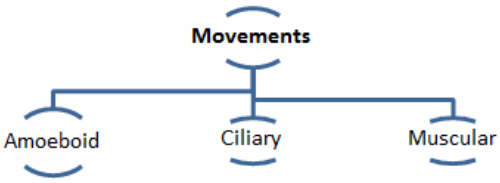
Locomotion: The movement of a whole individual from one place to another.
Movement: The change of position, exhibited either by the whole organism or any part of the body.
All locomotion are movement but all movements are not locomotion.

Types of Movement

Cells of the human body show three main types of movements:



- **Amoeboid Movement**: The movement with the help of finger-shaped protoplasmic extensions (pseudopodia). Ex: Macrophages and leucocytes in blood.
- **Ciliary Movement:** The Coordinated movement with the help of many fine, short, hair like structures i.e. cilia. Ex: In Trachea to remove dusts particles and passage of ova through fallopian tube.
- **Muscular Movement**: The Movement with the help of contractile property of muscles. Ex: Movement of limbs, jaw, tongue, etc.

Muscles are specialized tissues of mesodermal origin. They have property like excitability, contractility, extensibility and elasticity.

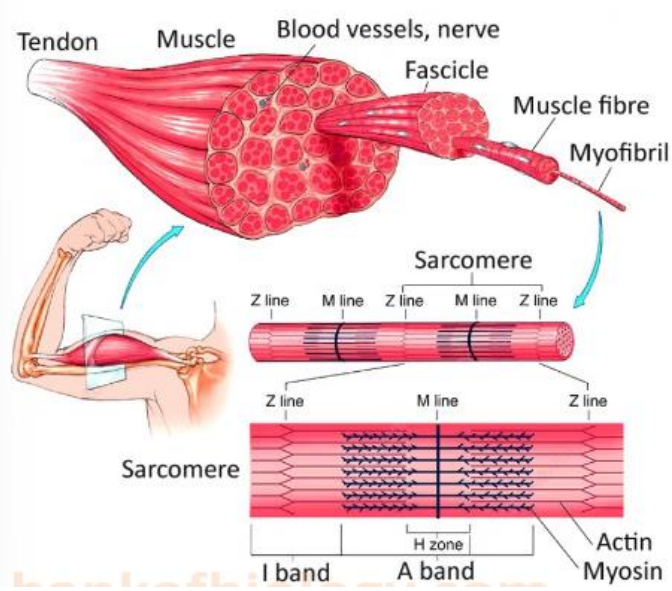
- Most abundant tissue in most animals.
- Human body has some 639 separate muscles.
- The study of muscle is called Myology.
- Muscles of iris and ciliary body are ectodermal in origin.
- The largest muscle in human body is gluteus maximus (hip muscle), the longest muscle is sartorius (back muscle), the strongest muscle is masseter (jaw muscles).
- The longest smooth muscle is rectus abdomins and the shortest muscle is stapedial muscle.

Based on their location, three types of muscles are identified

Skeletal/Striated/ Voluntary Muscles	**Smooth/Non-Striated /Visceral/Involuntary Muscles**	**Cardiac Muscles**
• Attached with skeletal system. • Cylindrical Shaped, Multinucleated (peripheral) • Striations (alternate light and dark bands)Present. • Get Fatigued. • Voluntary muscles ,controlled by CNS	• Found in inner wall of internal visceral organs. • Spindle Shaped, Uninucleated • No-striations (light & dark band) found. • Do not get Fatigued. • Involuntary muscles ,controlled by ANS	• Cylindrical & Branched. • Muscles of heart, having branching pattern, (alternate light and dark bands) with Inter-calated Disc. • Do not get Fatigued. • Involuntary muscles ,controlled by ANS

Skeletal Muscle is made up of

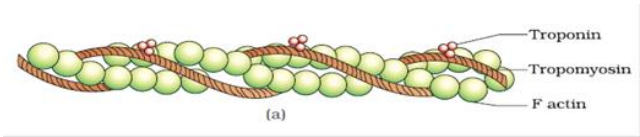
- **Fascicles**: Muscles bundles containing many muscle fibres.
- **Fascia** : Collagenous tissue holding muscle bundles together.
- **Sarcolemma**: Plasma membrane lining the muscle fibre.
- **Sarcoplasm:** Cytoplasm of muscles
- **Myofibrils/Myofilaments**: Large no. of parallelly arranged filaments in sarcoplasm of muscle fibre.
- **Sarcoplasmic Reticulum:** Specialised endoplasmic reticulum of muscles for storage of calcium.
- Muscle fibre is a **syncitium** as the sarcoplasm contains many nuclei
- Note:- Each Myofibril has Light and dark bands in muscles which are present due to the protein **actin and myosin** & are arranged parallel to each other.
- **I-band** (Isotropic band): Light thin bands containing actin.
- **A-band** (Anisotropic band): Dark thick band contains myosin.



- **Z line (**Zwischen line): The Centre of each I-band is elastic fibre
- **M line** (Mittelsclzeibe Line): A thin fibrous line in the middle of A-band
- **H Zone** (Hensen's Zone): The centre part of A Band during resting stage in which myosin do not overlapped by actin.
- **Sarcomere** : The portion of myofibrils between two successive 'Z' lines (The structural & functional unit of muscle).

Function	Distribution (location)	Muscle Type
1. Hair movement, squeezing oil from oil glands.	Dermis of skin, between hair follicle and basement membrane of epidermis	Smooth
2. Digestion	Lips, jaw muscles, tongue, pharynx.	Striated
	Walls of oesophagus, stomach, intestines and villi	Smooth
	Internal anal sphincter	Smooth
	External anal sphincter	Striated
3. Breathing (ventilation)	Diaphragm, intercostal muscles	Striated
4. Blood circulation	Heart	Cardiac
	Walls of arteries & veins	Smooth
5. Excretion	Walls of renal pelvis, ureters & bladder	Smooth
	Internal sphincter between bladder and urethra	Smooth
	External sphincter near exit from body	Striated
6. Maintenance & change of posture	Skeletal muscles	Striated
Locomotion	Skeletal muscles	Striated
7. Heat production	Skeletal muscles (exercise, shivering)	Striated
8. Vision	Iris, ciliary body	Smooth
Eye movement	Extrinsic eye muscles	Striated
9. Ejaculation	Wall of genital tract	Smooth
Parturition	Uterine wall, cervix	Smooth
	Abdominal muscles, diaphragm	Striated
Scrotal sac movement	Wall of scrotal sac	Smooth
10. Movement of secretions	Walls of ducts	Smooth

Structure of Contractile Protein

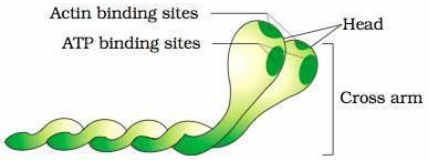


Actin: (Thin Filament) Made up of two types of proteins

1st **Filamentous Actins:** Two Filamentous (F) actins made up of globular actin (monomer) helically bound to each other.

2nd **Tropomyosin :** Two protein filament that attached to Z line and run parallel to F Actin.

Troponin: A complex protein distributed at regular intervals on the tropomyosin (actin) which mask the active binding sites for Myosin.



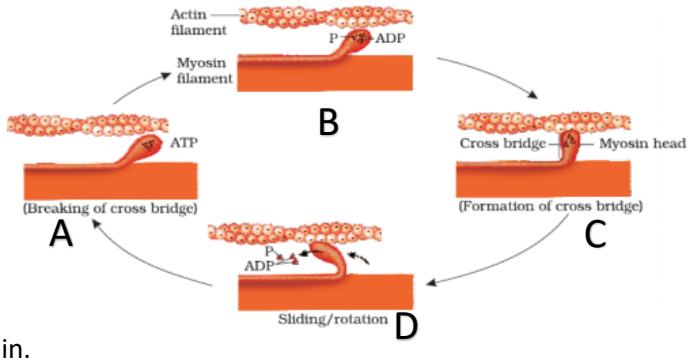
Myosin: (Thick Filament) Made up of many meromyosin (monomer). Each meromyosin has two parts :

1: Globular Head with short arm or Cross Arm (HMM- Heavy Meromyosin): Is an active ATPase & has active ATP binding site and active Actin binding site.

2: Tail (LMM-Light Meromyosin).

Mechanism of Muscle Contraction

Signal by CNS via motor neuron release neurotransmitter (Acetyl choline) to generate action potential in the sarcolemma. This causes release of Ca^{++} from sarcoplasmic reticulum.



A: Relaxed Stage:

- New ATP binds ATP-binding site of Globular Head.

B: Transition of Crossbridge:

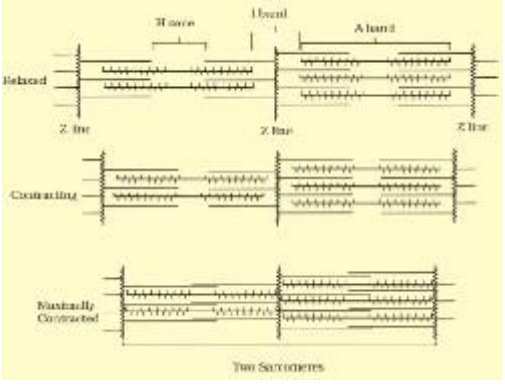
- Ca^{++} binds to Troponin removing masking of active site for myosin.
- ATPase in Myosin Head breaks down ATP to ADP and iP and its energy is used to bind actin at active site of Actin.

C: Formation of Crossbridge:

- Myosin binds to actin at Actin binding site.
- Cross bridges forms that pull the actin towards A Band.

D: Sliding/Rotation :

- H zone & I Band are highly reduced as Z line is pull inwards, while A Band retains its length.
- Causing contraction due to sliding of LMM over HMM.
- Myosin head release ADP & iP causing low energy & Myosin head detached & moves to its original position.



A: Breaking of Crossbridge-

- Actin filament, Z line, H zone & I Band returns to its original position.
- Ca^{++} ions are returned to sarcoplasmic cisternae which inactivate the actin.

Note: Repeated activation of muscles cause accumulation of Lactic acid causing fatigue.
Muscles are classified as:
Red fibres (aerobic muscles-) Thin muscles contain more myoglobin that has plenty of mitochondria, store oxygen as oxymyoglobin. Undergo slow contraction for long period. Found in Marathon Racers (extensor muscles in black man)
White fibres (anaerobic muscle) – Thick muscles white or pale in appearance, containing less number of Myoglobin and more Sarcoplasmic Reticulum. Undergo rapid contraction for short period. Get fatigue easily. Found in Sprint Racers (white mans), eye balls.