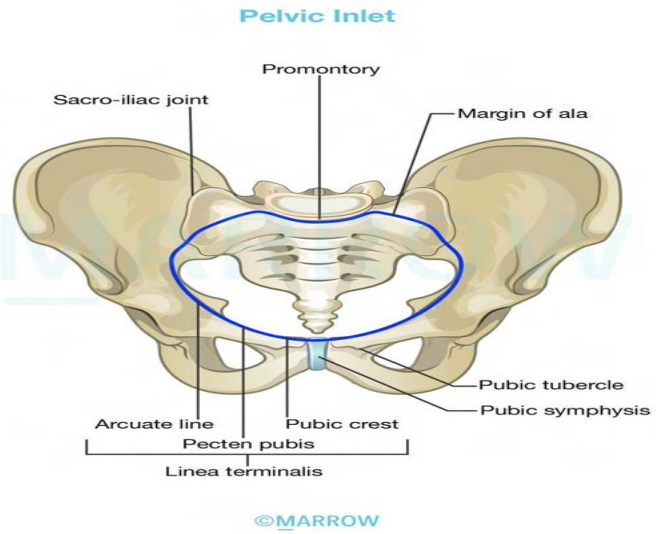
The structure involved in cephalopelvic disproportion at the level of inlet is the pelvic inlet. Ischial tuberosity does not form a boundary of the pelvic inlet.

Boundaries of the pelvic inlet:

• Posterior - sacral promontory

• Lateral - arcuate line on the inner surface of the ilium and the pectineal line on the superior ramus.

• Anterior - pubic symphysis



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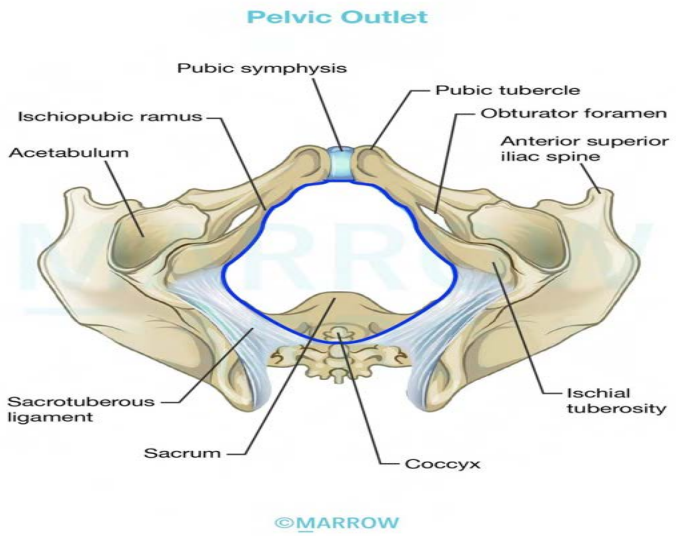
Boundaries of the pelvic outlet:

• Posterior - tip of the coccyx

• Lateral - ischial tuberosities and the inferior margin of the sacrotuberous ligament

• Anterior - pubic arch



Clinical significance:

Cephalopelvic disproportion can occur when any of the inlet or outlet diameters are shortened by more than 0.5 cm, thus leading to the fetal head not getting engaged during labor. A primigravida presenting with a non-engaged head at term should raise suspicion of a contracted pelvis and cephalopelvic disproportion.

Solution to Question 5:

The marked muscle is the piriformis muscle.

• Origin:

• The anterior surface of the sacrum

• The posterior inferior iliac spine

• The capsule of the sacroiliac joint

• Sacrotuberous ligament

• Insertion - greater trochanter of the femur.

• Action - lateral rotation of the thigh in extension and abduction of the thigh in the flexed position

The muscle forms the posterolateral wall of the pelvic cavity. The sciatic nerve is closely related to the muscle and it passes through the muscle fibres or below the muscle.

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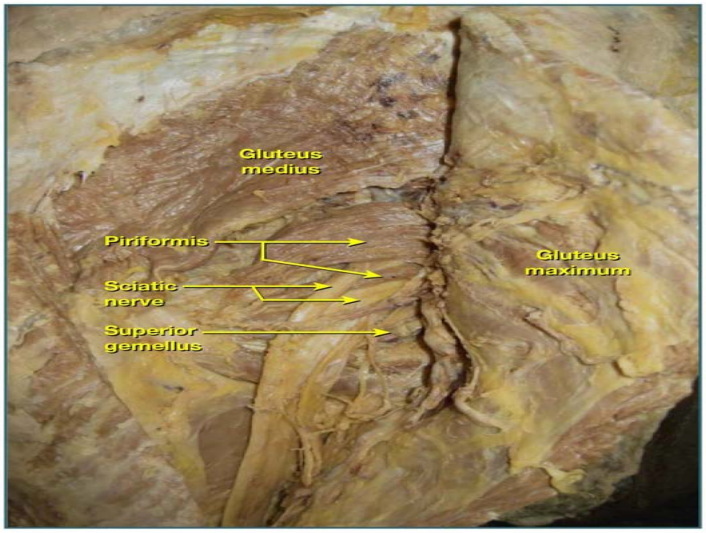
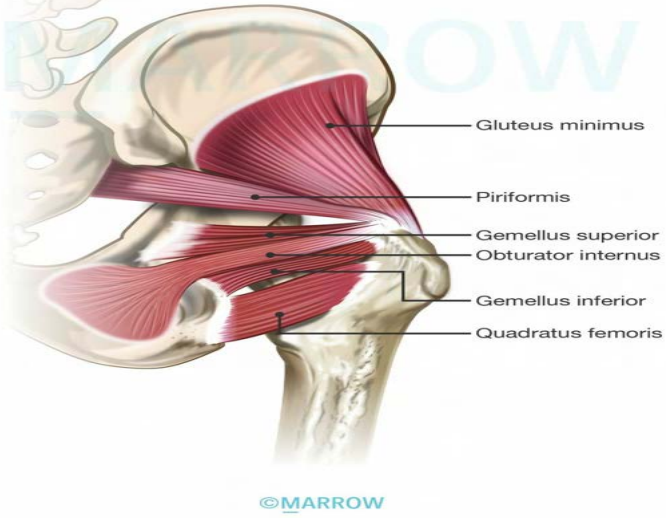
Clinical significance:

Piriformis syndrome is a clinical condition characterized by the compression of the sciatic nerve by the piriformis muscle. This can occur due to inflammation of the piriformis muscle. The patient will present with pain along the distribution of the sciatic nerve which is also known as sciatica.

The following image shows relationship of sciatic nerve with the piriformis.





Solution to Question 6:

Obturator internus with its fascia forms the anterolateral wall of the true pelvis.

Muscles forming walls of the true pelvis:

• Anterolateral wall - obturator internus and the fascia over its upper and inner (pelvic) surface.

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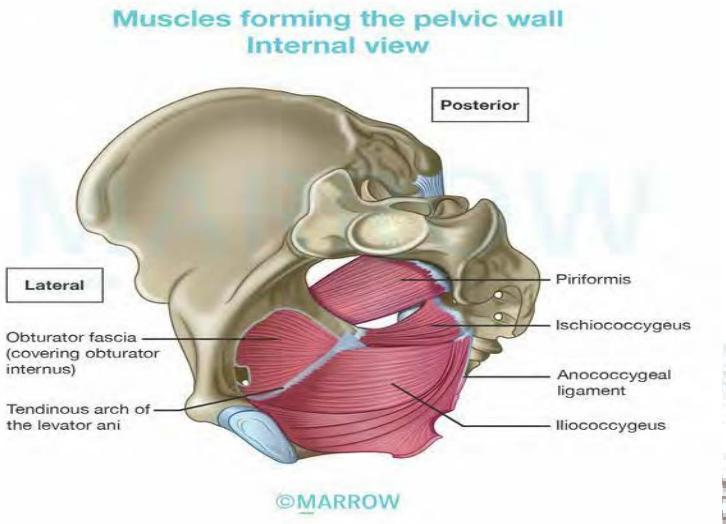
• Posterolateral wall - piriformis

• Floor - levator ani and coccygeus



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Solution to Question 7:

The given case scenario and image is suggestive of uterine prolapse which occurs due to weakness of the levator ani muscle. Ischiococcygeus is not a part of the levator ani. It is a separate muscle that lies at the posterosuperior part of the pelvis and is not a part of the supports of the uetrus.

The levator ani forms a large portion of the pelvic floor. It is composed of three separate paired muscles:

• Pubococcygeus – this starts from the posterior part of the pubis and runs lateral to the urethra and it' spinchter while passing through the pelvic floor.

• Puborectalis - This muscle starts from the ischiopubic rami and runs medial to pubococcygeus and iliococcygeus to terminate posterior to the rectum at anorectal junction.

• Iliococcygeus - This muscle is placed posterior most as a triangular musculotendinous sheet where the apex is attached to the tip of the ischial spine and the base is attached to the lateral margin of coccyx and the fifth sacral segment.

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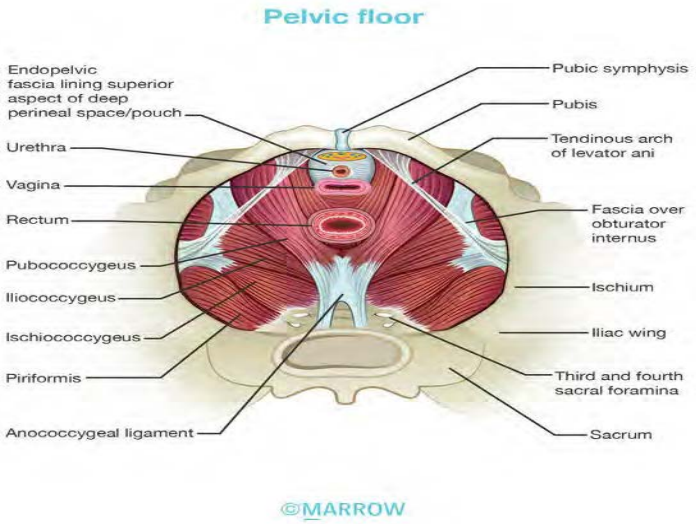

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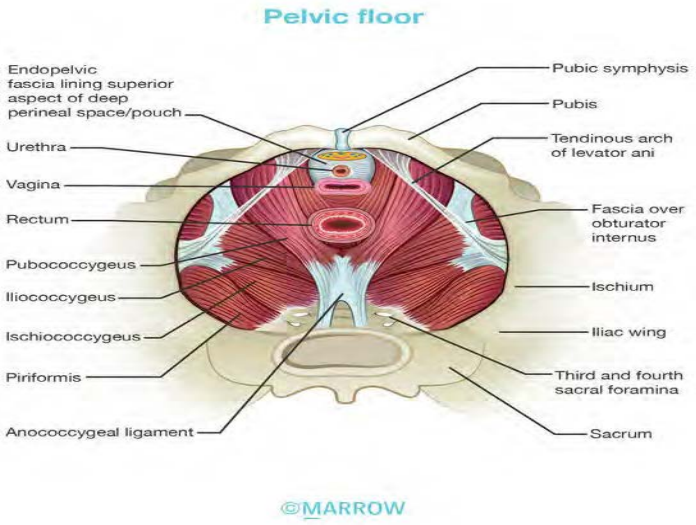
Solution to Question 8:

The levator ani muscle arises from condensations of the obturator fascia which forms the tendinous arch of the levator ani.

The vaginal, urethral, and rectal lumen are occluded by the contraction of the levator ani and relaxation of the muscle is needed for defecation and urination.

The pubococcygeus and puborectalis parts of the levator ani help maintain the tone of the rectum as well as create the anorectal angle.



Solution to Question 9:

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The anterior division of the internal iliac artery gives rise to the internal pudendal artery.

The internal iliac artery is the major artery of the pelvis. At the superior border of the greater sciatic foramen in the pelvis, it divides into anterior and posterior trunks.

Branches of the anterior trunk of internal iliac artery:

• Obturator artery

• Superior vesical artery

• Inferior vesical artery

• Inferior gluteal artery

• Middle rectal artery

• Vaginal artery (in females)

• Uterine artery (in females)

• Internal pudendal artery

Branches of the posterior trunk of internal iliac artery:

• Iliolumbar artery

• Lateral sacral arteries

• Superior gluteal artery

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Solution to Question 10:

The lateral boundary of Hesselbach's triangle is formed by the inferior epigastric artery. It originates from the external iliac artery.

The external iliac artery is the main artery of the lower limb. Its branches are:

• Deep circum■ex iliac

• Inferior epigastric

• Small branches to psoas major and nearby lymph nodes

• Femoral artery

Clinical significance:

Apart from being a landmark in hernia surgery, the inferior epigastric artery contributes to the corona mortis. This is an anastomosis between the common iliac, internal iliac, obturator, inferior epigastric, and external iliac vessels. Iatrogenic injury in this region leads to torrential hemorrhage.

Solution to Question 11:

The median sacral vein is a tributary of the common iliac vein.

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Tributaries of common iliac vein:

• Median sacral veins

• Iliolumbar vein

• Lateral sacral veins (occasionally)

Tributaries of internal iliac vein:

• Superior and inferior gluteal veins

• Internal pudendal vein

• Obturator vein

• Lateral sacral veins (usually)

• Middle rectal vein

• Vesical veins

• Uterine and vaginal veins

Tributaries of external iliac vein:

• Inferior epigastric vein

• Deep circum■ex iliac vein

• Pubic vein

Clinical Note: Agenesis of the external iliac vein has been reported in association with Klippel–Trenaunay syndrome.

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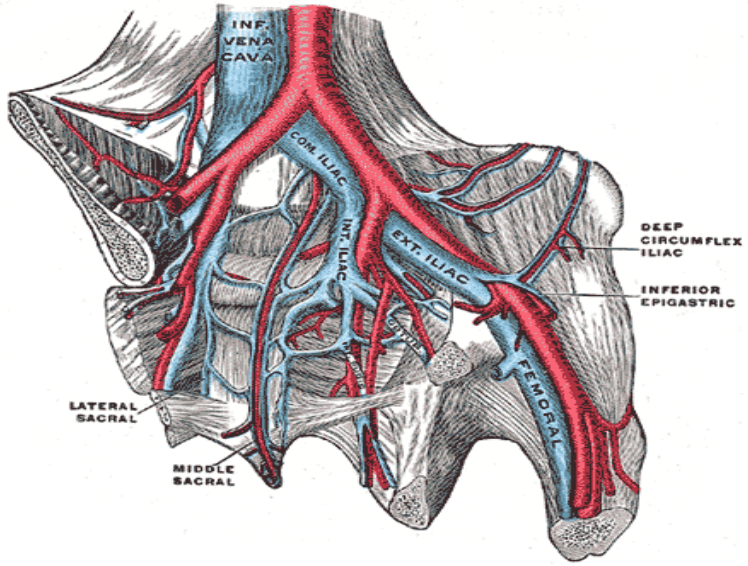

Solution to Question 12:

The structure marked in red is the ischial spine and the pudendal nerve is related to it.

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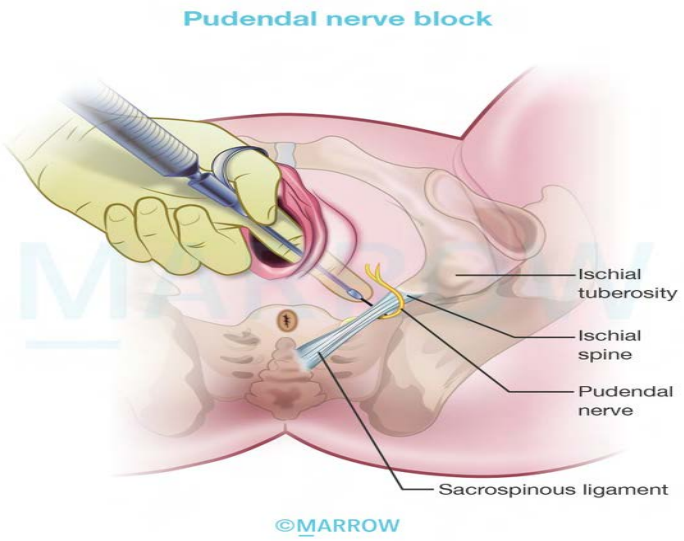
The pudendal nerve originates from the sacral plexus S2-S4. It exits out of the pelvis by passing through the greater sciatic foramen. It then enters the perineum below the pelvic floor by passing around the ischial spine. The ischial spine is used as a landmark for pudendal nerve block.



Solution to Question 13:

The sacrospinous ligament does not form an anatomical boundary of the perineum.

The perineum is a diamond-shaped region that overlies the pelvic outlet.

Boundaries of perineum:

- Anteriorly: Pubic symphysis and its arcuate ligament.
- Posteriorly: Coccyx
- Anterolaterally: Ischiopubic rami and the ischial tuberosities.
- Posterolaterally: Sacrotuberous ligaments

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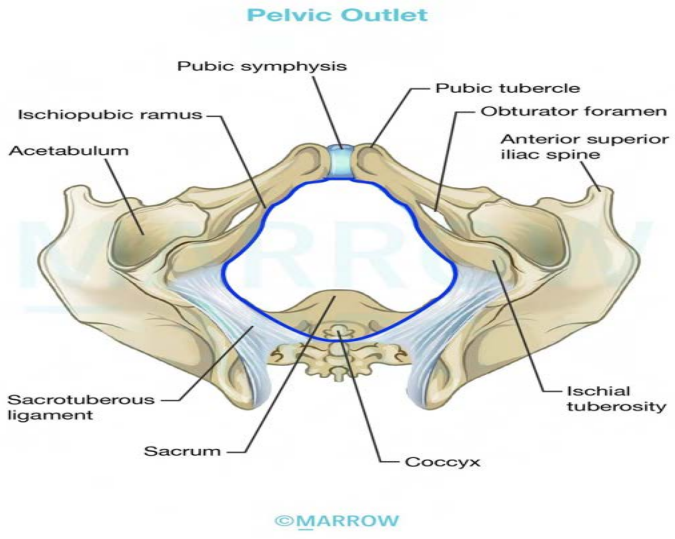

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Solution to Question 14:

An imaginary line joining the ischial tuberosities (the inter-ischial line) divides the perineum into an anterior urogenital triangle and a posterior anal triangle.

The urogenital triangle faces downwards and forwards and has the following structures:

In males:

• Scrotum

• The root of the penis

In females:

• Mons pubis

• Labia with the vestibule

The anogenital triangle faces downwards and backwards and has the following structures common to both males and females:

• Anal canal with its sphincters

• Ischioanal fossa with its contents

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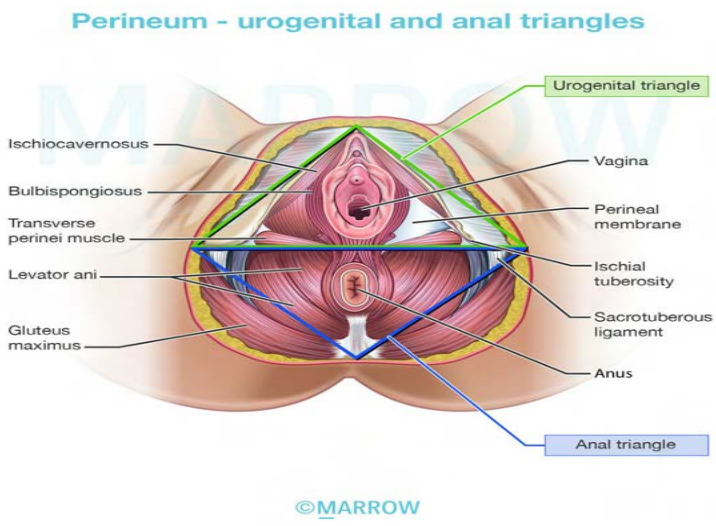

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Solution to Question 15:

Colle's fascia prevents the extravasation of the urine from spreading into the thigh and anal triangle.

Scarpa's fascia is continuous with the superficial fascia of the scrotum and becomes the Colles' fascia. In women, it continues into the labia majora and is continuous with the fascia of the perineum. Colle's fascia has the following attachments:

• Posterior - perineal membrane. It prevents the extravasation of fluids such as blood, pus, or urine into the anal triangle.

• Lateral - ischiopubic rami and fascia lata along Holden's line. This line extends from the pubic tubercle laterally for 8 cm. It prevents the extravasation of fluids into the thigh.

Option A: Camper's fascia is the superficial fatty layer of the superficial fascia of the abdomen.

Option B: Scarpa's fascia is the deep membranous layer of the superficial fascia of the abdomen.

Option C: Buck's fascia is the deep fascia of the penis

Clinical significance:

When a urethral injury occurs, urine can extravasate into the superficial perineal pouch, penis, scrotum, labia majora and the anterior abdominal wall.

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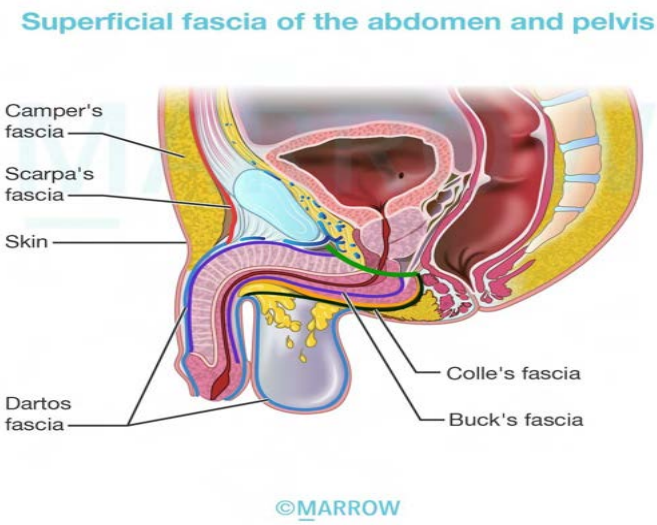

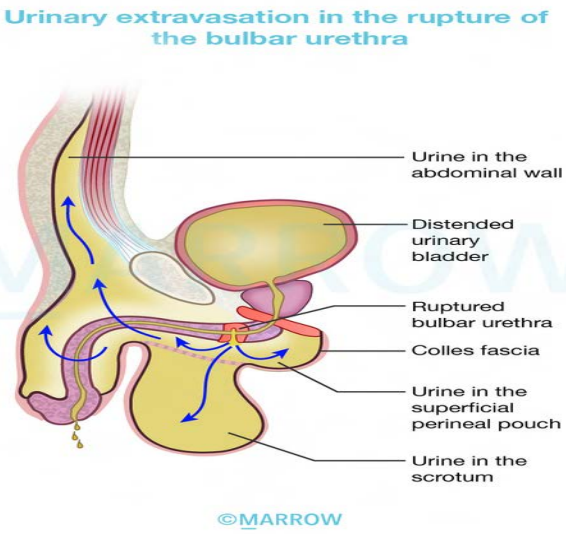

Solution to Question 16:

Bulbourethral glands are not a content of the superficial perineal pouch. They are located in the deep perineal pouch.

The superficial perineal pouch is a potential space between the perineal membrane above and the membranous layer of perineal fascia (Colle's fascia) below.

Contents of superficial perineal pouch:

Males	Common to both	Females
Root of the penis	Urethra	Body of the clitoris

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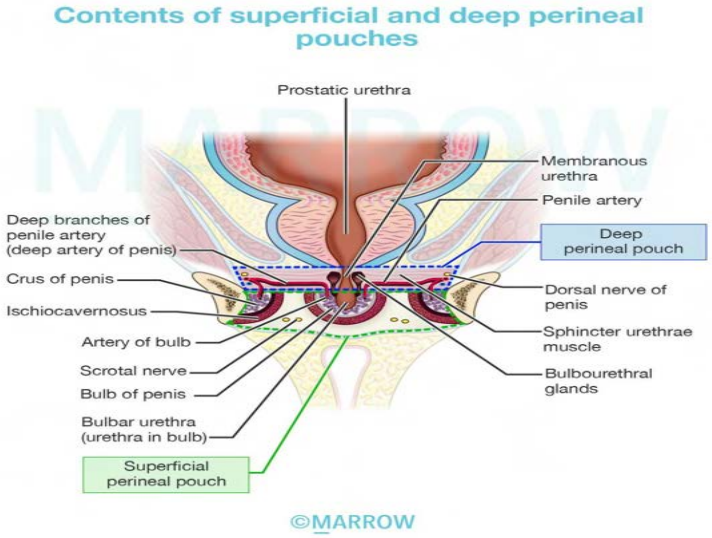
Males	Common to both	Females
Muscles:Two corpora cavernosaCorpora spongiosa	Muscles:Superficial transverse perineiIschiocavernosusBulbocavernosus	Bulbs of vestibule
Perineal nerve branches:Posterior scrotumBulb of penis	Perineal nerve: muscular branches	Perineal nerve branches:LabiaBulbs of vestibule
Perineal artery branches:Posterior scrotal arteryBranches of the penile artery	Perineal artery branches:Transverse perineal branch	Perineal artery branches:Posterior labial arteryBranches of the clitoral artery
The duct of the bulbourethral gland		Greater vestibular gland and its ducts



Solution to Question 17:

The root of the penis consists of two crura and one bulb. It is a content of the superficial perineal pouch.

The deep perineal pouch is used to describe the space enclosed between the endopelvic fascia and the perineal membrane and includes the following contents:

Males	Common to both	Females
Nerves: Dorsal nerve of penis	Muscles:Deep transverse perineiSphincter urethrae	Nerves: Dorsal nerve of clitoris
Arteries:Penile arteryOrigin of the branches of the penile artery	Arteries:Origin of the urethral artery	Arteries:Clitoral arteryOrigin of the branches of the artery of clitoris
Bulbourethral glands	Urethra	

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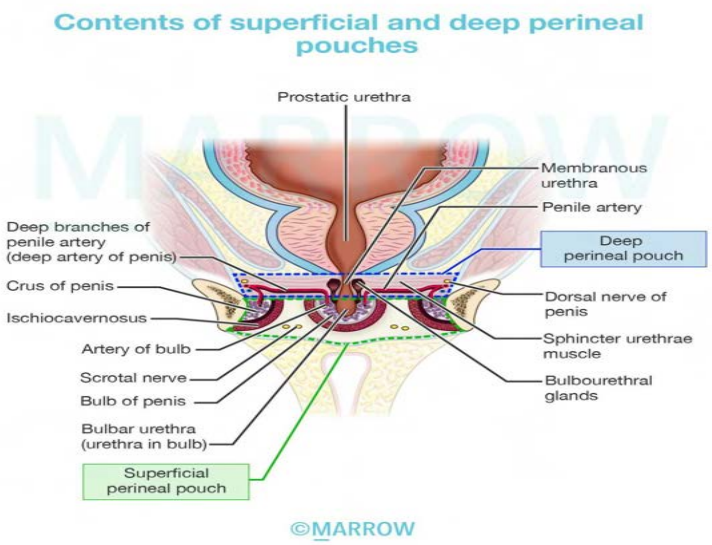

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Solution to Question 18:

The internal anal sphincter is not involved in the formation of the perineal body.

The perineal body is a fibromuscular structure present in the midline at the junction between the anal and urogenital triangle. It attaches to various muscles in the pelvis:

- Anterior - superficial and deep transverse perinei, bulbospongiosus
- Posterior - external anal sphincter
- Superior - puborectalis, pubovaginalis and the rectovaginal septum

It is continuous with the perineal membrane and the superficial perineal fascia. In males, it continues as the perineal raphe, and in females, it is attached to the posterior commissure and the introitus.

The following image shows the perineal body and its muscular attachments.

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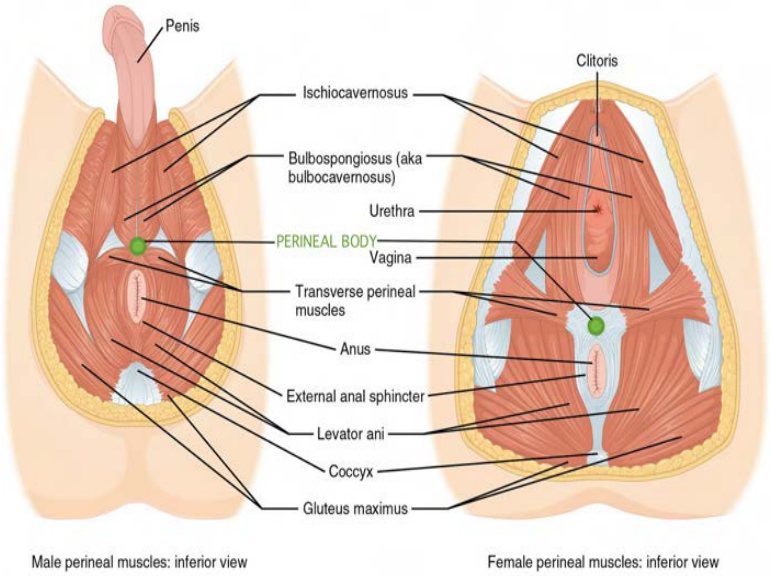

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Solution to Question 19:

The lateral boundaries of the ischioanal fossa are formed by obturator internus(with its fascia).

The ischioanal fossa is a wedge-shaped space on either side of the anal canal in the anorectal triangle. It has a pad of fat. The boundaries include:

• Anterior: Posterior border of perineal membrane

• Posterior: Gluteus maximus muscle, Sacrotuberous ligament

• Lateral: Ischial tuberosity, Obturator internus

• Medial: Sphincter ani externus, Pelvic diaphragm (levator ani).

Clinical significance:

Ischioanal fossa provides a relatively bloodless field during resection of anal cancers, therefore it is an important surgical plane.

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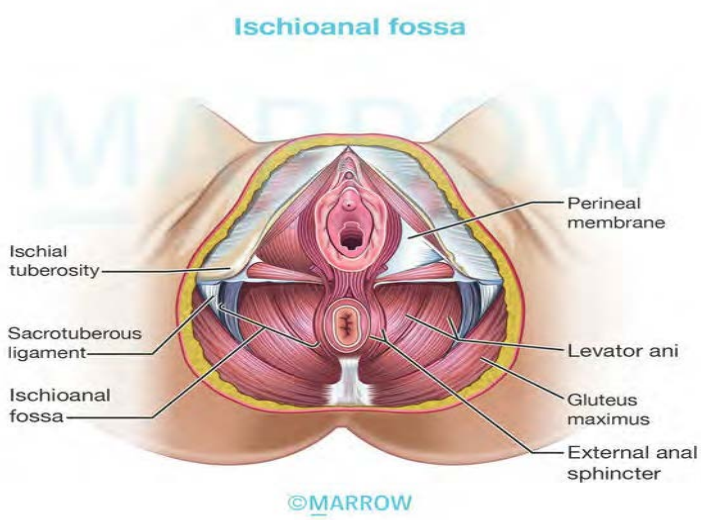

Solution to Question 20:

The Alcock's (pudendal) canal is formed by the fascia of the obturator internus muscle.

It is formed by connective tissue binding the vessels and nerve to the medial surface of the fascia covering obturator internus.

Contents of the pudendal canal:

• Internal pudendal artery and vein

• Pudendal nerve

Clinical significance:

• Infiltration of a local anesthetic around the trunk of the pudendal nerve at the level of the ischial spine results in analgesia of the lower vagina, posterior perineum, and vulva.

• Pudendal neuralgia can occur due to compression of pudendal nerve in the pudendal canal.

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Bones of the Lower Limb

Question 1:

A crying 3-year-old boy is brought by his mother and stepfather following an alleged history of a fall. X-ray shows a spiral fracture of the proximal femur. Which structure is related to the anterior surface of the affected bone?

a) Linea aspera

b) Pectineal line

c) Intertrochanteric line

d) Intertrochanteric crest

Question 2:

What is the normal angle of the neck of the femur to the shaft?

a) 105°

b) 125°

c) 135°

d) 115°

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Question 3:

An 80 kg boy with hypothyroidism developed sudden pain in the left hip with restricted abduction and internal rotation as a result of a minor fall. What is true about the linea aspera of the affected bone?

a) It is present on the anterior surface

b) It gives attachment to the long head of biceps femoris

c) The lateral border continues as pectineal line

d) It gives attachment to the adductor longus

Question 4:

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A 60-year-old woman develops osteonecrosis of the femoral head after a trivial fall. Which of the following arteries supply the affected part?

a) Lateral epiphyseal artery

b) Medial circumflex femoral artery

c) Ligamentous teres artery

d) Lateral circumflex femoral artery

Question 5:

Which of the following provides the nutrient artery to the femur?

a) Femoral artery

b) Lateral circumflex femoral artery

c) Medial circumflex femoral artery

d) Profunda femoris artery

Question 6:

On performing USG of a full-term fetus, which of the following ossification centers is likely to be seen?

a) Head of the femur

b) Greater trochanter

c) Lesser trochanter

d) Distal end of femur

Question 7:

A patient came to the casualty after a road traffic accident with a fracture of the femur. The upper end of this fractured bone ossifies from how many ossification centers?

a) 1

b) 2

c) 3

d) 4

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Question 8:

What type of bone is the patella?

a) Flat bone

b) Pneumatic bone

c) Sesamoid bone

d) Irregular bone

Question 9:

Which of the following forms the apex of the tibial triangular area?

a) Epicondyle

b) Tibial crest

c) Tibial tuberosity

d) Malleolus

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Question 10:

At what time of intra-uterine life, would you be able to see the primary ossification center of the tibia on an USG?

a) 3rd week

b) 5th week

c) 7th week

d) 9th week

Question 11:

Which of the following structures is attached to the head of the bone depicted in the image below?

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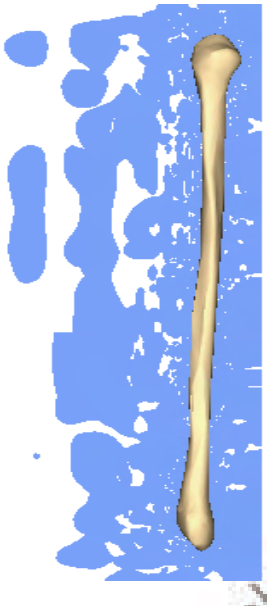

a) Lateral meniscus

b) Popliteus tendon

c) Biceps femoris

d) Posterior cruciate ligament

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Question 12:

An adolescent presented with a foot drop was found to have an injury to the common peroneal nerve. Fracture at which of the following sites most likely causes the given condition?

a) Shaft of tibia

b) Shaft of fibula

c) Neck of fibula

d) Tibial tuberosity

Question 13:

The fibula ossifies from how many ossification centres?

a) 2

b) 3

c) 4

d) 5

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Question 14:

Which of the following bones is interposed between the head of the talus and the cuneiforms?

a) Calcaneus

b) Cuboid

c) Navicular

d) Metatarsal

Question 15:

The sustentaculum tali is a projection present on which of the following tarsal bones?

a) Talus

b) Calcaneus

c) Navicular

d) Cuneiforms

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Answer Key

Question No.	Correct Option
1	c
2	b
3	d
4	b
5	d
6	d
7	c
8	c
9	c
10	c
11	c
12	c
13	b

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14	c
15	b

Detailed Explanations

Solution to Question 1:

The structure related to the anterior surface of the affected bone i.e. the proximal femur is the intertrochanteric line. It is present at the junction of the neck and shaft of the femur.

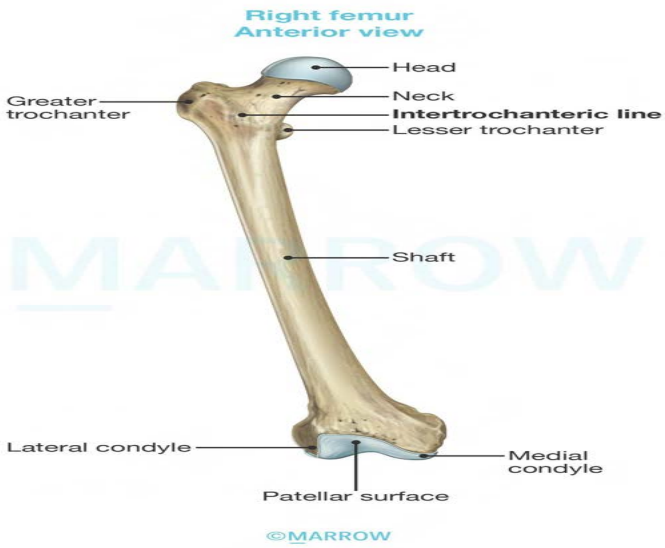
The femur can be divided into:

• Proximal femur - consists of the head, neck, greater and lesser trochanters. The intertrochanteric line is present on the anterior surface at the junction of the neck and shaft of the femur. The intertrochanteric crest is present on the posterior surface.

• Shaft of the femur - consists of linea aspera (bony crest present on the posterior surface), gluteal tuberosity, and pectineal line.

• Distal femur - consists of the medial condyle, lateral condyle, intercondylar fossa, and patellar surface.

The images given below shows the anatomy of the femur bone.



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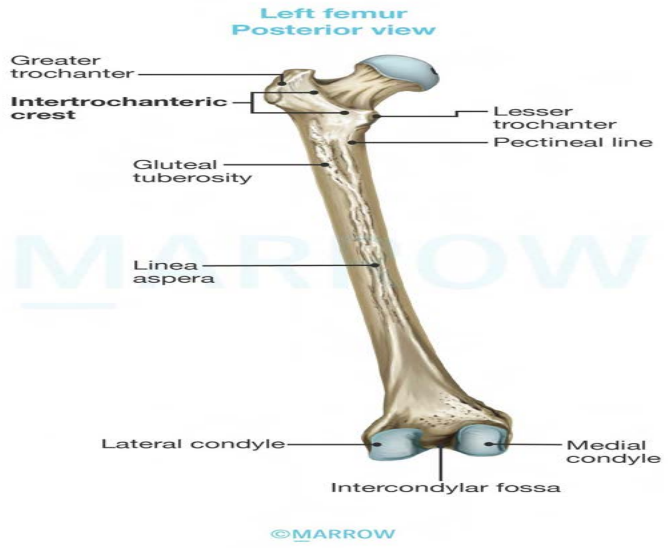

Spiral fractures of long bones such as femur or humerus in a child suggest an external application of a twisting force. This is highly suspicious of non-accidental trauma. The probable diagnosis is battered baby syndrome.

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Solution to Question 2:

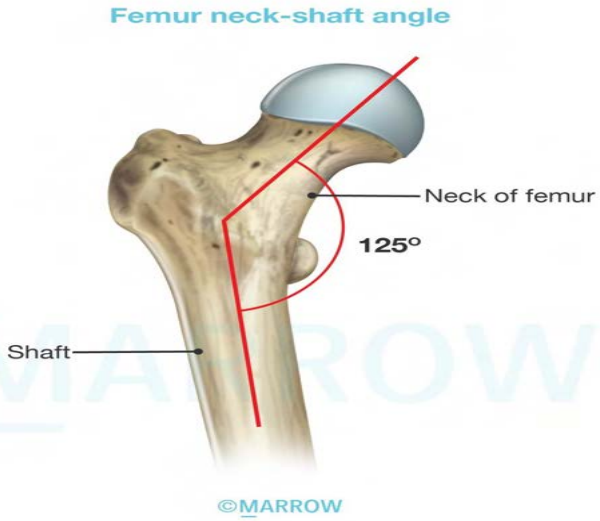
The normal angle of the neck of the femur to the shaft is approximately 125°. This is known as neck-shaft angle or angle of inclination.

This facilitates the movement at the hip joint, enabling the limb to move freely.

• When the angle is > 135°, the condition is known as coxa valga

• When the angle is < 120°, the condition is known as coxa vara

The image given below shows the normal neck-shaft angle of femur.



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Solution to Question 3:

The given clinical scenario is suggestive of slipped capital femoral epiphysis (SCFE). Linea aspera of the affected bone i.e. femur gives attachment to:

• Adductor longus

• Intermuscular septa

• Short head of biceps femoris.

Linea aspera is the roughened ridges of bone present on the posterior surface of the femoral shaft. It is made of medial and lateral edges.

Proximally:

• Medial edge is continuous as spiral line

• Lateral edge is continuous as gluteal tuberosity

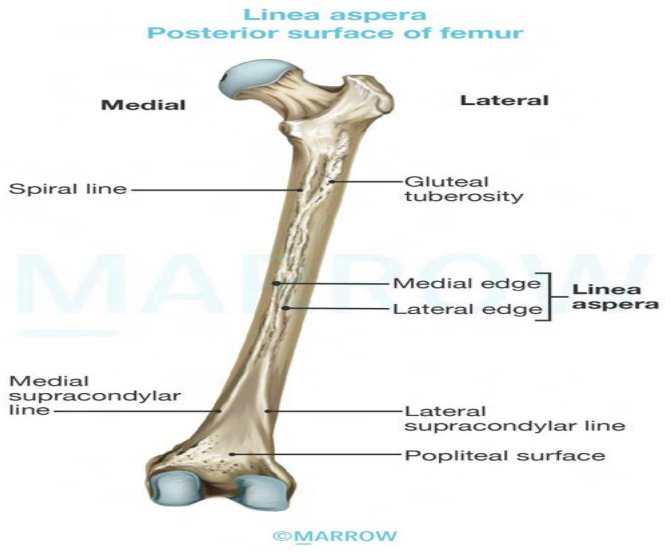
Distally:

• Medial border is continuous as medial supracondylar line

• Lateral border is continuous as lateral supracondylar line

• Surface between the medial and lateral supracondylar line is the popliteal surface

The image given below shows posterior surface of the femur.



Solution to Question 4:

The arterial supply to the femoral head is mostly by the medial circumflex femoral artery.

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The blood supply of the femoral head is derived from an arterial ring (trochanteric anastomosis) around the neck of the femur constituted by:

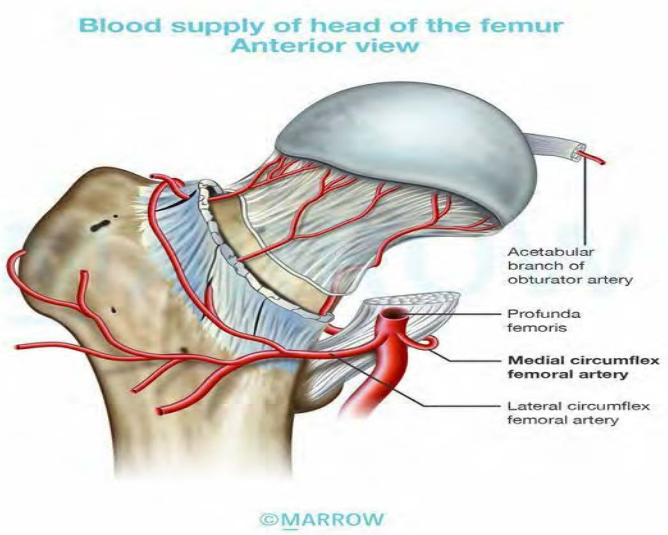
• Medial and lateral circumflex femoral arteries, branches of profunda femoris artery

• Superior and inferior gluteal vessels (minor contributions)

In the fetus and early postnatal period, the medial and lateral circumflex femoral arteries contribute equally. Whereas in the later life the supply from the lateral circumflex femoral artery diminishes and it is mainly supplied by two major arteries of the medial circumflex femoral arteries.

A small acetabular branch of the obturator artery also reaches the head, through the ligament of the head of the femur. However, it is a minor source.

The image given below shows the blood supply of the head of the femur:



Solution to Question 5:

The second perforating branch of the profunda femoris artery is the nutrient artery to the femur.

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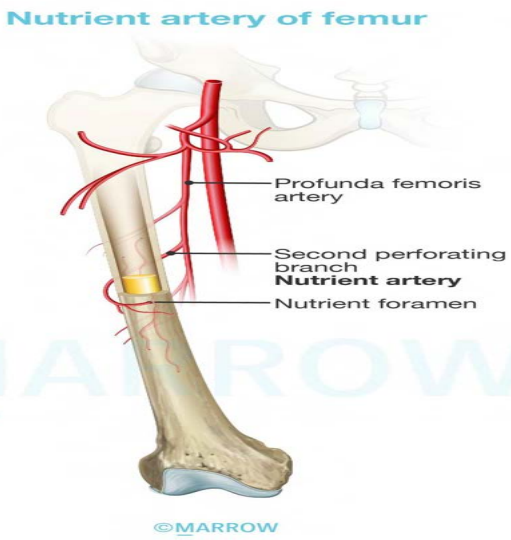

The following table shows bones of the lower limb and their nutrient arteries:

Bones of the Lower limb	Nutrient arteries
Femur	2ndperforating branch of the profunda femoris
Tibia	Branch of posterior tibial artery
Fibula	Peroneal artery, a branch of posterior tibial artery

Solution to Question 6:

The secondary ossification centres of the distal end of the femur appear at the 9th month (full-term) of intrauterine life. They form the condyles and epicondyles of the femur.

Femur ossifies from one primary centre and four secondary centres:

• Primary centre appears in the midshaft in the seventh week of the prenatal period

• The secondary ossification centres appear at the following sites:

• Distal end of the femur during ninth month of intrauterine life

• Head of the femur during six months after birth

• Greater trochanter during the fourth year

• Lesser trochanter between twelfth and fourteenth year

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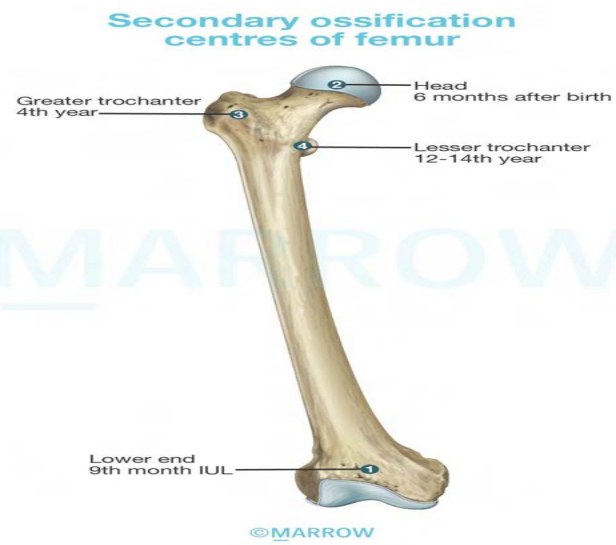

Solution to Question 7:

The upper end of the femur ossifies from 3 ossification centers:

- Head which appears at 6 months after birth
- Greater trochanter which appears at 4th year
- Lesser trochanter which appears between 12-14 years

The image given below shows secondary ossification centers of the femur.

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MARROW
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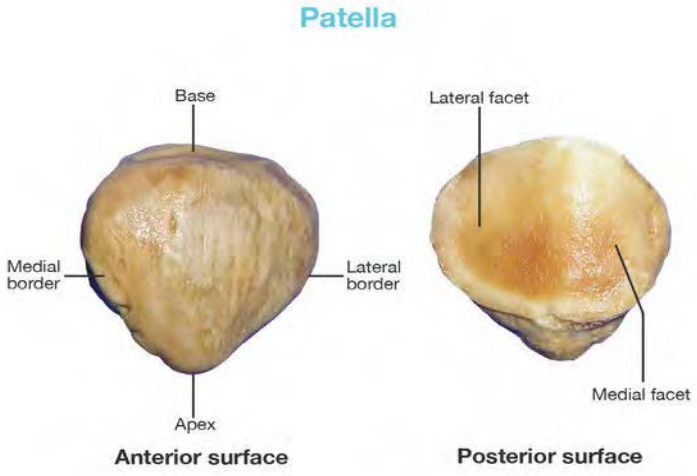
Solution to Question 8:

The patella is an example of sesamoid bone, which is formed within the tendon of the quadriceps femoris muscle.

It is triangular in shape and lies in the patellofemoral groove. The apex is directed inferiorly which gives attachment to the patellar ligament and the base is directed superiorly which gives attachment to the quadriceps femoris muscle.

Its convex anterior surface is perforated by numerous nutrient vessels and is separated from the skin by a prepatellar bursa. Its posterior surface has an oval articular area crossed by a smooth vertical ridge that fits into the intercondylar groove. This ridge divides the patellar articular area into medial and lateral facets. These facets articulate with the corresponding condyles of the femur.



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Important sesamoid bones:

• Patella - largest sesamoid bone in the tendon of quadriceps femoris.

• Pisiform - tendon of flexor carpi ulnaris.

• Fabella - lateral head of the gastrocnemius.

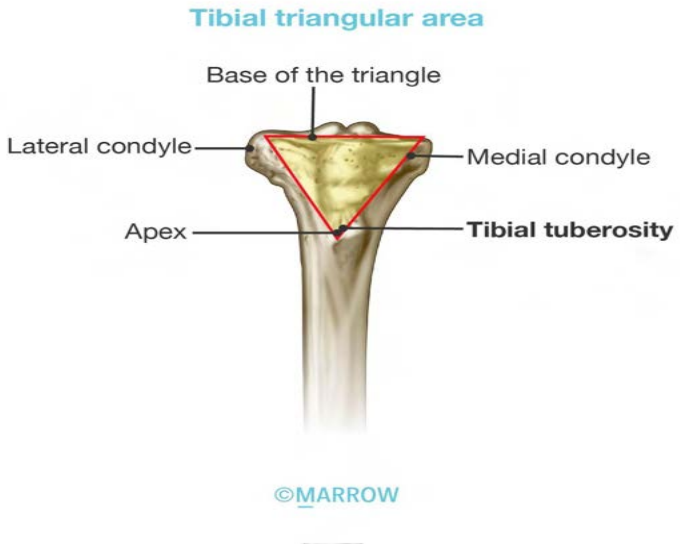
• Two sesamoid bones can be found in the first metacarpal within the tendons of flexor pollicis brevis and adductor pollicis.

• Two sesamoid bones can be found in the first metatarsophalangeal articulation within the double tendon of flexor hallucis brevis.

Solution to Question 9:

The apex of the tibial triangular area is formed by tibial tuberosity.

The tibial triangular area is a small area present in front of the anterior condylar surface. The apex is directed downwards and is formed by tibial tuberosity and the base is continuous with the anterior condylar surfaces of the tibia.



The tibial tuberosity gives attachment to the patellar ligament and is divided into distal rough and proximal smooth regions. The distal region is palpable and is separated from the skin by the infrapatellar bursa.

Solution to Question 10:

The primary ossification center of the tibia appears at the 7th week of intra-uterine life.

Tibia is ossified from three centers: one primary center in the shaft and two secondary centers, one in each epiphysis.

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• Primary center

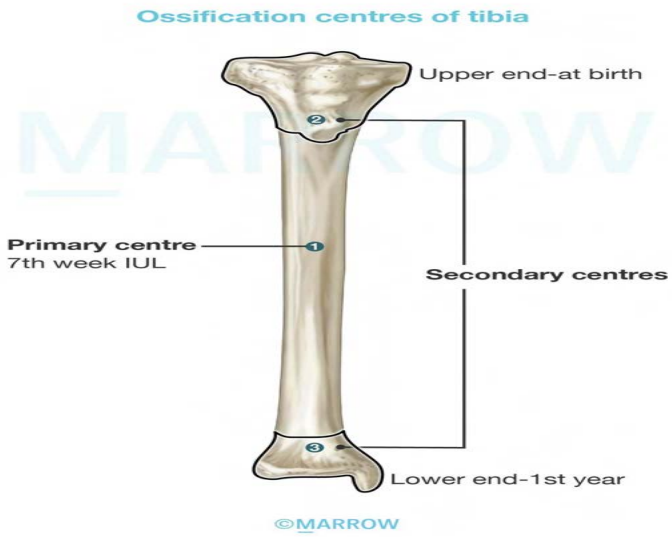
• Ossification in the shaft appears at the 7th week of intrauterine life.

• Secondary center

• In the upper end, the ossification center is usually present at birth and fuses with the shaft in 16 years in females and 18 years in males.

• In the lower end, the ossification center appears early in the first year and fuses with the shaft in the 15th year in females and 17th year in males.

The image given below shows ossification centers of tibia.



Solution to Question 11:

The bone depicted here is the fibula. The biceps femoris is attached to the head of this bone.

Important structures related to fibula:

• Fibular collateral ligament and biceps femoris are attached to the head

• The common peroneal nerve can be rolled against the neck

• The shaft has 3 surfaces and is related to the muscles of the leg:

• The lateral surface is related to fibular muscles

• The anteromedial surface is related to extensors

• The posterior surface is related to flexor muscles

Solution to Question 12:

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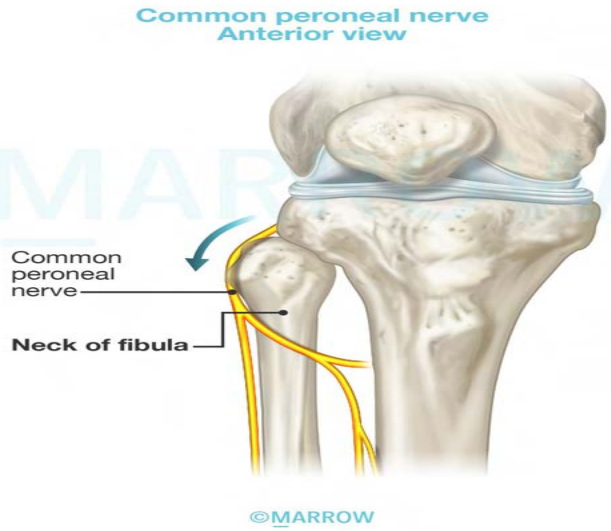
The patient is likely to have a fracture involving the neck of the fibula, which is closely related to the common peroneal nerve (injury - foot drop).



Clinical considerations of the fibula:

• Since fibula does not take part in the transmission of body weight, it is a common source of bone for grafting. The lateral malleolus and the ligaments attached to it are very important in maintaining stability at the ankle joint.

• The common peroneal nerve can be rolled against the neck of the fibula. This nerve is commonly injured.

• In the first stage of Pott's fracture, the lower end of the fibula is fractured spirally.

Solution to Question 13:

Fibula ossifies from three ossification centres.

One primary centre in the shaft and two secondary centres at extremities.

Ossification in the shaft begins at 8 week of intrauterine life. The ossification in the distal end begins in the first year and unites with the shaft by 15 year in females and 17 years in males. The proximal end appears at three to four years and unites with shaft at around 17 years in females and 19 years in males.

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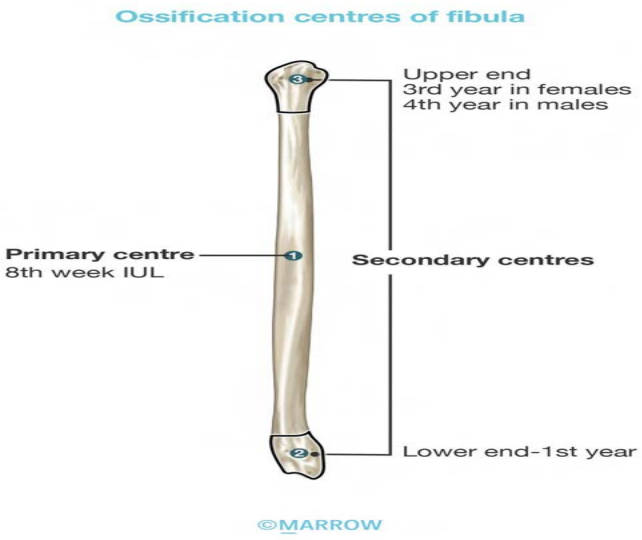

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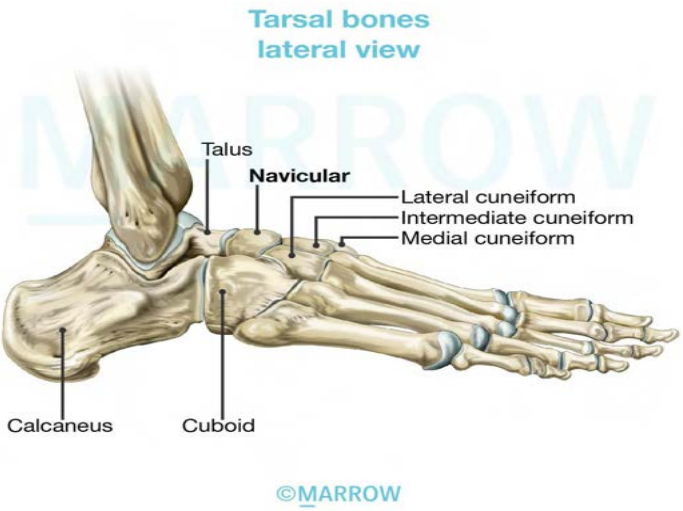
Solution to Question 14:

The navicular bone is interposed between the head of the talus and the cuneiforms.

There are 7 tarsal bones that occupy the proximal half of the foot. The proximal row is made up of the talus and calcaneum. The distal row, from medial to lateral, contains the medial, intermediate, and lateral cuneiforms and the cuboid. Medially the navicular bone is interposed between the head of the talus and the cuneiforms.

The images given below show the tarsal bones of the foot.



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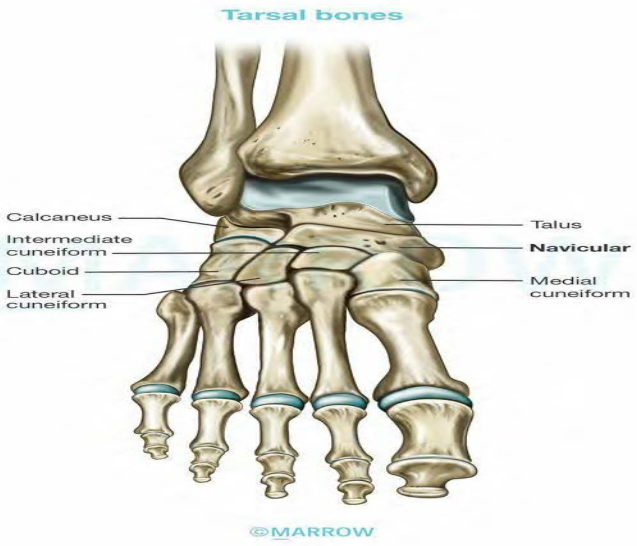

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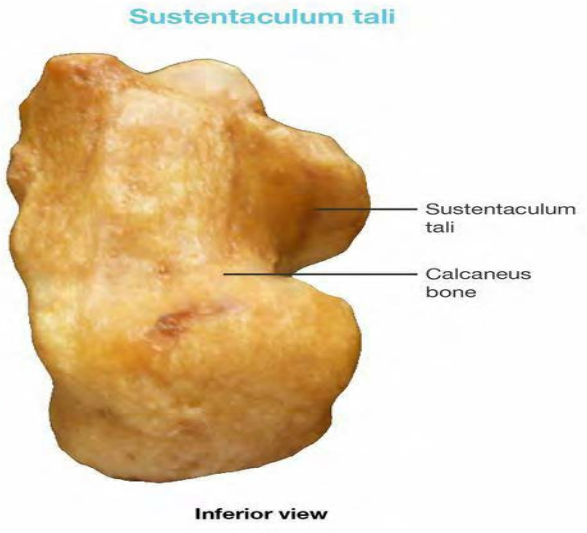
Solution to Question 15:

The sustentaculum tali is a projection present on the calcaneus, on its medial surface.

The superior surface has a facet, to articulate with the middle facet on the head of the talus. It supports the posterior part of the head of the talus.

The inferior surface of the sustentaculum tali has a groove along which the tendon of flexor hallucis longus muscle travels into the sole of the foot.

The image given below shows the sustentaculum tali on the calcaneus.



Given below are the 3 ligaments attached to the sustentaculum tali:

• Plantar calcaneonavicular ligament (anterior surface)

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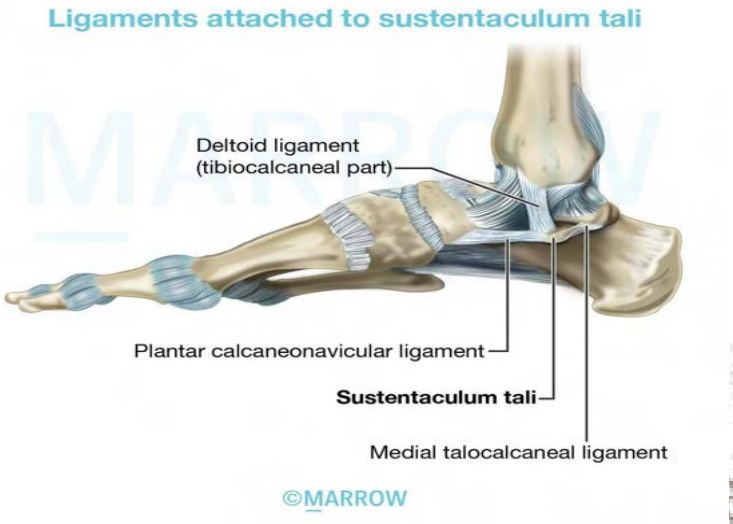
• Deltoid ligament (medial surface)

• Medial talocalcaneal ligament



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Joints of the Lower Limb

Question 1:

What is the zona orbicularis related to?

a) Tibial tuberosity

b) Neck of femur

c) Anatomical neck of humerus

d) Ankle joint

Question 2:

Which of the following statements is false about the ligaments of the hip joint?

a) Iliofemoral ligament is the strongest ligament of hip joint

b) Transverse acetabular ligament contains cartilage cells

c) Ischiofemoral fibers fuse with the zona orbicularis

d) Pubofemoral ligament is triangular in shape

Question 3:

A 16-year-old gymnast was brought to the emergency department after suffering severe trauma during the performance. She presented with painful hip instability. MRI revealed ligament tear which is caused by hyperextension of the hip joint. Which of the following■ ligaments is likely to be torn?

a) Pubofemoral ligament

b) Ischiofemoral ligament

c) Iliofemoral ligament

d) Ligament of head of femur

Question 4:

A 30-year-old male presented with pain and stiffness of the right hip. Ultrasonography revealed effusion in the right hip joint. At which position of hip joint will the pain be

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minimal?

a) Completely flexed and adducted

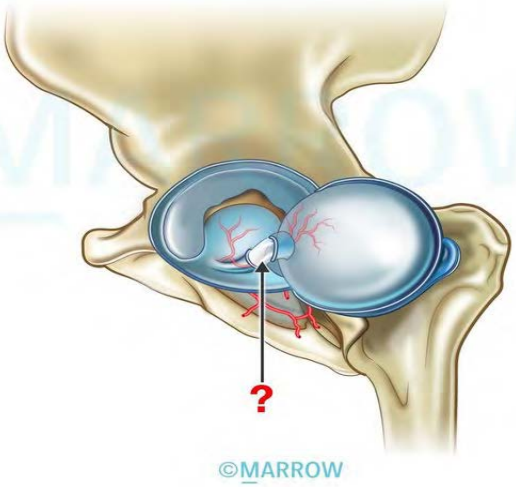
b) Extended and abducted

c) Partially flexed and abducted

d) Extended and adducted

Question 5:

Artery passing through the structure marked in the diagram below is a branch of:



a) Medial circumflex femoral artery

b) Lateral circumflex femoral artery

c) Obturator artery

d) Profunda femoris artery

Question 6:

Identify the structures attached to the areas marked 1, 5, and 6 in the tibial plateau below?

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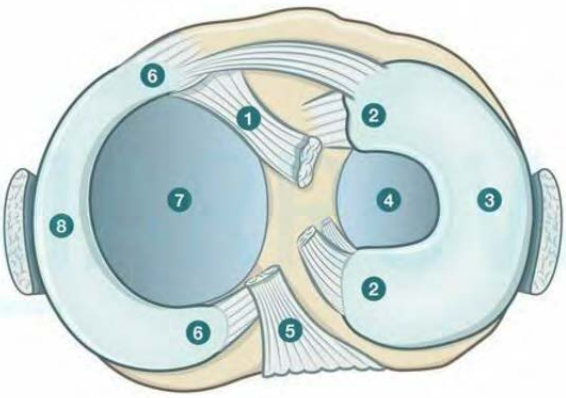

a) Anterior cruciate ligament, posterior cruciate ligament, anterior and posterior horns of medial meniscus

b) Anterior horn of medial meniscus, posterior horn of medial meniscus, anterior and posterior cruciate ligaments

c) Anterior cruciate ligament, posterior cruciate ligament, anterior and posterior horns of lateral meniscus

d) Anterior horn of lateral meniscus, posterior horn of lateral meniscus, anterior and posterior cruciate ligaments

Question 7:

A 19-year-old football player was brought to the hospital after he suffered an ■injury caused by a lateral blow to the knee joint. MRI revealed an injury to the ligaments commonly referred to as the 'unhappy triad'. Which of the following ligaments are involved?

a) Medial meniscus and lateral meniscus

b) Posterior cruciate ligament and lateral meniscus

c) Anterior cruciate ligament and medial meniscus

d) Anterior and posterior horns of lateral meniscus

Question 8:

A 35-year-old basketball player with knee pain was diagnosed to have coronary ligament strain. Which of the following ligaments is involved?

a) Anterior meniscofemoral ligament

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b) Posterior meniscofemoral ligament

c) Oblique popliteal ligament

d) Meniscotibial ligament

Question 9:

Which of the following statements is false?

a) Lateral meniscus covers a larger area of the articular surface than medial meniscus

b) Movements of lateral meniscus is restricted compared to medial meniscus

c) Peripheral tears of the menisci heal better than central tears

d) Suprapatellar bursa is an extension of knee joint cavity

Question 10:

Which of the following is involved in locking of knee?

a) Lateral rotation of the femur on tibia during extension

b) Medial rotation of the femur on tibia during flexion

c) Lateral rotation of the femur on tibia during flexion

d) Medial rotation of the femur on tibia during extension

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Question 11:

Which bursae are involved in patients with clergyman's knee and housemaid's knee?

a) Prepatellar bursa and infrapatellar bursa respectively

b) Subcutaneous and deep infrapatellar bursa respectively

c) Infrapatellar bursa and prepatellar bursa respectively

d) Suprapatellar and infrapatellar bursa respectively

Question 12:

A 23-year-old cricketer was diagnosed with ligamentum mucosum tear. Range of movements of which of the following joints is affected?

a) Temporomandibular joint

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b) Hip joint

c) Shoulder joint

d) Knee joint

Question 13:

A patient presented to the orthopedics■ OPD with ankle sprain caused due to hyper inversion of the right foot. Which of the following ligaments is commonly injured?

a) Deltoid ligament

b) Anterior talofibular ligament

c) Spring ligament

d) Posterior talofibular ligament

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Question 14:

The superficial part of deltoid ligament is attached to all of the following except:

a) Navicular

b) Talus

c) Calcaneum

d) Fibula

Question 15:

Which ligament is related to the inferior surface of the structure marked in the image?

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a) Deltoid ligament

b) Tibionavicular ligament

c) Spring ligament

d) Tibiocalcaneal ligament

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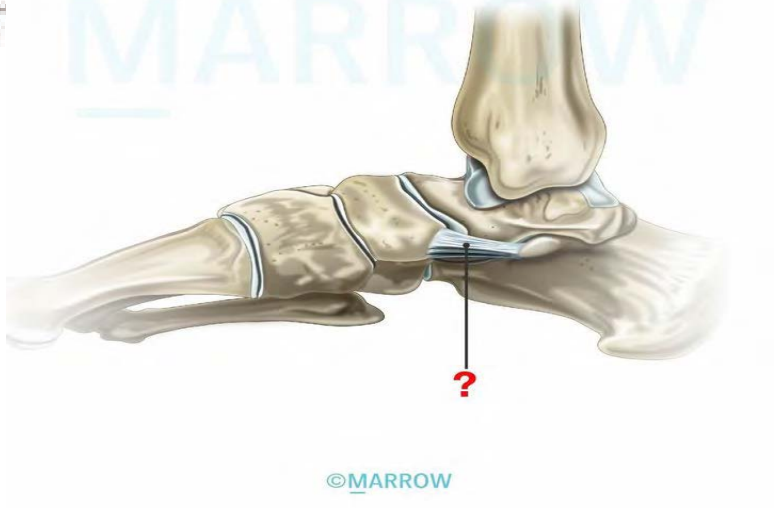
Question 16:

Which of the following statements is false regarding the structure marked in the image?



a) It has a triangular fibrocartilaginous facet on which part of the talar head rests

b) Transection of the ligament leads to adult acquired flat foot

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c) It is a complex of two ligaments

d) It maintains the medial longitudinal arch of foot

Question 17:

What is Lisfranc's ligament?

a) Cuneometatarsal interosseous ligament

b) Transverse acetabular ligament

c) Plantar calcaneocuboid ligament

d) Fibular collateral ligament

Question 18:

Chopart's ligament is related to which of the following joints?

a) 2, 4, 5

b) 1 and 2

c) 1, 2, 3

d) 1 and 3

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Answer Key

Question No.	Correct Option
1	b
2	b
3	c
4	c
5	c
6	a
7	c
8	d
9	b
10	d
11	c

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12	d
13	b
14	d
15	c
16	c
17	a
18	d

Detailed Explanations

Solution to Question 1:

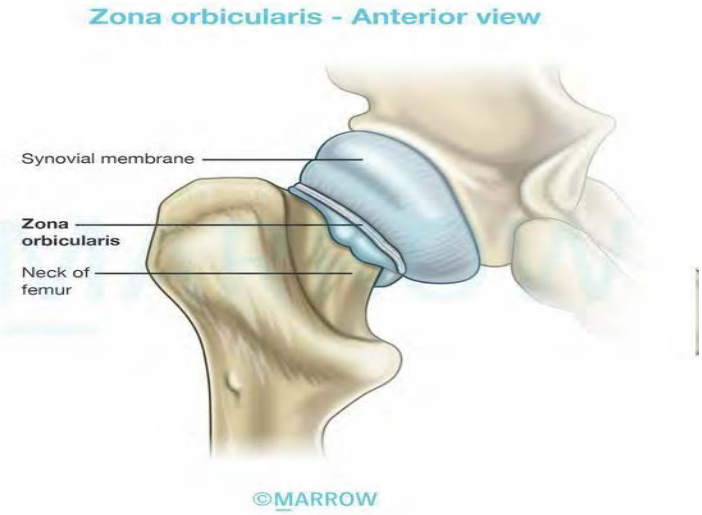
Zona orbicularis is related to the neck of femur. They are the circular fibers of the capsule of hip joint.

Capsule of the hip joint is made up of 2 sets of fibers:

• Circular fibers or zona orbicularis - They are internal and form a collar around the neck of femur. They are blended with the pubofemoral and ischiofemoral ligaments

• Longitudinal fibers - They are external. These fibers are numerous in the anterosuperior region and are joined by iliofemoral ligament.

The image given below shows the zona orbicularis.



Solution to Question 2:

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Transverse acetabular ligament does not contain cartilage cells. This ligament crosses the acetabular notch and continues peripherally with the labrum.

Ligaments of the hip joint are:

• Iliofemoral ligament - strongest ligament of hip joint

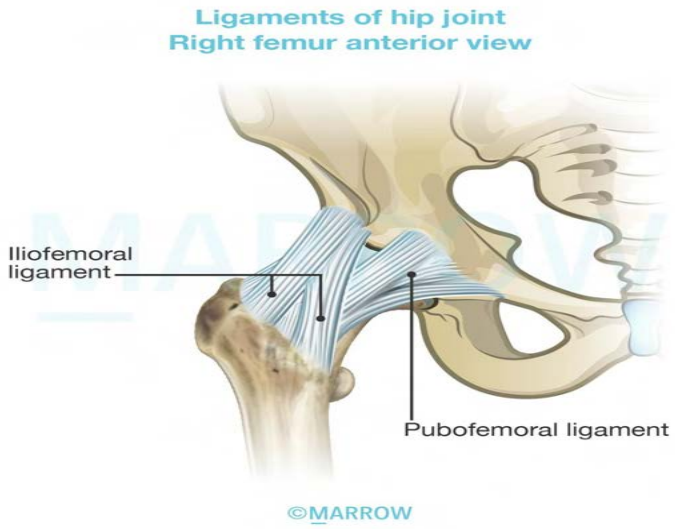
• Pubofemoral ligament - triangular in shape

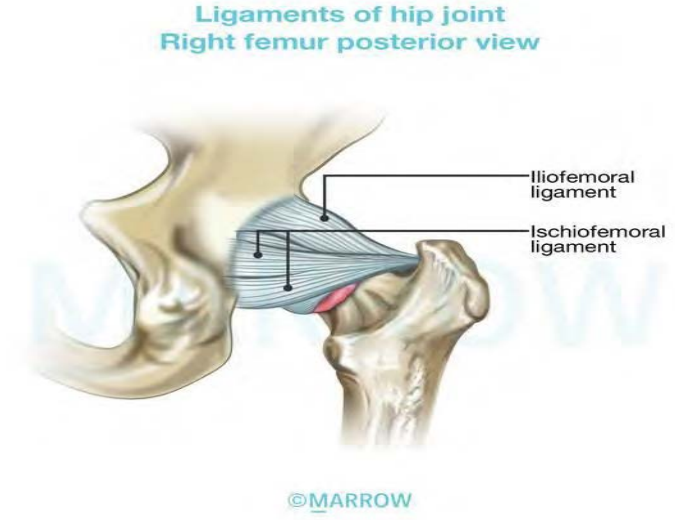
• Ischiofemoral ligament - some fibers fuse with zona orbicularis and inferior fibers attach to the posterior circumference of femoral neck

• Transverse acetabular ligament - forms a foramen to allow vessels and nerves to enter the hip joint

• Ligament of head of femur - apex is attached to fovea and base is attached to the edges of acetabular notch

The images given below show the ligaments of the hip joint.





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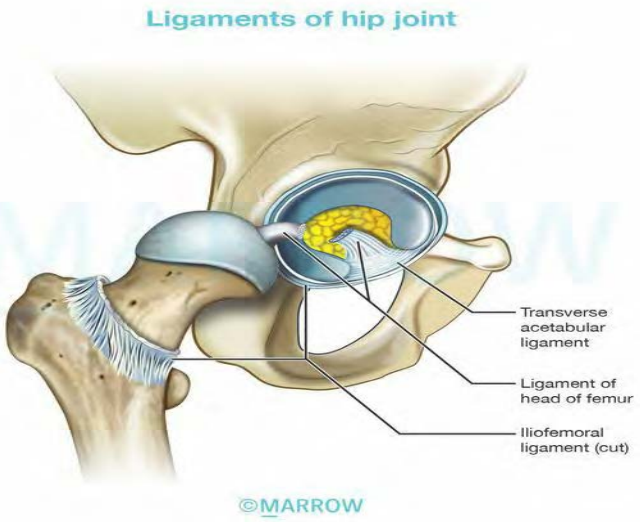


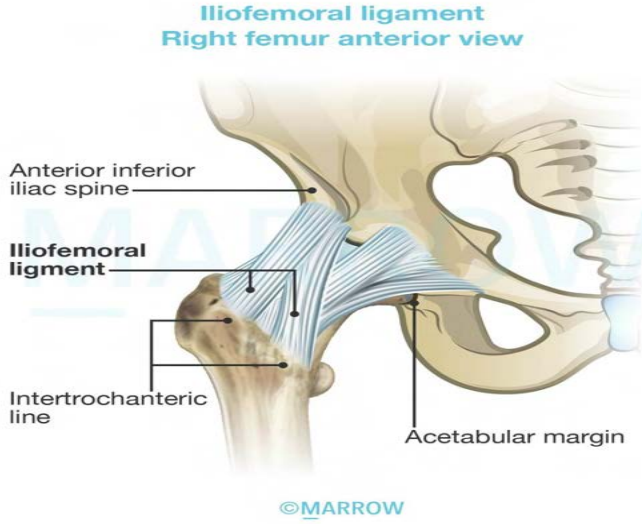
Note: Iliocapsularis is a muscle that lies immediately deep to the tendon of iliopsoas and above the anterior hip capsule. The function of the muscle is not clear and is thought to taut the hip capsule to prevent its impingement during the hip flexion.

Solution to Question 3:

The iliofemoral ligament resists the hyperextension of hip joint and hence, is likely to be injured.

Iliofemoral ligament or ligament of Bigelow is the strongest ligament of the hip joint. It is an inverted-Y-shaped ligament. The apex is attached between the anterior inferior iliac spine and acetabular margin. The base is attached to the intertrochanteric line. This ligament prevents the hyperextension of the hip joint.

The image given below shows the iliofemoral ligament.



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Solution to Question 4:

A patient with an effusion in the hip joint is has least pain in flexed and abducted position.

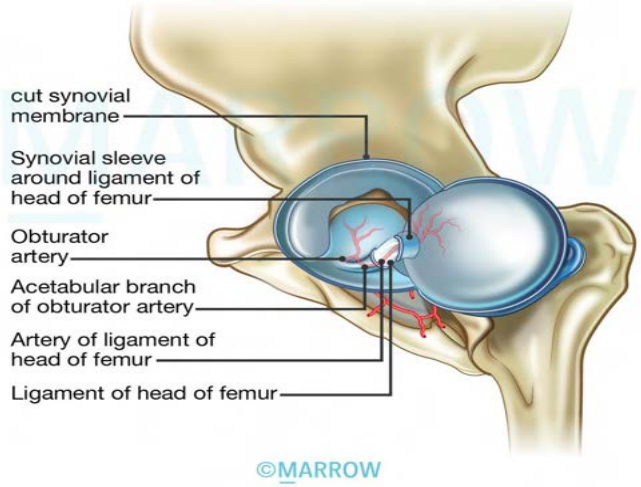
Joint capacity is maximal when the hip joint is held in a partially flexed and abducted position. Hence, a patient with an effusion in the hip joint is therefore most comfortable in this position.

Solution to Question 5:

The image shown is the ligament of head of the femur and the artery passing through it is the foveal artery/ artery of ligament of head of femur. It is derived from the acetabular branch of obturator artery.

The blood supply of the femoral head is derived from an arterial ring (trochanteric anastomosis) around the neck of femur constituted by:

- Medial circumflex femoral arteries
- Lateral circumflex femoral arteries
- Superior and inferior gluteal vessels (minor contributions)



Solution to Question 6:

The structures attached to the areas marked 1, 5, and 6 in the tibial plateau are anterior cruciate ligament, posterior cruciate ligament, anterior and posterior horns of medial meniscus respectively.

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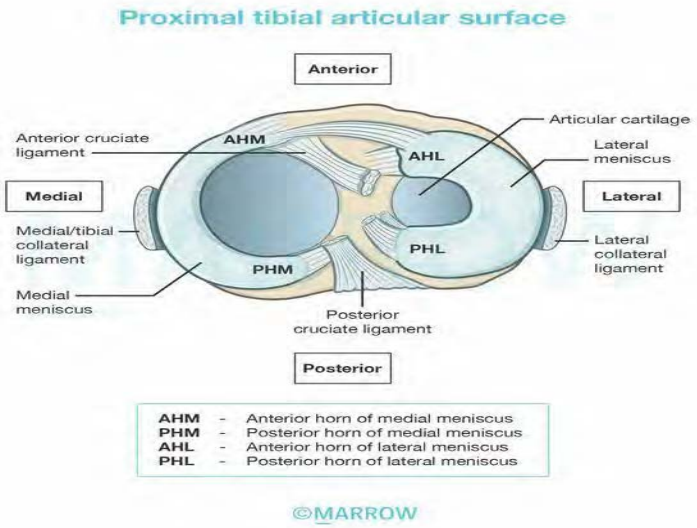

Remember the attachments of ligaments from anterior to posterior as:

Mnemonic: Medical College Ludhiana Ludhiana Medical College

- M: Medial meniscus (Anterior horn)
- C: Cruciate ligament (Anterior)
- L: Lateral meniscus (Anterior horn)
- L: Lateral meniscus (Posterior horn)
- M: Medial meniscus (Posterior horn)
- C: Cruciate ligament (Posterior)

Solution to Question 7:

The unhappy triad of the knee involves:

- Medial meniscus
- Anterior cruciate ligament
- Tibial collateral ligament

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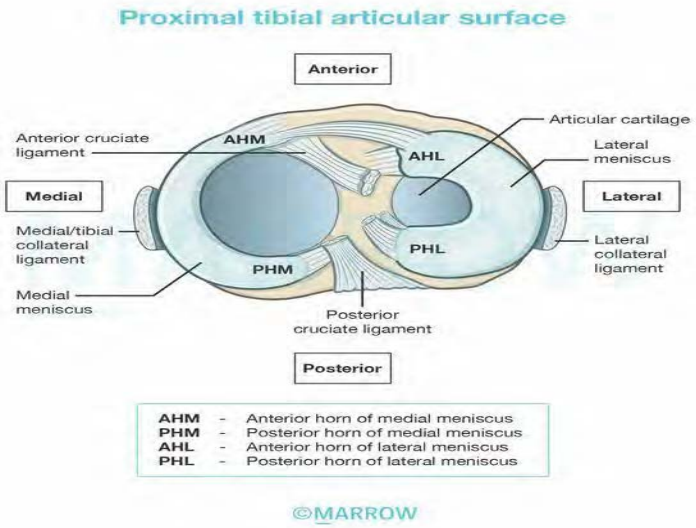

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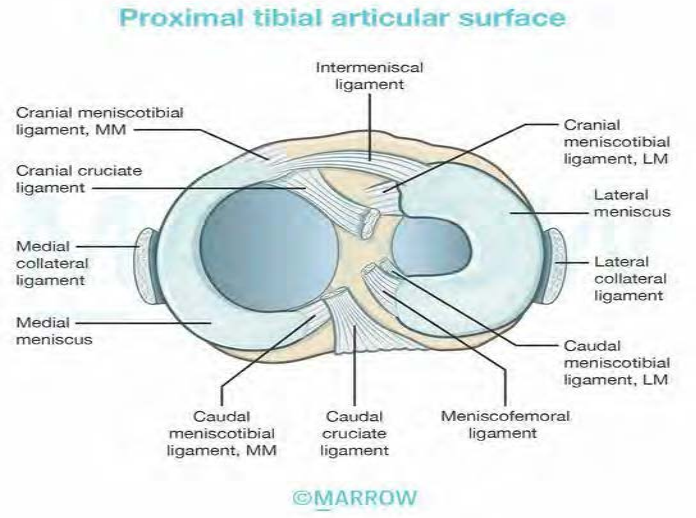
Solution to Question 8:

Coronary ligaments are also known as meniscotibial ligaments. It refers to the tibial attachment of medial meniscus.

The medial meniscus is almost a semicircle in shape. It is attached by its anterior horn to the anterior tibial intercondylar area in front of the anterior cruciate ligament. The posterior horn is fixed to the posterior tibial intercondylar area, between the attachments of the lateral meniscus and posterior cruciate ligament.

These attachments ensure that the medial meniscus is relatively fixed and moves much less than the lateral meniscus.

The image given below shows the cranial and caudal meniscotibial ligament.



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Solution to Question 9:

The movements of medial meniscus are restricted compared to the lateral meniscus

Comparison between medial and lateral menisci:

Option C: Peripheral zone of menisci are vascularized by capillary loops and inner regions are less vascular. Hence, relative healing rate is better in peripheral zone.

Option D: Suprapatellar bursa is the superior extension of the knee joint cavity. It lies between the femur and suprapatellar part of quadriceps femoris.

Feature	Lateral meniscus	Medial meniscus
Mobility	More mobile	Relatively fixed and therefore moves much less than lateral meniscus
Shape	Forms approximately 4/5th o f a circle	Semicircular in shape
Area covered	Covers alarger area	Covers less area than lateral meniscus
Additionalfeature s	Grooved posterolaterally by P opliteus tendon, which separ ates it from fibular collateral ligament	-

Solution to Question 10:

Locking of knee is medial rotation of femur on tibia during the later stages of extension.

When standing, the knee joint is locked into position to reduce the amount of muscle work needed to maintain the standing position. The muscle responsible for locking is vastus medialis.

The image given below shows the locking of knee joint on standing.

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Unlocking of the knee joint is the lateral rotation of femur on tibia during the beginning of flexion. This is brought by the action of popliteus muscle.

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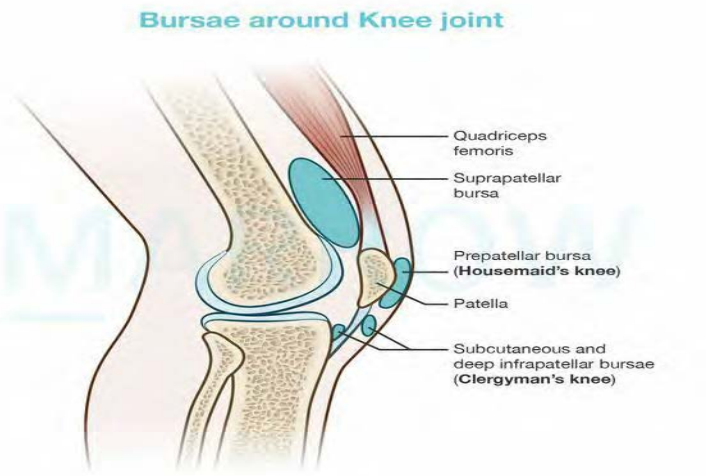
Solution to Question 11:

Clergyman's knee and housemaid's knee results from inflammation of infrapatellar bursa and prepatellar bursa respectively.

Lower limb major bursitis:

- Prepatellar Bursitis (Housemaid's Knee)
- Infrapatellar bursitis (Clergyman's knee)
- Trochanteric Bursitis (Above hip abductor)

The image shows a sagittal section through the left knee joint (lateral aspect) with bursae.



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Solution to Question 12:

Ligamentum mucosum is related to the knee joint. It is a plica present at the intercondylar notch of the knee joint.

Plicae are the embryological remnants of synovial folds. Major plicae around knee joint are:

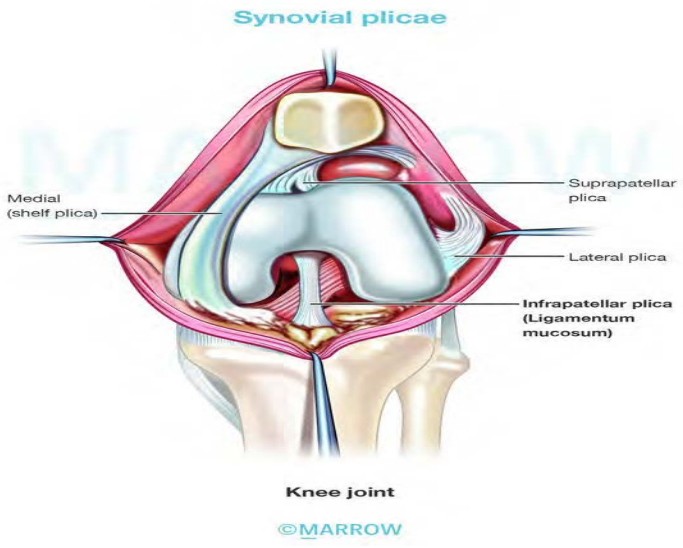
• Ligamentum mucosum - intercondylar notch

• Suprapatellar plica - suprapatellar space

• Medial plica - extending from infrapatellar fat pad to medial wall of knee

Plica syndrome is a painful knee function due to thickened and inflamed synovial folds. It most commonly involves the medial plica.

The image given below shows the synovial plicae.



Solution to Question 13:

The anterior talofibular ligament is most commonly injured with inversion sprains.

Important ligaments of ankle present on the lateral side, and therefore likely to be injured in inversion sprains include:

• Anterior talofibular ligament (ATFL) - most commonly injured

• Posterior talofibular ligament (PTFL)

• Calcaneofibular ligament (CFL)

The image given below shows the ligaments attached to the lateral side of ankle.

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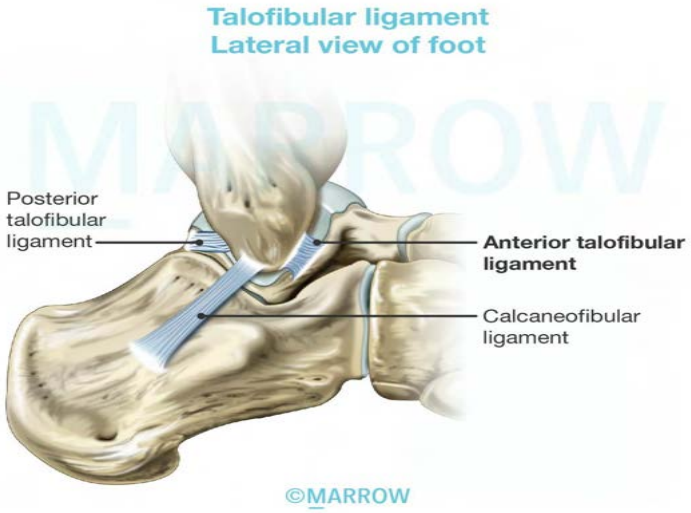
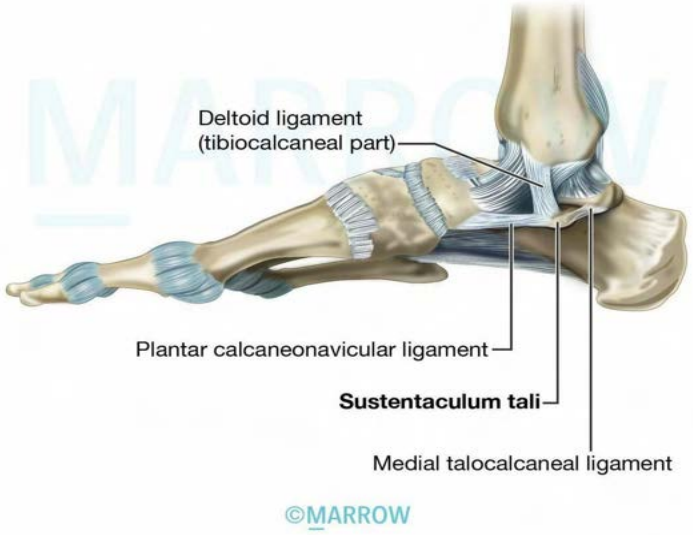


Important ligaments of ankle present on the medial side, and therefore likely to be injured in eversion sprains include:

• Deltoid ligament (Medial collateral ligament)

• Spring ligament (calcaneonavicular ligament)

The image given below shows the ligaments attached to the medial side of ankle.



Solution to Question 14:

Superficial part of deltoid ligament is attached to all bones except fibula.

Deltoid ligament or medial collateral ligament is a strong triangular band, attached to the apex, the anterior and posterior borders of the medial malleolus. It has 2 layers, superficial and deep:

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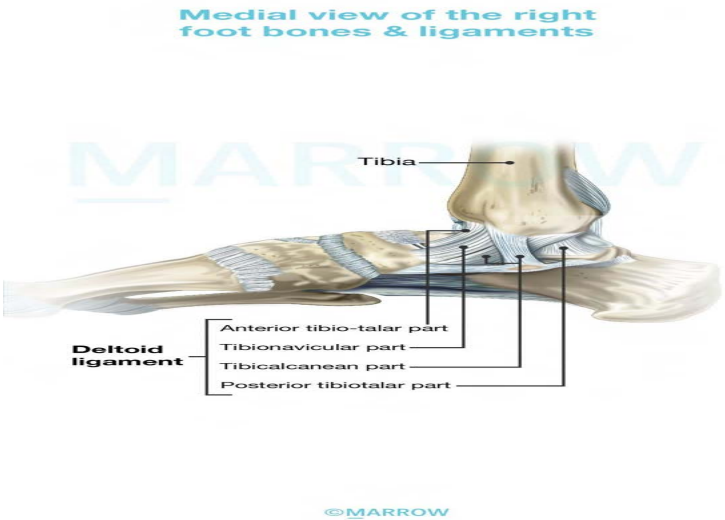
• Superficial layer consists of tibionavicular fibers anteriorly, tibiocalcaneal fibers in the middle, and superficial posterior tibiotalar fibers posteriorly.

• Deep layer consists of anterior tibiotalar fibres, tibiocalcaneal in the middle and deep posterior tibiotalar posteriorly.



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Solution to Question 15:

The structure marked in the image is the head of talus. The ligament related to its inferior surface is the spring ligament/ calcaneonavicular ligament.

The inferior surface of the head of talus has three facets:

• Posterior facet - It is the largest facet and articulates with the sustentaculum tali of the calcaneus.

• Anterolateral facet - It articulates with the anterior facet of the calcaneus.

• Medial facet - It is related to the spring ligament.

Solution to Question 16:

In the given image, the structure marked is the spring ligament (plantar calcaneo-navicular ligament). It is a complex of three ligaments, namely:

• Superomedial calcaneonavicular ligament

• Medioplantar oblique calcaneonavicular ligament

• Inferoplantar longitudinal calcaneonavicular ligament

The spring ligament is a thick band connecting the anterior margin of the sustentaculum tali to the plantar surface of the navicular.

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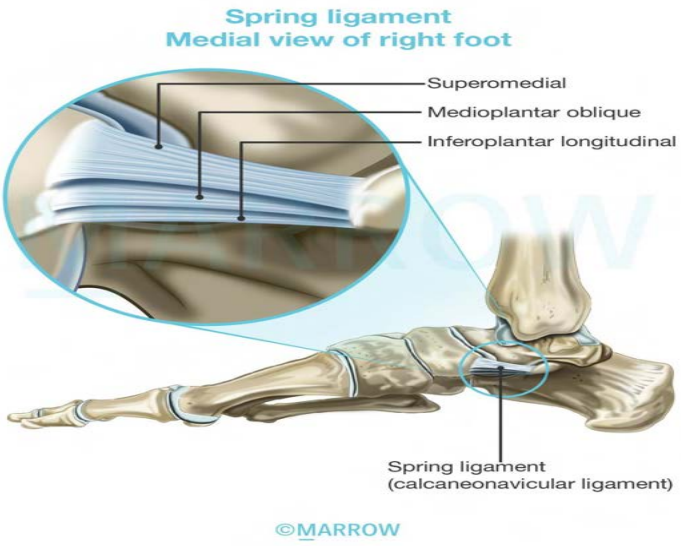
It is the stabilizer of medial longitudinal arch and the head of the talus. Disruption of this ligament leads to the collapse of medial longitudinal arch and causes flat foot.

The image given below shows the spring ligament.



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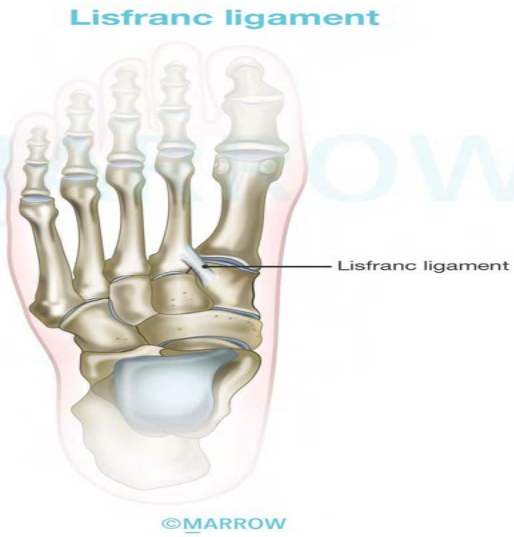
Solution to Question 17:

Lisfranc's ligament is cuneometatarsal interosseous ligament.

There are three cuneometatarsal interosseous ligaments and the strongest ligament is Lisfranc's ligament. It passes from the lateral surface of the medial cuneiform to the adjacent angle of the second metatarsal bone. Deformity of this ligament can lead to instability and deformity of tarsometatarsal joint.



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Solution to Question 18:

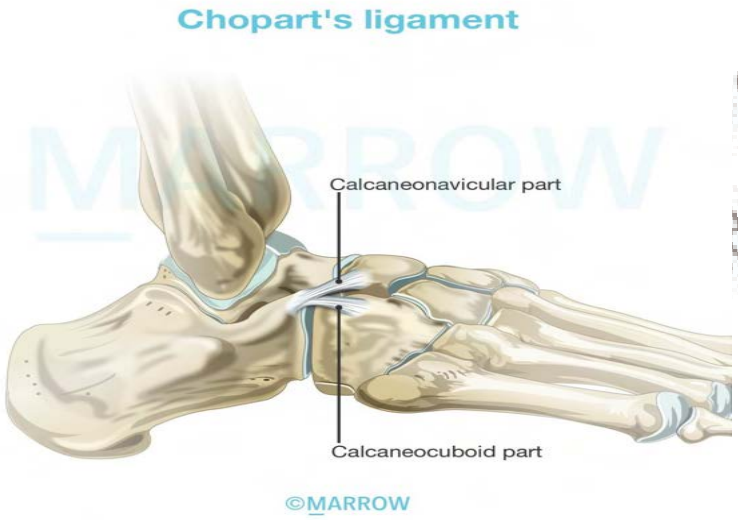
Chopart's ligament is related to both calcaneocuboid and calcaneonavicular joints.

Chopart's ligament/ Bifurcate ligament is a strong Y- shaped band, having a proximal stem and 2 distal limbs.

• The proximal limb is attached by a stem to the anterior part of upper calcaneal surface.

• The distal limb divides into calcaneocuboid and calcaneonavicular parts.

The image given below shows the Chopart's ligament.



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Muscles of the Lower Limb

Question 1:

Which of the following is the longest muscle in the body?

a) Gracilis

b) Sartorius

c) Adductor longus

d) Biceps femoris

Question 2:

The gluteus maximus muscle is attached to:

a) Greater trochanter

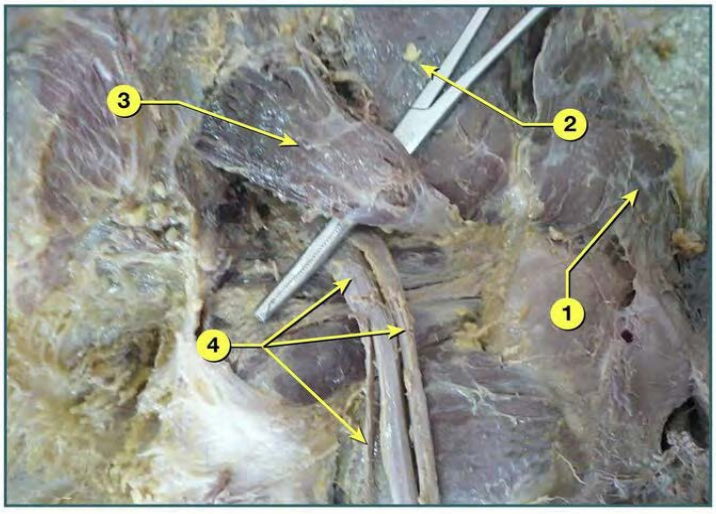
b) Lesser trochanter

c) Iliotibial tract

d) Spiral line

Question 3:

A boy with a history of a fall from a tree presents with a lurching gait and dragging of his feet. Which of the following structures are involved?



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a) 1

b) 2

c) 3

d) 4

Question 4:

A 50-year-old woman underwent total hip replacement surgery. During the procedure, the surgeon accidentally severed a nerve. Post-operatively, the patient had a gluteus maximus lurch and wasting of the muscle. Which of the following nerves is likely to be injured?

a) Sciatic nerve

b) Superior gluteal nerve

c) Inferior gluteal nerve

d) Femoral nerve

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Question 5:

What is the action of the muscle at the hip, which is attached to the marked area in the image below.

a) Abduction and external rotation

b) Extension and lateral rotation

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c) Extension, adduction, and lateral rotation

d) Flexion and abduction

Question 6:

Which of the following muscles is attached to the lateral surface of the greater trochanter?

a) Gluteus minimus

b) Gluteus medius

c) Gluteus maximus

d) Piriformis

Question 7:

Iliotibial tract receives the insertion of which of the following muscles?

a) Gluteus minimus

b) Gluteus medius

c) Tensor fasciae latae

d) Sartorius

Question 8:

Which of the following muscles is a powerful abductor of hip joint?

a) Gluteus maximus

b) Obturator internus

c) Quadratus femoris

d) Gluteus medius

Question 9:

Which of the following muscles causes external rotation of the hip joint?

a) Gluteus medius

b) Gluteus maximus

c) Tensor fascia lata

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d) Adductor longus

Question 10:

The posterior femoral muscles are innervated by which nerve?

a) Femoral nerve

b) Obturator nerve

c) Sciatic nerve

d) Inferior gluteal nerve

Question 11:

All of the the following muscles are attached to the ischial tuberosity except:

a) Semimembranosus

b) Semitendinosus

c) Short head of biceps femoris

d) Adductor magnus

Question 12:

A 40-year-old woman presented with severe pain in the buttocks extending down the back of the right leg. MRI revealed inflammation of the piriformis muscle. Entrapment of which of the following nerves is likely to cause the given condition?

a) Obturator nerve

b) Superior gluteal nerve

c) Inferior gluteal nerve

d) Sciatic nerve

Question 13:

An Indian fast bowler suffered a hamstring injury while practicing due to which he was dropped out of the team. Which of the following muscle is not likely to be injured?

a) Biceps femoris

b) Sartorius

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c) Semitendinosus

d) Semimembranosus

Question 14:

Which of the following muscles is not a part of the anterior compartment of the thigh?

a) Vastus lateralis

b) Rectus femoris

c) Vastus medialis

d) Gracilis

Question 15:

A 30-year-old woman suddenly falls during her dance performance. She was rushed to the hospital by her friends. On examination her knee was swollen and her movements were restricted. On X-ray examination, lateral displacement of the patella was noted. The weakness of which of the following muscle is responsible for this condition?

a) Vastus medialis

b) Vastus intermedius

c) Vastus lateralis

d) Rectus femoris

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Question 16:

Which of the following muscles cause medial rotation of the flexed knee?

a) Semimembranosus

b) Biceps femoris

c) Quadriceps femoris

d) Tensor fasciae latae

Question 17:

A patient presents the OPD with complaints of acute pain and swelling over the dorsum of her right midfoot. On examination, tenderness was present and the resisted dorsiflexion test

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for the great toe was positive. The muscle affected is innervated by which nerve?

a) Superficial peroneal nerve

b) Deep peroneal nerve

c) Tibial nerve

d) Sciatic nerve

Question 18:

The anterior compartment of the leg contains all of the following muscles except:

a) Peroneus brevis

b) Extensor hallucis longus

c) Peroneus tertius

d) Extensor digitorum longus

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Question 19:

Which muscle is not involved in the inversion of foot?

a) Tibialis anterior

b) Tibialis posterior

c) Peroneus longus

d) Extensor hallucis longus

Question 20:

A patient with weakness of leg is not able to perform the movement shown in the image. Which muscle weakness causes loss of this movement?

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a) Extensor digitorum longus

b) Tibialis anterior

c) Peroneus tertius

d) Gastrocnemius

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Question 21:

Which of the following muscles is known as triceps surae?

a) Gastrocnemius and plantaris

b) Soleus and plantaris

c) Gastrocnemius and soleus

d) Gastrocnemius, soleus and plantaris

Question 22:

Which of the following passive movements causes pain in a patient suffering from deep posterior compartment syndrome?

a) Foot inversion

b) Dorsi flexion of foot

c) Plantar flexion of foot

d) Foot eversion

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Question 23:

The first layer of the sole consists of:

a) Abductor hallucis

b) Adductor hallucis

c) Flexor hallucis longus

d) Flexor hallucis brevis

Answer Key

Question No.	Correct Option
1	b
2	c
3	b
4	c
5	b
6	b
7	c
8	d
9	b
10	c
11	c
12	d
13	b
14	d
15	a
16	a
17	b
18	a
19	c
20	d
21	c
22	b
23	a

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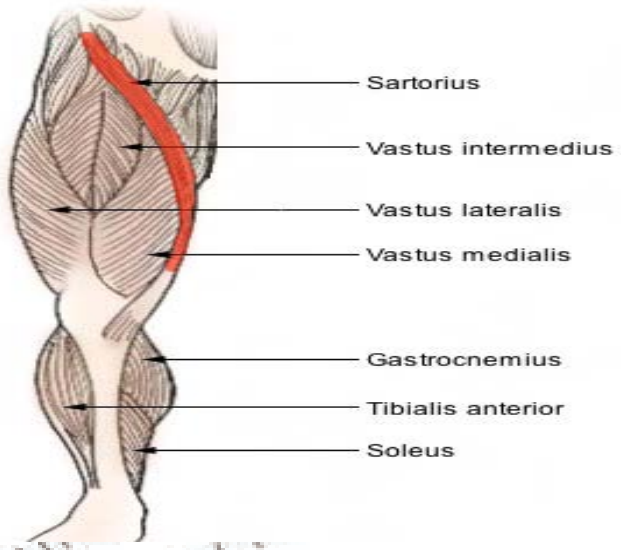
Detailed Explanations

Solution to Question 1:

The sartorius muscle is the longest muscle in the body.

It originates from the anterior superior iliac spine and inserts into the superior aspect of the medial surface of the tibial shaft near the tibial tuberosity (joins gracilis and semitendinosus at the pes anserinus).

It flexes and laterally rotates the hip joint and flexes the knee and is innervated by the femoral nerve (L2, L3, and L4).



Solution to Question 2:

The gluteus maximus muscle is attached to the iliotibial tract of the fascia lata.

Origin:

• Posterior aspect of dorsal ilium, posterior to posterior gluteal line

• Posterior superior iliac spine

• Posterior aspect of sacrum and coccyx

• Sacrotuberous ligament.

Insertion - It is inserted mainly in fascia lata at the iliotibial band and also into the gluteal tuberosity on the posterior femoral surface.

Action:

• Major extensor of hip joint

• Lateral rotation of hip joint

• Active in powerful abduction of thigh

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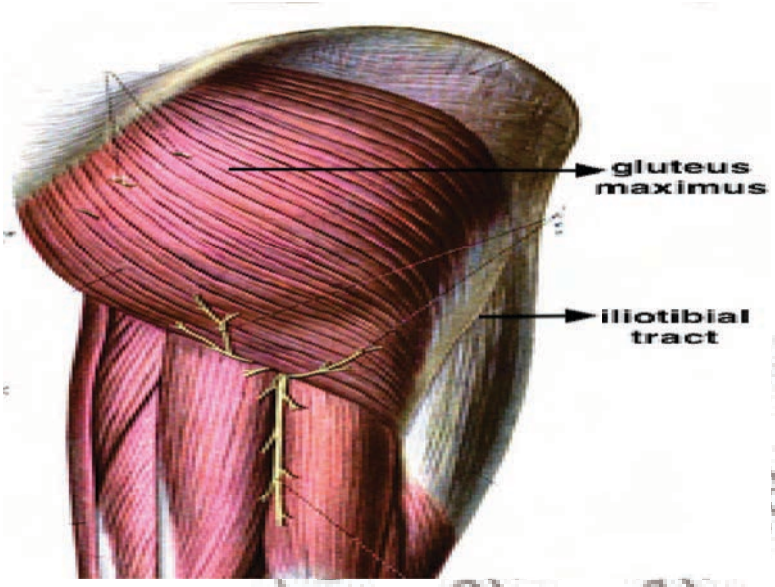
Arterial Supply - Inferior and superior gluteal arteries and the first perforating branch of the profunda femoris artery.

Nerve Supply- Inferior gluteal nerve (L5, S1 and S2).



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Solution to Question 3:

The structure involved in causing lurching gait in the child is gluteus medius (marked as 2).

The gluteus medius originates from the outer surface of the ilium between the anterior and posterior gluteal lines. Insertion of the muscle is at the lateral surface of the greater trochanter. It is supplied by the superior gluteal nerve.

Gluteus medius and minimus are powerful abductors of the hip joint. Mechanism of actions of gluteus medius and minimus:

• When the leg on one side is lifted off the ground, the gluteus medius and minimus muscles, on the opposite supported side, exert traction on the hip bone by acting from the femur. This action results in a slight raising of the pelvis on the unsupported side, which helps maintain the trunk in the upright position.

• The actions of these muscles are affected when there is an injury to the superior gluteal nerve, neck of the femur, or loss of normal angulation of the shaft of the femur. This occurs in conditions like paralysis of the glutei, developmental dysplasia of the hip, etc.

• When the gluteus medius and minimus are paralyzed, the pelvis sinks down on the unsupported (normal) side, when the patient tries to stand on the affected limb. This leads to a positive Trendelenburg's sign with a characteristic lurching gait - the patient lurches towards the affected side with contralateral pelvis drop.

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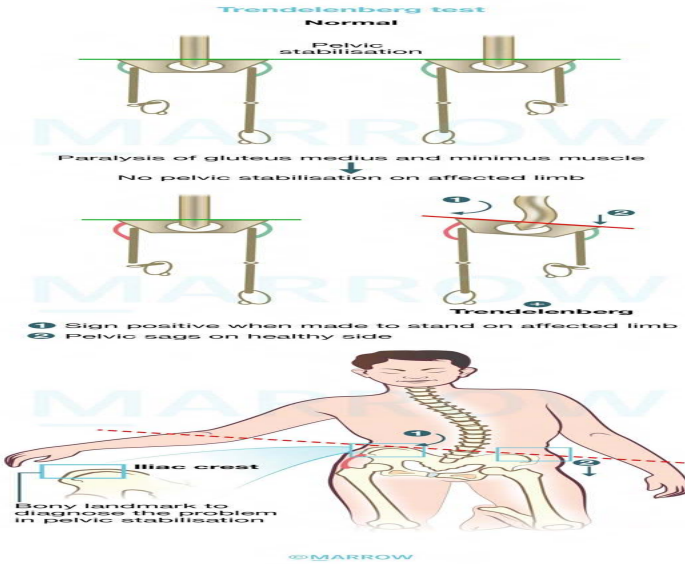
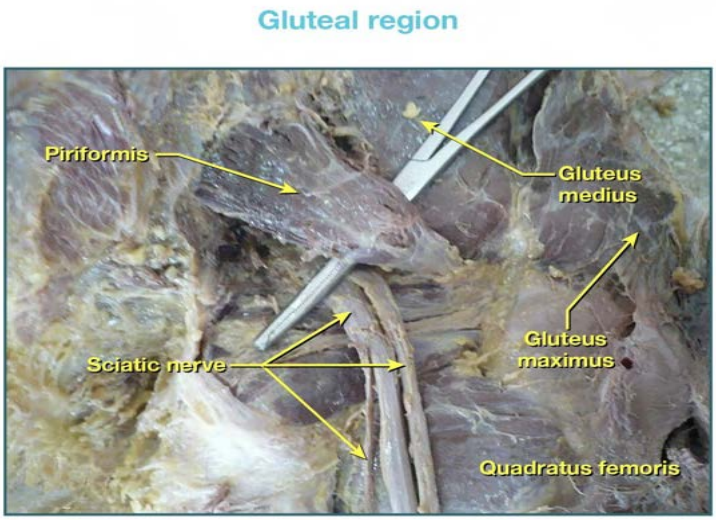


Other options

1 - Gluteus maximus - involved in the extension of flexed thigh, abduction (only upper fibres), and lateral rotation at the hip joint. Insertion is at the iliotibial tract.

3 - Piriformis - involved in lateral rotation and assists abduction at the hip joint. It is inserted into the medial side of greater trochanter of the femur. Entrapment of the sciatic nerve in the piriformis can lead to piriformis syndrome.

4 - Sciatic nerve - The nerve passes over the obturator internus, gemellus superior, gemellus inferior and quadratus femoris. It supplies knee flexors and muscles below the knee. Paralysis of this nerve results in flail foot and severe difficulty in walking.



Solution to Question 4:

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In the given clinical scenario, the inferior gluteal nerve is likely to be injured.

The gluteus maximus is innervated by the inferior gluteal nerve. Injury to the nerve causes atrophy of the muscle causing weakness in the extension of the thigh. The patients typically have a gluteus maximus lurch.

The gluteus maximus may be tested by extension of the hip against resistance, in the supine or prone position.

Solution to Question 5:

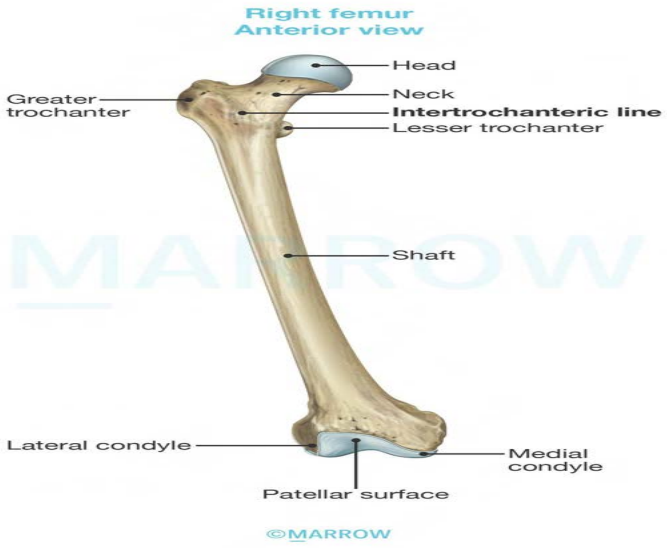
The image shows the posterior surface of the femur, and the structure marked is gluteal tuberosity, to which the gluteus maximus muscle is attached. It causes extension and lateral rotation at the hip joint.

The femur can be divided into:

• The proximal femur - Consists of the head, neck, greater and lesser trochanters. The intertrochanteric line is present on the anterior surface at the junction of the neck and shaft of the femur while the intertrochanteric crest is present on the posterior surface.

• The shaft of the femur - Consists of linea aspera (bony crest present on the posterior surface), gluteal tuberosity, and pectineal line

• The distal femur - Consists of the medial condyle, lateral condyle, intercondylar fossa, and patellar surface



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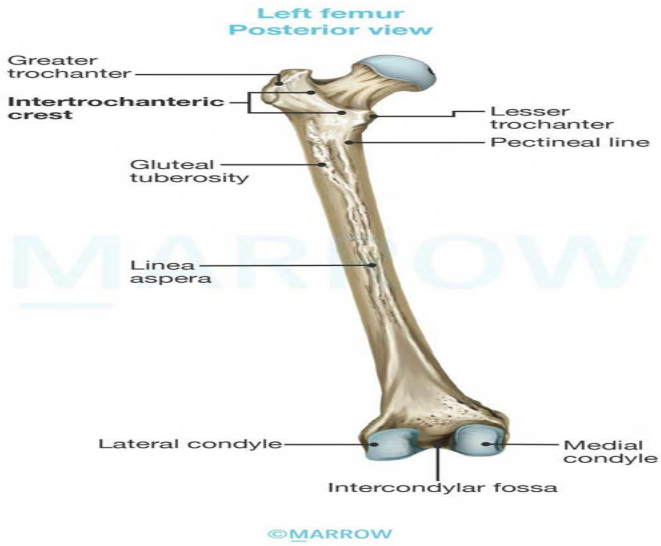
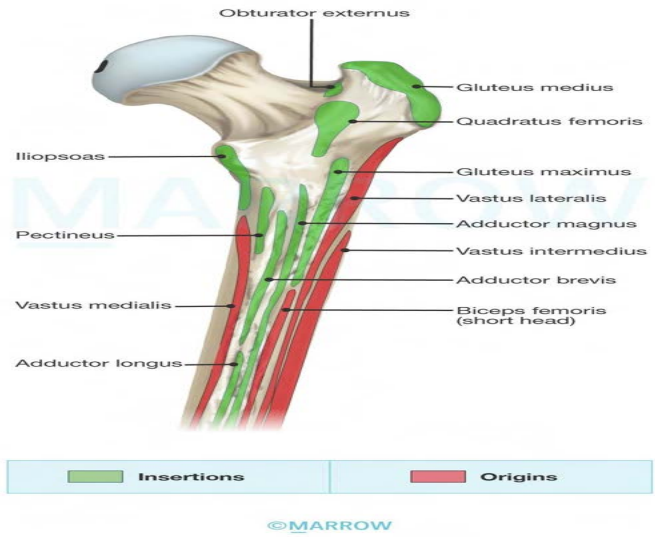


The image below shows attachments of various muscles over the posterior surface of the right femur.



Gluteus maximus muscle:

Origin:

• Posterior aspect of the dorsal ilium, posterior to the posterior gluteal line

• Posterior superior iliac spine

• Posterior aspect of sacrum and coccyx

• Sacrotuberous ligament.

Insertion - It is inserted mainly in fascia lata at the iliotibial band and also into the gluteal tuberosity on the posterior femoral surface.

Action:

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• Major extensor of the hip joint

• Lateral rotation of the hip joint

• Active in powerful abduction of the thigh

Arterial Supply - Inferior and superior gluteal arteries and the first perforating branch of the profunda femoris artery.

Nerve Supply- Inferior gluteal nerve (L5, S1 and S2).

Solution to Question 6:

The gluteus medius muscle is attached to the lateral surface of the greater trochanter.

• Greater trochanter: It is a large and quadrangular projection arising from the junction of the neck and shaft of the femur. Muscles inserted into it are -

• Gluteus minimus

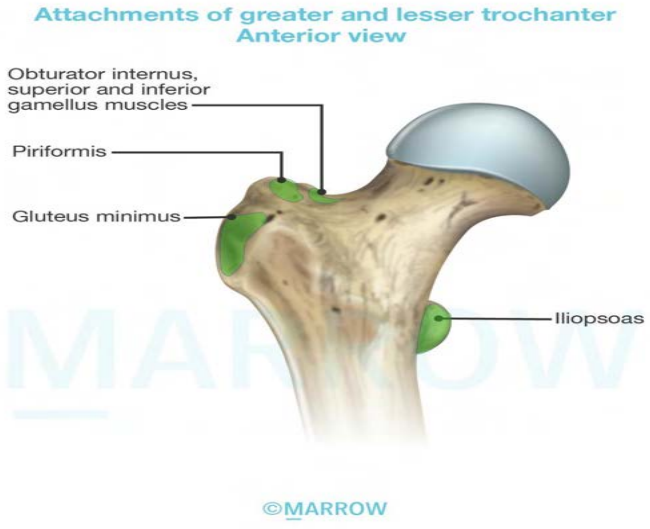
• Gluteus medius

• Piriformis

• Common tendon of obturator internus and gamelli.

• Lesser trochanter: It is a conical projection of the shaft present posteromedially. Muscles inserted to it are iliacus and psoas major

Surface marking: Greater trochanter lies inferior to the midpoint of the iliac crest and at the level of the horizontal plane passing through the pubic tubercle.



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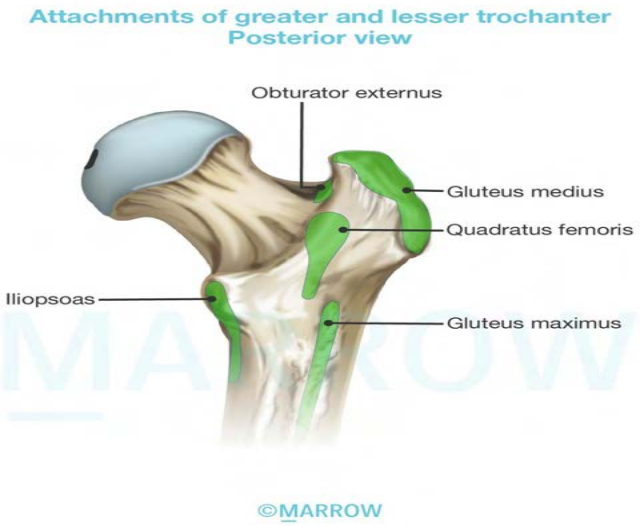

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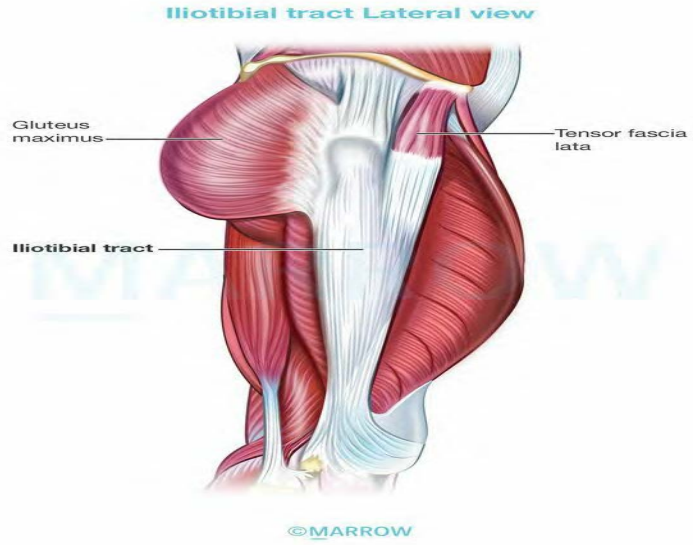
Solution to Question 7:

The iliotibial tract receives the insertion of tensor fasciae latae.

The iliotibial tract is the modification of the deep fascia of the thigh. The proximal end gives attachment to the tensor fascia lata and gluteus maximus. The distal end is attached to Gerdy's tubercle present on the lateral condyle of the tibia.



Solution to Question 8:

The powerful abductor of hip joint is the gluteus medius.

Abduction is assisted by the following muscles:

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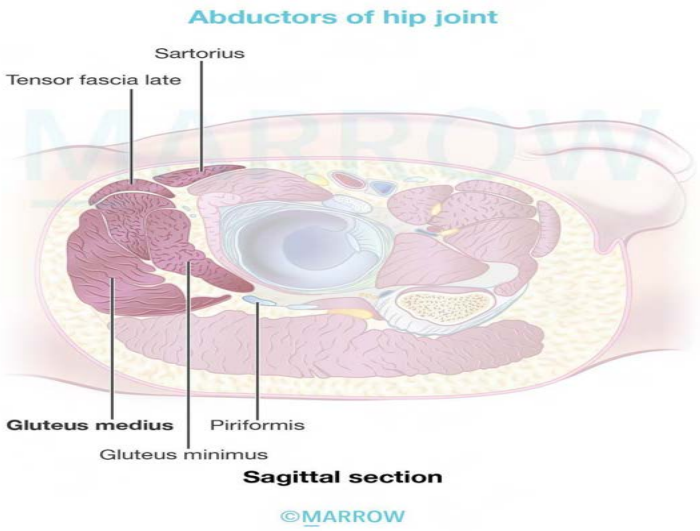
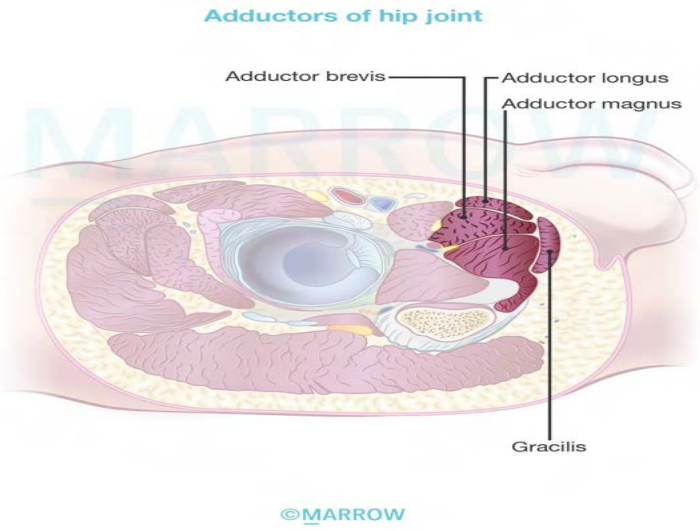
• Gluteus minimus
• Tensor fascia lata
• Piriformis
• Sartorius



Adduction of the hip joint is mainly caused by
• Adductor longus
• Adductor brevis
• Adductor magnus
• Gracilis



Flexion of the hip joint is caused by:

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• Psoas major

• Iliacus

• Rectus femoris

• Assisted by:

• Pectineus

• Tensor fascia lata

• Sartorius

Extension of the hip joint is caused by:

• Gluteus maximus

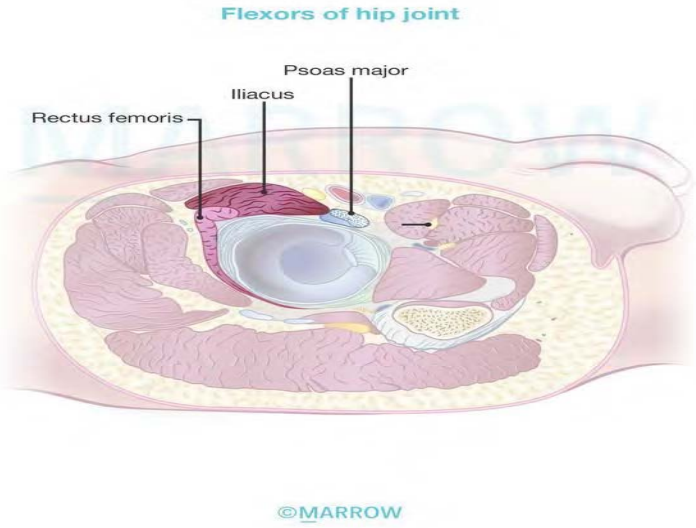
• Biceps femoris

• Semitendinosus

• Semimembranosus (hamstrings)

• Adductor magnus

• Assisted by - posterior fibers of gluteus medius



@itachibot someone else, mmed.

Solution to Question 9:

The external rotation of the hip joint is caused by the following muscles:

• Gluteus maximus

• Obturator internus

• Superior and inferior gemelli

• Quadratus femoris

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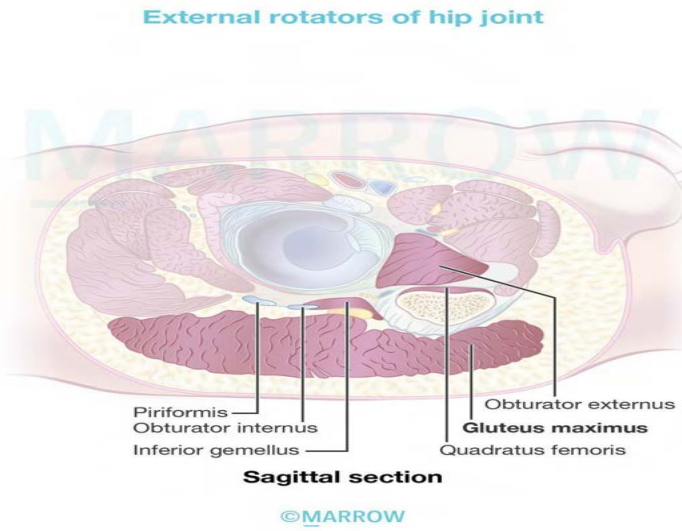
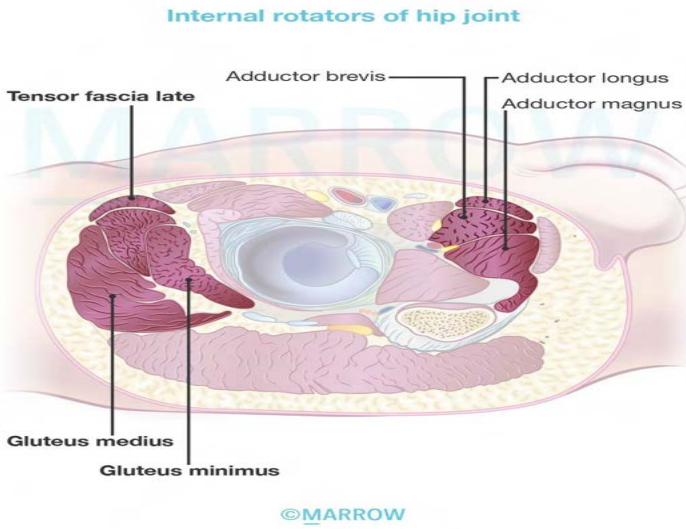
• Piriformis
• Assisted by
• Obturator externus
• Sartorius



Internal rotation of the hip joint is caused by the following muscles:
• Gluteus medius
• Gluteus minimus
• Tensor fascia lata
• Adductor muscles



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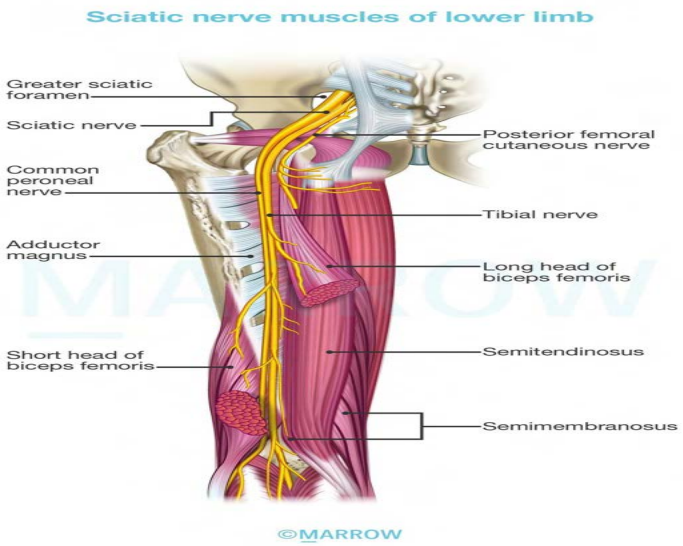
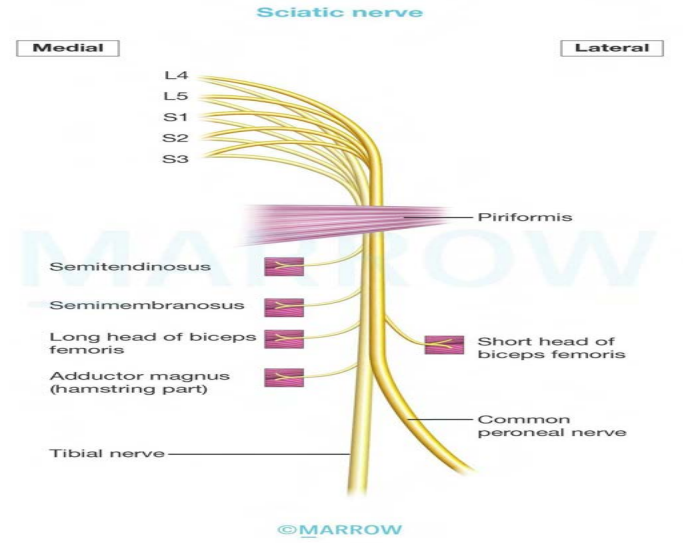
Solution to Question 10:

The posterior femoral muscles (hamstring muscles) are innervated by the sciatic nerve.

• Semitendinosus, semimembranosus, and the long head of biceps femoris are innervated by tibial division of the sciatic nerve (L5, S1, and S2)

• The short head of biceps femoris is innervated by the common peroneal division of the sciatic nerve.





Solution to Question 11:

The short head of the biceps femoris is not attached to the ischial tuberosity. It is attached to the lateral lip of the linea aspera, lateral supracondylar ridge of the femur, and the lateral intermuscular septum of the thigh.

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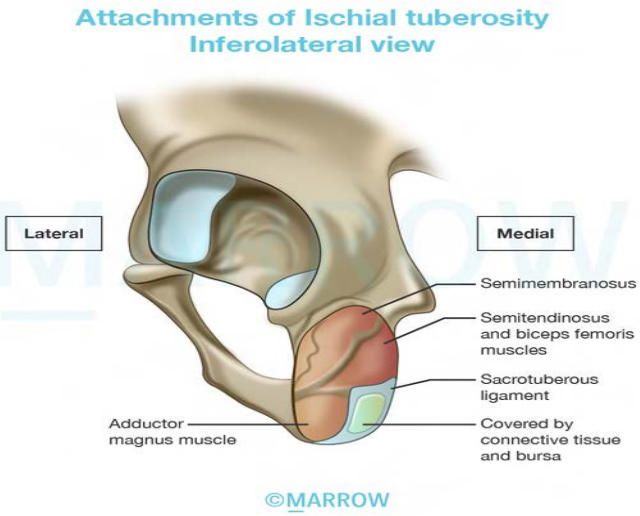
The ischial tuberosity is broadly divided into upper and lower areas:

• The upper area is further subdivided into a superolateral part for the semimembranosus and an inferomedial part for the long head of the biceps femoris and the semitendinosus.

• The lower area is subdivided by an irregular vertical ridge, into lateral and medial areas. The larger lateral area is for the adductor magnus. The smaller medial area is covered by adipose tissue, which usually contains the sciatic bursa of the gluteus maximus, which supports the body in sitting.



Solution to Question 12:

The clinical features are suggestive of piriformis syndrome, which occurs due to the entrapment of the sciatic nerve.

It is triggered by sitting for a long time or running, climbing stairs, or applying firm pressure directly over the piriformis muscle. Early signs include pain, tingling, or numbness in the buttocks. Later it may lead to severe pain extending down the length of the sciatic nerve.

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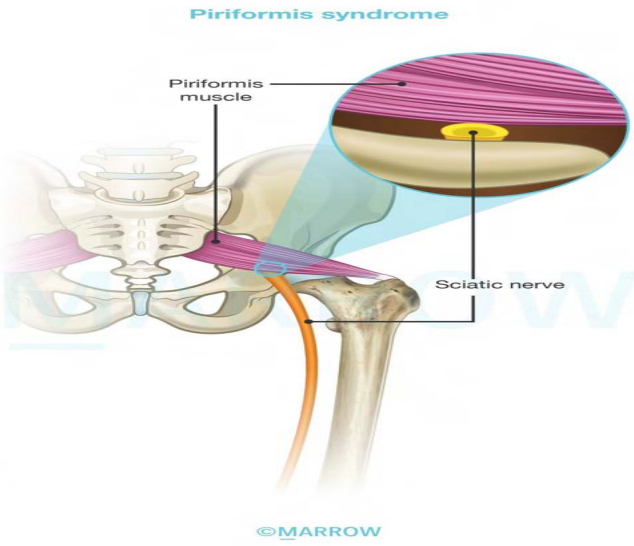

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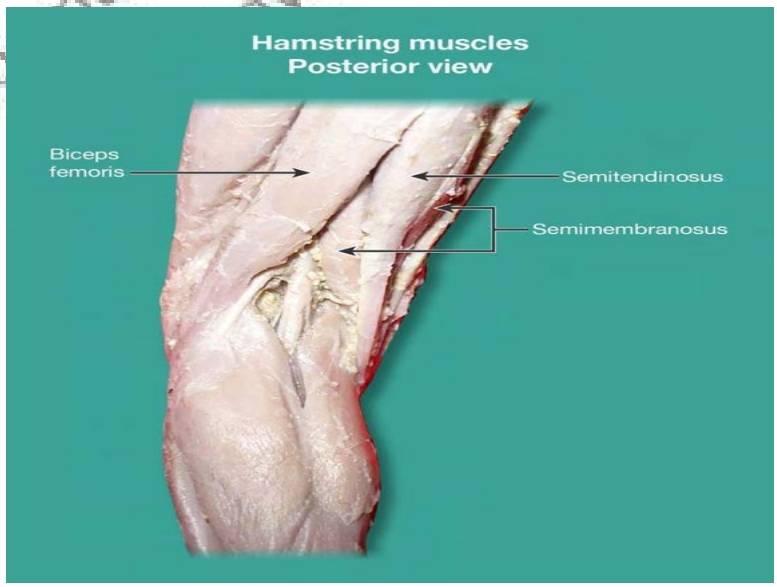
Solution to Question 13:

The sartorius muscle is not a part of hamstring muscles.

Hamstring muscles are present in the posterior compartment of the thigh and include semimembranosus, semitendinosus, and biceps femoris.

They cause the flexion of the knee joint and extension of the hip joint. In addition to this, semimembranosus and semitendinosus cause medial rotation of the hip and knee joint, and biceps femoris causes lateral rotation of the hip and knee joint.



Solution to Question 14:

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The gracilis muscle belongs to the medial compartment of the thigh.

Muscles of the anterior compartment:

• Sartorius

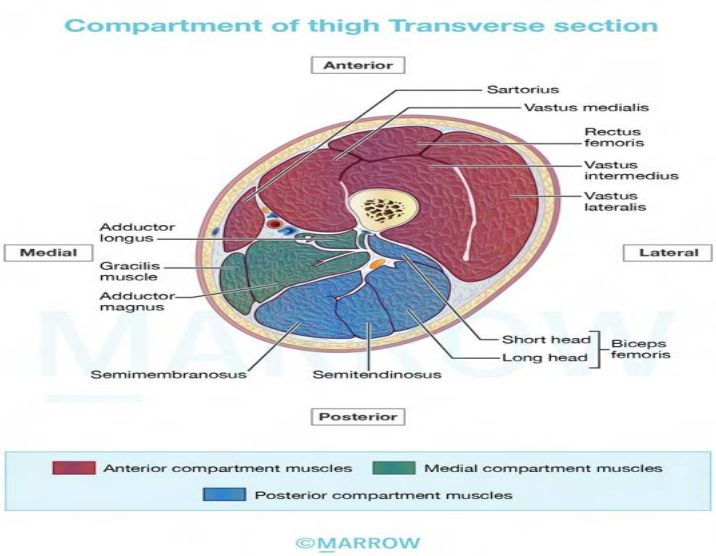
• Rectus femoris

• Vasti medialis, lateralis, and intermedius

• Articularis genus

Note:

Adductor longus and pectineus are sometimes considered to be part of both the anterior and the medial compartments.



Solution to Question 15:

The weakness of the vastus medialis is responsible for the lateral displacement of the patella.

The lowest fibers of the vastus medialis muscle, which are attached medially to the upper half of the patella are referred to as vastus medialis obliquus. These fibers of the vastus medialis prevent the lateral displacement of the patella, during knee motion. The weakness of the vastus medialis obliquus may lead to patellar instability and pain.

Solution to Question 16:

Medial rotation of the flexed knee is produced by the following muscles:

• Semimembranosus

• Popliteus

• Semitendinosus

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• Assisted by

• Sartorius

• Gracilis

Knee joint is a complex synovial joint consisting of tibiofemoral and patellofemoral articulations. Movements occurring at knee joint are flexion, extension, medial rotation, and lateral rotation.

• Flexion - biceps femoris, semitendinosus, and semimembranosus (hamstrings)

• Extension - quadriceps femoris, assisted by tensor fasciae latae

• Medial rotation of the flexed leg - popliteus, semimembranosus, and semitendinosus

• Lateral rotation of the flexed leg - biceps femoris

Note: Semimembranosus tendinopathy may develop as a result of the overuse of muscle usually cyclists and marathon runners. Patients may complain of insidious pain in the posteromedial part of the knee radiating distally to the medial calf or proximally to the posteromedial thigh. It is a cause of chronic knee pain that often goes undiagnosed as it is poorly understood.

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Solution to Question 17:

In the given scenario, the muscle likely to be affected is extensor hallucis longus, which is innervated by the deep peroneal nerve.

Solution to Question 18:

Peroneus brevis muscle belongs to the lateral compartment of the leg.

Muscles of the anterior compartment of the leg produce dorsiflexion (extension) of the ankle. They are:

• Extensor digitorum longus

• Extensor hallucis longus

• Tibialis anterior

• Peroneus tertius (inverts and everts foot)

Muscles of the posterior compartment produce plantar flexion. They include superficial and deep groups which are separated by the transverse intermuscular septum.

• The superficial flexor group consists of the gastrocnemius, plantaris, and soleus.

• The deep flexor group consists of popliteus, flexor digitorum longus, flexor hallucis longus, and tibialis posterior.

Muscles of lateral compartment evert the ankle and include peroneus longus and peroneus brevis.

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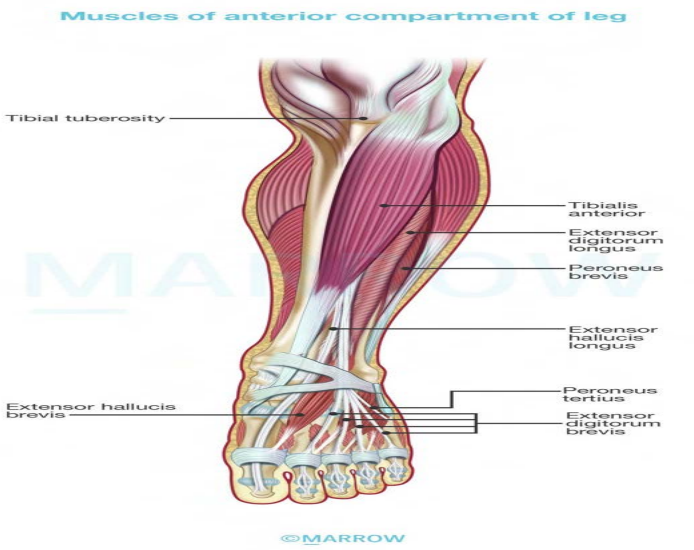

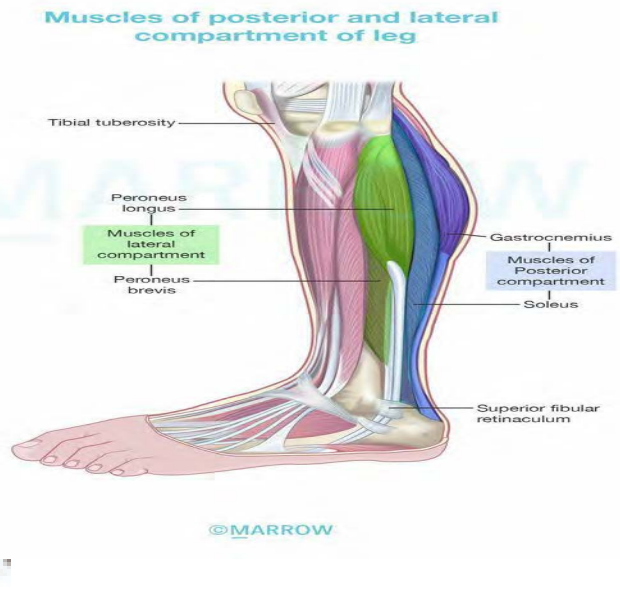

Solution to Question 19:

Peroneus longus muscle is not involved in the inversion of the foot. It causes eversion and plantar flexion.

Inversion of the foot is a movement in which the medial border of the foot is elevated so that the sole faces medially.

• Tibialis anterior - Causes dorsiflexion and inversion of the foot

• Tibialis posterior - Causes plantar flexion and inversion of the foot

• Extensor hallucis longus - Causes extension of the great toe, dorsiflexion of the foot, and inversion of the foot (minimal action)

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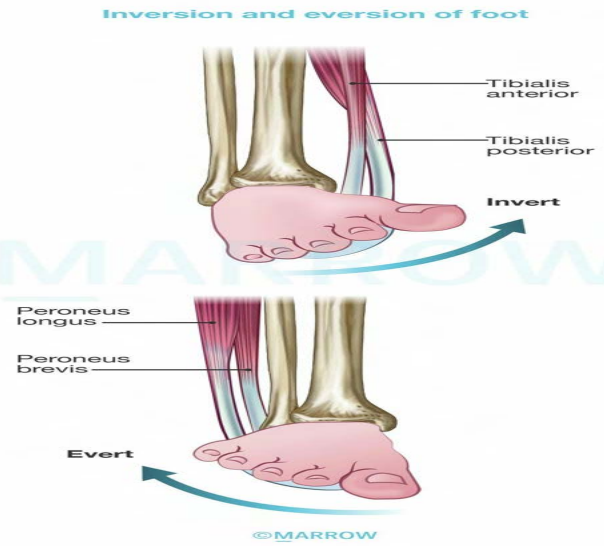
Eversion of the foot is a movement where the lateral border of the foot is elevated so that the sole faces laterally. Peroneus longus, peroneus brevis, and peroneus tertius are the muscles involved.

These movements take place, mainly at the talocalcaneal and the talocalcaneonavicular joints, and partly at the transverse tarsal joint.



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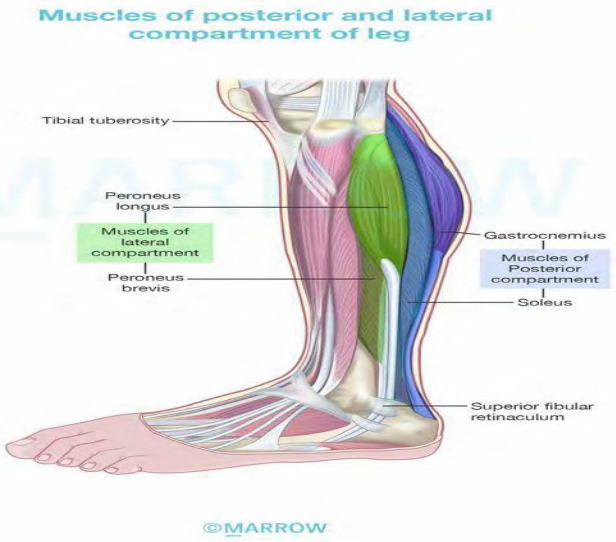
Solution to Question 20:

The action shown in the image is plantar flexion of the ankle joint and weakness of gastrocnemius muscle causes loss of this movement.

The plantar flexion of the toe is produced mainly by gastrocnemius and soleus, assisted by plantaris, tibialis posterior, flexor hallucis longus, and flexor digitorum longus.

Dorsiflexion is caused by the tibialis anterior and assisted by extensor digitorum longus, extensor hallucis longus, and peroneus tertius.



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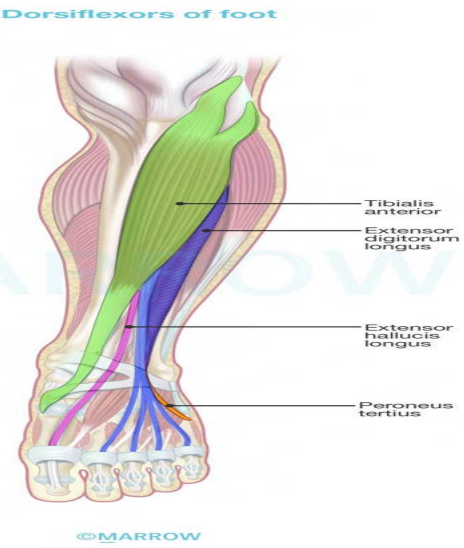

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Solution to Question 21:

The gastrocnemius (two heads) and soleus muscles are collectively known as triceps surae. They constitute a powerful muscular mass whose main function is plantar flexion of the foot.

The main bulk of the calf is formed by gastrocnemius, plantaris, and soleus muscles. These 3 muscles form the superficial flexor group of the posterior compartment of the lower leg.

Solution to Question 22:

Dorsiflexion of the foot causes pain in the deep posterior compartment syndrome of the leg.

All tibial fractures should be monitored for signs of compartment syndrome. Severe pain is the most important clinical feature. Regular clinical evaluation is important because swelling, blistering, and skin necrosis is associated with late, severe compartment syndrome.

Compartment syndromes of the lower limb:

• Superficial and deep posterior compartment syndrome - There will be pain on passive dorsiflexion of the foot and on the toe extension

• Anterior compartment syndrome - There will be pain on passive plantar flexion of the foot and toe flexion

• Lateral compartment syndrome - There will be pain on passive foot inversion.

Solution to Question 23:

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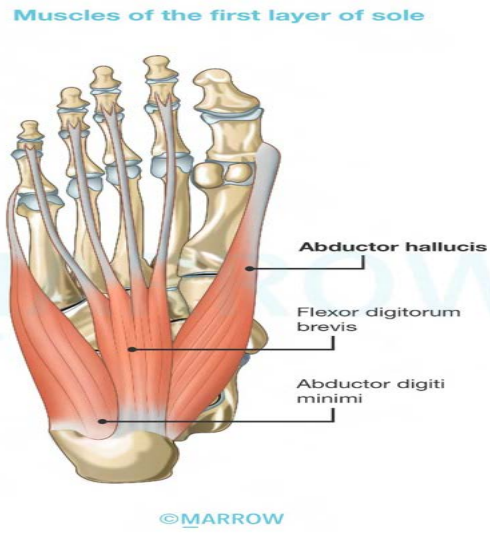
The first layer of the sole consists of abductor hallucis.

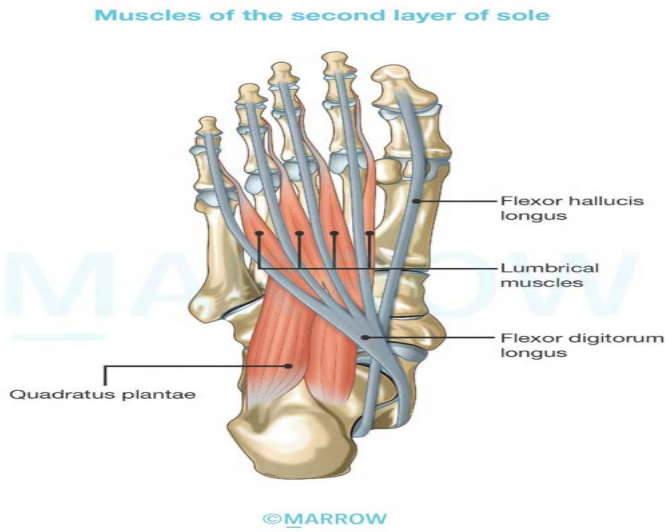
The muscles of the sole of the foot are arranged in 4 layers. From superficial to deep, the layers are numbered from one to four.

Muscles of the sole of the foot are:

1st layer: This is the superficial layer which includes abductor hallucis, abductor digiti minimi, and flexor digitorum brevis.



2nd layer: It consists of flexor accessorius and the four lumbrical muscles,the tendons of flexor hallucis longus and flexor digitorum longus run in the same plane as the muscles of the second layer.



3rd layer: It contains the shorter intrinsic muscles of the toes, which are flexor hallucis brevis, adductor hallucis and flexor digiti minimi brevis.

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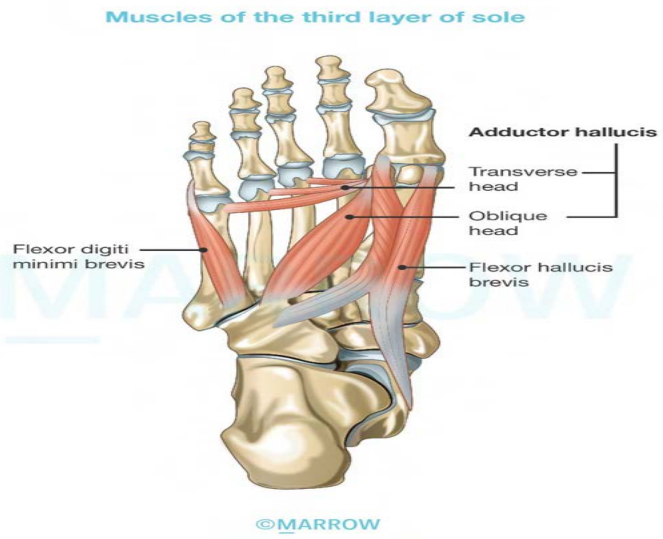
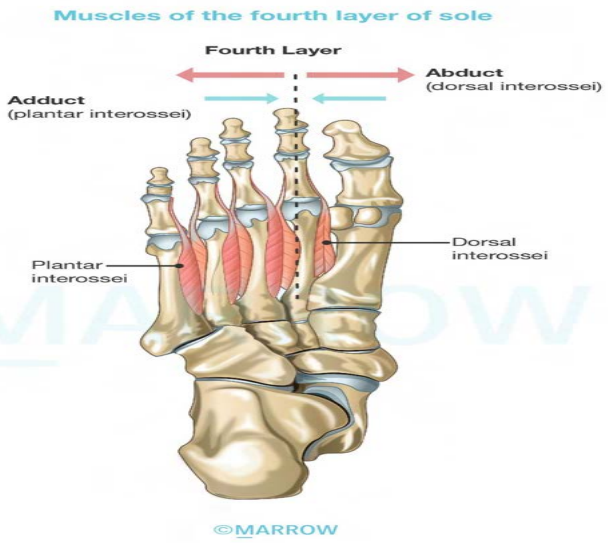


4th layer: It consists of plantar and dorsal interossei and the tendons of tibialis posterior and fibularis longus.



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Nerves & Vessels of Lower Limb

Question 1:

Which of the following nerve is a branch of lumbar plexus?

a) Sciatic nerve

b) Femoral nerve

c) Posterior femoral cutaneous nerve

d) Nerve to obturator internus

Question 2:

A patient presents with tingling, numbness, and burning pain in the outer part of the right thigh. There is no motor dysfunction. What is the root value of this patient's affected nerve?

a) L1, L2

b) L2, L3

c) L1, L2, L3

d) L2, L3, L4

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Question 3:

Which of the following nerve is a branch of the sacral plexus?

a) Iliohypogastric nerve

b) Ilioinguinal nerve

c) Obturator nerve

d) Sciatic nerve

Question 4:

The femoral nerve is split into the anterior and posterior divisions by which of the following arteries?

a) Profunda femoris artery

b) Deep external pudendal artery

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c) Lateral circumflex femoral artery

d) Medial circumflex femoral artery

Question 5:

Which of the following branches of the femoral nerve arises from its main trunk and passes below the inguinal ligament?

a) Nerve to sartorius

b) Nerve to iliacus

c) Nerve to pectineus

d) Nerve to rectus femoris

Question 6:

A 60-year-old woman after a trivial fall presents with pelvic fracture along with left femoral nerve injury. The function of all of the following muscles will be affected except:

a) Pectineus

b) Gracilis

c) Sartorius

d) Quadriceps femoris

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Question 7:

A patient presents with a loss of extension of the knee joint. On examination, decreased sensation over the anterior aspect of the thigh is noted. Which of the following nerve is likely damaged in this patient?

a) Obturator nerve

b) Common peroneal nerve

c) Tibial nerve

d) Femoral nerve

Question 8:

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In a patient, following venous cut down for access to the great saphenous vein, sensation over the medial side of the leg was lost. The affected nerve is a branch of which of the following nerves?

a) Obturator nerve

b) Posterior division of femoral nerve

c) Sural nerve

d) Anterior division of femoral nerve

Question 9:

Obturator nerve block is performed on a patient with severe chronic hip pain. Anterior division of this nerve innervates all of the following muscles except:

a) Gracilis

b) Adductor longus

c) Adductor brevis

d) Adductor magnus

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Question 10:

Which of the following nerve does not innervate the muscles of the gluteal region?

a) Nerve to quadratus femoris

b) Nerve to obturator internus

c) Sciatic nerve

d) Nerve to piriformis

Question 11:

A 40-year-old man comes with a history of a hip fracture which was treated surgically, four months ago. You observe him walking with the gait shown below. Injury to which of the following nerves is most likely in this patient?

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a) Right inferior gluteal nerve

b) Right superior gluteal nerve

c) Left inferior gluteal nerve

d) Left superior gluteal nerve

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Question 12:

Foot drop is caused by damage to:

a) Common peroneal nerve

b) Femoral nerve

c) Tibial nerve

d) Sciatic nerve

Question 13:

A 45-year-old man came for his cast removal after a right tibial fracture. You noted that the patient lifted his right leg high to take a step. On examination, the right foot was inverted and sensory loss was present on the whole dorsum of the right foot. Which of the following nerves is most likely affected in this patient?

a) Sural nerve

b) Superficial fibular nerve

c) Deep fibular nerve

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d) Common fibular nerve

Question 14:

Which of the following does not share its nerve supply with the rest of the given muscles?

a) Peroneus longus

b) Peroneus tertius

c) Tibialis anterior

d) Extensor digitorum longus

Question 15:

In a patient with Morton's neuroma, branches of which of the following nerves will get entrapped?

a) Sural nerve

b) Medial plantar nerve

c) Superficial peroneal nerve

d) Saphenous nerve

Question 16:

Baxter's nerve is a branch of which of the following nerves?

a) Medial calcaneal nerve

b) Lateral calcaneal nerve

c) Medial plantar nerve

d) Lateral plantar nerve

Question 17:

What is the root value of cremasteric reflex?

a) L1,L2

b) L3,L4

c) S1,S2

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d) T8,T9

Question 18:

Which of the following is not a branch of the femoral artery?

a) Deep circumflex iliac artery

b) Superficial external pudendal artery

c) Superficial circumflex iliac artery

d) Deep external pudendal arteries

Question 19:

Which of the following artery does not take part in the cruciate anastomosis?

a) First perforating artery

b) Inferior gluteal artery

c) Superior gluteal artery

d) Lateral circumflex femoral artery

Question 20:

A 60-year-old man presented with pain while walking after a prolonged flight travel. Ultrasonography revealed thrombus in the short saphenous vein. If the thrombus gets dislodged, it is likely to enter which of the following veins first?

a) Popliteal vein

b) Femoral vein

c) Posterior tibial vein

d) Long saphenous vein

Question 21:

What are above knee perforators known as?

a) Dodd veins

b) Hunter veins

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c) Cockett veins

d) Boyd veins

Answer Key

Question No.	Correct Option
1	b
2	b
3	d
4	c
5	c
6	b
7	d
8	b
9	d
10	c
11	d
12	a
13	d
14	a
15	b
16	d
17	a
18	a
19	c
20	a
21	a

Detailed Explanations

Solution to Question 1:

The femoral nerve is a branch of the lumbar plexus and arises from the posterior (dorsal) divisions of the ventral rami of L2–L4.

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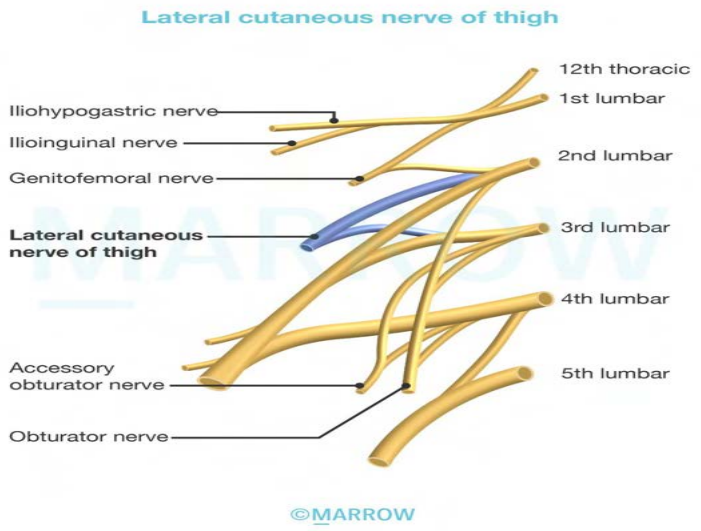
The sciatic nerve, posterior femoral cutaneous nerve, and nerve to obturator internus are a part of sacral plexus.

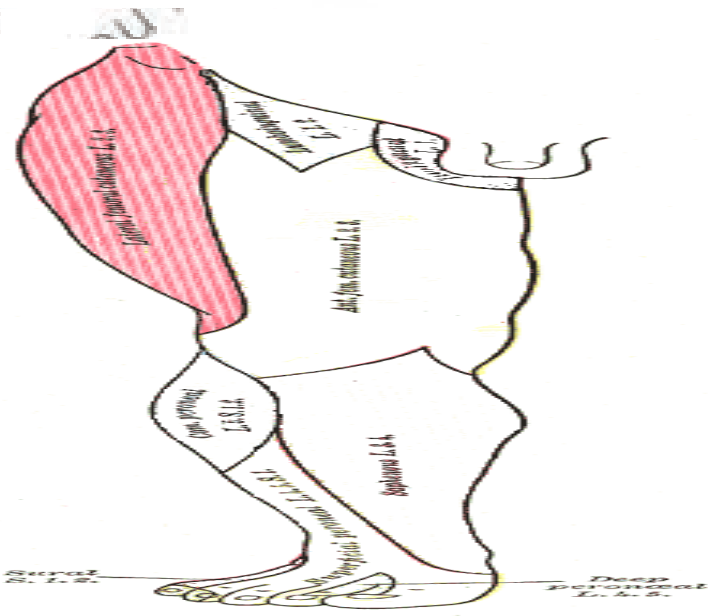
Solution to Question 2:

The given scenario is suggestive of meralgia paresthetica, in which the lateral cutaneous nerve of the thigh is affected. The root value of this nerve is L2 and L3.

It arises from the posterior divisions of the ventral rami of L2 and L3 and supplies the skin of the anterior and lateral surfaces of the thigh upto the knee.

The images given below represent the root value and the area supplied by the lateral cutaneous nerve of the thigh.





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Solution to Question 3:

The sciatic nerve is a branch of the sacral plexus. It is the largest branch of the sacral plexus.

Solution to Question 4:

The femoral nerve is split into the anterior and posterior divisions by the lateral circumflex femoral artery.

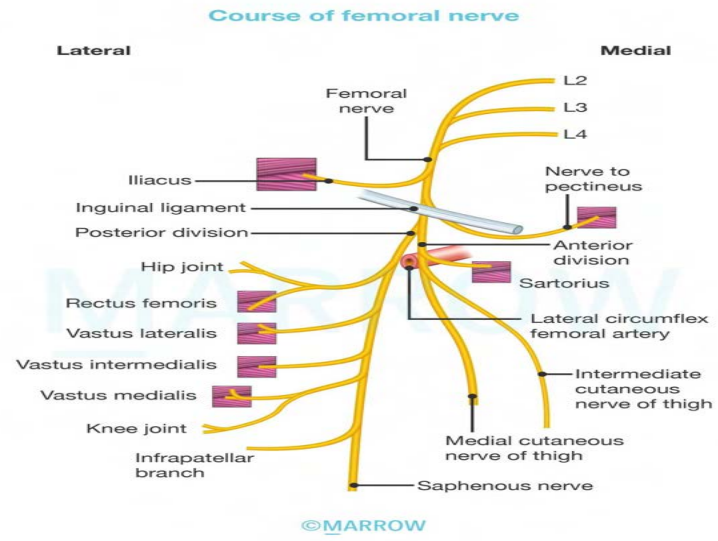
The course of femoral nerve is given below:

• Arises from posterior division of ventral rami of L2-L4 spinal segments on the posterior abdominal wall

• Enters the femoral triangle by passing under the inguinal ligament

• In the femoral triangle, it lies lateral to the femoral artery and outside the femoral sheath

• Divided into anterior and posterior branches by lateral circumflex femoral artery



Note: Obturator nerve is divided into anterior and posterior divisions by obturator externus in the upper part and adductor brevis in the lower part.

Solution to Question 5:

The Nerve to pectineus arises near and passes below the inguinal ligament and then runs behind the femoral sheath.

The femoral nerve gives off the nerve to iliacus and pectineus before it divides into the anterior and posterior divisions.

The image given below shows the course of the femoral nerve.

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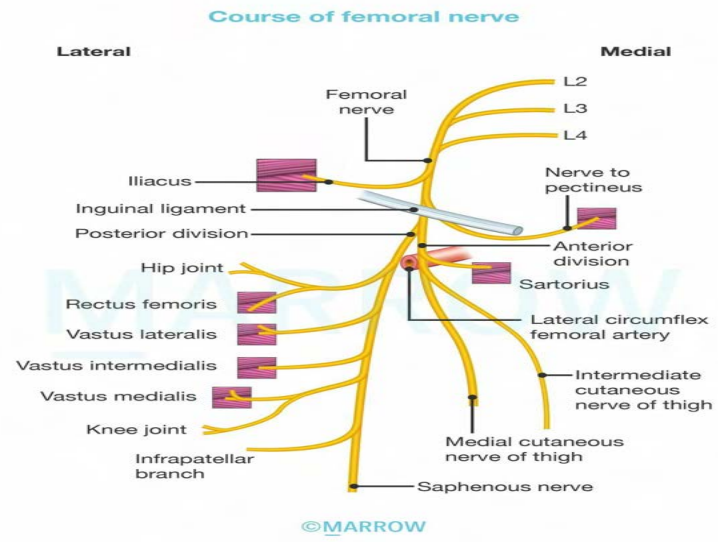

Solution to Question 6:

Gracilis is supplied by the obturator nerve and not the femoral nerve. Hence, the function of gracilis muscle will be normal in this patient.

Branches of the femoral nerve:

• Before entering the thigh, the femoral nerve supplies branches to the iliacus and pectineus muscles

• The anterior division of femoral nerves supplies the sartorius and gives sensation to the anteromedial aspect of the thigh by the branches medial cutaneous nerve of the thigh and intermediate cutaneous nerve of the thigh

• The posterior division of the femoral nerve supplies branches to the quadriceps femoris muscles, knee joint and gives sensation to the medial aspect of the leg by the saphenous nerve.

The image given below shows the course of the femoral nerve.

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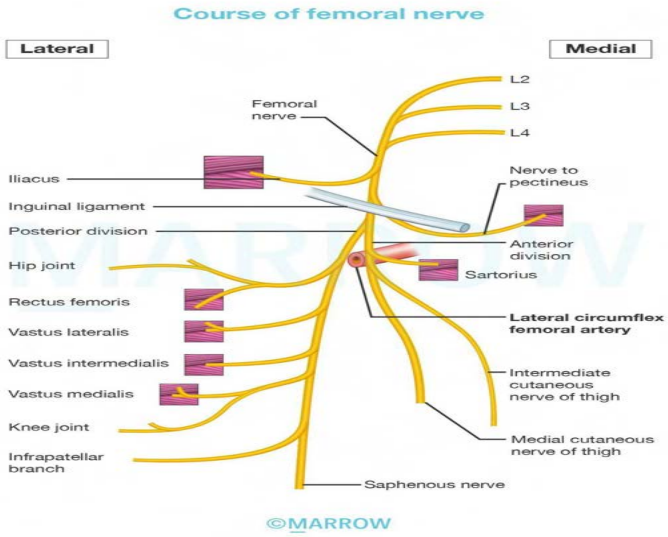
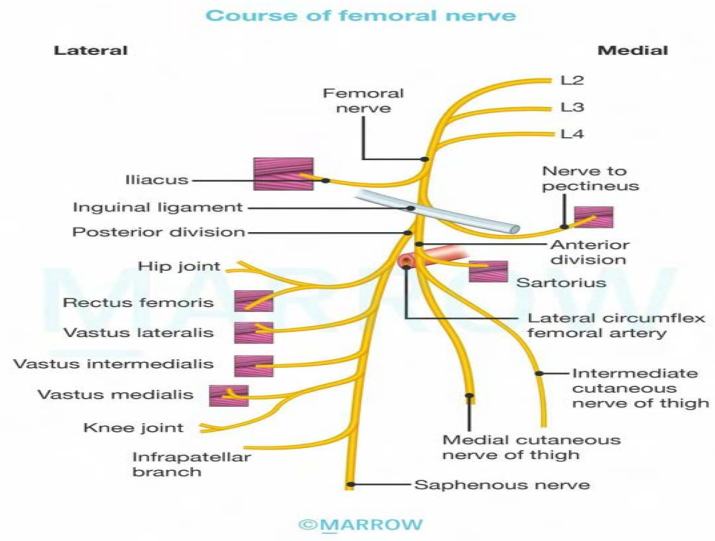


Solution to Question 7:

Loss of extension of the knee joint with decreased sensation over the anterior aspect of the thigh suggests damage to the femoral nerve.

The femoral nerve innervates the quadriceps femoris muscles which are the extensors of the knee joint. It provides sensory branches to the anterior and medial aspect of the thigh by medial and intermediate cutaneous nerves of the thigh.

The image given below shows the course of the femoral nerve.



Solution to Question 8:

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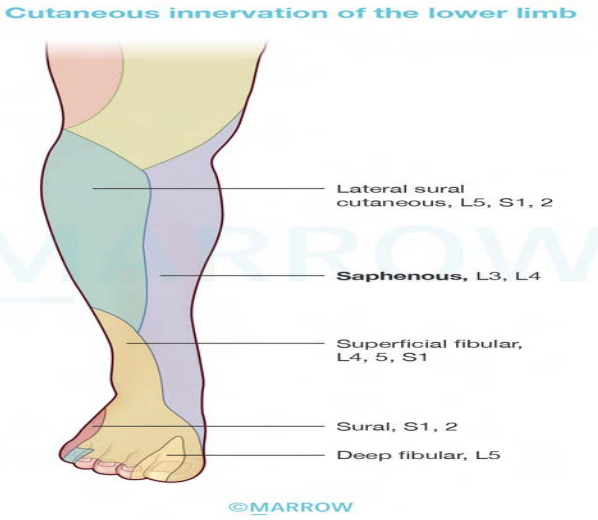
Loss of sensation of the medial side of the leg denotes injury to the saphenous nerve. It is a branch of the posterior division of the femoral nerve.

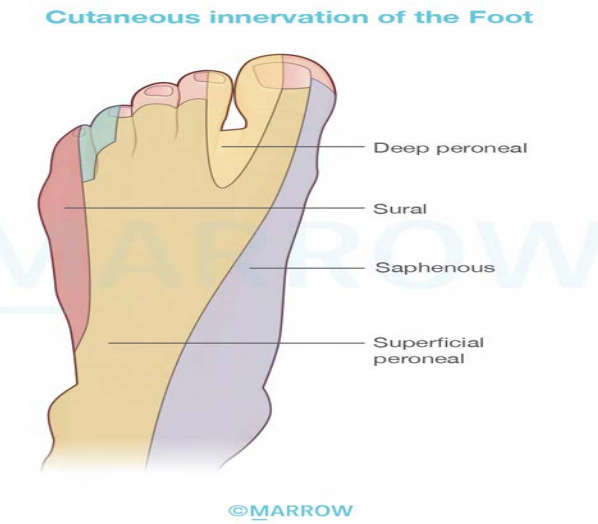
The saphenous nerve is the largest cutaneous branch of the femoral nerve.

It arises from the posterior division of the femoral nerve. In the femoral triangle, it lies lateral to the femoral artery. It then enters the adductor canal where it crosses anterior to the femoral artery to lie medial to it. It leaves the adductor canal by piercing the fascia lata between the gracilis and sartorius and supplies the skin over the patella.

It then descends along the medial border of the tibia along with the long saphenous vein and supplies the skin on the medial side of the knee leg and foot as far as up to the first metatarsophalangeal joint.

The images given below show the cutaneous innervation of the lower limb.





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Solution to Question 9:

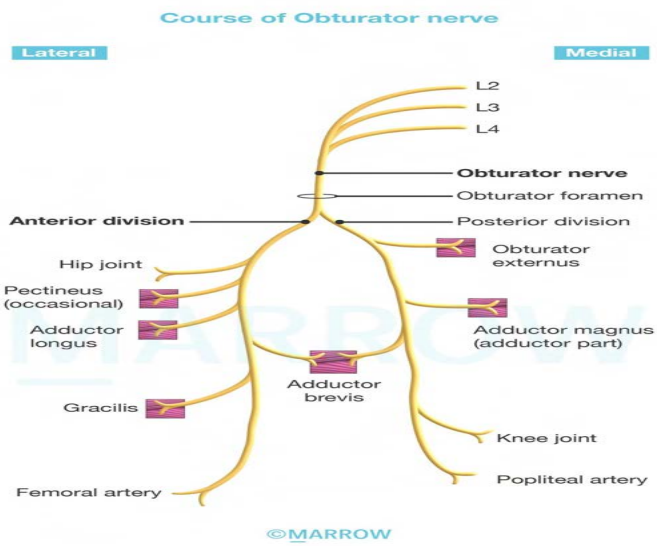
The anterior division of the obturator nerve does not innervate the adductor magnus. It is supplied by the posterior division of the obturator nerve.

The obturator nerve arises from the anterior division of the ventral rami of L2-L4. Near the obturator foramen, it divides into anterior and posterior branches.

• Anterior division supplies pectineus, adductor longus, adductor brevis, and gracilis

• Posterior division supplies adductor magnus, obturator externus. It also supplies adductor brevis if the muscle is not supplied by the anterior division

The image given below shows the course of the obturator nerve.



Solution to Question 10:

The sciatic nerve does not innervate the muscles of the gluteal region.

It is the largest nerve of the body and is made up of L4 to S3 spinal nerves of the sacral plexus. It leaves the pelvis through the greater sciatic foramen, inferior to the piriformis. It descends in the posterior thigh and divides into the tibial and common peroneal nerves proximal to the knee joint.

The tibial component of the sciatic nerve supplies:

• Semimembranosus

• Semitendinosus

• Ischial part of adductor magnus

• Long head of biceps femoris

The common fibular component of the sciatic nerve supplies a short head of the biceps femoris.

The images given below shows the course of the Sciatic nerve.

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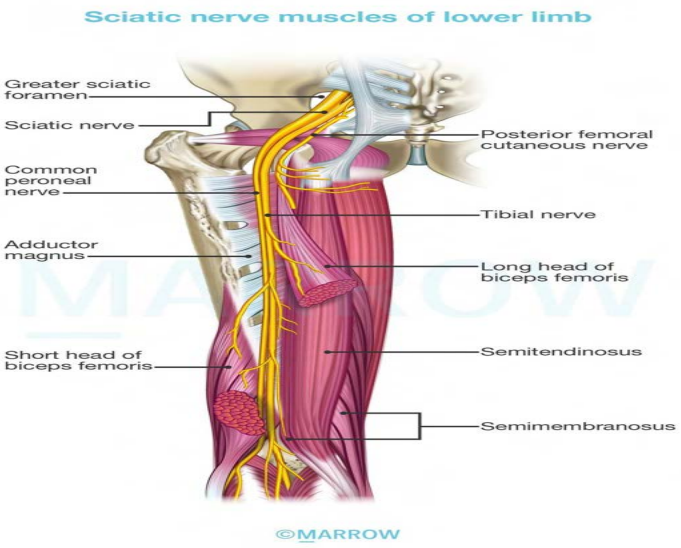

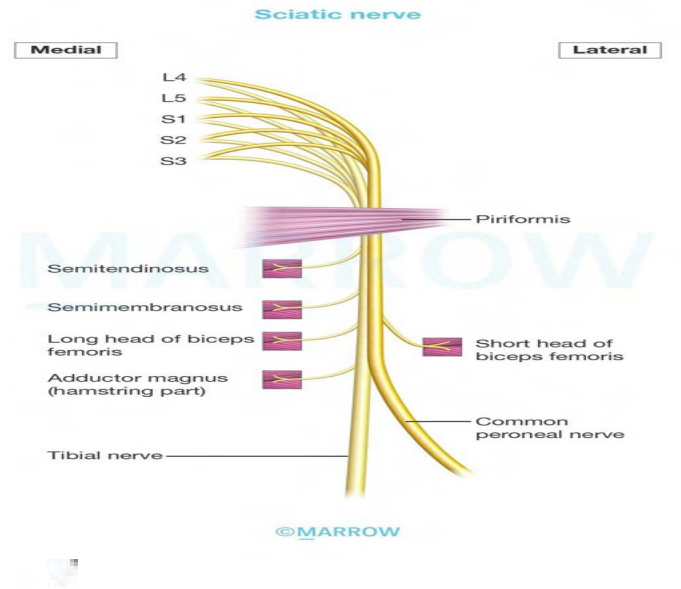

Solution to Question 11:

The given clinical scenario is suggestive of left superior gluteal nerve injury.

The patient shows characteristic lurching gait/ Trendelenburg's gait (positive Trendelenburg's sign), which is seen in paralysis of gluteus medius and gluteus minimus muscles. These muscles are supplied by the superior gluteal nerve.

When the leg on one side is lifted off the ground, the gluteus medius and minimus muscles, on the opposite supported side, exert traction on the hip bone by acting from the femur. This action results in the slight raising of the pelvis on the unsupported side, which helps maintain the trunk in the upright position.

When the gluteus medius and minimus are paralyzed, the pelvis sinks down on the unsupported (normal) side, when the patient tries to stand on the affected limb.

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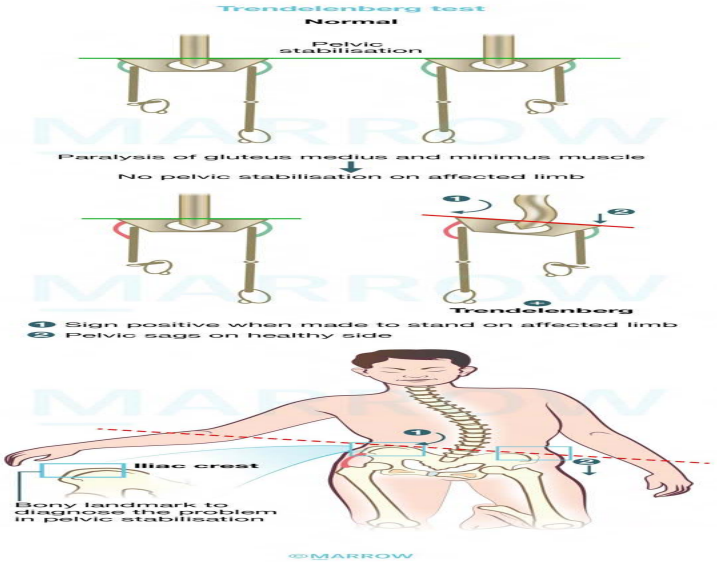
In the given case, when the patient lifts up his right leg and tries to stand on the left leg, his right pelvis tilts down. This shows that the left side abduction mechanism is paralyzed and the right side is normal. Hence, the left superior gluteal nerve injury is present in this case.

The image given below shows the Trendelenberg test.



Note: Inferior gluteal nerve supplies the gluteus maximus muscle.

Solution to Question 12:

Foot drop is caused by damage to the common peroneal nerve.

The common peroneal nerve is a component of the sciatic nerve. In the posterior thigh, it supplies the short head of the biceps femoris. It curves around the neck of the fibula deep to peroneus longus and divides into superficial and deep peroneal nerves.

• The superficial peroneal nerve innervates peroneus longus and peroneus brevis which are the evertors of the foot and to the skin over the dorsal area of the foot except for the first webspace and lateral side of the little toe.

• The deep peroneal nerve innervates all muscles of the anterior compartment which are the dorsiflexors of the foot, extensor digitorum brevis, first two dorsal interossei muscles, and skin between great and second toes.

Hence, injury to the common peroneal nerve will lead to:

• Weakness of dorsiflexion of foot or foot drop

• Loss of eversion

• Loss of extension of toes

• Sensory loss

• Anterior and lateral side of the leg

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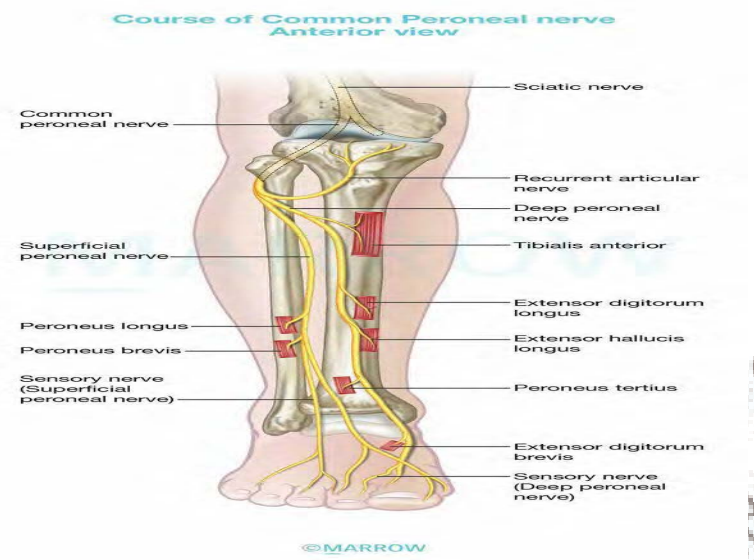
• Dorsum of the foot including the medial side of the great toe

Th image given below shows the course of common peroneal nerve.



Solution to Question 13:

The nerve affected in this patient is the common fibular nerve (common peroneal nerve).

It is derived from the dorsal branches of the L4 - L5 and S1 - S2 ventral rami.

The sciatic nerve divides into the tibial nerve and the common fibular nerve.

The common fibular nerve runs obliquely along the lateral side of the popliteal fossa to the fibular head. It lies between the biceps femoris and lateral head of the gastrocnemius. It then curves laterally around the neck of the fibula, where it is most commonly injured (e.g., due to a tight plaster cast).

It gets divided into superficial and deep fibular nerves.

Injury to the common peroneal nerve will lead to:

• Weakness of dorsiflexion of foot or foot drop

• Loss of eversion

• Loss of extension of toes

• Sensory loss

• Anterior and lateral side of the leg

• Dorsum of the foot including the medial side of the great toe

The images given below show the common peroneal nerve course and the sensory area supplied.

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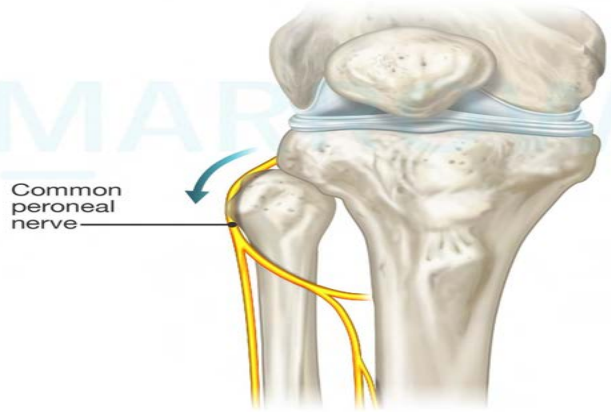
Common peroneal nerve anterior view



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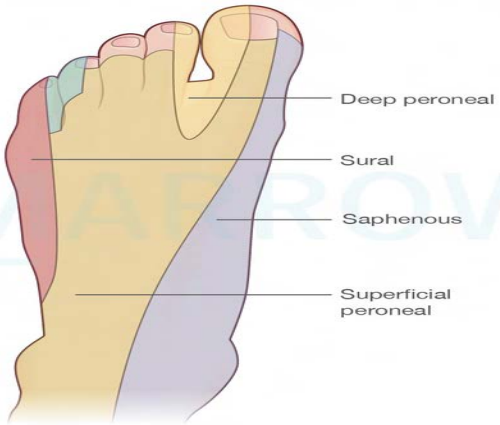
Cutaneous innervation of the Foot



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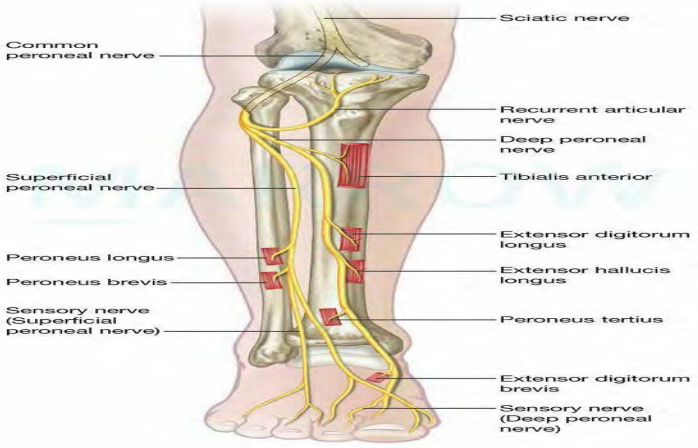
Course of Common Peroneal nerve Anterior view



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Note: Ankle reflex is preserved in common peroneal nerve palsy.

Solution to Question 14:

Peroneus longus is innervated by the superficial peroneal nerve. The rest of the muscles mentioned above are innervated by the deep peroneal nerve.

The anterior compartment of the leg is supplied by the deep peroneal nerve. It consists of:

- Tibialis anterior
- Extensor hallucis longus
- Extensor digitorum longus
- Peroneus tertius

The lateral compartment of leg is supplied by the superficial peroneal nerve. It consists of peroneus longus and peroneus brevis.

The posterior compartment of leg is supplied by the tibial nerve. It consists of

- Gastrocnemius
- Soleus
- Plantaris
- Popliteus
- Flexor hallucis longus
- Flexor digitorum longus
- Tibialis posterior

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Solution to Question 15:

Morton's neuroma may occur due to the entrapment of branches of the medial plantar nerve.

It is the most common form of nerve entrapment in the foot. It is due to the entrapment of the 3rd common digital nerve which is a branch of the medial plantar nerve.

The medial plantar nerve can also be compressed at the Knot of Henry. It is the point where the tendon of flexor hallucis longus passes deep to the tendon of flexor digitorum longus to reach the medial side of the sole of the foot.

The image given below shows the Morton's neuroma.

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Solution to Question 16:

Baxter's nerve is a branch of the lateral plantar nerve.

Clinical significance: Compression of Baxter's nerve by the deep fascia that covers abductor hallucis is implicated to be a possible cause of chronic heel pain and plantar fasciitis.

Solution to Question 17:

Cremasteric reflex is mediated by L1 and L2. In this reflex, there is ipsilateral elevation of the testicle following stroking of the medial thigh.

The cremasteric reflex's afferent and efferent branches:

• Afferent - Femoral branch of genitofemoral nerve

• Efferent - Genital branch of genitofemoral nerve

Given below are the various reflexes with their root values.

Deep reflexes	Superficial reflexes
Biceps -C5, C6	Corneal - CN V(A) - CN VII(E) - Pons
Brachioradialis - C5, C6	Conjunctival - CN V (A) - CN VII(E) - Pons
Triceps - C6, C7	Scapular - C5, T1
Finger flexion - C8	Abdominal - T7-T12
Knee jerk - L3,L4	Anal - S3, S4
Ankle -S1, S2	Cremastric -L1, L2

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Deep reflexes	Superficial reflexes
Jaw jerk - CN V (Pons)	Plantar - L5S1

Solution to Question 18:

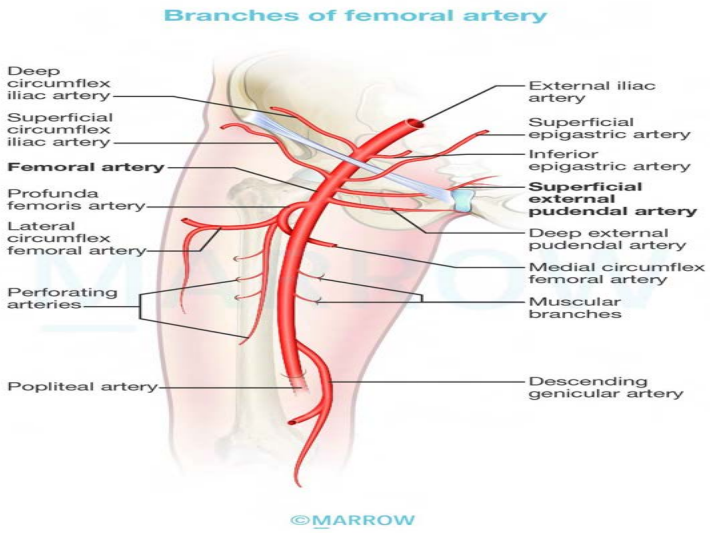
The deep circumflex iliac artery is a branch of the external iliac artery, not the femoral artery.

The femoral artery is the continuation of the external iliac artery. It starts behind the inguinal ligament midway between the anterior superior iliac spine and pubic symphysis.

It descends in the thigh anteromedially in the femoral triangle and passes through the adductor canal. It exits the adductor canal by passing through adductor hiatus, to reach the popliteal fossa and becomes the popliteal artery.

Branches of the femoral artery given below:

- Superficial epigastric artery
- Superficial circumflex iliac artery
- Superficial external pudendal artery
- Deep external pudendal arteries
- Muscular branches
- Profunda femoris artery
- Descending genicular artery



Solution to Question 19:

The superior gluteal artery does not contribute to the formation of cruciate anastomosis.

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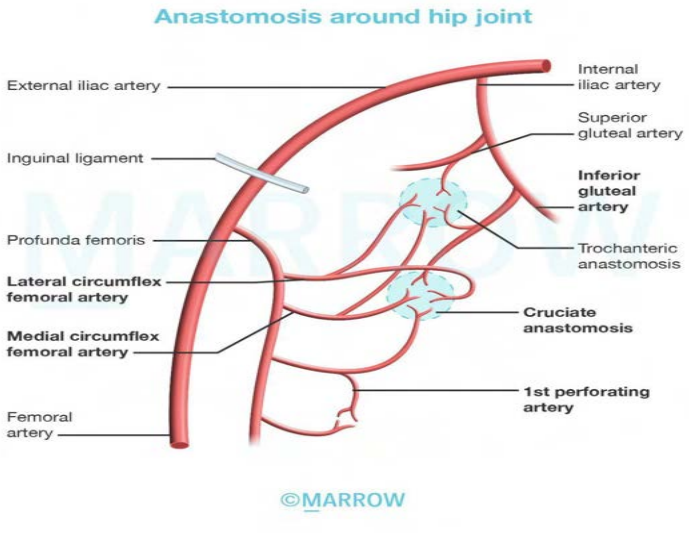
Cruciate anastomosis lies at the level of the lesser trochanter and is formed by:

- Transverse branches of medial and lateral circumflex femoral arteries
- Descending branch of the inferior gluteal artery
- Ascending branch of the first perforating artery

The image given below shows the anastomosis around the hip joint.



Note: Traumatic insults to the lower extremity (fractures, stab wounds, or gunshot wounds) can result in blood loss. It is important for the clinician to understand the arterial anastomoses in the affected area so that bleeding can be appropriately managed and exsanguination can be avoided.

Solution to Question 20:

A thrombus in the short saphenous vein may get dislodged and enter the popliteal vein. The embolus may further travel into the right heart and eventually may cause a pulmonary embolism.

The short saphenous vein is the continuation of the lateral side of the dorsal venous arch. It passes behind the lateral malleolus and drains into the popliteal vein in the popliteal fossa. The popliteal vein continues as the femoral vein proximal to the knee.

The image given below shows the venous drainage of the lower limb.

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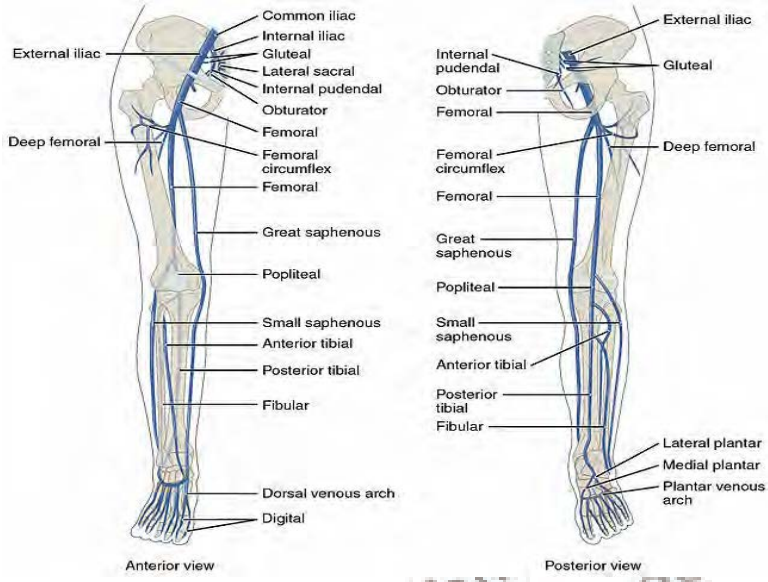

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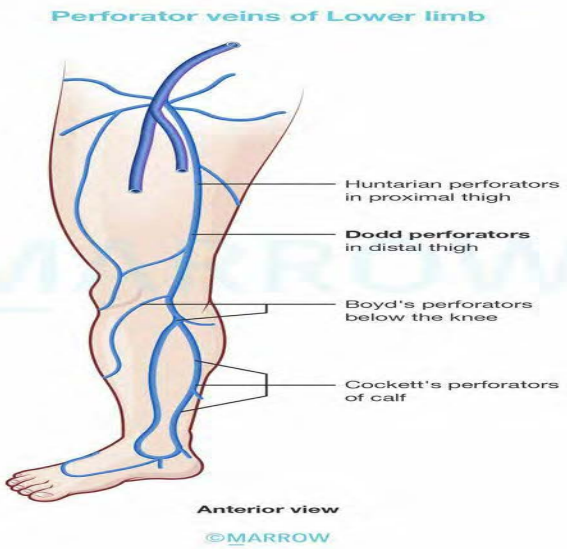
Solution to Question 21:

Above knee perforators are known as Dodd's veins.

Perforator veins connect the deep and superficial venous systems, allowing the passage of blood in between them. Following are the named perforators of the lower limb:

- Proximal thigh level perforators - Hunter perforator veins
- Distal thigh perforators - Dodd perforator veins
- Below the knee perforators - Boyd perforator veins
- Calf level perforators - Cockett perforator veins



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Important Structures of Lower Limb

Question 1:

Which of the following structures do not pass through both greater and lesser sciatic foramens?

a) Pudendal nerve

b) Tendon of obturator internus

c) Nerve to obturator internus

d) Internal pudendal vessels

Question 2:

All of the following structures are derived from the aponeurosis of the external oblique muscle except:

a) Pectineal ligament

b) Inguinal ligament

c) Lacunar ligament

d) Linea semilunaris

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Question 3:

Which of the following muscles does not form the floor of the femoral triangle?

a) Iliacus

b) Psoas minor

c) Pectineus

d) Adductor longus

Question 4:

Which of the following forms the lateral boundary of the femoral triangle?

a) Lateral margin of adductor longus

b) Medial margin of adductor longus

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c) Lateral margin of sartorius

d) Medial margin of sartorius

Question 5:

A resident was inserting a central venous line through the femoral vein. He accidentally injured the structure medial to the femoral vein, within the femoral sheath. Which structure is likely to be injured?

a) Lymphatic vessels

b) Femoral Artery

c) Femoral Nerve

d) Genitofemoral nerve

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Question 6:

A patient underwent an aortic valve replacement surgery through the femoral artery. Post-operatively, he complaints of groin pain radiating down the anteromedial thigh. Which of the following is true regarding the nerve injured?

a) It lies medial to the femoral artery

b) It is not a content of the femoral sheath

c) The nerve injured is the sciatic nerve

d) It arises from the anterior cords of the lumbar plexus

Question 7:

A middle aged man is found to have a globular swelling below and lateral to the pubic tubercle. A diagnosis of femoral hernia is made. Which structure forms the posterior border of the ring the hernia passes through?

a) Inguinal ligament

b) Lacunar ligament

c) Pectineal ligament

d) Femoral vein

Question 8:

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An adolescent is crossing the road while playing loud music on his headphones. He is struck by a car and rushed to the emergency room. The physicians notice a distal femur fracture with vascular compromise. Intraoperatively, the femoral vessels are found to be injured at the adductor hiatus. Which muscle is likely to be involved in this injury ?

a) Adductor longus

b) Adductor brevis

c) Adductor magnus

d) Sartorius

Question 9:

The hunter's canal lies beneath which muscle?

a) Vastus medialis

b) Adductor longus

c) Sartorius

d) Adductor magnus

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Question 10:

A 40 year old basketball player who sustained an ACL tear is being posted for ACL reconstruction surgery. The anesthetist plans an adductor canal block for the procedure. Which of the following structures is he least likely to encounter while giving the block ?

a) Saphenous nerve

b) Nerve to vastus medialis

c) Femoral nerve

d) Femoral artery

Question 11:

Which of the following is the correct relationship with regards to the saphenous nerve in the adductor canal?

a) Medial to the femoral vein

b) Posterior to femoral vein

c) Anterior to femoral artery

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d) Posterior to femoral artery

Question 12:

A patient presents with a chronic ulcer in the popliteal fossa. The surgeon plans to make a musculocutaneous flap using a muscle from the superolateral boundary of the fossa. Which muscle is to be used for the flap?

a) Semitendinosus

b) Semimembranosus

c) Medial head of Gastrocnemius

d) Biceps femoris

Question 13:

Which of the following is not a content of the popliteal fossa?

a) Posterior femoral cutaneous nerve

b) Articular branch of obturator nerve

c) Lateral sural cutaneous nerve

d) Lateral femoral cutaneous nerve

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Question 14:

Which of the following bones form the anterior pillar of the lateral longitudinal arch of the foot?

a) Talus, navicular, 3 cuneiform and 1st, 2nd and 3rd metatarsal

b) 4th, 5th metatarsals

c) 3rd, 4th, 5th metatarsals

d) Talus, navicular, 3 cuneiform and 1st, 2nd metatarsal

Question 15:

The keystone of the medial longitudinal arch is formed by _____.

a) Talus

b) Cuboid

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c) Calcaneus

d) Navicular

Question 16:

A 42-year-old man had trauma to the right foot, following which he complained of difficulty in walking. Examination showed collapse of the medial longitudinal arch. Injury to all of the following structures may cause the given condition except:

a) Peroneus longus

b) Tibialis posterior

c) Flexor digitorum longus

d) Plantar aponeurosis

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Question 17:

Which of the following structures does not pass deep to the superior extensor retinacula of foot?

a) Deep peroneal nerve

b) Tendon of peroneus tertius

c) Tendon of tibialis posterior

d) Tendon of extensor digitorum longus

Question 18:

Which of the following statements is false about the inferior extensor retinaculum of the foot?

a) The upper band is attached to the lower end of the fibula

b) Y shaped

c) The lower band is attached to the deep fascia of sole

d) Laterally it is attached to calcaneum

Question 19:

Which of the following is the most medial structure passing through the canals in the flexor retinaculum of the foot?

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a) Flexor digitorum longus tendon

b) Tibial nerve

c) Tibialis posterior tendon

d) Posterior tibial vessels

Answer Key

Question No.	Correct Option
1	b
2	d
3	b
4	d
5	a
6	b
7	c
8	c
9	c
10	c
11	c
12	d
13	d
14	b
15	a
16	a
17	c
18	a
19	c

Detailed Explanations

Solution to Question 1:

The tendon of the obturator internus muscle passes only through the lesser sciatic foramen.

Structures passing through both the greater and lesser sciatic foramen:

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- Pudendal nerve
- Internal pudendal vessels
- Nerve to obturator internus.

Solution to Question 2:

Linea semilunaris is derived from the aponeurosis of the internal oblique muscle.

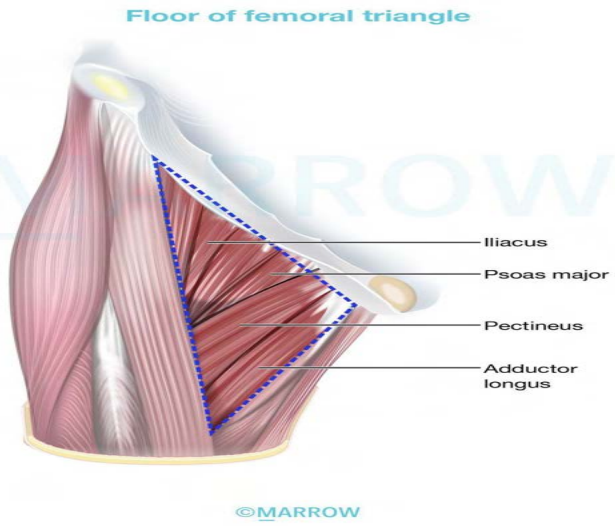
Pectineal ligament, inguinal ligament and lacunar ligament are derived from the external oblique aponeurosis.

Solution to Question 3:

Psoas major forms the floor of the femoral triangle, not psoas minor.

The femoral triangle is an intermuscular space in the anteromedial aspect of the thigh. Its boundaries are:

- Lateral boundary is formed by the medial margin of sartorius
- Medial boundary is formed by the medial margin of adductor longus.
- Floor of the femoral triangle from lateral to medial is formed by:
- Iliacus
- Psoas major
- Pectineus
- Adductor longus



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Solution to Question 4:

The lateral boundary of the femoral triangle is formed by the medial margin of the sartorius.

Its medial boundary is formed by the medial margin of adductor longus.

Solution to Question 5:

The lymphatic vessels lie medial to the femoral vein and are likely to be injured in this case.

Femoral sheath is the funnel-shaped prolongation of the fascia which contains femoral vessels. Anteriorly it is made of transversalis fascia and posteriorly it is made of fascia iliaca.

It is divided into three compartments:

• The lateral compartment contains femoral artery

• The intermediate compartment contains femoral vein

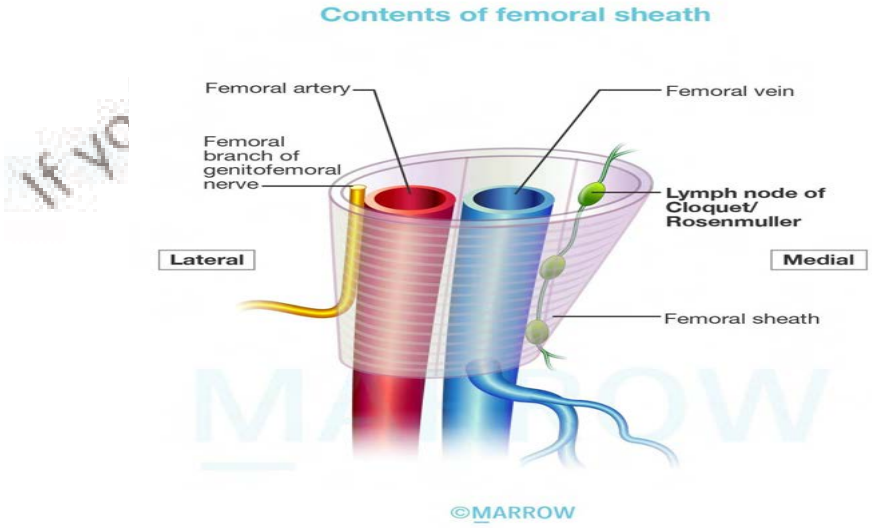
• The medial compartment which is termed as femoral canal contains:

• Lymphatic vessels

• Areolar tissue

• Lymph node of Cloquet.

The empty space in the femoral canal allows distension of the adjacent femoral vein, so it can cope with increased venous return, or increased intra-abdominal pressure.



Solution to Question 6:

The nerve injured is the femoral nerve. Femoral nerve is not a content of the femoral sheath.

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Femoral sheath forms a fascial compartment which is further divided into 3 compartments by the intervening septae:

• The lateral compartment contains femoral artery

• The intermediate compartment contains femoral vein

• The medial compartment which is termed as femoral canal contains

• Lymphatic vessels

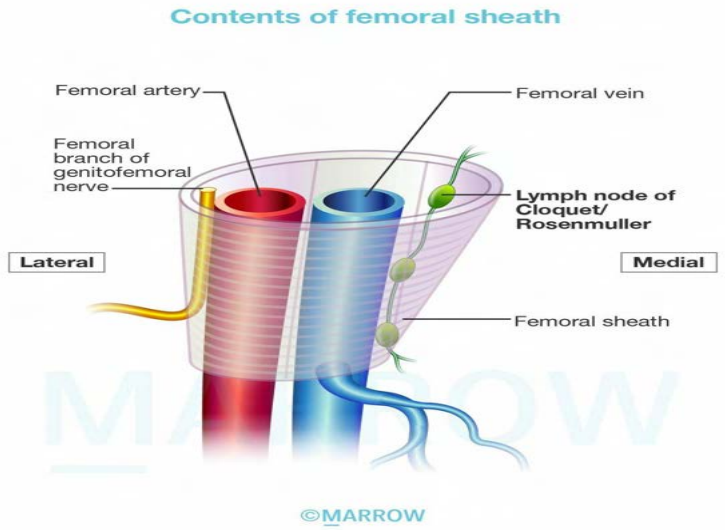
• Areolar tissue

• Lymph node of cloquet

The empty space in the femoral canal allows distension of the adjacent femoral vein, so it can cope with increased venous return, or increased intra-abdominal pressure.

Option A - Femoral nerve lies lateral to the femoral artery

Option C - Sciatic nerve injury may occur after misplaced intramuscular injection in the gluteal region. It leads to loss of sensation at the outer side of ankle and heel and foot drop.



Solution to Question 7:

Femoral hernia will pass through the femoral ring proximally. The posterior border of the femoral ring is formed by the pectineal ligament.

Relations of the femoral ring:

• Anterior border by the inguinal ligament

• Posterior border by the

• Pectineal ligament

• Superior ramus of the pubic bone

• Pectineus muscle

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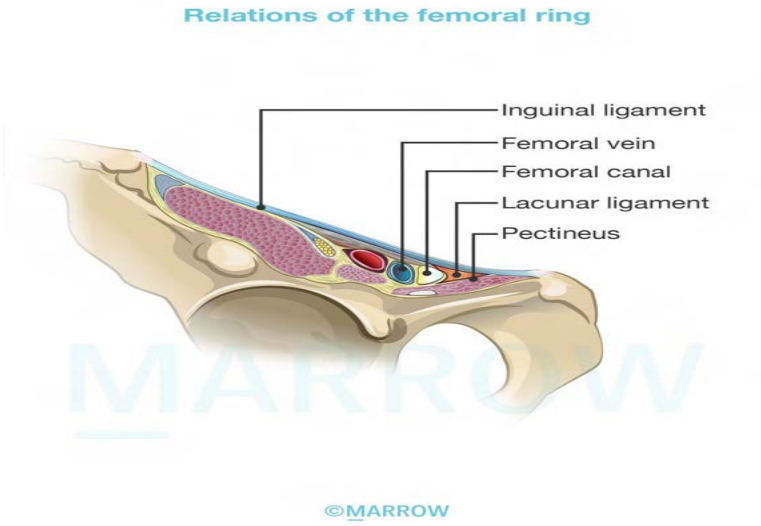
- Medial border by the lacunar ligament
- Lateral border by the femoral vein



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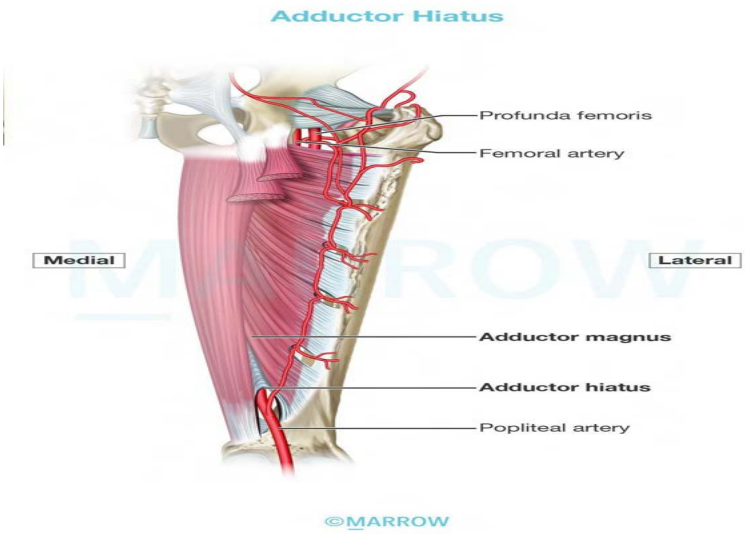
Solution to Question 8:

In the given scenario, femoral vessels are injured at the adductor hiatus. The adductor hiatus is an opening in the tendon of the adductor magnus. Hence, the muscle likely to be injured is the adductor magnus.

Clinical relevance: The adductor part of the adductor magnus attaches to the distal femur. Distal femur fractures may cause femoral artery injury and impairment of the blood supply to the lower leg.



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Solution to Question 9:

The hunter's canal lies beneath the sartorius muscle. It is also referred to as the subsartorial canal or adductor canal.

The hunter's canal is a triangular intermuscular tunnel occupying the lower two-thirds of the medial aspect of the thigh.

Solution to Question 10:

The femoral nerve is least likely to be encountered while giving an adductor canal block. Adductor canal does not contain the femoral nerve. However, it contains its branches - the saphenous and and nerve to vastus medialis.

Contents of the adductor canal:

- Saphenous nerve (largest cutaneous branch of the femoral nerve)
- Nerve to vastus medialis
- Femoral artery
- Descending genicular artery
- Femoral vein
- Deep lymphatic vessels

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Solution to Question 11:

The saphenous nerve is anterior to the femoral artery in the adductor canal.

Solution to Question 12:

The surgeon plans to use the biceps femoris muscle for the flap.

Biceps femoris forms the superolateral border of the popliteal fossa.

Popliteal fossa is a diamond-shaped region present posterior to the knee.

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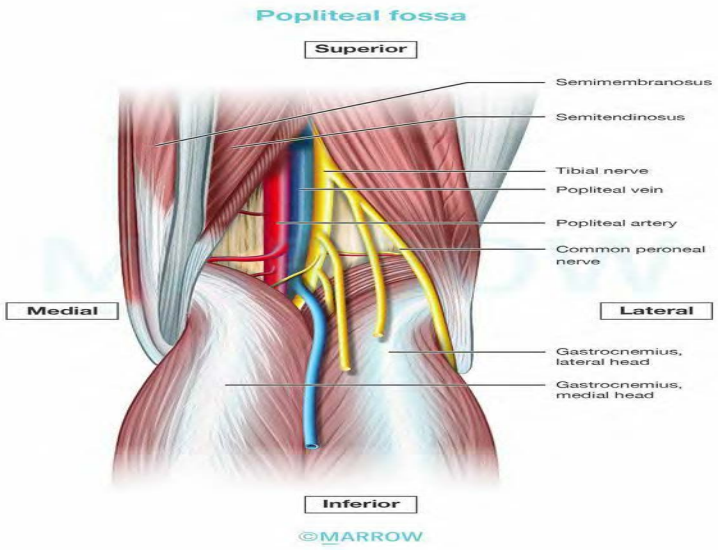

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Solution to Question 13:

The lateral femoral cutaneous nerve is not a content of the popliteal fossa. It arises from the ventral rami of L2 and L3, and ends up supplying the skin of anterolateral thigh.

Contents of Popliteal fossa:

- Popliteal artery and its branches
- Popliteal vein and its tributaries
- Tibial nerve
- Common fibular (Peroneal) nerve
- Short saphenous vein
- Posterior femoral cutaneous nerve
- Articular branch of the obturator nerve
- Medial and Lateral sural cutaneous nerve
- Lymph nodes
- Fat
- Bursae

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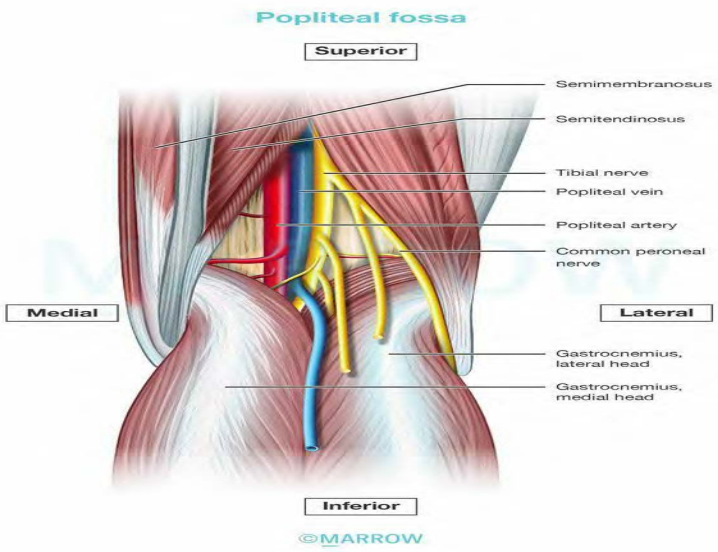
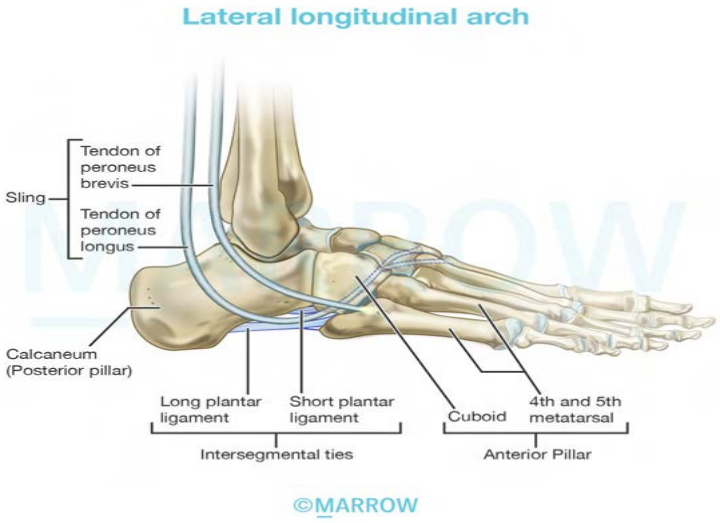


Solution to Question 14:

The anterior pillar of the lateral longitudinal arch of the foot is formed by 4th and 5th metatarsals.



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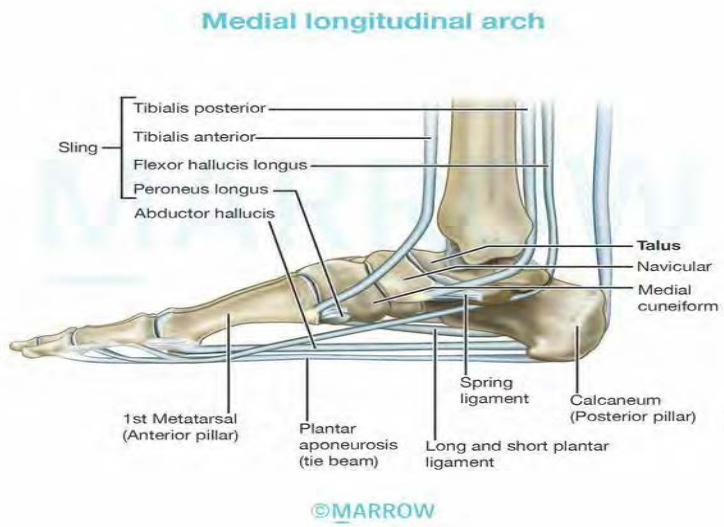

Solution to Question 15:

The keystone (summit) of the medial longitudinal arch is formed by the talus.

Solution to Question 16:

Peroneus longus muscle maintains the lateral longitudinal arch and not the medial arch.

The muscles, tendons, and aponeurosis that maintain the longitudinal arches of the foot are of two types:

• Slings: These structures help to maintain the arch by suspending the arch from above.

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• Tie beams (bowstrings): These are present between the anterior and posterior pillars and help maintain the arch by preventing the separation of the pillars.

Solution to Question 17:

The tendon of tibialis posterior does not pass deep to the superior extensor retinacula of the foot.

The following are the structures passing deep to the superior and inferior extensor retinacula:

• Tibialis anterior tendon

• Extensor hallucis longus tendon

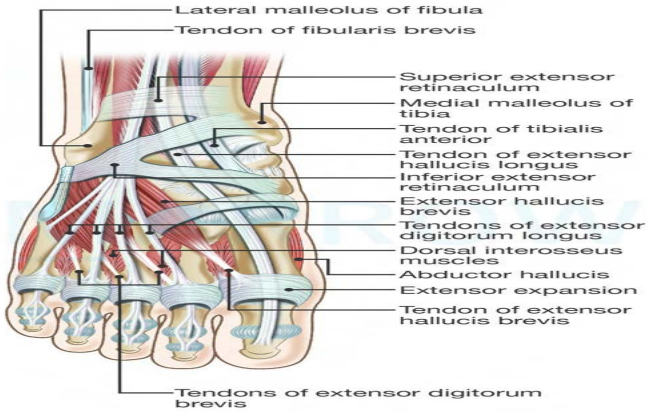
• Deep peroneal nerve

• Extensor digitorum longus tendon

• Peroneus tertius tendon

The anterior tibial vessels pass deep to the superior extensor retinaculum, while the dorsalis pedis vessels pass deep to the inferior extensor retinaculum.

Note: The tendon of tibialis posterior passes deep to the flexor retinaculum of the foot



Extensor retinaculum of foot

©MARROW

Solution to Question 18:

Upper band is attached to medial malleolus of the tibia and not fibula.

Inferior extensor retinaculum:

• It is a Y-shaped band lying anterior to the ankle joint.

• The stem of the Y is at the lateral end and is attached to the upper surface of the calcaneus.

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• The limbs of the Y are at the medial end. The proximal limb attaches to the medial malleolus and the distal limb blends with the plantar aponeurosis.

Structures passing deep to retinaculum are:

• Peroneus tertius

• Extensor digitorum longus

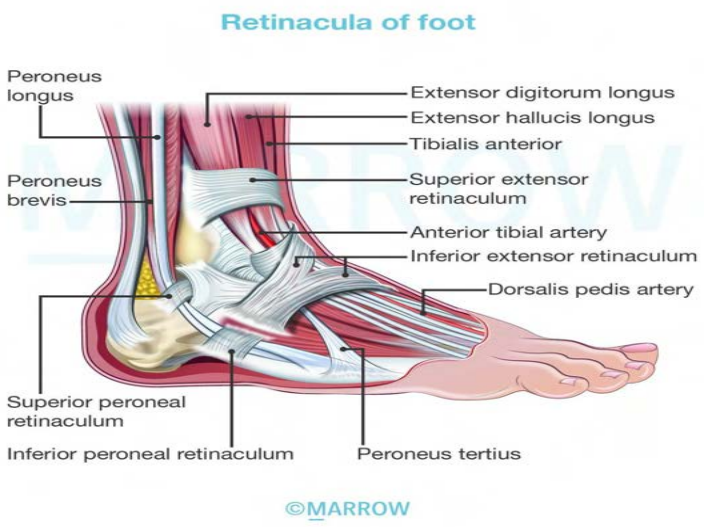
• Extensor hallucis longus

• Tibialis anterior

• Anterior tibial vessels

• Dorsalis pedis artery

• Deep peroneal nerve



Solution to Question 19:

Tibialis posterior tendon is the most medial structure passing through the canals in the flexor retinaculum of the foot.

The flexor retinaculum of the foot converts grooves on the tibia and calcaneus into canals for the tendons. The structures passing through canals formed by flexor retinaculum are as follows: (from medial to lateral)

• Tendons of tibialis posterior

• Flexor digitorum longus

• The posterior tibial vessels

• The tibial nerve

• The tendon of flexor hallucis longus

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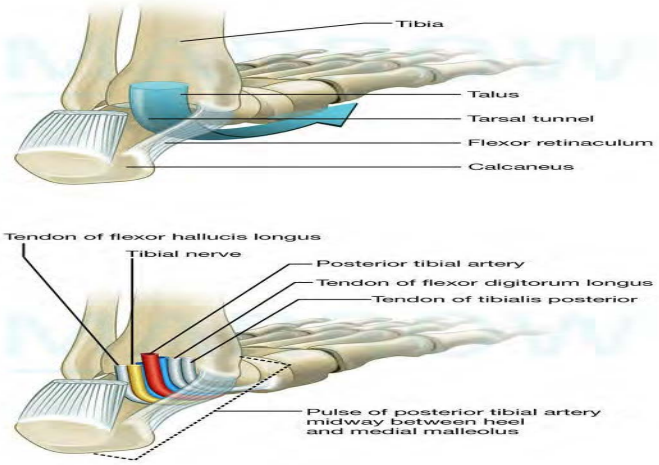
Tarsal tunnel



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Vertebral Column

Question 1:

Which of the following is a characteristic difference between a typical cervical and thoracic vertebra?

a) Cervical vertebrae have longer spinous processes

b) Cervical vertebrae have foramen transversarium

c) Thoracic vertebrae foramina are bigger than the body

d) Thoracic vertebrae have turbercles on transverse processes

Question 2:

What is the number of bones in the vertebral column?

a) 27

b) 29

c) 31

d) 33

Question 3:

Which of the following pairs of 'vertebral segment-normal curvature' is incorrectly matched?

a) Cervical-Kyphosis

b) Thoracic-Kyphosis

c) Lumbar-Lordosis

d) Pelvic-Anteroinferiorly concave

Question 4:

Which statement regarding normal vertebral column curvature is false?

a) Primary curves are convex dorsally.

b) Thoracic curve develops when the infant starts walking.

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c) Cervical curve appears when the infant starts supporting its head.

d) Lumbar curve appears when the child assumes the upright posture.

Question 5:

A 32-year-old man suffered from iatrogenic trauma of the craniovertebral joint following occipitocervical fusion and stabilization surgery. Which of the following structures are not included in this joint?

a) Atlas

b) Axis

c) Wings of sphenoid

d) Occipital condyles

Question 6:

The movements at the _____ joint permit a person to look to the right and left.

a) Atlanto-occipital

b) Atlanto-axial

c) C2-C3

d) C3-C4

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Question 7:

An orthopedician performing surgical decompression in a patient with cervical spondylosis accidentally damages the transverse atlantal ligament. What is this a component of?

a) Cruciform ligament

b) Ligamenta flava

c) Anterior longitudinal ligament

d) Posterior longitudinal ligament

Question 8:

A 44-year-old man is brought to the casualty with a suspected whiplash injury following a road traffic accident. Which ligament would be injured in this condition?

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a) Interspinous ligament

b) Posterior longitudinal ligament

c) Supraspinous ligament

d) Anterior longitudinal ligament

Question 9:

MRI of a 54-year-old woman with rheumatoid arthritis showed tectorial membrane thickening. This structure is derived from which of the following ligaments?

a) Anterior atlanto-occipital membrane

b) Posterior atlanto-occipital membrane

c) Anterior longitudinal ligament

d) Posterior longitudinal ligament

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Question 10:

A 75-year-old cachexic man presents with nagging back pain in the lumbar region that shoots down his right leg. He was diagnosed with prostate cancer 2 months back. Which of the following movements is anatomically restricted in the lumbar region?

a) Flexion

b) Extension

c) Lateral flexion

d) Rotation

Question 11:

An army personnel complains of lower backache following a bullet wound. On examination, she has sensory loss on the ipsilateral side below the level of the lesion. What is false about the visceral landmarks of the affected structure?

a) Heart lies in T5-T8 in recumbent position.

b) SVC enters right atrium at T5.

c) Azygous vein enters SVC at T5.

d) Hemiazygous vein crosses left to right at T5.

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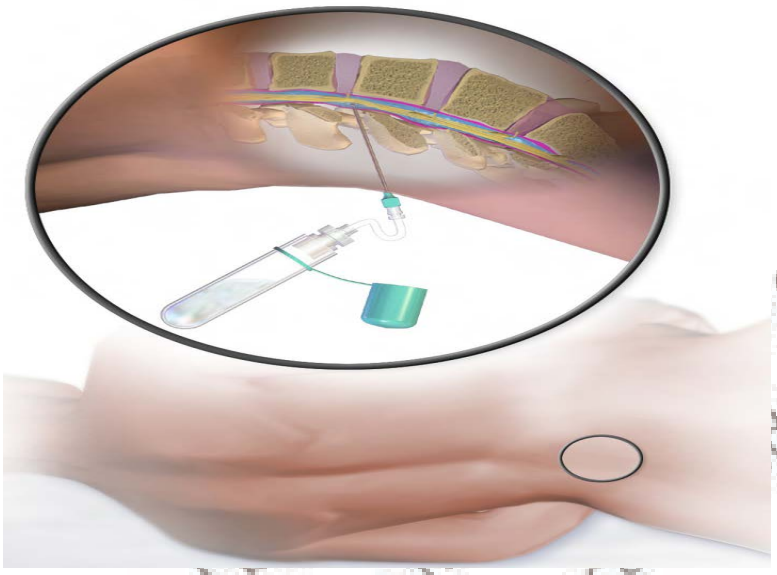
Question 12:

The following procedure was planned for a patient with a suspicion of Guillain-Barré syndrome. What is not pierced during this procedure?



a) Ligamentum flavum

b) Interspinous ligament

c) Posterior longitudinal ligament

d) Supraspinous ligament

Question 13:

You are asked to auscultate a patient presenting with chronic cough. Which of the following is not a boundary of the triangle of auscultation?

a) Scapula

b) Trapezius

c) Latissimus dorsi

d) Serratus anterior

Question 14:

The muscle marked by the arrow in the image below is innervated by the_____.

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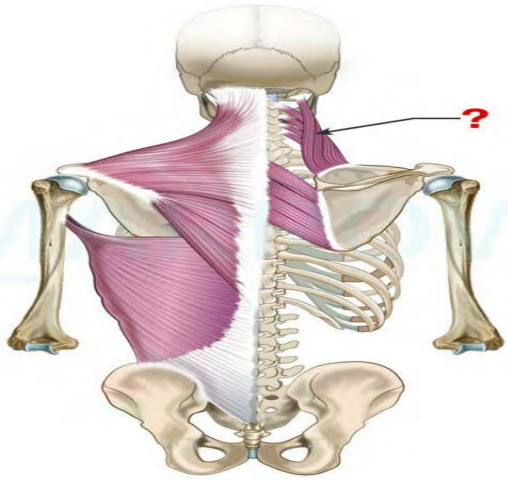

a) Dorsal scapular nerve

b) Suprascapular nerve

c) From the dorsal rami of C1

d) Subscapular nerve

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Answer Key

Question No.	Correct Option
1	b
2	d
3	a
4	b
5	c
6	b
7	a
8	d
9	d
10	d
11	d
12	c
13	d
14	a

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Detailed Explanations

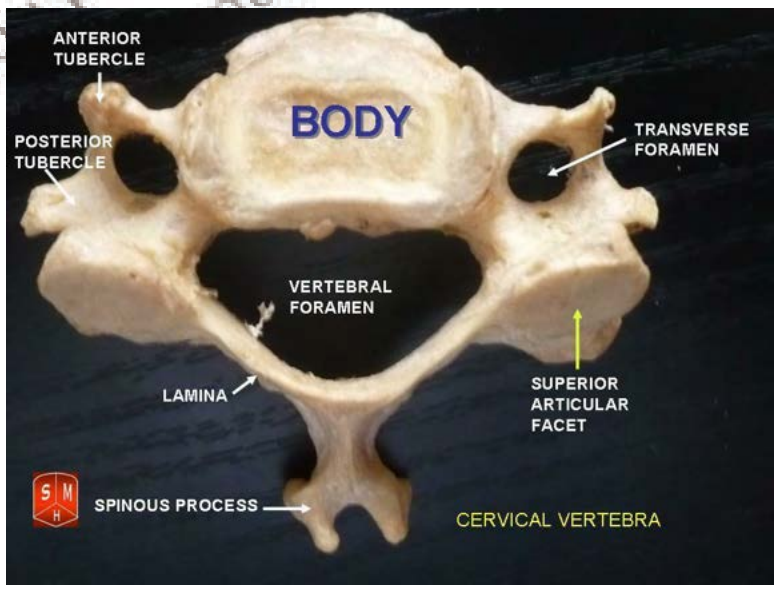
Solution to Question 1:

The typical cervical vertebrae are characterized by a foramen in the transverse process called the foramen transversarium.

This foramen transversarium transmits the vertebral artery and vein, along with a branch from the cervicothoracic ganglion (vertebral nerve). Lateral parts of the transverse processes of the cervical vertebrae also contain the anterior and posterior tubercles.

The images given below illustrate a typical cervical and thoracic vertebrae respectively.

Feature	Typical cervical vertebrae	Typical thoracic vertebrae
Vertebral body	Smaller and thinner	Intermediate in size between cervical and lumbarCostal fac etsfor the ribs seen on either the vertebral body, the transv erse process, or both
Vertebral foramina	Larger and wider than the ve rtebral body	Smaller than the size of the v ertebral body
Transverse process es	Small and have transverse fo ramen, and 2tubercles	Longer, larger, and stronger; no transverse foramina
Spinous processes	Horizontally behind the body and usually bifid (C1-C5)	Longer and slender; terminat es in a distinct tubercle



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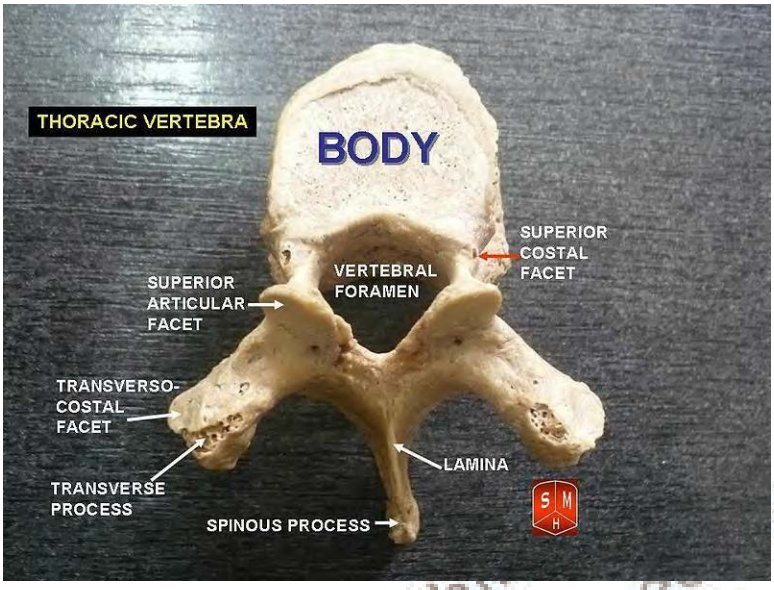

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Solution to Question 2:

The vertebral column consists of 33 bones. Generally, the number of vertebrae found in each segment are as follows:

- 7 cervical
- 12 thoracic
- 5 lumbar
- 5 sacral
- 4 coccygeal

However, this total is subject to frequent variability, and there have been reports of variation between 32 and 35 vertebrae.

The total length of vertebral column is about 70 cm in males and about 60 cm in females on an average. Fibrocartilaginous intervertebral discs separate neighboring vertebrae in the cervical, thoracic and lumbar region (except the first 2 cervical vertebrae). The vertebral column supports the trunk, protects the spinal cord and nerves, and provide attachments for muscles. It is also an important site of hematopoiesis throughout life.

The image given below illustrates the adult vertebral column.

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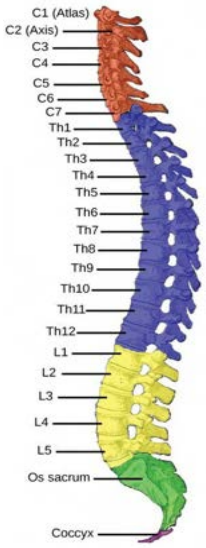

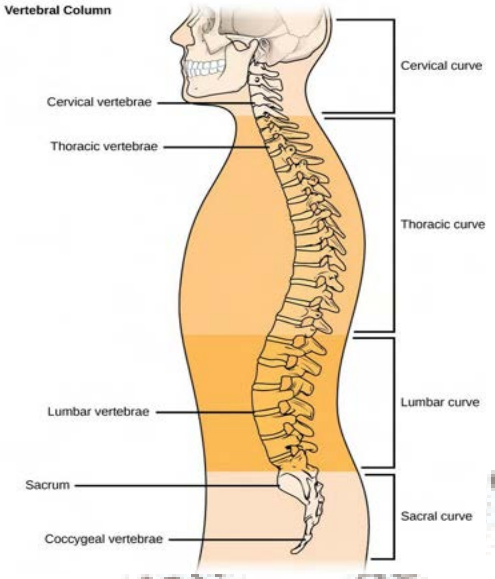

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Solution to Question 3:

The cervical-kyphosis pair is incorrectly matched. The cervical part of the vertebral column normally demonstrates lordosis.

During embryonic life, the body appears flexed and has 2 primary spinal curvatures. These are the thoracic and the pelvic curves, which are convex dorsally. After birth, functional muscle development leads to the early appearance of secondary spinal curvatures. These are the cervical and the lumbar curves, both of which are convex forwards (lordosis).

Normal adult curvatures of the vertebral column are as follows:

• The cervical curve is lordosis (convex forwards)

• The thoracic curve is kyphosis (convex dorsally)

• The lumbar curve is lordosis (convex forwards)

• The pelvic curve is concave anteroinferiorly

The image given below illustrates the adult vertebral column.

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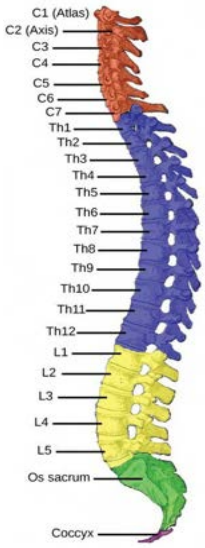

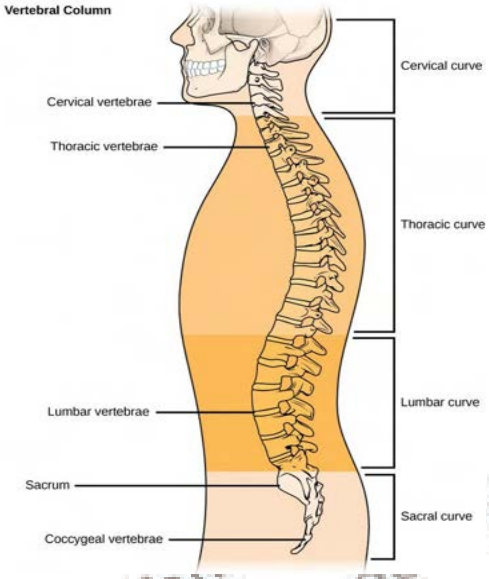

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Solution to Question 4:

The thoracic curvature is a primary curve and is developed during embryonic life itself.

Both the primary curves (thoracic and pelvic) that appear during embryonic life are convex dorsally. After birth, functional muscle development results in the appearance of secondary cervical and lumbar spinal curvatures in the sagittal plane.

• The secondary cervical curvature occurs with the development of function in the muscles responsible for the head extension.

• The secondary lumbar curvature occurs with the development of function in the muscles responsible for sitting upright and walking.

Solution to Question 5:

The craniovertebral joints do not include the wings of the sphenoid.

These connect the cranium to the vertebral column.

• They include the atlanto-occipital joints and atlanto-axial joints.

• The bones involved include the occipital condyles, the atlas, and the axis.

These joints are specialized to provide greater mobility than seen in the rest of the axial skeleton. Together, they function as a universal joint that allows horizontal and vertical scanning movements of the head.

Occipitocervical fusion and stabilization surgery is the treatment of choice for patients with occipitocervical pathologies including trauma, rheumatoid arthritis, congenital malformations, neoplasms, and degeneration. High degree of mobility and the sharp angle at which the occiput meets the upper cervical spine, makes rigid surgical fixation challenging.

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Solution to Question 6:

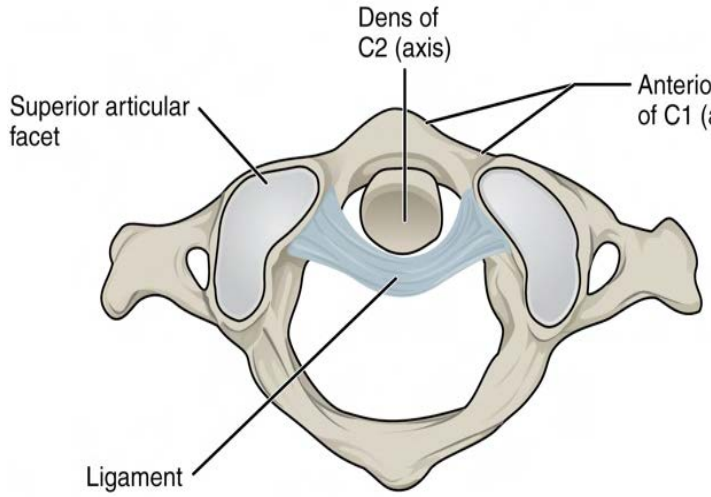
The movements at the atlanto-axial joint allow a person to look left and right.

The atlanto-axial joints include 3 synovial joints:

• Median atlanto-axial joint- The central pivot joint between the dens of the axis and a ring formed by the anterior arch and transverse atlantal ligament

• Lateral atlanto-axial joints- Plain synovial joints between lateral masses of atlas and upper facets of the body of axis

Movements at the atlanto-axial joint almost exclusively is rotation around the axis, which help side-to-side rotation of the head. The normal range of atlanto-axial rotation is about 40°.



Superior view of atlas

Solution to Question 7:

The transverse atlantal ligament is a component of the cruciform ligaments at the atlanto-axial joints.

Cruciform ligaments are shaped like a cross:

• The horizontal component of the cross is formed by the transverse atlantal ligament. It is attached on each side to the lateral mass of atlas. It retains the dens in position.

• The vertical component of the cross is formed by the superior and inferior longitudinal ligaments.

• Superior longitudinal ligament arises from the upper margin of the transverse atlantal ligament and inserts into the basilar part of the occipital bone.

• Inferior longitudinal ligament arises from the lower margin of the transverse atlantal ligament and inserts to the posterior surface of the axis vertebra.

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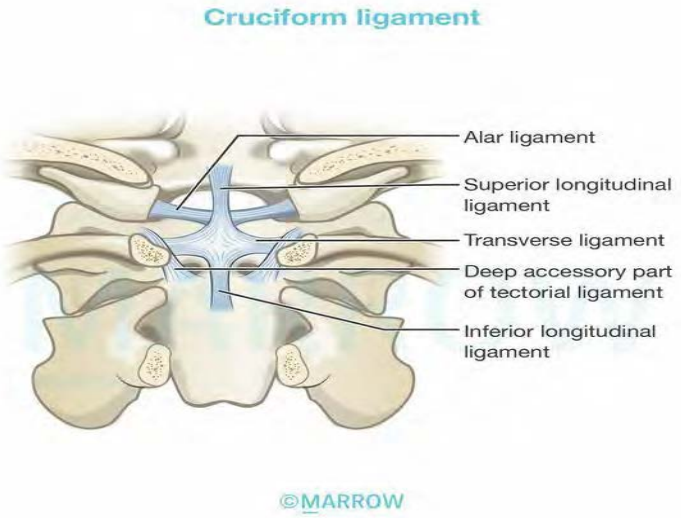

Other ligaments at the atlanto-axial joints:

• Membrana tectoria- Strong band found inside the vertebral canal, which is the upward continuation of the posterior longitudinal ligament

• Alar ligaments- Thick cords from the apex of the dens to the medial side of the occipital condyles

• Apical ligament of the dens- Connects the apex of dens to the anterior margin of the foramen magnum between the alar ligaments

Solution to Question 8:

The given clinical scenario is suggestive of a whiplash injury. In this, the anterior longitudinal ligament of the spine is damaged.

Whiplash is a form of cervical acceleration-deceleration injury. There is hyperextension followed by flexion in the recoil. The main pathological features seen in these cases include tear (strain) of the anterior longitudinal ligament and the capsular fibers of the facet joints in the spine. In some cases, the intervertebral discs may be damaged. Fracture is seen in severe cases only.

Anterior longitudinal ligament:

• It is a strong band that extends along the anterior surface of the vertebral bodies

• It extends from the basilar part of the occipital bone to the upper sacrum

• It is attached to the anterior tubercle of C1 and the body of C2

Solution to Question 9:

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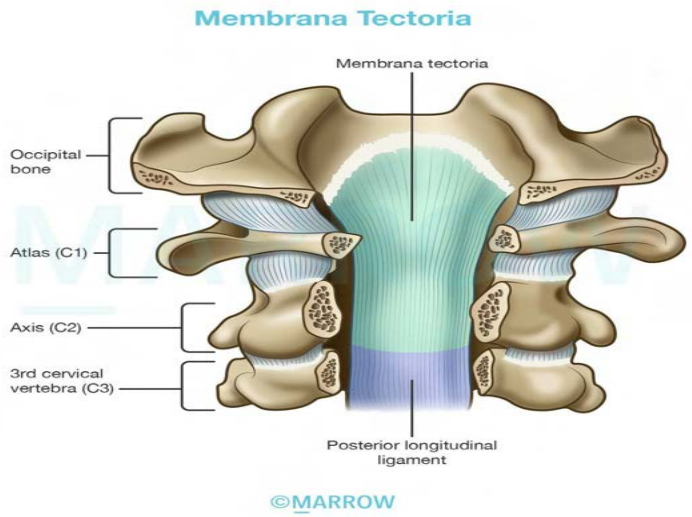
Membrana tectoria or tectorial membrane is the cranial continuation of the posterior longitudinal ligament.

The posterior longitudinal ligament is present in the vertebral canal on the posterior surfaces of the vertebral bodies. The posterior longitudinal ligaments stretch from the body of the axis (C2) to the sacrum.

Above the level of axis, the posterior longitudinal ligament continues as membrana tectoria. Membrana tectoria extends from the axis to the foramen magnum.



Solution to Question 10:

Rotation is anatomically restricted in the lumbar region.

The given clinical vignette is suggestive of carcinoma prostate, which has metastasised to the lumbar spine. Anatomically, the lumbar region of the vertebral column has a restricted range for rotational movements.

Movements of the vertebral column:

• Flexion of the spine is accompanied by relaxation of the anterior longitudinal ligament and compression of the anterior parts of the intervertebral discs. Flexion is effectively absent in the thoracic region. Flexion movements are greater than extension or lateral flexion in the lumbar region.

• Extension is marked in cervical and lumbar regions. It is significantly less at thoracic levels as their discs are thinner and because of the ribs and chest musculature.

• Lateral flexion is flexion combined with coupled axial rotation. Lateral movements occur in all parts of the column but are the greatest in the cervical and lumbar regions.

• Axial rotation is the highest in the cervical region, 50% of which occurs at the atlantoaxial joint. All the other spine segments below the cervical have only a slight range of rotation, among which the thoracolumbar junction has the most. The remainder of the lumbar region has very little rotation.

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Solution to Question 11:

The given clinical scenario is suggestive of Brown-Sequard syndrome caused due to injury to the vertebral column by a bullet wound. The hemiazygous vein crosses from left to right at the level of the T8 vertebra (and not T5).

Solution to Question 12:

A lumbar puncture is planned for this patient with a suspicion of Guillain-Barré syndrome. The posterior longitudinal ligament is not pierced during lumbar puncture.

Structures pierced during lumbar puncture (in that order):

- Skin
- Subcutaneous tissue
- Supraspinous ligament
- Interspinous ligament
- Ligamentum flavum
- Epidural space
- Dura mater
- Arachnoid mater

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Solution to Question 13:

The serratus anterior is not a boundary of the triangle of auscultation. As there are fewer impedances between the examiner's stethoscope and the lungs, this area allows for better auscultation of the patient.

Boundaries of the triangle of auscultation:

- Medially- trapezius muscle's lateral border
- Laterally- scapula's medial border
- Inferiorly- lattssisimus dorsi's upper border
- Floor- 5th and 7th rib, 6th intercostal space, and the rhomboid major

The triangle overlies the inferior lobe of both lungs. For exposure of the floor of the triangle, the patient needs to fold their arm across their chest to rotate the scapula laterally and bend forward resembling somewhat a fetal position.

The image given below illustrates the triangle of auscultation.

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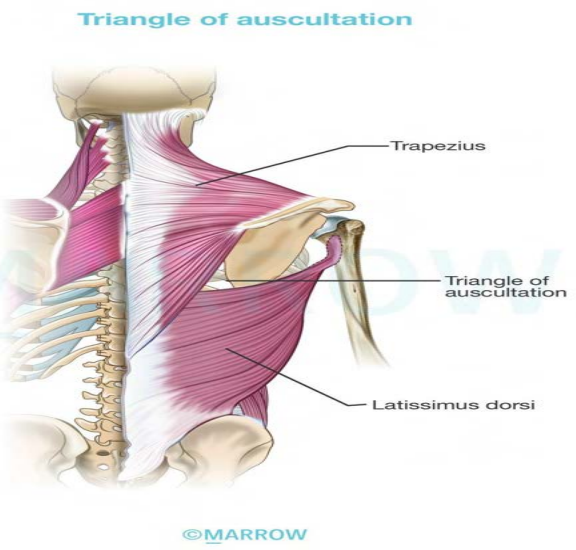

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Solution to Question 14:

The muscle marked in the above image is levator scapulae, which is innervated by the dorsal scapular nerve.

The appendicular group of back muscles and their innervations include:

Option B: The suprascapular nerve innervates the supraspinatus and infraspinatus muscles.

Option D: The subscapular nerves supply the teres major and subscapularis muscles.

Muscle	Nerve Supply
Trapezius	Accessory nerve
Latissimus dorsi	Thoracodorsal nerve
Levator scapulae	Dorsal scapular nerve
Rhomboid major and minor	Dorsal scapular nerve

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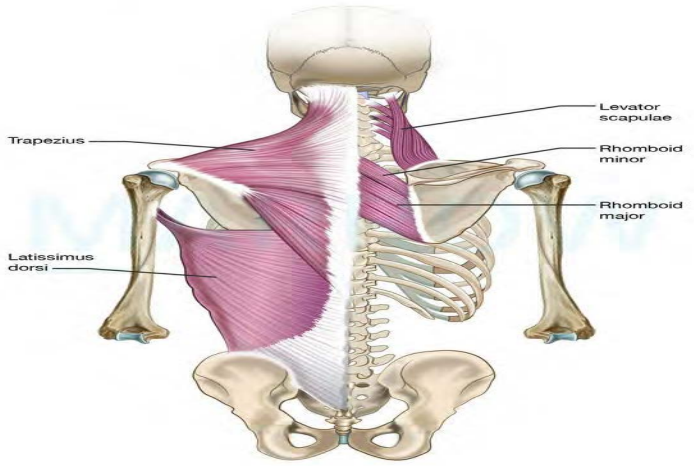
Appendicular muscles of the back



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Bones, Joints and Cartilage

Question 1:

The total number of bones present in the axial skeleton and appendicular skeleton in an adult human being is _____ and _____, respectively.

a) 88, 118

b) 84, 122

c) 76, 130

d) 80, 126

Question 2:

Which of the following statements regarding bones is false?

a) Osteocytes are the major cell type in mature bone

b) Collagen is synthesized in bone by osteoblasts

c) Bone mainly contains type 2 collagen fibres

d) Calcium phosphate is the major inorganic mineral

Question 3:

Which of the following is a modified long bone?

a) Humerus

b) Fibula

c) Metacarpal

d) Clavicle

Question 4:

Which of the following is not a sesamoid bone?

a) Fabella

b) Os trigonum

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c) Patella

d) Pisiform

Question 5:

Which of the following is an example of a ■pneumatic bone?

a) Carpal bones

b) Maxilla

c) Sternum

d) Hip bone

Question 6:

Which of the following accurately describes fabella?

a) Accessory bone

b) Pneumatic bone

c) Sesamoid bone

d) Irregular bone

Question 7:

Which of the following statements is true regarding long bones?

a) Cancellous bone is absent in the epiphysis

b) Cancellous bone is present in the outer cortex

c) Haversian system is absent in cancellous bone

d) Compact bone has lamellae arranged in a meshwork

Question 8:

A 16-year-old boy presented to your OPD with progressive swelling and worsening knee pain over the past 2 months. An X-ray reveals the following finding. Which of the following is true regarding the layer of bone involved?

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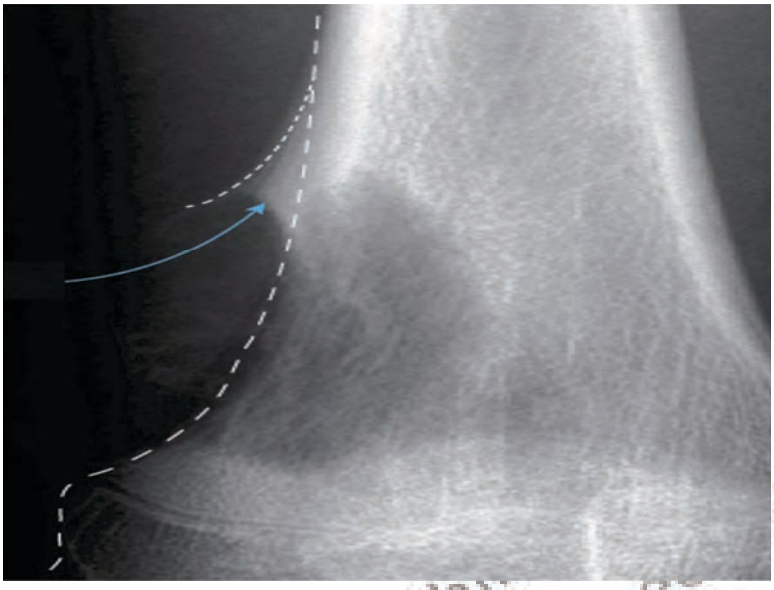

a) It contains three fibrous layers

b) Progenitor cells are present in the outer fibrous layer

c) It is continuous with the capsule of the joint

d) It is devoid of nerve supply

Question 9:

Which of the following structures do the Sharpey's fibers connect?

a) Periosteum to synovial membrane

b) Joint capsule to periosteum

c) Periosteum to bone

d) Enamel to dentin

Question 10:

Which of the following bones develops through intramembranous ossification?

a) Ribs

b) Tibia

c) Frontal bone

d) Humerus

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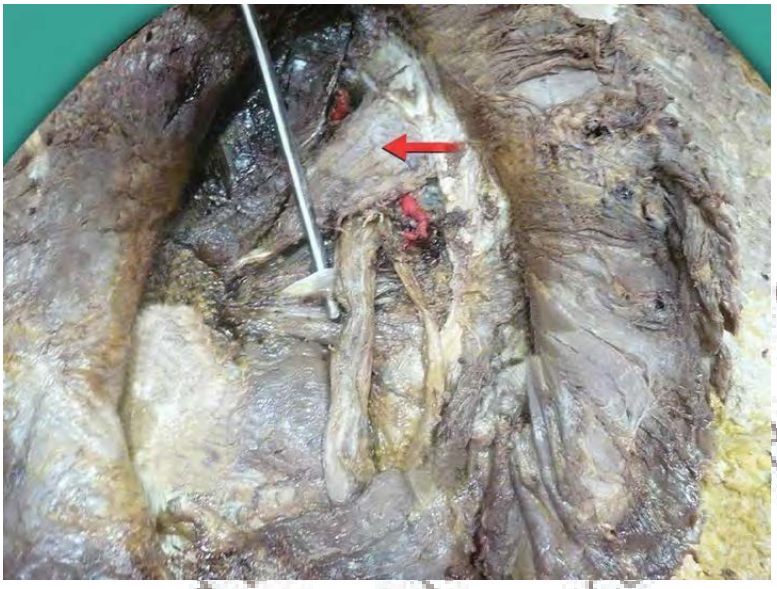
Question 11:

The structure that the marked muscle in the gluteal region inserts into has ____ type of epiphysis?



a) Pressure epiphysis

b) Traction epiphysis

c) Atavistic epiphysis

d) Aberrant epiphysis

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Question 12:

While assessing a child with short stature, the senior resident orders an X-ray to better evaluate the structure marked X in the radiograph. Which of the following is a true statement regarding this structure?

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a) It is made of elastic cartilage

b) It is supplied only by epiphyseal arteries

c) It separates epiphysis from diaphysis

d) It is the site for enchondral ossification

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Question 13:

'The secondary ossification center that appears first, fuses last'. Which of the following bones violates this law?

a) Radius

b) Fibula

c) Ulna

d) Sternum

Question 14:

Which of the following parts of the bone is not nourished by the nutrient artery?

a) Medullary cavity

b) Inner 2/3 of the cortex

c) Outer 1/3 of the cortex

d) Metaphysis

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Question 15:

In which of the following parts of the bone are hairpin bends of end arteries abundantly present?

a) Epiphysis

b) Metaphysis

c) Diaphysis

d) Epiphyseal plate

Question 16:

Which of the following statements regarding cartilage is false?

a) Hyaline cartilage has perichondrium

b) Fibrocartilage lacks perichondrium

c) Articular cartilage has perichondrium

d) Elastic cartilage has perichondrium

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Question 17:

Which of the following does not have yellow cartilage?

a) Epiglottis

b) Pinna

c) Apex of the arytenoid

d) Septal nasal cartilage

Question 18:

What is the type of cartilage found in the structure marked X in the following radiograph?

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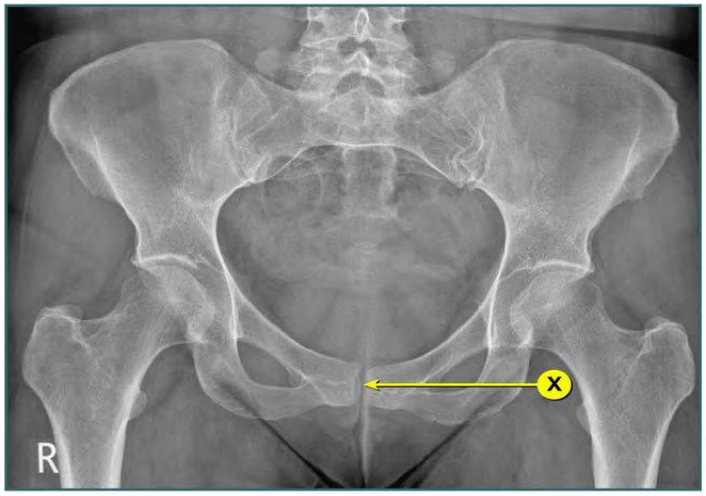

a) Hyaline cartilage

b) Calcified cartilage

c) Fibrocartilage

d) Elastic cartilage

Question 19:

In which of the following cartilages is type I collagen predominantly seen?

a) Reticular tissue

b) Fibrocartilage

c) Elastic cartilage

d) Basement membrane

Question 20:

Ligamentum flavum has high levels of:

a) Type 1 collagen

b) Type 2 collagen

c) Reticular fibres

d) Elastin fibres

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Question 21:

Which of the following is not a fibrous joint?

a) Cranial sutures

b) Syndesmosis

c) Symphysis

d) Gomphosis

Question 22:

What are synovial joints functionally classified as?

a) Synarthroses

b) Amphiarthroses

c) Diarthroses

d) Syndesmosis

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Question 23:

Which of the following accurately describes a joint with three or more articular surfaces?

a) Simple joint

b) Complex joint

c) Synarthrosis joint

d) Compound joint

Question 24:

Which of the following joints is known as a peg-and-socket joint?

a) Syndesmosis

b) Gomphosis

c) Hinge joint

d) Pivot joint

Question 25:

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What type of joint is an incudostapedial joint?

a) Saddle

b) Hinge

c) Ball and socket

d) Pivot

Question 26:

A 47-year-old lady diagnosed with rheumatoid arthritis presented to the clinic with the following deformity. The joint involved in this condition is an example of_____

a) Pivot joints

b) Saddle joints

c) Ellipsoid joints

d) Hinge joints

Question 27:

The talocalcaneonavicular joint is a _____type of joint.

a) Ball and Socket

b) Saddle type

c) Plane

d) Ellipsoid

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Question 28:

Forward and backward movements of the mandible that occur at the temporomandibular joint is called as_____and _____, respectively.

a) Opposition and reposition

b) Excursion and incursion

c) Protraction and retraction

d) Depression and elevation

Question 29:

All of the following are rounded or irregular elevations of bones, except_____

a) Tubercle

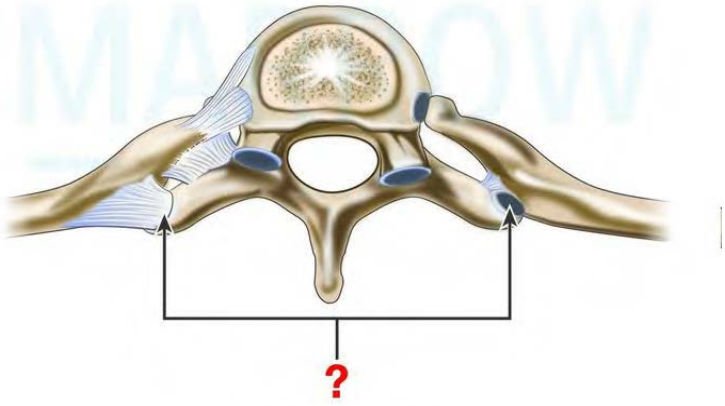
b) Epicondyle

c) Styloid process

d) Trochanter

Question 30:

The type of joint marked in the image below is _____:



a) Syndesmosis

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b) Synarthrosis

c) Synchondrosis

d) Synovial

Answer Key

Question No.	Correct Option
1	d
2	c
3	d
4	b
5	b
6	c
7	c
8	c
9	c
10	c
11	b
12	d
13	b
14	c
15	b
16	c
17	d
18	c
19	b
20	d
21	c
22	c
23	d
24	b
25	c
26	c
27	a
28	c

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29	c
30	d

Detailed Explanations

Solution to Question 1:

In the adult, 80 bones are present in the axial skeleton, and 126 bones in the appendicular skeleton.

Region	Number	Bones
Skull	28	Cranial bones (8)Facial bones (14)Auditory ossicles (6)
Hyoid	1	Hyoid bone (1)
Vertebral column	26	Cervical vertebrae (7)Thoracic vertebrae (12)Lumbar vertebrae (5)Sacrum (1)Coccyx (1)
Thoracic cage	25	Ribs (24)Sternum (1)
Axial Skeleton -80		
Pectoral girdle	4	Clavicle (2)Scapula (2)
Upper extremity	60	Humerus (2)Radius (2)Ulna (2)Carpals (16)Metacarpals (10)Phalanges (28)
Pelvic girdle	2	Hip bones (2)
Lower extremity	60	Femur (2)Tibia (2)Fibula (2)Patella (2)Tarsals (14)Metatarsals (10)Phalanges (28)
Appendicular Skeleton -126		

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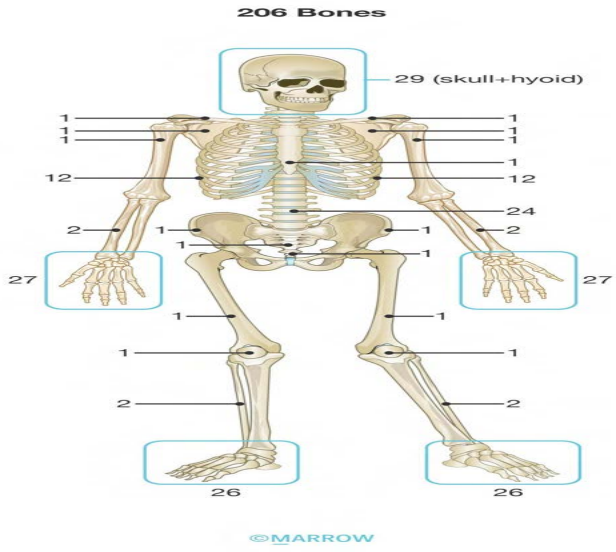

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Solution to Question 2:

Bone mainly contains type 1 collagen fibres. Bones are made up of mineralized collagenous extracellular matrix around specialized cells.

The extracellular matrix is composed of:

• Organic component - around 30% of the organic matrix of bone is made up of collagen, mainly type 1 collagen.

• Inorganic component - the major inorganic mineral in the bone matrix is calcium phosphate in the form of microcrystalline hydroxyapatite.

The specialized cells are:

• Osteoblasts - responsible for the synthesis, deposition, and mineralization of the bone matrix. Collagen is synthesized in bone by osteoblasts. Osteoblasts get embedded in the matrix to become osteocytes.

• Osteocytes - major cell type of a mature bone and is distributed throughout the matrix. They have lost the ability to divide or to secrete new matrix.

• Osteoclasts - responsible for the local removal of bone during bone growth and remodelling.

Solution to Question 3:

The clavicle is a modified long bone, as it has a modified shaft and no medullary cavity.

Long bones are classified as follows:

• Typical long bones (see figure) have an elongated shaft (diaphysis) and two expanded ends (epiphysis). The shaft has a central medullary cavity and a nutrient foramen directed away from the growing end. e.g., humerus, ulna, radius, femur, tibia, and fibula.

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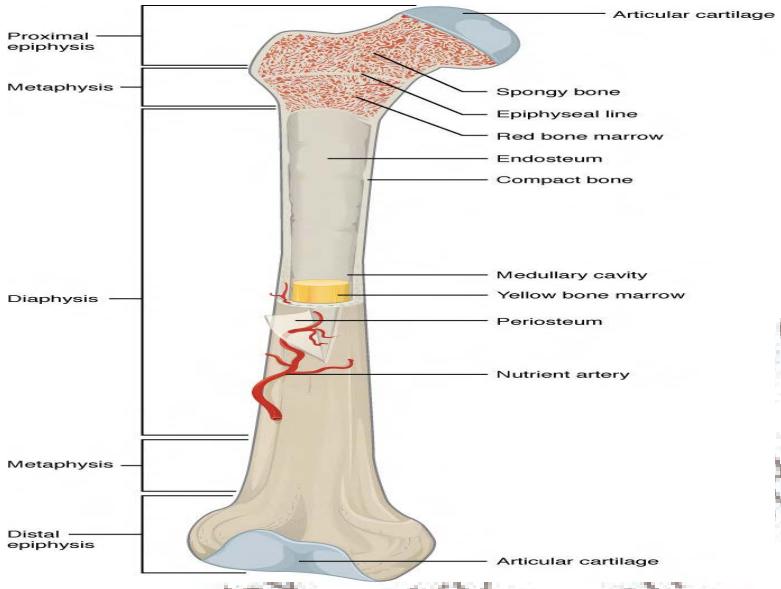
• Miniature long bones contain only one epiphysis. e.g., metacarpals, metatarsals, and phalanges.

• Modified long bones have a modified shaft or ends, and no medullary cavity. e.g., clavicle.

The following image shows a graphical illustration of a typical long bone:



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Solution to Question 4:

Os trigonum is an accessory bone, not a sesamoid bone.

Accessory bones, also known as supernumerary bones are not always present. They may arise due to ununited epiphysis developed from extra ossification centres. Clinically, they may be mistaken for fractures.

Examples of accessory bones:

• Os trigonum - Uncommon accessory bone seen behind the talus. Also known as lateral tubercle of the talus.

• Os vesalianum - Uncommon accessory bone located proximal to the fifth metatarsal and found within the peroneus brevis tendon. Also known as tuberosity of the fifth metatarsal.

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Os Trigonum

Os Vesalianum

Solution to Question 5:

The maxilla is a pneumatic bone.

Pneumatic bones contain air-filled cavities, which make them light-weight. They also aid in the resonance of sound and act as air conditioning chambers for inspired air. e.g., maxilla, sphenoid, ethmoid, etc.

Short bones: Carpal bones and tarsal bones

Flat bones: Sternum, ribs, scapula, and bones of the skull vault

Irregular bones: Hip bones, vertebra, and bones in the base of the skull.

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Solution to Question 6:

Fabella is a sesamoid bone. This term is used to describe a bone embedded within a tendon or a muscle. It is a variant of normal anatomy present in 10% to 30% of individuals. Fabella is found within the tendon of the lateral head of gastrocnemius, where it moves over the lateral femoral condyle.

Important sesamoid bones:

• Patella - largest sesamoid bone in the tendon of quadriceps femoris.

• Pisiform - tendon of flexor carpi ulnaris.

• Fabella - lateral head of the gastrocnemius.

• Two sesamoid bones can be found in the first metacarpal within the tendons of flexor pollicis brevis and adductor pollicis.

• Two sesamoid bones can be found in the first metatarsophalangeal articulation within the double tendon of flexor hallucis brevis.

The X-ray image below depicts the fabella (marked with an arrow).

Solution to Question 7:

The Haversian system is seen in compact bones, not cancellous bones.

Based on their macroscopic structure, bones can be classified as compact and cancellous (spongy) bones.

Compact bones are composed of cylindrical structural units called Haversian systems or osteons. Each Haversian system contains a central canal within which the small blood vessels, nerves, and endosteum are present. This canal is surrounded by multiple layers or lamellae of the calcified matrix containing type I collagen fibers. These canals communicate with each other by Volkmann's canal.

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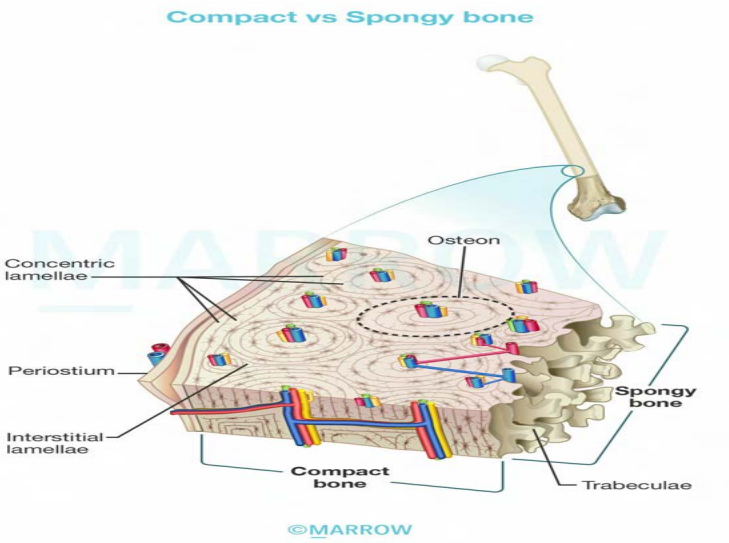
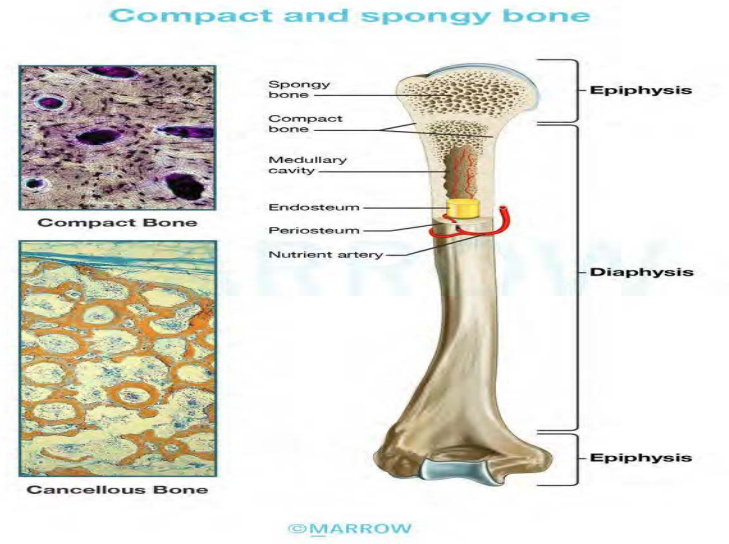
The lamellae of the cancellous/spongy bone are arranged in a meshwork, and hence do not form Haversian systems.

The diaphysis and outer cortex of long bones are predominantly made of compact bone, while the epiphysis and inner medulla are predominantly made of cancellous bone.





Solution to Question 8:

The given X-ray shows Codman's triangle, which is due to an irregular periosteal reaction (outermost layer), commonly seen in patients with osteosarcoma. The periosteum is a thick fibrous membrane that covers the outer surface of all bones, except at the joint surfaces and insertion points of tendons and ligaments (entheses). At the articular margin, the periosteum is continuous with the capsule of the joint.

The periosteum has 2 layers:

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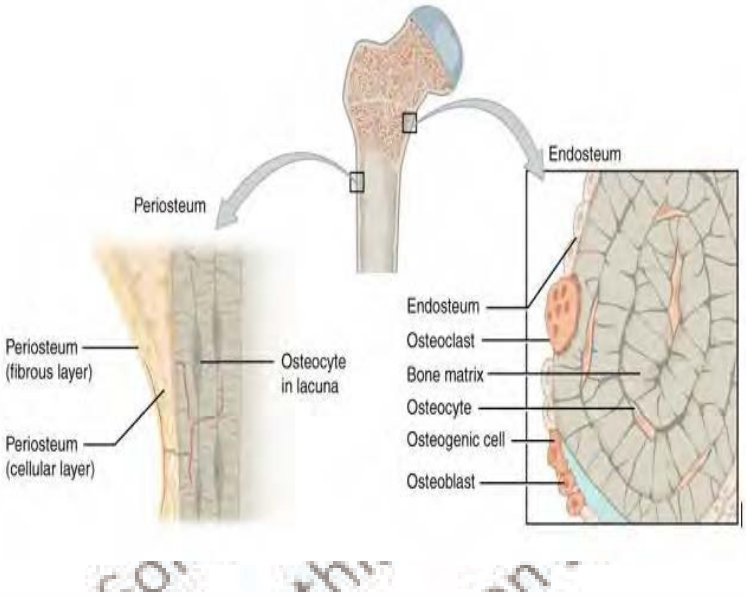
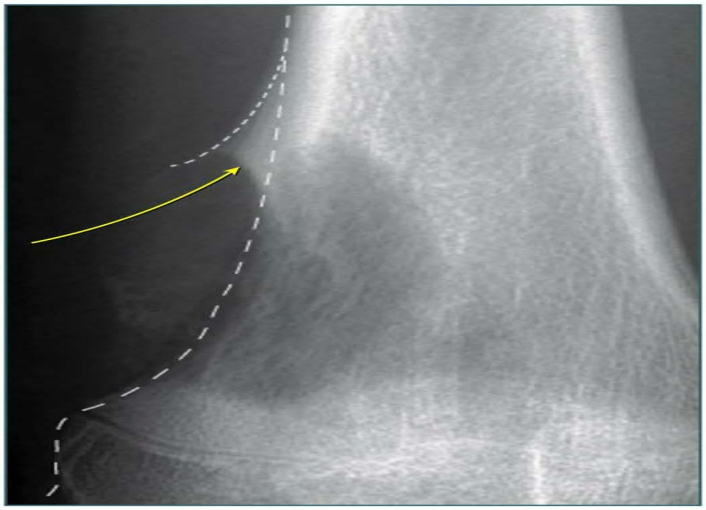
• The outer fibrous layer - contains fibroblasts.

• The inner cambium layer (osteogenic layer) - contains progenitor cells that develop into osteoblasts.

Periosteum gets nourishment from periosteal arteries. It has a rich nerve supply, which makes it the most sensitive part of the bone.



Osteosarcoma - Codman Triangle



Solution to Question 9:

Sharpey's fibers are thick collagen fibers that connect the periosteum to the underlying bone.

Sharpey's fibers are present in the bone and the teeth.

• Bone - tether the periosteum to the underlying bone.

• Teeth - connect the cementum to the periosteum of the alveolar bone (tooth socket).

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Solution to Question 10:

Frontal bones undergo intramembranous ossification. Other bones listed have enchondral ossification.

Based on their development, bones can be classified into 3 categories:

• Membranous bones (dermal bones) are formed through intramembranous ossification. There is direct bone formation within highly vascular sheets or 'membranes' derived from mesenchymal condensations. e.g., bones of the facial skeleton including the frontal, lacrimal, zygomatic, and nasal bones.

• Cartilaginous bones are formed by intra-cartilaginous (enchondral) ossification. Bone forms by ossification of preformed hyaline cartilage model. This is the main method of bone formation in the body. e.g., bones of limbs, vertebral column, and thoracic cage.

• Membranocartilaginous bones ossify from both cartilage and mesenchymal condensation. e.g., clavicle, mandible, occipital bone, temporal bone, sphenoid bone, etc.

Solution to Question 11:

The muscle marked in the image is the piriformis and its insertion is at the greater trochanter of the femur, which is an example of traction epiphysis.

Traction epiphysis is nonarticular and does not transmit weight. They provide attachment to one or more tendons that exert traction on the epiphysis. Examples of traction epiphysis include greater and lesser tubercles of the humerus and greater and lesser trochanters of the femur.

Solution to Question 12:

The structure marked X in the radiograph is the epiphyseal plate. It is the site for enchondral ossification that is mainly responsible for the growth of long bones.

The epiphyseal plate (growth plate) is a hyaline cartilage layer that separates the epiphysis from the metaphysis. It receives nourishment from both the epiphyseal and metaphyseal arteries. Fractures involving epiphyseal plates are known as Salter-Harris fractures.

The growing ends of bones include:

• Upper limb: Upper end of humerus, and lower ends of radius and ulna

• Lower limb: Lower end of femur, and upper end of tibia

Solution to Question 13:

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The fibula violates the law of ossification which states that the secondary ossification center that appears first is the last to fuse.

The secondary ossification center at the lower end of the fibula appears before the ossification center of the upper end and fuses before the upper end.

Ossification centers are of two types:

• Primary centers appear before birth, usually during late embryonic or early fetal life (seventh week to the fourth month). They form the diaphysis.

• Secondary centers usually appear after birth. They form the epiphysis.

Solution to Question 14:

The nutrient artery does not nourish the outer one-third of the cortex.

The nutrient artery enters the bone shaft through the nutrient foramen and runs obliquely through the cortex.

Nutrient arteries of the long bones are directed away from the dominant growing epiphysis as the growing bone might pull and rupture the artery. So the nutrient foramina are directed away from the growing end. The direction of the nutrient artery can be remembered by the axiom 'To the elbow, I go, from the knee I flee'.

Blood supply of the Bone	
Artery	Regions supplied
Nutrient artery	Medullary cavity, inner 2/3 of the cortex, metaphysis
Metaphyseal arteries	Metaphysis and growth plate
Epiphyseal arteries	Epiphysis and growth plate
Periosteal arteries	Periosteum, outer 1/3 of the cortex

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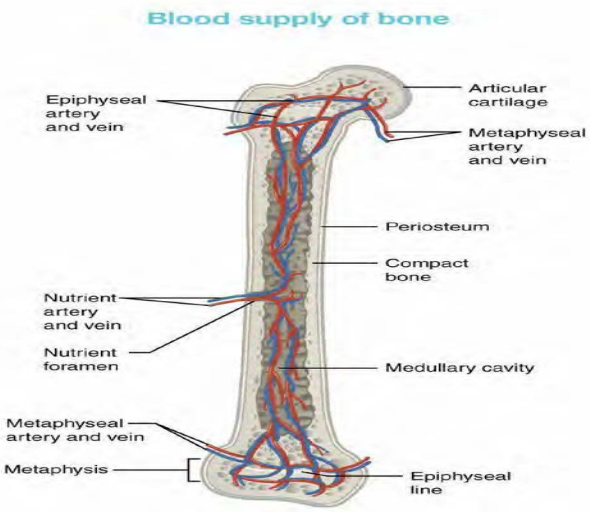

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Solution to Question 15:

Hairpin bends of end arteries are seen abundantly in the metaphysis.

The metaphysis is the portion of a long bone between the epiphysis and diaphysis. It is the zone of active growth and is highly vascular. Before epiphysial fusion, the metaphysis is richly supplied through end arteries that form 'hairpin' bends.

The metaphysis is the most common location for osteomyelitis in children because the bacteria or emboli are easily trapped in the hairpin bends, thereby causing infection.

Solution to Question 16:

Articular cartilage despite being a type of hyaline cartilage lacks perichondrium.

Cartilage is a connective tissue composed of cells (chondrocytes) and fibers (collagen or yellow elastic fibers). These are embedded in a firm, gel-like matrix that is rich in mucopolysaccharides. It is much more elastic than bone. Cartilage does not have blood vessels or lymphatics. Chondrocytes get their nutrition by diffusion. Cartilage has no nerves and is insensitive.

There are three types of cartilages:

• Hyaline cartilage

• Elastic cartilage

• Fibrocartilage

Hyaline cartilage (except the subtype of articular cartilage) and elastic cartilage have perichondrium. Fibrocartilage does not have perichondrium.

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Solution to Question 17:

The septal nasal cartilage has hyaline cartilage and not yellow (elastic) cartilage.

Elastic cartilage (or yellow cartilage) contains a matrix rich in fine yellow elastic fibers containing the protein elastin. It is present in:

- Apices of arytenoid
- Epiglottis
- Corniculate cartilages
- Cuneiform cartilages
- Eustachian tube
- Pinna (Auricle)
- External auditory meatus

Solution to Question 18:

The structure marked X is the pubic symphysis and the type of cartilage seen is fibrocartilage.

Fibrocartilage contains a mixture of white fibrous tissue and cartilaginous tissue. This mix of fibrous and cartilaginous components make this tissue extremely tough and resilient. Fibrocartilage is present in the following sites:

- Pubic symphysis
- Manubriosternal joint
- Articular discs of temporomandibular and sternoclavicular joints
- Anulus fibrosus of intervertebral discs
- Menisci of the knee
- Acetabular labrum
- Glenoid labrum
- The lining of bony grooves for tendons

Solution to Question 19:

Fibrocartilage predominantly contains type I collagen. Hyaline and elastic cartilages mainly contain type II collagen.

Collagen	Locations	Mnemonic
Type I	Bone, Fibrocartilage, Fascia, Tendon, Ligaments	B-one

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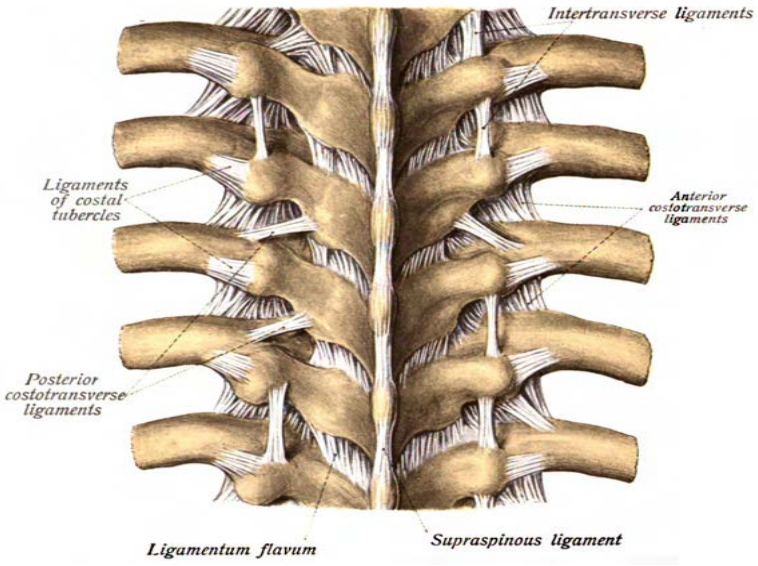
Collagen	Locations	Mnemonic
Type II	Hyaline and Elastic cartilage	Car-two-lage
Type III	Reticular tissue	Re-three-cular
Type IV	Basement membrane	Floor-four

Solution to Question 20:

Ligamentum flavum has high levels of elastin fibres.

The ligamenta flava are a series of ligaments that connect the ventral parts of the laminae of adjacent vertebrae. They predominantly contain elastic tissue and form part of the posterior surface of the vertebral canal. The high content of elastin allows it to be stretched by 80% without damage. The ligamentum flava resist separation of the laminae in flexion and assist in extension back to the anatomical position.



Solution to Question 21:

The symphysis is not a fibrous joint, but a secondary cartilaginous joint.

Structural classification of joints is as follows:

Type	Subtypes
Fibrous joints	Cranial suturesSyndesmosisGomphosis

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Type	Subtypes
Cartilaginous joints	Primary cartilaginous joints (or synchondrosis)Secondary cartilaginous joints (or symp hysis)
Synovial joints	Ball-and-socket or spheroidal jointsSellar or saddle jointsC ondylar or bicondylar jointsE llipsoid jointsHinge jointsPiv ot or trochoid jointsPlane joi nts

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Solution to Question 22:

Synovial joints are freely movable joints and therefore functionally classified as diarthrosis.

Functional classification of joints:

• Synarthroses - These are immovable. e.g., fibrous joints

• Amphiarthroses - They are slightly mobile. e.g., cartilaginous joints

• Diarthroses - These are freely mobile. e.g., synovial joints.

Solution to Question 23:

A joint with three or more articular surfaces is classified as a compound joint.

Classification of joints based on the number of articulating surfaces:

• Simple joints have 2 articulation surfaces. e.g., shoulder joint, hip joint.

• Compound joints have 3 or more articulation surfaces. e.g., elbow joint, wrist joint.

• Complex joints have an intra-articular disc between the articular surfaces which divides the joint space. e.g., temporomandibular joint, sternoclavicular joint.

Solution to Question 24:

Gomphosis (dentoalveolar syndesmosis) is a peg-and-socket joint between a tooth and its socket.

Fibrous joints are joints where bones are joined together by fibrous tissue. They are further classified as sutures, syndesmosis, and gomphosis (see Table).

The following image shows the types of fibrous joints:

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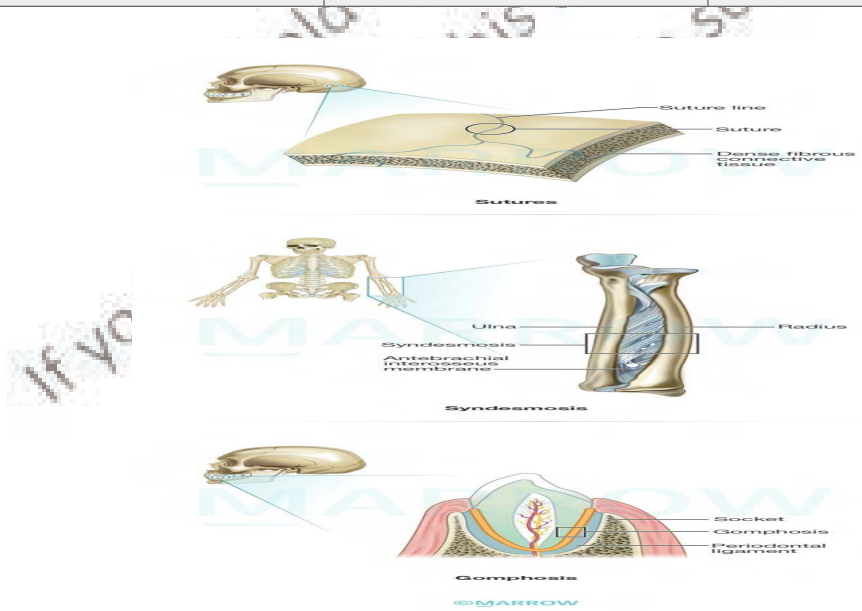
Classification of Fibrous joints		
Subtype	Description	Examples
Sutures	Peculiar to the skull. Bones are separated by a layer of membrane-derived connective tissue.	Plane-internasal sutureSerrate-interparietal sutureSquamous-temporoparietal sutureDenticulate-lambdoid sutureSchindylesis type, specialized suture in which a ridged bone fits into a groove on a neighboring bone-the cleft between the alae of the vomer receives the rostrum of the sphenoid
Syndesmosis	There is a true fibrous connection between bones.	Connected by interosseous ligament-tibiofibular syndesmosis and radioulnar syndesmosisConnected by a dense fibrous membrane-posterior region of sacroiliac joint
Gomphosis	A peg sits inside a socket supported by fibrous connections.	The tooth in its socket



Solution to Question 25:

The incudostapedial joint is a ball and socket type of joint.

In ball and socket type of joints, the articular surfaces include a globular head (male surface) fitting into a cup-shaped socket (female surface). These joints are multi-axial and movements occur around a number of axes. Flexion, extension, abduction, adduction, medial rotation, lateral rotation, and circumduction, all occur quite freely. E.g., shoulder joint, hip joint,

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talocalcaneonavicular joint, and incudostapedial joint.

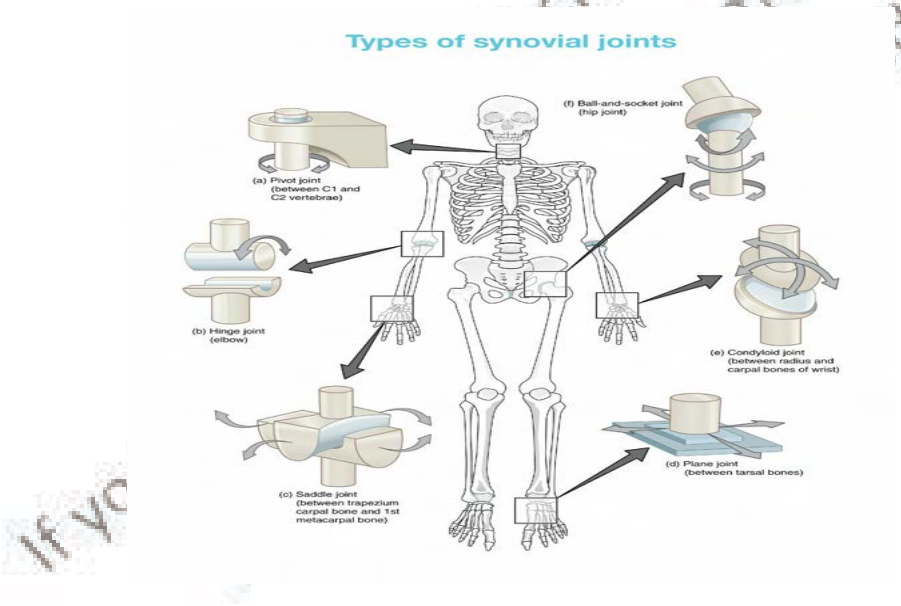
Note: The other joint between the incus and malleus (incudomalleolar joint) is a saddle joint.

Solution to Question 26:

The deformity shown is hallux valgus. This is caused due to an excessive lateral deviation at the first metatarsophalangeal joint. It is an example of an ellipsoid joint.

Ellipsoid joints have an oval, convex (male) surface fitting into an elliptical concave (female) surface. They show biaxial movements such as flexion-extension, and abduction–adduction. A combination of these movements results in circumduction. Movement on the third axis is prevented due to the general articular shape.

E.g., Wrist (radiocarpal) joint, atlanto-occipital joints, metacarpophalangeal joints, and metatarsophalangeal joints.



Solution to Question 27:

The talocalcaneonavicular joint is a ball and socket joint.

• The ball part is formed by the rounded head of the talus.

• The socket is formed by 3 structures:

• Posterior surface of the navicular

• Anterior articular surface of the calcaneus

• Upper surface of the plantar calcaneonavicular ligament (spring ligament).

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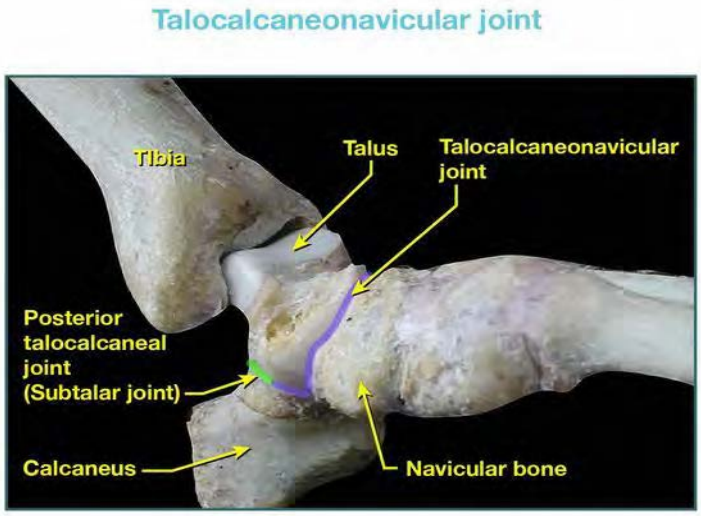

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Solution to Question 28:

Forward and backward movement of the mandible that occurs at the temporomandibular joints are called as protraction and retraction, respectively. Protraction occurs when the lower jaw is pushed forward, while retraction pulls the lower jaw backward.

Protraction and retraction also occur in the scapula. During protraction, the scapula is moved laterally and anteriorly along the chest wall, such as during rowing movements. Retraction is bringing scapula back to the original position after protraction.

Option A: Opposition is the thumb movement that brings the tip of the thumb in contact with the tip of a finger. Returning the thumb to its anatomical position next to the index finger is called reposition.

Option B: Excursion is the side to side movement of the mandible.

Option D: Depression and elevation are downward and upward movements of the mandible (or scapula), respectively.

Solution to Question 29:

The styloid process is a sharp elevation of bone.

Bony elevations can be sharp or rounded:

• Rounded or irregular elevations include a tubercle, tuberosity, epicondyle, malleolus, and trochanter.

• Sharp elevations of bones include styloid process, spine, cornu (horn), and hamulus (hook-like).

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Solution to Question 30:

The joint marked in the above image is the costotransverse joint, which is a synovial type of joint.

The various types of joints in the thoracic wall include:

Sternocostal joints: These are the joints between the costal cartilages of the first seven ribs and the sternum.

• The joint between the 1st costal cartilage and manubrium is a fibrocartilaginous joint (synarthrosis).

• The joints between the 2nd to 7th costal cartilages and the sternum are synovial joints.

The interchondral joint between the costal cartilages of the 9th and 10th ribs is never synovial and is usually absent.

Type of Joint	Examples
Synovial joint	Costovertebral jointCostotransverse jointInterchondral joints
Primary cartilaginous joint/Synchondrosis	Costochondral joint
Secondary cartilaginous/Symphyses joint	Manubriosternal and xiphisternal joints

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Muscles and Tendons

Question 1:

Which of the following statements is true regarding muscles in general?

a) Origin of muscle moves during contraction

b) Insertion of muscle is fixed during contraction

c) Origin and insertion of muscle is fixed during contraction

d) Origin of muscle is fixed during contraction

Question 2:

Which of the following statements about muscles is false?

a) Smooth muscles and cardiac muscles are bounded by plasmalemma

b) Intercalated discs are absent in skeletal muscles and smooth muscles

c) Skeletal muscle and smooth muscle fibres are multi-nucleated

d) Smooth muscles and cardiac muscles are supplied by autonomic nervous system

Question 3:

Which of the following is a true statement regarding skeletal muscle?

a) Muscle groups are surrounded by endomysium

b) Muscle fibers are surrounded by endomysium

c) Muscle groups are surrounded by perimysium

d) Muscle fibers are surrounded by perimysium

Question 4:

Which of the following muscles does not predominantly contain oblique fasciculi?

a) Deltoid

b) Rectus femoris

c) Rectus abdominis

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d) Tibialis anterior

Question 5:

Which of the following accurately describes the shape of trapezius muscle?

a) Quadrangular

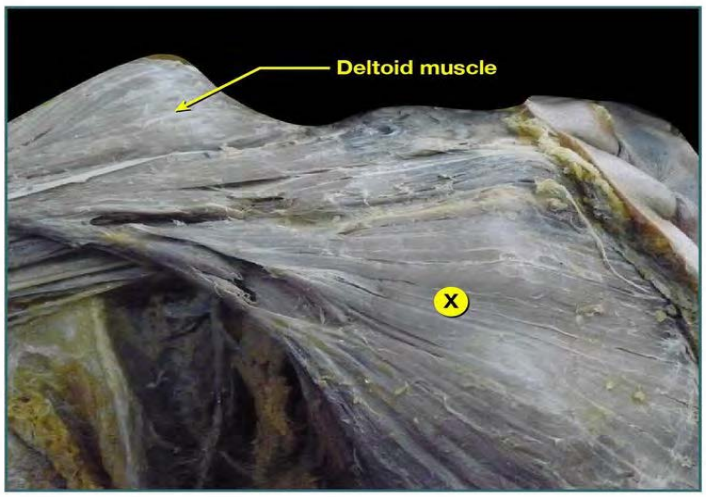
b) Triangular

c) Multipennate

d) Fusiform

Question 6:

Identify the type of muscle marked as X in the image below.



a) Spiral

b) Multipennate

c) Parallel

d) Cruciate

Question 7:

Which of the following muscles do not have parallel oriented muscle fibers?

a) Sartorius

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b) Rectus abdominis

c) Sternohyoid

d) Tibialis anterior

Question 8:

Which of the following accurately describes a muscle with two bellies with an intervening tendon?

a) Biceps

b) Diarthric

c) Digastric

d) Biaxial

Question 9:

A 40-year-old man with chronic liver disease presented with complaints of inability to straighten his ring finger completely as shown in the image. The broad sheet-like tendon involved in this condition is the_____

a) Retinaculum

b) Raphe

c) Aponeuroses

d) Fascia

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Question 10:

Which of the following statements regarding myofibrils is false?

a) The A band consists of both thick and thin filaments

b) The I band consists of only thin filaments

c) The H zone consists of only thick filaments

d) Z disc is present in the middle of A band

Question 11:

Identify the true statement about the motor nerve supply of the muscle.

a) α-efferents are small unmyelinated nerve fibers

b) Autonomic efferents supply vascular smooth muscles

c) γ-efferents innervate extrafusal muscle fibers

d) α-efferents supply the intrafusal muscle fibers

Question 12:

The 'flower spray endings' present in the muscle spindle are _____

a) Beta efferent nerve endings

b) Gamma efferent nerve endings

c) Primary sensory nerve endings

d) Secondary sensory nerve endings

Question 13:

How many muscle fibers do a small motor unit consist of?

a) 5-10 muscle fibres

b) 10-100 muscle fibres

c) 100-1000 muscle fibres

d) 1000-2000 muscle fibres

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Question 14:

Which of the following is not a hybrid muscle?

a) Flexor digitorum profundus

b) Biceps femoris

c) Pectineus

d) Flexor carpi ulnaris

Question 15:

What type of muscle fibers do the postural muscles predominantly contain?

a) Type IIA fibers

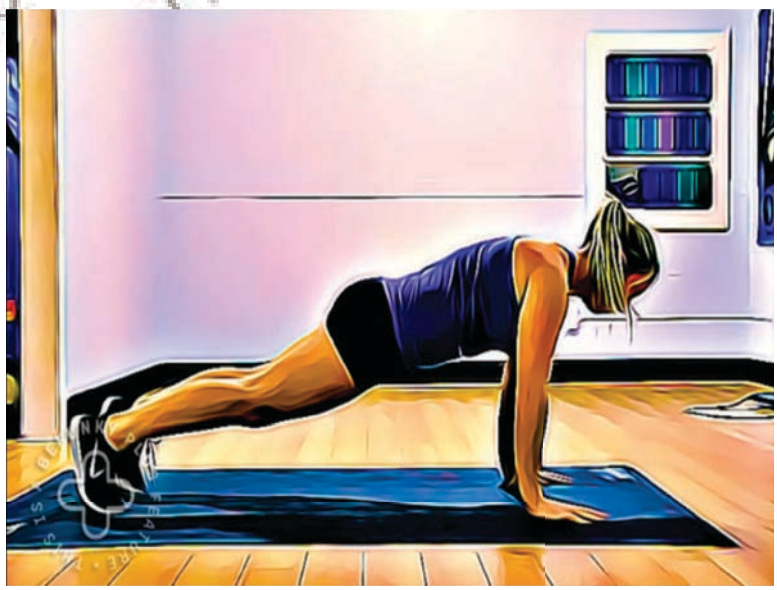
b) Type IIB fibers

c) Type I fibers

d) Both type I and II fibers

Question 16:

You notice a lady performing the following exercise to strengthen her abdominal muscles at the gym. It involved maintaining the muscle contraction without a change in muscle length, by not moving any of her joints. It is a type of_____



a) Isotonic contraction

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b) Isomorphic contraction

c) Isometric contraction

d) Isovolumetric contraction

Answer Key

Question No.	Correct Option
1	d
2	c
3	b
4	c
5	b
6	a
7	d
8	c
9	c
10	d
11	b
12	d
13	a
14	d
15	c
16	c

Detailed Explanations

Solution to Question 1:

The origin of the muscle is fixed, while the insertion moves during contraction.

Skeletal muscles exert their force on the bones through their tendon attachments and the force generated helps in generating movements or in maintaining posture.

Solution to Question 2:

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Skeletal muscles are multinucleated, while smooth muscles are uninucleated.

There are three major muscle types in the human body:

• Skeletal muscle

• Smooth muscle

• Cardiac muscle

Solution to Question 3:

The muscle fibres are surrounded by a delicate network of connective tissue called the endomysium.

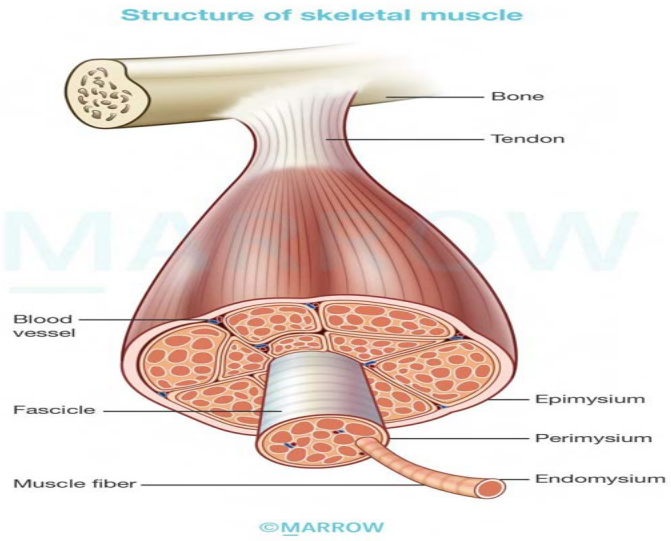
Muscles are supported by connective tissue in various layers namely:

• Endomysium - surrounds individual muscle fibers.

• Perimysium - surrounds a bundle of muscle fibers (fasciculi).

• Epimysium - surrounds whole muscle or muscle groups.

The endomysial, perimysial and epimysial layers fuse at locations where the muscles connect to adjacent structures such as tendons, aponeuroses, and fasciae.



Solution to Question 4:

The rectus abdominis muscle contains parallel fasciculi. The other muscles listed have oblique fasciculi.

Muscles can be classified based on the arrangement of muscle fibers relative to the direction of pull as follows:

• Parallel - muscle fasciculi are parallel to the line of pull.

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• Oblique - muscle fasciculi are oblique to the line of pull.

• Spiral - muscle fasciculi have a spiral or twisted arrangement.

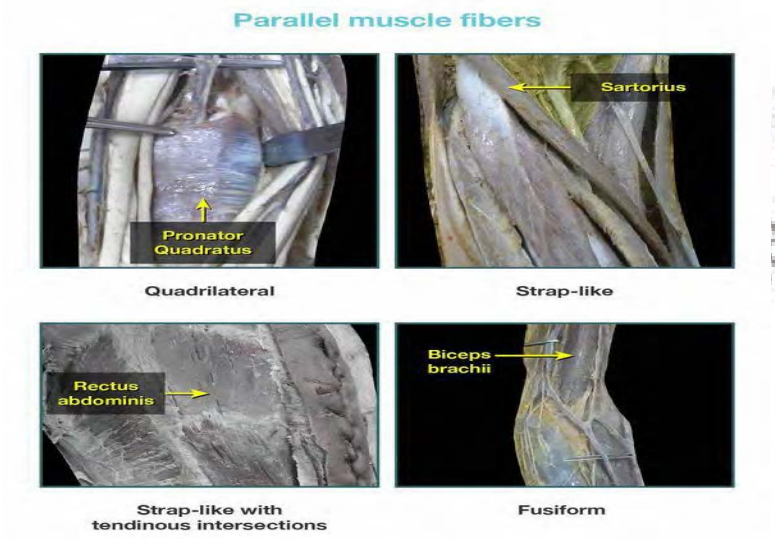
Parallel muscles can be further grouped based on their shape as follows:

• Quadrilateral - parallel fibers run for a short distance.

• Strap-like - parallel fibers run for a long distance.

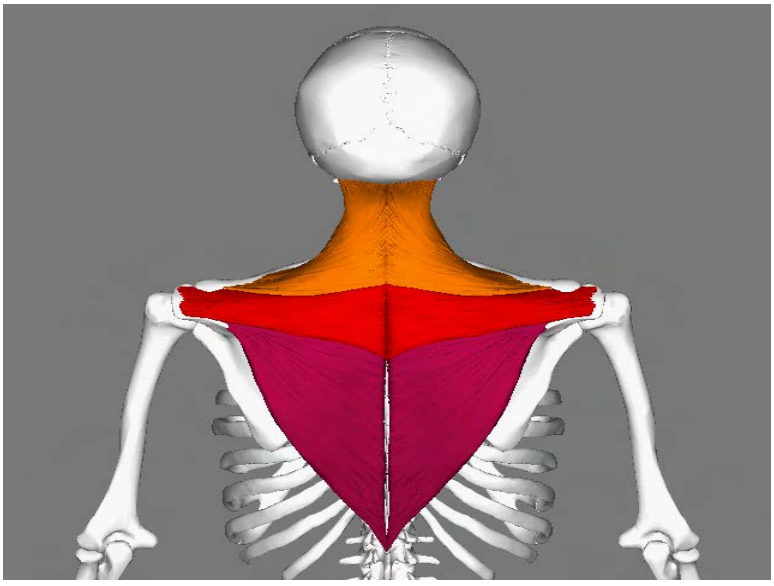
• Strap-like with tendinous intersections - parallel fibers are interrupted by tendinous insertions.

• Fusiform - parallel fibers in the muscle belly that converge at the tendon region.



Solution to Question 5:

The trapezius muscle individually is a flat, triangular muscle that extends over the back of the neck and upper thorax. When paired together, they resemble a trapezium and hence the name.



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Muscles with oblique fibers are further subclassified as follows:

• Triangular - They are triangular in shape.

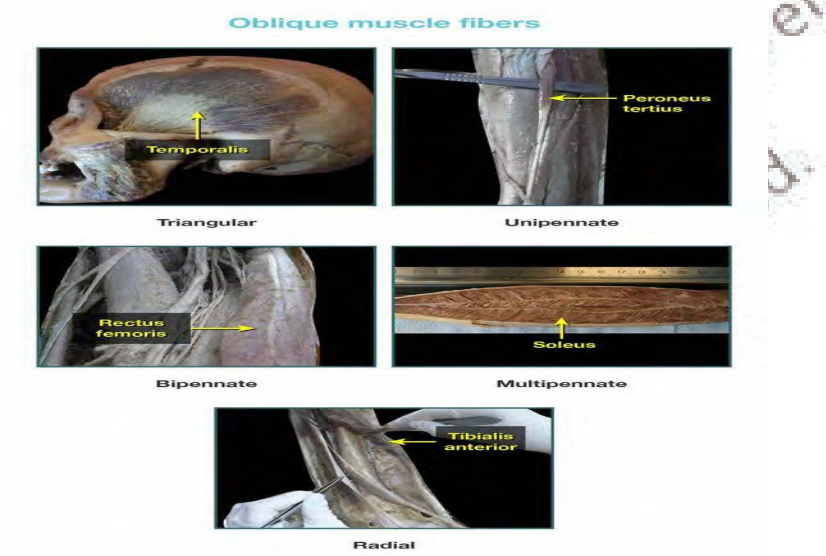
• Pennate - They are feather-shaped. Based on their complexity, they can have the following subtypes:

• Unipennate - fascicles on one side of the tendon.

• Bipennate - fascicles on two sides of the tendon.

• Multipennate - central tendon branches into two or more branches within the muscle.

• Circumpennate (radial) - muscle fibers converge to a central tendon in a radial fashion.



Solution to Question 6:

The muscle marked X in the cadaveric image is the pectoralis major, which is a spiral muscle.

Spiral muscles have fiber architecture as follows:

• The muscle fibers have a spiral or twisted arrangement. e.g., pectoralis major (sternocostal fibers) and latissimus dorsi that undergo a 180° twist between their medial and lateral attachments.

• The entire muscle takes a spiral course around a bone. e.g., supinator winds obliquely around the proximal radial shaft.

Cruciate is a type of spiral muscle where two or more planes of muscle fibers are arranged in differing directions. e.g., sternocleidomastoid, masseter and adductor magnus are all partially spiral and cruciate.

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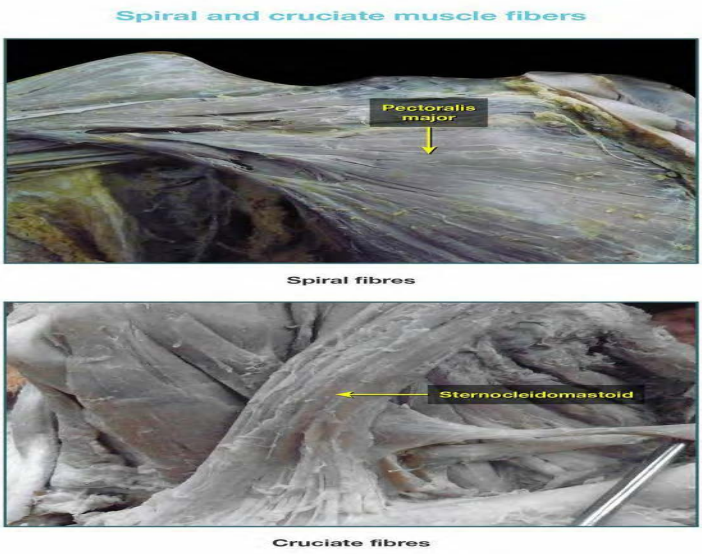

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Solution to Question 7:

The tibialis anterior muscle has oblique muscle fibers arranged in a circumpennate (radial) fashion and not parallel fibers. The muscle fibers start from the walls of osteofascial compartment in the leg and converge obliquely in a radial fashion on a central tendon.

The other muscles listed (sartorius, rectus abdominis, and sternohyoid) have parallel fibers.

Solution to Question 8:

A muscle with two bellies with an intervening tendon is called a digastric muscle. Examples include the digastric muscle (digastricus) that has anterior and posterior belly with an intermediate tendon and omohyoid that has superior and inferior belly with an intermediate tendon.

Diarthric muscles are those which extend over two joints.

Biaxial is a term used for joints that have movements in 2 axes.

The following image shows an illustration of the anterior and posterior belly of the digastric muscle with an intervening tendon:

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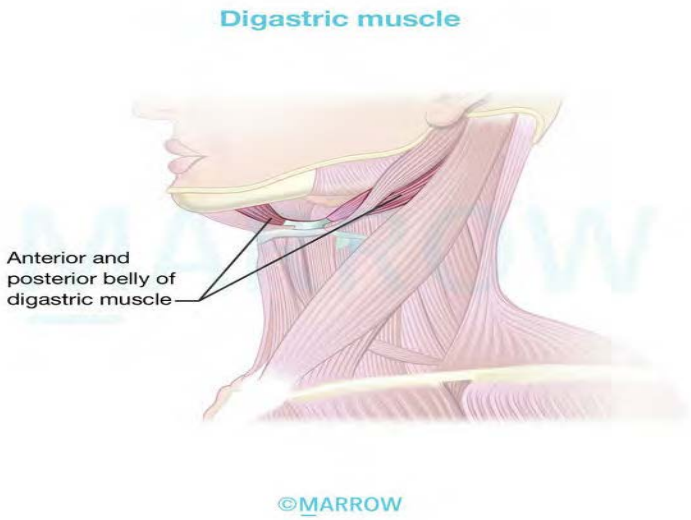

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Solution to Question 9:

The condition shown above is Dupuytren's contracture. It is the contracture of the flat or broad sheet-like tendon known as the aponeurosis, which leads to flexion deformities of the fingers, especially the ring and little fingers.

The aponeurosis is a pearly-white sheet of fibrous tissue that replaces tendons in sheet-like muscles having wide areas of attachment. They are whitish-silvery in colour and shiny. It is similar to tendons in histology and are sparingly supplied with blood vessels and nerves.

Examples of aponeuroses include:

- Palmar aponeuroses on the palms of the hands
- Plantar aponeuroses on the plantar aspect of the foot
- Anterior abdominal aponeuroses superficial to the rectus abdominis muscles
- Anterior and posterior intercostal membranes between the ribs
- Scalp aponeuroses or galea aponeurotica in the scalp

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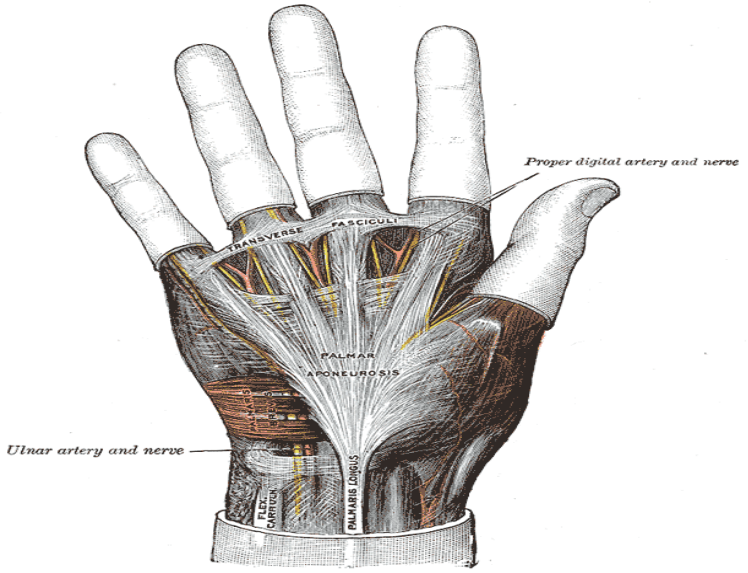

Option A: The retinaculum is a strong, short, and broad fibrous band around the tendons which holds them in place.

Option B: The linear fibrous band formed by interdigitation of the tendinous or aponeurotic ends of the muscles is known as raphe.

Option D: Fascia is a generic term applied to sheaths, sheets or other dissectible masses of connective tissue that are large enough to be visible to the unaided eye.

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Solution to Question 10:

Z disc or Krause's membrane is present in the middle of the I band of the myofibril.

Each myofibril has alternating dark (Anisotropic or A-band) and light (Isotropic or I-band) regions.

• A band

• The A-band contains both thick and thin filaments

• In the middle of the A-band, there is an H-band with only thick filaments

• In between the H-band, there is the dark M line

• I band

• The I-band contains only thin filaments

• In the middle of the I-band, there is a dark Z-disc or Krause's membrane

• The segment of the myofibril between two Z-discs is known as the sarcomere

The following photomicrograph of the skeletal muscle shows alternating dark and light regions with the Z-disc:

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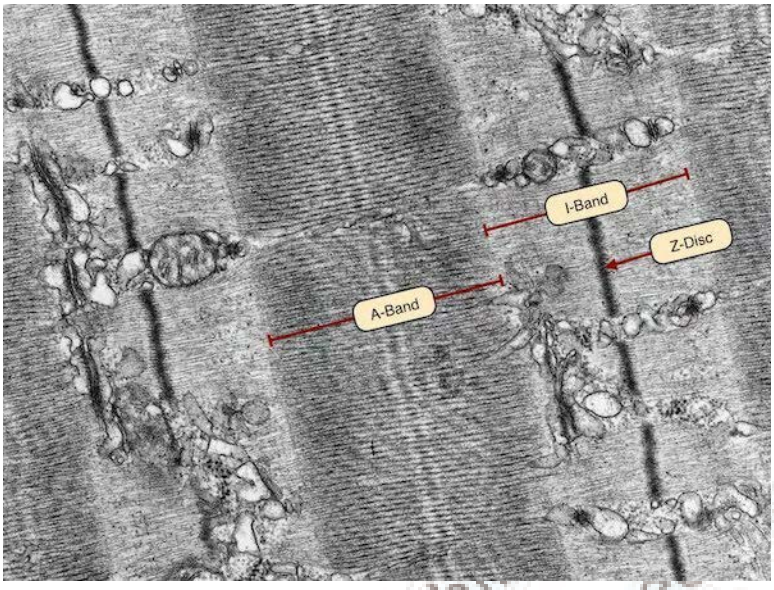

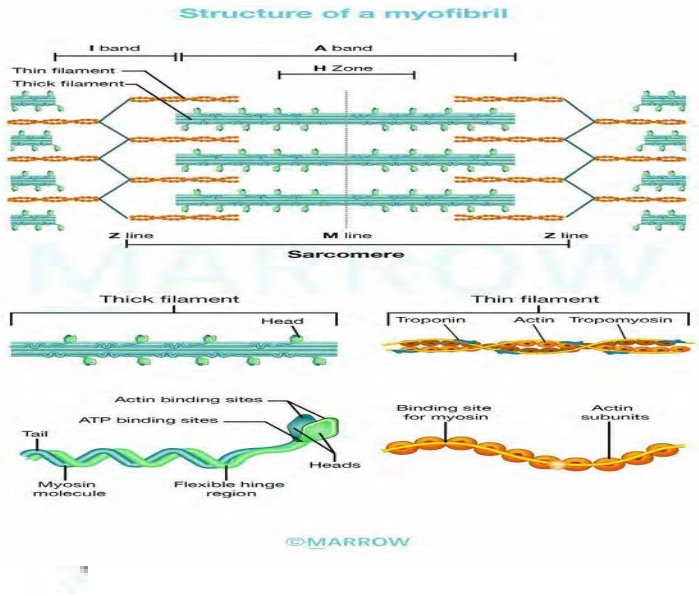

Solution to Question 11:

Autonomic efferents supply the smooth muscle fibres of the blood vessels.

Every skeletal muscle is supplied by a motor nerve, which actually is a mixed nerve that contains motor and sensory fibres.

The motor supply of muscle contains the following efferents:

• Extrafusal muscle fibers are supplied by α-efferents that are large and myelinated.

• Intrafusal muscle fibers of muscle spindle are supplied by γ-efferents that are small and myelinated.

• Vascular smooth muscle fibers get autonomic efferents that are fine and unmyelinated.

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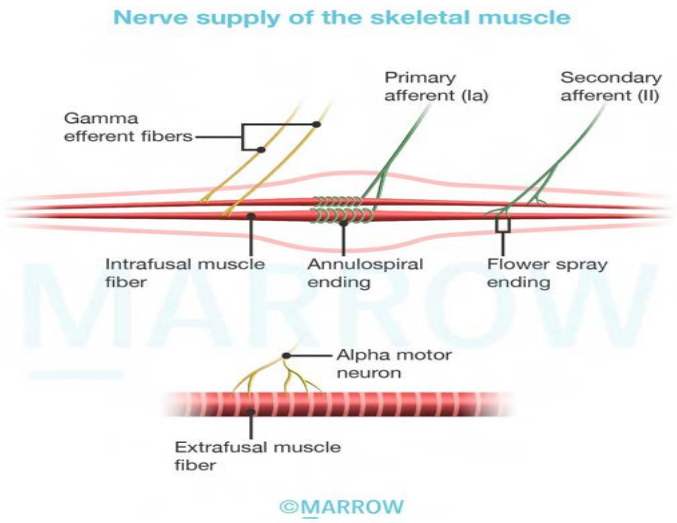

Solution to Question 12:

Flower spray endings present in the muscle spindles are the secondary sensory nerve endings.

The sensory nerve supply of muscle is as follows:

• Muscle spindles are supplied by thickly myelinated (IA) and thinly myelinated (II) afferents. The sensory nerve endings in the muscle spindle are of the following types:

• Primary sensory endings (type IA - Annulospiral endings) present in the central nuclear region of the intrafusal fibres.

• Secondary sensory endings (type II- Flower spray endings) present on either side of the nucleus of the intrafusal fibres.

• Golgi tendon organ is supplied by large, myelinated (IB) afferents.

• Connective tissue sheaths are supplied by fine, myelinated and unmyelinated axons that carry pain and other sensations.

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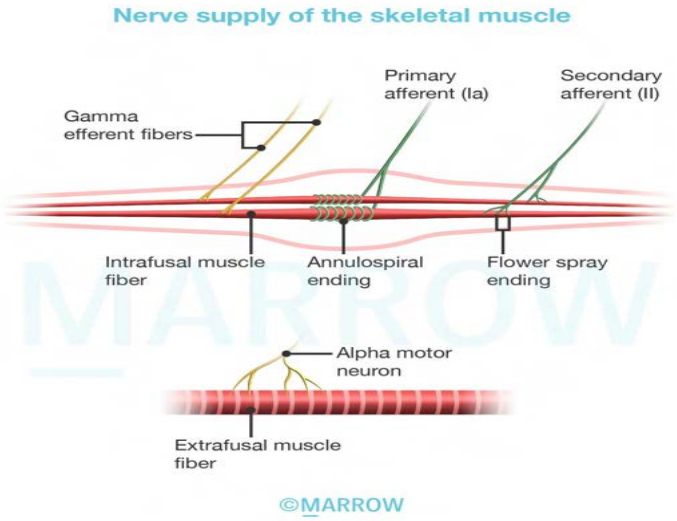

MARROW
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Solution to Question 13:

A small motor unit has 5-10 muscle fibers.

A motor unit (myone) is a single α motor neuron together with the muscle fibers supplied by it. The size of motor unit depends upon the precision of muscle control. Muscles that require fine control have fewer muscle fibers innervated by each neuron, muscles that participate in less controlled movements may have many fibers innervated by one neuron.

Motor units can be classified as follows:

• Small motor units (5–10 muscle fibers) are found in muscles of fine movements (such as extraocular muscles).

• Large motor units (100–2000 muscle fibers) are found in muscles of gross movements (such as proximal limb muscles).

Solution to Question 14:

Flexor carpi ulnaris is not a hybrid muscle as it is supplied by a single nerve (ulnar nerve).

A muscle supplied by two different nerves with different root values is called a composite or hybrid muscle. These muscles usually have more than one set of fibers and get their supply from different nerves for the different sets of fibers.

Examples of composite or hybrid muscles include:

• Brachialis

• Pectoralis major

• Iliopsoas

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• Subscapularis

• Biceps femoris

• Adductor magnus

• Digastric

• Flexor pollicis brevis

• Flexor digitorum profundus

• Pectineus

• Opponens pollicis

• Trapezius

Mnemonic: BP IS BAD FOR FUN POT

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Solution to Question 15:

Postural muscles predominantly contain Type I (slow-twitch) fibers that demonstrate slow, tonic contraction.

Muscle fibers belong to two main categories:

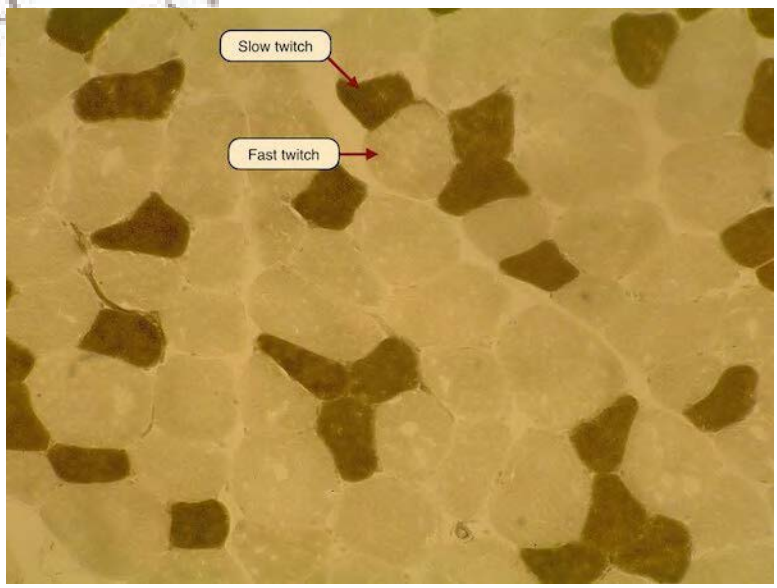
• Type I fibers (slow contracting or slow-twitch)

• Type II fibers (fast contracting or fast-twitch) - further subdivided to 2 types:

• Type IIA fibers

• Type IIX or IIB fibers

The following light micrograph shows fast-twitch fibers and myoglobin rich slow-twitch fibers:



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Solution to Question 16:

Muscle contraction without a change in muscle length is known as isometric contraction. The lady is performing a plank exercise which is an isometric exercise to strengthen the abdominal muscles.

Muscles can generate force through isotonic contraction or isometric contraction:

• Isotonic contraction involves maintaining constant tension as the muscle changes length. It can be concentric or eccentric.

• Concentric contraction involves shortening of the muscle. Example: biceps and brachialis contracting while lifting a weight by elbow flexion.

• Eccentric contraction involves lengthening of the muscle. Example: biceps and brachialis lengthening while lowering the weight by elbow extension.

• Isometric contraction involves force generation in the muscle while maintaining constant length. Example: Holding a crouched position or doing a wall-sit exercise.

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Cardiovascular, Lymphatic and Nervous Systems

Question 1:

Fenestrated capillaries are absent in_____

a) Kidneys

b) Lungs

c) Endocrine glands

d) Small intestines

Question 2:

Which of the following layers of a large blood vessel wall does the vasa vasorum supply blood to?

a) Tunica adventitia only

b) Tunica adventitia and outer part of Tunica media

c) Tunica adventitia, Tunica media

d) Tunica adventitia, Tunica media and outer part of Tunica intima

Question 3:

Collateral circulation refers to circulation through _____

a) Capillaries

b) Sinusoids

c) Anastomosis

d) Plexuses

Question 4:

Which of the following statements is true regarding arteries?

a) Arteries always carry oxygenated blood

b) Pulmonary artery carries oxygenated blood

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c) Arteries have valves to allow unidirectional flow

d) Umbilical artery carries deoxygenated blood

Question 5:

A middle-aged patient with recently detected hypertension is started on calcium channel blockers to reduce blood pressure by decreasing the peripheral vascular resistance. Which of the following vessels primarily contribute to the peripheral resistance to blood flow?

a) Elastic arteries

b) Small muscular arteries

c) Capillaries

d) Muscular arterioles

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Question 6:

Which of the following are end arteries?

a) 2,3,4 & 5

b) 1,2 & 3 only

c) 2,3 & 4 only

d) 1,2,3 & 4

Question 7:

Which of the following veins have valves?

a) Hepatic veins

b) Inferior venacava

c) Cerebral veins

d) Testicular veins

Question 8:

In which of the following structures are the sinusoids not present?

a) Suprarenal glands

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b) Parathyroid glands

c) Parotid glands

d) Carotid body

Question 9:

Compared to their corresponding arteries, the veins do not have

a) Larger lumen

b) Valves

c) Thinner walls

d) More elastic tissue

Question 10:

Which of the following vessels belong to the circulatory system referred to as the drainage system of coarse type?

a) 1 & 3

b) 3 & 4

c) 2 & 4

d) 5 only

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Question 11:

Which of the following lymphoid tissue has both afferent and efferent lymphatics?

a) Spleen

b) Thymus

c) Lymph node

d) Tonsil

Question 12:

An 86-year-old woman presented with sepsis and a massive right pleural effusion. She developed a chylous effusion 2 days after a chest tube insertion. An injury to the thoracic duct is suspected. Which of the following parts is not drained by it?

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a) Right upper limb

b) Right lower limb

c) Left upper limb

d) Left lower limb

Question 13:

Which of the following statements regarding lymph capillaries is false?

a) Are closed at their tips

b) Narrower than blood capillaries

c) Wall consists of thin endothelium

d) Lower pressure than blood capillaries

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Question 14:

How many spinal nerves are present in the cervical region?

a) 6 pairs

b) 7 pairs

c) 8 pairs

d) 9 pairs

Question 15:

Bipolar neurons are present in all of the following except _____

a) Spiral ganglia

b) Spinal ganglia

c) Vestibular ganglia

d) Retina

Question 16:

While trying to grab a cup of coffee, you suddenly withdrew your hands from the cup as it was too hot. The reflex arc responsible for this quick action is made up of all the parts except:

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a) Receptor

b) Sensory neuron

c) Motor Neuron

d) Affector

Question 17:

Which of the following neuroglial cells is not derived from neuroectoderm?

a) Astrocytes

b) Oligodendrocytes

c) Microglia

d) Glioblasts

Question 18:

Which of the following is not a component of the blood-brain barrier?

a) Capillary endothelium without fenestrations

b) Basement membrane of the endothelium

c) End feet of astrocytes covering the capillary walls

d) Capillary endothelium with fenestrations

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Question 19:

The nerve plexuses are formed only by _____

a) Dorsal rami

b) Ventral rami

c) Dorsal roots

d) Ventral roots

Question 20:

A patient was rushed to the hospital with an alleged history of overdose with a sympathomimetic drug. Which of the following signs would you not expect to see due to the sympathetic stimulation of the drug?

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a) High blood pressure

b) Sudomotor

c) Dilated pupils

d) Dry skin

Answer Key

Question No.	Correct Option
1	b
2	b
3	c
4	d
5	d
6	d
7	d
8	c
9	d
10	c
11	c
12	a
13	b
14	c
15	b
16	d
17	c
18	d
19	b
20	d

Detailed Explanations

Solution to Question 1:

Fenestrated capillaries are absent in the lungs.

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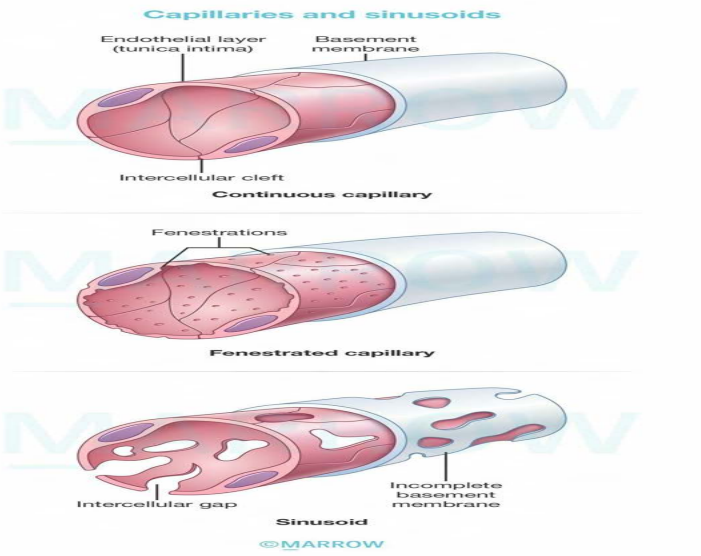
Fenestrated capillaries have gaps between endothelial cells. They are present in certain tissues that allow the passage of larger molecules such as the renal glomeruli, endocrine glands, intestinal mucosa, and pancreas.



Solution to Question 2:

The vasa vasorum (Latin: vessels of the vessels) is a network of small blood vessels that supply tunica adventitia and the outer part of tunica media of large blood vessels.

Blood supply of arteries:

• Small arteries- The vessel wall gets nourishment by diffusion from the blood circulating in the vessel itself. When the vessel wall thickness is more than 1 mm, simple diffusion from the lumen becomes inadequate.

• Larger arteries- They have their own vascular supply within the adventitia called vasa vasorum. It supplies the adventitia and the outer part of the tunica media. The intima and the inner part of the media of large vessels are nourished directly by diffusion from the luminal blood.

The given image shows a transverse section of the aorta showing vasa vasorum and the layers as follows:

• Tunica intima

• Tunica media

• Tunica adventitia

• Vasa vasorum

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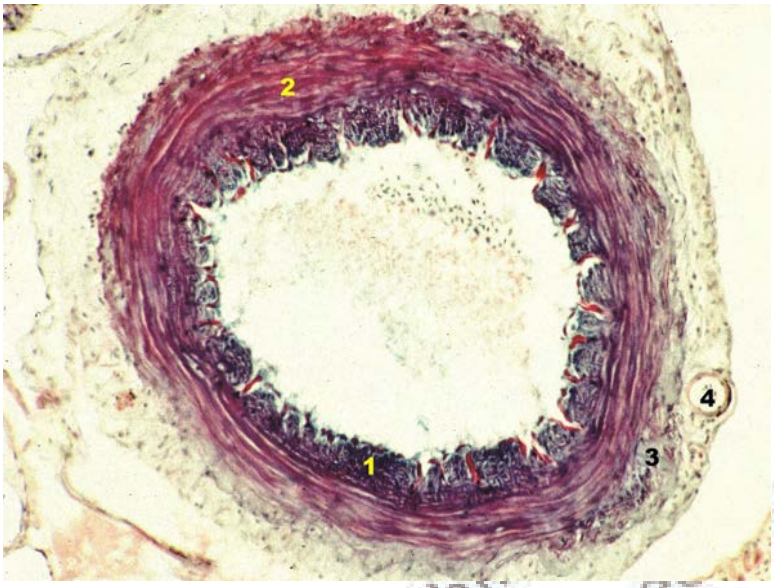

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Solution to Question 3:

Circulation through the anastomosis is called collateral circulation.

Precapillary or postcapillary communication between neighbouring vessels is called anastomoses. Anastomoses are of the following types:

• Arterial anastomoses are communications between the arteries or branches of arteries. e.g., palmar arch, plantar arch, the circle of Willis.

• Venous anastomoses are communications between the veins or tributaries of veins. e.g., dorsal venous arches of the hand and foot.

• Arteriovenous anastomosis (shunt) are communications between an artery and a vein. e.g., av shunts found in the skin of nose, lips, ears, mucosa of nose and intestines, and erectile tissue.

The image below is a graphical representation of superficial and deep palmar arch.

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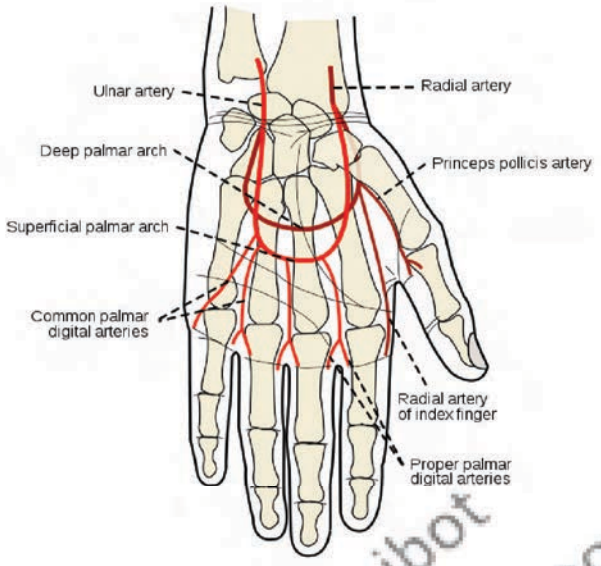

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Solution to Question 4:

Umbilical arteries carry deoxygenated blood from the heart to the placenta during the fetal period.

Arteries carry oxygenated blood away from the heart, with the exception of the pulmonary and umbilical arteries that carry deoxygenated blood.

Solution to Question 5:

Muscular arterioles contribute to the major part of peripheral resistance to blood flow.

The smallest arteries of the muscular type are called arterioles. They have a tunica media that is relatively thicker than the tunica adventitia. Arterioles cause the largest drop in blood pressure before the blood flows into the tissue capillary beds. They are densely innervated by sympathetic fibres. The contraction of arterioles is mainly regulated by local vasoactive and metabolic factors, but central mechanisms also play a role.

The following image shows a micrograph of a muscular arteriole:

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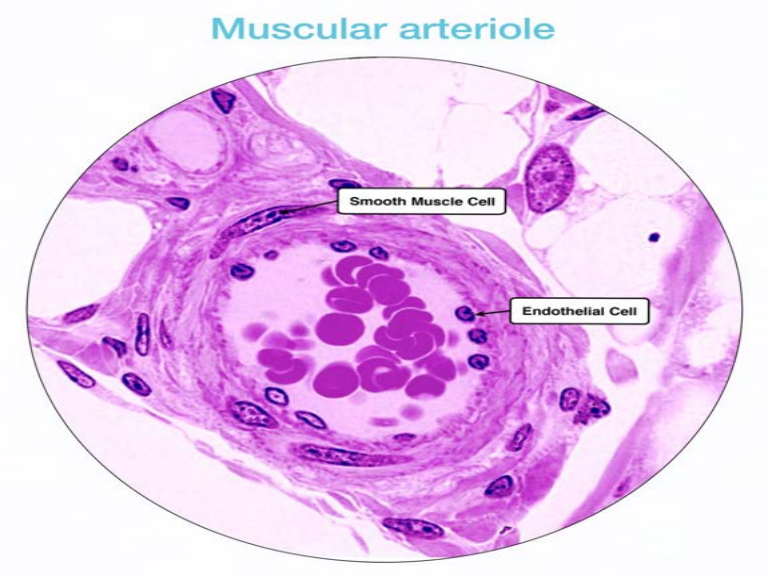

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Solution to Question 6:

All the other arteries except the posterior cerebral artery are end arteries.

Arteries whose terminal branches do not anastomose with branches from neighbouring arteries are called end arteries or terminal arteries. They can be of two types:

• Anatomic end arteries (or true end arteries) - do not have anastomoses. e.g., central artery of retina, internal auditory artery (labyrinthine artery of the internal ear).

• Functional end arteries - have anastomoses but they are insufficient to provide adequate blood supply when the main vessel is occluded. e.g., segmental arteries supplying the kidney.

Solution to Question 7:

The testicular veins have valves.

Valves within the veins maintain a unidirectional flow of blood, even against gravity. Congenital absence of valves in testicular veins may be a predisposing factor for the development of varicocele. The inferior vena cava also has a valve (the Eustachian valve) to direct the flow of oxygenated blood towards the foramen ovale to escape the pulmonary circulation. After birth, with the establishment of the pulmonary circulation and the increase in systemic vascular resistance driving the closure of foramen ovale, the valve has no function and tends to regress.

The valves are absent in the following veins:

• Veins less than 2 mm in diameter

• Venae cavae

• Hepatic, renal, uterine, ovarian, cerebral, spinal, pulmonary, and umbilical veins.

The following image is a histological section showing the valve within a vein:

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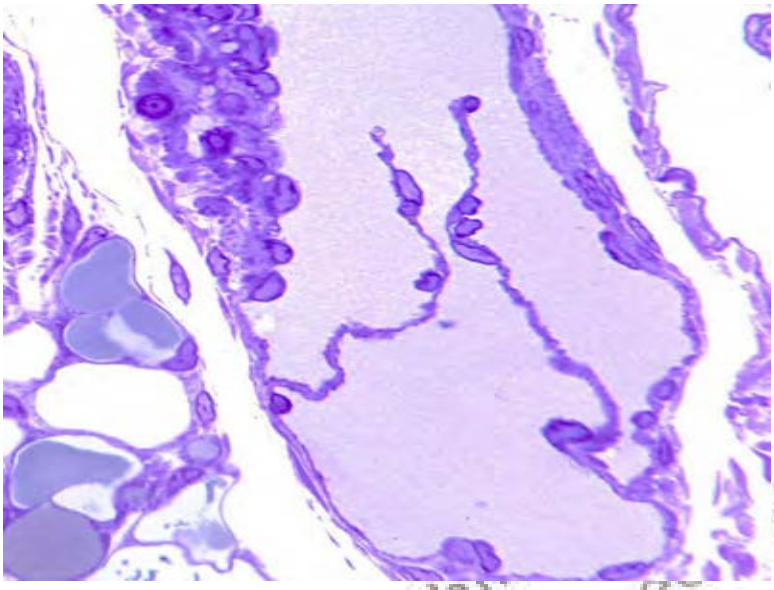

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Solution to Question 8:

Sinusoids are absent in parotid glands.

Sinusoids are large, irregular, vascular spaces with true discontinuities in their walls. This allows close contact between blood and parenchyma of the surrounding organ.

Sinusoids are present in:

- Liver
- Spleen
- Bone marrow
- Suprarenal glands
- Adenohypophysis
- Parathyroid glands
- Carotid body

Solution to Question 9:

Compared to their corresponding arteries, the veins have a much lesser muscular and elastic content. This explains the venous pressures being lower than the arterial pressures.

The following image shows a graphical illustration of the structure of the vessels (a & b) and a micrograph of the cross-sections(c):

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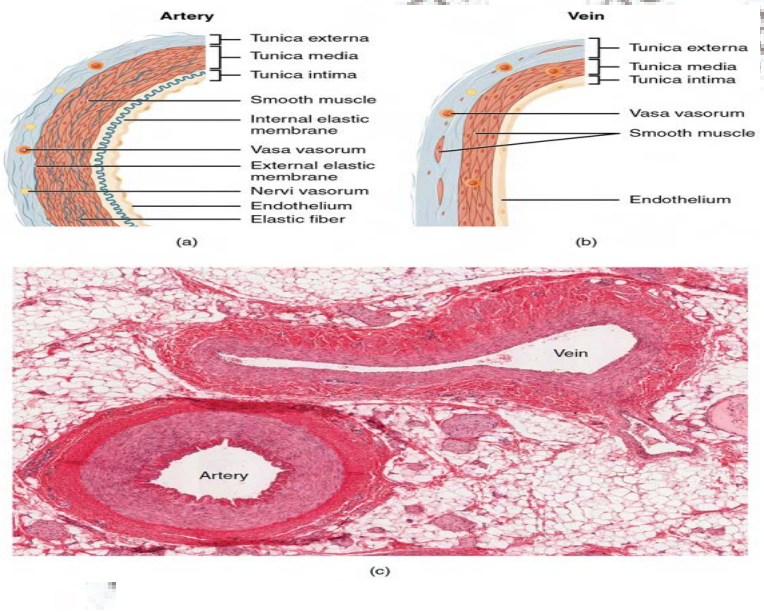
Comparison of arteries and v eins	
Arteries	Veins
Carry oxygenated blood away from the heart except for pul monary artery	Carry deoxygenated blood to wards the heart except for pu lmonary veins
Thick-walled,highly muscular except arteries of cranium a nd vertebral column	Thin-walled
Narrow lumen	Wide lumen
Valves absent	Valves present to maintain u nidirectional blood flow
High-pressure flow	Low-pressure flow
Reddish in colour	Bluish in colour



Solution to Question 10:

The thoracic and right lymphatic ducts are vessels of the lymphatic system which is referred to as the drainage system of coarse type.

The lymphatic system helps remove larger particles such as proteins and particulate matter from the tissue fluid. Therefore, they are considered as the drainage system of coarse type.

The venous system is considered as the drainage system of fine type.

Solution to Question 11:

The lymph nodes have both afferent and efferent lymphatics.

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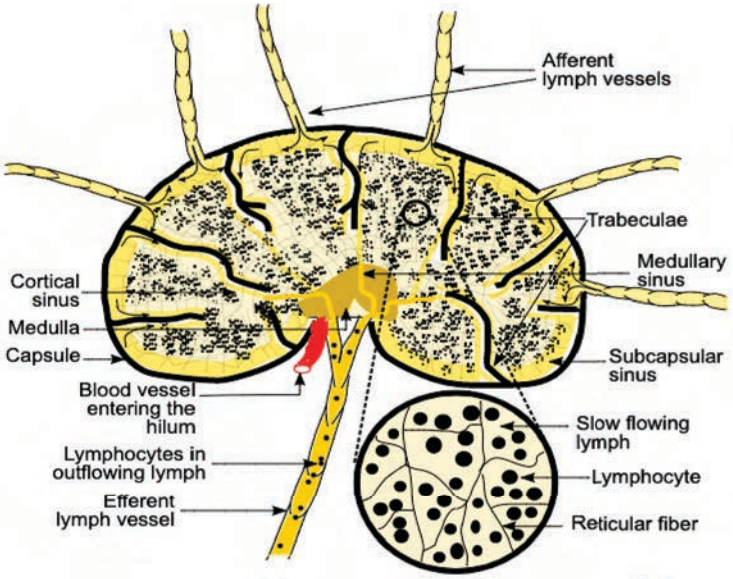
• The afferent lymphatics enter the lymph node at different parts of its periphery.

• The efferent lymphatics exit at the hilum.

The following image shows a schematic representation of a lymph node:



The tonsils, thymus, and the spleen have no afferent lymphatics.

Solution to Question 12:

The right upper limb is drained by the right lymphatic duct, not the thoracic duct.

The filtered lymph passes through larger lymphatics and eventually collect into two large trunks, the thoracic duct and right lymphatic duct, which in turn drain into the brachiocephalic veins.

• Thoracic duct - drains both lower limbs, left upper limb, abdomen, left halves of thorax, and left side of the head and neck regions (areas shaded green in the image).

• Right lymphatic duct - drains right upper limb, and right halves of thorax, and right side of the head and neck regions (areas shaded blue in the image).

Injury to the thoracic duct is a rare complication of traumatic chest tube insertion.

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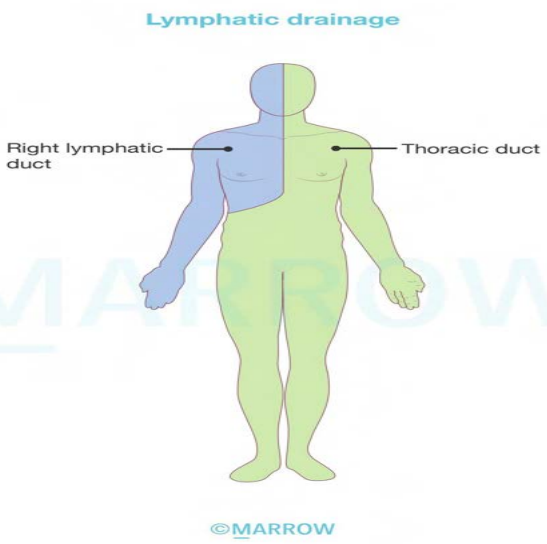

Solution to Question 13:

Lymph capillaries are wider than blood capillaries.

Lymph capillaries begin blindly (tips are closed) in the tissue spaces and form intricate networks. The endothelial wall is thin and is permeable to substances of much greater molecular size. They have relatively lower pressure than blood capillaries.

Lymph capillaries	Blood capillaries
Colourless, difficult to observe	Reddish, easy to observe
Blind (closed at the tip)	Joined to arterioles at one end and to venules at another end
Wider than blood capillaries	Narrower than lymph capillaries
Wall consist of thin endothelium and poorly developed basement membrane	Wall consist of normal endothelium and basement membrane
Contain colourless lymph	Contain red blood
Have relatively low pressure	Have relatively high pressure
Absorb tissue fluid from intercellular spaces	Add tissue fluid to intercellular spaces

Solution to Question 14:

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There are 8 pairs of spinal nerves in the cervical region.

The cerebrospinal nervous system includes 12 pairs of cranial nerves and 31 pairs of spinal nerves.

The 31 pairs of spinal nerves are distributed as follows:

• Cervical nerves - 8 pairs

• Thoracic nerves-12 pairs

• Lumbar nerves-5 pairs

• Sacral nerves-5 pairs

• Coccygeal nerves-1 pair

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Solution to Question 15:

Biploar neurons are not seen in spinal ganglia. Spinal ganglia consist of pseudounipolar neurons.

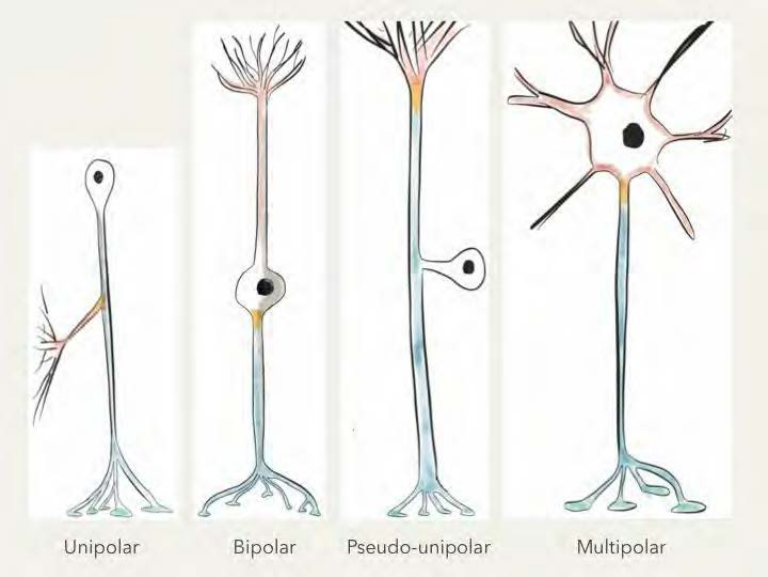
Neurons are classified based on the number of processes as:

• Unipolar, e.g., mesencephalic nucleus

• Pseudo-unipolar, e.g., sensory ganglia or spinal ganglia.

• Bipolar, e.g., spiral and vestibular ganglia, and bipolar neurons of the retina.

• Multipolar, e.g., neurons in cerebrum and cerebellum.



Solution to Question 16:

The reflex arc consists of an effector, usually a muscle and not an affector.

A reflex arc is the basic functional unit of the nervous system which can perform an integrated neural activity.

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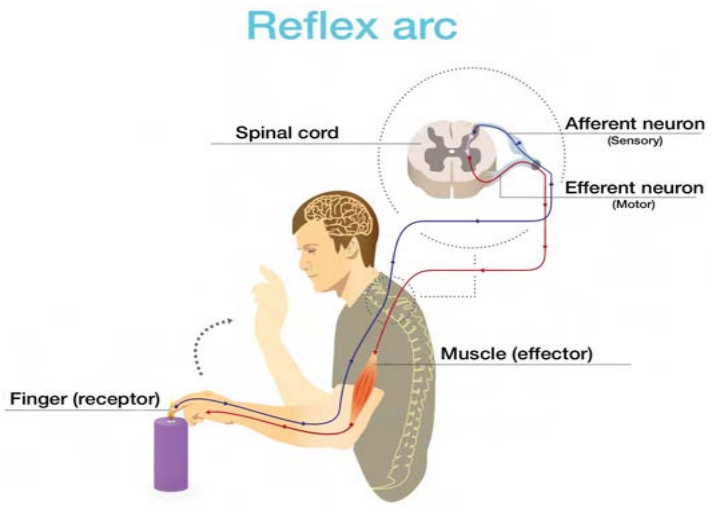
A mono-synaptic reflex arc is made up of:

• Receptor, e.g., skin

• Sensory or afferent neuron

• Motor or efferent neuron

• Effector, e.g., muscle.



Solution to Question 17:

Microglial cells do not originate from the ectoderm but are derived from the mesoderm. Microglia are possibly derived from the circulating monocytes which migrate into the CNS during the late fetal and early postnatal life.

Neuroglial cells found in the parenchyma of the brain and spinal cord are broadly classified as follows:

• Macroglia cells of ectodermal origin (neuroectoderm) including the astrocytes, oligodendrocytes, and glioblasts.

• Microglia cells of mesodermal origin.

Solution to Question 18:

Capillaries with fenestrations are not part of the blood-brain barrier.

The blood-brain barrier is formed by:

• Capillary endothelium with tight junctions (no fenestrations).

• Basement membrane of the endothelium.

• End feet of astrocytes covering the capillary walls.

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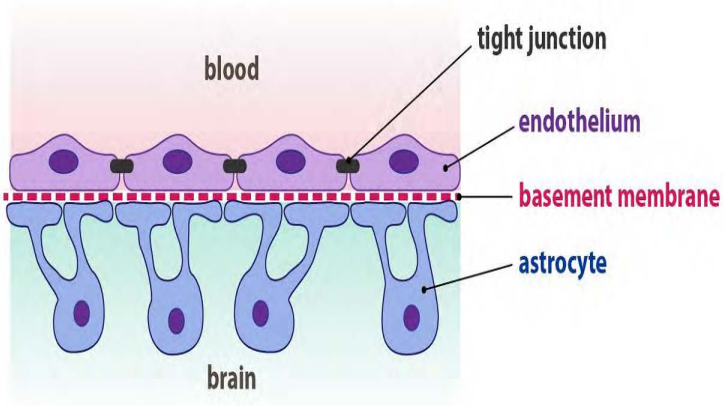
The barrier permits a selective passage of blood constituents to the nervous tissue.



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Solution to Question 19:

Nerve plexuses are formed only by the ventral rami.

Nerve plexuses contain afferent and efferent fibers that arise from the ventral rami of spinal nerves. The spinal nerve emerges from the intervertebral foramen and divides into a ventral and a dorsal ramus. All nerve plexuses are formed only from the ventral rami and not from the dorsal rami.

List of spinal plexuses:

- Cervical plexus
- Brachial plexus
- Lumbar plexus
- Sacral plexus
- Coccygeal plexus

Solution to Question 20:

Dry skin is not expected to see due to sympathetic stimulation.

The sympathetic nervous system (SNS) arises from the lateral horn of T1 to L2 segments of the spinal cord (thoracolumbar outflow). Sympathetic stimulation causes the following effects:

- Sweating due to secretomotor supply to sweat glands - Sudomotor
- Erection of hair due to contraction the arrector pili muscle - Pilomotor
- Raised blood pressure due to vasoconstriction - Vasomotor

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• Dilated pupils

• Dry mouth

• Tachycardia

Common examples of sympathomimetic drugs include phenylephrine, albuterol, cocaine and amphetamines.

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Skin, Connective Tissue and Ligaments

Question 1:

Which of the following is the correct order of layers of epidermis from deep to superficial?

a) 4-3-1-2

b) 3-4-1-2

c) 3-1-2-4

d) 4-3-2-1

Question 2:

In which of the following layers are non-nucleated cells present?

a) Stratum Granulosum

b) Stratum Spinosum

c) Stratum Basale

d) Stratum Corneum

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Question 3:

Which of the following factors does not affect the colour of human skin?

a) Melanocyte morphology and activity

b) Number of melanocytes in the skin

c) Number of melanosomes in melanocytes

d) Number of melanosomes in keratinocytes

Question 4:

A middle-aged woman presented with a rapidly growing, itchy lesion on her face as shown in the image. On dermoscopy, there is an atypical pigmented network. In which of the following layers of the skin are the cells forming these lesions present?

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a) Stratum corneum

b) Stratum granulosum

c) Stratum basale

d) Dermis

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Question 5:

Which of the following cells act as touch receptors?

a) Melanocytes

b) Keratinocytes

c) Langerhans cells

d) Merkel cells

Question 6:

In which of the following layers of the skin are Meissner corpuscles present?

a) Stratum spongiosum

b) Stratum basale

c) Reticular dermis

d) Papillary dermis

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Question 7:

On exposure to a sudden gush of cold air, you notice the following change in the appearance of your skin for a brief period. Which of the following accurately describes the muscle responsible for this phenomenon?

a) It is a skeletal muscle

b) It is a smooth muscle

c) It is a mixture of skeletal and smooth muscle, with dominant skeletal muscle

d) It is a mixture of skeletal and smooth muscle, with dominant smooth muscle

Question 8:

Which of the following statements is true regarding sweat glands?

a) Apocrine sweat glands help maintain the temperature

b) Eccrine sweat glands are supplied by adrenergic neurons

c) Apocrine sweat glands help generate an odor

d) Eccrine sweat glands become active at puberty

Question 9:

The white opaque crescent present in the proximal part of the nail is known as _____

a) Free border

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b) Root

c) Lunula

d) Nail body

Question 10:

Which of the following forms the non-fibrous element of the extracellular matrix in the connective tissue?

a) Collagen

b) Elastin

c) Reticulin

d) Ground substance

Question 11:

Which of the following statements regarding ligaments is false?

a) Most ligaments have collagen fibres

b) Ligamenta flava is an elastic ligament

c) Extrinsic ligaments are independent of the joint

d) Ligaments are devoid of nerve supply

Question 12:

The structure marked X in the following image is a modified form of_____

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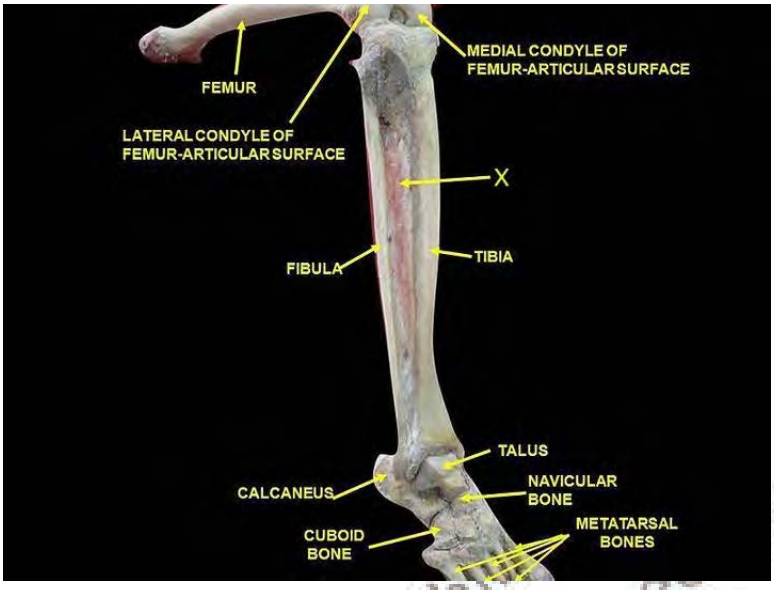

a) Ligament

b) Tendon

c) Superficial fascia

d) Deep fascia

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Question 13:

The linear fibrous band formed by interdigitation of the tendinous or aponeurotic ends of the muscles is known as _____

a) Ligament

b) Interosseous membrane

c) Raphe

d) Fascia

Answer Key

Question No.	Correct Option
1	b
2	d
3	b
4	c

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5	d
6	d
7	b
8	c
9	c
10	d
11	d
12	d
13	c

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Detailed Explanations

Solution to Question 1:

The correct order of the given layers from deep to superficial is stratum basale, stratum spinosum, stratum granulosum, stratum corneum.

Most of the body is covered by thin skin that has 4 layers as follows (superficial to deep):

• stratum corneum

• stratum granulosum

• stratum spinosum

• stratum basale

Some parts of the body such as the palms, soles and flexor surfaces of digits have thick skin (glabrous skin) with 5 layers as follows (superficial to deep):

• stratum corneum

• stratum lucidum

• stratum granulosum

• stratum spinosum

• stratum basale

Mnemonic for skin layers (superficial to deep): Come Let's Get Some Beer (Corneum, Lucidum, Granulosum, Spinosum, and Basale).

The following image shows an illustration of layers of epidermis:

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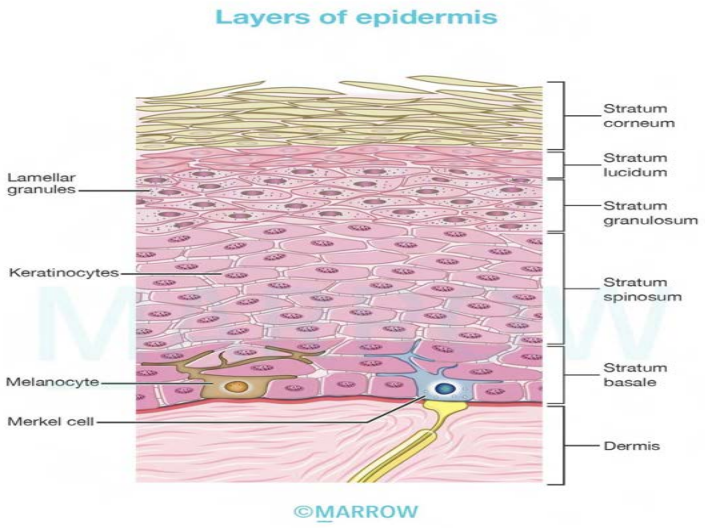
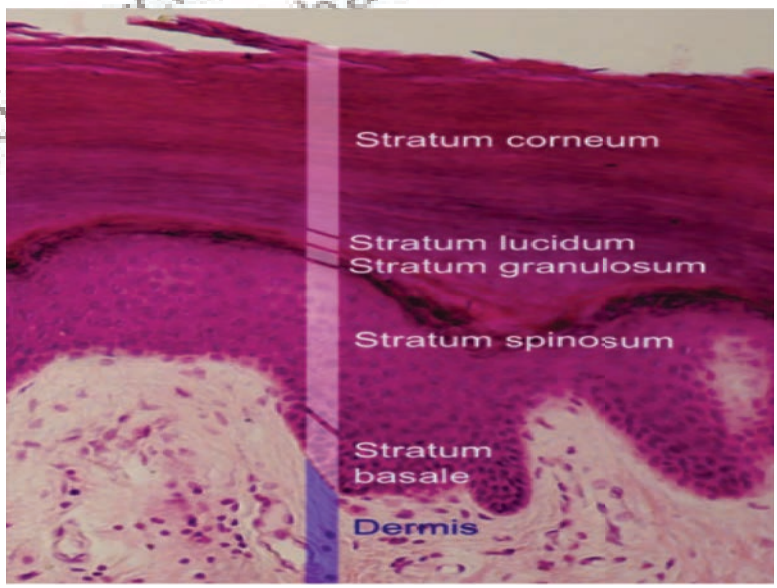


Solution to Question 2:

Non-nucleated cells are present in the stratum corneum layer of the epidermis. The cells are devoid of both a nucleus and membranous organelles.

The cells in this layer contain densely arranged keratin filaments within the cytoplasmic matrix providing a barrier function that prevents the entry of microbes from the environment and leakage of fluids from the body.



Solution to Question 3:

The number of melanocytes does not affect the colour of human skin.

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The racial differences in skin colour is determined by:

• Melanocyte morphology and activity.

• Number and size of melanosomes in melanocytes.

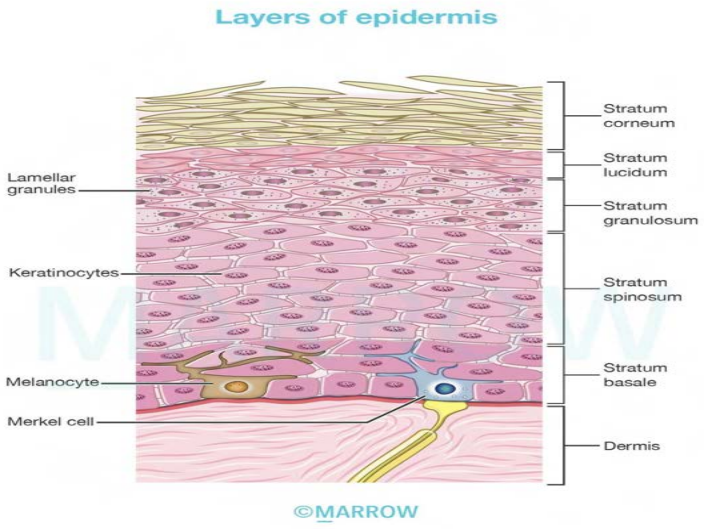
• The number of melanosomes individually dispersed within keratinocytes.

Melanin pigmentation is influenced by constitutive (genetically determined) and facultative factors (reversible changes due to environmental factors like UV-rays, chemicals, and hormones).

Solution to Question 4:

The given clinical scenario of an itchy, asymmetrical pigmented lesion on the face with an irregular border(image) that rapidly grew in size, points towards a diagnosis of malignant melanoma arising from the melanocytes. These cells are present in the stratum basale layer of the epidermis.

Melanocytes are derived from neural crest cells. They produce melanin which is packed into organelles called melanosomes and transferred via finger-like processes called dendrites to the keratinocytes.



Solution to Question 5:

The Merkel cells act as touch receptors. They are present in the basal layer of the epidermis and outer root sheath of some big hair follicles and their functions are as follows:

• Act as slowly adapting mechanoreceptors in the skin that convey touch sensation.

• Detects the directional deformation of the epidermis and hair movement.

• Sense sustained pressure and edges of applied objects on the skin.

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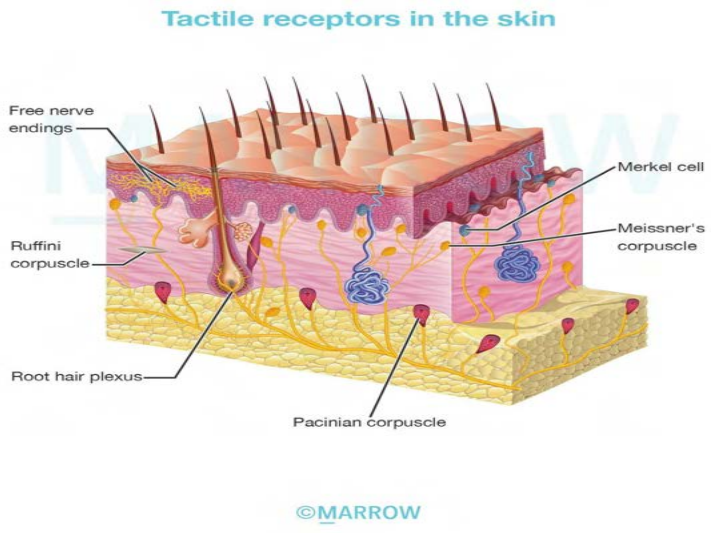

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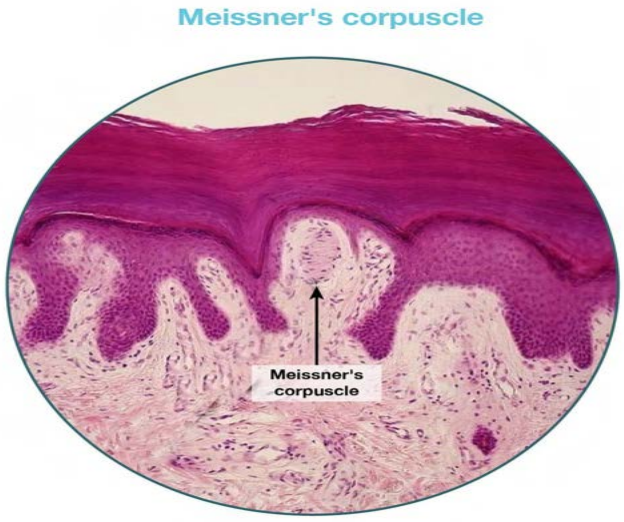
Solution to Question 6:

Meissner corpuscles are present in the dermal papillae (upper dermis).

They are primarily present in the dermal papillae of all parts of the hand and foot, the lips, the anterior aspect of the forearm, palpebral conjunctiva and mucous membrane of the apical part of the tongue. They are highly concentrated in the finger pads.

Meissner's corpuscles are rapidly adapting mechanoreceptors that are sensitive to shape and textural changes during exploratory and discriminatory touch. Their high sensitivity provides the neurological basis for sensing the Braille text.



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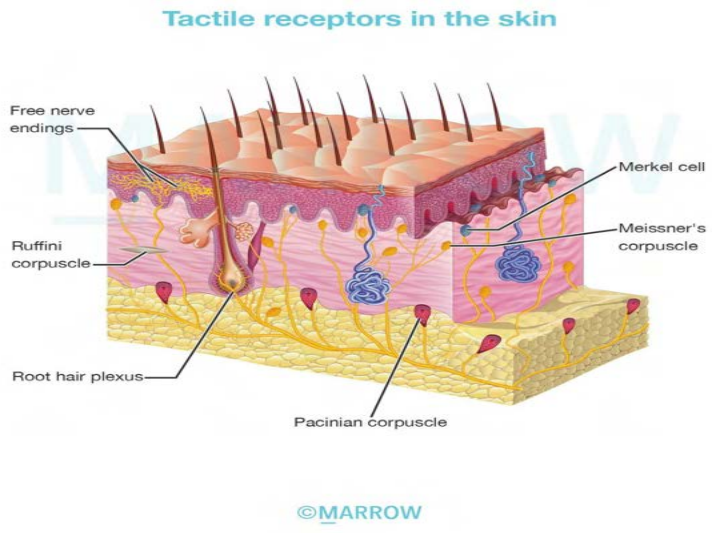

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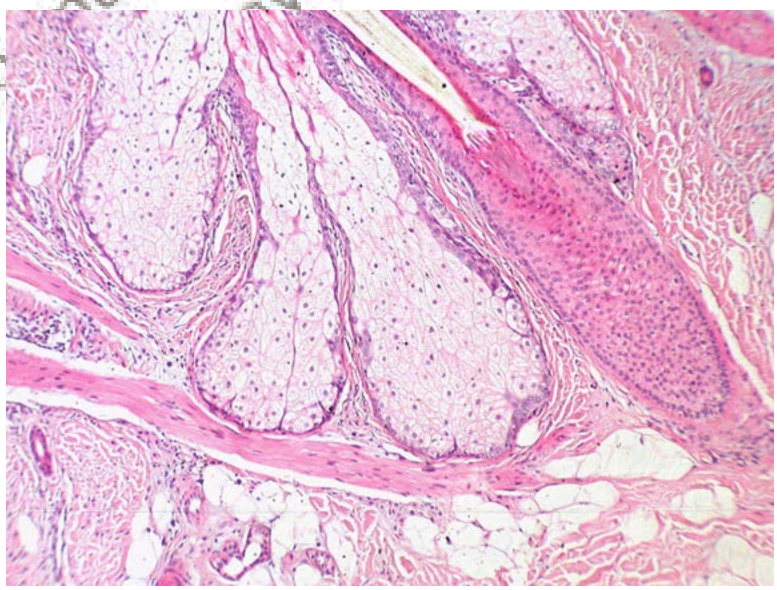
Solution to Question 7:

The muscle responsible for goosebumps (image) is the arrector pili muscle which is a smooth muscle supplied by the sympathetic nerves. It connects the dermal sheath of the hair follicles to the papillary layer of the dermis.

Contraction of these muscles makes the hair more vertical (piloerection), elevates the epidermis around the hair (goosebump), and dimples the skin surface where the muscle is inserted.

The image given below shows the arrector pili muscle attached to the hair follicles:



Solution to Question 8:

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Apocrine sweat glands produce secretions that undergo bacterial decomposition to generate odour.

Sweat glands are classified as follows:

• Eccrine sweat glands - The majority of sweat glands in the body are eccrine and open via rounded pores to the skin surface.

• Apocrine sweat glands - They are present in the axillae, perianal area, areolae, periumbilical skin, and genitalia.

Solution to Question 9:

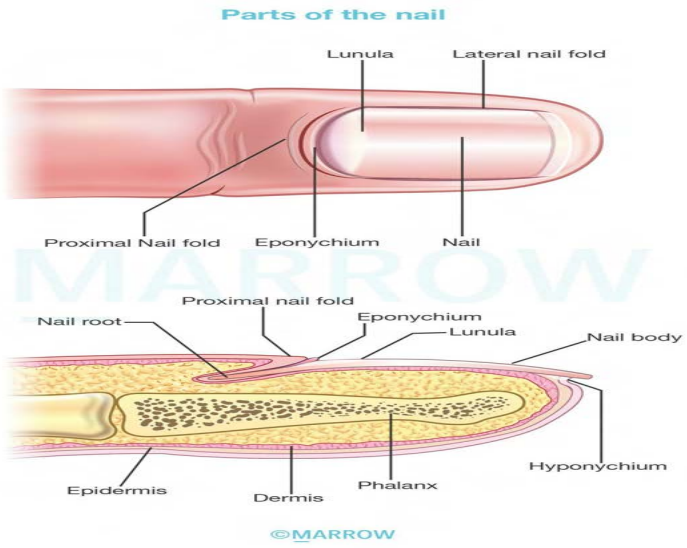
The white opaque crescent present in the proximal part of the nail is known as the lunula.

Parts of the nail:

• Root - It is the proximal hidden part, buried into the nail groove and is overlapped by the nail fold of the skin.

• Free border - It is the distal part of the nail that is free from the skin.

• Body - It is the exposed part of the nail that is adherent to the underlying skin.



Solution to Question 10:

The non-fibrous element of the extracellular matrix in the connective tissue is formed by the ground substance.

Connective tissue consists of cells and extracellular matrix:

• The cells include fibroblasts, macrophages, plasma cells, mast cells, fat cells, and pigment cells.

• The extracellular matrix contains fibrous and non-fibrous elements.

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• The fibrous element has three types of fibres - collagen, elastin and reticulin

• The non-fibrous element is formed by the ground substance

Solution to Question 11:

The statement 'ligaments are devoid of nerve supply' is false.

Ligaments have a rich nerve supply. This helps them function as sense organs and participate in reflex mechanisms important for monitoring the position and movements of the joint. Intrinsic ligaments surround the joint, whereas extrinsic ligaments are away and independent of the joint.

The majority of ligaments are made up of collagen fibres predominantly. These are inelastic and not stretchable. Ligamentum flavum and ligaments of auditory ossicles are exceptions, as they predominantly have elastin fibres that make them elastic and stretchable.

Solution to Question 12:

The structure marked X in the image is the interosseous membrane which is a modified form of deep fascia. It is present in the forearm and leg.

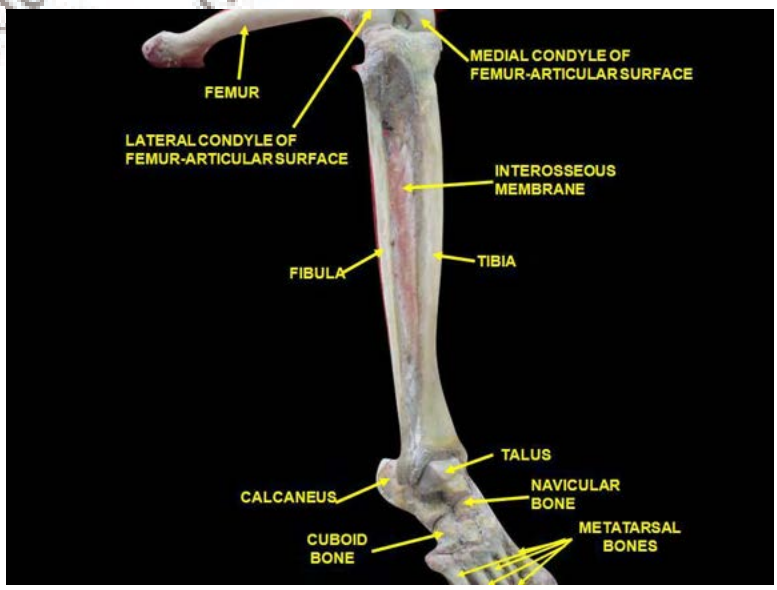
The interosseous membrane helps in:

• Maintaining optimum distance between bones

• Increasing surface area for attachment of muscles

• Transmission of weight from one bone to another

The following image shows the graphical illustration of interosseous membrane of the Leg:



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Solution to Question 13:

The linear fibrous band formed by interdigitation of the tendinous or aponeurotic ends of the muscles is known as raphe.

Unlike most ligaments, the raphe are stretchable. Examples of raphe include:

- linea alba
- pterygomandibular raphe
- mylohyoid raphe
- median pharyngeal raphe
- anococcygeal raphe

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