Yourwish

1. GENERAL PHYSIOLOGY

CONTROL SYSTEM

00:00:59

Types of Control Systems

- Two main types
  - Feedback control system
    → Negative feedback control system
    → Positive feedback control system
  - Feed-forward control system

Feedback control system

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Negative Feedback Control System	Positive Feedback Control System

• End product inhibits the earlier step
• Maintains the stability of the system
• Most important biological control system
• Examples:
  ○ Blood pressure regulation: ↑ BP → baroreceptor stimulation → ↓ sympathetic activity → ↓ BP
  ○ Endocrine System: TRH → TSH → T4 → inhibits TRH and TSH
	• End product stimulates the earlier step
	• Causes instability
	• Aka Vicious Cycle System
	• Dangerous if uncontrolled
	• Examples:
	1. Process of Blood Clotting
	2. A spike in estrogen and LH (LH surge)
	3. Uterine contraction during childbirth (Ferguson reflex)
	4. Lactation (Suckling of baby)
	5. Generation of an action potential
	6. Release of sarcoplasmic calcium through ryanodine receptors, particularly in the case of cardiac muscle

Feed-Forward Control System

- Type of anticipatory control system
  - Predicts disturbance before it occurs
  - Takes preventive action

Examples of Feed-Forward Control

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1. Thermoregulation	• Thermoregulatory center → hypothalamus
	• Thermoregulation has both a feedback and a feed-forward control system
	• Feed-forward control
	  ○ Skin temperature ↓ before core temperature ↓
	  ○ When Skin temperature drops → Skin receptors signal the hypothalamus → Hypothalamus activates heat conservation early → Feed-forward control
	• Feedback control

	○ When core temperature actually ↓→ Body raises temperature → this is feedback control
2. Increase in HR and RR even before the start of exercise	• Due to psychic stimulus • The body prepares in advance
3. Cephalic phase of gastric secretion	• By the Sight, smell, or chewing of food → Gastric secretion starts (even before food enters the stomach)
4. Receptive relaxation of the stomach	• When Food enters the upper part of the esophagus → Stomach dilates
5. Cerebellum (Feed-Forward Circuit)	• Granular cell → stimulates basket & stellate cells • Basket/stellate cells → inhibit Purkinje cell → No feedback to basket cell or granular cell • One-directional signal only • Example of a feed-forward system

GAIN OF CONTROL SYSTEM

00:11:51

- Gain = Correction/Error
- Measures the effectiveness of the control system
- Example: Baroreceptor Reflex
  - Normal MAP = 100 mmHg
  - MAP rises to 110 mmHg
    → Disturbance = 10 mmHg
  - Baroreceptor correction = 8 mmHg
  - Residual error = 2 mmHg
  - Gain = 8 / 2 = 4
    → Negative gain (brings value toward normal)
- Normally
  - Baroreceptor reflex gain = −2
  - Thermoregulatory system gain = −33

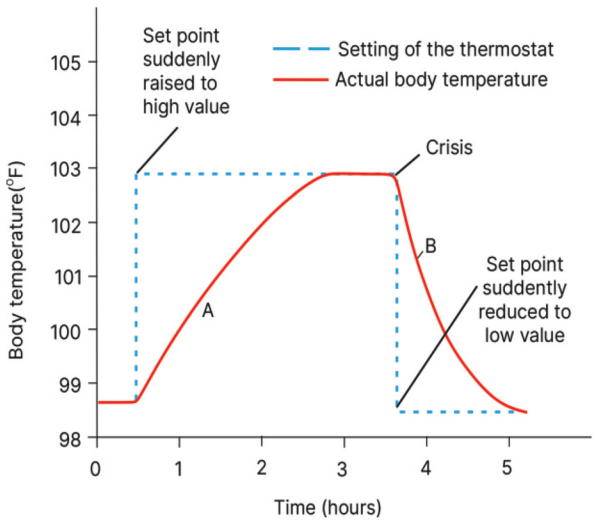
Infinite Gain Control System

- Correction = 100%
- Residual error = 0
- Gain = ∞
- Example: Kidney regulation of blood pressure and volume

MCQ

Q. The following diagram shows the change in hypothalamic set points to body temperature. Which change will be seen at A as compared to B

a. Sweating
b. Increased blood flow to the skin
c. **Shivering**
d. Shutdown of the chemical thermoregulator



Explanation

- For thermoregulation, the setpoint is located at the preoptic nucleus of the anterior hypothalamus
- Fever Mechanism
  - Pyrogens ↑ hypothalamic set point
  - Body temperature is initially lower than the set point
  - Person feels cold, chills
  - The body generates Heat by: Vasoconstriction, Piloerection, Epinephrine secretion, Shivering
  - Body temperature rises gradually
- Crisis Phase
  - Pyrogens removed
  - Set point suddenly ↓ to normal
  - Body temperature is higher than the set point
  - Heat Loss by: Vasodilation, Sweating
- At Point A → Heat conservation by Shivering
- Point B → Heat loss by sweating, ↑ skin blood flow

BODY WATER DISTRIBUTION

00:21:25

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Total Body Water (TBW)

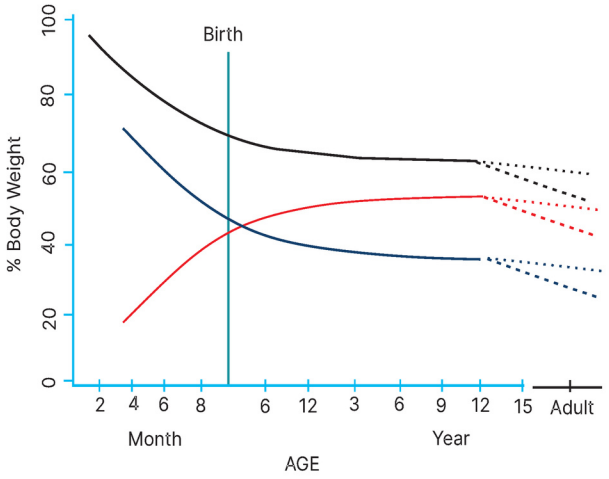
- Adult TBW = 60% of body weight
  - 70 kg adult → 42 L TBW
- TBW can be divided into ICF and ECF
  - Intracellular fluid (ICF)
    → 2/3rd of TBW
    → 40% of body weight
  - Extracellular fluid (ECF)
    → 1/3rd of TBW
    → 20% of body weight
- ECF Subdivision
  - Interstitial fluid
    → 3/4th of ECF
    → 15% of body weight
  - Plasma
    → 1/4th of ECF
    → 5% of body weight
- Blood volume = Plasma (5%) + RBC volume (3%)
  - Total = 8% of body weight

Transcellular Fluid

- Separate fluid compartment
- Examples
  - CSF → 150 mL
  - Pleural fluid → 10-20 mL
  - Pericardial fluid → ~50 mL
  - Peritoneal fluid → ~0 mL (up to 20 mL post-ovulation)
  - Synovial fluid → 1 mL per large joint

Change in body fluid with age

- Y-axis → % body water
- X-axis → Age (intrauterine to adult)
- Total Body Water: TBW ↓ with age
  - TBW is ~75% of birth weight for a term infant (90% for a preterm infant)
- Gender Difference
  - Appears around puberty (~12 years)
  - TBW of Male > Female
- ICF vs ECF
  - Before birth → ECF > ICF
  - By ~3 months postnatal → ICF = ECF
  - After 3 months → ICF > ECF
- Clinical Correlation
  - Infants have a higher ECF proportion → Prone to severe diarrhea



Measurement of Body Water

00:31:18

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- Method: Volume of Distribution Principle
  - Inject a known quantity (Q) of substance
  - Allow uniform distribution
  - Measure final concentration ©
  - Subtract excreted/metabolized amount (e)
  - Formula: Volume = (Q – e) / C

Compartment	Indicator used
Total body water	D_2O, tritium oxide, antipyrine
ECF volume	Inulin, sucrose, ^{22}Na, ^{125}I-iothalamate, mannitol
ICF volume	= (TBW-ECF)
Plasma	^{125}I-albumin, Evans' blue
ISF	= (ECF-Plasma)
RBC	^{51}Cr, ^{59}Fe tagged RBC
Blood volume	= Plasma volume / (1 – hematocrit)

Darrow-Yannet (DY) Diagram

00:37:29

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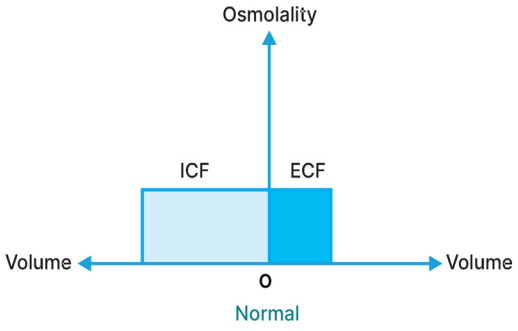
- X-axis → Volume
- Y-axis → Osmolality

Normal DY Diagram

- Left box → ICF (larger)
- Right box → ECF (smaller)
- Osmolality of ICF = ECF



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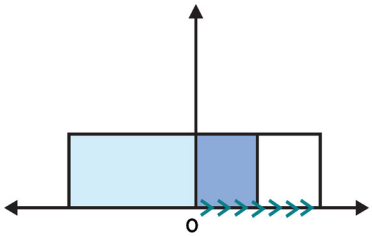
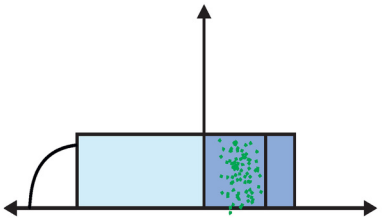
Isotonic Gain (0.9% NaCl)

- ↑ ECF volume
- Osmolality unchanged
- ICF unchanged



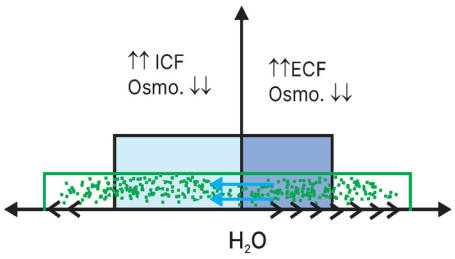
Isotonic Loss (Hemorrhage, diarrhea)

- ↓ ECF volume
- Osmolality unchanged



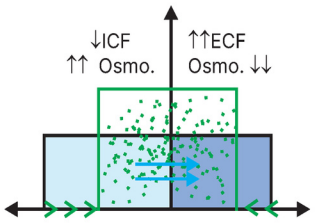
Hypotonic Gain (Water intake, SIADH)

- Initial
  - ↑ ECF volume
  - ↓ ECF osmolality
- Water shifts ECF → ICF
- Final
  - ↑ ECF volume
  - ↑ ICF volume
  - ↓ Osmolality in both
- Distribution
  - 2/3rd to ICF
  - 1/3rd to ECF



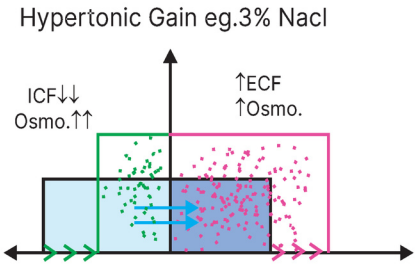
Hypotonic Loss (Diabetes insipidus)

- Initial
  - ↓ ECF volume
  - ↑ ECF osmolality
- Water shifts ICF → ECF
- Final
  - ↓ ECF volume
  - ↓ ICF volume
  - ↑ Osmolality in both



Hypertonic Gain (3% NaCl)

- ↑ ECF volume and ↑ ECF osmolality
- Water shifts ICF → ECF
- Final
  - ↑ ECF volume
  - ↓ ICF volume
  - ↑ Osmolality in both

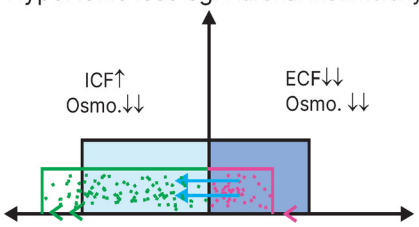


Hypertonic Loss (Adrenal insufficiency)

- ↓ ECF volume and ↓ ECF osmolality
- Water shifts ECF → ICF

- Final
  - ↓ECF volume
  - ↑ICF volume
  - ↓Osmolality in both

Hypertonic loss eg. Adrenal insufficieny



TYPES OF TRANSPORT

00:49:17

- Active transport
- Passive transport
- Exocytosis and Endocytosis:
  - Receptor-mediated endocytosis by Clathrin

INICET 2018, 2024, 2025
NEET PG 2018
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Active Transport

- Requires ATP
- Moves solutes from low → high concentration
- Types
  - Primary active transport
    - → ATPase-based
    - → Examples: Na^+/K^+ ATPase, H^+/K^+ ATPase
  - Secondary active transport
    - → Uses the gradient created by primary transport
    - → Symporter: e.g SGLT
    - → AntiporterL e.g Na^+/Ca^{2+} exchanger

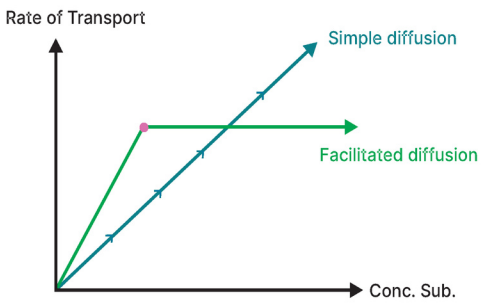
Passive Transport

- No ATP required
- High → low concentration
- Types:
  - Osmosis
  - Diffusion

Diffusion

Simple diffusion	Facilitated diffusion	Non-ionic diffusion
• No carrier protein required • No saturation	• Carrier protein • No ATP • Saturation present	• Transport of weak acids at the Kidney and the GIT

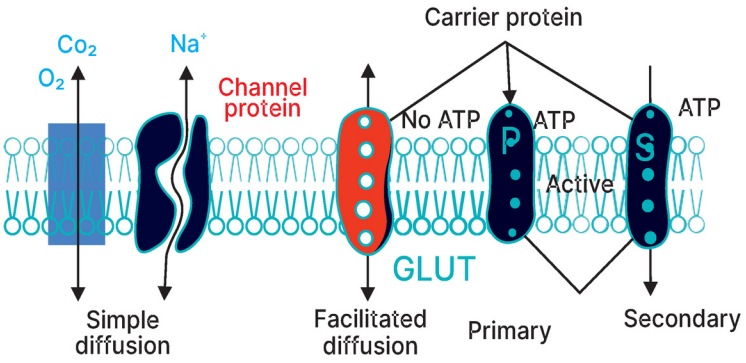
- **Simple and Facilitated Diffusion**
- Simple diffusion→ Linear increase
- Facilitated diffusion
  - Initial rapid rise
  - Plateau due to carrier saturation
- Fick's Law: used to calculate the rate of simple diffusion



- Rate = (D × A × ΔC) / X
  - ➢ D → diffusion constant
  - ➢ A → surface area
  - ➢ ΔC → concentration difference
  - ➢ X → membrane thickness

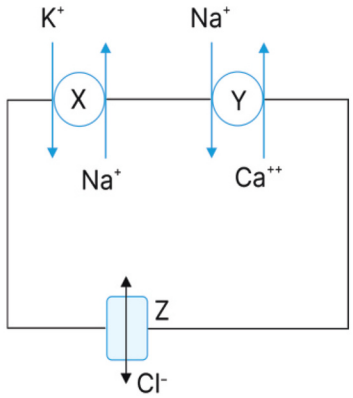
Transporter Summary

- Carrier protein:
  - Binds with the transported substance
  - Undergoes conformational (shape) change
  - Releases a substance on the opposite side of the membrane
    - → If Utilising ATP → Active transport
    - → If Without ATP → Facilitated diffusion
- Channel Protein:
  - Does not bind with the substance
  - No conformational change
  - Provides an open pore for movement
- Gaseous exchange through the cell membrane and channel protein-mediated transport are examples of simple diffusion



MCQ

Q. A model cell with three different transporters (X, Y, and Z) & a RMP of −75 mV is shown in the figure below. Consider the intracellular and extracellular concentrations of all three ions to be typical of a normal cell. Which of the following best describes transporter Y?



A. Facilitated diffusion
B. Primary active transport
C. Secondary active transport
D. Simple diffusion

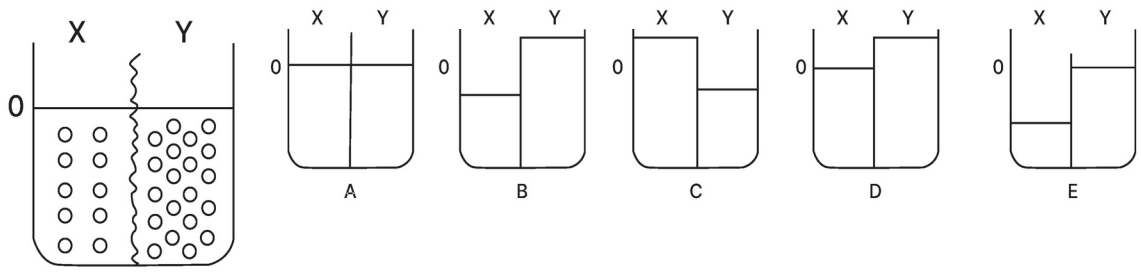
Ans. *C*

Explanation

- X → Na^+/K^+ ATPase → Primary active
- Y → Na^+/Ca^{2+} exchanger → Secondary active
- Z → Cl^- channel → Channel protein → Simple diffusion

Osmosis MCQ Concept

Q. In the figure below, two compartments (X and Y) are separated by a typical biological membrane. The concentrations of glucose in compartments X and Y at time zero are shown in the first diagram. The membrane is impermeable to glucose. Which of the figures below best represents the volumes of compartments X and Y when the system reaches equilibrium?



- Glucose concentration is high in compartment Y
- Glucose is impermeable to the cell membrane
- Water moves from low to high solute concentration via osmosis
- Volume decrease in X compartment and Equal volume increase in Y
- Correct option → Proportional change (**Option B**)

SGLT and GLUT

01:02:02

- SGLT: secondary active transport
- GLUT: facilitated diffusion

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Name	Expression Site
SGLT1	Kidney (PST), intestinal luminal membrane
SGLT2	Kidney (PCT)
SGLT3	Skeletal muscle, small intestine (glucose sensor)
GLUT1	RBC, BBB, placenta (universal GLUT)
GLUT2	β-cell pancreas, liver, basolateral membrane of PCT & intestinal epithelium
GLUT3	WBC, neuronal membrane
GLUT4	Insulin-responsive GLUT; muscle & adipose tissue
GLUT5	Fructose transporter; luminal membrane of intestine, sperm

Important GLUTs:

- **Insulin-responsive GLUT:** GLUT4 and GLUT12
- **Insulin-responsive GLUT in blastocyst:** GLUT8**Fructose transporter GLUT:** GLUT5 and GLUT11
- **GLUT in CNS:**
  - GLUT1: Endothelium cell (BBB)
  - GLUT3: Neuron
  - GLUT5: Astrocyte
- **Major GLUT in placenta & foetus:** GLUT1

CELL CYTOSKELETON

01:04:09

- Functions: Maintains the shape and size of the cell

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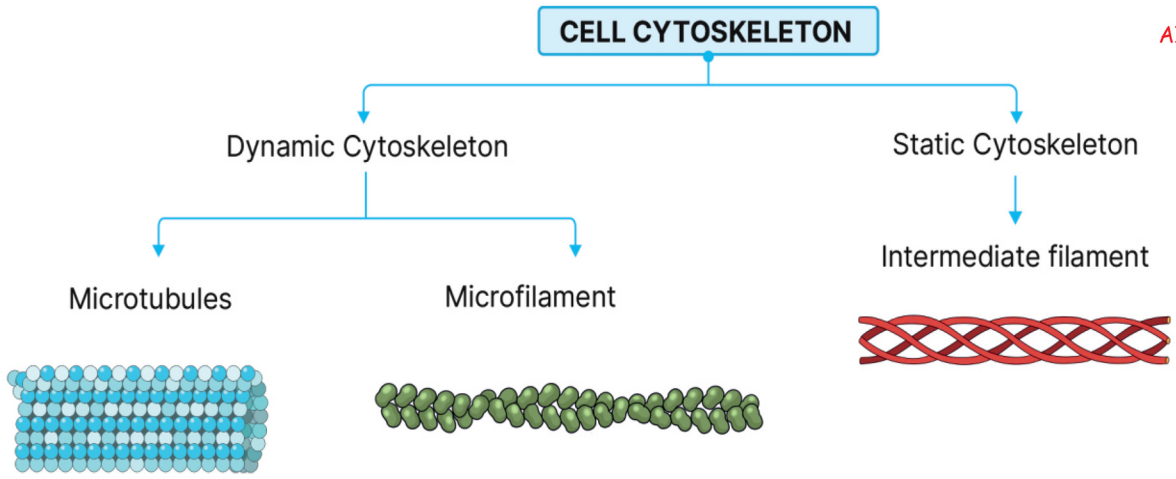


- Dynamic cytoskeleton:
  - Length changes according to cell size and shape
  - Grows or shortens as the cell grows or shrinks
- Static cytoskeleton: length remains fixed
- Dynamic cytoskeleton can be divided into microtubules and microfilament

Microtubules	Microfilaments

• Diameter → 25 nm
• Thickest cytoskeletal element
• Dynamic structure
• Subunits
  ○ α-tubulin
  ○ B-tubulin
• α and β tubulin assemble to form a hollow cylindrical structure
• Polymerization
  ○ Requires GTP
  ○ Plus end grows
	• Diameter → 7 nm
	• Thinnest cytoskeletal element
	• Dynamic structure
	• Single microfilament = F-actin (filamentous actin)
	• F-actin is formed by the polymerization of multiple G-actin (globular actin) subunits
	• Polymerization
	  ○ Requires ATP

Intermediate Filaments

- Diameter → 10 nm
- Static
- Cell markers
  - Examples
    → Cytokeratin → marker of epithelial cells
    → Desmin → muscle cells

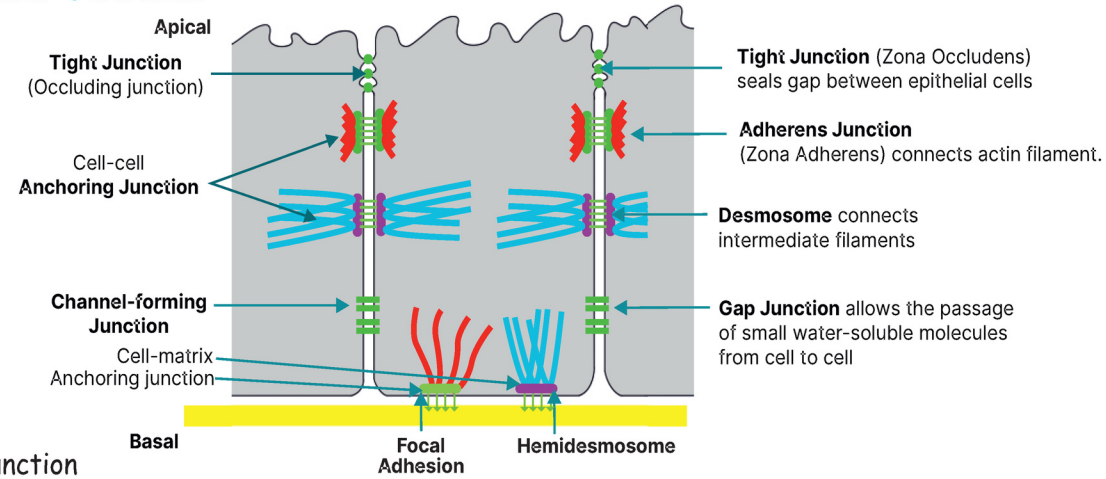
Drugs Affecting the Cytoskeleton

- **Colchicine and Vinblastine:**
  - Microtubule assembly (polymerization) is prevented
  - This, in turn, blocks mitosis
- **Paclitaxel (Taxol):**
  - Binds to microtubules

- Makes microtubules excessively stable
- Organelles cannot move
- Mitotic spindle cannot form
- Cell division is blocked → cells die

Intercellular Junctions

01:09:47



- Tight Junction
  - Apical-most junction
  - Also known as Zona occludens
  - Formed by two Proteins: Claudin, Occludin
- Cell-Cell Anchoring Junctions
  - Adherens junction
    → Proteins → Cadherin, Catenin
    → Connected intracellularly with microfilaments
  - Desmosome
    → Protein → Desmoglein
    → Connected to intermediate filaments
- Gap Junction
  - Channel-forming junction
  - Protein → Connexin
  - Allows small molecules to pass
- Cell-Matrix Anchoring Junctions
  - Attach the cell to the extracellular matrix
  - Type
    → Focal adhesion
    → Hemidesmosome
  - Protein → Integrins

SUMMARY

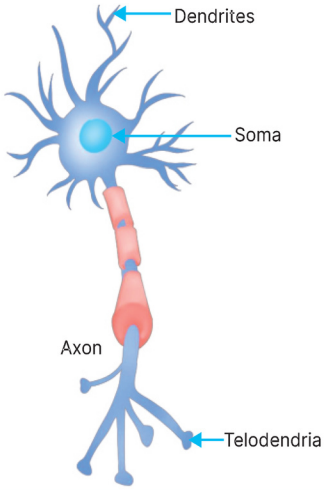
01:12:40

- Baroreceptor reflex is an example of which control system: Negative feedback
- In negative feedback, the feedback gain is infinity in the Kidney
- ^{125}I-labelled albumin is used for measurement of → Plasma volume
- Interstitial fluid volume can be calculated by → (ECF – Plasma)
- Normal anion gap is 8-12 mEq/L (mmol/L)

2. NERVE MUSCLE PHYSIOLOGY

FUNCTIONAL AREAS OF THE NEURON

00:01:00



- **Afferent Parts :** Dendrites &Soma (Cell body)
  - Receives information from different neurons
- **Efferent Parts (Delivering Information):** Axon
  - Delivers information from this neuron to other parts/neurons
- **Axon Hillock:**
  - Last portion of the cell body
  - The membrane is a little bit thick
- **Initial Segment:**
  - The first portion of the axon that is attached to the axon hillock
- Myelination
  - Space In between myelinated parts = **Node of Ranvier**

Location	Cell Type	Ratio
Peripheral Nervous System	Schwann Cell	1:1 (one Schwann cell is responsible for myelination in a single neuron)
Central Nervous System	Oligodendrocyte	1:30 to 1:50 (one oligodendrocyte can myelinate 30-50 neurons)

- **Graded Electrogenesis Location:**
  - Generated at: Soma (cell body) + Dendrites
- **Voltage-Gated Sodium Channel Density:**
  - Maximum Density: Node of Ranvier > Initial segment
  - Minimum Density: Surface of myelin sheath > Telodendria (axon terminal)
- **Action Potential Initiation Site:**
  - Motor Neurons / Interneurons: Initial Segment (Lowest threshold due to high channel density).
  - Sensory Neurons: First Node of Ranvier

TYPES OF AXONAL TRANSPORT.

FMGE 2020
00:07:12

- Transport relies on microtubules (cytoskeleton) running through the axoplasm
- Microtubule Orientation: The (-) end is toward the Soma; the (+) end is toward the Axon Terminal

Type of Transport	Direction	Speed	Mechanism	Transported Material
Fast anterograde	Plus end directed	~400 mm/day	Kinesin	Vesicles and mitochondria
Fast retrograde	Minus end directed	~200 mm/day	Dynein	Toxin (tetanus) , growth factor and viruses (Rabies)
Slow anterograde	Plus end directed	0.5-10 mm/day	Not known	Components of microtubules(tubulin), microfilament(G-actin)

GIBBS-DONNAN EFFECT

00:12:02

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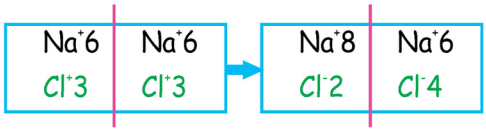


- Initial setup: A semipermeable membrane separates Compartment A and Compartment B
- Both compartments contain Na^+ and CI^-, which are permeable ions
- At equilibrium (initially):
  - Na^+ concentration is equal on both sides.
  - CI^- concentration is equal on both sides.
- Change in the system:
  - Six protein molecules are added only to Compartment A.
  - Proteins are large, impermeable, negatively charged molecules at normal pH.
  - They cannot cross the membrane.
  - This creates an imbalance because the proteins carry a negative charge.
- Effect on Na^+ (positive ion):
  - The negatively charged proteins attract Na^+
  - Therefore, more Na^+ remains in Compartment A.
- Effect on CI^- (negative ion):
  - Since proteins are negatively charged, they repel Cl^-.
  - As a result, more CI^- moves to Compartment B.
- The Gibbs-Donnan effect occurs due to the presence of large impermeable charged molecules (e.g., proteins) on one side of a semipermeable membrane, causing an unequal distribution of permeable ions across the membrane

Gibbs-donnan Equilibrium Equations

Equation 1

- Total positive charge on Compartment A = Total negative charge on Compartment A
- Total positive charge on Compartment B = Total negative charge on Compartment B

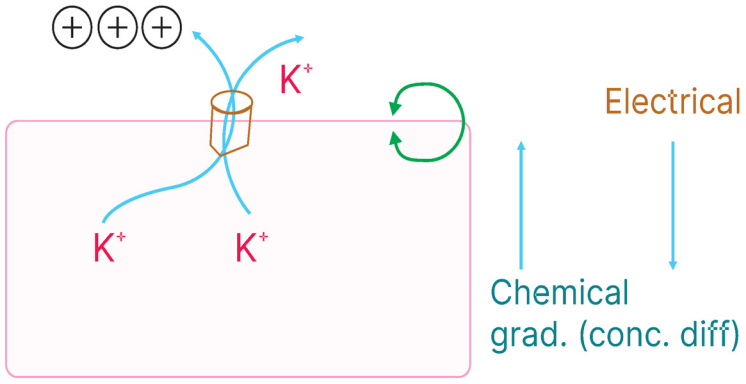
Equation 2

- (Na^+ in Compartment A) × (Cl^- in Compartment A) = (Na^+ in Compartment B) × (Cl^- in Compartment B)

Equation 3

- Osmotic tension of Compartment A >>> Osmotic tension of Compartment B
- Depends on the total number of molecules due to the addition of a protein molecule

EQUILIBRIUM POTENTIAL & NERNST EQUATION



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- In the resting state of a cell, some ion channels remain open even without stimulation
- These are called leak channels, which allow ions to move freely across the membrane
- Example: K^+ Leak Channels
  - K^+ diffuses from inside → outside of the cell due to its concentration (chemical) gradient
  - As K^+ leaves, the outside becomes more positive and the inside becomes more negative
  - This electrical difference pulls some K^+ back into the cell (electrical gradient)
  - Eventually, the chemical gradient pushing K^+ out and the electrical gradient pulling K^+ in become equal
  - At this point, electrochemical equilibrium is reached
- Equilibrium (Nernst) Potential
  - The equilibrium potential, also called the isoelectric potential, is the potential difference across the cell membrane when there is no net movement of a specific ion
- Nernst Equation

FMGE 2018

  - The mathematical equation that is used to measure the equilibrium potential of the cell membrane
  - **Formula:** $E_Q = (RT/ZF) \times Ln([outside]/[inside])$
    → $E_Q = (+61/Z) \times \log([outside]/[inside])$
    - R = Gas constant
    - T = Temperature (constant at body temp)
    - Z = Charge of ion
    - F = Faraday constant
    - +61 = Constant value after putting all constants
  - **Equilibrium Potentials of Different Ions (Normal Mammalian Cell)**

Ion	Charge (Z)	Equilibrium Potential
Na^+	+1	**+63 mV**
K^+	+1	**-90 mV**
Cl^-	-1	**-70 mV**
$Ca2^+$	+2	**+132 mV**

MCQ

Q. The Intracellular and extracellular concentrations of K ions across the plasma membrane of a model cell are 140 mM and 14 mM, respectively. This model cell is permeable to K+ ions only. What is the RMP of this cell?

a. O millivolts

b.-122 millivolts

c. 61 millivolts 10

d.-61 millivolts

Solution:

- $E_Q = (+61/Z) \times \log_{10}([outside]/[inside])$
- $E_Q = +61/(+1) \times \log_{10}(14/140) = +61 \times \log(1/10) = +61 \times \log(10^{-1}) = +61 \times (-1) = -61\ mV$

Ans. Option D (-61 mV)

FMGE 2019

Resting Membrane Potential (rmp)

00:25:40

- In the resting state of a cell, the electrical difference between the inside and outside of the cell membrane is called the Resting Membrane Potential (RMP).
  - Inside the cell: Total positive charges = Total negative charges
  - Outside the cell: Total positive charges = Total negative charges

- Thus, both the inside and outside of the cell are electrically neutral (electroneutral).
- However, a potential difference still exists across the membrane due to the selective permeability of the membrane through leak channels.
- Relationship Between Equilibrium Potential and RMP
  - If the cell membrane contains only one type of leak channel:
  - Equilibrium potential of that ion = RMP
  - Example: If only K^+ leak channels → RMP = -90 mV (E_Q)
- In Mammalian Cells (Multiple Leak Channels are Present)
  - 3 types of leak channels: K^+, CI^-, Na^+
  - Number of leak channels: K^+ >>> CI^- > Na^+
- RMP is determined by the equilibrium potential of all three ions
- RMP is mainly determined by K^+ (Due maximum number of leak channels)
- RMP will be close to the equilibrium potential of the K^+ Ion

Important Points

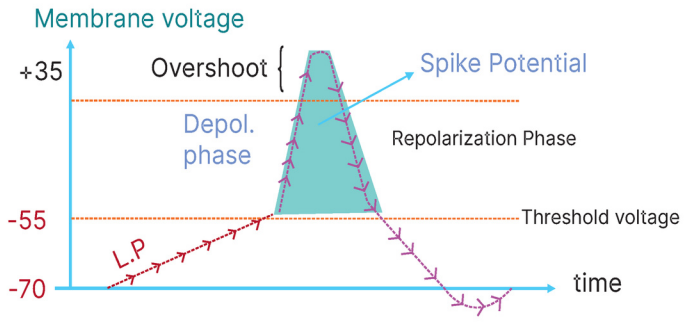
- The resting cell membrane is most permeable to K ion
- Permeability: K^+ > CI > Na
- RMP of almost all vertebrate cells is close to the equilibrium potential of K+
- RMP of neuron is equal to the equilibrium potential of CI- (-70mV)
- RMP of myocardium is equal to the equilibrium potential of K (-90mV)

Cell Type	RMP Value
Neuron	-70 mV
Myocardium	-90 mV
Skeletal Muscle	-90 mV
Smooth Muscle	-60 to -40 mV

ACTION POTENTIAL

00:31:40

- Action potential = sudden change in membrane voltage from RMP towards **+35 mV**



Phases Of Action Potential

- **Starting Point:** RMP of neuron = -70 mV
- **Phase 1 - Local Potential: Non-propagated potential** that cannot travel from one part to the distal part
  - Gradual increase in membrane potential towards positivity
  - Leads to Gradual depolarization
  - Membrane Voltage rises towards **threshold voltage = -55 mV**
- **Phase 2 - Depolarization Phase:** local potential crosses threshold (-55 mV) and there is a sudden rise of potential to +35 mV
  - **Cause:** Influx of Na^+ into the cell through **voltage-gated Na^+ channels**
- **Phase 3: Repolarization Phase**
  - Membrane voltage goes back towards RMP
  - Part of the membrane voltage goes below RMP, then returns to RMP
  - **Cause:**
    → Efflux of K^+ from the cell
    → Na^+ channels get inactivated and K^+ channels open up

- **Phase 4: After-Hyperpolarization Phase**
  - Part of repolarization, where the membrane voltage goes below RMP
  - Goes more negative than RMP
  - **Cause:** Efflux of K^+ (same as repolarization)
  - **Mechanism:** Due to the slow closure of K^+ channels
    → K^+ channels are very slow to close → some channels still remain open when reaching RMP → extra K^+ exits → membrane voltage goes more negative
- **Overshoot Phase:**
  - Part of depolarization, where the membrane voltage goes above 0 mV
- **Spike Potential:**
  - Part of the action potential above the threshold voltage
  - Includes both Part of depolarization + Part of repolarization (both above threshold)

Ap & Ionic Permeability

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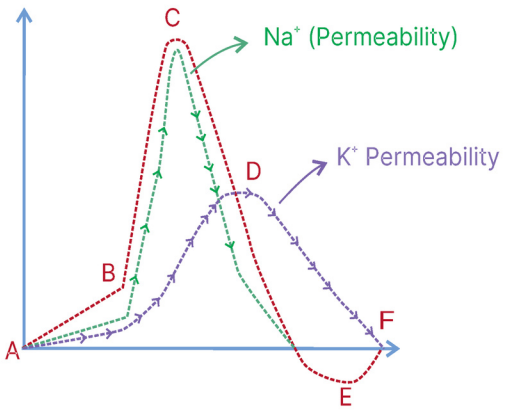
- Voltage-Gated Na^+ Channels (Na_v): Very fast in nature
- Voltage-Gated K^+ Channels: Very slow in nature
- Permeability Changes During Action Potential
  - Na^+ Permeability Curve (Green curve):
    → Initially: Very few Na^+ channels open (during local potential)
    → At threshold: Sudden huge increase in Na^+ channel opening will happen
    → This increases the permeability of the Na^+ channels very high level
    → Immediately after that, there will be Rapid inactivation (opening decreases to zero)



  - **K^+ Permeability Curve:**
    → Take a long time to open
    → Maximum K^+ channels open during **middle part of repolarization**
    → Take a long time to close

Question	Answer
Maximum Na^+ permeability	Point C
Maximum K^+ permeability	Point D
Point where Vm close to E_QNa (+63 mV)	Point C
Point where Vm close to E_QK (-90 mV)	Point E

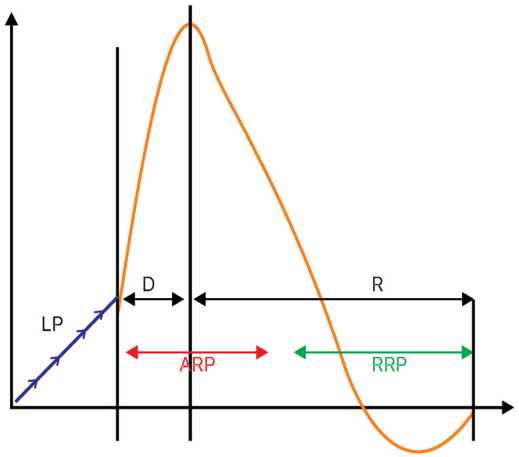
Refractory Period

00:44:00

- RF is the inability to generate a new action potential when a different action potential is already in progress

Types Of Refractory Periods

- Inactive channels must first convert to closed, then can be opened. Direct opening from the inactive state is not possible.



Aspect	Absolute Refractory Period (ARP)	Relative Refractory Period (RRP)
Definition	It is the period during which a second action potential can never be generated, no matter how strong the stimulus is.	It is the period during which a second action potential can be generated, but only with a higher strength of stimulus
Duration	Entire depolarization + first 1/3rd of repolarization	Later 2/3rd of repolarization
Mechanism	Voltage-gated Na^+ channels (Na V) are mostly inactivated or already open from the first action potential, so they cannot reopen to generate a second action potential.	Most voltage-gated Na^+ channels have returned to the closed (resting) state. A stronger stimulus can reopen them and generate a second action potential

NERVE FIBER CLASSIFICATION

00:49:42

- A and B fibers are myelinated
- C fiber is not myelinated

Fiber Type		Numerical Classification	Functions / Location	Conduction Velocity (m/sec)	Diameter (μm)
A	Alpha	• Ia, • Ib	• Proprioception (Ia) • Motor (Ib)	70-120	12-20
	Beta	• II	• Pressure • Touch	30-70	5-12
	Gamma		• Muscle spindles (efferent)	15-30	3-6
	Delta	• III	• Temperature [Cold] • Pain[Fast] • [Myelinated fibers are fast in response]	12-30	2-5
B			• Preganglionic autonomic fiber	3-15	< 3
C		• IV	• Pain [Slow] • Temperature (warm) • Postganglionic sympathetic fiber • [This property is due to non myelinated nature of C fibers]	0.5-2	0.4-1.2

Important Points

- Cold sensation: Carried by Aδ
- Warm, burning pain and freezing pain: carried by C
- Local anesthetic: Aγ and A >> A and A >> B >> C
- Pressure: A > B > C
- Hypoxia: B>A>C
- Spike duration: C > B > A

Yourwish

STIMULUS PARAMETERS

00:54:45

- **Rheobase:**
  - The minimum current (or voltage) intensity required to produce an action potential (AP) when applied for a long duration
  - We do not consider the Duration of the stimulus
- **Utilization Time:**
  - The minimum time (duration) of stimulus which will produce an AP with a voltage of rheobase strength.
- **Chronaxie:**
  - The minimum time of stimulus which will produce an AP with a voltage of double the rheobase strength

MCQ

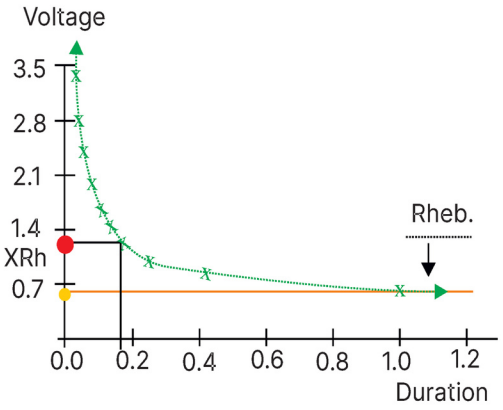
Q. Find out the chronaxie and rheobase from the graph given:

a. Chronaxie 0.15ms, rheobase 0.6V

b. Chronaxie 0.6ms, rheobase 0.15V

c. Chronaxie 0.6ms, rheobase 0.13V

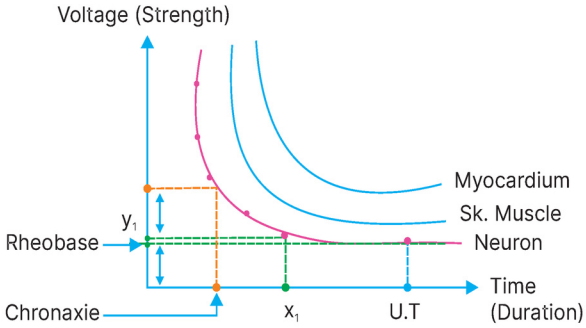
d. Chronaxie 0.1ms, rheobase 0.6V



Clinical Application

Comparing Two Curves (a And B):

- Curve B has more chronaxie than Curve A
- Curve B has more rheobase than Curve A
- **Excitability Rule:**
  - Less chronaxie = Less rheobase = More excitability
  - More chronaxie = More rheobase = Less excitability
- Example:
  - Curve A (neuron) vs Curve B (skeletal muscle)
  - Neuron more excitable than skeletal muscle



- **Excitability Order in Body: Neuron > Skeletal muscle > Myocardium > Smooth muscle**
- **It shows the excitability of the tissue**

DHPR AND RYR COUPLING

01:01:35

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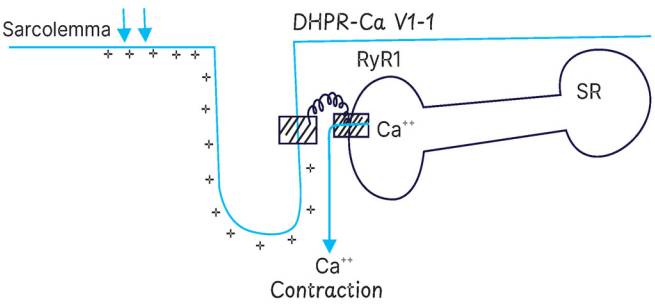
Skeletal Muscle Coupling

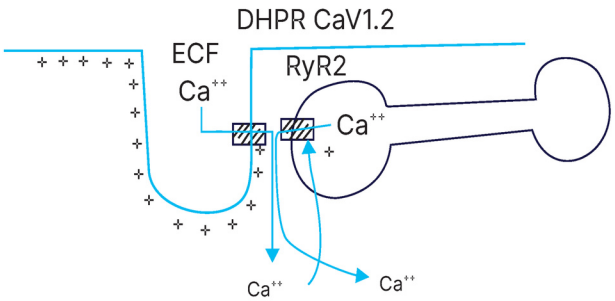
- Structure
  - Sarcolemma (muscle membrane)
  - Invagination of sarcolemma = T-tubules
  - Beside the T tubule, there is Sarcoplasmic Reticulum (SR), aka LTT (Longitudinal tubules)
- **DHPR (Dihydropyridine Receptor):**
  - Location: T-tubular membrane
  - Type: Voltage-gated calcium channel
  - Subtype: **CaV 1.1** (L-type calcium channel)



- **RYR (Ryanodine Receptor):**
  - Location: Sarcoplasmic reticulum membrane surface
  - Subtype: **RYR1** (in skeletal muscle)
- **Mechanism:**
  - Action potential on sarcolemma
  - Depolarization travels down the T-tubule
  - Depolarization reaches DHPR → DHPR is activated
  - DHPR undergoes conformational change
  - DHPR **mechanically interacts** with RYR1 (physical interaction)
  - DHPR causes **twisting** of RYR1
  - RYR1 opens due to twisting force
  - A large amount of $Ca2^{+}$ enters the cytoplasm from the SR
  - $Ca2^{+}$ causes muscle contraction
- **Type of Coupling:**
  - Electromechanical coupling (mechanical coupling in the presence of electrical activity) > Mechanical coupling
- **Source of Ca^{2+} for Skeletal Muscle Contraction:**
  - 100% from Sarcoplasmic Reticulum (intracellular source)

Cardiac Muscle Coupling

- **Structure:** Same as skeletal muscle
- **Channels Involved:**
  - **DHPR:**
    → Location: T-tubular membrane
    → Subtype: **CaV 1.2** (different from skeletal CaV.1.1)
  - **RYR:**
    → Location: SR membrane
    → Subtype: **RYR2** (different from skeletal ryr1)



- **Mechanism:**
  - Action potential on the cardiac muscle membrane
  - Depolarization activates the T-tubular membrane
  - DHPR channel activated
  - DHPR channel **opens** (unlike skeletal, where it stays closed)
  - **A small amount of Ca^{2+} trickles** from ECF into cytoplasm (through DHPR)
  - This ECF **Ca^{2+} stimulates RYR2** (not mechanical interaction)
  - RYR2 opens
  - **A huge amount of Ca^{2+}** enters from SR into the cytoplasm
  - **Ca^{2+}** causes contraction
- **Type of Coupling:**
  - Electrochemical coupling (chemical coupling through **Ca^{2+}** in the presence of electrical activity)
- **Source of Ca^{2+} for Cardiac Muscle Contraction:**
  - ECF calcium = 20%
  - SR calcium (ICF) = 80%
  - Essential source = ECF calcium (without ECF **Ca^{2+}**, ICF **Ca^{2+}** won't release)
- **Calcium-Induced Calcium Release (CICR):**
  - ECF calcium induces the release of SR calcium

- Phenomenon specific to cardiac muscle
- **Clinical Significance:**
  → If blood calcium decreases, → Cardiac muscle contraction is directly affected
  → Skeletal muscle NOT affected by blood calcium (100% SR calcium)

Ryr 1 Mutation

01:11:00

Malignant Hyperthermia	Central core disease
Gain of function mutation	Loss of function
Muscle rigidity, high fever, and rapid heart rate, rhabdomyolysis → high plasma K^+ level	Hypotonia (decreased muscle tone) at birth, mild delay in child development, weakness of the facial muscles
Tx: dantrolene (antagonizes RyR1)	No specific treatment.

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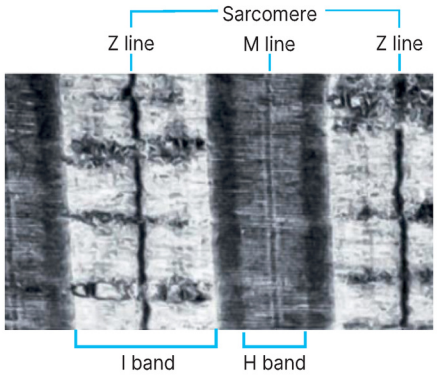
SARCOMERE STRUCTURE

01:11:59



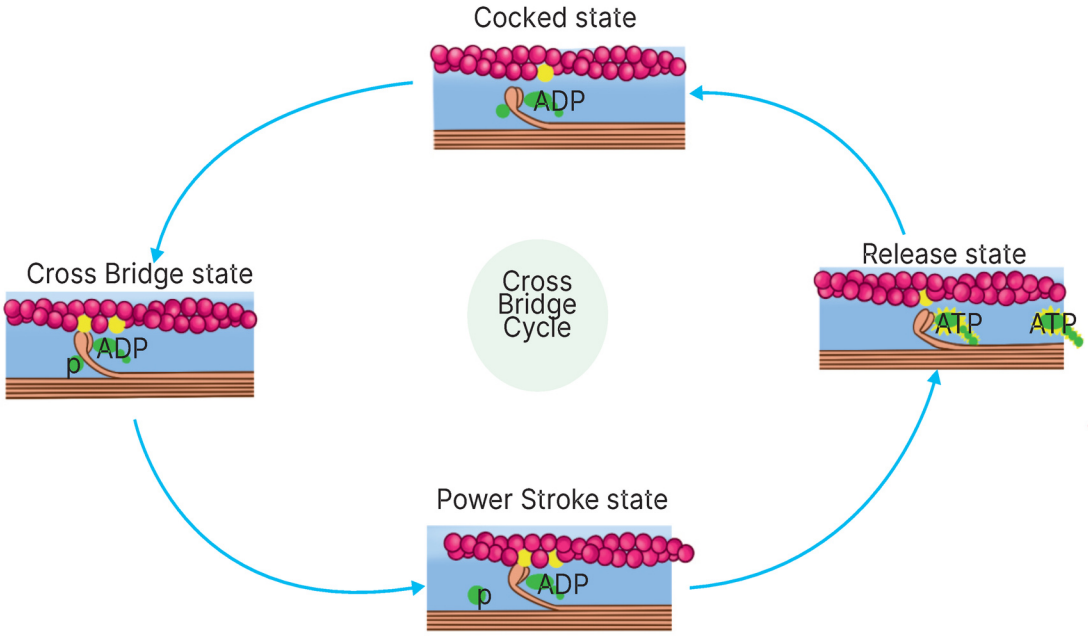
- **Sarcomere:** Distance between **2 Z-lines**
  - Z-line (Pink line in diagram):
  - Actin is attached to the Z-line
- **Myosin:**
  - Present between actin filaments
- **A Band:**
  - Length of myosin band
  - Thick filament band (where myosin is present)
  - Some parts overlapped with actin
- **H Band:**
  - Portion of the A band where Myosin is present, but without an actin overlap
- **I Band:**
  - Thin filament band where no myosin is present
  - Only actin present
- **M Line:**
  - At the center of the myosin filament
  - Center of A band
- **Titin:**
  - The elastic molecule of the sarcomere is present from the M line to the Z line
  - Function:

Changes During Muscle Contraction

Band/Line	Change During Contraction
A band length	Remains SAME
H band length	Decreases
I band length	Decreases
M line	Becomes more prominent

Mechanism Of Muscle Contraction

- Myosin head attaches to a specific area on actin
- Tropomyosin:
  - **Normally prevents actin-myosin interaction**
  - Blocks the myosin binding site on actin
- Resting state / cocked state
  - Angle between myosin neck and head = 90°
  - ADP (Adenosine Diphosphate) & Inorganic phosphate (Pi) is attached to the myosin head
  - Myosin head NOT attached to actin
  - Tropomyosin causing hindrance
- Cross-Bridge State
  - Ca^{2+} entry into muscle cytoplasm
  - Ca^{2+} binds with **troponin**
  - Calcium-troponin complex formation
  - Leads to **tropomyosin movement**
  - Myosin head attaches to actin at a **90° angle**



- Power Stroke State
  - **Inorganic phosphate (Pi) is removed** from the myosin head
  - Myosin head moves from **90° → 45°**
  - This movement is known as **Power stroke generation.**
  - Result:
    → Actual shortening of the sarcomere
    → Actual contraction of the muscle
  - Single power stroke = Only 1 nm shortening
  - **To shorten the muscle by 1-2 cm:** The power stroke must be repeated again and again
- Detachment State
  - **ATP (Adenosine Triphosphate)** attaches to the myosin head
  - ATP attachment causes the **detachment** of the myosin head from actin
  - **ATP function:** It causes detachment of the myosin head from actin.

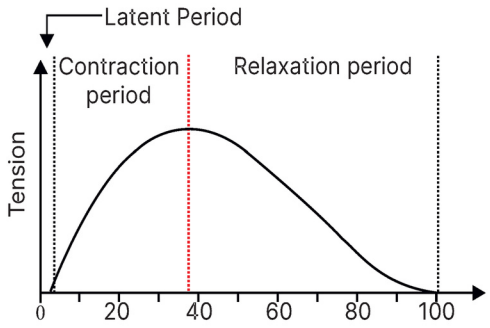
- Cross-Bridge Recycling
  - → **Cycle:** Resting → Cross-bridge → Power stroke →Detachment (by ATP) → Resting → Cross-bridge (if **Ca^{2+}** still present) → Power stroke → Detachment...
  - → **Continuation:** The cycle continues as long as **Ca^{2+}** is present in the cytoplasm
  - → **Result:** Multiple cross-bridge cycling → Actual muscle shortening

Tetanic Contraction Of Muscle

01:22:00

Q Graph below is showing simple muscle twitch recorded in the frog gastrocnemius muscle. Calculate the tetanizing frequency of this muscle.

a. 25 Hz
b. 20 Hz
c. 10 Hz
d. 5 Hz



Ans. 25 Hz

- Simple Muscle Twitch: A single contraction followed by relaxation.
  - Contraction Period: From the start of contraction to the peak
  - Relaxation Period: From the peak to the baseline
- Treppe (Staircase Phenomenon):
  - Occurs when a second stimulus is given just after full relaxation.
  - Result: Step-by-step increase in contraction height.
  - Mechanism: Accumulation of Calcium. (New Ca++ release + residual Ca++ from previous twitch).
- Tetanus:
  - Incomplete Tetanus:
    - → Stimulus given during the relaxation phase (before full relaxation)
    - → Result: Wavy, summation of contractions
  - Complete Tetanus (Tetanization):
    - → Stimulus given during the contraction phase (before any relaxation starts)
    - → Result: Smooth, sustained maximum contraction
- Tetanizing Frequency Calculation
  - **Formula:**
    - → Tetanizing Frequency = 1000 ms / Contraction period duration (ms)

      Or:

    - → Tetanizing Frequency (Hz) = 1 second / Contraction period (seconds)
  - 1000MS/ 40MS = 25Hz

SMOOTH MUSCLE

01:28:20

Feature	Skeletal Muscle	Smooth Muscle
T-tubules	Present	Absent (Equivalent structure: Caveolae)
Z-line	Present	Absent (Equivalent structure: Dense body)
Actin & Myosin	Present	Present (causes contraction)

Troponin	Present (Ca^{2+} binding)	Absent (Calmodulin- Calcium-binding molecule is present)
Tropomyosin function	Prevents actin-myosin interaction	Increases actin-myosin interaction
Proteins preventing actin-myosin interaction	Tropomyosin	Caldesmon + Calponin
Nebulin	Present (surrounds actin, protects actin length)	**Absent**
Titin	Present (M line to Z line, elastic)	**Absent**

SUMMARY

01:31:01

Topic	Answer
Ion is most responsible for RMP of cell	Potassium
RMP of the nerve fiber close to potential of	Potassium
Slowest conducting fiber is	C fiber (unmyelinated)
L-type Ca^{2+} channel location	T-tubules
Absent dystrophin protein in muscle fibre causes	Duchenne muscular dystrophy Partially present = Becker muscular dystrophy
DHPR-RYR coupling in skeletal muscle	Electromechanical coupling
Detachment of the myosin head during muscle contraction	Adenosine Triphosphate (ATP)

3. CNS PHYSIOLOGY

CELLS OF CNS

00:01:16

- Number of neurons: 100 billion
- Number of glial cells (supporting cells): 2 to 10 times more than neurons

TYPES OF GLIAL CELLS

- Astrocytes:
  - Found in:
    - → Fibrous (white matter)
    - → Protoplasmic (grey matter)
  - Functions:
    - → Growth factor production
    - → Nutrition to neurons
    - → Maintains extracellular glutamate and potassium levels in interstitial fluid
    - → Regulation of permeability of the Blood-Brain Barrier (BBB)
- Microglia:
  - Role: phagocytosis of the CNS
- Oligodendrocytes (CNS)
  - Function: Myelination in CNS
  - One cell → myelinates 30 neurons
  - Damage → Multiple sclerosis (MS)

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Important Information

- Schwann Cells (PNS)
  - Myelination in PNS
  - One cell → myelinates one neuron
  - Damage → Guillain-Barré syndrome (GBS)
- Formation of the BBB is by endothelial cells of blood vessels, along with tight junctions

Q. Which cells are impacted in multiple sclerosis?

A. Microglia

B. Oligodendrocytes

C. Astrocytes

D. Ependymal cells

Answer: B

- In multiple sclerosis, the antibodies are directed against:
  - MBP/Myelin Basic Protein
  - MOG/Myelin Oligodendrocyte Glycoprotein
- In MS, ↓ Conduction velocity of AP

SYNAPTIC TRANSMISSION

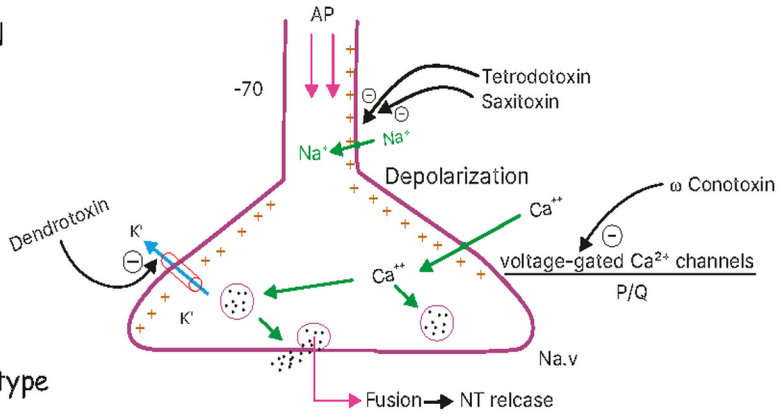
00:06:43

Pre Synaptic Event

- Pre-synaptic terminal
  - Axon terminals contain synaptic vesicles.
  - Vesicles contain neurotransmitters.

Mechanism of Neurotransmitter Release

Action potential reaches the axon terminal
↓
Opening of voltage-gated Na+ channels
↓
Na^+ influx into the neuron
↓
Depolarization of the axon terminal
↓
Opening of voltage-gated Ca^{2+} channels (P/Q type calcium channels)
↓
Ca^{2+} enters the axon terminal
↓
Ca^{2+} binds to proteins on the vesicle membrane
↓
Synaptic vesicles move toward the presynaptic membrane
↓
Fusion of vesicle membrane with presynaptic membrane
↓
Vesicle ruptures
↓
Neurotransmitter is released into the synaptic cleft



Toxins Affecting Pre-Synaptic Transmission

Toxin	Target Channel	Effect
Tetrodotoxin	Voltage-gated Na+ channel	Prevents neurotransmitter release
Saxitoxin	Voltage-gated Na+ channel	Prevents neurotransmitter release
Omega-conotoxin	P/Q type Ca^{2+} channel	Prevents neurotransmitter release
Dendrotoxin	Voltage-gated K+ channel	Enhances neurotransmitter release

Post synaptic events

Epsp (excitatory post-synaptic potential)

- Local depolarization of the postsynaptic membrane
- Main neurotransmitter: Glutamate

Yourwish

Mechanism of Action

Glutamate binds with the post-synaptic receptor

↓

- Metabotropic receptor → Ca^{2+} entry +, K^+ channel closure
- AMPA receptor → Na^+ entry
- Kainate receptor → Na^+ entry
- NMDA receptor → Na^+ entry + Ca^{2+} entry

↓

Positive charge accumulates

↓

Depolarization of the post-synaptic membrane

↓

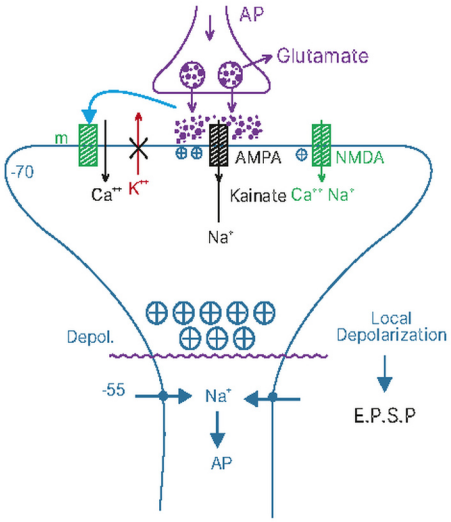
If the threshold (-55 mV) is reached

↓

Voltage-gated Na^+ channels open

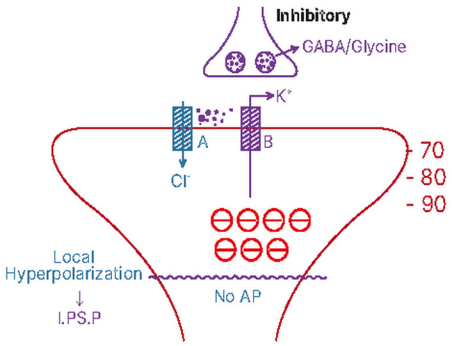
↓

Action potential generated



IPSP (Inhibitory Post-Synaptic Potential)

- Local hyperpolarization of the postsynaptic membrane.
- Main neurotransmitters:
  - GABA- In the brain
  - Glycine - In spinal cord
    → Similar to GABA-A



Mechanism Of Action

GABA / Glycine binds to the receptor

↓

- GABA-A receptor → Cl^- entry
- GABA-B receptor → K^+ channel opening → K^+ exit
- Glycine receptor → Cl^- entry

↓

The membrane becomes more negative

↓

Hyperpolarization

↓

Action potential generation is inhibited

SOMATOSENSORY RECEPTORS

00:20:58

Classification Of Somatosensory Receptors

FMGE 2020, INICET 2021

Receptor Type	Stimulus Detected	Examples
Mechanoreceptors	Mechanical deformation/stretch	Tactile- Touch, pressure
Thermoreceptors	Temperature	Cold and warm receptors

Photoreceptors	Light (electromagnetic stimulus)	Rods, cones
Chemoreceptors	Chemical stimuli	Smell and taste receptors
Polymodal receptors	Multiple stimulus modalities	Nociceptors

Mechanoreceptors

- Mechanoreceptors respond to mechanical deformation or stretch.

Mechanoreceptor	Function
Tactile receptors	Detect touch and pressure
Nociceptors	Pain due to mechanical stimulus
Proprioceptors	Detect joint position (flexion or extension)
Hair cell receptors	Present in the organ of Corti

Tactile Receptors (Touch & Pressure)

- Detect touch and pressure
- Pressure → sustained touch
- Maximum tactile receptors → Fingertips > Lips
- Divided into:
  - Rapidly adapting
  - Slow adapting

Receptor	Adaptation	Key Function	Important Features
Pacinian corpuscles	Rapid	Deep pressure and vibration	Largest tactile receptor Most rapidly adapting Located in the deep dermis Best stimulus: High-frequency vibration (~200 Hz)
Meissner corpuscles	Rapid	Moving touch and vibration	Most numerous touch receptors Present only in glabrous (hairless) skin Detect low-frequency vibration
Hair end organ	Rapid	Movement on hairy skin	Activated by the bending of hair follicles Detects first touch on hairy skin
Merkel receptors	Slow	Sustained touch and point detection	Best receptor for Sustained touch Only tactile receptor in the epidermis Detects edges, corners, and points Important for two-point discrimination & Braille reading
Ruffini endings	Slow	Skin stretch	Activated when the skin stretches during holding large objects Helps detect size and shape
Free nerve endings	Slow	Itching and tickling	Some also function as nociceptors

Thermoreceptors

- Thermoreceptors detect temperature changes.

Receptor	Activation Range	Maximum Activation
Cold receptors	10°C - 40°C	24°C
Warm receptors	30°C - 49°C	45°C

A. If the temperature is:
  - <10°C or >49°C → nociceptors are activated → pain sensation
- Distribution
  - Cold receptors > Warm receptors
  - Maximum cold receptors are at the lips, followed by the fingertips

Photoreceptors

- AKA: Electromagnetic receptors.
- Rods and cones.

Chemoreceptors

- Detect chemical sensations
  - Smell
  - Taste

Q. Select the correct option regarding the function of receptors?
A. Ruffini corpuscle - sustained pressure
B. Merkel cells - stretching
C. Meissner's corpuscle - deep resource
D. Pacinian corpuscle - vibration

Answer : D

Q. Which sensory receptors are accountable for tactile discrimination among the options provided?
1. Merkel disc
2. Ruffini end organ
3. Pacinian corpuscle
4. Meissner's corpuscle

A. 1 and 4 are correct
B. 2 is correct
C. 3 is correct
D. None are correct

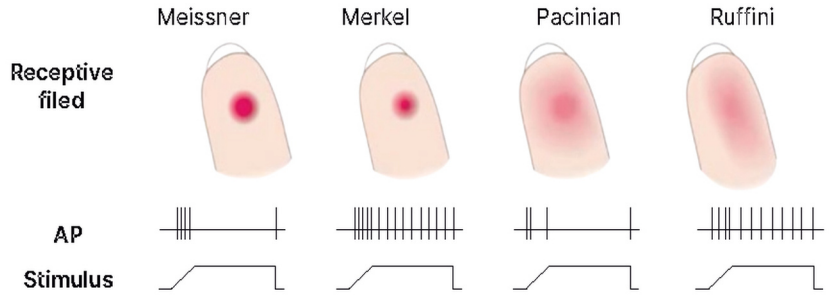
Answer: A

Adaptation Of Receptors

00:34:46

- Receptive Field
  - Area of skin from which one receptor detects stimulus.

- Two-Point Discrimination Principle
  - If touches fall in TWO separate receptive fields → Brain perceives TWO points
  - If touches fall in the SAME receptive field → Brain perceives ONE point
- Smallest receptive field - Merkel receptor
- Most densely packed receptors -Meissner corpuscles
- Sustained touch: When skin indentation is maintained for a prolonged duration.
- Receptor response: Measured as the frequency of action potentials generated by the sensory receptor
- Adaptation Pattern
  - Merkel - Slow adapting
  - Ruffini - Slow adapting
  - Meissner - Rapid adapting
  - Pacinian - Most rapidly adapting



NOCICEPTORS

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- AKA: Pain receptors
- Can be activated by
  - Mechanical stimuli
  - Thermal stimuli
  - Chemical stimuli

Types of Pain

Pain Type	Fiber	Description
Fast pain / First pain	A-delta fibers	Activated by mechanical or thermal stimulus
Slow pain / Second pain	C fibers	Activated by chemical pain

Types of receptor

Mechanical receptor

Receptor	Function
TRPA1 (Transient Receptor Potential Ankyrin 1)	Mechanical pain
ATP	Activated by ATP released during tissue damage Act on P2X and P2Y
MRGPCR (Mas-related G protein-coupled receptors)	Activated by sharp pain (cut by a blade, knife)

Thermal receptor

Cold pain

Receptor	Temperature Range
TRPA1	< 17°C
TRPM (Transient Receptor Potential Melastatin)	8 - 28°C

Yourwish

Warm Pain

Receptor (Transient Receptor Potential Vanilloid)	Activation
TRPV1	Temperature > 43°C, H^+ ion , Capsaicin
TRPV2	Temperature > 52°C
TRPV3	33 - 39°C
TRPV4	25 - 34°C

Chemical Receptor

Substance	Role
Bradykinin	Most potent pain-producing substance
Serotonin	Second most potent
Histamine	Pain mediator
H+ ions	
Nerve growth factor	

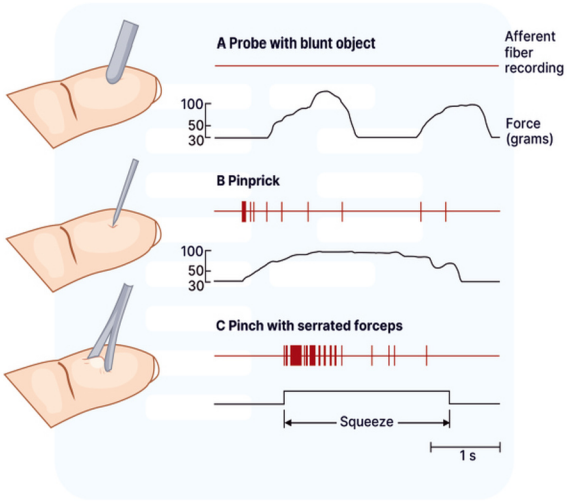
Q. Mechanical nociceptors and their response to a probe with a blunt object, pinprick, and toothed forceps with serrations are recorded as an output of a force transducer coupled to the stimulator. What could be inferred from this?

A. There are no responses from the nociceptors when stimulated by blunt forceps.

B. Pinching with toothed forceps causes stimulation of mechanonociceptors but no pain.

C. Pricking with a needle does not stimulate nociceptors

D. Sharp pain sensation is carried by C fibres



Answer: a.

- An increase in the intensity of a stimulus leads to an increase in the frequency of action potential.

Important Information

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- Clinical Terms
  - Hyperalgesia - Exaggerated response to a noxious stimulus
  - Allodynia - Sensation of pain in response to normally innocuous stimuli
  - Innocuous stimulus - Both signify increased sensitivity of nociceptive fibers
- Pain-insensitive structures in the brain :
  - Brain parenchyma, Ependyma, Choroid plexus, Pia matter and arachnoid are insensitive.

Q. A woman who suffered a sunburn while enjoying a vacation on the beach now experiences pain when lukewarm water (40 C) touches her back during a shower. What type of receptors were activated by the lukewarm water, and why did she experience pain?

A. Thermal nociceptors and nociceptive pain.
B. Thermal nociceptors and allodynia.
C. Innocuous thermal receptors and hyperalgesia.
D. Innocuous thermal receptors and allodynia.

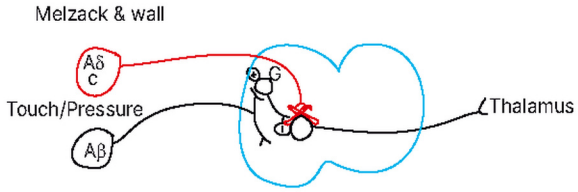
Answer : D

GATE CONTROL THEORY OF PAIN

00:51:19

- By Meizack & Wall

Pain Pathway



Peripheral nociceptor activation
↓
Pain carried by A-delta fibers and C fibers
↓
First-order neuron enters the spinal cord through dorsal root
↓
Synapse with second-order neuron in the dorsal horn
↓
Second-order neuron travels to the thalamus
↓
Thalamus sends signal to the cortex
↓
Pain perception

- Fibers entering the dorsal horn
  - A-delta fiber- Fast pain
  - C fiber - Slow pain
  - A-beta fiber - Touch and pressure

Gate Control Mechanism

- Location: Substantia gelatinosa
- Contains G neuron (inhibitory neuron).

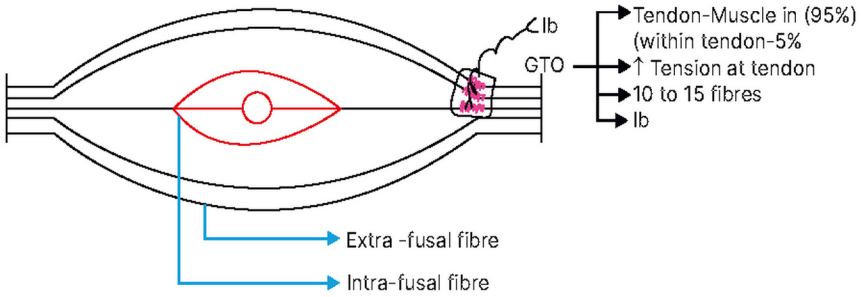
GATE OPEN (PAIN PERCEIVED)	GATE CLOSED (PAIN REDUCED)
A-delta or C fiber stimulated ↓ G neuron not activated ↓ Pain pathway remains active ↓ Pain perception occurs	Touch or pressure stimulus ↓ Activation of A-beta fiber ↓ A-beta fiber stimulates G neuron ↓ G neuron inhibits pain pathway ↓ Gate closes at dorsal horn ↓ Pain perception reduced

- Activation of A-beta fibers
  - Massaging
  - Acupuncture
  - Balm application
  - TENS (Transcutaneous Electrical Nerve Stimulation)

PROPRIOCEPTORS

00:56:05

- Detect the position of joints



Types of proprioceptors

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Receptor	Location	Function
Muscle spindle	Inside the muscle belly	Detects muscle length
Golgi tendon organ	Tendon-muscle junction (95%) Within tendon (5%)	Detects tension at tendon 10 to 15 fibres Golgi tendon organ transmits signals to the spinal cord via Type Ib afferent fibers.
Joint capsule receptor	Joint capsule	Detects joint position

Muscle spindle fibres

- Extrafusal fibers - Contractile muscle fibers responsible for muscle contraction
- Intrafusal fibers - Form the muscle spindle (sensory receptor)
  - Nuclear bag fiber: 2-3 in number, Central bag-like region containing nuclei
    → Dynamic bag fiber - Detects the velocity of muscle stretch
    → Static bag fiber - Detects increased length
  - Nuclear chain fiber: 5-9 in number, Nuclei arranged in chain form
    → Always static

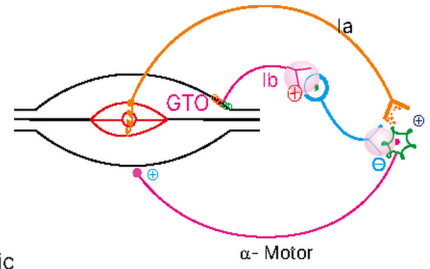
Muscle Spindle Afferent Fibres

Afferent Type	Name	Function	Origin
Type Ia	Primary ending / Annulospiral ending	Detects velocity and muscle length	Dynamic bag, static bag, nuclear chain fibers
Type II	Secondary ending / Flower-spray ending	Detects muscle length only	Static bag and nuclear chain fibers

STRETCH AND INVERSE STRETCH REFLEX

01:04:28

FMGE 2021



Mono-synaptic
Sudden Stretch → Contraction
Sudden Contraction → Relaxation

Inverse stretch
Autogenic

Bisynaptic inhibit

Stretch Reflex Pathway

- Mediated by Muscle spindle

Sudden stretch of muscle
↓
Muscle spindle activated
↓
Ia afferent fiber carries signal to spinal cord
↓
Ia fiber synapses with Aα-motor neuron in spinal cord
↓
Aα-motor neuron activates extrafusal muscle fibers
↓
Muscle contraction

Synapses

- Sudden stretch → Reflex contraction of the same muscle
- One synapse in the spinal cord → Monosynaptic reflex pathway

Inverse Stretch Reflex (Autogenic Inhibition)

- Mediated by the Golgi Tendon Organ (GTO).
- Prevents excess tension in the tendon → Prevents tendon rupture
- Sudden strong muscle contraction leads to increased tendon tension
- AKA: Autogenic inhibition

Pathway

Increased tendon tension
↓
Golgi tendon organ is activated
↓
Ib afferent fiber enters the spinal cord
↓
Synapse with inhibitory interneuron
↓
Interneuron inhibits α-motor neuron
↓

Extrafusal muscle fibers inhibited

↓

Muscle relaxes

Synapses

- Sudden contraction → Relaxation of the same muscle
- Bisynaptic reflex:
  - Ib afferent → interneuron
  - Interneuron → a motor neuron

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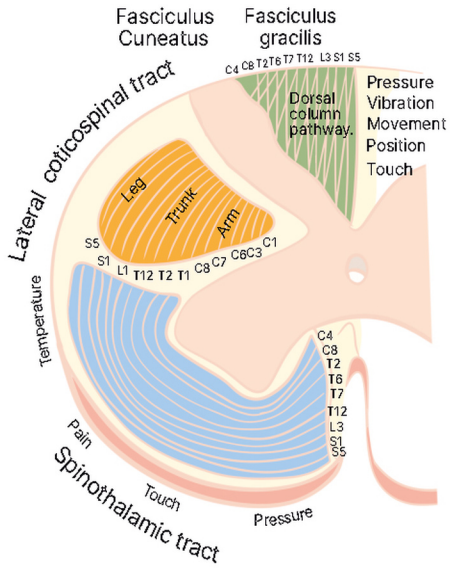
01:09:12

ASCENDING TRACTS OF SPINAL CORD

- Dorsal Column Pathway
- Anterior spinothalamic pathway
- Lateral spinothalamic pathway



Dorsal Column Pathway

- Sensations Carried
  - Fine touch
  - Vibration
  - Localizing pressure
  - Proprioception
  - Two-point discrimination
- Organization of Fibers
  - Fasciculus gracilis - Lower body (sacral, lower thoracic)
  - Fasciculus cuneatus - Upper body (cervical, upper thoracic)
- Spatial Arrangement
  - Sacral fibers → medial
  - Cervical fibers → lateral
  - If compression occurs from the lateral side
    → Cervical fibers are affected first
    → Sensory loss begins in the upper body

Spinothalamic Pathway

- Two components
  - Anterior spinothalamic - Carries Crude touch, pressure, tickling, itching, and sexual sensation
  - Lateral spinothalamic - Carries Pain and temperature
- Spatial Arrangement
  - Sacral fibers → Outer part
  - Cervical fibers → Inner part

Q. Which findings would be observed in a patient who has suffered a cervical spine injury due to road traffic accident, whereby the fracture fragment has penetrated the lateral aspect of the dorsal column tract?

A. Absence of ipsilateral lower limb proprioception.

B. Absence of fine motor movement of fingers.

C. Absence of ipsilateral arm proprioception

D. Absence of contralateral lower limb proprioception

Answer: C

Brown-Sequard Syndrome

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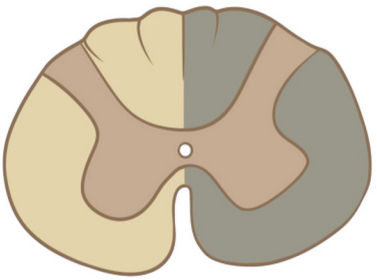
- Hemisection of the spinal cord

Sensory Effects

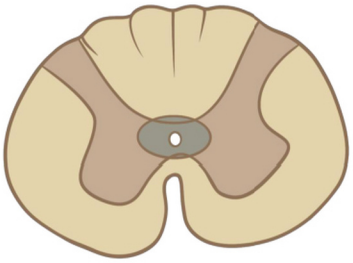


- Same side of lesion - loss of dorsal column sensations
  - Fine touch
  - Proprioception
  - Vibration
  - Tactile discrimination
- Opposite side of lesion - loss of spinothalamic sensations
  - Pain
  - Temperature

Motor Deficit

- Damage to corticospinal tract on the side of the lesion:
  - LMN paralysis at the level of the lesion
  - UMN paralysis below the lesion

Syringomyelia

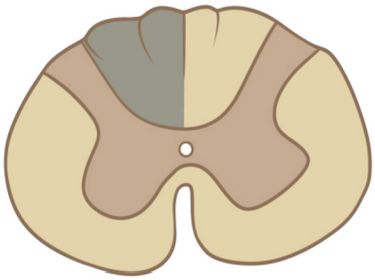


- Syrinx (Cavity): Lesion around the central canal of the spinal cord.
- Disrupts the lateral spinothalamic fibers without affecting the fibers of the dorsal column
- Sensory Findings
  - Loss of pain and temperature
  - Preservation of
    - → Fine touch
    - → Proprioception
    - → Vibration
    - → Two-point discrimination
- Dissociated sensory loss
  - In cervical syringomyelia → loss of pain & temperature in both arms, but touch is preserved.
- Motor paralysis may occur due to anterior horn cell involvement

Tabes Dorsalis

- Tabes → Wasting away
- Destruction of the dorsal root and dorsal column fibres

- Maybe B/L
- Cause - Neurosyphilis
- Effects
  - Loss of Position Sense and Vibration
  - Sensory ataxia
  - Numbness and Lightning pain
  - Diminished reflex & weakness

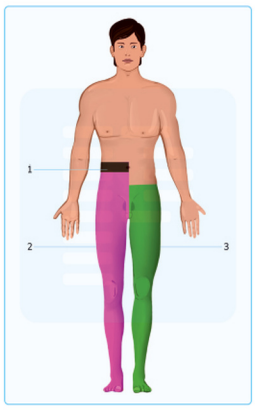


Q. Which of the following is not characteristic of Brown-Séquard Syndrome?
A. Complete transection of spinal cord
B. Ipsilateral loss of vibration and touch
C. Contralateral loss of pain and temperature
D. Ipsilateral loss of proprioception

Answer : A

Q. The patient exhibits symptoms depicted in the image provided below.
1. Shows the site of the lesion
2. Experiences decreased proprioception, vibration, and discriminative touch on the affected side.
3. Has loss of pain and temperature beginning one or two segments below the side of the lesion on the contralateral side.

What is the most likely diagnosis?
A. Weber's syndrome
B. Dejerine syndrome
C. Brown-Sequard syndrome
D. Wallenberg syndrome



Answer: C

Dejerine Syndrome

- AKA: Thalamic pain syndrome
- Damage to VPL/VPM nuclei of the thalamus → Agonising pain

Weber's Syndrome

- A/k/a midbrain stroke syndrome or superior alternating hemiplegia
- Stroke affects the medial portion of the midbrain.
- Characterized by an ipsilateral lower motor neuron type oculomotor nerve palsy and contralateral hemiparesis or hemiplegia

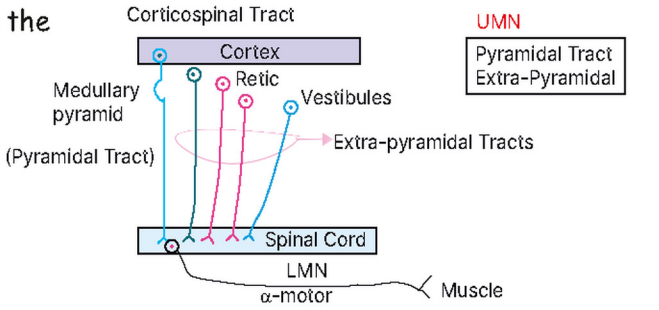
Wallenberg Syndrome

- A/k/a Lateral Medullary Syndrome or Posterior Inferior Cerebellar Artery Syndrome
- Stroke occurring in this region of the brainstem
- Patients typically present with motor, sensory, cognitive, perceptual, speech, and language deficits

DESCENDING TRACTS OF SPINAL CORD

01:20:33

- Descending tracts are nerve fibers that descend from the brain to the spinal cord to control motor activity.



Corticospinal Tract (Pyramidal Tract)

Cerebral cortex (Layer 5)
↓
Fibers descend through the brainstem
↓
Form elevation in medulla
(Medullary pyramids)
↓
Continue to the spinal cord
↓
Act on α-motor neurons

- Controls voluntary movement of skeletal muscles
- Because it forms medullary pyramids, it is called the pyramidal tract.

Extrapyramidal Tracts

- These tracts do not pass through the medullary pyramids.

Origin	Tract
Red nucleus (midbrain)	Rubrospinal tract
Reticular nucleus (pons)	Pontine reticulospinal tract
Reticular nucleus (medulla)	Medullary reticulospinal tract
Vestibular nucleus	Vestibulospinal tract

- All descending tracts ultimately act on the α-motor neuron (lower motor neuron)
  - Lower motor neuron → Final common pathway
- The upper motor neuron includes
  - Pyramidal tract (corticospinal)
  - Extrapyramidal tracts

Umn Vs Lmn Lesion

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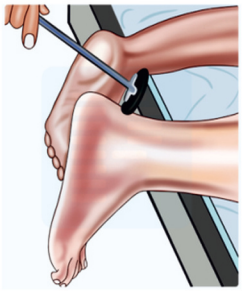
Feature	Upper Motor Neuron Lesion	Lower Motor Neuron Lesion
Muscle atrophy	None (disused atrophy)	Severe (loss of trophic factor)
Fasciculation	None	Present
Tone	Hypertonia (spasticity/rigidity)	Decreased

Yourwish

Stretch Reflexes	Hyperactive	Hypoactive /absent
Muscle group affected	Regional, Large muscle groups	Segmental/ distal muscles
Babinski sign	Present	Absent

Q. The following clinical examination was performed. What lesion would cause an exaggerated reflex?

A. Polyneuropathy
B. Radiculopathy
C. Upper motor neuron
D. Lower motor neuron



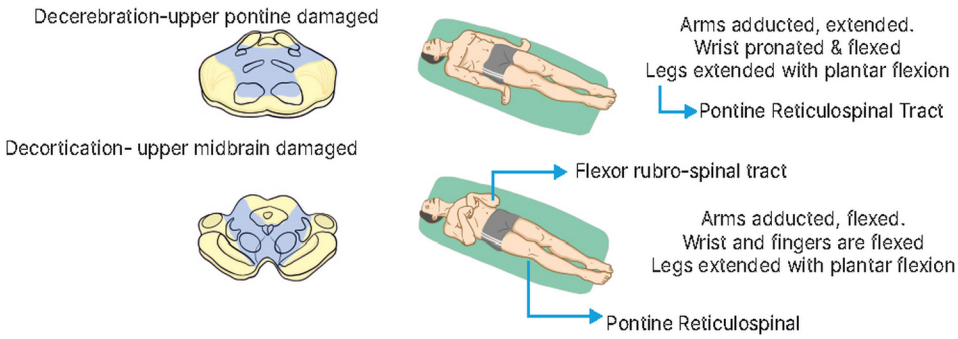
Answer: C

- Deep tendon reflexes (DTRs) - Stretch reflex
  - UMN lesion → DTR exaggerated
  - LMN lesion → DTR diminished

Umn Lesions

DECEREBRATE RIGIDITY	DECORTICATE RIGIDITY

• Upper pontine damage
• Increased muscle tone
• Extension of both upper and lower limbs
• Cause: Activation of the pontine reticulospinal tract
	• Upper midbrain lesion
	• Tracts Involved
	  ○ Rubrospinal tract - Upper limb flexion
	  ○ Pontine reticulospinal tract - Lower limb extension



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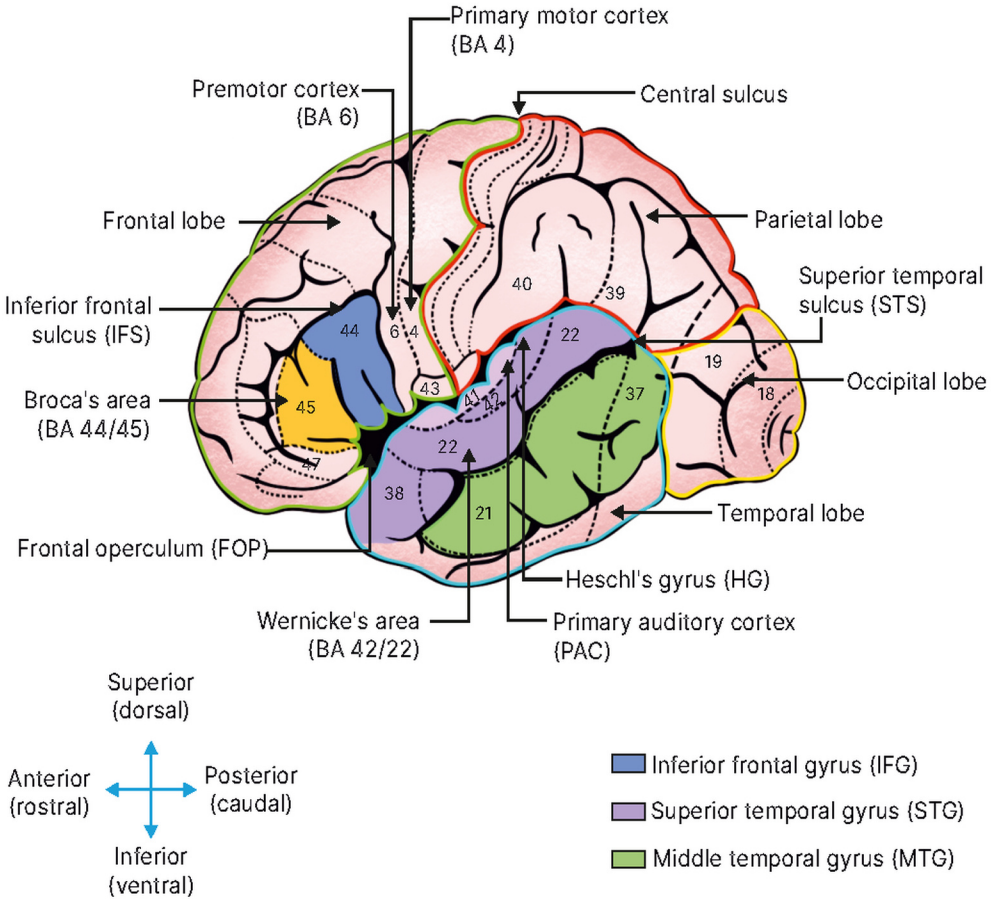
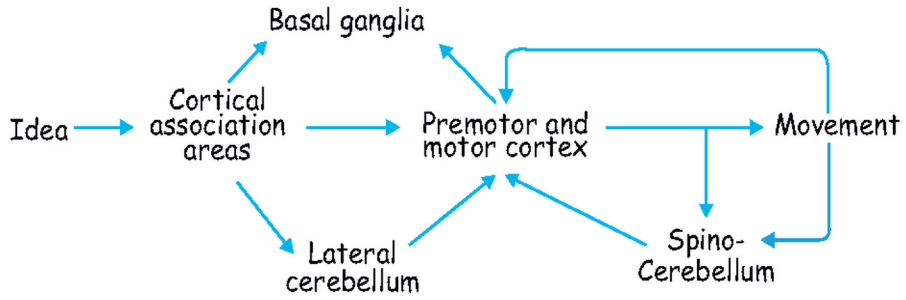
1:31:16

BRODMANN AREAS

Function	Area
Primary visual cortex	17
Primary auditory cortex	41, 42
Somatosensory cortex	1-3
Primary motor cortex	4
Broca's area (motor speech)	44-45
Wernicke's area (sensory speech)	42/22



Plan Of Movement



Role Of Brain Structures

Structure	Function
Basal ganglia	Planning and programming of movement
Lateral cerebellum	
Spinocerebellum	Smooth execution of movement

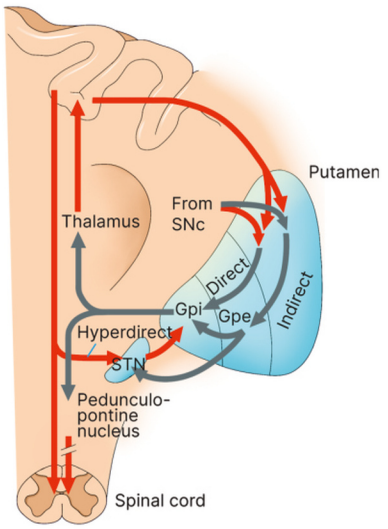
BASAL GANGLIA NUCLEI

1:34:16

- Striatum: Caudate nucleus & Putamen
  - 95%: GABA
  - 5%: Ach, Somatostatin
- Globus pallidus: GABA

- Externus (Gpe)
- Internus (Gpi)

- Subthalamic nucleus: Glutamate (excitatory)
- Substantia nigra
  - Pars compacta: Dopamine
  - Pars reticulata: GABA



Basal Ganglia Pathways

DIRECT PATHWAY	INDIRECT PATHWAY
Substantia nigra ↓ Globus pallidus internus	Striatum → Globus pallidus externus → Globus pallidus internus Putamen → Globus pallidus externus → Subthalamic nucleus → Globus pallidus internus

- Globus pallidus internus → efferent nucleus of the basal ganglia
- Dopaminergic fibers from the Substantia nigra project to the Striatum of the basal ganglia

Basal Ganglia Functions

- Motor function:
  - Basal ganglia and motor cortex form a processing loop whereby the basal ganglia enable the proper motor programme (planning & programming).
- Cognitive function:
  - Basal ganglia are thought to play a role in cognitive function.
  - Striatum is also involved in skill & procedural memory

Basal Ganglia Disorders

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Disorder	Site of Lesion
Parkinsonism	Substantia nigra
Hemiballismus	Subthalamic nucleus Ipsilateral, sudden ballistic high-amplitude movements
Huntington disease	Striatum (indirect pathway) Involuntary movement similar to Hemiballismus (chorea)
Athetosis	Globus pallidus (internus & externus) Slow writhing movement

Q. Which is the site of the lesion that leads to the occurrence of hemiballismus in a patient displaying forceful, flinging movements?

A. Putamen

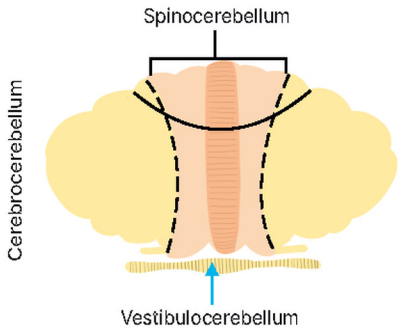
B. Subthalamic nucleus
C. Caudate nucleus
D. Globus pallidus

Answer: B

CEREBELLUM

01:38:15

- From surface → interior
  - Cerebellar cortex
  - Inner white matter
  - Deep cerebellar nuclei
    - → Dentate nucleus
    - → Fastigial nucleus
    - → Interposed nucleus (globose + emboliform)



Region	Formed by
Vestibulocerebellum	Flocculonodular lobe Oldest part
Spinocerebellum	Vermis and paravermis
Cerebrocerebellum	Newest part

Functions Of The Cerebellum

Division of Cerebellum	Functions
Vestibulo-cerebellum	• Involved in vestibular reflexes • Maintenance of balance and posture
Spino-cerebellum	• Integration of sensory input with motor commands to produce adaptive motor coordination • Coordinates & smoothens voluntary movements
Cerebro-cerebellum	• Planning and timing of movements (motor learning) • Involved in cognitive functions such as language

Cerebellar Diseases (Danish)

D	Dysdiadochokinesia, Dysmetria, Decomposition of movement, and Delay in initiation of movement
A	Ataxia (drunken gait)
N	Nystagmus
I	Intention tremor
S	Slurring/ scanning speech (skilled movement)
H	Hypotonia (same side of body)

Yourwish

- No sensory deficit
- No abnormalities at rest
  - Except for the changes in stretch reflexes

HYPOTHALAMIC NUCLEI AND FUNCTIONS

01:41:50

Nucleus	Function
Anterior nucleus	Thermoregulation (in Hot) Sexual behaviour and osmoreceptors
Posterior nucleus	Thermoregulation (shivering)
Suprachiasmatic nucleus	Circadian rhythm
Lateral nucleus	Hunger & thirst center
Ventromedial nucleus	Satiety center
Medial forebrain bundle, Ventral tegmental area, Nucleus accumbens	Reward centre
Periaqueductal gray (PAG)	Punishment centre (rage centre)

THALAMIC NUCLEI

Nucleus	Function
VPL & VPM	Part of the somatosensory system
Lateral geniculate body	Vision
Medial geniculate body	Hearing
VL nucleus	afferents from basal ganglia & cerebellum
VA nucleus	Receives most of its input from the basal ganglia
Dorsomedial nucleus	Controls eye movement (projection from frontal eye field) + olfactory pathway

EEG WAVES

01:45:13

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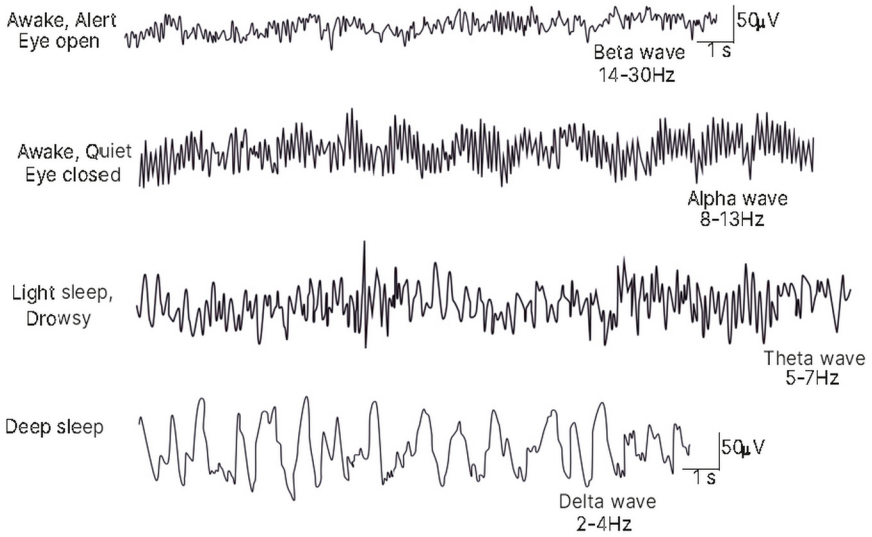

Wave	Frequency	Condition
Beta	14-30 Hz	Awake, alert, eyes open
Alpha	8-13 Hz	Awake, relaxed, eyes closed
Theta	5-7 Hz	Light sleep
Delta	2-4 Hz	Deep sleep

- Brain activity ↓→ Frequency ↓
- Amplitude ↑ in deeper sleep
- Gamma Waves
  - Frequency: 30-80 Hz
  - Seen in
    → Meditation
    → High mental activity
    → Intense concentration

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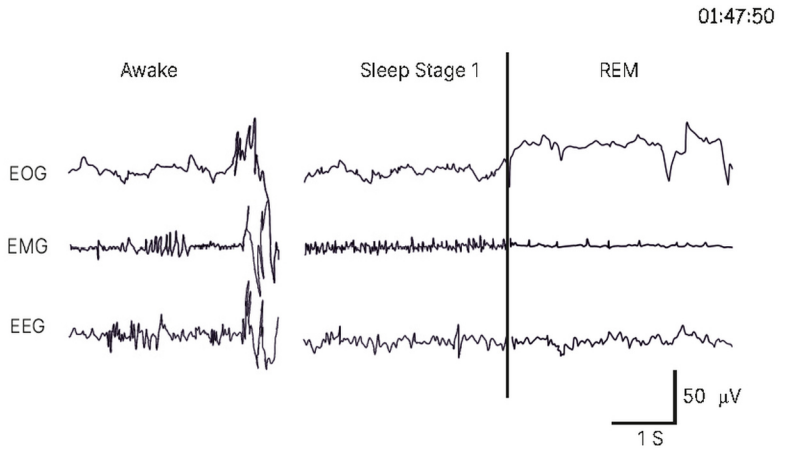
POLYSOMNOGRAPHY

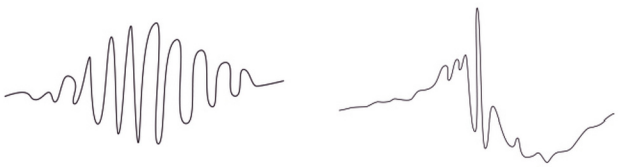
- Combined recording of
  - EEG
  - EMG
  - EOG
  - SpO_2
  - ECG
  - Nasal airflow
  - Breathing movements
- Used to study sleep physiology



Types Of Sleep

- NREM Sleep (slow wave sleep): 75-80% time
- REM sleep (paradoxical sleep): 20-25%

Non-Rem Sleep

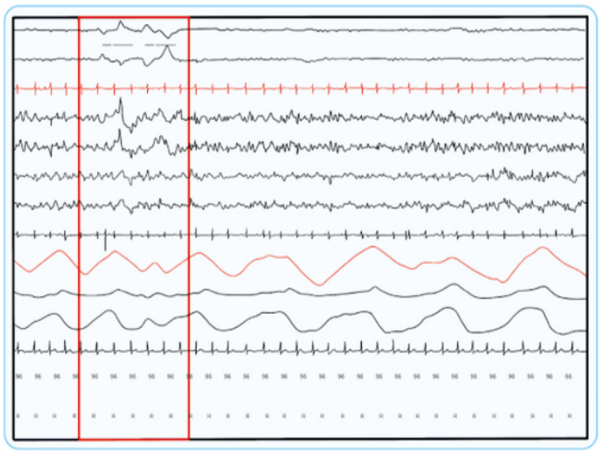
Stages	% Duration	EEG Pattern
N1	5 %	Alpha to Theta waves
N2	55 %	Sleep spindles: Spindle-shaped K complexes: Sudden polyspike wave 
N3	15 %	Delta waves

NREM disorder	
Sleepwalking (somnambulism)	Stage III and IV (N23) Can occur during REM sleep
Sleep talking (Somniloquy)	Stages I (N2) and II (N2) mainly, but possible in all
Bruxism	Stages II and I mainly
Nocturnal enuresis	All stages of NREM (N3 main) and REM except Stage I (max during stage II)
Night terrors	Transition from Stage III to Stage IV

Rem Sleep

- Rapid eye movements
- Silent EMG (muscle atonia)
- Beta-like EEG
- Also called Paradoxical sleep (because EEG resembles awake state, but person is asleep)
- REM Sleep Disorders:
  - Narcolepsy
  - Nightmare

Q. On performing polysomnography in a patient, the waves of EOG, EEG, and EMG, from above downwards, are seen below. Which stage of sleep do the marked areas represent?

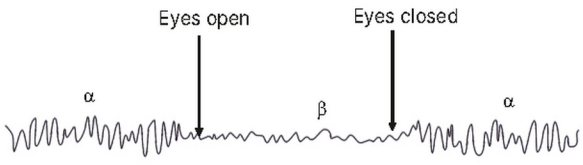


- EOG - Electroculography
- EEG - Electroencephalography
- EMG - Electromyography

A. REM sleep
B. NREM I sleep
C. NREM II
D. NREM III sleep

Answer: A

Q. During the recording of the EEG, a resting and awake person was instructed to close his eyes and then open them. The dominant wave that decreases on opening his eyes is?



A. Alpha
B. Beta
C. Theta
D. Delta

Answer : A

- Alpha block phenomenon:
  - Transition of alpha waves to beta waves on the EEG when the eyes are opened.

MEMORY

01:54:43

Types Of Memory

INICET 2021

- Working Memory
  - Form of short memory
  - Duration: 18-20 sec (max ~30 sec)
  - Capacity: 7 ± 2 chunks of information
  - Centre: Prefrontal cortex
- Short-Term Memory
  - Duration: Seconds → Hours
  - Centre: Ventral Hippocampus (CA1 neurons)
- Long-Term Memory
  - Memories for years and sometimes for life
  - Centre site: Neocortex

Q. What is the duration of short term memory?

A. 3-6 hours

B. 12-18 hours

C. 30-300 seconds

D. 3-4 seconds

Answer: C

INICET 2025

Forms of Memory

- Explicit or declarative memory
  - Memory of words, rules, and language
  - Requires conscious processing at hippocampus and medial temporal lobe.
  - Example: Recalling first day in college
- Implicit or non- declarative memory
  - Does not require awareness or processing at hippocampus.
  - Example: Remembering how to brush your teeth
- Riding a bicycle: Explicit initially, implicit once learned

Q. Which of the following brain regions is primarily associated with the processing of explicit memory?

A. Hippocampus

B. Amygdala

C. Insular cortex

D. Prefrontal cortex

Answer: A

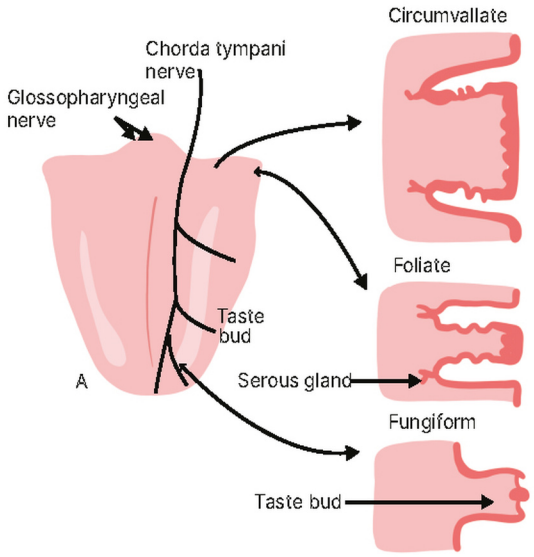
TONGUE PAPILLAE

01:58:36

Papilla	Location	Taste Buds
Circumvallate	Posterior V-shaped region (posterior)	~100
Foliate	Lateral edges of the tongue	~100

Yourwish

Fungiform	Tip of tongue	Up to 5
Filiform	Throughout tongue	No taste buds



Taste Receptors

Ionotropic Receptor	Metabotropic Receptor
Salt taste: mediated by a Na^+ selective channel (ENac)	All 3 tastes are mediated by T1R and T2R family of GPCR.
Sour taste: mediated by H^+ ions (TRP-P3). H^+ also affects HCN and ASIC channels.	• Umami taste: T1R1 and T1R3 family • Bitter taste: T2R family • Sweet taste: T1R2 and T1R3

SUMMARY

02:00:40

- Sensation detected by Pacinian Corpuscle: Deep pressure/Vibration
- Discriminate touch sensation identified by: Merkel's > Meissner's
- Vanilloid receptors are activated by: TRPV1 → Pain receptor
- Golgi tendon organ senses: Increased tension in the muscle tendon
- Physiological mechanism behind transcutaneous electrical stimulation (TENS) to provide pain relief is: Gate Control Theory
- The processing of short-term memory to long-term memory occurs at Hippocampus
- Renshaw cell inhibition is a Feedback / Recurrent inhibition
  - In the spinal cord, a motor neuron activates Renshaw cells, which in turn inhibit the same motor neuron (recurrent inhibition).
- Which tongue papillae do not have taste buds: Filiform Papilla
- Sour taste is mediated by: TRP-P3
- Endocochlear potential is +80 to +85mV
- Neurotransmitter released by inner hair cells during depolarization: Dopamine
- Without external cues, the duration of the sleep-wake cycle in humans will be: >24 (24.15) hours
  - Circadian rhythm = 24 hours
- Cell bodies of Orexinergic neurons are located at Lateral hypothalamus.
  - Orexin → Hypocretin
  - Destruction of the orexin-producing neurons in the lateral hypothalamus → Narcolepsy

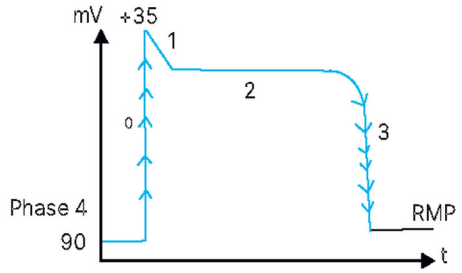
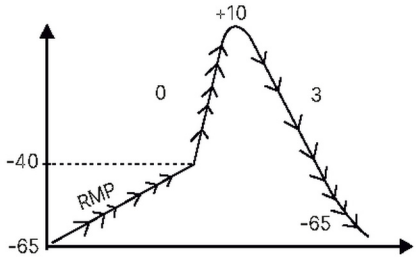
4. CARDIOVASCULAR PHYSIOLOGY

CARDIAC ACTION POTENTIAL

Types Of Action Potential

00:00:54

FMGE 2018, 2019, 2020, 2023, 2024,2025
INICET 2018 2020, 2023, 2024
NEET PG 2019, 2020, 2022, 2023, 2024

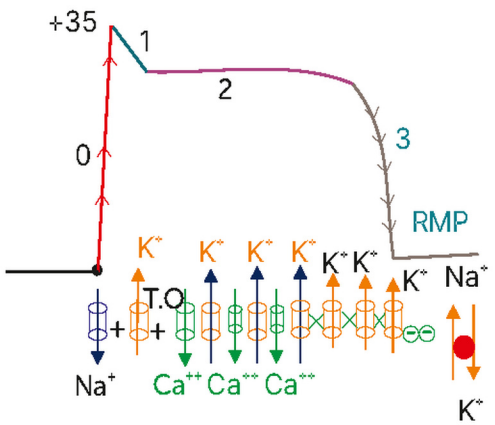
FAST TYPE AP	SLOW TYPE AP
	

• Seen in Myocardium and Purkinje Fibers
• Resting Membrane Potential (RMP)
  ○ Myocardium: -90 mV
  ○ Purkinje Fibers: -80 mV
• Phases
  ○ Phase 4 → RMP (-90 mV)
  → Stable resting membrane potential
  ○ Phase 0 → Depolarization
  → Rapid ↑ to +35 mV
  ○ Phase 1 → Initial Rapid Repolarization
  → Transient dip
  ○ Phase 2 → Plateau Phase
  → Membrane voltage stable
  ○ Phase 3 → Repolarization
  → Return to RMP
	• Locations: SA Node, AV Node.
	• Key Features:
	  ○ No Phase 1 or Phase 2
	  ○ RMP is unstable
	• Phase 4 = Prepotential
	  ○ Also called: Pacemaker potential / Diastolic depolarization phase
	  ○ RMP range: -65 mV → -40 mV
	• Phase 0: Depolarisation phase
	  ○ Membrane Voltage (+ 10mV)
	• Phase 3: Repolarisation Phase

Ionic basis of action potential

00:06:30

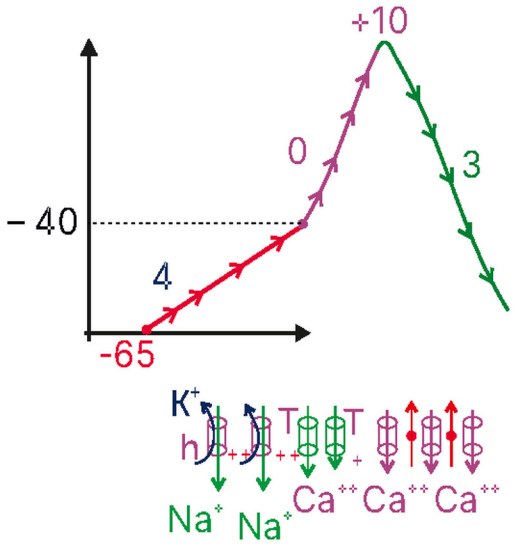
Fast type action potential (myocardium & purkinje fibers)



PHASE	NAME	MEMBRANE POTENTIAL	IONIC BASIS
Phase 4	Resting membrane potential	Stable at -90 mV	• Na^+/K^+ ATPase pump • Na^+-Ca^{2+} exchanger (NCX)
Phase 0	Depolarisation Phase	Rises rapidly to +35 mV	• Rapid Na^+ influx through Fast voltage-gated Na^+ channels
Phase 1	Initial rapid repolarisation	Slight fall from peak	• Transient K^+ efflux • Inactivation of fast Na^+ channels
Phase 2	Plateau phase	Prolonged, near-stable potential	• Ca^{2+} influx via L-type Ca^{2+} channels • Balanced by K^+ efflux
Phase 3	Repolarisation	Returns to -90 mV (RMP)	• Closure of Ca^{2+} channels • Continued K^+ efflux

Slow type action potential (nodal tissue)

0:11:00



PHASE	NAME / ALIAS	IONIC BASIS

Phase 4	Pre-potential	• Na^+ Entry
		  ○ Via HCN channels (Hyperpolarisation-activated cyclic nucleotide-gated channels)
		  → Activated by hyperpolarisation, ↑ cAMP (β_1 stimulation)
		  → Current: Funny current
		• Rapid entry of Ca^{2+} (T-type Ca^{2+} channels)
		• Closure of K^+ channel

Phase 0	Depolarisation	• Ca^{2+} influx via L-type Ca^{2+} channels
Phase 3	Repolarisation	• Closure of Ca^{2+} channels • K^+ efflux

- Fast Na^+ channels are NOT involved in nodal depolarisation

- Ivabradine blocks HCN channels
- Sympathetic stimulation ↑ slope of phase 4 → ↑ heart rate

MCQ

The pacemaker potential is due to:

A) Fast Na^+ channel
B) Decrease in K^+ permeability
C) Slow Ca^{2+} channel
D) Rapid repolarization

Answer: **B**

False about funny channel in heart:

A. It is an Na-K channel
B. It is responsible for spontaneous rhythm producing tissue of heart
C. They are voltage dependent channel only
D. They are responsible for diastolic depolarization

Answer: **C**

DEPOLARISATION & REPOLARISATION OF HEART

00:20:22

FMGE 2019, 2020
NEET PG 2023
INICET 2024

- Atrial Depolarisation: Starts near SA node
- Arterial Repolarisation also starts near SA node
- Ventricular depolarization:
  - First part: left endocardial surface of the interventricular septum at the middle portion
  - Last part: uppermost part of the interventricular septum and the postero-basal epicardial surface of left ventricle
- Ventricular repolarization:
  - The apical epicardial surface is the first to repolarize; the base endocardial surface is the last to repolarize

NORMAL ECG - IMPORTANT NORMAL PARAMETER

AIIMS 2020, FMGE 2019, 2025, NEET PG 2024

00:23:04

WAVES / INTERVAL	PHYSIOLOGICAL CORRELATES	AMPLITUDE	DURATION
P wave	Atrial depolarization	0.1 - 0.3 mV	< 0.1 sec
PR interval	Time from start of atrial depolarization to start of ventricular depolarization		0.12 - 0.20 sec
Q wave	Septal depolarization		0.06 - 0.10 sec
R wave	Ventricular depolarization	≈ 1 mV	
S wave	Depolarization of base of ventricles		
ST segment	Ventricular depolarization complete (isoelectric line)		0.08 - 0.12 sec

Yourwish

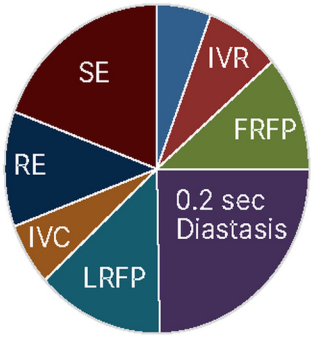
T wave	Repolarization of right and left ventricles	0.2 - 0.3 mV	
QT interval	Ventricular depolarization and repolarization Tetanization is not possible due to long action potential		0.2 - 0.4 sec

PHASES IN CARDIAC CYCLE

00:26:00

- Duration of Cardiac cycle = 0.8 s
  - V. Systole: 0.3 s
  - V. Diastole: 0.5 s
  - A. systole : 0.1 (rest ie .7 is diastole)

PHASE	SUB-PHASE	KEY FEATURES	DURATION / SOUND
Diastole	Protodiastole	Initial ventricular relaxation	~0.04 s
	Isovolumic Relaxation	All valves closed Begins with closure of semilunar valves	0.06s Produces S2
	Rapid Filling Phase (FRFP)	AV valves open Passive ventricular filling	0.1 s Produces S3
	Slow Filling Phase (Diastasis)	Minimal ventricular movement 70% filling occur in FRFP and Diastasis phase	~0.22 s(highest)
	Atrial Systole (Last Rapid Filling)	Active filling (25-30%)	0.1 s Produces S4
Systole	Isovolumic Contraction	Begins with AV valve closure	0.05 s Produces S1
	Rapid Ejection (RE)	2/3 of stroke volume ejected	0.1 s
	Slow Ejection (SE)	Remaining 1/3 ejected	0.15 s



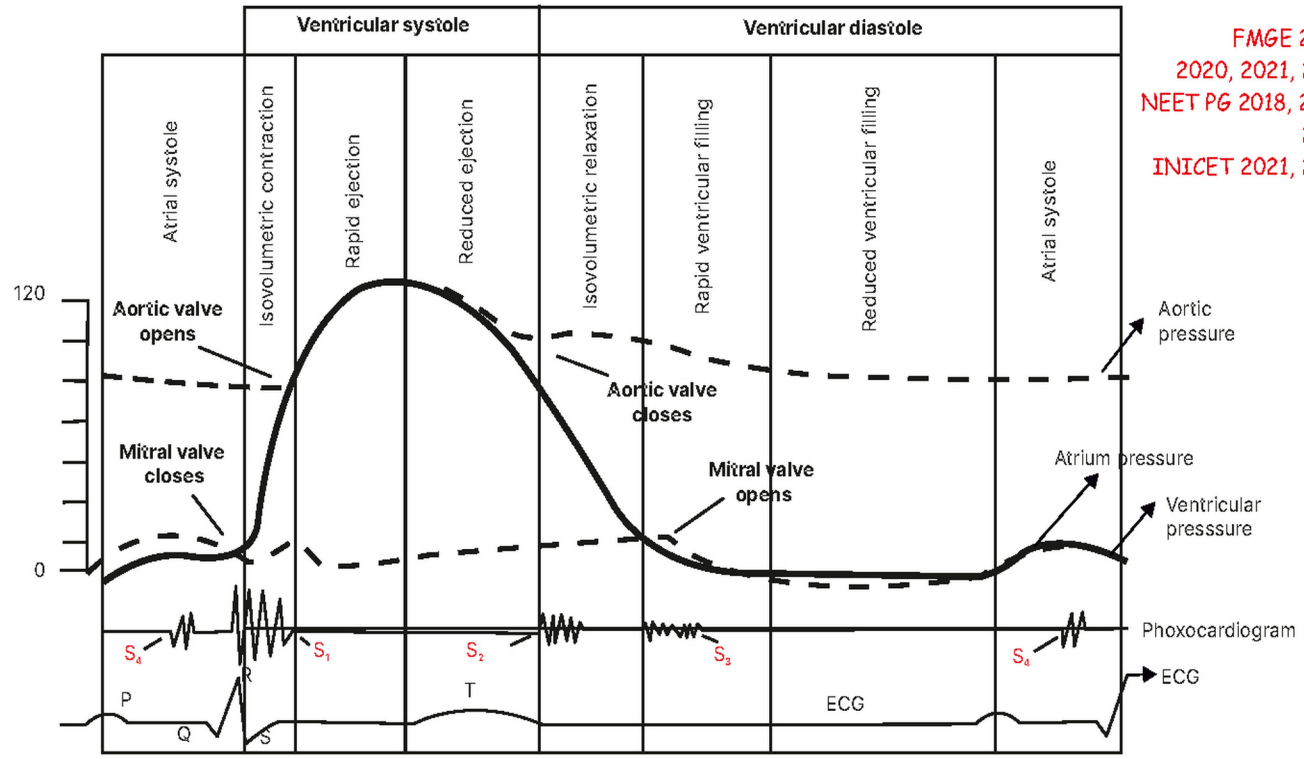
Volumes

- End-diastolic volume (EDV): ~130 mL
- Stroke volume (RE + SE): ~90 mL
- Remaining: End-systolic volume

WIGGERS DIAGRAM

00:36:47

FMGE 2019, 2020, 2021, 2023
NEET PG 2018, 2019, 2020
INICET 2021, 2022



Ventricular Pressure (solid Line)

- Near zero in atrial systole
- Rises steeply during isovolumic contraction
- When it surpasses aortic pressure, the aortic valve opens and ejection begins
- During ejection:
  - Ventricular pressure rises and then falls
  - Aortic pressure rises and then falls with it
- When ventricular pressure falls below aortic pressure → aortic valve closes
- That closure marks beginning of isovolumic relaxation

Aortic Pressure Curve (broken)

- When no ejection, it stays around 80 mmHg (mentioned as diastolic BP)
- During ejection, rises and then falls again
- Dicrotic notch (Incisura): Sudden dip due to aortic valve closure
- Dicrotic wave: Small secondary rise from elastic recoil of the aortic arch pushing blood forward

Atrial Pressure Curve

- Right Atrial pressure tracing = same as Jugular Venous Pressure (JVP)
  - Positive pressure change: a-wave, c-wave, v-wave
  - Negative pressure change: x-descent, y-descent

ECG - Heart Sound - JVP Correlation

00:43:34

ECG and heart sounds

ECG COMPONENT	CORRESPONDING HEART SOUND
P wave	S4 (atrial contraction)

R wave	S1 (AV valve closure)
End of T wave	S2 (semilunar valve closure)
TP segment	S3 (rapid filling phase)

JVP and heart sounds correlation

JVP WAVE	CORRESPONDING EVENT	HEART SOUND
A wave	Atrial contraction	S4
C wave	Isovolumic contraction	S1
V wave	Venous return	S2 & S3 around V wave peak

Important Information

Wiggers Diagram

- P wave → atrial contraction → a wave in JVP → S4
- QRS complex → onset of Ventricular systole → S1 → c & x wave in JVP
- T wave → S2 → Dicrotic notch
- V wave in JVP → S3 → y wave in JVP

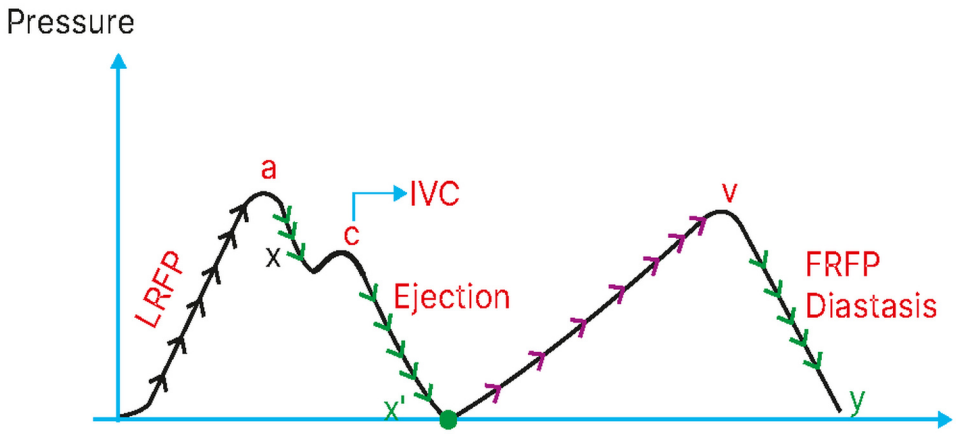
JUGULAR VENOUS PRESSURE (JVP)

00:48:11

- JVP records pressure changes within the Right Atrium (RA)
- RA receives blood from Inferior Vena Cava (IVC) and Superior Vena Cava (SVC)

COMPONENT	TYPE	CAUSE	MECHANISM	CARDIAC CYCLE CORRESPONDENCE / ASSOCIATION
a-wave	Positive	Atrial contraction (Atrial Systole)	Contraction causes atrial pressure to peak	Corresponds to Last Rapid Filling Phase Associated with 4th heart sound
x-descent (Early)	Negative	Atrial relaxation	Atrial pressure falls during relaxation	
c-wave	Positive	Bulging of tricuspid valve cusp	During isovolumic contraction: tricuspid valve closes; high ventricular pressure pushes cusps into RA → slight ↑ in atrial pressure	Occurs during Isovolumic Contraction
x'-descent (Late / Principal)	Negative	Pulling of tricuspid valve during ejection	Ventricle contracts strongly → tricuspid valve pulled downward → atrial volume ↑ → pressure ↓	

v-wave	Positive	Venous return	After x-descent: low atrial pressure draws blood from SVC/IVC → gradual ↑ in pressure due to filling	Corresponds to Protodiastole + Isovolumic Relaxation
y-descent	Negative	Opening of tricuspid valve	Atrium full → tricuspid valve opens → blood flows from atrium to ventricle → atrial pressure drops	Corresponds to Ventricular Filling Phase (First Rapid Filling + Diastasis); Does **not** include last rapid filling (which starts next a-wave)



SUMMARY TABLE

CATEGORY	WAVE	DESCRIPTION
Positive Wave	a	Atrial contraction
	c	Bulging of the tricuspid valve (cusp) into the right atrium
	v	Increase in volume of the right atrium (venous return)
Descent Wave	x	Atrial relaxation
	x'	Right ventricle pulls the tricuspid valve downward during ventricular systole
	y	Tricuspid valve opening

JVP ABNORMALITIES

0:55:30

JVP PATTERN	CONDITION	EXPLANATION
Large / Prominent a-wave	Tricuspid Stenosis	Atrium contracts against a valve that does not open completely
	Pulmonary Hypertension	Difficulty releasing blood to the ventricle
Cannon a-wave (Very Large a wave)	Complete Heart Block	Atrioventricular dissociation (atrium contracts while ventricle is also contracting)

Yourwish

	Junctional Rhythm	—
Absent a-wave	Atrial Fibrillation	Rate is too high; improper contraction prevents pressure development
Large v-wave	Tricuspid Regurgitation	Blood regurgitates from ventricle to atrium → positive pressure during venous return
Sharp y-descent	Constrictive Pericarditis	—
Sharp x-descent	Cardiac Tamponade	—

PRELOAD & AFTERLOAD

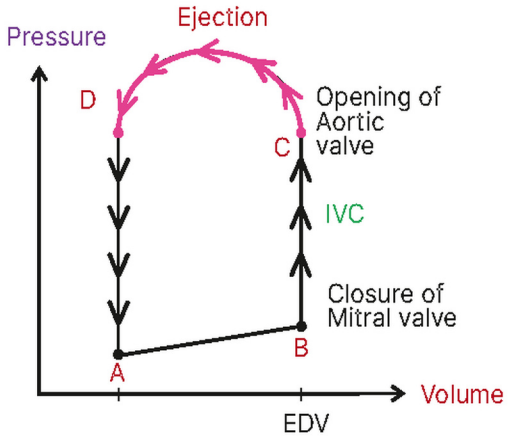
00:57:12

PARAMETER	PRELOAD	AFTERLOAD
Definition	Load on the ventricle before onset of contraction (Diastolic load)	Load on ventricular muscle after onset of contraction (Systolic load)
Mechanism	Blood fills ventricle during diastole → stretches ventricular wall	Systolic Ventricular wall pressure
Best Index	End-Diastolic Volume (EDV) > End-Diastolic Pressure (EDP)	Mean Aortic Pressure (for Left Ventricle)
Main Determinant	Venous Return (↑ Venous Return → ↑ EDV)	Total Peripheral Resistance

Pressure Volume (PV) Loop

- X-axis: Ventricular Volume
- Y-axis: Ventricular Pressure

FMGE 2019, 2020, 2021, 2023
NEET PG 2018, 2019 2020
INICET 2021, 2022



PHASE	NAME	EVENTS	VOLUME	PRESSURE	HEART SOUNDS
A → B	Filling phase	Ventricular filling	Increases	Rises minimally	S3 & S4 may occur

B → C	Isovolumic contraction	Mitral valve closes	Constant	Rises sharply	S1
C → D	Ejection phase	Aortic valve opens	Decreases	First rises then falls	—
D → A	Isovolumic relaxation	Aortic valve closes	Constant (ESV)	Falls	S2

Point	Event
B	Mitral valve closes (S1)
C	Aortic valve opens
D	Aortic valve closes (S2)
A	Mitral valve opens

Heart sounds comparison

1ST HEART SOUND (S_1)	2ND HEART SOUND (S_2)
Loud	Soft (low amplitude)
Long duration	Short duration
Low frequency	Sharp (high frequency)

Pv loop in valvular disease

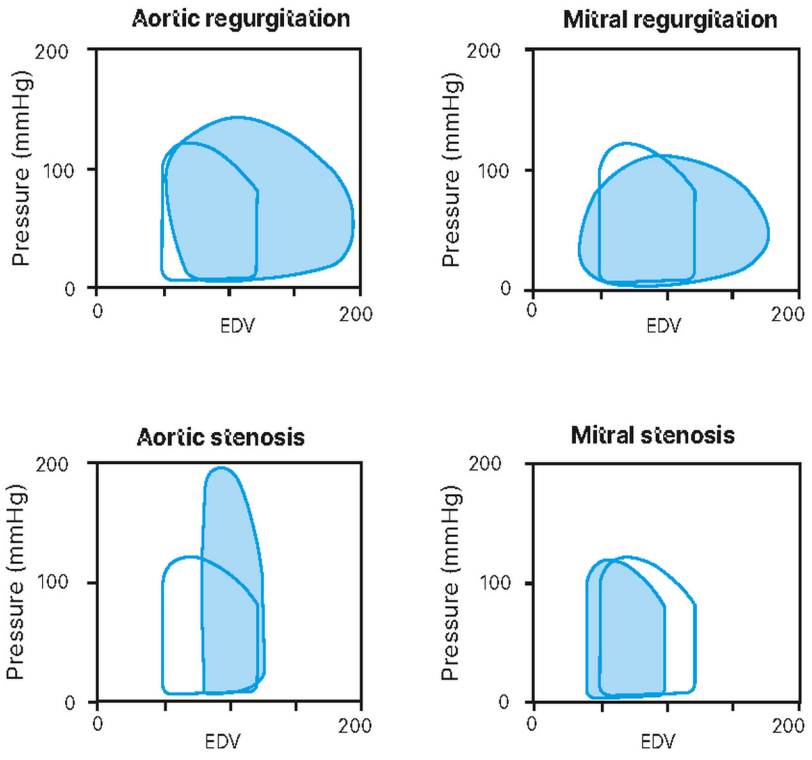
Category	Condition / Change	PV Loop Shift	Explanation
	↑ End-Diastolic Volume (Preload)	Right shift	
	↑ Afterload (Aortic Pressure)	Upward shift	
	↑ Contractility (Exercise/Digoxin)	Left shift	
Valvular Diseases	Aortic Regurgitation	Right shift + slight upward shift	↑ EDV → right shift
	Mitral Regurgitation	Pure right shift	↑ EDV
	Aortic Stenosis (Acute)	Upward shift	High afterload

	Aortic Stenosis (Chronic)	Upward + left shift	Hypertrophy increases contractility
	Mitral Stenosis	Left shift	↓ EDV
	Dilated Cardiomyopathy	Marked right shift	EDV very high
	Restrictive Cardiomyopathy	Upward baseline shift	Fibrosis prevents relaxation; high filling pressure
	Hypertrophic Cardiomyopathy	Left shift	↑ Contractility

PHYSIOLOGICAL SHIFTS

Change	Effect on Loop
↑ End-Diastolic Volume (Preload)	Right shift
↑ Afterload (Aortic Pressure)	Upward shift
↑ Contractility (Exercise/Digoxin)	Left shift

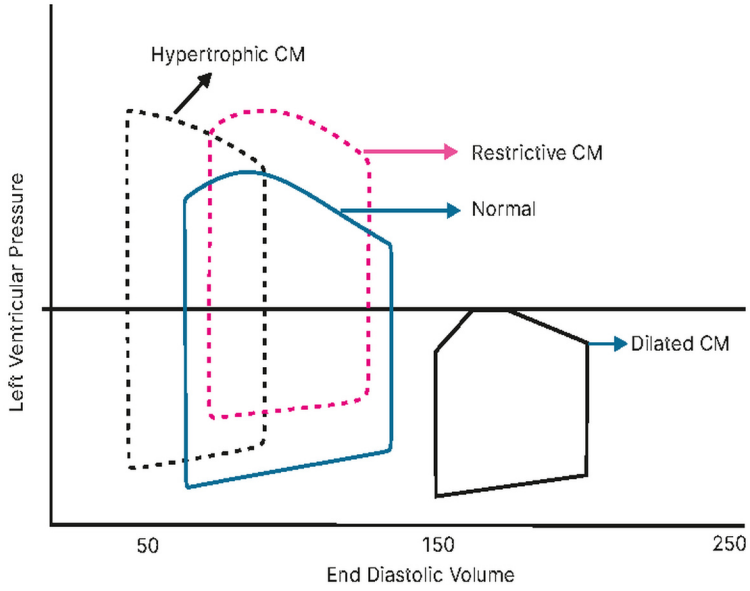
VALVULAR DISEASES



Condition / Change	PV Loop Shift	Explanation
Aortic Regurgitation	Right shift + slight upward shift	↑ EDV → right shift
Mitral Regurgitation	Pure right shift	↑ EDV
Aortic Stenosis (Acute)	Upward shift	High afterload

Aortic Stenosis (Chronic)	Upward + left shift	Hypertrophy increases contractility
Mitral Stenosis	Left shift	↓ EDV

CARDIOMYOPATHIES



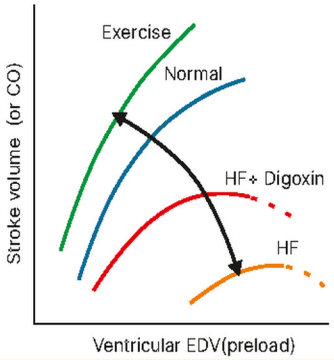
Condition / Change	PV Loop Shift	Explanation
Dilated Cardiomyopathy	Marked right shift	EDV very high
Restrictive Cardiomyopathy	Upward baseline shift	Fibrosis prevents relaxation; high filling pressure
Hypertrophic Cardiomyopathy	Left shift	↑ Contractility

01:12:06

FRANK-STARLING CURVE

FMGE 2019, 2020, 2021, 2023
NEET PG 2018, 2019, 2020
INICET 2021, 2022

- Graph: X-axis = EDV (Preload); Y-axis = Stroke Volume / Contractility
- Frank-starling Law: ↑ Length (EDV) → ↑ Contractility (up to a physiological limit)
- Normal Curve: Shows proportional increase.
- Exercise (Sympathetic): Curve shifts Up and Left (↑Contractility).
- Heart Failure: Curve drops/flattens (Low SV despite high EDV).



Important Information

- Frank-Starling Law: ↑EDV →↑Contractility.
- Bowditch Effect: ↑ Heart Rate →↑ Contractility.
- Anrep Effect: ↑ Afterload →↑ Contractility

Yourwish

Heart Failure Management & Frank-starling Curve Shifts

Treatment	Mechanism	Effect on Preload	Effect on Afterload	Effect on Contractility	Curve Shift
Digoxin Therapy	Increases myocardial contractility	No change	No change	↑ Contractility	Pure upward shift
Diuretics	Excretes water → reduces circulating volume	↓ Preload (↓ EDV)	No change	No change	Pure leftward shift along the curve
ACE Inhibitors	Reduce preload and afterload	↓ Preload	↓ Afterload	—	Upward and leftward shift (↑ Stroke Volume / Cardiac Output)

01:17:38

BLOOD PRESSURE REGULATION

INICET 2018, 2019, 2020, 2022, 2023
FMGE 2019, 2022, 2023, 2025 NEET PG 2022

Time Frame	Mechanism
Rapid Acting (Seconds-Minutes)	• Baroreceptor reflex (Most rapid)
	• Chemoreceptor reflex (2nd most rapid)
	• CNS ischemic response (2nd most potent)
	• Epinephrine from adrenal medulla
Intermediate (Hours)	• Capillary fluid shift
	• Stress relaxation
	• Renin - Angiotensin vasoconstriction phase

Long-Term (Days-Months)	• Renin-Angiotensin-Aldosterone System
	  ○ Most potent
	  ○ Gain is infinity

	• ADH
	• ANP
	• Renal fluid regulation

Baroreceptor and Chemoreceptor Reflex

01:21:11

Baroreceptor Reflex	• Located in the adventitial layer of Carotid sinus and Aortic arch wall
	• Type: Stretch receptors (Mechanoreceptors)
	• Stimulus: ↑ Blood Pressure (BP)
	• Sensitivity
	  ○ Detects: Systolic, Diastolic, Mean Arterial Pressure (MAP), and Pulse Pressure
	  ○ Most sensitive to: Pulse Pressure > MAP

	• Innervation (Afferent)
	  ○ Carotid sinus → Glossopharyngeal nerve (9th CN)
	  ○ Aortic arch → Vagus nerve (10th CN)
	• Center: Medulla
	• Effector: Sympathetic and Parasympathetic systems
	• Range of Activation: BP > 50 -200mmHg
	
	Mechanism of Action (High BP)
	• High BP
	  ○ ↑ BP → Stretch → Activation of Nucleus Tractus Solitarius (NTS)
	  ○ NTS → activates Caudal Ventrolateral Medulla (CVLM)
	  ○ CVLM → inhibits Rostral Ventrolateral Medulla (RVLM) (Vasomotor Center)
	  ○ ↓ RVLM → ↓ Sympathetic outflow → ↓ Heart Rate (HR) → ↓ Contractility → ↓ Stroke Volume
	• Simultaneously:
	  ○ NTS → stimulates Cardiac Inhibitory Center (CIC)
	  ○ ↑ CIC → ↑ Parasympathetic outflow → ↓ HR
	• Result: Normalization of BP

Chemoreceptor Reflex	• Location
	  ○ Carotid body (small tissue near carotid sinus, outside vessel wall)
	  ○ Aortic body (outside aortic arch wall)
	• Carotid and aortic body contain Glomus cell type 1
	  ○ Glomus cell type 1 contains oxygen-sensitive potassium channels
	  ○ Whenever there is ↓ PO_2 (Hypoxia), ↑ PCO_2 (Hypercapnia), ↑ H^+ (Acidosis) → stimulates it
	• Afferent and center same as Baroreceptor (9th/10th CN → Medulla)
	• Activation Range: Mean aortic pressure < 70 mmHg
	
	Mechanism of Action
	• Stimulates RVLM (Vasomotor Center) directly → ↑ Sympathetic system → ↑ BP
	• Effect on Heart Rate (Direct effect):
	  ○ Stimulation of CIC → ↑ Parasympathetic → ↓ HR (Bradycardia)
	  ○ Severe stimulation (Severe Hypoxia): ↑ Ventilation → Lung stretch receptors activated → ↑ HR (Tachycardia)

Cns Ischemic Response

- Activation: BP < 50 mmHg
- Mechanism
  - Massive activation of Sympathetic system
  - Result: ↑↑ BP, ↑↑ HR

Cushing Reflex

- Type: Specialized CNS ischemic response

- Mechanism

↑ Intracranial Tension (ICT) / CSF pressure
↓
Compression of brain microvasculature
↓
Brain hypoxia
↓
Activates CNS ischemic response
↓
↑ BP (Hypertension), Reflex bradycardia (activates baroreceptors)

- Cushing's Triad
  - Hypertension
  - Bradycardia
  - Irregular ventilation

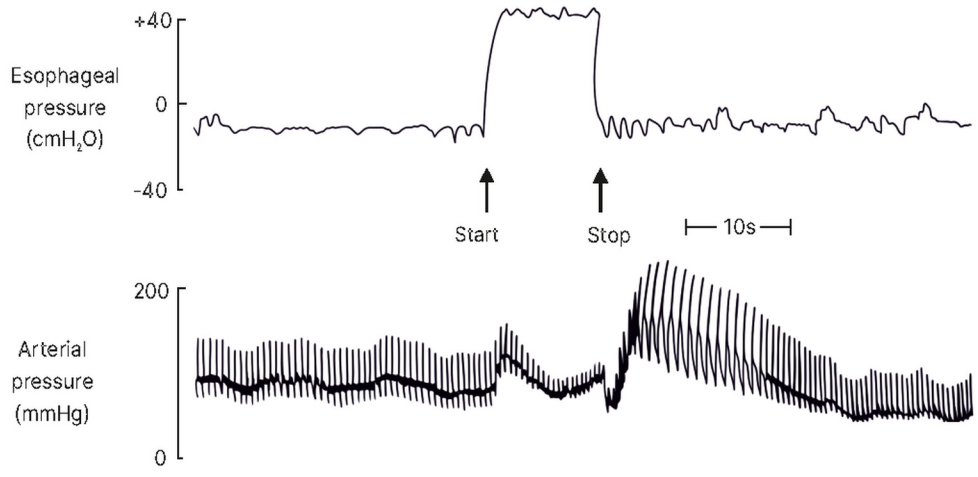
Other Reflexes

1:30:00

Feature	Bainbridge Reflex	Bezold-Jarisch Reflex
Receptors	Stretch receptors of atria	• Ventricular wall
Activation / Activator	Stretch on RA (increased blood volume)	• Veratridine, serotonin, capsaicin, nicotine, bradykinin, ANP
Response	Stimulates heart rate (↑ HR)	• Bradycardia, hypotension, coronary vasodilation • Apnoea followed by hyperventilation
Clinical Scenario		• Coronary angiography • Reperfusion therapy after MI

VALSALVA MANEUVER

01:31:30



- Forceful expiration against a closed glottis.
- Effect: Sustained ↑ intrathoracic pressure (10–15 seconds) followed by release

Phases of Blood Pressure (BP) Change

PHASE	STAGE	BP CHANGE	REASON
1	Onset of Strain	↑ BP	Compression of aorta and pulmonary circulation cause extra blood to LV
2	Continued Strain	↓ BP	Sustained compression → ↓ venous return **Note:** Murmurs are evaluated in this phase
3	Release of Strain	Further ↓ BP	Sudden dilation of pulmonary vessels → blood pools in pulmonary circulation → ↓ left ventricular filling
4	Recovery	↑↑ BP (Overshoot)	Sympathetic activation → strong vasoconstriction → ↑↑ venous return

IMPORTANT FORMULAS

01:36:41

Cardiac Output (FICK'S LAW)

- Formula: CO= Oxygen Consumption / (Arterial O_2-Venous O_2)
- Normal Values
  - O_2 Consumption: 250 ml/min
  - Arterial O_2: 20 ml/dl (0.2 ml/ml)
  - Venous O_2 (Mixed venous / Pulmonary artery): 15 ml/dl (0.15 ml/ml)
- Calculation
  - CO = 250/(0.2-0.15) = 250/0.05 = 5000 ml/min = 5 L/min

Resistance (HAGEN-POISEUILLE LAW)

Q. Calculate change of resistance in a vessel after 50% decrease in vessel radius.

- Formula: $R=8\eta L / \pi r^4$
  - η (Eta) = Viscosity
  - L = Length
  - r = Radius
- Key Relationship
  - $R \propto 1/r^4$
- Example
  - If radius decreases by 50% (becomes 1/2) → Resistance increases 16 times
  - Flow decreases 16 times (Flow is inversely proportional to resistance)

Reynolds number (turbulence)

- Formula: $Re=\rho Dv/\eta$
  - ρ = Density
  - D = Diameter
  - V = Velocity
  - η = Viscosity
- Interpretation
  - Re > 3000 → Turbulent flow
  - Re < 2000 → Laminar flow
- Key Determinant of turbulence of blood flow: Velocity

Yourwish

TYPES OF BLOOD VESSEL

01:42:01

INICET 2018, 2019, 2020, 2022, 2023
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NEET PG 2022

Vessel classifications

Vessel Type	Description / Example
Windkessel Vessels	• Contain large elastic tissue (Aorta, major arteries)
Conduit Vessels	• Conduct blood • E.g., Arteries
Resistance Vessels	• Exert maximum resistance • E.g., Arterioles
Exchange Vessels	• Site of exchange • E.g., Capillaries
Capacitance Vessels	• Store large amount of blood • E.g., Veins
Shunt Vessels	• Present at arteriovenous anastomosis • Have thick muscular wall • Sympathetic innervation • Located in tip of finger and earlobe

Important Table

Organ	Blood Flow (ml/min)	Blood Flow (ml/100g/min)	Oxygen Consumption (ml/min)	Oxygen Consumption (ml/100g/min)	A-V O_2 difference (ml/min)	% of total Cardiac Output (%)
Liver	1500	57.7	51	2	34	28
Kidney	1260	420	18	6	14	23
Brain	750	54	46	3.3	62	14
Heart	250	110	29	9.7	114	4.7
Skeletal Muscle	840	27.7	50	0.2	60	15.6
Skin	462	12.8	12	0.3	25	8.6

- Maximum total blood flow: Liver
- Maximum blood flow per 100 g: Kidney
- Maximum total O_2 consumption: Liver
- Maximum O_2 consumption per 100 g: Heart
- Maximum A-V O_2 difference: Heart

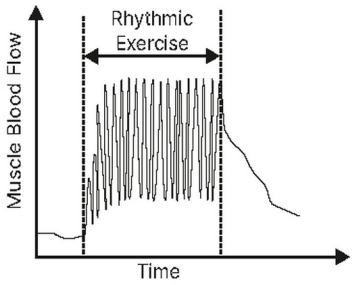
EXERCISE PHYSIOLOGY

01:44:40

MCQ

Effect of isotonic exercise on blood flow in the calf muscle during strong rhythmic contractions is shown below. The blood flow was much less during contraction than between contractions. Rhythmic increase in blood flow is mainly caused by:

A. Increase in arterial blood pressure
B. Metabolic vasodilation
C. Sympathetic mediated vasodilation
D. Cholinergic sympathetic system



Answer: **B**

Isotonic exercise

- Examples: Running, Cycling, Dumbbell curls

Mechanism of Increased Blood Flow

- Primary Cause:

Metabolite-mediated vasodilation (Adenosine, K^+, H^+, ATP)

↓

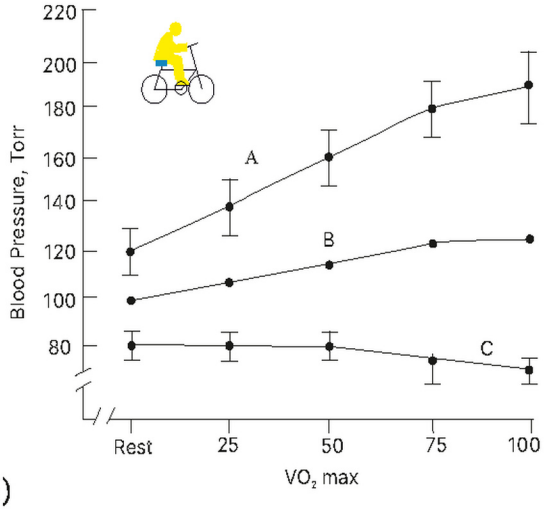
Dilation of arterioles + Opening of precapillary sphincters

- Secondary Causes:
  - ↑ BP pushing blood
  - Sympathetic β_2-mediated vasodilation
- **Note:** Cholinergic sympathetic vasodilation occurs in animals (dogs/cats), not humans

MCQ

Recording of blood pressure (SBP, DBP, MAP, PP) during isotonic exercise is done in a normal healthy person. Curve A, B and C represent:

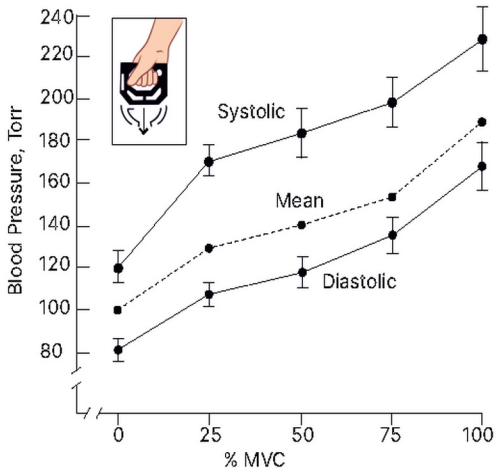
Option	Curve A	Curve B	Curve C
a)	MAP	SBP	DBP
b)	DBP	MAP	PP
c)	PP	SBP	MAP
d)	SBP	MAP	DBP



- During Isotonic Exercise
  - Heart Rate: ↑ (Psychic stimulation, Sympathetic activity, EP/NE)
  - Stroke Volume: ↑ (↑ Contractility + ↑ Venous return via vasoconstriction elsewhere)
  - Cardiac Output: ↑
  - Systolic BP: ↑
  - Total Peripheral Resistance (TPR): ↓ (due to muscle vasodilation)
  - Diastolic BP: Same or ↓ (never increases)
  - Mean Arterial Pressure (MAP): Slight ↑

Isometric exercise

- Example: Weightlifting (holding weight above head)
- Mechanism: Sustained muscle contraction compresses vessels
- Hemodynamics
  - Heart Rate: ↑
  - Stroke Volume: Constant (thoracic compression prevents increased venous return)
  - Cardiac Output: ↑ (due to HR)
  - TPR: ↑ (compression of vessels in contracted muscles)
  - Diastolic BP: ↑ (never decreases)
  - Systolic BP: ↑↑
  - Mean Arterial Pressure: ↑↑



SUMMARY

01:55:24

- Resting membrane potential of cardiac muscle is: -90 mV
- Normal AV nodal delay is: 100 ms (60 to 125 ms)
- When the HR is 70 beats per minute, cardiac cycle duration is: 0.8 sec
- Best index for preload is: EDV (EDP)
- Best index for afterload is: Mean aortic pressure (MAP) > TPR
- Carotid baroreceptor is most sensitive to: Pulse pressure > MAP
- Main site of peripheral vascular resistance is: Arterioles
- Highest total cross-sectional area in vascular system: Capillaries

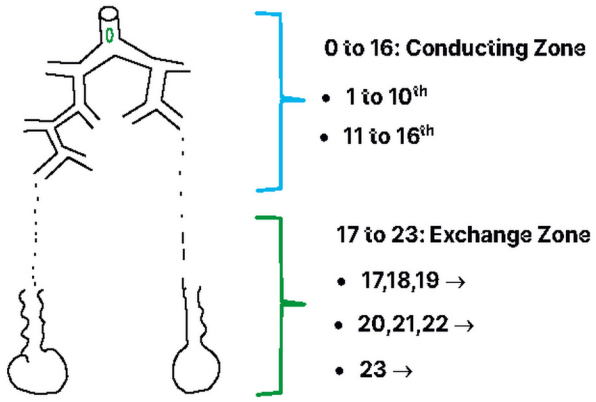
5. RESPIRATORY PHYSIOLOGY

MECHANICS OF VENTILATION

Weibel's Classification

00:00:40

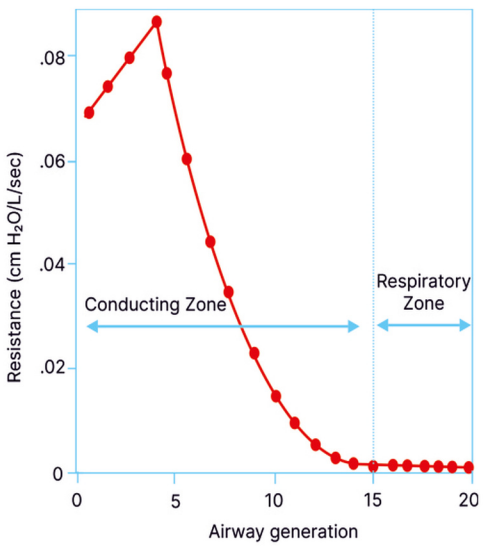
- Entire respiratory tree (Trachea → Alveoli) = 23 divisions



Conducting Zone	Exchange Zone
• Division 0-16 ○ No gas exchange ○ Only conduction ○ Contains Anatomical dead space → Volume ≈ 150 mL → Measurement: Single breath nitrogen washout method (Fowler's method) ○ **Division 1-10:** Bronchi. ○ **Division 11-16:** Terminal Bronchioles	• Division 17-23 ○ Site of Gas exchange ○ Division 17-19: Respiratory Bronchioles (Gas exchange begins) ○ Division 20-22: Alveolar Ducts ○ Division 23: Alveoli

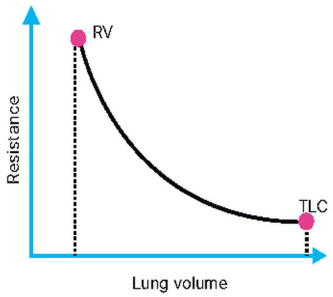
AIRWAY RESISTANCE

- Maximum Resistance:
  - Occurs at weibel division 4-5 (Medium to large bronchi/Lobar & Segmental bronchi, 2-4mm diameter)
- Resistance at Alveoli: Minimal due to parallel arrangement.
- FRC: Functional Residual capacity or Resting Lung volume
- TLC (Total Lung Capacity)
  - Lung volume after maximal inspiration from FRC
- RV (Residual Volume)
  - Minimum air remaining after forceful expiration from FRC



Yourwish

- Airway Resistance vs Lung Volume
  - Maximum resistance → at Residual Volume (RV)
  - Minimum resistance → at TLC
  - As lung volume increases from RV → TLC:
    → Airway diameter ↑
    → Resistance ↓



Velocity of Airflow

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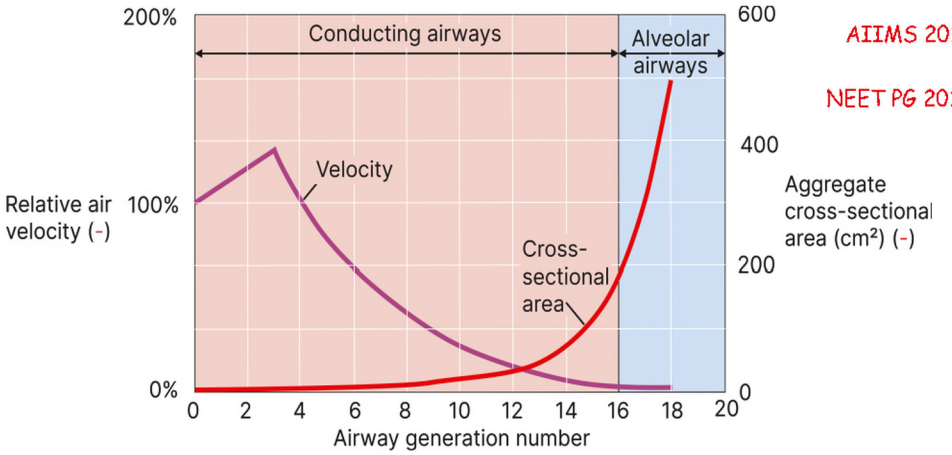


- Velocity ∝ 1 / total cross-sectional area
- Maximum velocity of airflow: Around Weibel division 3 (Bronchi)
  - Cross-sectional area is minimum at division 3

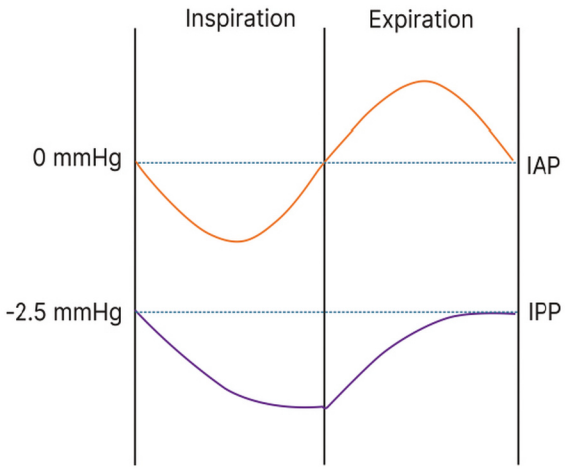
Turbulence of Airflow

00:09:03

- Determined by Reynolds number
  - Depends on velocity + diameter
- Maximum turbulence: Trachea
  - Due to large diameter + high velocity

PRESSURE CHANGES DURING NORMAL BREATHING

0:09:52



Intra-pleural Pressure	Intra-alveolar Pressure

• Always negative during normal breathing
• At rest: -2.5mmHg/-5 cm H_2O
• Inspiration: becomes more negative
  ○ Maximum negative value: -6 mmHg
• Expiration: returns to resting value
• Never becomes positive in normal respiration
	• At rest: 0 mmHg
	• Inspiration:
	  ○ Becomes negative
	  ○ Maximum negativity at mid-inspiration
	• Expiration:
	  ○ Becomes positive
	  ○ Maximum positivity at mid-expiration
	• Maximum negative value: -1 mmHg (inspiration)
	• Maximum positive value: +1 mmHg (expiration)

- Transpulmonary Pressure = Alveolar pressure - Intrapleural pressure
  - It is always positive

VENTILATION-PERFUSION (V/Q)

00:14:10

- Pulmonary Ventilation (minute ventilation) = Tidal Volume × Respiratory Rate
- Alveolar Ventilation = (Tidal Volume - Dead space) × RR
  - Normal ≈ 4.2 L/min
- Perfusion = Cardiac Output ≈ 5.4 L/min
- Normal V/Q Ratio → 4.2 / 5.4 = 0.8

Distribution in Upright Posture

- Ventilation max → Base
- Perfusion max → Base
- V/Q ratio max → Apex

Zone	Ventilation	Perfusion	V/Q
Apex	↓	↓↓↓	3.3
Middle	Average	Average	0.8
Base	↑	↑↑↑	0.6

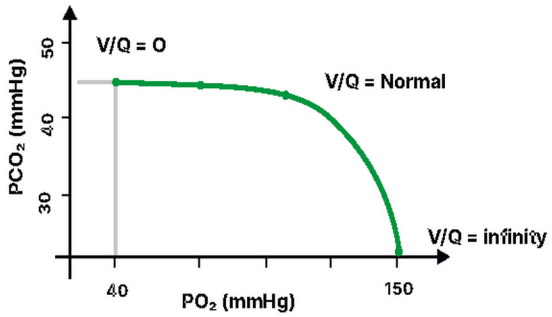
Alveolar Gas Values (upright Position)

Region	P_AO_2	P_ACO_2
Apex	132 mmHg	28 mmHg
Middle	100 mmHg	40 mmHg
Base	89 mmHg	42 mmHg

- Apex has highest O_2 tension
- Explains TB preference for lung apex

Extreme V/Q Conditions

00:19:59



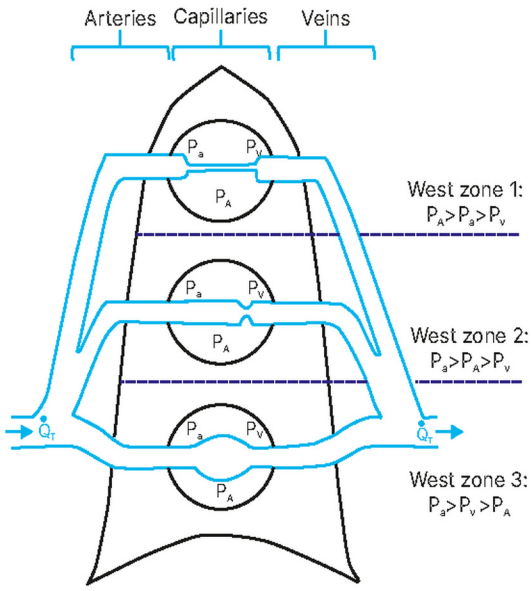
V/Q = 0 (No ventilation, perfusion present)

- Example: airway obstruction
- Alveolar gas = venous blood gas composition
  - $PO_2 \approx 40$ mmHg
  - $PCO_2 \approx 46$ mmHg

V/Q = ∞ (Ventilation present, no perfusion)

- Example: pulmonary embolism
- Alveolar gas ≈ inspired air
  - $PO_2 \approx 150$ mmHg
  - $PCO_2 \approx 0.3$mmHg

Perfusion Zones of Lung



Zone 1:
- No Blood flow
- (does not exist in normal lung)

Zone 2:
- Intermittent Blood flow
- (apex and the hilum)

Zone 3:
- Continuous blood flow
- (below the level of the hilum)

Zone	Pressure Relationship	Blood Flow	Key Feature	Location	Seen In
Zone 1	PA > Pa > Pv	No blood flow	Not present in normal lung		Hypovolemia, Cardiogenic shock, Positive pressure ventilation

Zone 2	Pa > PA > Pv	Intermittent flow	"Waterfall effect"	Apex → Hilum	—
Zone 3	Pa > Pv > PA	Continuous flow	—	Located below the level of hilum	—

COMPLIANCE CURVE

00:30:47

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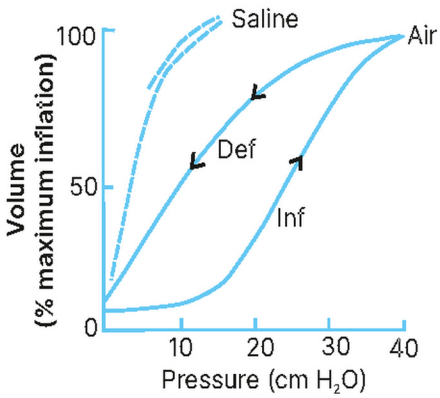
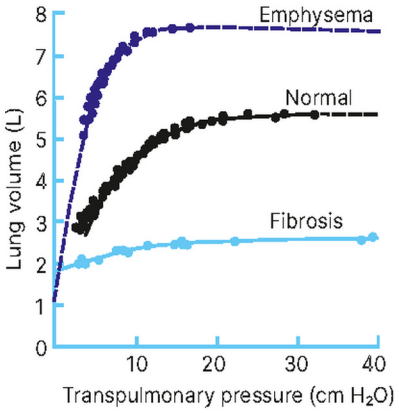
COMPLIANCE CURVE 1

- Compliance = ΔV / ΔP
- Change in lung volume per unit change in pressure
- Opposing forces preventing expansion of alveoli:
  1. Surface tension (2/3)
  2. Elastic recoil (1/3)
- Inflation Curve (expansion of lung)
  - Initial flat (high surface tension) → Rapid expansion → Final plateau
- Deflation Curve
  - Lies above inflation curve
  - Because elastic recoil + surface tension assist deflation
- Difference between inflation & deflation compliance curve = Hysteresis
  - Main cause of hysteresis → Surface tension
- Saline water-Filled Lung
  - Air-water interface removed
  - Surface tension ≈ 0
  - No hysteresis
  - Compliance higher than normal lung

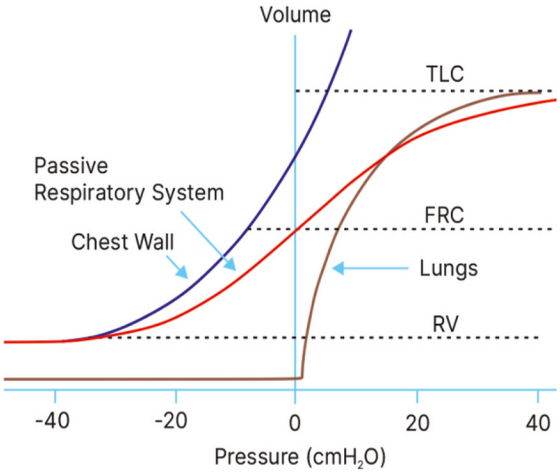


COMPLIANCE CURVE 2

- High Compliance
  - Seen when elastic tissue is destroyed→ Emphysema
    Or
  - Increased surfactant (Surface tension ↓)
- Low Compliance:
  - ↑ Surface tension → Hyaline membrane disease (↓ surfactant) or IRDS
  - Fibrosis of Lung (Restrictive disease)



COMPLIANCE CURVE 3



Structure	Neutral Volume (Pressure = 0)	Key Feature
Lung alone	~500 mL (Minimal volume)	Collapses
Chest wall alone	~70% of TLC	Expands outward
Lung + Chest wall	FRC	Normal resting state

SPIROMETRY

00:46:00

Static Lung Volumes

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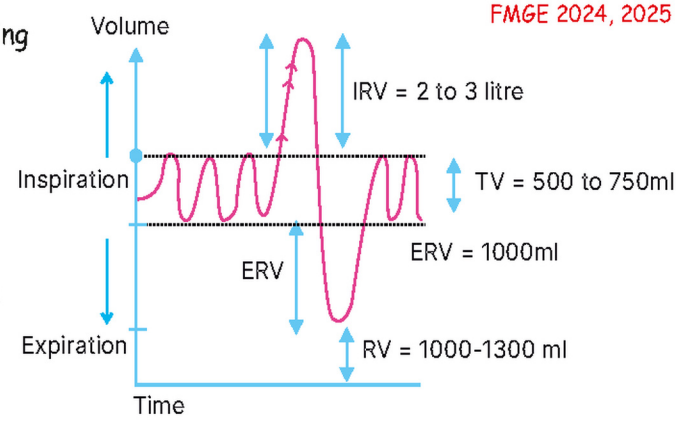
- Tidal Volume (TV):
  - Volume of air inhaled or exhaled during normal breathing
  - 500-750 ml
- Inspiratory Reserve Volume (IRV):
  - Extra air inhaled forcefully after a normal inspiration
  - 2-3 L
- Expiratory Reserve Volume (ERV):
  - Extra air exhaled forcefully after a normal expiration
  - 1000 ml
- Residual Volume (RV):
  - Air remaining in lungs after forceful expiration
  - 1000-1300 ml
  - Cannot be measured by spirometry



Residual Volume Measurement

- Helium dilution
- Nitrogen washout
- Body plethysmography (Best)

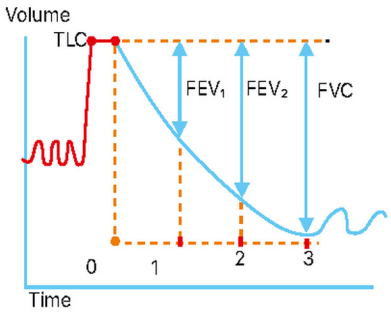
Lung Capacities

- Inspiratory Capacity: IRV + TV
- Vital Capacity (VC): IRV + TV + ERV
- Functional Residual Capacity (FRC): ERV + RV (Resting volume of lung)
  - Cannot be measured by spirometry
- Total Lung Capacity (TLC): VC + RV
  - Cannot be measured by spirometry

Dynamic Lung Volumes

00:50:54

- **Forced Vital Capacity (FVC):** Total volume exhaled forcefully after deep inspiration
- **FEV1**: Forced Expiratory Volume in 1 second
  - FEV1/ FVC = ~80%
- **FEV2**: Volume exhaled in 2 seconds
  - FEV2/ FVC = ~95%
- **FEV3**: Volume exhaled in 3 seconds
  - FEV3/FVC = ~99-100%
- **Tiffeneau Index**: FEV1/FVC ratio (Normal ~80%)



Obstructive Vs Restrictive Disease

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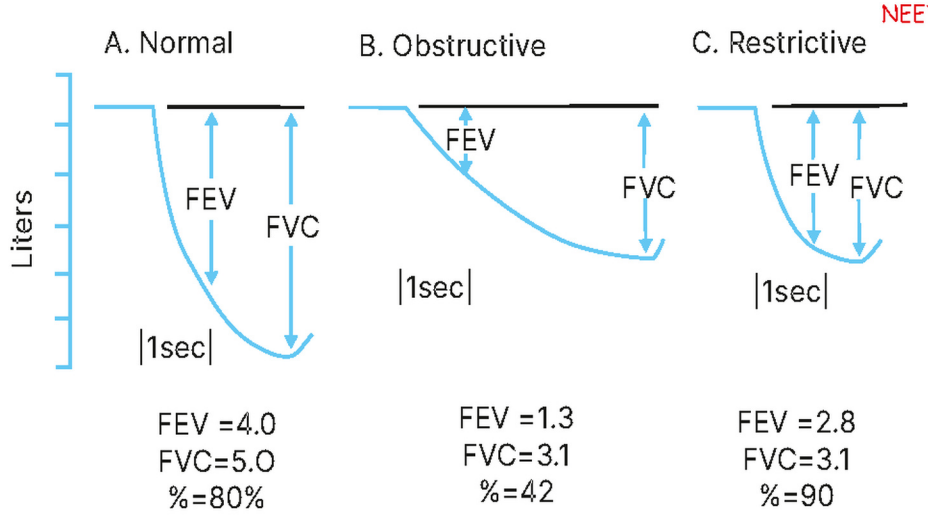


FEV =4.0
FVC=5.0
%=80%

FEV =1.3
FVC=3.1
%=42

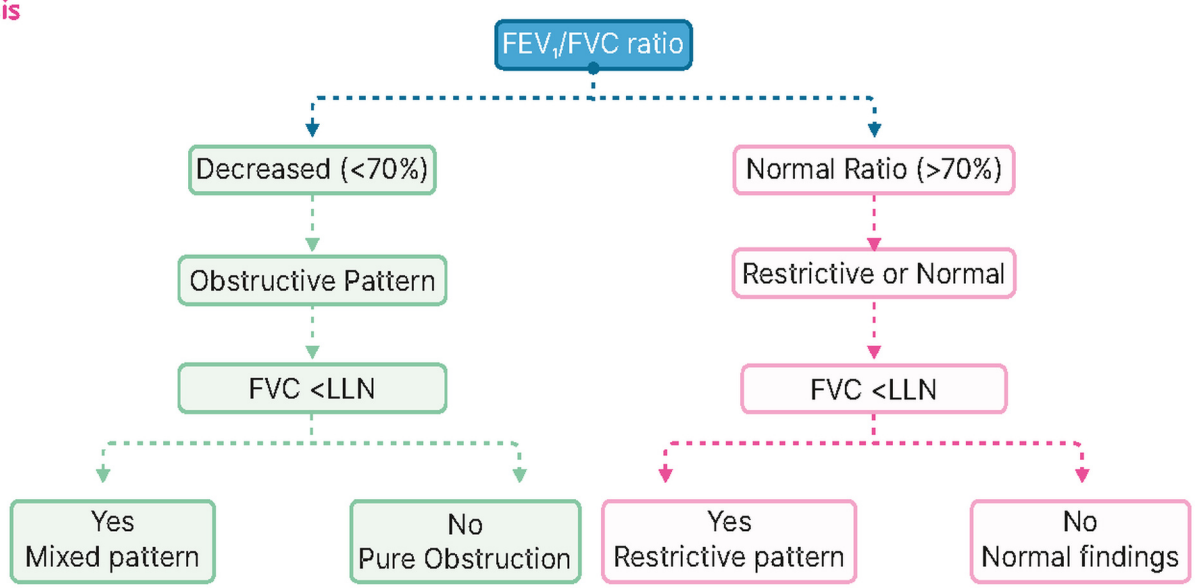
FEV =2.8
FVC=3.1
%=90

Obstructive Disease (e.g., Asthma, COPD/Emphysema)	Restrictive Disease (e.g., Fibrosis)
• Pathology: Airway obstruction/collapse leads to slow expiration. • FEV1: Severely decreased. • FVC: Normal or slightly decreased. • FEV1/FVC Ratio: Significantly Decreased (<70%).	• Pathology: Lung expansion is restricted • FVC: Significantly Decreased (Hallmark) • FEV1: Decreased (proportionate to FVC). • FEV1/FVC Ratio: Normal or Increased

Parameter	Emphysema (Obstructive)	Asthma (Obstructive)	Parenchymal - Fibrosis (Restrictive)	Extra-parenchymal - MG (Restrictive)
FEV_1	↓↓ 35% (38% post-b.d)	↓↓ 35% (75% post-b.d)	↓ 75%	↓ 60%
FVC	↓ 60%	↓ 90%	↓↓ 60%	↓↓ 60%
FEV_1/FVC Ratio	Reduced	Reduced	Increased	Normal or Variable
TLC	↑ 130%	Normal (100%)	↓ 60%	↓ 75%
RV	↑↑ 310%	↑ 120%	↓ 60%	↑↑ 120%

- Reversibility Criteria
  - ≥10% increase in FEV_1 percent predicted 15 min after β2-agonist (new)
  - 12% increase in baseline FEV_1 with ≥200 mL change (old)

Diagnosis



FLOW VOLUME LOOP

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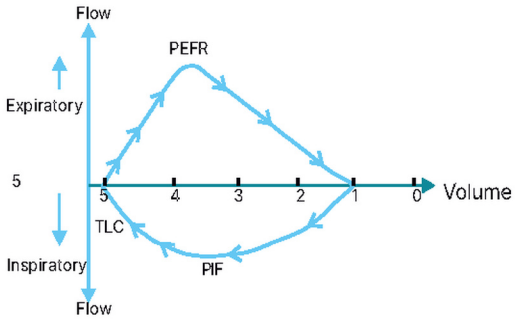
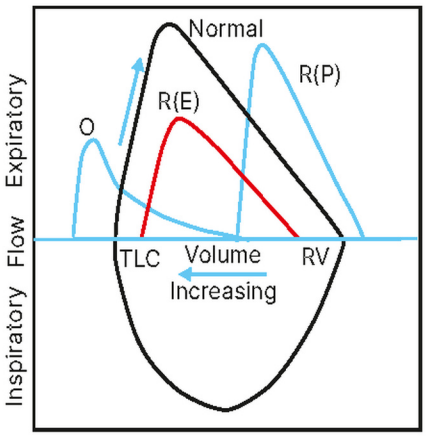
Normal Flow Volume Loop



- X-axis → Volume
- Y-axis → Flow
- Direction of Plotting:
  - Inspiration: Plotted in the downward direction.
  - Expiration: Plotted in the upward direction.
- Inspiration:
  - The subject takes a deep breath → Flow increases to a peak (Peak Inspiratory Flow) and then decreases
  - Lung volume increases from Residual Volume to Total Lung Capacity
- Expiration:
  - From maximum inspiration, the subject exhales forcefully
  - Flow increases rapidly to a high peak (Peak Expiratory Flow Rate - PEFR) and then decreases linearly until the lungs are empty
- Key Volumes:
  - TLC (Total Lung Capacity): The point reached at the end of deep inspiration (e.g., 5 Liters)
  - RV (Residual Volume): The volume remaining in the lungs at the end of forceful expiration (e.g., 1 Liter)
  - FVC (Forced Vital Capacity): Calculated as TLC - RV (e.g., 5L - 1L = 4 Liters)

Abnormal Flow Volume Loop



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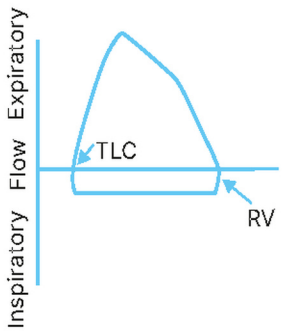
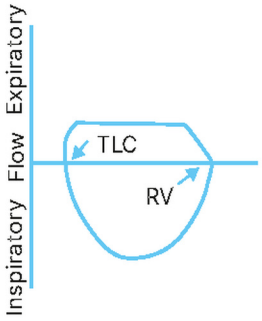
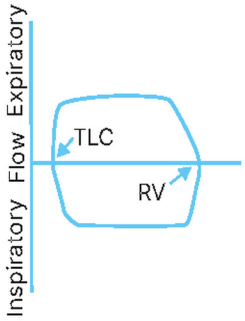
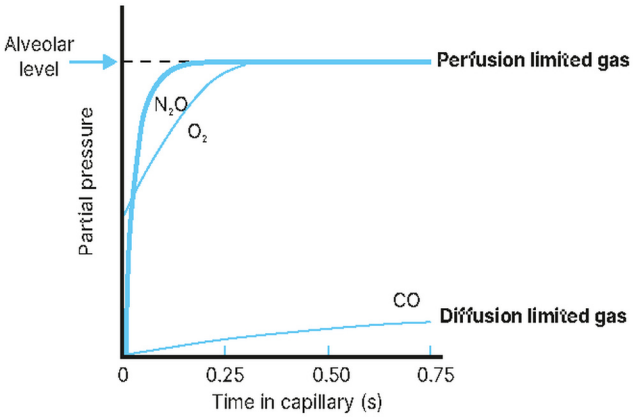
1. **Obstructive Disease (e.g., COPD):**
   - Shape: The expiratory portion shows a deep invagination or "scooped out" pattern.
   - Volume: TLC is typically higher than normal (hyperinflation).
2. **Restrictive Disease:**
   - Shape: The loop appears narrow (low volume loop).
   - Differentiation:
     → Parenchymal Restriction (e.g., Fibrosis): Narrow loop with decreased Residual Volume (lower than normal)
     → Extra-Parenchymal Restriction (e.g., Chest wall issues): Narrow loop with increased Residual Volume (higher than normal)
3. **Upper Airway Obstruction:**

Variable Extrathoracic Obstruction	Variable Intrathoracic Obstruction	Fixed Obstruction
		
• E.g., Vocal cord paralysis, Enlarged Lymph nodes, Flabby Pharyngeal muscle • The Inspiratory limb is flattened.	• E.g., M/c caused by Tumors, Tracheomalacia • The Expiratory limb is flattened	• Both inspiratory and expiratory limbs are flattened (box-shaped) • E.g., Foreign bodies, Scarring of the airway, Enlarged Thyroid

DIFFUSION-LIMITED & PERFUSION-LIMITED GASES

01:16:25

- Gas transport from the alveoli to the pulmonary capillary is analyzed based on how partial pressure changes during the blood transit time (0.75 seconds)



Diffusion Limited Gas (Example: Carbon Monoxide - CO)

- CO has an affinity for Hemoglobin (Hb) 250 times higher than Oxygen.
- As CO diffuses, it immediately binds to Hb chemically. Because it binds, it does not exert partial pressure in the plasma

Yourwish

- The partial pressure curve remains flat (near zero) across the capillary
- Oxygen transport in a hypoxic patient behaves as diffusion-limited

Perfusion Limited Gas (Example: Nitrous Oxide - N2O)

- N2O is an inert gas and does not combine with Hemoglobin; it stays dissolved.
- Partial pressure rises rapidly to equalize with alveolar pressure.
- To transport more gas, you must increase blood flow (fresh blood).
- Oxygen transport in a normal lung is perfusion-limited.

OXYGEN-HEMOGLOBIN DISSOCIATION CURVE (OHDC)

01:20:57

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- X-axis = Partial Pressure of Oxygen (pO2)
- Y-axis = Saturation of Hemoglobin.
- Shape: Sigmoid (S-shaped)
  - D/t Cooperative Binding (The binding of the first oxygen molecule facilitates the binding of subsequent molecules)
- Key Values
  - P50: The partial pressure required for 50% Hb saturation.
    → Normal value: 23-26 mm Hg.
  - Venous Blood: At pO2 of 40 mm Hg, saturation is roughly 75%
  - Arterial Blood: At pO2 of 98 mm Hg, saturation is roughly 97%
- Oxygen Carrying Capacity
  - 100% Saturation: 1 gram of Hb carries 1.34 ml of Oxygen.
  - 97% Saturation (Normal physiological state): 1 gram of Hb carries approx 1.29 ml of Oxygen

Shifting of The Curve

- The curve can shift right or left, changing the affinity of hemoglobin for oxygen

RIGHT SHIFT (BOHR EFFECT):	• Characteristics: Increased P50, decreased affinity for oxygen, increased unloading of oxygen at the tissues. • Causes: ○ ↑ Temperature ○ ↑ CO2 ○ ↑ H+ ○ ↑2,3-DPG: → Chronic hypoxia → Exercise → Anemia → ↑ Hormones like thyroid hormone, GH, and androgens → Inosine, Pyruvate & phosphate of RBC
LEFT SHIFT:	• Decreased P50, increased affinity for oxygen (hemoglobin holds onto oxygen tightly), decreased unloading. • Causes: Hypocapnia, Alkalosis, Hypothermia.

- Special Pathological/Physiological Causes:
  - Fetal Hemoglobin (HbF):
    → Contains Gamma chains instead of Beta chains
    → Since 2,3-DPG binds to Beta chains, HbF cannot bind 2,3-DPG effectively, resulting in higher oxygen affinity.
  - Stored Blood:
    → Cold storage and acidic preservative solutions deplete 2,3-DPG, causing a left shift.
  - Carbon Monoxide (CO) Poisoning:
    → CO binds to hemoglobin and forces the remaining oxygen binding sites into a high-affinity state, preventing oxygen release.
  - Methemoglobinemia

REGULATION OF RESPIRATION

01:29:00

- Regulation of respiration
  - Neural regulation
  - Chemical regulation

Neural Regulation of Respiration

- Respiration is controlled by two distinct neural mechanisms:

Voluntary Control:

- Mediated by the Cerebral Cortex
- Allows conscious control of breathing (e.g., holding breath).

Important Information

Clinical Condition: Ondine's Curse

- Aka Congenital Central Hypoventilation Syndrome.
- Pathology:
  - The automatic control center (Medulla) is damaged (via tumors, bulbar polio, or congenital defects), but voluntary control remains intact
  - Result: The patient breathes while awake but stops breathing immediately upon falling asleep

Automatic Control:

- Mediated by the Pons and Medulla
- Functions during sleep and unconsciousness

Pons (Modulation):

- Pneumotaxic Center (Upper Pons): Controls the rate of respiration
- Apneustic Center (Lower Pons): Controls the depth of respiration

Medulla (Rhythm Generation):

- Ventral Respiratory Group (VRG):
  - Has four subdivisions

→ Botzinger complex
→ Pre-Bötzinger Complex, which is the Pacemaker of Respiration
→ Rostral VRG
→ Caudal VRG

- Dorsal Respiratory Group (DRG):
  - Acts as a sensory integration center, receiving input from peripheral receptors (Vagus nerve) and relaying it to the VRG

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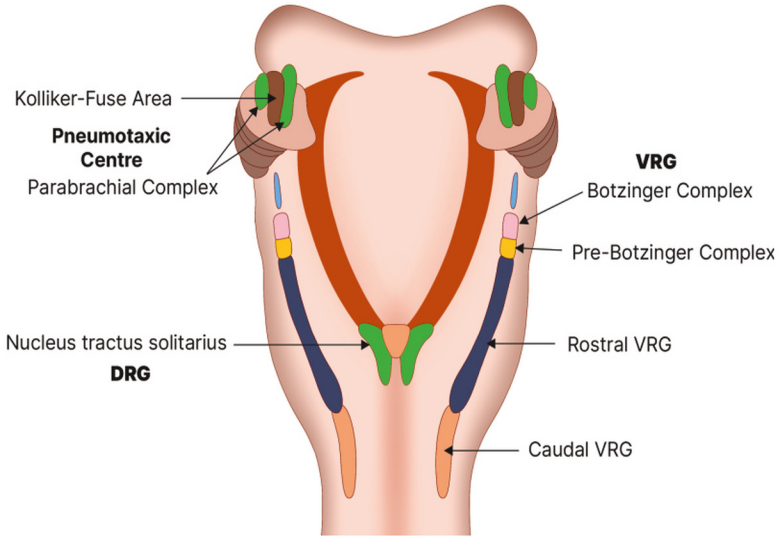
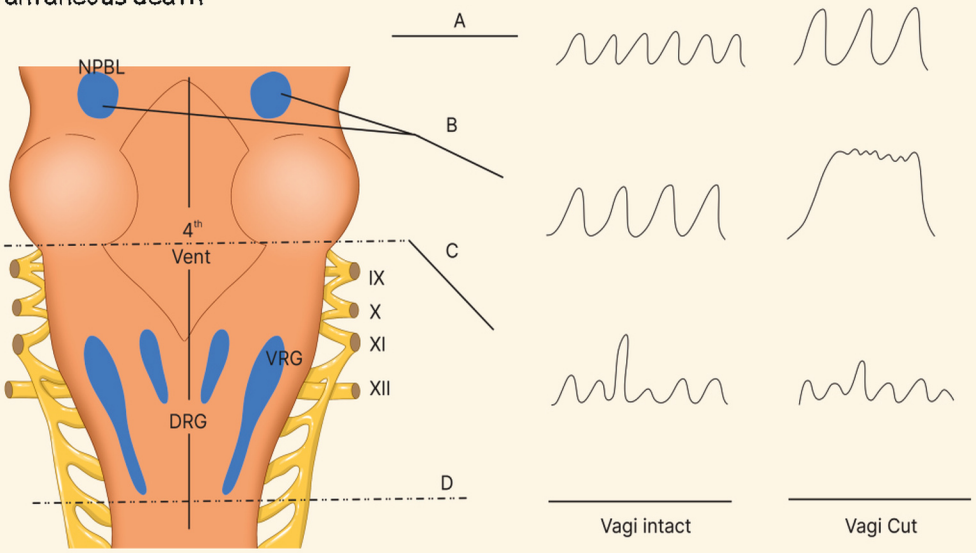


Important Information

Sectioning of Brain at different levels

1. Cut Above Pons:
   - Vagus intact: Normal respiration (Voluntary control is lost, but automatic is intact)
   - Vagus Cut: Slow and deep breathing
2. Cut at Mid-Pons (removing Pneumotaxic Center):
   - Vagus Intact: Slow and deep breathing
   - Vagus Cut: Apneusis occurs (Deep sustained inspiration followed by an inspiratory spasm/pause)
3. Cut Above Medulla (removing all Pontine centers):
   - Result: Irregular respiration (Gasping). The medullary pacemaker works, but rate and depth are unregulated
4. Cut Below Medulla:
   - Result: Instantaneous death



Chemical Regulation Of Respiration

01:41:08

A. Peripheral Chemoreceptors

- Location: Carotid Bodies and Aortic Bodies
- Mechanism: Glomus Type 1 cells contain oxygen-sensitive potassium channels.
- Stimuli:
  1. Hypoxia (Decreased pO2) - Primary direct stimulus.
  2. Hypercapnia (Increased CO2) - Most sensitive stimulus.
  3. Acidosis (Increased H+).

B. Central Chemoreceptors

- Location: Ventral surface of the Medulla.
- Mechanism: Stimulated only by H+ ions in the CSF/Brain Interstitial Fluid

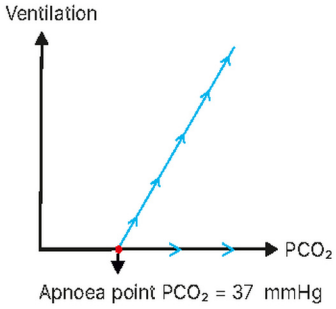
Important Information

- H+ in the blood cannot cross the Blood-Brain Barrier (BBB)
- However, CO2 crosses the BBB easily, enters the CSF, and produces H+ → Stimulus

Chemical Regulation of Ventillation

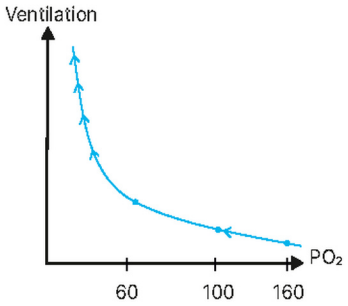
01:45:21

CO_2 vs Ventilation



- Relationship is linear
- ↑ $PaCO_2$ → ↑ Ventilation (strong respiratory drive).
  - Apnea Point: If arterial pCO2 drops below 37 mmHg, the respiratory drive ceases, and breathing stops (apnea) until carbon dioxide levels rise again.

O_2 vs Ventilation

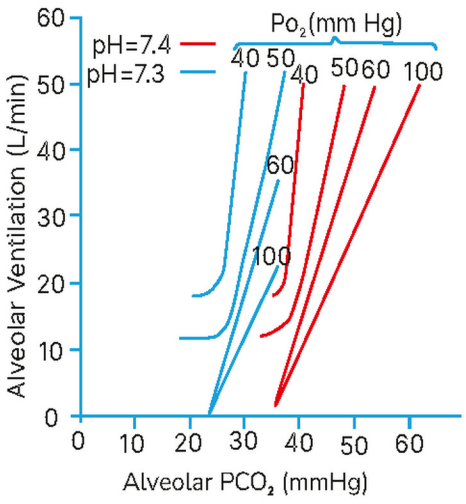


- Relationship is non-linear.
- PaO_2 160-60 mmHg → minimal change in ventilation
- PaO_2 < 60 mmHg → steep ↑ in ventilation (severe hypoxia activates peripheral chemoreceptors)

Combined Effects on Ventilation

Hypoxia + Hypercapnia

- Progressive Hypoxia + ↑ $PaCO_2$ → Left shift of ventilation curve
- Slope ↑ (ventilatory sensitivity increases).
- Apnea point ↔ (remains ~37 mmHg).
- Only sensitivity changes, not the apnea threshold



Acidosis + Hypercapnia / Hypoxia

- If Acidosis (low pH) is present (e.g., pH drops from 7.4 to 7.3), the Apnea Point shifts to the left.
- The curves remain parallel to the non-acidotic curves, but ventilation starts at a lower pCO2

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HIGH ALTITUDE CHANGES

01:52:00

Acclimatization

- When ascending to high altitude, the body faces Hypoxic Hypoxia. The body adapts through Acclimatization
- Physiological Changes
  - ↑ Ventilation
  - ↑ Diffusion capacity
  - ↑ RBC count (EPO)
  - ↑ Capillaries
  - ↑ Mitochondria
  - ↑ Cytochrome oxidase

Change in Ventillation

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- Hypoxia → Peripheral chemoreceptor stimulation → Hyperventilation
- Hyperventilation → CO_2 washout → Respiratory alkalosis
- Alkalosis → ↑ 2,3-DPG → Right shift of O_2-Hb dissociation curve → ↑ O_2 unloading
- Renal compensation: Kidneys excrete HCO_3^- → CSF acidic → Central chemoreceptor stimulation → Sustained hyperventilation at high altitude

High Altitude Disease

01:56:40

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Condition	Key Features	Time of Onset
Acute Mountain Sickness (AMS)	Headache, Anorexia, Nausea, Alteration of Sleep	Within 24 hours
High Altitude Cerebral Edema (HACE)	AMS symptoms + Ataxia, Mental changes	Usually progression of AMS
High Altitude Pulmonary Edema (HAPE)	Cough, Dyspnea, Sputum	2-4 days

Treatment

Condition	Treatment
HAPE & HACE (Most reliable treatment)	• Immediate descent (≥ 1000 m) + Oxygenation (supplemental oxygen)
AMS & HACE	• Corticosteroids • Sumatriptan (5-HT agonist) • Gabapentin
HAPE	• Calcium channel blocker - Nifedipine (20 mg slow-release) • Phosphodiesterase inhibitors - Tadalafil / Sildenafil • Theophylline & Aminophylline
Prophylaxis (Acclimatization)	• Acetazolamide 125 mg BD (Start 1-2 days before climbing)

Decompression Sickness

01:59:00

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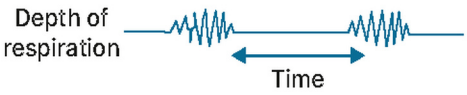
- Occurs in deep-sea divers who ascend to the surface too rapidly.
- Mechanism:
  - Under high pressure (deep water), Nitrogen dissolves in the blood
  - Upon rapid ascent (depressurization), Nitrogen forms bubbles in the blood, blocking small capillaries
- Aka: Caisson's Disease / Disease of Bends / Dysbarism / Diver's Palsy
- **BENDS:** 80-90% - pain in the joints and muscles
  - **CNS:** 5-10% - dizziness, unconsciousness, collapse, paresthesia, amnesia, paralysis, urinary incontinence and fecal incontinence
- **CHOKES:** 2% - shortness of breath, dry cough
- **Cutaneous:** marbled skin & pitting edema
- **Audiovisual:** Hearing loss, Visual abnormalities

DIFFERENT TYPES OF BREATHING

02:01:00

Conditions	Description	Causes	Recording
Eupnea	Normal breathing rate and pattern	—	
Tachypnea	Increased respiratory rate	Fever, anxiety, exercise, shock	
Bradypnea	Decreased respiratory rate	Sleep, drugs, metabolic disorder, head injury, stroke	
Hyperpnea	Normal rate, but deep respirations (increased depth)	Emotional stress, diabetic ketoacidosis	
Cheyne-Stokes breathing	Gradual increase and decrease in respirations with periods of apnea	Severe cardiac failure, brain damage, increasing intracranial pressure, brain stem injury	
Biot's breathing	Rapid, deep respirations (gasps) with short pauses between sets	Spinal meningitis, CNS causes, head injury	
Kussmaul's breathing	Tachypnea and hyperpnea	Diabetic ketoacidosis, uremia, sepsis, salicylates, methanol, aldehyde, lactic acidosis	

EXERCISE PHYSIOLOGY

02:04:00

MCQ

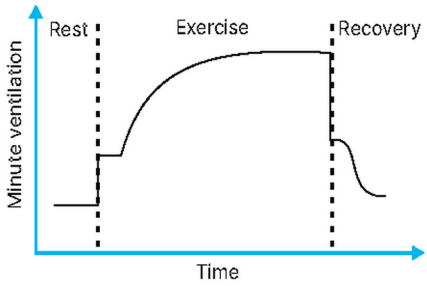
Change in ventilation during exercise is graphically shown here. Ventilation increases abruptly with the onset of exercise, which is followed after a brief pause by a further, more gradual increase. The abrupt increase in ventilation is due to which of the following:

a. Increased P_aCO_2

b. Decrease P_aO_2

c. Increased lactic acid in muscle

d. Stimulation of proprioceptors



Ans. D

Ventilation During Exercise

- Abrupt increase (Phase 1) - Neural response:
  Due to psychic stimuli and afferent impulses from proprioceptors in muscles, tendons, and joints.
- Gradual increase:
  During moderate exercise: ↑↑ in body temperature & plasma K^+ → stimulate peripheral chemoreceptors [arterial pH, PCO_2, and PO_2 remain constant during moderate exercise]
  During severe exercise: Lactic acid buffered by HCO_3^- produces CO_2. (Also, ↑ sensitivity of the respiratory centre to Co_2). ↑↑ CO_2 → stimulates ventilation.

SUMMARY

02:08:36

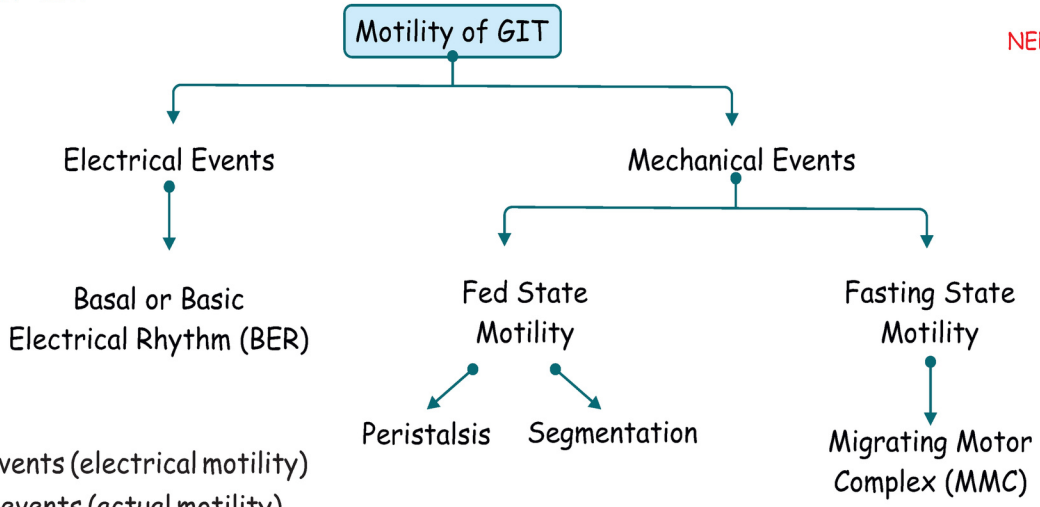
- FRC is the volume which remains in lungs after:→ Normal Expiration (RV + ERV)
- Anatomical dead space is calculated by→ N_2 washout (Fowler's)
- If lung was allowed to recoil without the chest wall what would be the lung volume→ Collapsed (Minimal vol. ≈ 500 ml)
- Ventilation perfusion ratio is maximum at → Apex (3:3)
- V/Q ratio is infinity when → No blood flow to alveoli
- Rhythmicity of respiration is maintained by → Pacemaker (Pre-Botzinger complex)

6. GASTROINTESTINAL PHYSIOLOGY

MOTILITY OF GIT

00:00:50

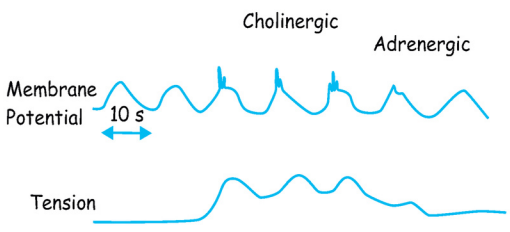
NEET PG 2019, 2020
FMGE 2020
INICET 2021



1. Electrical events (electrical motility)
2. Mechanical events (actual motility)
   - Fed state motility
     → Segmentation > Peristalsis
   - Fasting state motility
     → MMC

Electrical event (basic electrical rhythm — ber)

- Rhythmic fluctuation of resting membrane potential (RMP) of GI smooth muscle
- Not actual movement
- Also called:
  - Basal electrical rhythm
  - Slow waves
- Membrane Potential; Fluctuates between:
  - -65 mV → -45 mV (≈ -40 mV)
  - Not stable unlike neuron (-70 mV)
- Cause
  - Presence of pacemaker cells: Interstitial cells of Cajal
  - Marker → Ckit
- Mechanism:
  - BER alone → No contraction (Tension = 0)
  - BER crosses Threshold (-45 mV) → Spike Potentials appear → Contraction (Tension generated)
- Stimulation:
  - Acetylcholine (Cholinergic): ↑Spike potentials → ↑ Contraction strength
  - Adrenaline (Adrenergic stimulation): Disappearance of spike potentials → Relaxation/Hyperpolarization
- Contraction strength ∝ frequency of spike potentials



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- Frequency of BER
  - Stomach 4/min
  - Duodenum → 12/min (maximum)
  - Jejunum → 11/min
  - Ileum → 8/min
  - Cecum → 2/min (minimum)
  - Sigmoid 6/min

MCQ

Q. A small segment of mammalian small intestine was mounted over Dale's tissue bath and movement was recorded. A substance was added at point 'x'. Which of the following will correspond to x?

a. Acetylcholine
b. Adrenaline
c. Kcl
d. BaCl

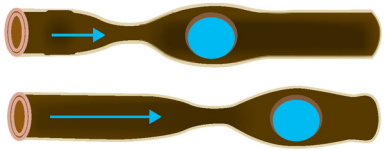
Ans: (b) Adrenaline

Mechanical events (actual motility)

00:14:40

Fed state motility

Peristalsis:



- Type: Propulsive motility
- Speed: 2 to 25 cm/sec (High speed)
- Mechanism (Law of Gut):
  - Proximal Contraction: Mediated by Acetylcholine and Substance P
  - Distal Relaxation: Mediated by VIP, NO, and ATP

Segmentation (dominant):

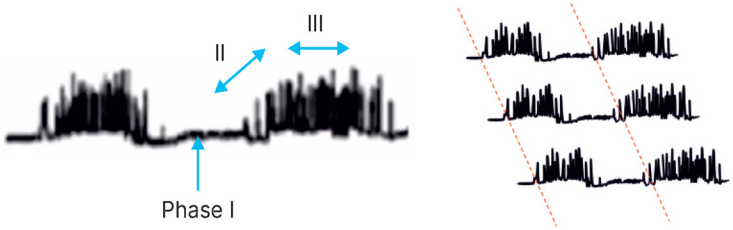
- Type: Non-propulsive (mixing movement)
- Mechanism:
  - D/t circular muscle contraction, multiple contractile rings appear simultaneously → Food moves to and fro (Pendular movement)
- Function: Mixes food with juices, aids digestion and absorption

Fasting motility

00:20:15

Migratory motor complex (mmc):

- During the period of Fasting
- Range:
  - Starts from Mid-Stomach
  - Ends at Terminal Ileum.
- Start: 90-120 minutes after a meal
- Interval between 2 MMC: 90 minutes
- Speed: ~5 cm/min (Slow)
- Function: Housekeeping motility
  - Clears residual food
  - Clears gastric & intestinal secretions



- Prepares GIT for next meal
- Regulator: Motilin hormone
  - Secreted by MO cells of Duodenum/Jejunum

Extrinsic git reflexes

00:24:40

- Enterogastric Reflex:
  - Stimulus:
    → Acidity of content (pH<4)
    → High or low osmolarity of chyme (Fat/ Protein) in duodenum
    → Distension of Duodenum
  - Response: ↓ Gastric emptying (Pyloric contraction).
  - Mediator: Vagus nerve
- Gastroileal Reflex:
  - Stimulus: Gastric distension.
  - Response: ↑ Ileal motility + Relaxation of Ileocecal valve
  - Mediator: Vagus nerve
- Gastrocolic Reflex:
  - Stimulus: Gastric distension (Post-prandial) → ↑ Colonic motility (Mass movement → Defecation in infants).
  - Max Motility (post-prandial): Sigmoid colon > Transverse colon
  - Mediator: Vagus nerve, gastrin, CCK

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GI HORMONES

00:28:20

Hormone (Cell)	Stimulus for Secretion	Major Functions
Gastrin (G cell – antrum and duodenum)	• Peptides most potent stimulus • Distension of stomach & Ca++ • GRP (gastrin releasing peptides) – parasympathetic • Fat & carbohydrate: NO effect	• ↑ Acid and pepsin secretion • ↑ ECL proliferation
CCK (I cell – duodenum and jejunum)	• Peptides most potent stimulus • FA • Carbohydrate: NO effect	• ↑ Pancreatic enzyme secretion • Gallbladder contraction
Secretin (S cell – upper portions of the small intestine)	• Acid most potent • Protein digestive product • Fat: Minor role • Carbohydrate: NO role	• ↑ Pancreatic bicarbonate and H_2O secretion • ↑ Cholangiocyte HCO_3^- secretion

- **Secretin** → acts on pancreatic **duct**
  - ↑ Bicarbonate secretion
- **CCK** → acts on pancreatic **acinar cells**
  - ↑ Enzyme secretion
- Secretin also ↑ bicarbonate secretion from endothelial site

Other gi hormones

Hormones	Origin	Major Actions
Pancreatic polypeptide (36 AA)	Pancreatic PP cell (F cell)	• ↓Pancreatic bicarbonate secretion • Inhibits gall bladder contraction
Peptide YY (36 AA)	L-cells of ileum and colon	• ↓acid secretion & motility of stomach • Decrease food intake
NPY (36 AA)	Neurotransmitter in CNS & PNS (enteric neurons)	• Potent stimulant of food intake
GIP (Glucose dependent insulinotropic polypeptide)	K cell of small intestine Stimulus for secretion: Carbohydrate, Proteins, Fat	• Exocrine: ↓ fluid absorption • Endocrine: ↑ insulin release from pancreas
Somatostatin	D-cells of the GI tract and pancreas; hypothalamus	• ↓Gastric acid secretion and gastric motor activity • ↓Cholangiocyte HCO_3 secretion

Q. Which of the following is an incorrect match?

a. Gastrin – G cells from stomach

b. Motilin – Mo cells from duodenum and jejunum

c. CCK – D cells of duodenum and pancreas

d. Secretin – S cells of duodenum and jejunum

Ans: c. CCK – D cells of duodenum and pancreas

NEET PG 2024
INICET 2022

GIT SECRETIONS

00:37:20

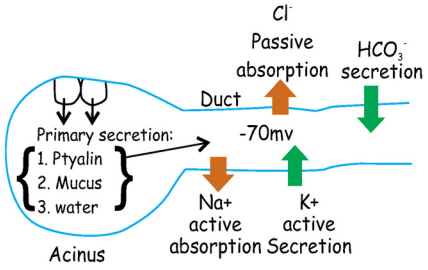
Secretion	Daily Volume (ml)	pH
Saliva	1000	6.0-7.0
Gastric Juice	1500 to 2000	1.0-3.5
Bile	500 to 1000	7.8
Pancreatic Juice	1000	8.0-8.3
Small intestine	1800	7.5-8.0
Large intestine	200	7.5-8.0
Brunner's gland	200	8.0-8.9

Points to remember

- Maximum Potassium (Amount): Salivary Secretion
- Maximum Potassium (Concentration): Colorectal fluid

- High concentration, but low volume
- Maximum Sodium (Amount) and least K+ → Bile
- Max K+ & least Na+ → Saliva
- Maximum Bicarbonate: Pancreatic Secretion
- Maximum Chloride: Stomach Secretion

Salivary secretion



- **Primary Secretion (Acinar Cells):**
  - Contains Ptyalin (Alpha-amylase), Mucus, and Water.
  - Isotonic to plasma
- **Ductal Modification:**
  - Active Reabsorption of Na+ (High amount)
  - Active Secretion of K+ (Lesser amount than Na+ reabsorbed)
  - Passive Reabsorption of Cl– : Driven by negative luminal charge due to net cation loss
  - HCO3– (Bicarbonate) Secretion (partly Active and Passive)
- **Result:** Final saliva is Hypotonic to plasma (Exception: All other GI secretions are generally isotonic)

MCQ

Q. Second phase of salivary secretion involves modification of secretion at the salivary duct. Which of the following is true regarding second phase?

a. Active Na^+ absorption, Passive Cl^- absorption, Active K^+ secretion, active & passive secretion of HCO_3^-

b. Passive Na^+ absorption, Passive Cl^- absorption, Active K^+ secretion, active & passive secretion of HCO_3^-

c. Active Na^+ absorption, Active Cl^- absorption, Active K^+ secretion, active & passive secretion of HCO_3^-

d. Active Na^+ absorption, Passive Cl^- absorption, Passive K^+ secretion, active & passive secretion of HCO_3^-

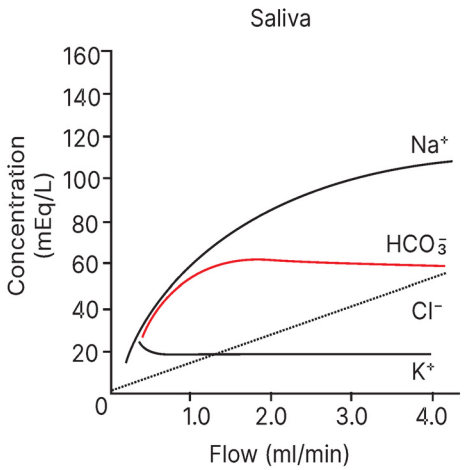
Ans: a. Active Na^+ absorption, Passive Cl^- absorption, Active K^+ secretion, active & passive secretion of HCO_3^-

Summary (duct actions)

- Na^+ → active reabsorption
- K^+ → active secretion
- Cl^- → passive reabsorption
- HCO_3^- → active + passive

Salivary secretion composition (flow dependent)

HIGH SALIVARY FLOW	LOW SALIVARY FLOW
• ↑ Sodium • ↑ Chloride • ↑ Bicarbonate • ↓ Potassium	• ↓ Sodium • ↓ Chloride • ↓ Bicarbonate • ↑ Potassium (highest at very low flow)



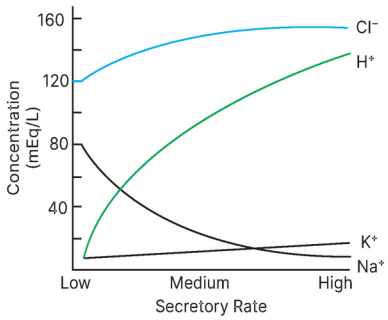
Bottom line

- High flow → everything ↑ except potassium
- Low flow → everything ↓ except potassium

Yourwish

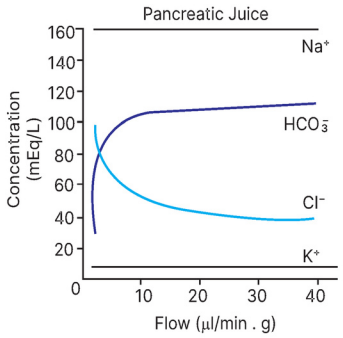
Gastric secretion (flow changes)

- ↑ Flow → ↑ H^+ secretion
- ↑ Flow → ↑ Cl^- secretion → secretion becomes more acidic
- Slight ↑ potassium
- ↓ Sodium



Pancreatic secretion

- Sodium concentration → constant
- Potassium concentration → constant
- ↑ Flow → ↑ bicarbonate
- ↑ Flow → ↓ chloride → secretion becomes more alkaline



ABSORPTION OF NUTRIENTS

00:47:23

Nutrient	Site of Maximum Absorption
Carbohydrates, Proteins, Lipids	Duodenum> Jejunum > Ileum.
Iron & Folic Acid	Duodenum (maximum) and proximal jejunum
Vitamin B12 (Cobalamin) & Bile Salts	Distal Ileum

- Total Daily Fluid Load: ~9 Liters (Oral intake + Secretions)
- Small intestinal absorption is : ~8.8 Liters
  - Jejunum: 5.5 L
  - Ileum 2.0 L
  - Colonic absorption 1.3 L
- Excreted in Stool: ~100 ml/day (1%)

SUMMARY

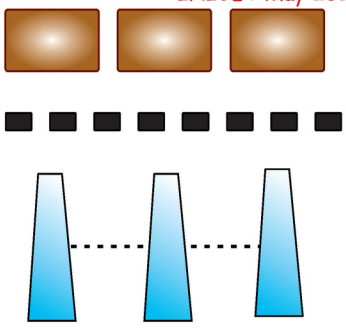
00:48:49

- Highest Frequency of BER is seen in : Duodenum > jejunum
- Generator of Slow Waves (BER): Interstitial Cells of Cajal
- Anterograde relaxation during gut peristalsis is caused by:
  - VIP
  - Nitric oxide
  - ATP
- MMC reappear after an interval of → 90 minutes
- Highest potassium concentration is seen in → colon/rectal fluid
- Late emptying of gastric content due to presence of hypertonic and acidic content in the duodenum is due to: Enterogastric reflex (vagus mediated)

7. RENAL PHYSIOLOGY

GLOMERULAR FILTRATION BARRIER

00:00:55
FMGE Jan 2024
INICET May 2024

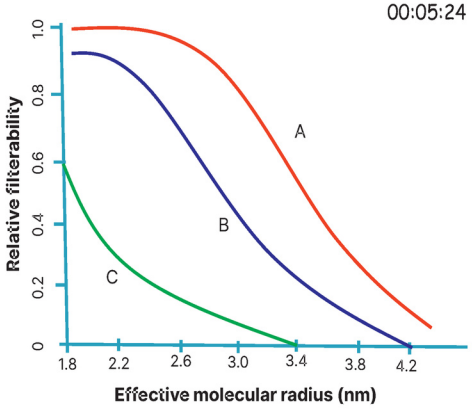


- Composed of 3 layers,

1. Endothelium:
   - First layer of the filtration barrier.
   - Fenestrated in nature (70nm)
   - Coated by a negatively charged molecule: glycocalyx
2. Glomerular basement membrane:
   - Composed of a negatively charged protein, heparan sulfate proteoglycans (HSPG).
   - Fenestrated (10nm).
3. Podocyte's foot process:
   - The gap is 25 nm, aka slit pore
   - The thin membrane in the slit pore k/a slit diaphragm (4-14 nm), composed of nephrin (Gene - NPHS1) and podocin (Gene - NPHS2)
     → Mutation in NPHS 1 → Congenital nephrotic syndrome
     → Mutation in NPHS2 → steroid-resistant nephrotic syndrome
   - Covered by a negatively charged molecule, sialoglycoproteins such as podocalyxin and podoendin

GFR

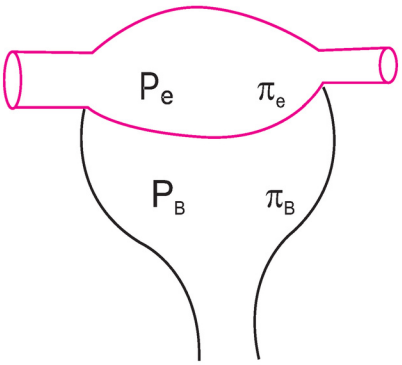
00:05:24



- Freely filterable: molecular radius of <1.8 nm
  - Na^+, K^+, H_2O, urea, Cl^-, glucose, sucrose, inulin, polyethylene glycol
- Selectively permeable: molecular radium of 1.8 to 4.2 nm
  - More favorable for positively charged particles > neutral > negative charge
  - Hemoglobin, lysozyme, myoglobin, lactoglobulin, egg albumin, Bence Jones protein, and serum albumin.
- Impermeable: molecular radius > 4.2 nm

FILTRATION PRESSURE AT GLOMERULUS

00:10:48



- Hydrostatic Pressure (Pc)
  - Pushes fluid from higher pressure to lower pressure
  - Glomerular capillary hydrostatic pressure (Pc) pushes fluid from capillaries into Bowman's capsule
- Oncotic Pressure
  - Tends to retain fluid within capillaries.
  - Plasma oncotic pressure (πc) pulls fluid from Bowman's capsule back into capillaries
  - Depends on plasma protein concentration.
- Net filtration pressure (NFP): $[(Pc - P_B) + (\pi_B - \pi c)] = \{(60 - 18) + (0 - 32)\} = 10$ mmHg

- GFR = NFP x Kf (Kf = filtration coefficient); GFR = 125 ml/min, NFP = 10 mmHg, thus Kf = 12.5 ml/min/mmHg
  - Kf depends on the surface area of the glomerular capillary and the permeability of the glomerular capillary.

GFR AUTO-REGULATION

00:15:38

- 70 - 180/220 mmHg: Between these two arterial blood pressures, renal blood flow is constant
- This constant maintenance of renal blood flow irrespective of the change in arterial pressures is known as autoregulation
- Thus, GFR is also autoregulated under these pressures and renal blood flow
- > 220 mmHg, both the renal blood flow and the GFR rise

Mechanism of autoregulation:

1. Myogenic mechanism:
   - Stretch of smooth muscles of the afferent arterioles causes influx of Ca^{2+} ions, thus causing contraction, regulating the blood flow to the kidneys
2. Tubulo-glomerular feedback mechanism:
   - Increased NaCl at macula densa causes contraction of afferent arterioles, mediated by adenosine
3. Angiotensin II-mediated vasoconstriction: Due to the vasoconstriction caused by the angiotensin

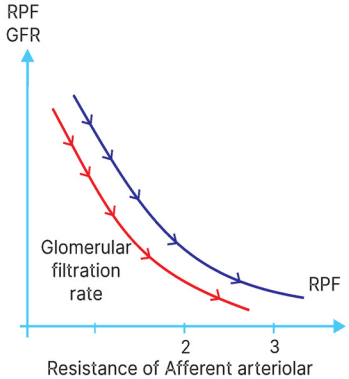
GFR REGULATION:

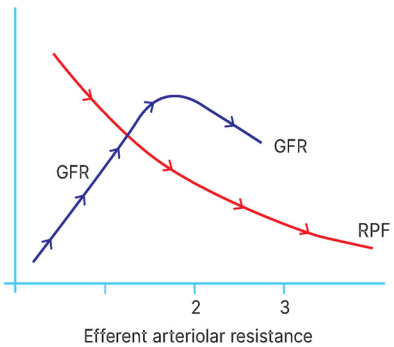
00:20:08

	RPF	GFR	Filtration Fraction	
Afferent	Constriction	↓↓	↓↓	Normal
	Relaxation	↑↑	↑↑	Normal
Efferent	Constriction	↓↓	↑↑ (Normal/mild) ↓↓ (Severe constriction)	Increased
	Relaxation	↑↑	↓↓	Decreased

- Constriction of arterioles increases their resistance, thereby decreasing renal plasma flow (RPF).
- Constriction of efferent arterioles reduces the forward flow, thus increasing the time for filtration, causing an increase in GFR.
- FF = GFR/RPF = (125ml/min) / (625-700 ml/min) = 0.16 to 0.2 = 16 to 20% of the plasma is only getting filtered

Regulation curves:



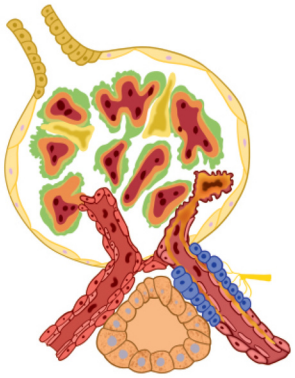


JUXTAGLOMERULAR APPARATUS:

00:27:51

- Junction formed by the uppermost portion of the thick ascending loop of Henle (TAL) and the distal convoluted tubule (DCT).

- Composed of,
  - Juxtaglomerular cell:
    → Modified smooth muscle cells of the afferent arterioles.
    → Contains multiple granules that produce renin, thus called the granular cells of the kidney
    → Has intrarenal baroreceptors that detect a ↓ in BP and produce renin.
    → Supplied by the sympathetic nerve fibers
  - Macula Densa:
    → Cells of the TAL/DCT junction
    → Contains chemoreceptors that sense the NaCl load in the nephron
  - Lacis Cell (Extraglomerular Mesangial Cells)
    → Located in the triangular area between the afferent and efferent arterioles of the nephron
    → Anti-inflammatory cells.



CLEARANCE:

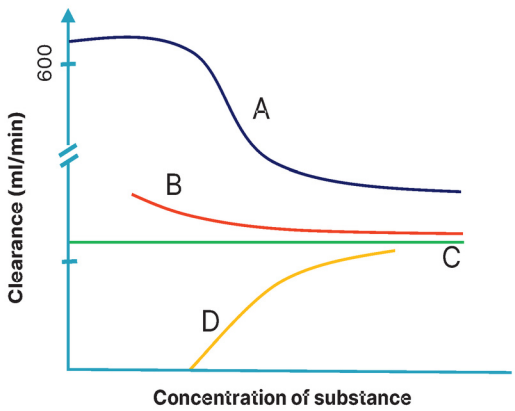
00:32:56

NEET PG 2023

- Plasma volume is being cleared at the level of the glomerular capillary
- C = UV/P = amount of substance in urine/plasma concentration
  - U: urine concentration of the substance (mg/mL)
  - V: urine flow rate (mL/min)
  - P: plasma concentration of the substance (mg/mL)
- Amount in urine = Filtration + Secretion - Absorption
- C (inulin) = Filtration / Plasma concentration = Filtration rate = GFR (125ml/min), as there is no secretion and absorption of inulin in our body.
- If secretion predominates: C>>GFR
- If reabsorption predominates: C<<GFR
- Clearance of various substances: PAH (para-aminobenzoic acid) > K^+ > creatinine > inulin > urea > Na^+ > glucose
- As the concentration of a substance increases, it falsely gives a low clearance value/renal plasma flow

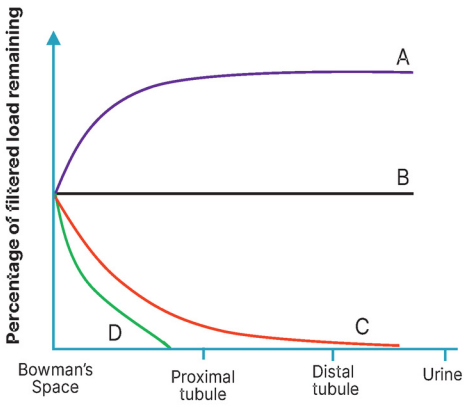
Clearance through the nephrons:

- A: PAH (Para-aminohippuric acid)
  - Clearance ≈ Renal Plasma Flow (RPF) because PAH is filtered and strongly secreted.
- B: Creatinine
  - Clearance slightly higher than GFR (~100–125 mL/min) because a small amount is secreted by the tubules
- C: Inulin
  - Straight horizontal line on the graph because it is freely filtered and neither secreted nor reabsorbed.
  - Therefore Clearance = GFR (~125 mL/min).



Yourwish

- D: Glucose / Amino acids
  - Completely reabsorbed under normal conditions → Clearance = 0.

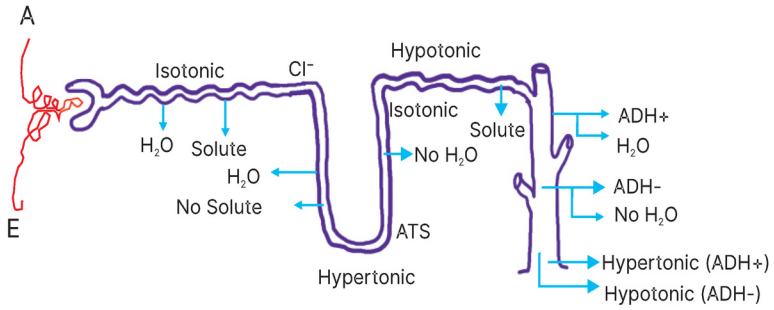


- A: PAH, as huge amounts are secreted as they move forward.
- B: Inulin, as it is neither secreted nor reabsorbed.
- C: Na^+, HCO_3^-, and H_2O, concentrations are getting decreased as they are reabsorbed, and only minimal amounts are excreted in the urine.
- D: Glucose / amino acids, as all the substance has been reabsorbed 100%.

TUBULAR FUNCTIONS:

00:44:20

Proximal tubule



- Consists of PCT (proximal convoluted tubule) and PST (proximal straight tubule).
- Proximal Convoluted Tubule (PCT)
  - Site of proportional reabsorption of solutes (mainly with Na^+) and water
  - This maintains isotonicity of the tubular fluid (isotonic reabsorption)
- Proximal Straight Tubule (PST): Cl^- reabsorption occurs predominantly here

Loop of henle

- Descending Limb
  - Thin segment
  - Highly permeable to water → water is reabsorbed
  - Minimal solute reabsorption
  - Tubular fluid becomes progressively hypertonic (concentrated)
- Ascending Limb
  - Thin Ascending Limb
    → Impermeable to water
    → Some passive NaCl reabsorption
  - Thick Ascending Limb
    → Impermeable to water
    → Active reabsorption of solutes (Na^+, K^+, Cl^- via NKCC transporter)
- Result
  - Tubular fluid becomes progressively diluted, reaching the early distal tubule as hypotonic fluid

DCT

- Due to continued reabsorption of more solutes, the tonicity here becomes hypotonic in this region.

Collecting duct:

- Primary site of action of ADH (vasopressin).
- ADH increases water permeability (via aquaporin-2 channels) → more water reabsorption → urine becomes concentrated (hypertonic).

In presence of adh

- Increased water reabsorption in collecting duct
- Maximum tonicity: End of collecting duct (maximally concentrated urine)
- Minimum tonicity: Distal convoluted tubule (DCT)

In absence of adh

- Collecting duct is impermeable to water → minimal water reabsorption
- Urine becomes dilute (hypotonic)
- Maximum tonicity: Tip of loop of Henle
- Minimum tonicity: End of collecting duct

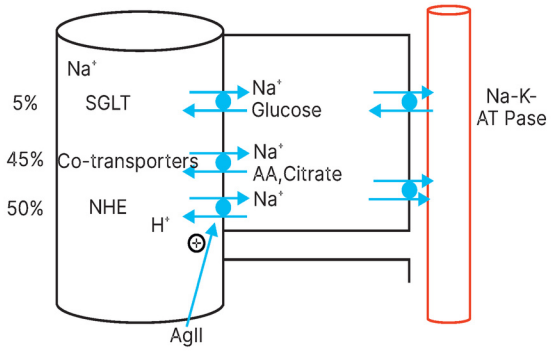
Major transporters

PCT

1. SGLT (Sodium-Glucose Cotransporter)
   - Reabsorbs Na^+ and glucose.
   - Normally ~100% of filtered glucose is reabsorbed

(majority via SGLT in PCT).

2. Na^+-Solute Cotransporters
   - Transport Na^+ with amino acids, citrate, and other solutes.
3. Na^+-H^+ Exchanger (NHE)
   - Major mechanism for Na^+ reabsorption
   - Na^+ enters the cell while H^+ is secreted into the tubular lumen
   - Stimulated by angiotensin II



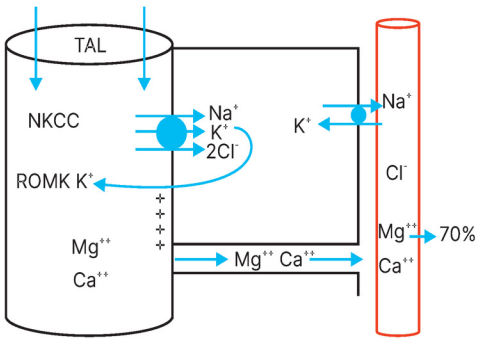
Basolateral transport

- After entering tubular cells, Na^+ is pumped into the blood via the Na^+-K^+ ATPase pump on the basolateral membrane
- This pump is the main driving force for Na^+ reabsorption in the proximal tubule.

TAL

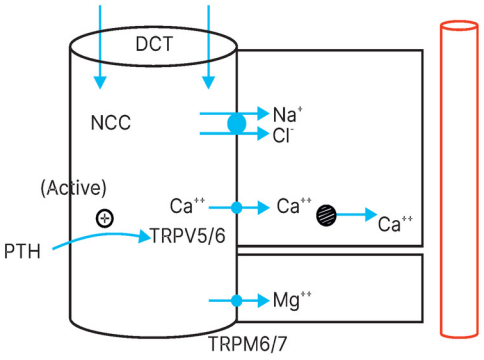
- NKCC: Na^+-K^+-$2Cl^-$ Cotransporter
  - Location: Apical (luminal) membrane of TAL epithelial cells
  - Function: Simultaneously transports: 1 Na^+, 1 K^+ and 2 Cl^- from the tubular lumen into the tubular cell
  - Mutation → Barter Syndrome
  - It is blocked by loop diuretics
- Basolateral Side: Na^+-K^+ ATPase pump
  - Pumps Na^+ into blood
  - Maintains low intracellular Na^+ → drives NKCC2 function
- K^+ Recycling
  - K^+ returns to the lumen via the ROMK channel
  - Creates a positive luminal potential (~+10 mV)

- Paracellular Reabsorption
  - The positive luminal potential drives paracellular reabsorption of cations: Mg^{2+}, Ca^{2+}
  - It is passive reabsorption
  - About 70–75% of filtered magnesium is reabsorbed in the TAL
  - Key Point
  - K^+ recycling is responsible for generating the positive lumen potential, which enables the paracellular reabsorption of divalent cations (Mg^{2+} and Ca^{2+})



DCT

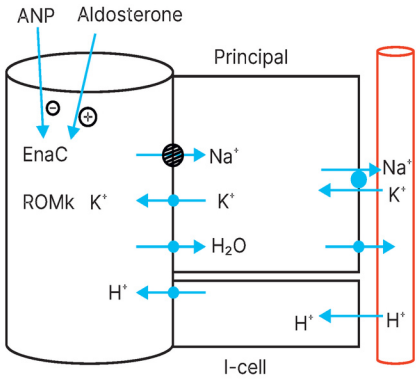
- Major Transporter: NCC (Na^+-Cl^- cotransporter):
  - Reabsorbs Na^+ and Cl^- from the tubular lumen.
  - Mutation of NCC → Gitelman syndrome
  - Thiazide diuretics inhibit the NCC transporter.
- Calcium Reabsorption
  - Ca^{2+} enters the cell via TRPV5 and TRPV6 channels
  - This process is stimulated by parathyroid hormone (PTH)
- Magnesium Reabsorption
  - TRPM6 and TRPM7 channels facilitate Mg^{2+} reabsorption



Collecting duct:

Principal Cells

- ENaC (Epithelial Na^+ Channel)
  - Reabsorbs Na^+ from the tubular lumen in the collecting duct
  - Stimulated by aldosterone
  - Inhibited by ANP (Atrial Natriuretic Peptide).
- Basolateral Transport
  - Na^+-K^+ ATPase pump moves Na^+ into the blood
  - K^+ is secreted back into the tubular lumen
- Water Reabsorption
  - Occurs through Aquaporin channels (AQP2)
  - Regulated by ADH (vasopressin)
- Clinical Correlation
  - Gain-of-function mutation of ENaC → Liddle syndrome



Intercalated Cells

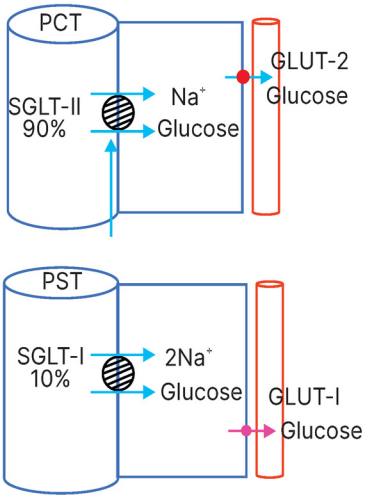
- Intercalated cell alpha→ Responsible for secretion of H^+ ions into the tubular lumen, causing acidification of the urine

GLUCOSE AND WATER REABSORPTION:

01:04:02

Glucose reabsorption

- Occurs in the proximal convoluted tubule (PCT) and proximal straight tubule (PST).



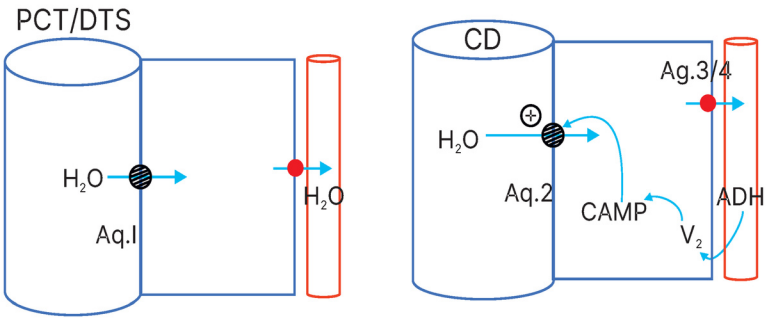
PCT

- SGLT2 (Na^+-glucose cotransporter) reabsorbs ~90% of filtered glucose along with Na^+
- GLUT2 on the basolateral membrane transports glucose into the blood.

PST

- SGLT1 reabsorbs the remaining ~10% of glucose (with 2 Na^+ : 1 glucose)
- GLUT1 on the basolateral membrane transports glucose into the blood.

Water reabsorption



- ~65% of filtered water is reabsorbed in the PCT, independent of ADH.
- ~20% of water is reabsorbed in the descending thin segment (DTS) of the loop of Henle

AQUAPORINS

- Aquaporin-1
  - Present in PCT (apical and basolateral membranes)
  - Facilitates water reabsorption into blood
- Aquaporin-2
  - Present on the luminal membrane of CD
  - Reabsorbs water from tubular fluid
- Aquaporin-3:
  - Present on the basolateral membrane of CD
  - Allows water to enter the blood

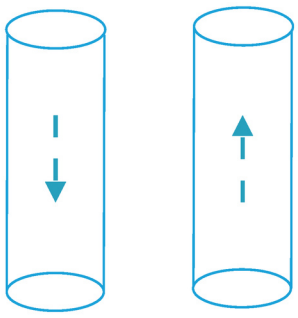
Role of ADH

- ADH acts on the basolateral surface of the V2 receptor that produces cAMP, which stimulates aquaporin-2, thus increasing water reabsorption.

Yourwish

COUNTERCURRENT MECHANISM:

01:09:01

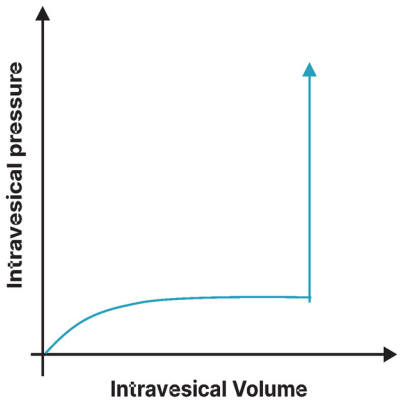


- These are also found in
  - Intestinal villus
  - Skin
  - Testes
  - Kidneys
  - Lung
  - Liver
- Criteria,
  1. 2 parallel tubes
  2. Opposite direction of fluid movement.
  3. Close proximity of tubes.
  4. Selectively permeable.
- The major goal of this system is to make the renal medulla hypertonic, which helps with water reabsorption and urinary concentration.
  - Countercurrent multiplier,
    → Generation of hypertonicity of medulla.
    → Loop of Henle - ATS and TAL, responsible for NaCl reabsorption.
    → Medullary collecting duct - responsible for urea reabsorption.
    → Na^+ is 30% responsible, Cl^- is 30% responsible, and urea is 40% responsible for medullary hypertonicity
  - Countercurrent exchanger,
    → Maintenance of hypertonicity of the medulla by the slow blood flow through the vessels at the medulla, vasa recta, which is a peritubular capillary loop.

CYSTOMETROGRAM:

01:14:01

- Bladder function assessment by plotting a relationship between intravesicular volume and intravesicular pressure
- When the urine keeps getting collected in the bladder,
  - The intravesicular pressure increases
  - The wall tension of the bladder is a force that is exerted through the muscle layer
    - Ia - pressure rises along with the rise in volume
    - Ib - considered the plateau part where volume increases but the pressure remains the same
  - Plasticity is a property where the bladder changes shape with the accumulation of more urine
  - The pressure remains the same due to the Laplace law, P = 2T/r (T is tension, r is radius, and P is pressure) - With increasing urinary flow, the radius keeps increasing (due to stretching), and wall tension also increases proportionally; thus, the pressure remains constant



- II - Beyond the 400 ml, the vesicular pressure increases, causing the onset of the micturition reflex

SUMMARY

01:19:05

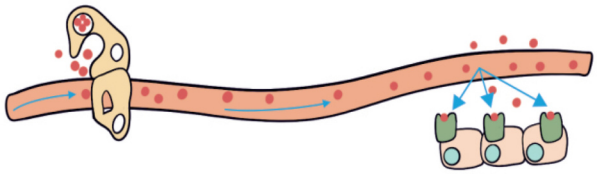
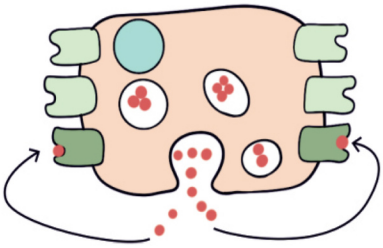
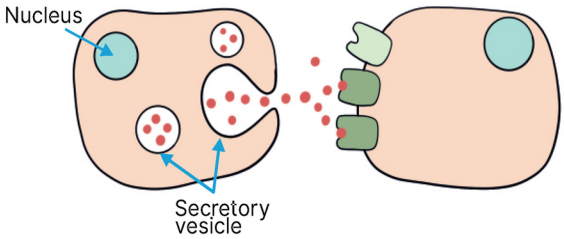
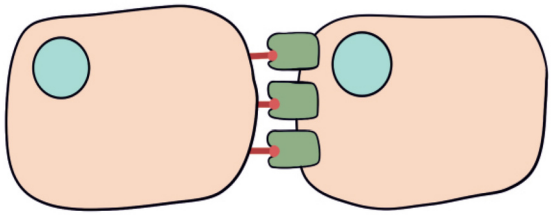
- Glycoproteins found in the glomerular basement membrane are heparan sulfate proteoglycans.
- The macula densa is formed by the TAL/DCT junction >> TAL >> DCT.

- In the late PCT of kidney, luminal concentration increases for Cl^-.
- Renin is secreted by JG cells of the kidney.
- Erythropoietin is secreted by
  - Peritubular capillary epithelium cells and NORN cells of the kidney (80-90%)
  - Perivenous hepatocytes of liver (15%)
- Glucose reabsorption present on the apical membrane of the PCT is SGLT2.
- Impaired function of aquaporin 2 causes nephrogenic diabetes insipidus.

8. ENDOCRINE AND REPRODUCTIVE PHYSIOLOGY

CELL SIGNALLING

00:01:33
NEET PG 2022

Endocrine Signalling 	Substances secreted into blood → Transported to distant site → Acts on receptors
Autocrine signalling 	Secretory products act on receptors on the same cell • **Eg:** Platelet-activating factor (PAF)
Paracrine signalling 	Secreted molecules act on nearby cells through the process of Simple diffusion • **Eg:** ○ Histamine → (+) gastric parietal cells ○ Somatostatin → (-) β-cells of pancreas
Juxtacrine signaling 	Ligand from one cell is directly in contact with the other cell • **Eg:** Transforming growth factor-a (TGF-a).

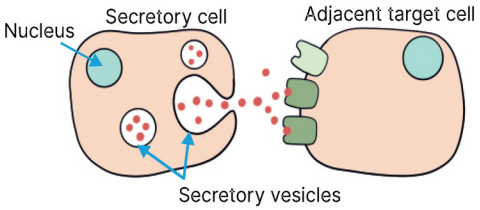
Q. Which of the following cell signalling is shown in the following picture:

a. Autocrine secretion

b. Paracrine secretion

c. Merocrine
d. Endocrine

Ans: b



CLASSIFICATION OF HORMONE RECEPTORS

00:05:30

Intracellular receptors

FMGE DEC 2021, INICET NOV 2024

Cytoplasmic (from cytoplasm → nucleus)	Nuclear (Genomic action)
• Glucocorticoid receptor • Mineralocorticoid receptor • Androgen receptor • Estrogen receptor • Progesterone receptor	• Thyroid hormone receptor • Vitamin D receptor • Retinoic acid receptors (RAR, RXR)

Q. Thyroid hormone acts via which type of receptor?
a. Cytoplasmic
b. Tyrosine kinase
c. Nuclear
d. GPCR

Ans: c

Membrane receptors

- G-protein coupled receptor (GPCR)
- Guanylyl cyclase receptor
- Tyrosine kinase receptor
- Cytokine receptor
- Serine kinase receptor

GPCR

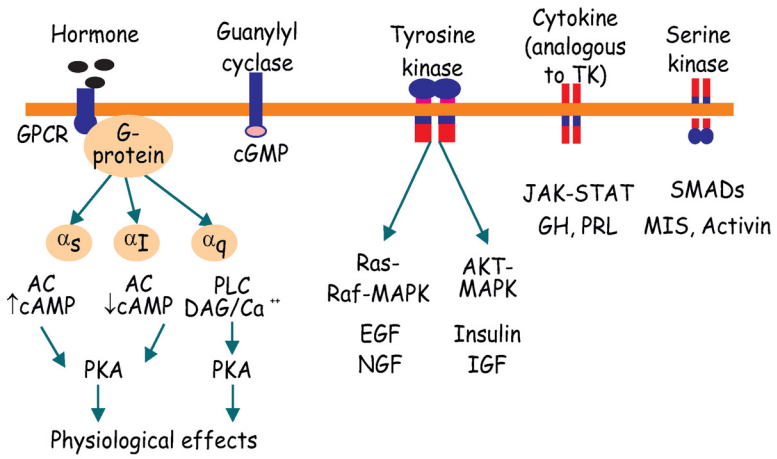
00:11:01

- G-protein(heterotrimeric protein) consists of three subunits: α, β, and γ
- Activation of GPCR → α-subunit (regulatory subunit) dissociates and acts on effector molecules.
  - Gs (stimulatory) → αs subunit → stimulates adenylyl cyclase → ↑ cAMP
  - Gi (inhibitory) → αi subunit → inhibits adenylyl cyclase → ↓ cAMP
  - Gq → αq subunit → activates phospholipase C → ↑ IP3 / DAG → ↑ Ca^{2+}

Effector	Messenger	Hormones
Gs - AC	↑ cAMP	ACTH, TSH, LH, FSH, CRH, PTH, MSH, Glucagon, Calcitonin, ADH (V2 receptor), β - adrenergic
Gi - AC	↓ cAMP	Somatostatin, α-2 adrenergic, Ach (M2,4), Ag II (AT2)

Gq - PLC	↑ IP_3/DAG	TRH, GnRH, GHRH, Oxytocin, ADH (V1 receptor), α-1 adrenergic, Ach (M1,3, 5), Ag II (AT1)

Other types of membrane receptors



Membrane receptors & associated hormones

NEET PG 2018

Type	Messenger/Signalling	Hormones
Guanylyl cyclase receptor	↑ cGMP	ANP, EDRF, Nitric oxide
Receptor tyrosine kinase	MAP kinases-AKT	Insulin, IGF-I
	Ras-Raf-MAPK	EGF, NGF
Cytokine receptor	JAK-STAT	GH, PRL, Leptin, EPO, TPO, GM-CSF, IL
Serine kinase	SMADs	Activin, TGF-beta, MIS

Q. Match the following Hormones with their receptors?

A. Insulin-receptor	1. JAK/STAT
B. Acetylcholine	2. Nuclear Receptor
C. Growth hormone	3. Tyrosine Kinase
D. Thyroxine	4. Ligand-gated

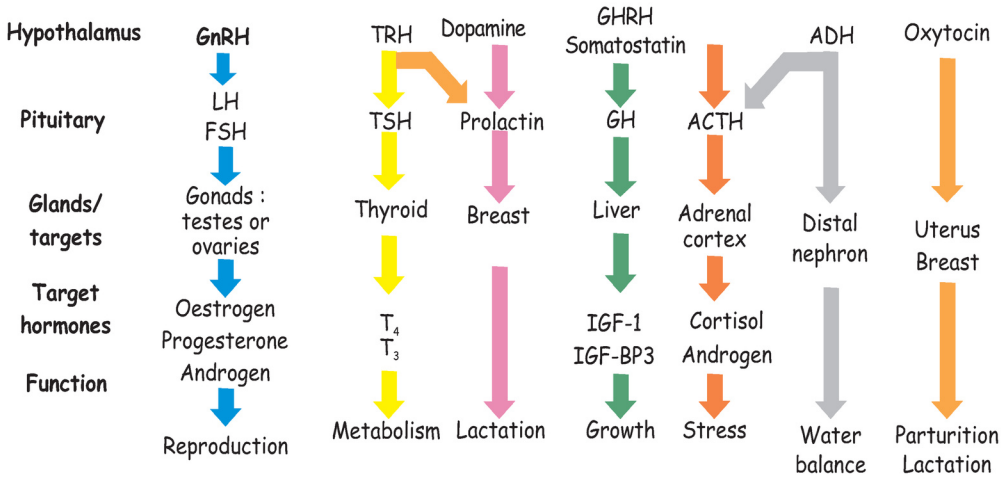
a. A-1, B-2, C-3, D-4
b. A-1, B-3, C-2, D-4
c. A-3, B-4, C-1, D-2
d. A-4, B-2, C-3, D-1

Ans: c

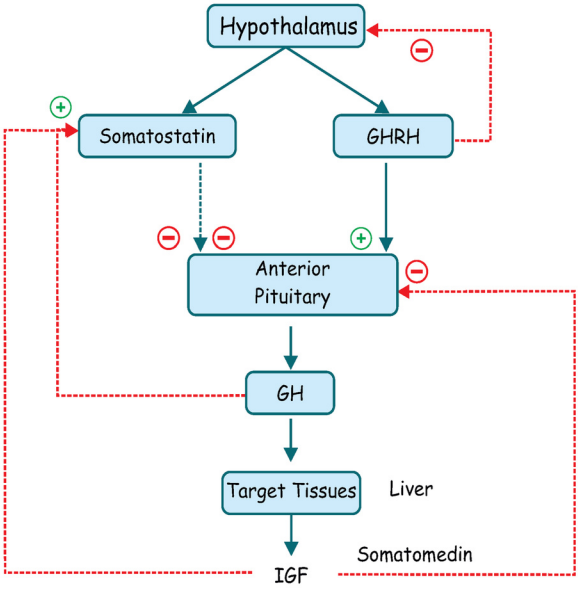
CONTROL OF PITUITARY HORMONES

00:21:27

FMGE 2020, 2023



Growth hormone: feedback control

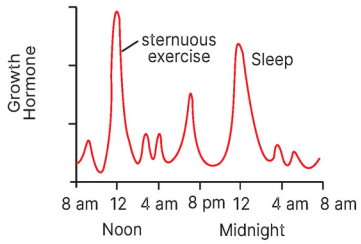


Factors controlling gh

Stimulus for GH Secretion	Inhibitor of GH Secretion
• Hypoglycemia (fasting, exercise) • ↑ Amino acids in plasma (protein meal) • Stressful stimuli (surgery, trauma) • Sleep (NREM ↑, REM ↓) ○ REM → (+) PRL, LH, FSH	• Hyperglycemia • Somatomedins (IGF) • Somatostatin • Obesity • Pregnancy

Q. Serum level of one hormone X is recorded throughout the day. Identify the hormone X from the picture given below:

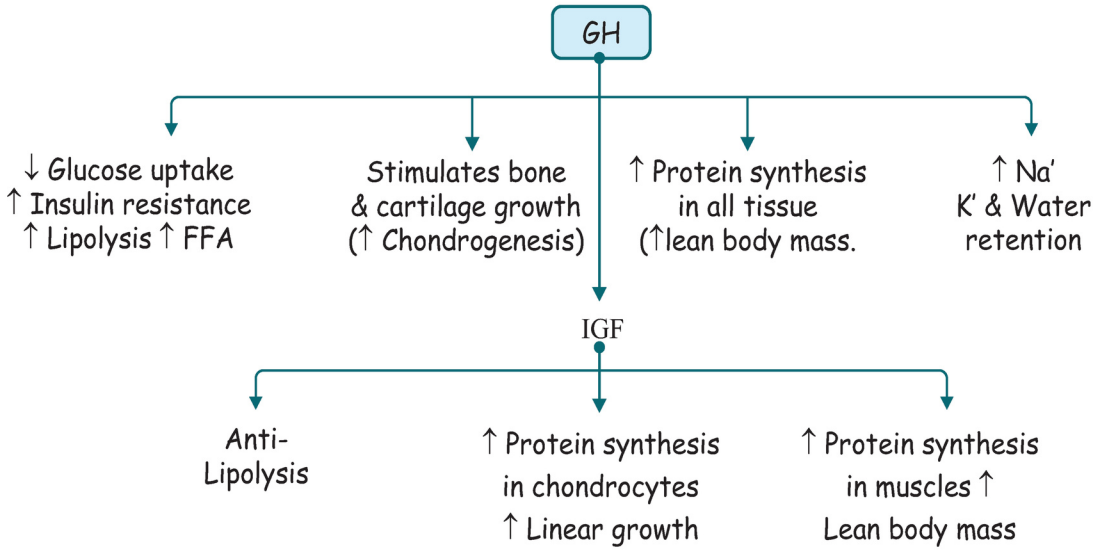
a. Growth hormone
b. Cortisol
c. Estrogen
d. Insulin



Ans: a.

- Pulsatile

Functions of gh



THYROID HORMONES

00:33:16

Feature	T4 (Thyroxine)	T3 (Triiodothyronine)
In secretion	More (80 µg/day; 93% of total)	Less (4 µg/day; 7% of total)
Plasma concentration	8 ng/dL	0.15 ng/dL
Half-life ($t_{\frac{1}{2}}$)	Longer (5-7 days)	Shorter (1 day)
Action	Slower onset	Faster onset
Potency	Less potent	3-5 times more potent
Binding to thyroid hormone receptors	Less	More

Q. A person presents with puffy skin and lethargy. His TSH levels are low and are improved on administration of TRH. What is the probable diagnosis?

a. Hypothyroidism because of hypothalamus defect
b. Diffuse thyroid enlargement
c. Hyperthyroidism because of hypothalamus defect

d. Hypothyroidism because of pituitary defect

Ans: a.

Explanation:

- The patient has symptoms of hypothyroidism.
- After TRH administration, TSH increases, which means the pituitary gland is functioning normally and can release TSH when stimulated.
  - Therefore, the defect must be in the hypothalamus, which normally secretes TRH.
- Hypothalamic defect → ↓ TRH → ↓ TSH → Hypothyroidism

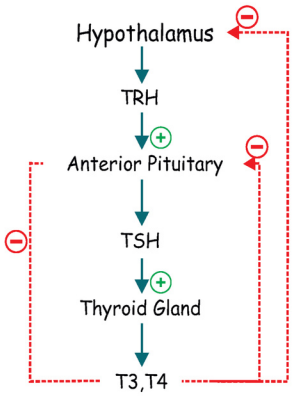
Hypothyroidism - subtypes

00:36:13

Type	Primary Defect Location	T4	TSH	TRH
Primary	Thyroid Gland	↓	↑	↑
Secondary	Anterior Pituitary	↓	↓	↑
Tertiary	Hypothalamus	↓	↓	↓

Hyperthyroidism - subtypes

Type	Primary Defect Location	T4	TSH	TRH
Primary	Thyroid Gland	↑	↓	↓
Secondary	Pituitary	↑	↑	↓
Tertiary	Hypothalamus	↑	↑	↑



AIIMS 2019, FMGE 2020

Q. The effect of different thyroid hormones in plasma during starvation is shown in the following curve. Curve B indicates which of the following?

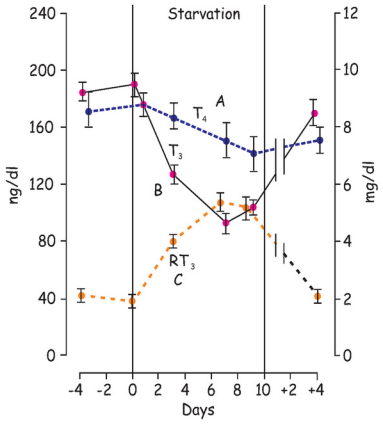
a. DIT
b. rT3
c. T3
d. T4

Yourwish

Ans: c

Explanation:

- T4 is converted into two different forms.
  - T3 (Active) → Decreases to slow down metabolism (Curve B)
  - rT3 (Inactive) → Increases (Curve C)
- During starvation, the body aims to lower the Basal Metabolic Rate (BMR) to conserve energy.
  - In starvation, the body shifts its conversion away from the active form and toward the inactive form.
- T4 levels remain relatively stable or show a slight decrease as starvation prolongs (Curve A).



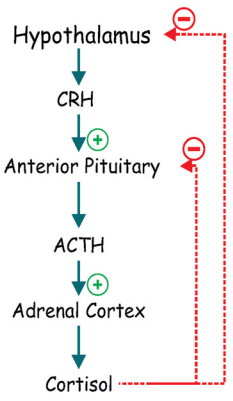
NEET PG 2018, FMGE 2019, 2025, INICET 2024,

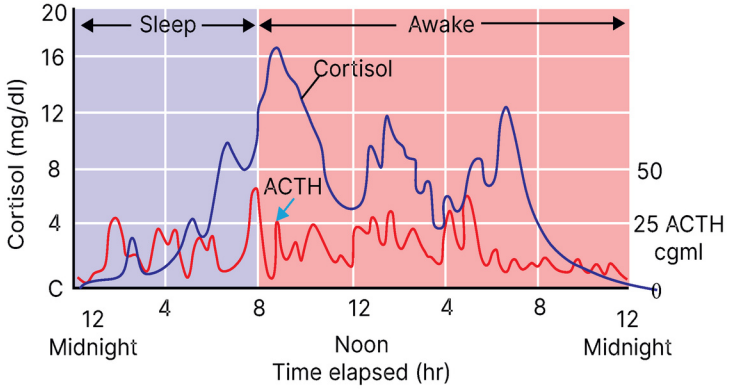
ADRENAL HORMONES

00:46:03

Layers (weight)		Hormone Production	Main Regulator
Cortex (72%)	Z. Glomerulosa (15%)	• Mineralocorticoids: ○ Aldosterone (main) ○ Deoxycorticosterone	Ag II (Angiotensin II)
	Z. Fasciculata (50%)	• Glucocorticoids (main) ○ Cortisol ○ Corticosterone • Sex steroids	ACTH
	Z. Reticularis (7%)	• Sex steroid (main) ○ DHEA (Dehydroepiandrosterone) ○ Androstenedione • Glucocorticoids	ACTH
Medulla (28%)		• Epinephrine (90%) • Nor-epinephrine (10%)	Sympathetic system

Cortisol: feedback control

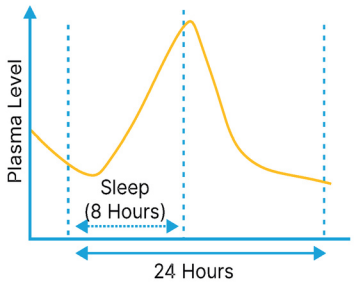




- Suprachiasmatic nucleus controls the hypothalamus
  - Producing a circadian (pulsatile) rhythm of ACTH and Cortisol
  - Levels are highest around 8:30 AM & lowest around midnight, 12:15 AM.
  - The difference between the two peaks → 24 hours → Diurnal (Circadian) rhythm

Q. A 52-year-old woman with a chief complaint of snoring is referred for a sleep study. As shown in the graph below, the concentration of a hormone varied over the 24-hour period of study. This diurnal variation in plasma level results from the secretion of which of the following hormones?

a. Cortisol
b. Oestrogen
c. Insulin
d. Thyroxine



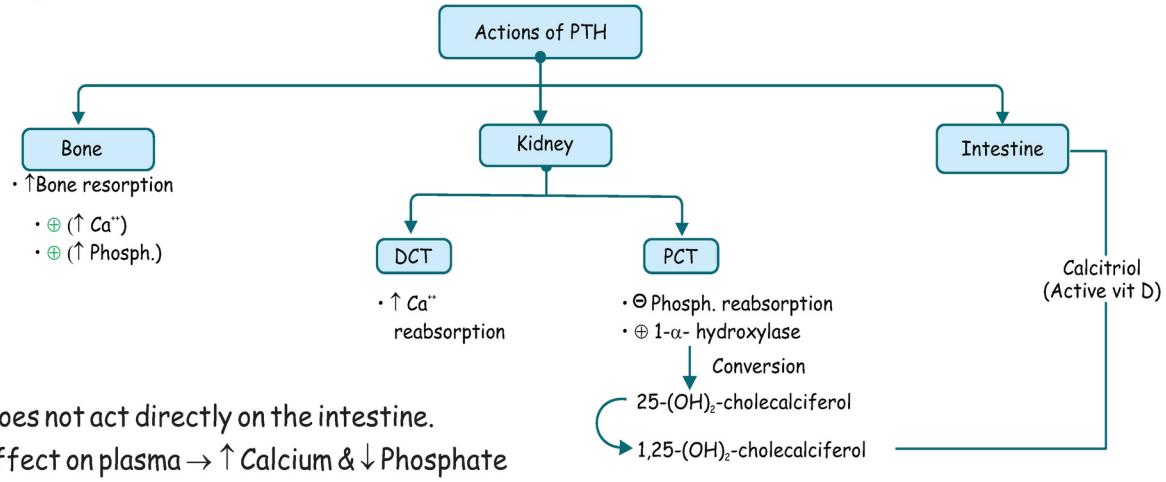
Ans: a.

INICET 2023
00:51:25

PTH SECRETION

Secretion Increased by	Secretion Decreased by
• Hypocalcemia • Decrease in plasma Mg^{2+} (mild) • Hyperphosphatemia • Catecholamines	• Hypercalcemia • $1,25(OH)_2D$ • Severe hypomagnesemia • Combined decrease in Mg^{2+} and Ca^{2+}

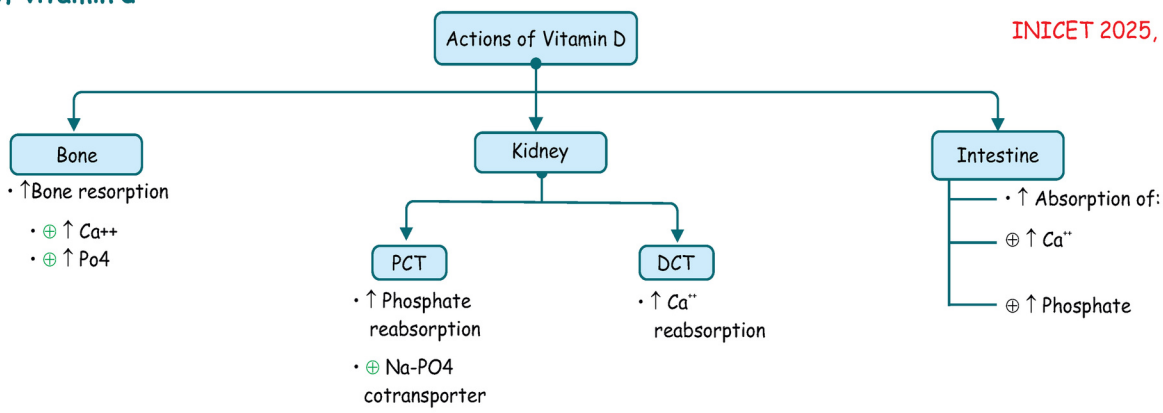
Actions of pth



- PTH does not act directly on the intestine.
- Net effect on plasma → ↑ Calcium & ↓ Phosphate

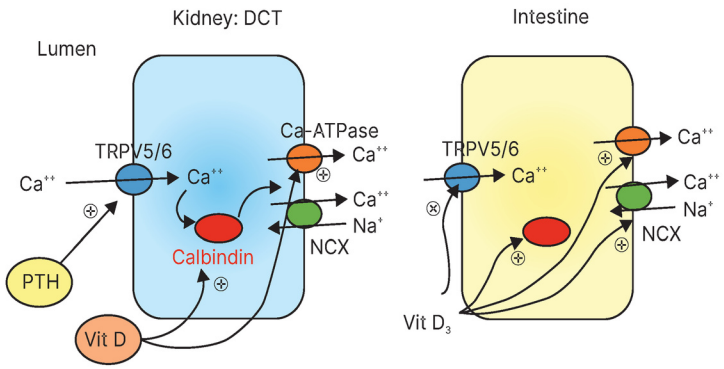
Actions of vitamin d

INICET 2025, FMGE 2025



- At the level of the kidney → PTH & Vit D act
- At the level of the intestine → Only Vit D acts

Mechanism of action of pth & vitamin d



Q. Which of the following statements is/are true regarding the mechanism by which PTH elevates blood calcium levels?

a) Increases renal absorption of calcium
b) Stimulation of osteoclast activity
c) Stimulates vitamin D synthesis
d) All are true

Ans: d.

Summary of calcium balance

	PTH	Vitamin D	Calcitonin
Stimulus for secretion	↓ Serum Ca^{2+} ↑ Serum Phosphate	↓ Serum Ca^{2+} ↓ Serum Phosphate	↑ Serum Ca^{2+}
Action on:			
Bone	↑ Resorption	↑ Resorption	↓ Resorption
Kidney	↓ P reabsorption ↑ Ca^{2+} reabsorption	↑ P reabsorption ↑ Ca^{2+} reabsorption	
Intestine	↑ Ca^{2+} absorption	↑ Ca^{2+} absorption ↑ P absorption	

Overall effect on blood

Overall effect on blood:	PTH	Vitamin D	Calcitonin
Serum Ca^{2+}	↑	↑	↓
Serum Phosphate	↓	↑	

PANCREATIC HORMONES

01:06:08

Cell type	Quantity	Location	Hormones
A	~20%	Peripheral	Glucagon
B	~70%	Central	Insulin, Amylin, C peptide
D	<10%	Variable	Somatostatin
F (PP cell)	Rare	Peripheral to central	Pancreatic polypeptide

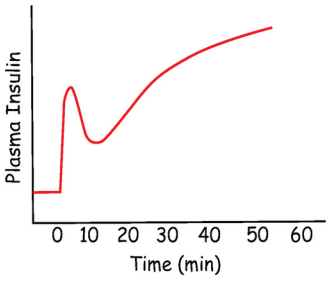
- Insulin: Amylin ratio → 100:1
- Insulin: C-peptide ratio → 1:1
- C-peptide → Helps differentiate between endogenous & exogenous insulin
- Pramlintide:
  - Amylin analogue
  - Treatment of DM
- Amylin → Promotes satiety, reduces gastric emptying → reduces blood glucose level

Stimulators for insulin secretion

- Glucose, Mannose → Increases ATP
- AA (leucin, arginine), β-keto acids → Increases ATP
- Intestinal peptides (GLP-1, GIP, Gastrin, Secretin, CCK)
- Parasympathetic: Ach (M3 receptor) → Gq → ↑↑ insulin
- Sympathetic: ↓↓ insulin via α-2 adrenergic stimulation (↓ cAMP).
  - After blocking α-2, sympathetic stimulates insulin via β2-receptor (↑ cAMP) → ↑ insulin
- Theophylline, Glucagon (↑ cAMP)

Glucose & insulin secretion

- Sustained Blood Glucose Increased:
  - ↑↑ Insulin within 3-5 min due to preformed insulin from the beta cells.
  - Second rise (after 15 min) due to additional preformed plus new synthesized insulin



Q. Which hormone binds to tyrosine kinase receptors and has 4 subunits and 2 units for receptor binding?

a. Insulin

b. Glucagon

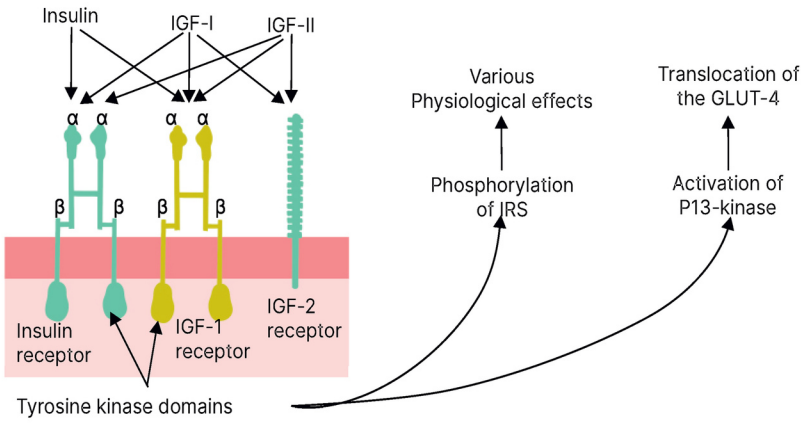
c. T3

d. AD

Ans: a.

Yourwish

Insulin receptor



Q. Which hormone has a permissive role in puberty?

a. Leptin
b. GnRH
c. Insulin
d. GH

Ans: a

- Leptin stimulates pulsatile release of GnRH

INICET 2025

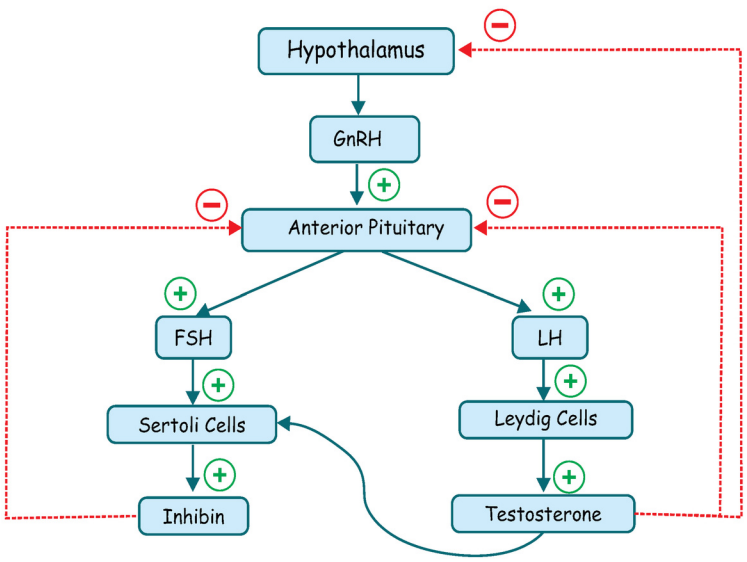
01:14:47

LEPTIN

- Leptin is released from white adipose tissue.
- More adipose tissue mass → more leptin in blood (so, high levels in obesity).
- Leptin sends anorexigenic (i.e., satiety) signals to the hypothalamus to decrease fat storage.
- Leptin also stimulates thermogenesis.
- Play a permissive role in puberty onset (facilitates an action without directly causing it).

HYPOTHALAMIC-PITUITARY-TESTICULAR AXIS

01:16:00



Sertoli & leydig cells

Sertoli cells

- Sertoli Cells contain receptors for FSH and androgens.
- Forms the blood-testis barrier
- Nourish and protect the developing sperm.
- Expresses aromatase enzyme (converts Testosterone to local estradiol).
- They produce Inhibin, androgen-binding protein (ABP), and AMH (MIS) that causes regression of müllerian ducts.

Leydig cells

- Leydig cells contain LH receptors.
- They can synthesise cholesterol de novo, as well as acquire cholesterol through LDL & HDL receptors
- Testosterone diffuses into the seminiferous tubules.
- Aromatase of Sertoli cells converts it into estradiol.

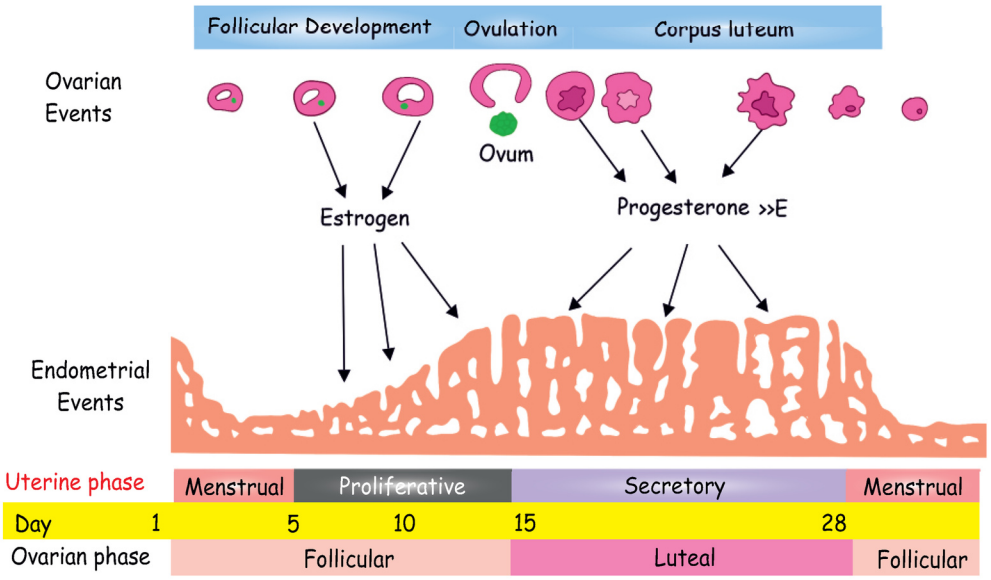
Q. Which of the following hormones are secreted by Sertoli cells and Leydig cells, respectively?

a. DHA and testosterone
b. Testosterone and inhibin
c. Testosterone and DHA
d. Inhibin and testosterone

Ans: d

FEMALE REPRODUCTIVE PHYSIOLOGY

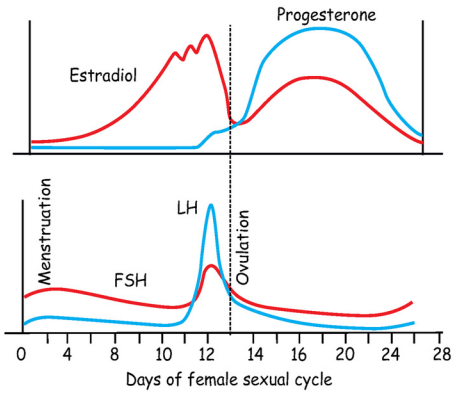
01:19:48



Ovarian events

- Developing follicles → Granulosa cells → Estrogen → Negative feedback on LH
  - Estrogen → Proliferation of endometrium
- Developing follicles → Granulosa cells → Inhibin B → Negative feedback on FSH

Hormonal changes



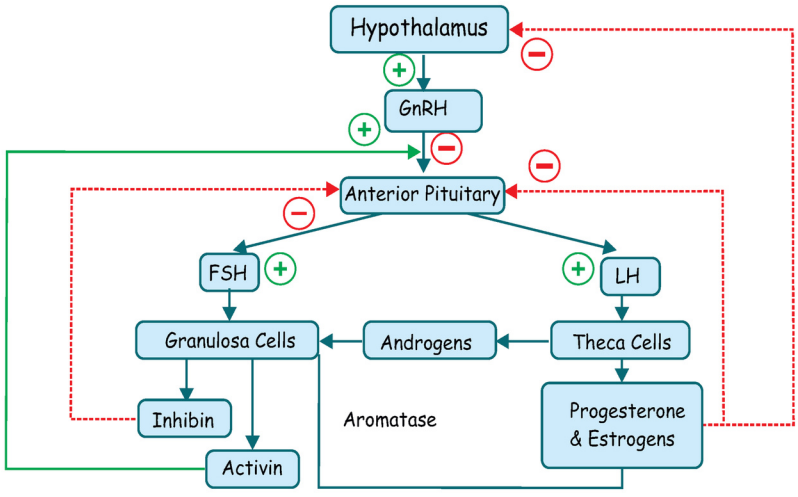
Proliferative phase

- Estrogen → (-) LH & Inhibin B → (-) FSH
- High estrogen levels (3x than normal) & persisting for 2 days → (+) LH → LH surge
  - LH → Release of ovum & maintains corpus luteum

Follicular phase/luteal phase

- Corpus luteum → Secretes Progesterone → negative feedback on LH → (-) Corpus luteum → (-) Progesterone
  - ↓Progesterone → Shedding of endometrium → Menstruation
  - Half-life of corpus luteum: 14 days
- Inhibin A → (-) FSH

Hypothalamic-pituitary-ovarian axis



SUMMARY

- IGF-1 acts through which type of receptors → Tyrosine Kinase receptor
- Phospholipase C acts through → DAG/IP_3 → ↑ Ca^{2+}
- Damaged of pituitary stalk during surgery causes an increase in which of the following hormones → Prolactin
- Hormones which is/are under inhibitory control of the hypothalamus → PRL, GH
- Hormone with a permissive role in puberty → Leptin
- After ovulation, the corpus luteum releases which of the following hormones → Progesterone
- In male testosterone is secreted from → Leydig cells