

THE PHYSIOLOGICAL BLUEPRINT: FROM CELL TO SYSTEM

A Curated guide to Core Medical Physiology



MBBS Curriculum

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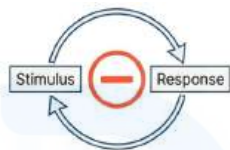
Dr Jayaprakash K
FMT

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THE GUIDING PRINCIPLE: THE QUEST FOR HOMEOSTASIS

The maintenance of the internal environment (milieu interieur) is the central theme of physiology, the ultimate goal of all bodily systems.



Negative Feedback

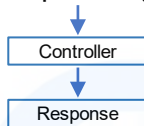
Dominant Loop.
Ensures stability.
Examples: Blood pressure regulation, Hormone control.



Positive Feedback

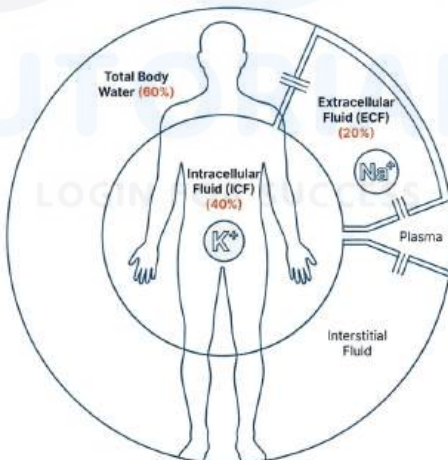
Amplifying Loop.
Requires a definitive endpoint. Examples (CLAPS): Clotting, LH surge, Action potential, Parturition, Shock.

Anticipated change



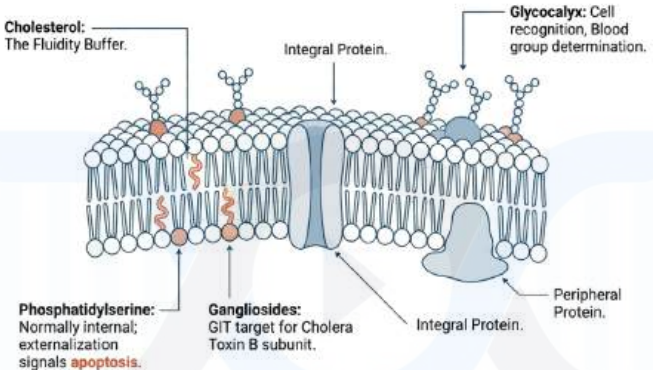
Feed-Forward

Anticipatory.
Example: Cardiovascular changes before exercise.



THE BLUEPRINT'S FOUNDATION: THE CELL MEMBRANE

The Fluid Mosaic Model: A sea of lipids with floating protein icebergs.

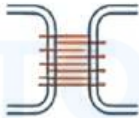


JUNCTIONAL COMPLEXES



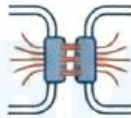
Tight Junction

Claudin/
Occludin -
Prevents
paracellular
transport (BBB).



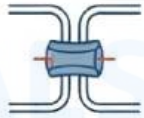
Adherens Junction

cadherin -
Cell-cell
adhesion under
stress.



Desmosome

Desmoglein -
Strong adhesion
(Skin, Heart).



Gap Junction

Connexins -
Cell-cell
communication
(Heart).



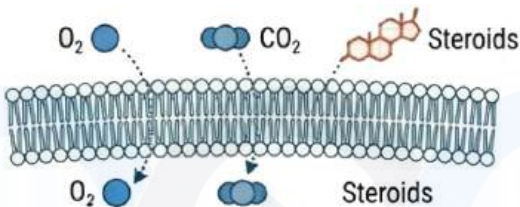
CLINICAL INSIGHT : CLINICAL CORRELATION: MEMBRANE PATHOLOGY

Deficiency of GPI-anchored proteins (CD55, CD59) on RBCs leads to Paroxysmal Nocturnal Hemoglobinuria (PNH) due to complement-mediated cell lysis.

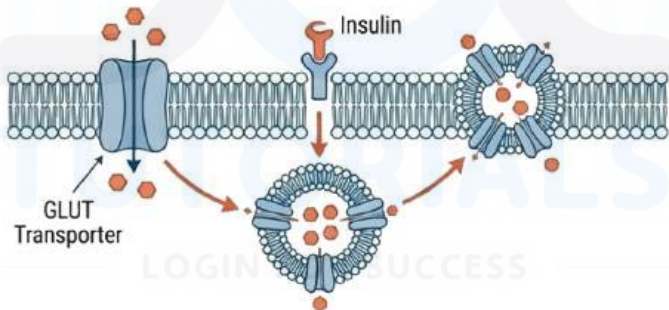
THE GATEKEEPERS: TRANSPORT ACROSS THE MEMBRANE

PASSIVE TRANSPORT (Down Gradient - No Energy)

Simple Diffusion: 021 C021 Steroids



Facilitated Diffusion

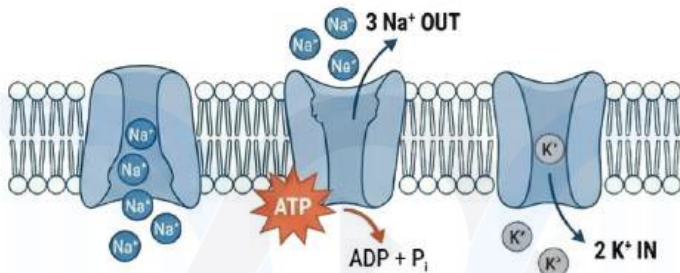


- GLUT-1: RBCs, Brain
- GLUT-2: Pancreatic β -cells (Glucose "sensor")
- GLUT-4: Muscle & Adipose (Insulin-dependent)

THE GATEKEEPERS: TRANSPORT ACROSS THE MEMBRANE

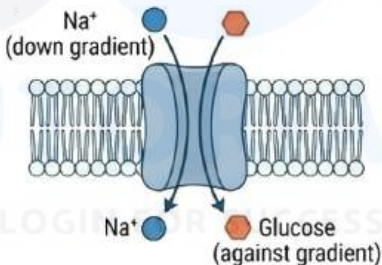
ACTIVE TRANSPORT (Against Gradient - Requires Energy)

Primary Active



Maintains RMP & Na⁺/K⁺ gradients.

Secondary Active (Cotransport)



CLINICAL INSIGHT : PHARMACOLOGICAL TARGETS

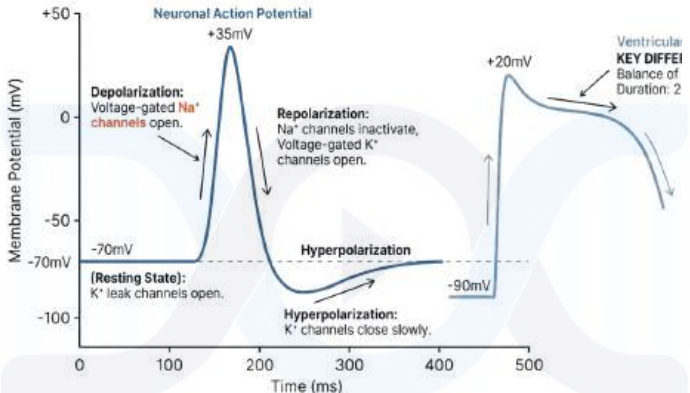
Cardiac glycosides (Digoxin) inhibit the Na⁺ - K⁺ ATPase.

SGLT-2 inhibitors (Gliflozins) are used in diabetes management.

Proton Pump Inhibitors (Omeprazole) block the H⁺- K⁺ ATPase in gastric parietal cells.

THE POWER GRID: ACTION POTENTIALS

Foundation: Resting Membrane Potential (RMP) is primarily due to K^+ permeability through leak channels. $E(K^+)$ is $\sim -90mV$.

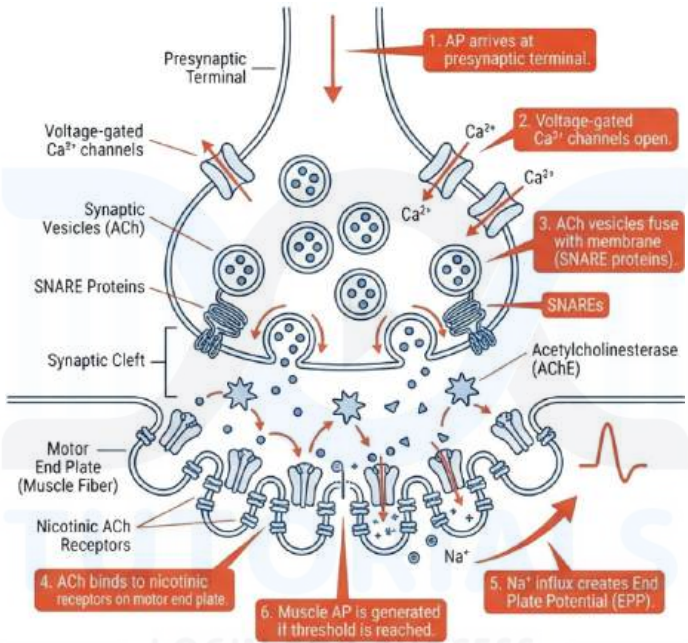


CLINICAL INSIGHT : ION EFFECTS ON EXCITABILITY

- Hyperkalemia: RMP becomes less negative $\rightarrow$ Initial hyperexcitability followed by paradoxical inactivation of Na^+ channels $\rightarrow$ Paralysis. ECG Peaked T waves. ECG:
- Hypocalcemia: Increases Na^+ channel excitability $\rightarrow$ tetany (Chvostek's/Trousseau's signs).

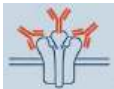


THE COMMUNICATION NETWORK: NEUROMUSCULAR TRANSMISSION



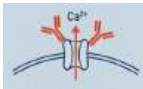
The NMJ under attack

MYASTHENIA GRAVIS



Antibodies attack postsynaptic ACh receptors.

LAMBERT-EATON SYNDROME



Antibodies attack presynaptic Ca^{2+} channels.

BOTULISM



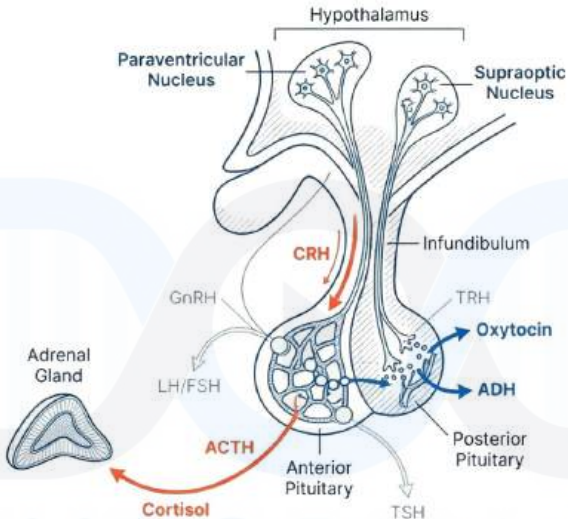
Toxin cleaves SNARE proteins, blocking ACh release.

ORGANOPHOSPHATE POISONING



Irreversible inhibition of AChE.

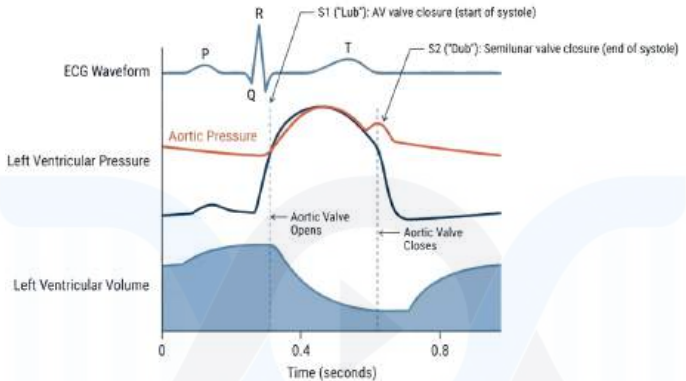
COMMAND & CONTROL: THE HYPOTHALAMUS-PITUITARY AXIS



HORMONE FUNCTION TABLE

Hormone	Source	Key Function	Disorder (Excess/Deficit)
Growth Hormone	Ant. Pit.	Anabolic Growth (via IGF-1)	Gigantism / Dwarfism
Cortisol	Adrenal Cortex	Stress, Anti-inflammatory, ↑ Glucose	Cushing's / Addison's
ADH	Post. Pit.	Water reabsorption (kidney)	SIADH / Diabetes Insipidus
Thyroid (T3/T4)	Thyroid	↑ Basal Metabolic Rate	Hyperthyroidism / Hypothyroidism

THE PUMPING STATION: THE CARDIAC CYCLE



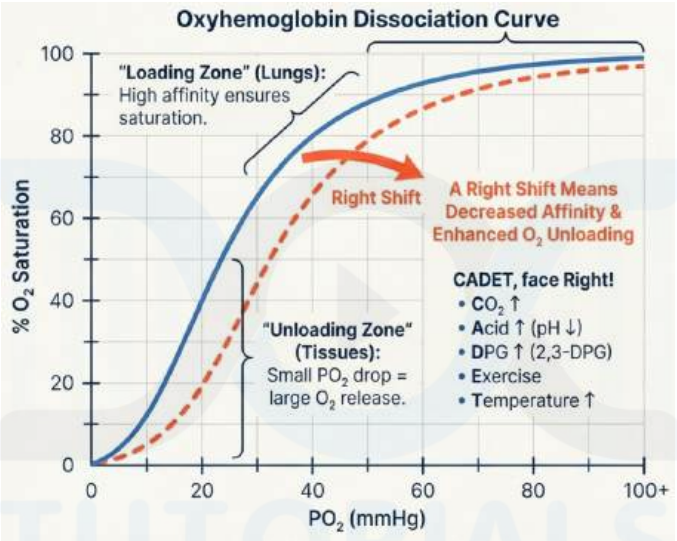
Key Performance Metrics

- Cardiac Output (CO) = Stroke Volume (SV) x Heart Rate (HR)
Normal: 5-6 L/min
- Ejection Fraction (EF) key = $(SV / \text{End-Diastolic Volume}) \times 100$
- Normal: 55-70%. **A key indicator** of systolic function.

LOGIN FOR SUCCESS

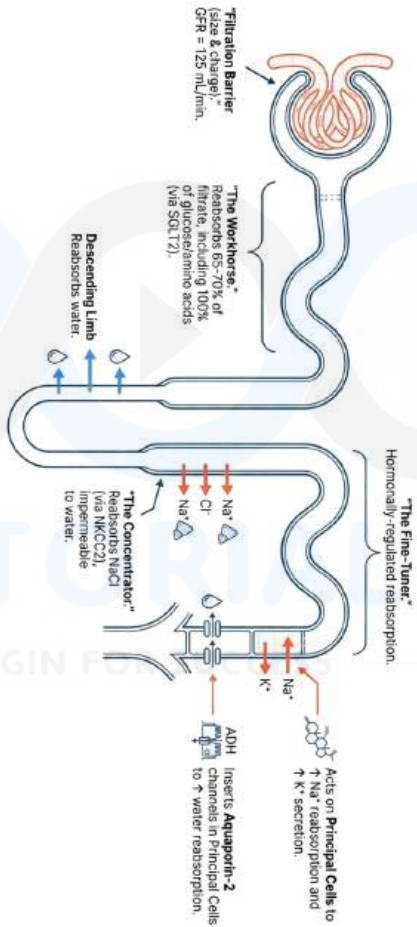
THE OXYGEN EXCHANGE:

RESPIRATION & GAS TRANSPORT



OBSTRUCTIVE VS. RESTRICTIVE LUNG DISEASE				
Disease Type	FEV1	FVC	FEV1/FVC Ratio	TLC
Obstructive (COPD)	↓↓	↓	(<70%)	↑
Restrictive (Fibrosis)	↓	↓↓	Normal or ↑	↓↓

THE FILTRATION PLANT: RENAL FUNCTION & REGULATION



CLINICAL INSIGHT : DIURETIC TARGETS

Loop Diuretics (Furosemide) block the **NKCC2** transporter in the TAL.
Thiazide diuretics block the NCC transporter in the DCT.

THE FUEL PROCESSOR:

GI HORMONES & DIGESTION

THE BIG THREE GI HORMONES

Gastrin
(from G cells)



Peptides,



Stomach
Distension



↑ HCl secretion,



↑ Gastric motility

Gastrin
(from G cells)



Fats & Proteins
in Duodenum



Gallbladder
contraction



Pancreatic
enzyme secretion



↓ Gastric emptying

Gastrin
(from G cells)



Acid in
Duodenum

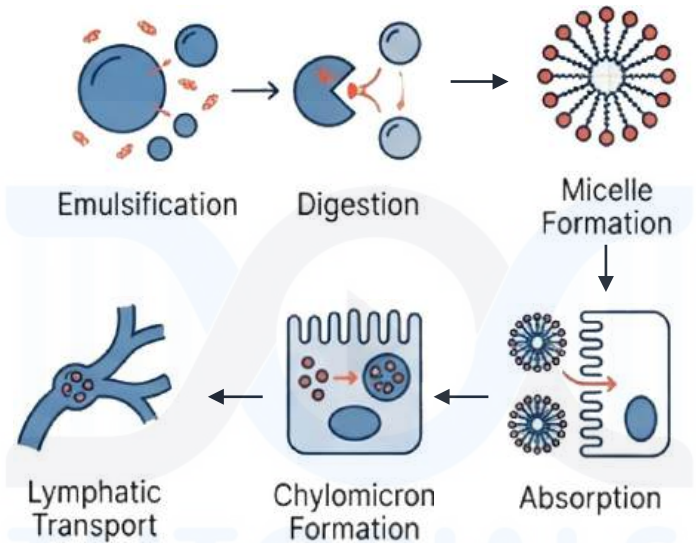


Pancreatic
HOC3 secretion



↓ Gastric acid
secretion

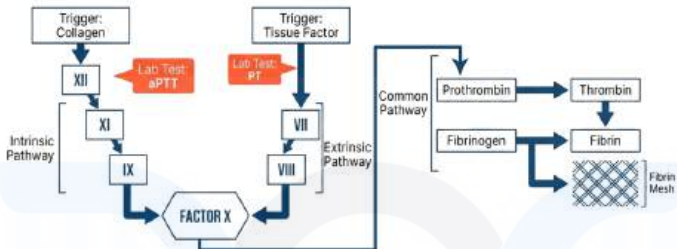
FAT ABSORPTION



CLINICAL INSIGHT : PATHOPHYSIOLOGY OF B₁₂ ABSORPTION

Vitamin B₁₂ requires Intrinsic Factor (secreted by gastric parietal cells) for absorption in the terminal ileum. Autoimmune destruction of parietal cells causes Pernicious Anemia.

THE DEFENSE GRID: HEMOSTASIS & IMMUNITY



Innate vs. Adaptive immunity

Feature	Innate Immunity	Adaptive Immunity
Response Time	Immediate (Minutes)	Delayed (Days)
Specificity	Non-specific Patterns	Highly Specific Antigens
Memory	None	Yes (Immunological Memory)
Key Cells	Neutrophils, Macrophages, NK Cells	B-Cells, T-Cells



CLINICAL INSIGHT : INHERITED BLEEDING DISORDERS

- Hemophilia A: Factor VIII Deficiency (Intrinsic Pathway)
- Hemophilia B: Factor IX Deficiency (Intrinsic Pathway)
- von Willebrand Disease: Defect in platelet adhesion & Factor VIII carrier function.

INTEGRATED FUNCTION: THE PHYSIOLOGY OF EXERCISE

1 CARDIOVASCULAR RESPONSE

- **Cardiac Output:** ↑ up to 5-6x
- **Blood Flow:** Redirected ↑ to muscles, ↓ to GI/kidneys.

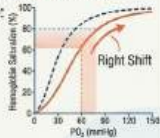


- **Blood Pressure:** Systolic ↑, Diastolic stable or ↓.

2 RESPIRATORY RESPONSE

- **Minute Ventilation:** ↑ up to 20x

- **Gas Exchange:** Right shift of O_2 -Hb curve facilitates O_2 unloading to muscles.



4 THERMOREGULATORY RESPONSE

- **Heat Production:** ↑ dramatically.
- **Heat Loss:** Evaporation (sweating) becomes the primary mechanism.



3 METABOLIC RESPONSE

ATP-PC System



0-10 sec

Glycolytic System



10s - 2 min

Oxidative System



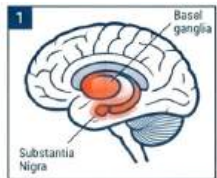
>2 min

BLUEPRINT DIAGNOSTICS:

HIGH-YIELD CLINICAL CORRELATION

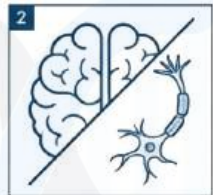
Parkinson's disease

- **Pathophysiology:** Loss of Dopaminergic neurons in the Substantia Nigra.
- **The Clinical Triad:** Resting Tremor, Bradykinesia, Rigidity ("Cogwheel").



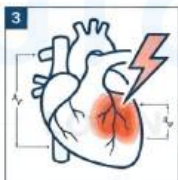
UMN vs. LMN lesions

Feature	UMN Lesion	LMN Lesion
Tone	Spasticity	Flaccidity
Reflexes	Hyperreflexia	Hyporeflexia
Babinski	Positive	Negative
Atrophy	Disuse	Denervation



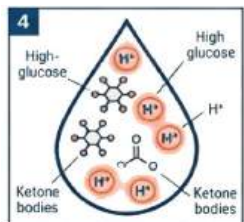
Myocardial infarction

- **Pathophysiology:** Coronary artery occlusion → Myocyte necrosis.
- **Key Markers:**
 - ✓ **Biochemical:** Rise in serum Troponin (TnI, TnT).
 - ✓ **ECG:** ST-segment elevation (STEW).



Diabetic ketoacidosis (DKA)

- **Pathophysiology:** Absolute insulin deficiency in Type 1 DM.
- **The Clinical Triad:** Hyperglycemia, High Anion Gap Metabolic Acidosis, Ketones.



THE ARCHITECT'S TOOL KIT: FOUR FOUNDATIONAL PRINCIPLES OF PHYSIOLOGY

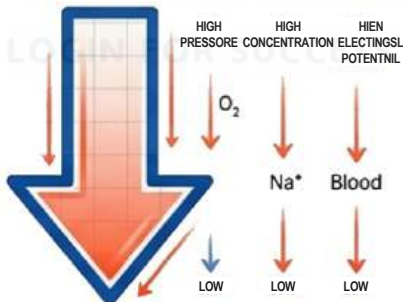
Homeostasis is the goal

- The body's systems work concert to maintain a stable internal environment. primarily through negative feedback loops.



Gradients drive flow

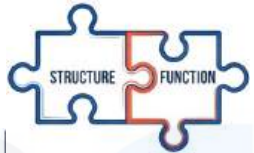
- Physiology is governed by the movement of substances down pressure, concentration, and electrical gradients. This powers everything from action potentials to blood flow.



THE ARCHITECT'S TOOL KIT: FOUR FOUNDATIONAL PRINCIPLES OF PHYSIOLOGY

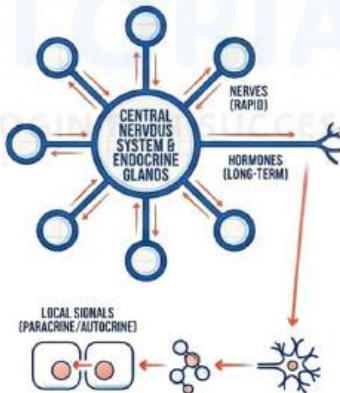
Gradients drive flow

- From the molecular shape of a receptor to the macroscopic Structure Of the nephron. form is precisely tailored to physiological function.

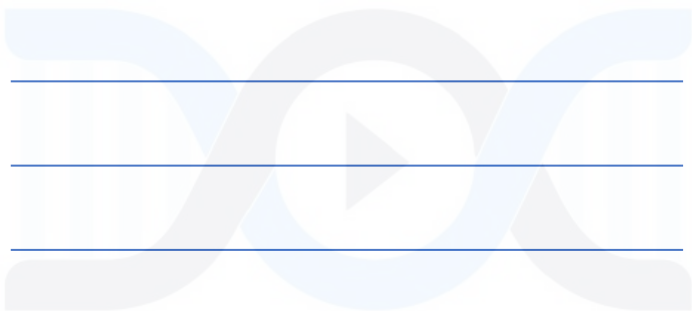


Communication is integration

- The body functions as a whole because of constant, multi-layered communication between cells and organs via nerves, hormones, and local signals.



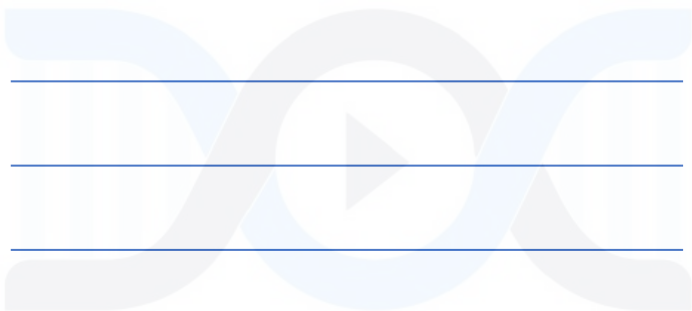
NOTES



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LOGIN FOR SUCCESS

NOTES



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The Jarvis to 'Your' Iron Man



Hardcopy Notes



ANK-1, 2,2 & 2.3 Types of Bones



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