

# Physiology of Muscle Contraction

Muscle contraction occurs in three main stages:

- 1 Excitation
- 2 Excitation-Contraction Coupling
- 3 Contraction (Sliding filament mechanism)

## 1 Neuromuscular Transmission (Excitation)

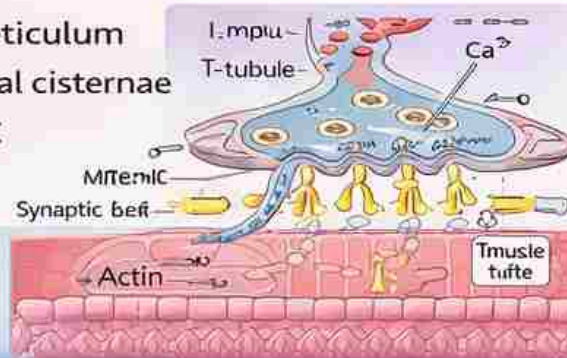
- ✓ Nerve impulse reaches motor nerve terminal
- ↑↑ Permeability to  $\text{Ca}^{2+}$
- ↑  $\text{Ca}^{2+}$  enters nerve terminal
- ↑ Release of Acetylcholine (ACh) → ACh diffuses into synaptic cleft.
- ◆ ACh binds to receptors on motor end plate
- ↑ Opening of  $\text{Na}^+$  channels
- ↑  $\text{Na}^+$  enters muscle fiber → produced
- ↑ If threshold reached → Action potential generated

## 2 Excitation-Contraction Coupling

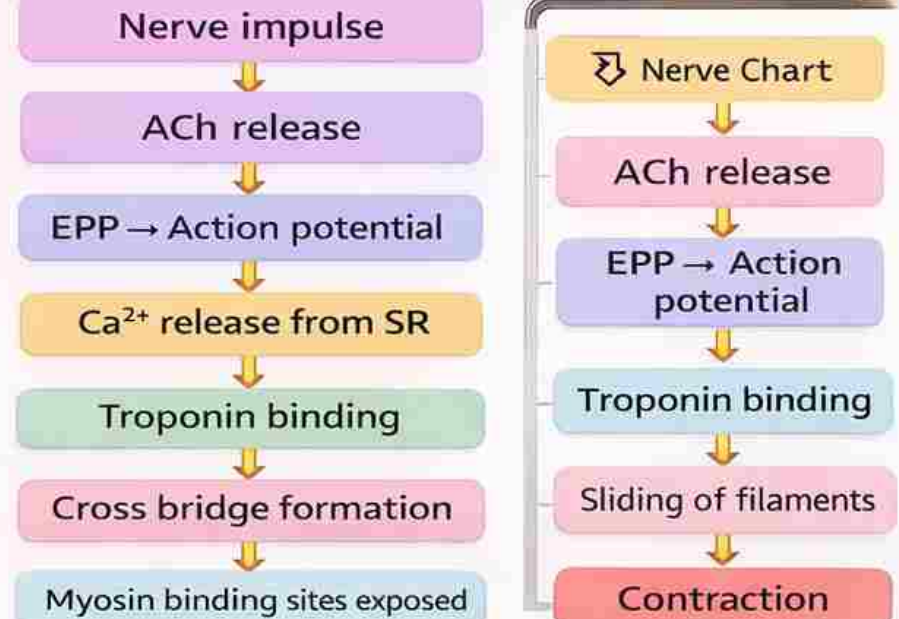
- ↑ Action potential spreads over sarcolemma
- ↑ Travels through T-tubules
- ↑ Stimulates sarcoplasmic reticulum
- ↑ Release of  $\text{Ca}^{2+}$  from terminal cisternae
- ↑  $\text{Ca}^{2+}$  binds with Troponin-C
- ↑ Tropomyosin shifts

### Flow Chart

- ♥  $\text{Ca}^{2+}$  release from SR



### Flow Chart (Very Important for Exam)



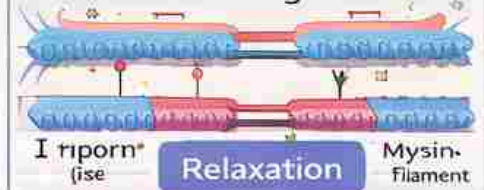
### Relaxation

- $\text{Ca}^{2+}$  pumped back into SR
- Troponin-tropomyosin covers binding sites
- Cross bridge breaks
- Muscle relaxes



### $\text{Ca}^{2+}$ pumped back into SR

- Troponin-tropomyosin covers binding sites



Actin - Filament

Myosin-Filament

|     |                                                                                                                                                             |    |    |   |  |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|---|--|
| ✓ 4 | <b>Muscle physiology:</b> <u>comparison of physiology of skeletal muscles, cardiac muscles and smooth muscles.</u> <u>Physiology of muscle contraction.</u> | II | 07 | 2 |  |
| ✓ 5 | <b>Adipose tissue:</b> <u>lipoproteins like VLDL, LDL and HDL triglycerides.</u> <u>Functions of skin, sweat glands and sebaceous glands.</u>               | II |    | 2 |  |

| Features           | Skeletal Muscle          | Cardiac Muscle   | Smooth Muscle         |
|--------------------|--------------------------|------------------|-----------------------|
| • Location         | Bones attached           | Heart            | Visceral organ        |
| • Shape            | unbranched & cylindrical | Branched         | unbranched & spindle  |
| • Length           | 1 to 4 cm                | 80 to 100 $\mu$  | 50 to 200 $\mu$       |
| • Diameter         | 10 to 100 $\mu$          | 15 to 20 $\mu$   | 2 to 5 $\mu$          |
| • No. of Nucleus   | More than one            | one              | one                   |
| • cross striations | Present                  | Present          | Present / Absent      |
| • Neuro-Muscular   | well defined             | Not well defined | Not well defined      |
| • Action           | Voluntary                | Involuntary      | Involuntary           |
| • Control          | Neurogenic               | Myogenic         | Neurogenic + Myogenic |
| • Nerve Supply     | Somatic Nerves           | Autonomic Nerves | Autonomic Nerves      |
| • Myofibrils       | Present                  | Present          | Absent                |
| • Sarcomere        | Present                  | Present          | Absent                |

|   |                                                   |                                  |                         |                  |
|---|---------------------------------------------------|----------------------------------|-------------------------|------------------|
| • | Sarcotubular system                               | well developed                   | well developed          | Poorly developed |
| • | T-tubules                                         | long                             | short                   | absent           |
| • | For trigger of contraction and calcium binds with | Troponin                         | Troponin                | calmodulin       |
| • | Source of calcium                                 | Sarco Plasmic Reticulum          | Sarco Plasmic Reticulum | Extracellular    |
| • | Speed of contraction                              | Fast                             | Intermediate            | slow             |
| • | Depolarization                                    | upon stimulation - spontaneous — |                         |                  |
| • | fatigue                                           | Possible                         | — Not Possible —        |                  |
| • | summation                                         | Possible                         | — Not Possible —        |                  |
| • | Tetanus                                           | Possible                         | — Not Possible —        |                  |
| • | Resting membrane potential                        | Stable                           | Stable                  | unstable         |

## Q. Skeletal Muscle (10 Marks)

- Skeletal muscle are voluntary striated muscle.
- change in length of the muscle fibers or change in tension developed by in the muscle

- Muscular contraction includes 3 stages.

- i) Excitation - contraction coupling
- ii) Role of troponin & tropomyosin
- iii) Sliding Mechanism

- The events which occurs during contraction and Relaxation in skeletal muscle when a excited by a nerve are summarized sequence wise.

→ Nerve excitation.

- Stimulation of Motor ~~Motor~~ Neuron.

- Initiation of Action - Potential in Motor Neuron.

→ Nerve conduction.

- Propagation of action - Potential in the Motor Nerve

- Impulse Reaching at Nerve ending

→ Neuromuscular transmission

- ↑ Permeability of Presynaptic membrane to  $Ca^{+2}$  ions.

- Inflow of  $Ca^{+2}$  ion from ECF into the Nerve terminals.

- Release of Ach from the microvesicles present at the nerve terminal.

- Diffusion of Ach into the synaptic cleft

- Binding of Ach to Receptors on the motor end plate (Postsynaptic)

- Opening of Ach gated channels

- In the motor end plate membrane

- entry of mainly  $Na^{+}$  ions and to a lesser extent  $Ca^{+2}$  ions through these channels into the muscle fibers.

- Development of EPP (end plate Potential)

→ Muscle excitation

- Local EPP when reaches a threshold magnitude voltage-gated  $Na^{+}$  channels are opened up at the side

- generation of action - Potential in muscle Fibre by the end Plate depolarization.

- Propagation of AP (action - Potential) in muscle Fibre along the surface and into the Fibre along the T-tubules.

→ Excitation - contraction coupling

- Release of  $Ca^{+2}$  ion from terminal cistern.

- Diffusion of  $Ca^{+2}$  ions into the sarcoplasm

- Binding of  $Ca^{+2}$  ions to troponin C

→ Muscle Contraction

- uncovering of Binding sites for myosin on actin
- cross-bridge formation b/w myosin Head and actin.

- Angular movement of cross Bridge.

- Sliding of thin filaments over thick filament

- Initiation of muscle contraction

## Glands of skin

→ Skin contains - 2 types →  
1) sebaceous glands  
2) sweat glands

### 1.) Sebaceous glands

- situated in the dermis of skin.

\* structure = situated at the side of the hair follicle.  
- this gland develop from hair follicle.  
- each gland is covered by a connective tissue capsule.  
- this glands open into the neck of the hair follicle through duct.  
- In some areas like - face, lips, nipple, penis etc.

\* secretion = secrete oily substance - called - sebum.



formed by the liquefaction of the corneal cell.

\* Composition of sebum = fatty acids, triglycerides, paraffin etc.

\* function = fatty acid → antibacterial & antifungal.

↳ prevents the infection of skin

↳ lipid - keep skin smooth & oily.

↳ lipid of sebum - prevent heat loss from the body.

→ sebaceous glands are inactive till puberty.

→ at puberty help of sex hormones - this gland activated.

→ Acne = inflammatory condition of the skin.

↳ characterized by pimples on face, back & chest.



→ overactivity of sebaceous gland.

function ⇒ prevent from excess heat loss

⇒ prevent dryness of hair &

prevent brittleness of hair

⇒ black heads ⇒ enlargement of sebaceous gland in face.

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## 2.0 sweat glands :- imp role in regulation of homeostatic activity

|                            | eccrine glands                                                    | Apocrine glands                                                       |
|----------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------|
| distribution               | - all over body                                                   | - certain area like - axilla, pubis, areola, umbilicus                |
| opening                    | - opens out through the sweat pore $\rightarrow$ exterior of skin | - opens into the hair follicle                                        |
| Period of functioning      | - at birth & throughout life                                      | - start only at puberty                                               |
| secretion                  | - clear & watery sweat                                            | - thick & milky                                                       |
| Regulation of body Temp.   | - play important role                                             | - do not play important role                                          |
| condition when secretion ↑ | - during Temp. ↑ & emotional conditions<br>take hot spicy food    | - during emotional conditions<br>during sexual cycle, sexual behavior |
| control of secretion       | - under nervous control                                           | - under hormonal control                                              |
| nerve supply               | - sympathetic cholinergic fibers                                  | - sympathetic adrenergic fibers                                       |

function :- Temp. regulation

:- excretion of water, electrolytes & waste product.

:- Maintain skin complexion & healthy skin

:- acid-base & water balance