YAKEEN NEET 2.0

2026

Locomotion and Movement

Zoology | Lecture -- 01

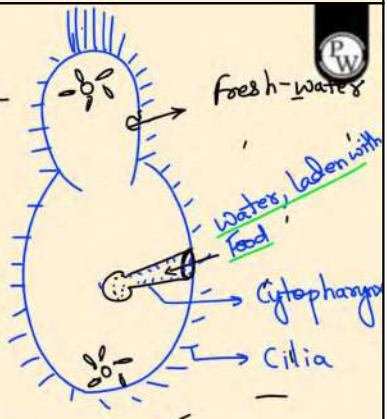
By- Akanksha Ma'am

* LOCOMOTION AND MOVEMENT :-

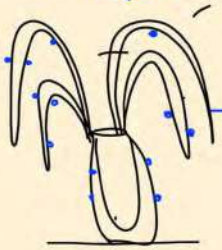
  - Voluntary movement which leads to change in location
  - Any change in body posture

- All movements are NOT locomotion
  But All locomotions are movements
- locomotory movements like walking, running, swimming, flying, Climbing etc.
- Why need of locomotion : In search of food, Shelter, mate, Protection from enemy/predator etc.

* PARAMOECIUM : CILIA
  (Protista, Ciliated)
  - locomotion
  - Movement of food through Cytopharynx



* HYDRA : TENTACLES
  - locomotion
  - Capture of food (Prey)



* Human locomotion by LIMBS

* Types of Movement – 3 types

I AMOEBOID Movement
- by Pseudopodia (=false feet)
- formed by streaming of protoplasm (Microfilaments / Actin protein)
- Eg: 1. Amoeba
  2. Macrophage
  3. White Blood Cells like Neutrophils, Monocytes → Phagocytic

II (9+2, Microtubular) CILIARY Movement
- Coordinated movement of Cilia in Trachea → Remove dust particles from Atmospheric air
- Passage of Ova through female Reproductive tract
- Cilia is present in Most of our Internal Tubular Structure, lined by Ciliated epithelium

III MUSCULAR Movement
- Movements of our limbs, jaws, tongue, eyelids etc. due to Contractile properties of Muscles
- By Coordinated activity of *Muscular, *Skeletal and *Nervous system.

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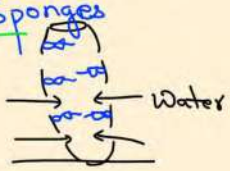
* Flagellar movement (9+2, Microtubular) :- Eg: 1. Human Sperm

2. Euglenoids
3. Dinoflagellates
4. Trypanosoma } Protozoa
5. Leishmania }
6. Water current in Canal System in Sponges

[Choanocytes / Collar cells]



* Method of locomotion VARY with their *HABITAT and *Demand of Situation

* Muscles constitute *40–50% of Adult body weight

Struc. Org. Chapter Lec–6

* MUSCULAR TISSUE :-

- Mesodermal in origin Except Iris and Ciliary body muscles of Eye (Ectodermal)
- Special Properties :-

1. Excitibility
2. Contractibility :- Contract (or shorten) in response to stimulation and then relax (=lengthen) to return to back uncontracted (=original) position in a coordinated fashion (NCERT)
3. EXTENSIBILITY ↳ Ability to extend/stretch
4. ELASTICITY : Return back to original position

NCERT
Lec-6
Struc. Organis.

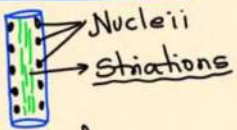
* Functions of Muscles :-

1. Role in ALL Movements of body
2. Their action moves the body to adjust to changes in environment and to maintain position of various parts of body

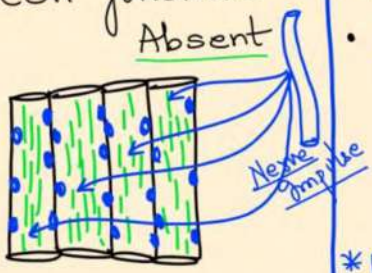
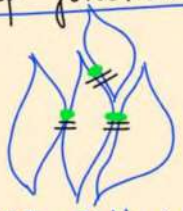
Lec-6
Struc. Org.

Skeletal Muscle	Smooth = Visceral Muscle	Cardiac Muscle
• Attached to Skeletal Bones eg: Biceps Muscle	• Present in Internal Organs (= Viscera) like Stomach, Intestine, Blood vessels etc.	• Found ONLY in HEART
• VOLUNTARY : under our will / control	• Involuntary	• Involuntary

i.e Functioning Cannot be controlled directly
i.e We can't make them Contract, merely by thinking

Skeletal Muscle	Smooth Muscle	Cardiac Muscle
• MUSCLE FIBRE (=CELL) 		
→ Cylindrical	→ Fusiform / Spindle i.e tapering at both ends	→ Cylindrical
→ Unbranched	→ Unbranched	→ Branched
→ Multi-nucleated Syncytial	→ Uni-nucleated	→ Uni-nucleated
→ Striated / Striped (Myofibrils Parallel fashion)	→ Un-striated / Un-striped = Smooth muscle	→ Striated / Striped (faint) (Parallel fashion)

Lec-6 Struc-Org

Skeletal Muscle	Smooth Muscle	Cardiac Muscle
* Cell junctions Absent	• Adhering junctions ⊕ • Gap junctions ⊕	* Special type of Communicating junction i.e INTER-CALATED Disc
		
	* NCERT: Cell junctions hold them together, and covered by Connective tissue sheath	= Gap jn + Adhering jn

* Skeletal muscle → Role in locomation and changes in body postures

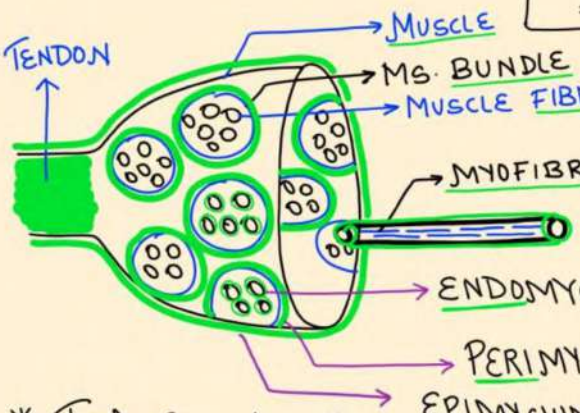
* Cardiac muscle → Muscle of Heart

* Visceral/Smooth muscle → In Inner wall of Hollow Internal organs (=Viscera) like Alimentary canal, Reproductive tract etc.
  → Assist in transfer of food, gametes etc.

[Dense, Regular, Connective tissue]

Lec-6 Struc-Org *

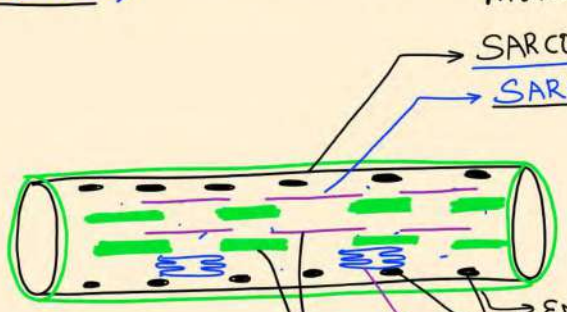
MUSCLE (Each) → Lot of Muscle Bundles = Fascicle → Each bundle → Lot of Muscle fibres (= Cells)



Each Muscle fibre → Lot of fine fibrils, called "Myofibrils"

* Tough Connective Tissue sheaths | coverings
* Muscle cell is long, hence called Muscle Fibre

* MUSCLE FIBRE (=Cell) (Skeletal) : Cylindrical, Unbranched, Multi-nucleated, Striated / Striped



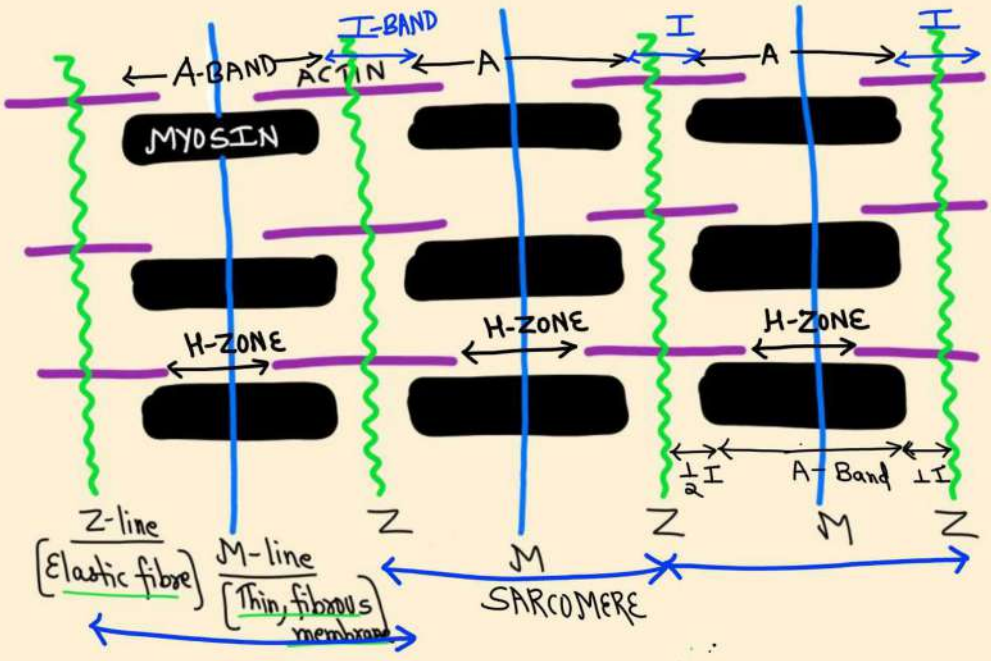
- large number of Paralally arrange Protein filaments in Sarcoplasm

Myofibrils / Myofilaments

Arranged Parallely and Alternately to each other

Thick filaments
- Myosin (मोटा) filaments
- longer (1.5 μm)

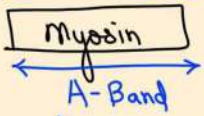
Thin filaments
- Actin filaments
- shorter (1 μm)



* Alternate A-Band (Anisotropic, Dark-Band) and I-Band (Isotropic, Light Band)

A-Band → Both Myosin and overlapping Actin

I-Band → Only Actin filament



* Thin filament partially overlaps edges of Thick filaments
[Muscle not contracts i.e Resting stage]

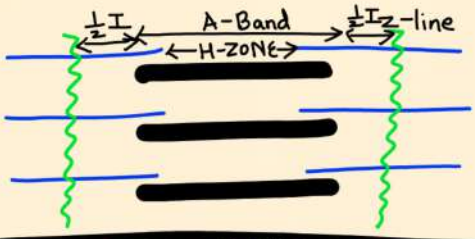
* Z-line Bisects I-Band (Light Band, Actin filament, Thin filament)

* M-line Bisects H-Zone / A / Dark-Band / Myosin filament / Thick filament

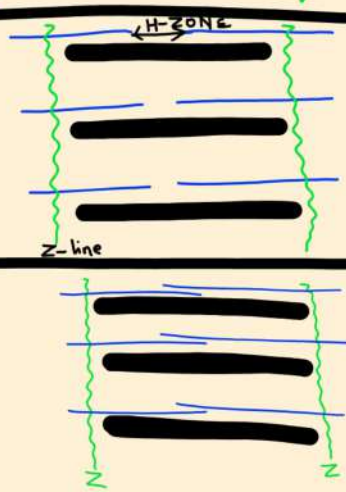
* SARCOMERE = Portion between 2 successive Z-lines
- Structural & functional Unit of Contraction
- $= \frac{1}{2}I + 1A + \frac{1}{2}I$-Band
- $= 0.5\mu + 1.5\mu m + 0.5\mu = 2.5\mu m$

Length of Sarcomere, in Relaxed/Resting stage

PYQ * H-ZONE (Hensen's) : Central portion of Thick-filament, Not overlapped by Thin filament



I When Muscle is NOT Contracting (Relaxed/Resting)



II When Muscle is CONTRACTING

- Length of Sarcomere ↓ (shorten)
- Distance between 2 Z-lines ↓
- Length of I-band ↓
- Length of H-Zone ↓
- Length of A-Band → Constant
- Length of Thick & Thin filament → Constant / Same

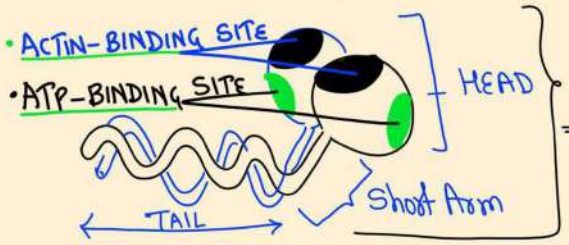
III When Muscle is Maximally Contracted

- H-Zone disappears

* Structure of Contractile Proteins :-
(Actin & Myosin filament)

* MYOSIN (2 NOS)

- It is a Polymer (Polymerised protein), made of many Meromyosin (Monomeric protein)
- Each Meromyosin 2 parts :
  - Tail = Light Meromyosin (LMM)
  - Head & Short Arm = Heavy MeroMyosin (HMM)



* Myosin Head = Globular
(ATP – cheque, Energy – Cash)

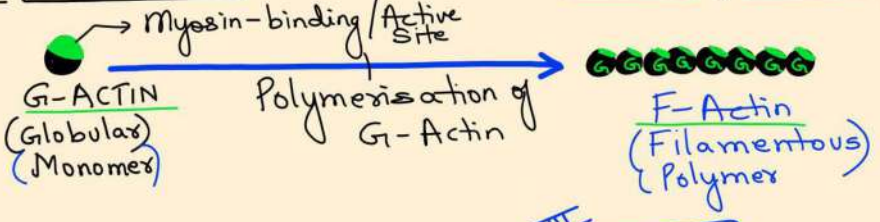
- Actin-binding site (Active Site)
- ATP-binding site
- Act as ATPase enzyme

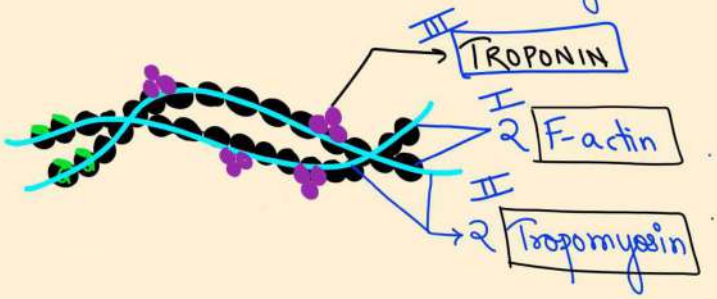
$$ATP \xrightarrow[\text{Breakdown of ATP}]{H_2O \text{ Hydrolysis of ATP}} ADP + P_i + Energy$$
ATPase Enzyme

* Head & Short arm, project outward, at regular distance & Angle from each other, from Surface of Polymerised Myosin filament, called CROSS-ARM

* ACTIN FILAMENT (Simran) :- 3 types of Proteins

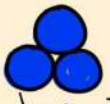
1. **F-ACTIN** → 2 F-actin, helically wound to each other





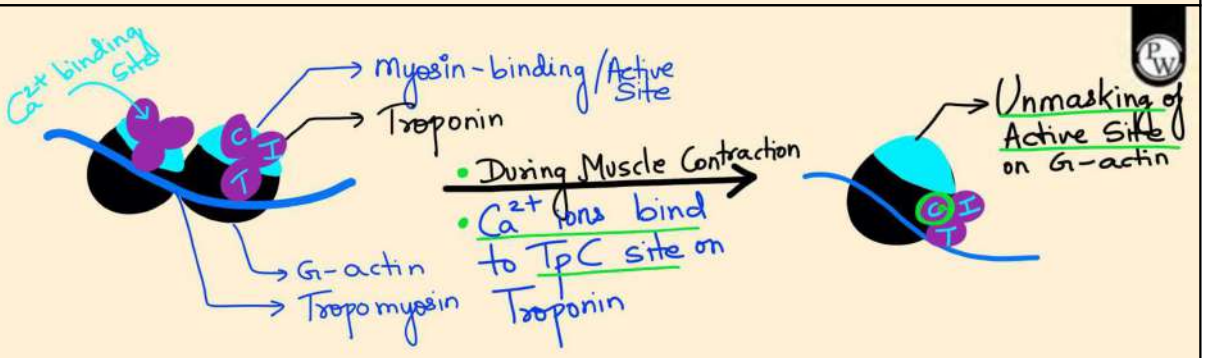
2. **TROPOMYOSIN** (2) :- Filamentous
   Runs close to F-actin, along its entire length

3. **TROPONIN**



- Each Troponin has 3 sub-units
- Distributed at regular intervals, on Tropomyosin
- In Resting Stage, its Subunit T_pI Mask/Covers Myosin-binding Active Site on G-actin

- T_C or T_pC : Site where Ca^{2+} ions bind, during muscle contraction
- T_I or T_pI (Inhibitory) :- Site, which Mask, Active Site on G-actin when muscle is relaxed
- T_T or T_pT : Site, where it attaches with Tropomyosin



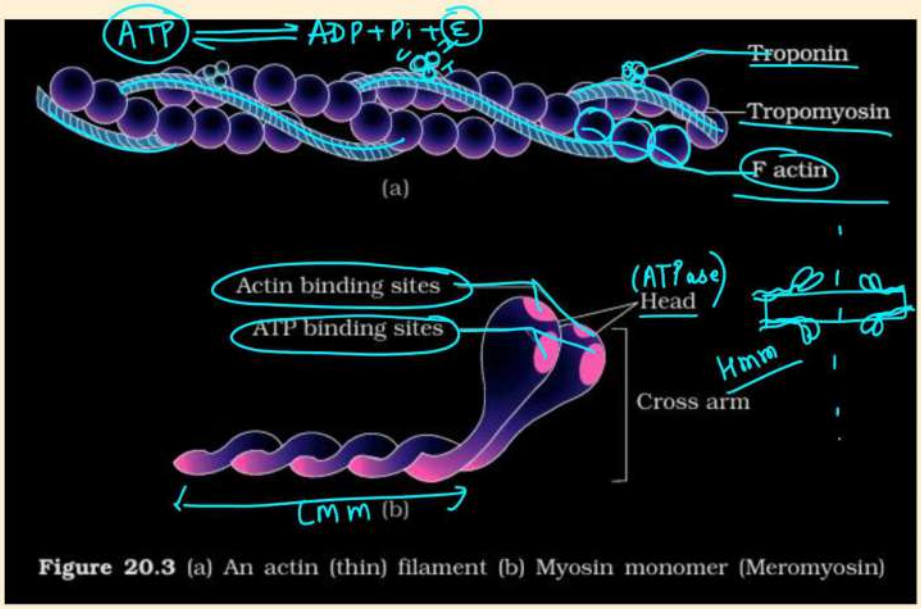
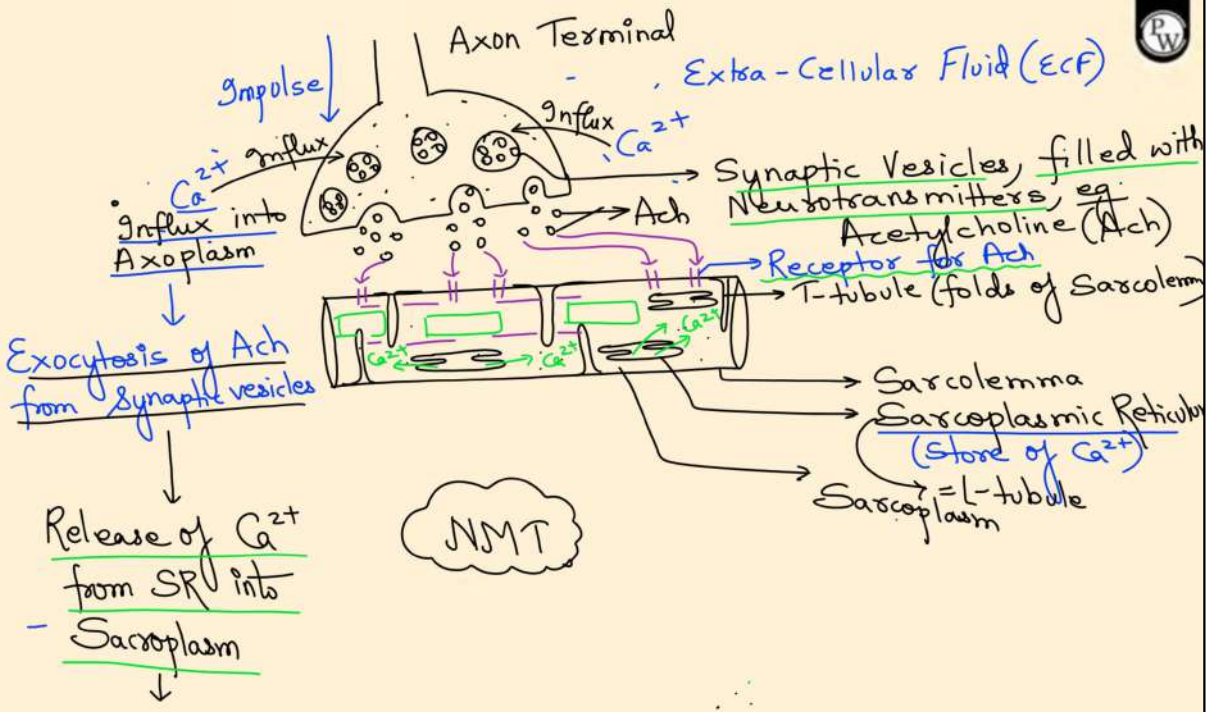


Figure 20.3 (a) An actin (thin) filament (b) Myosin monomer (Meromyosin)

Last Class
Lec-2

* MECHANISM OF MUSCLE CONTRACTION :-

- By SLIDING FILAMENT THEORY :-
  - ↳ Thin filament Slide over Thick filament
- Stimulus (Sense Organ) → Sensory Nerves → Central Nervous System (CNS) → Motor Signals → Neuro-Muscular Junction (NMJ) or Motor End-plate



Ca^{2+} ions bind with TpC site of Troponin

↓

Conformation change in Troponin & Tropomyosin

↓

Unmasking of Active sites (Myosin-binding) on G-actin

↓ + Myosin head acts as ATPase and hydrolyse ATP to release ADP + Pi + Energy

Binding of Active Site on Myosin and Actin to form a Cross-Bridge, with the use of Energy / ATP.

(Actin-binding) (Myosin-binding site)

↓

Sliding / Rotation of Actin filament on Myosin, towards Centre of A-band / H-Zone

↓

Z-lines pulled inwards [Shortening of Sarcomere i.e. Contraction]

↓

Joining of a new ATP molecule on Myosin Head

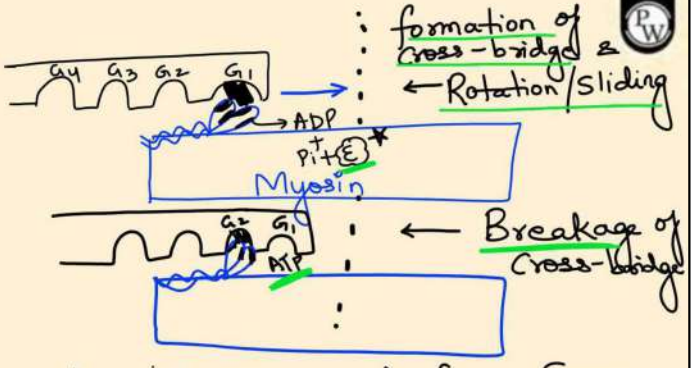
↓

Breakage of Cross-bridge between Actin & Myosin

↓ + Myosin hydrolyse ATP → ADP + Pi + E

New Cross-bridge formation, with next G-actin, by use of Energy ATP

↓



↓

Continues till Nerve impulse is removed from Sarcolemma

↓

Ca^{2+} ions actively transported / Pumped back into Sarcoplasmic reticulum (higher conc.) from Sarcoplasm (lower conc.)

↓

Masking of Active Sites on Actin

↓

↓

Return of Z-lines back to their original position

↓

Relaxation of Muscle

* NOTE → Reaction time of fibres VARY in different Muscles

→ Repeated activation of Muscle leads to,

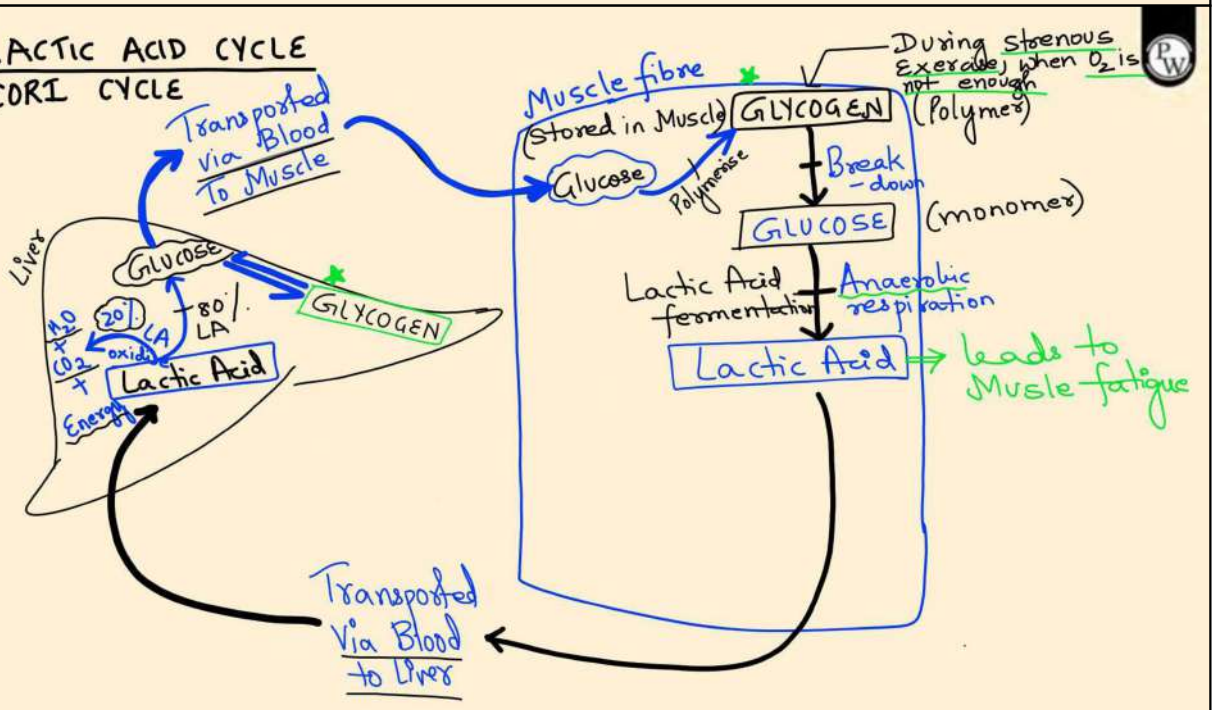
↓

Accumulation of Lactic Acid [Produced by Anaerobic breakdown of Glycogen]

↓

MUSCLE FATIGUE (थकान)

* LACTIC ACID CYCLE
CORI CYCLE



SLIDING FILAMENT MECHANISM

CNS sends impulse to muscle via motor neurons

↓

Impulse reaches Neuromuscular Junction/Motor End plate

↓ – Bursting of Ach vesicles with Ca^{2+} influx from ECF

Release of Acetylcholine neurotransmitter

↓

Transmits impulse to muscle fibre &
Impulse travels along sarcolemma

↓

Impulse recieved by T-tubules & L-tubules

↓

Release of Ca^{2+} ions from L-tubules (S.R) into sarcoplasm

↓

Binding of Ca^{2+} ions with Troponin –C

↓ – conformational change in Troponin

Unmasking of active site of Actin

↓

Binding of active site of Actin with Cross arm of myosin, forming Cross-bridge by use of ATP

↓

Sliding of Actin filament over Myosin, towards centre of A-Band/H-zone

↓

Z-Lines also pulled inwards

↓

Joining of another ATP molecule to Myosin head

↓

Breaking of cross-bridge between Actin & myosin

↓

Formation of new cross-bridge by use of ATP

↓

Continues till nerve impulse removed from Sarcolemma

↓

Ca^{2+} ions actively transported back into L-tubules of SR

↓

Relaxation of Muscle

V.V. imp

Character	Red Muscle Fibre	White Muscle Fibre
1. Amount of Myoglobin (Red color, O_2 storing pigment)	→ Plenty, hence red color	→ Little, hence white/Pale color.
2. Mitochondria	→ Plenty	→ very few
3. Respiration type	→ Aerobic	→ Anaerobic (Glycogen → Glucose → LA; LA fermentation)
4. Muscle fatigue	→ lesser	→ More, due to accumulation of Lactic Acid
5. Contraction	→ Slow but long-lasting	→ Faster but Short-lasting
6. Examples	→ Human back muscles → Flight muscles of Eagle	→ Eye-lids muscles, → Flight muscles of Sparrow
7. Amount of Sarcoplasmic Reticulum	→ lesser	→ Higher

* SKELETAL SYSTEM :-

- Framework of Bones and few Cartilages (Total: 206 in human)
- Responsible for Movements of body
- Bones & Cartilages : Specialised Connective tissue

Bones:
- Hard matrix
- Non-pliable due to Calcium Salts

Cartilages:
- Solid matrix and slightly pliable due to Chondroin salts

Human Skeletal System (206 Bones)

- **I. AXIAL** (80 Bones) (main axis of body)
  - **SKULL / HEAD** (29 bones)
    - CRANIUM / Brain Box — 8 bones
    - Facial — 14 bones
    - Ear Ossicles — 3 bones × 2 = 6 bones (Latest NCERT)
    - * HYOID — 1 bone, Not a part of Skull
    - NCERT, In Skull = 22 bones (Cranium 8 bones, Facial 14 bones)
  - **STERNUM** — 1 bone
  - **RIBS** — 12 Pairs = 24 bones
  - **Vertebral column** = 26 bones
- **II. APPENDICULAR** (126 Bones)
  - **LIMBS** (120 bones)
    - Upper limbs · 30 × 2 = 60 bones
    - Lower limbs · 30 × 2 = 60 bones
  - **GIRDLES** (6 bones)
    - Pectoral Girdle — 2 × 2 = 4 bones
    - Pelvic Girdle — 1 bone × 2 = 2 bones

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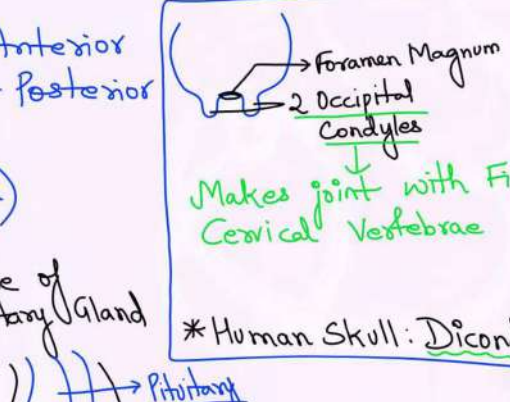
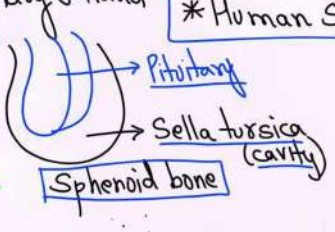
* **CRANIUM** (Brain-box) — Forms Outer Hard, protective Covering for Brain
  - 8 Bones :-
    1. Frontal bone (1) – Anterior
    2. Occipital bone (1) – Posterior
    3. Parietal bones (2)
    4. Temporal bones (2)
    5. Ethmoid (1)
    6. Sphenoid (1): House of Pituitary Gland





NOTE: At base of Skull, a large opening, Foramen Magnum present through which Medulla of Brain, continues into Spinal cord

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* **HYOID BONE**
  - Single, U-shaped bone
  - On floor of Buccal cavity
  - Do not articulate or form joint with any other bone of body

* **FACIAL BONES (14)** :- forms Front part of Skull
  1. Mandible (lower jaw) – 1
  2. Maxillae (upper jaw) – 2
  3. Palatine bones (Roof of buccal cavity, Hard palate) – 2
  4. Zygomatic (Cheek bones) – 2
  5. Nasal bones (2)
  6. Vomer (1) – Median bone in nasal cavity
  7. Lacrymal bones (2) (Orbit of Eye)
  8. Inferior turbinate – 2 (Conchae)

* Ear Ossicles :- Total = 3 bones in each ear × 2 ears = 6 tiny bones

- Each Middle ear — 3 ossicles
- Outer to Inner (MIS)

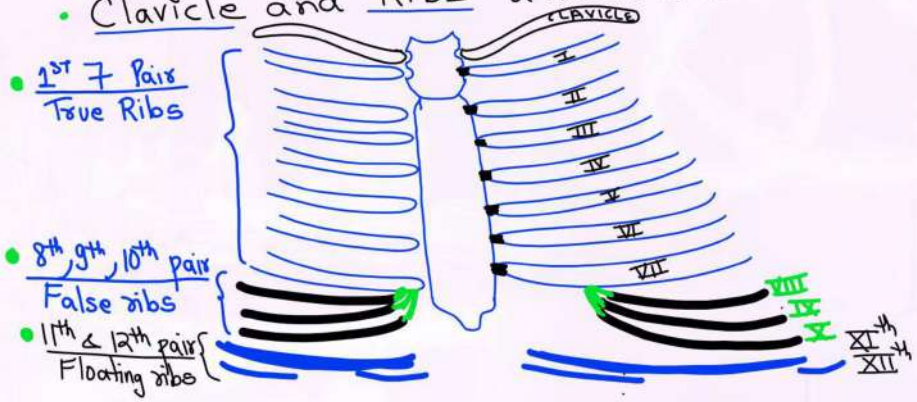
External Ear → Malleus → Incus → Stapes → Inner Ear

- Malleus: Outer, Hammer-shaped
- Incus: middle, Anvil shape
- Stapes: Inner, Stir-up shaped, Smallest bone of the body

- Role in Amplification of Sound

* STERNUM / Chest bone / Breast bone (1)

- Single
- Ventral
- Mid-line of thorax
- Flat bone
- Clavicle and Ribs attach to it

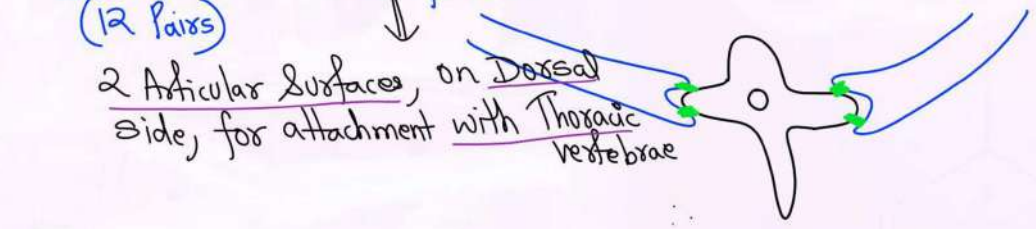


* RIBS (12 Pair = 24 bones)

- Thin, flat bones
- Connected ventrally to Sternum and Dorsally to Vertebrae (thoracic)

- True Ribs / Vertebro-Sternal Ribs (7 Pairs = 14; 1ST 7 Pairs)
  - Dorsally connected to 1ST to 7TH thoracic vertebrae
  - Ventrally, connected to Sternum directly, by hyaline cartilage
- False ribs / Vertebro-Chondral Ribs (8th, 9th, 10th pair; 3 pair = 6 bones)
  - Dorsally, connected to 8/9/10th thoracic vertebrae
  - Ventrally, Indirectly attached to Sternum (Directly attached to 7th Ribs by hyaline cartilage)

- Floating Ribs / Vertebral Ribs (11th & 12th pair; Total = 4 bones)
  - → Dorsally, attached to 11/12th thoracic vertebrae
  - → Ventrally, Not attached to Sternum, or any other rib
  - → Protect Kidneys
- Rib Cage = Thoracic vertebra (12) + Sternum (1) + 12 Pair Ribs (24)
- All Ribs are Bicephalic (12 Pairs)
  - 2 Articular Surfaces, on Dorsal side, for attachment with Thoracic vertebrae



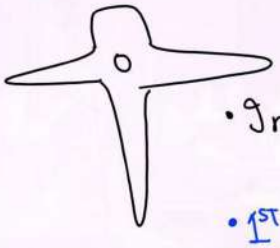
* VERTEBRAL COLUMN (Total = 26 Bones)

1. Cervical (neck) vertebrae (C) = 7 → In Most Mammals, including humans
2. Thoracic (chest) vertebrae (T) = 12
3. Lumbar (Back) vertebrae (L) = 5
4. Sacrum (Pelvic) (S) = (5) = 1 bone [5 fused bones = 1 Sacral vertebrae; 1 Sacrum]
5. Coccyx (Co/Cd) = (4) = 1 bone [4 fused bones = 1 Coccyx]
   - (Tail bone)
   - Caudal

Total :- Embryonic life = 33 bones; ~~Adult~~ = 26 bones / vertebrae

* Vertebral Formula: $C_7 T_{12} L_5 S_{(5)} Co_{(4)}$

- Vertebral Column → Dorsally placed
  - Extends From Base of Skull
  - → Constitute Main framework of trunk
  - → Site of attachment of Ribs and Musculature of Back
  - → Protects Spinal Cord
  - → Supports Skull



- In Centre of Each vertebrae, there is a Hollow, Central / Neural canal, through which Spinal Cord passes
- 1st Cervical vertebrae = ATLAS, articulate with Occipital condyles
- 2nd Cervical vertebrae = AXIS

- Atlas (C_1) → Yes Bone
  → Atlanto-Occipital joint (Atlas (C_1) – occipital condyle), resp. for Yes Movement / Nodding of head
- Axis (C_2) → No Bone
  → has Odontoid process, which articulate with C_1/atlas (Atlanto-Axial joint)
  → 'NO' movement

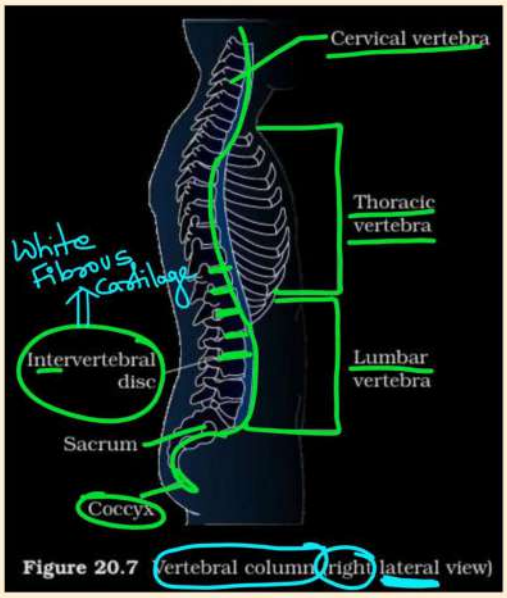


Figure 20.7 Vertebral column (right lateral view)

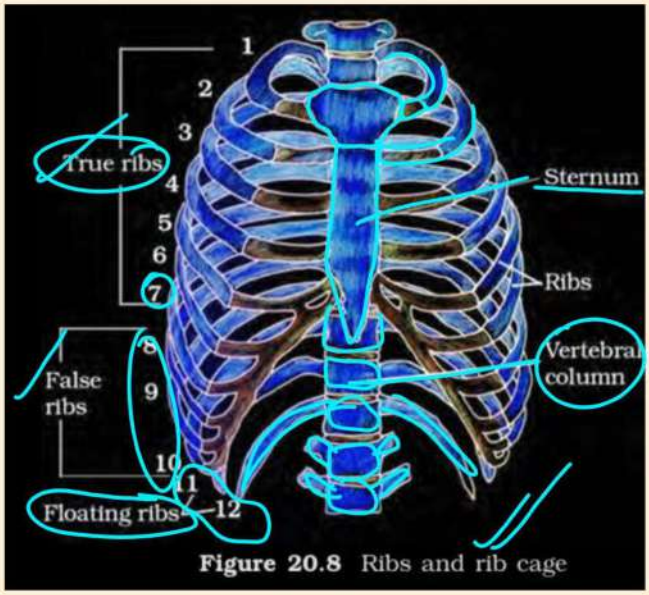
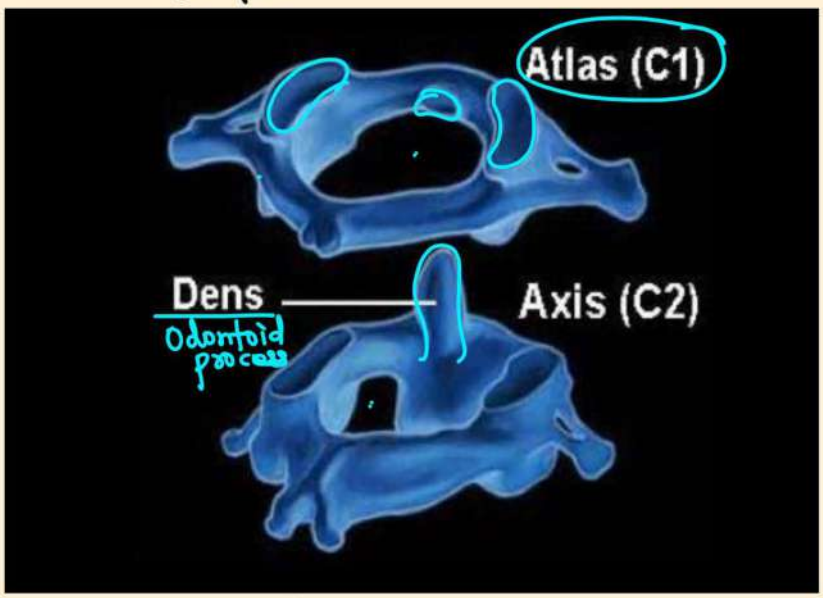
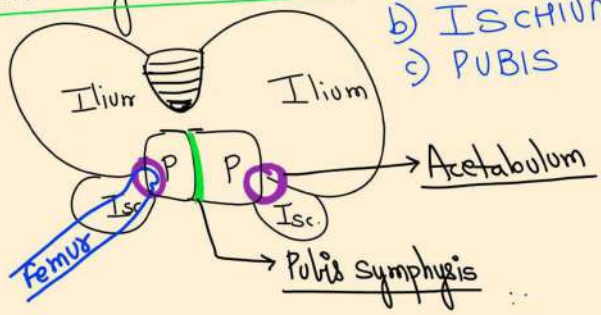


Figure 20.8 Ribs and rib cage

Out of NCERT



* APPENDICULAR SKELETON :- 126 Bones
* GIRDLE : Articulate Upper limbs (Pectoral Girdle) & lower limbs (Pelvic Girdle) with Axial skeleton
* PELVIC GIRDLE (Total 2 Coxal bones; Right half – 1, left half – 1)
  - Each Coxal bone is formed by fusion of 3 bones a) ILIUM (Small Intestine : Ileum)
    b) ISCHIUM
    c) PUBIS



  - At point of fusion of Ilium, Ischium and Pubis,
    ↓
    Cavity, called ACETABULUM
    ↓
    Articulate with Head of Femur to form HIP JOINT (Ball and Socket type of joint)
  - 2 halves of Pelvic Girdle, meet Ventrally, to form PUBIC SYMPHYSIS (White fibrous Cartilage)

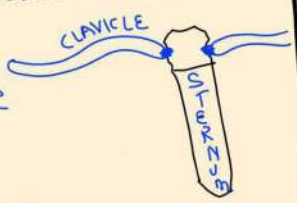
* PECTORAL GIRDLE (2 bones × 2 = 4 bones)

- Each Pectoral Girdle has 2 bones

CLAVICLE (Total = 2)

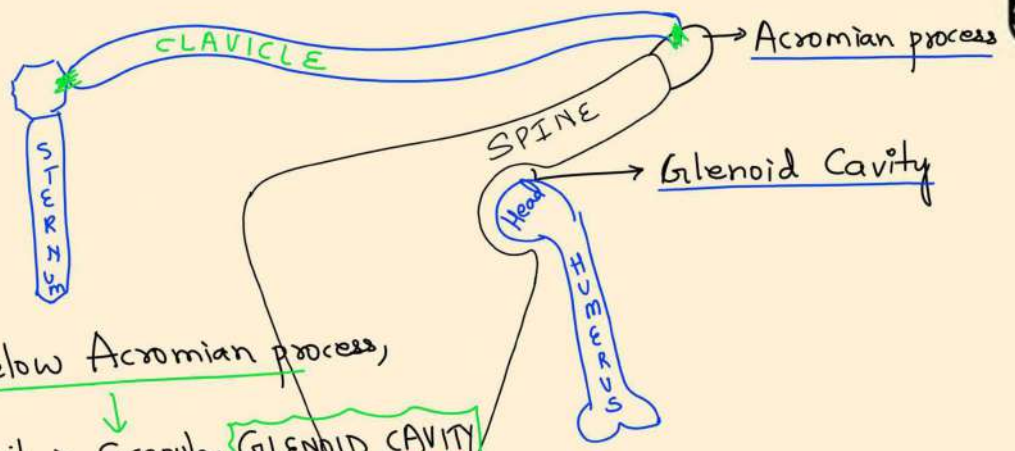
Collar-bone

- long, slender bone
- Ventral
- 2 Curvatures
- Attached
  - Medially to Sternum
  - laterally to Acromion process of Scapula



SCAPULA (Total = 2)

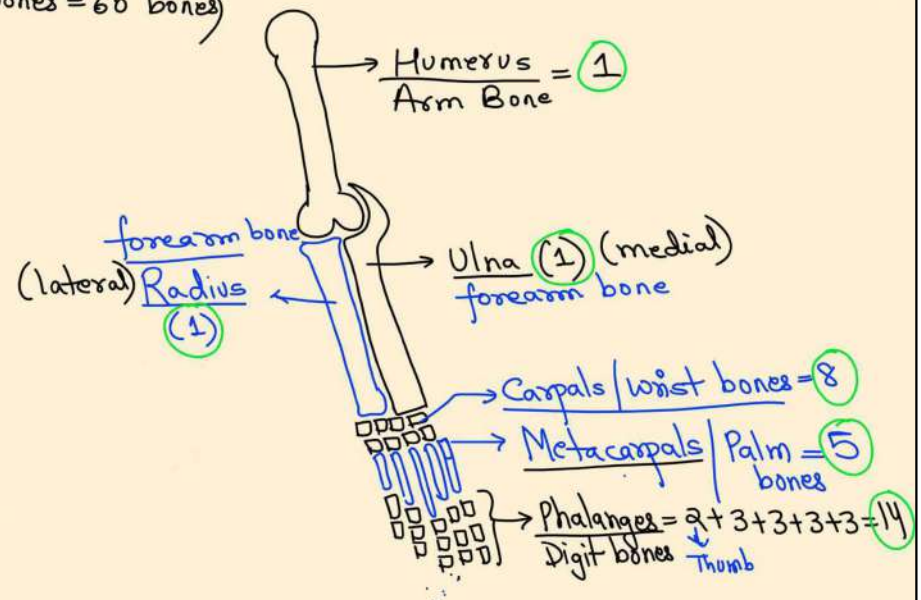
- Flat, triangular bone
- Dorsal part of Thorax
- Between 2nd and 7th Ribs
- Elevated ridge = SPINE
  - Project as flat, Expanded ACROMIAN Process, to which Clavicle is attached. (articulates)



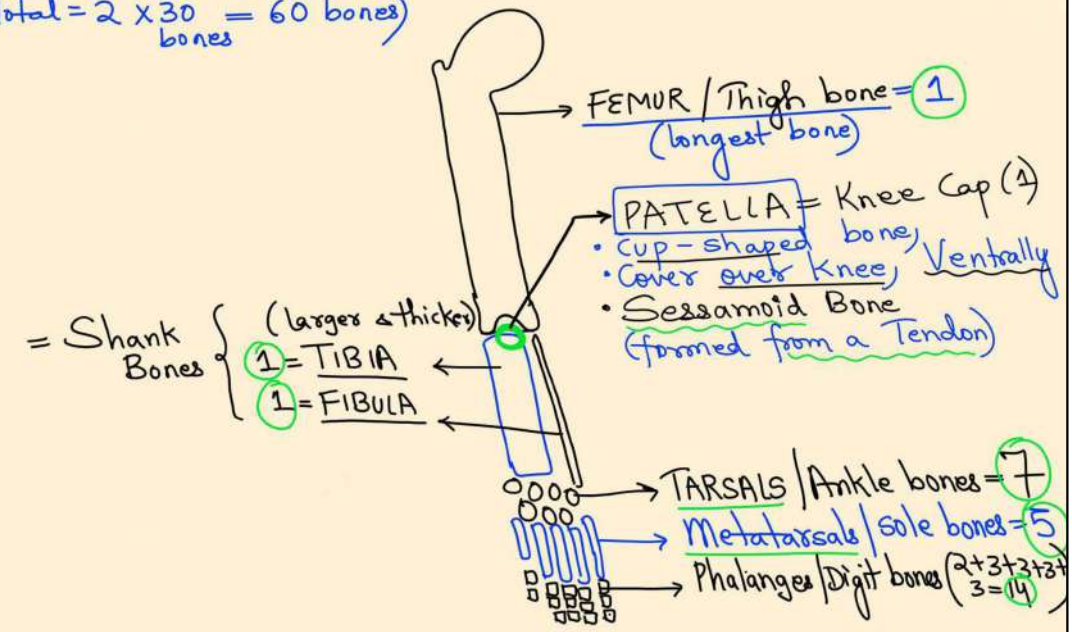
* Below Acromian process,
  - Cavity in Scapula, GLENOID CAVITY
    - Articulate with Head of Humerus, to form Shoulder joint (Ball and Socket joint)

* UPPER LIMBS; Each Upper limb = 30 bones

(2 × 30 bones = 60 bones)



* Lower limbs; Each lower limb = 30 bones
(Total = 2 x 30 bones = 60 bones)



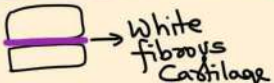
* JOINTS (जोड़) :
- Essential for all types of movements
- Point of Contact between 2 bones or Between a bone & a cartilage
- "Force, generated by Muscles," is used to carry out movements, through joints, where "joints act as fulcrum"

V.V. imp Types of JOINTS – 3 types

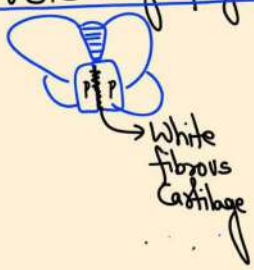
I FIBROUS JOINTS
Immovable
- Do not allow any movement
- No mobility
- Eg: Cranial Bones → Flat, Skull bones, Joint, end-to-end, with Sutures forming Cranium (Dense fibrous Connective Tissue)

II CARTILAGENOUS JOINT (Partially movable)
- allow limited movements

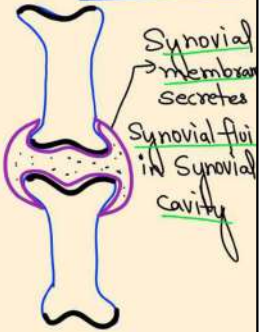
eg: 1. Inter-vertebral Dis



2. Pubic Symphysis



III SYNOVIAL JOINT (Freely Movable)
- Allow Considerable movements
- Help in Locomotion and other body movements



V.V.Imp

Types of Synovial Joints – 6 types

(A) Ball & Socket (3D movements)
1. Shoulder Joint
   [Glenoid cavity of Scapula with Head of Humerus]
2. HIP JOINT
   [Acetabulum of Pelvic girdle with Head of Femur]

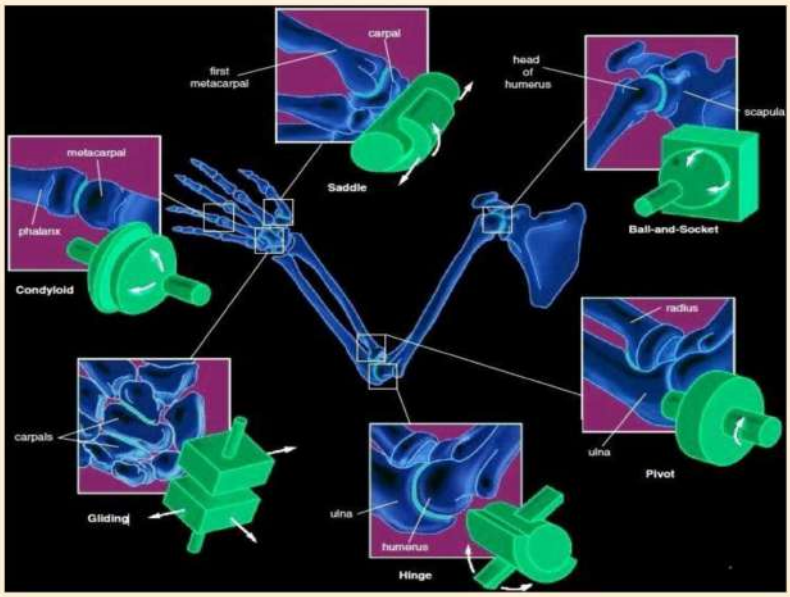
(B) HINGE JOINT (One directional) like a door
1. Elbow joint (Humerus & Ulna)
2. Knee joint
3. Inter-phalyngeal joint

(C) GLIDING JOINT
1. Between Carpals
2. Between Tarsals

(D) PIVOT JOINT
- Rotatory Movement
1. Atlanto-Axial Joint ($C_1 - C_2$)
2. Proximal Radio-Ulnar joint (Out of NCERT)

(E) SADDLE JOINT
- Reduced Ball & Socket
1. Between Carpal & Metacarpal of Thumb

(F) CONDYLAR JOINT (Out of NCERT)
1. Atlanto-occipital joint
   [C_1 and Occipital condyles]
2. Metacarpo-phalyngeal joint

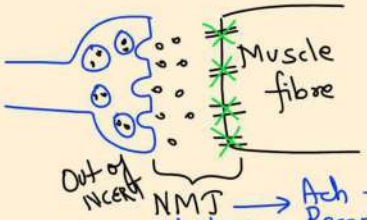


V.V.Imp*

Disorders of Muscular and Skeletal System:-

1. MYESTHENIA GRAVIS : Auto-immune disorder

(Myo = Muscle, Anaesthia = अनेस्थिया) (Grave = dangerous) [When our immune system starts attacking own cells]



Out of NCERT

NMJ affected → Ach Receptors destroyed → Ach will not bind → No Excitation of Muscle fibre → Paralysis of Muscle

Affecting Neuro-muscular Junction (NMJ), leading to fatigue, weakening and Paralysis of Muscles (Skeletal)

2. Muscular Dystrophy : ★ Genetic disorder

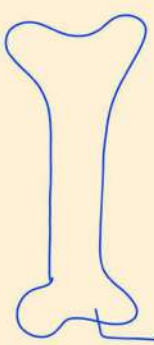
- Dystrophin Gene is damaged
  ↓
  No Dystrophin protein
  ↓
  Essential to maintain Structure of Muscle, as it connects thin filaments with Sarcolemma.

★ NCERT Progressive (Slowly) degeneration of Skeletal muscles

3. TETANY : Rapid Spasm (wild contractions) in Muscles, due to low Ca^{2+} ions in body fluids (=Hypocalcemia)
[Hypo-parathyroidism]

* Disorders of Skeletal System :-

1. OSTEOPOROSIS → Age-related disorder
   = Bone = Porous



* Causes :-
  1) Decreased Estrogen in Menopausal women
  2) Increased Parathyroid Hormone (PTH) (Hyperparathyroidism)

→ Ca^{2+} removed from Bones (=Decalcification) → Bones becomes Soft & Porous → Decreased Bone Mass → Increased chance of Fracture

2. ARTHRITIS :- Inflammation of joints
Arthro = joint inflammation

2a. OSTEOARTHRITIS : Most common joint disorder
Out of NCERT
- Degeneration of Articular Cartilage with Age (Larger joints)
- More common in Old Age

2b. Rheumatoid Arthritis : Auto-immune disorder
- → Antibodies formed against Synovial membrane, leading to ↑ Synovial fluid
- → Involves Smaller joints

2c. Gouty Arthritis / Gout :- Accumulation of Uric acid crystals in joints (in form of Sodium urate) PYQ

THANK YOU