MUSCLE PHYSIOLOGY

- Muscle is the means by which an organism can move.
- It is an **excitable tissue** ie, an **AP** is generated when it is stimulated

- Muscles form > 50 % of total body weight.

  skeletal muscles --- > 40%

  cardiac & smooth muscle ----> 10%

Classification of muscles

- Muscles are classified by 3 different methods

- 1 depending upon the **presence of striations**

striated muscles—cross lines are present on muscle fibre

eg----skeletal muscle and cardiac muscle

Non striated muscle--cross lines are absent

eg -----smooth muscle

2 depending upon the **control of muscles**

voluntary muscle– their activities can be controlled at will

eg –skeletal muscle

Involuntary muscle—their activities cannot be controlled at will

eg cardiac and smooth muscle

3 Depending upon the function

- Cardiac
- Skeletal
- Smooth muscle

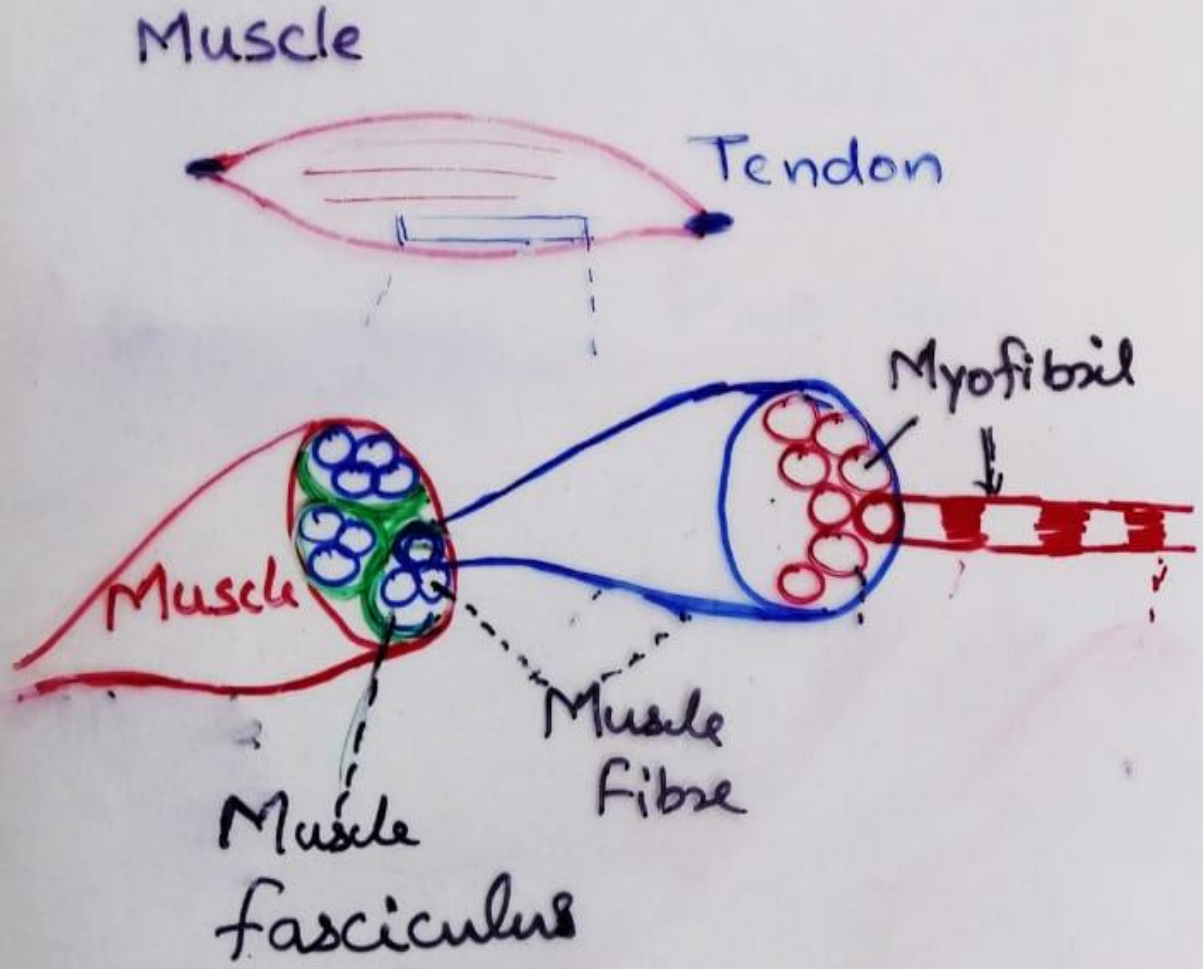
- Skeletal muscle --- in association with bones
  -- striated and voluntary
  - supplied by somatic motor neurons

- Cardiac muscle --- present in the heart
  --striated and involuntary
  -supplied by both symp and parasymp divisions of ANS

- Smooth muscle --- they are nonstriated and involuntary
- supplied by both symp & parasymp of ANS

– present in walls of intestine, bronchial tubes, urinary bladder . Blood vessels , iris, ciliary body and so on .

Structural Organisation of skeletal Muscle



Muscle

↓

Muscle Fibre — (Muscle fascicules) — bundle

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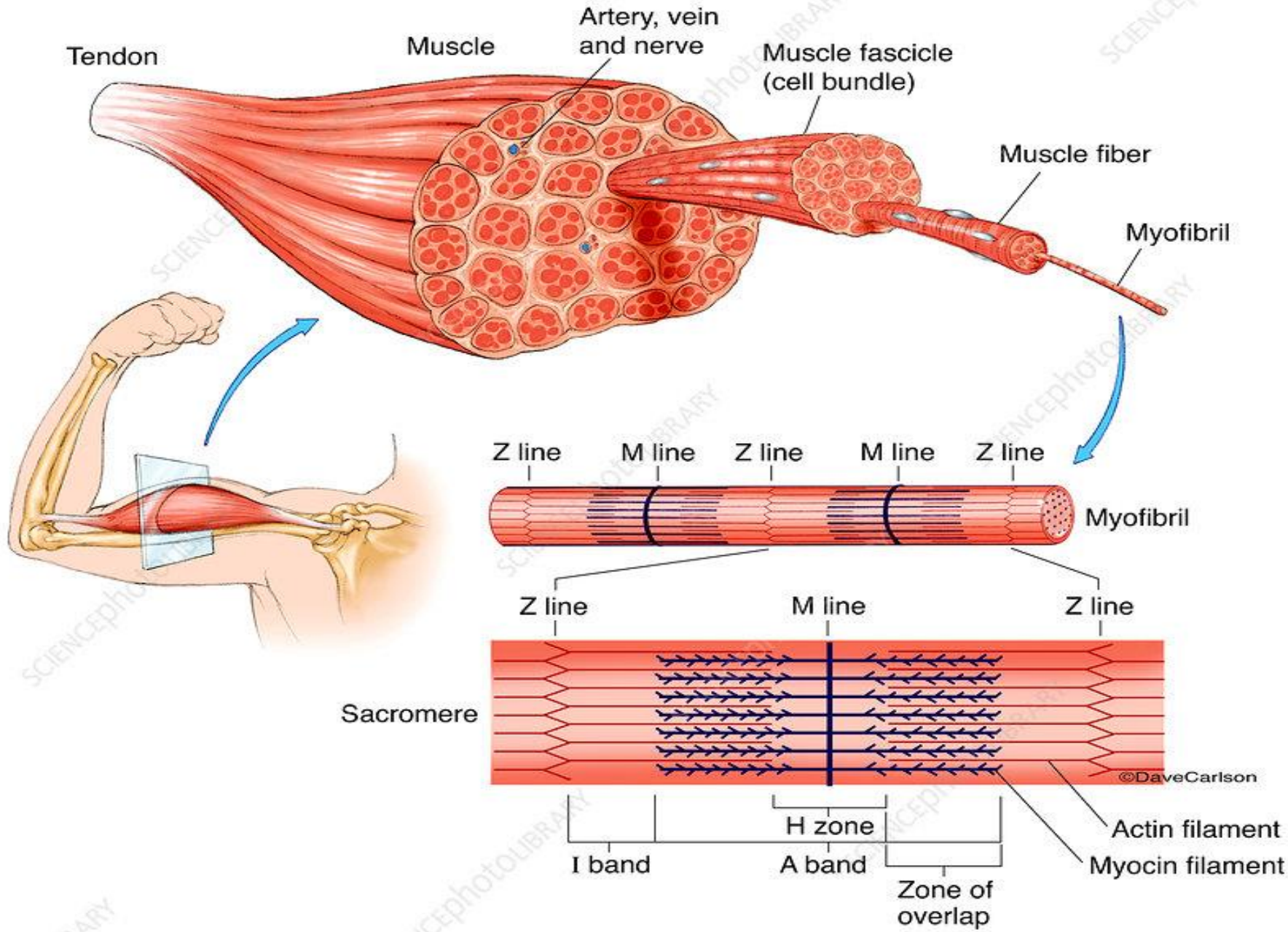
Myofibril

↓

Myofilaments < Thick, Thin

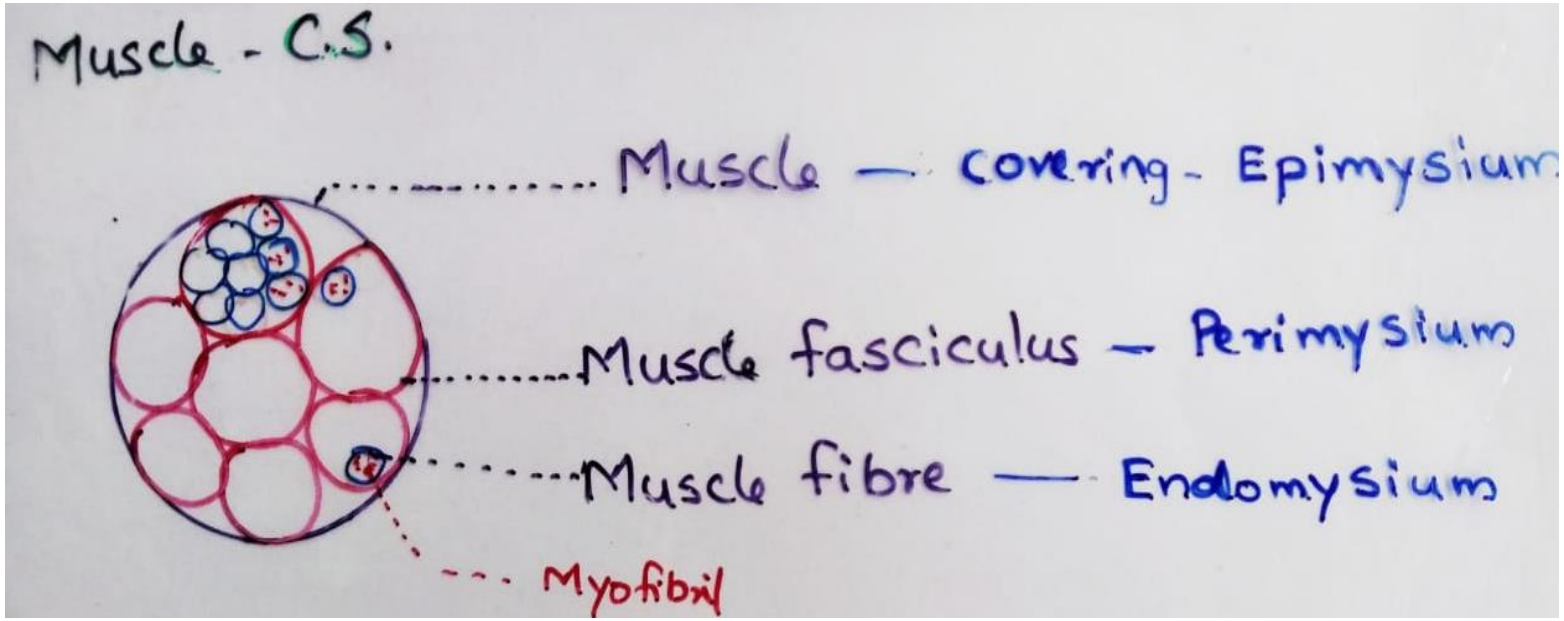
↓

Muscle proteins


Tendon
Muscle
Artery, vein
and nerve
Muscle fascicle
(cell bundle)
Muscle fiber
Myofibril
Z line
M line
Z line
M line
Z line
Myofibril
Z line
M line
Z line
Sacromere
©DaveCarlson
H zone
I band
A band
Zone of
overlap
Actin filament
Myocin filament

- **Skeletal muscle** -- structure
- A typical skeletal muscle -- a fat belly with tendon at either ends
- Through tendon it is attached to the bone

- Muscle
- Muscle fibres ---occur in bundles - muscle fasciculus
- Myofibrils
- Myofilaments
- Muscle proteins



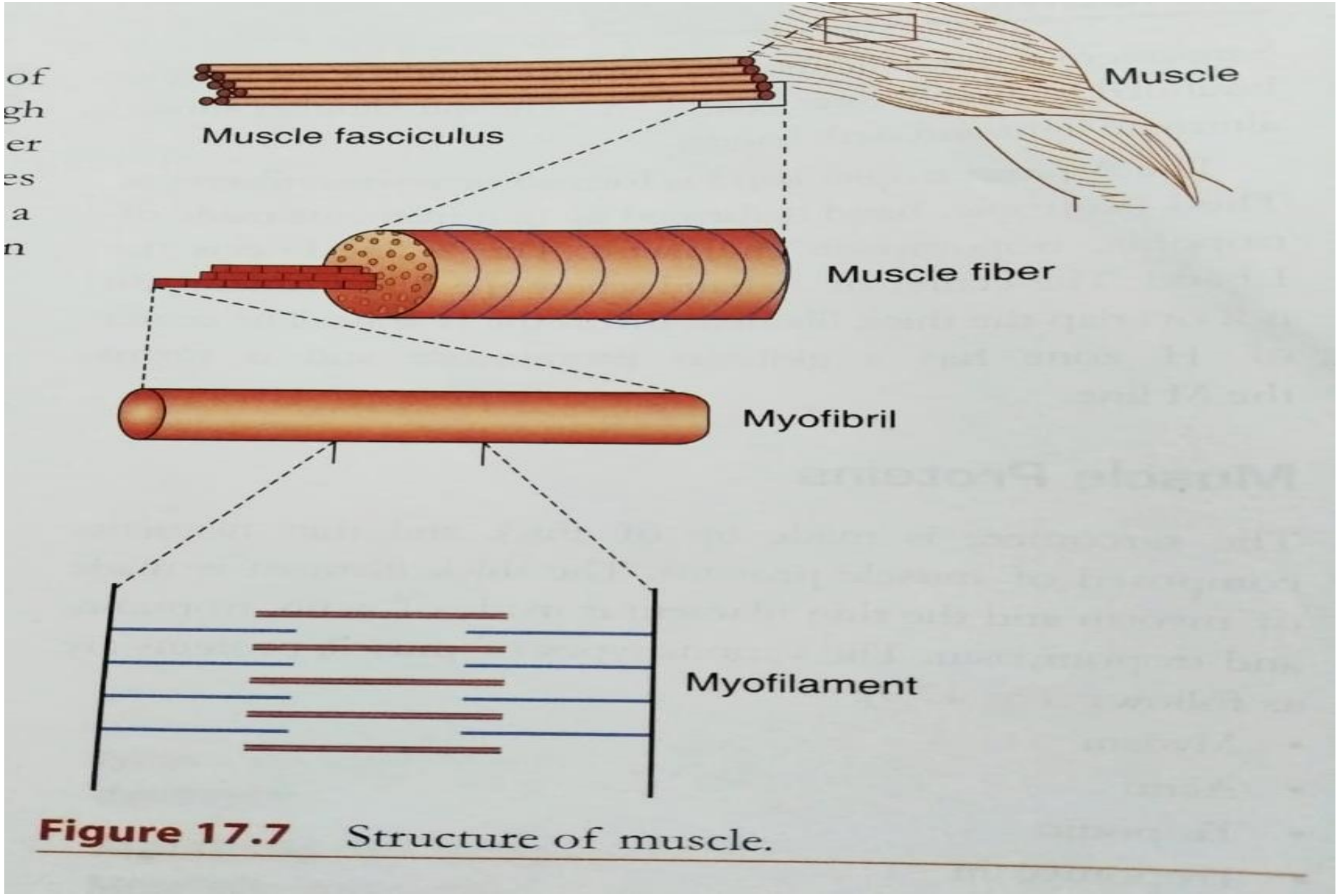


Figure 17.7 Structure of muscle.

- **Muscle fibre (muscle cell)**
- It is long cylindrical multinucleated cell.

Muscle fibres are the building blocks of muscular system.

- Each muscle fibre has cell membrane – sarcolemma

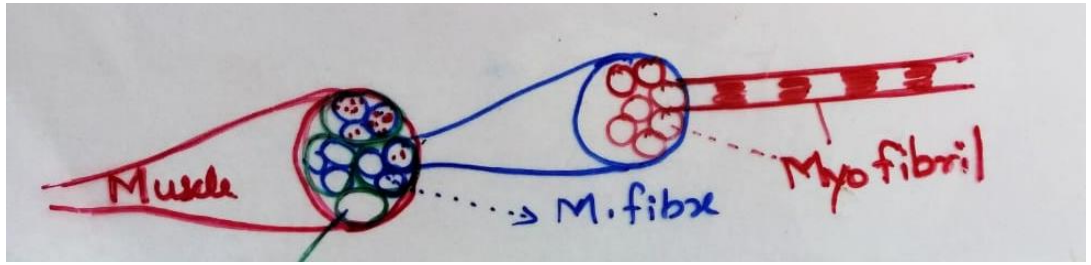
  cytoplasm - sarcoplasm

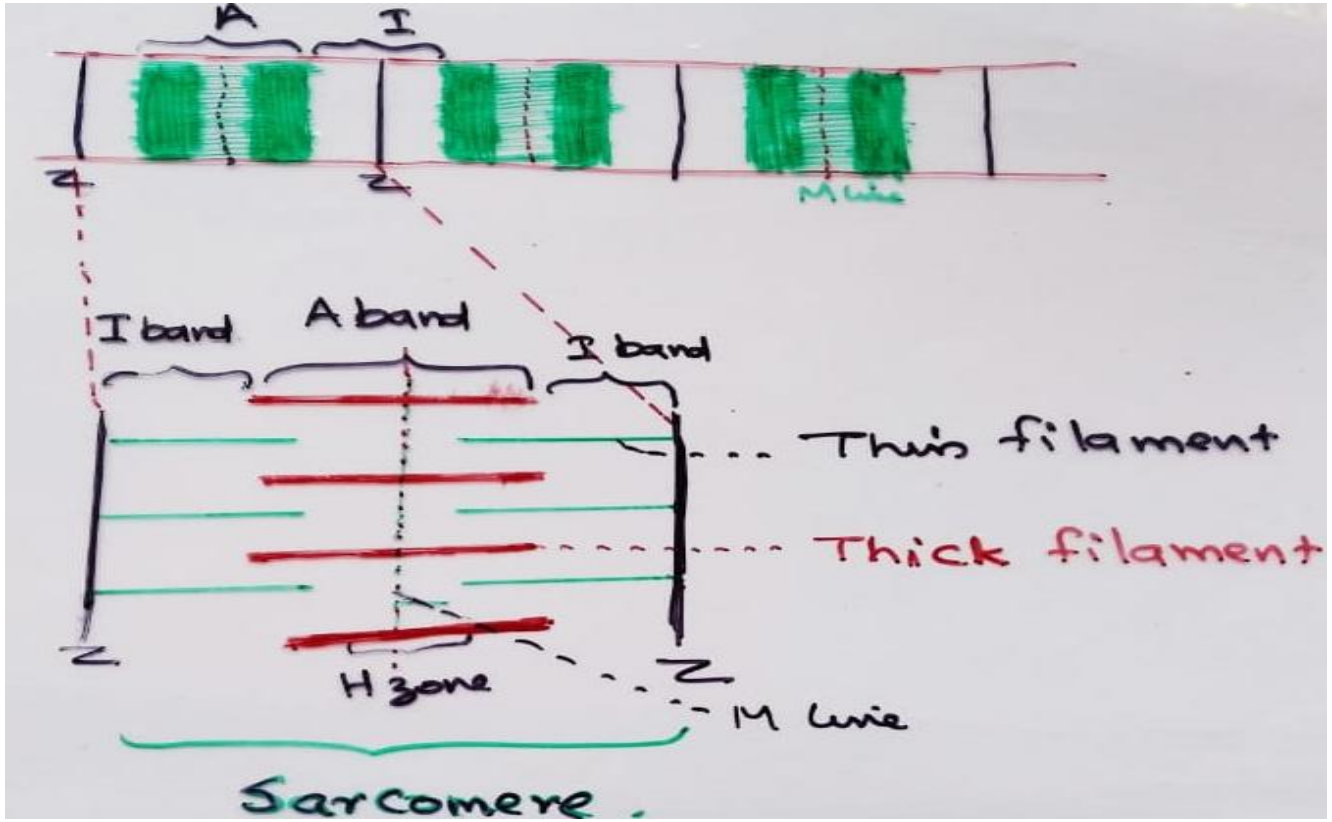
  endoplasmic reticulam– sarcoplasmic reticulum

- Muscle fibre also contains the cell organelles- mitochondria, ribosomes, golgi bodies , nuclei etc.
- Nuclei – numerous nuclei and present & they lie superficially.

muscle fibre is made up of large no of myofibrils

Myofibril





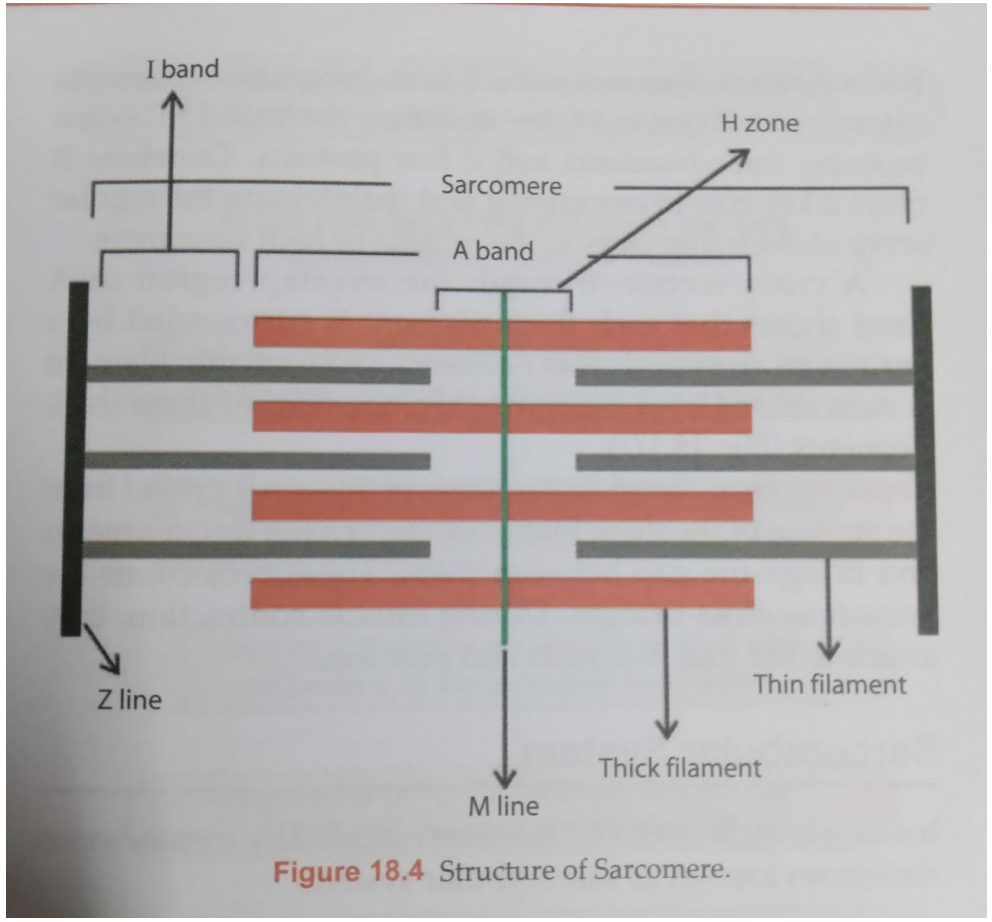


Figure 18.4 Structure of Sarcomere.

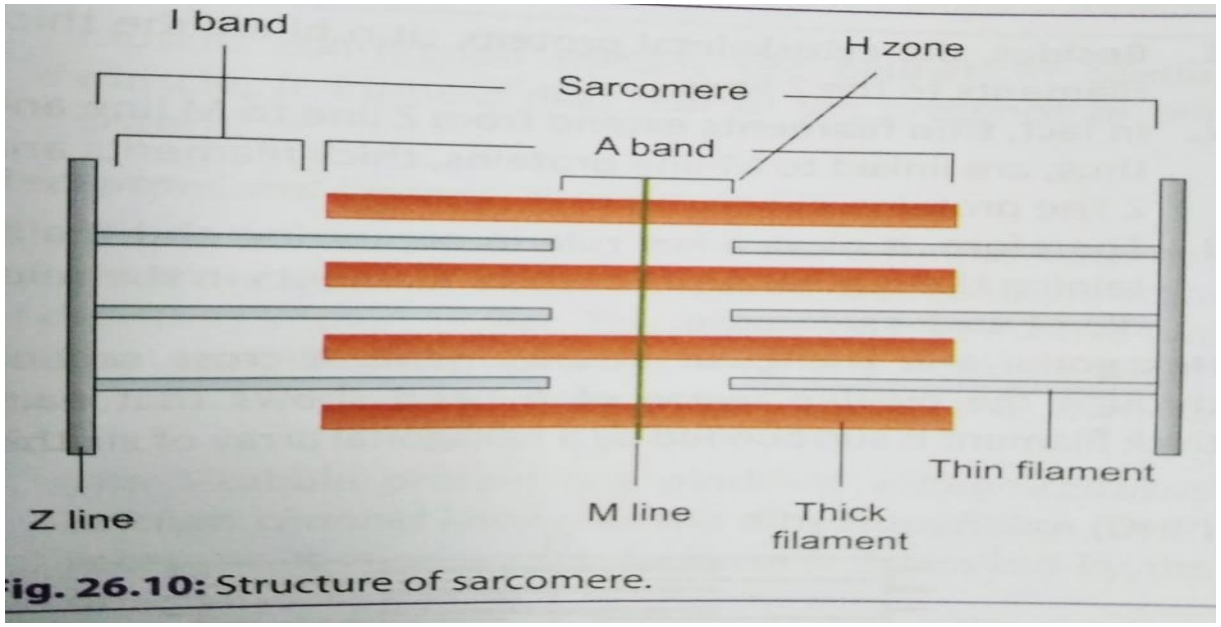
- Myofibril ------ **sarcomere**
- **Sarcomere** is the structural and functional unit of muscle fibre

- Dark band -- (**A band**) --made up of **thick myosin filaments**
  Light band (**I band**) " " **thin actin filaments.**

- In the centre of A band -- a lighter region -- **H zone**
  (here thick and thin filaments do not overlap).
- M line is present in the middle of H zone.

- In the centre of I band a dark line -- **Z line** is present

- **The portion of the myofibril between 2 adjacent z lines is known as sarcomere**
- 1 sarcomere = 1 full A band + ½ I band on either side of A band
- At H zone no overlapping between actin and myosin , during contraction it disappears.
- Average sarcomere length = 2.5 micron



ig. 26.10: Structure of sarcomere.

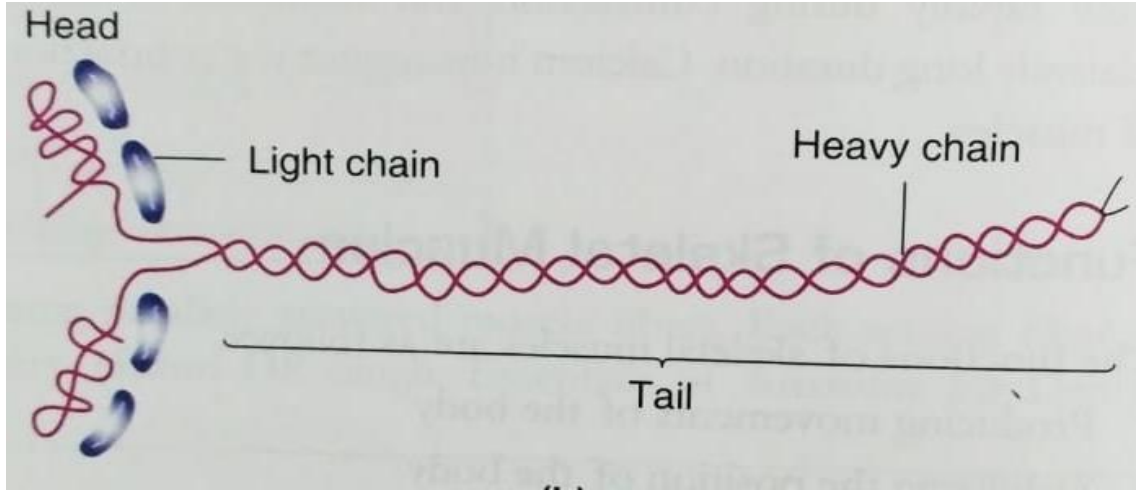
- **Myosin filament**
- It is made up of 300 myosin molecules
- **Myosin molecule**
- it is made up of 6 polypeptide chains

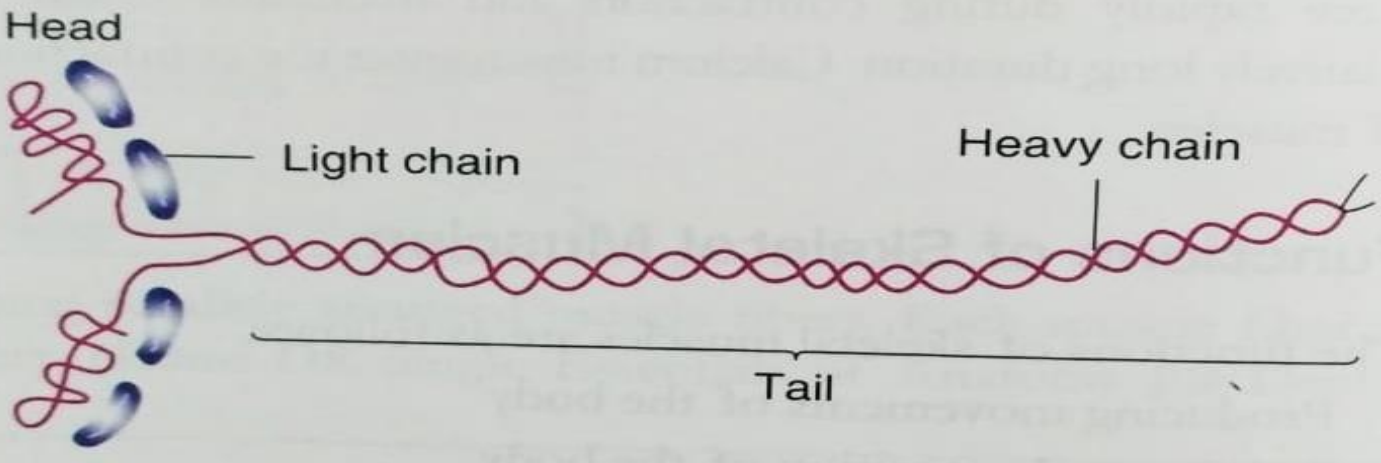
--- 2 heavy chains and 4 light chains

- 2 heavy chains are coiled around each other to form double helix.

one end of each strand folded and form globular **head** and the other part form the **tail of myosin**

4 light chains combine with **head**





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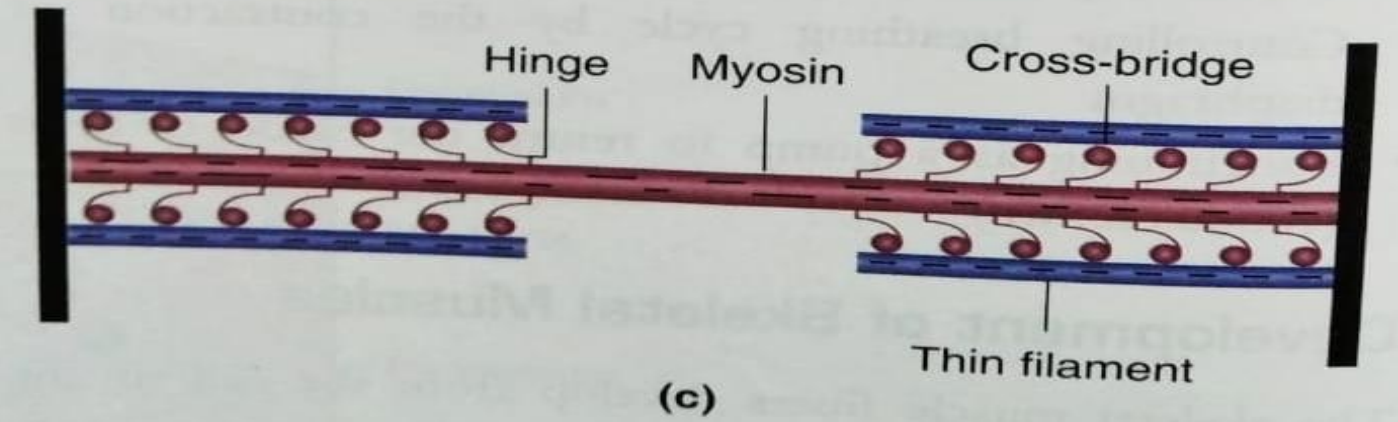
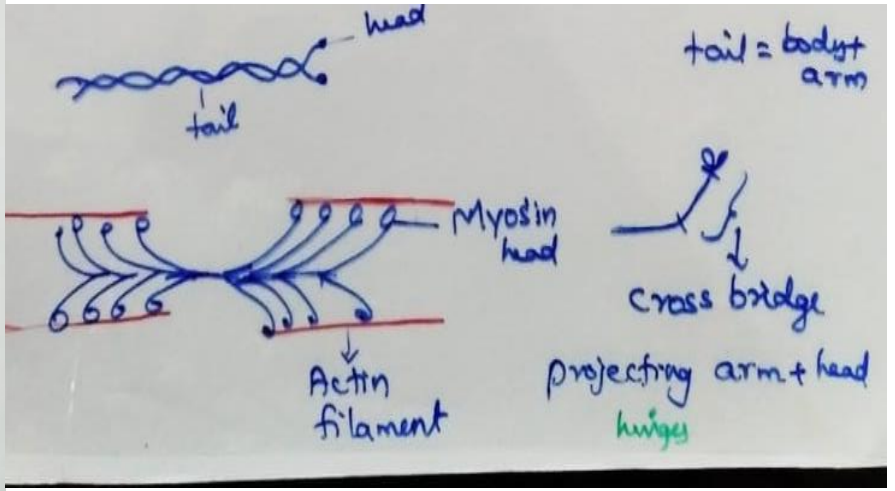


(c)

Figure 17.9 (a) Actin, (b) myosin, and (c) arrangement of actin and myosin.

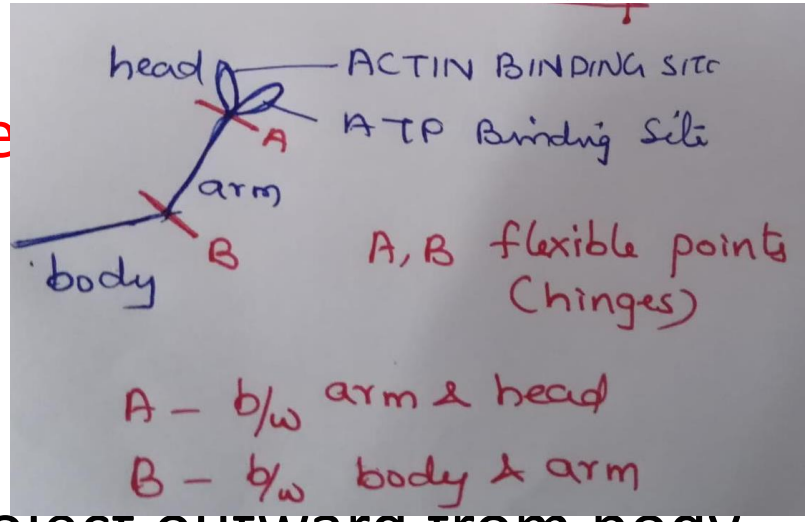


- Myosin molecules arrange symmetrically to form **myosin filament.** .

(Ie, Half arrange with their head in one direction, & half in opposite direction.)

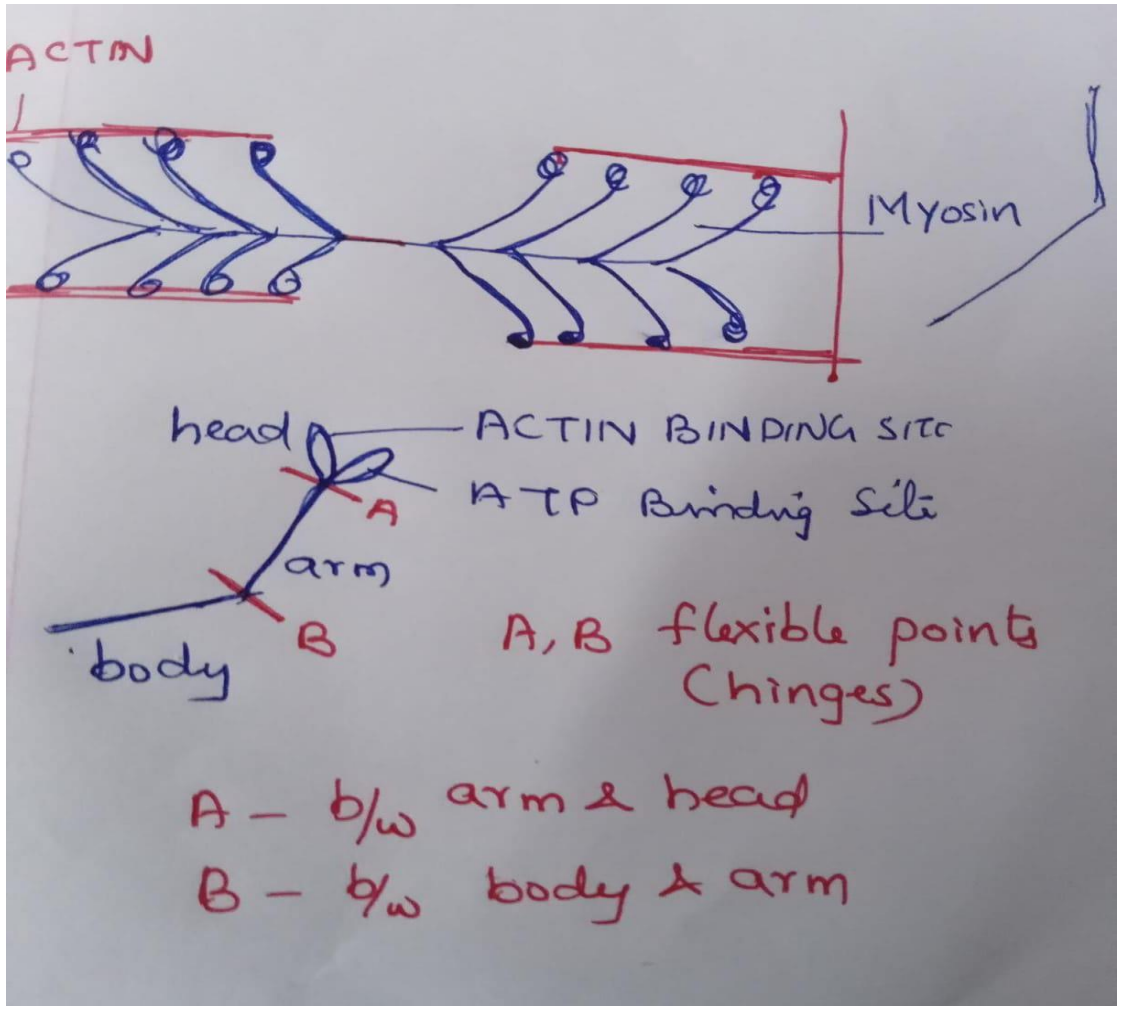
Head has 2 binding sites---actin binding site

- ATP binding site



- A part of double helix along with head project outward from body .
- This protruding arm and head together called **cross bridge.**

- Each cross bridge has 2 flexible points – **hinges**
- 1) between arm and head 2) between arm and body



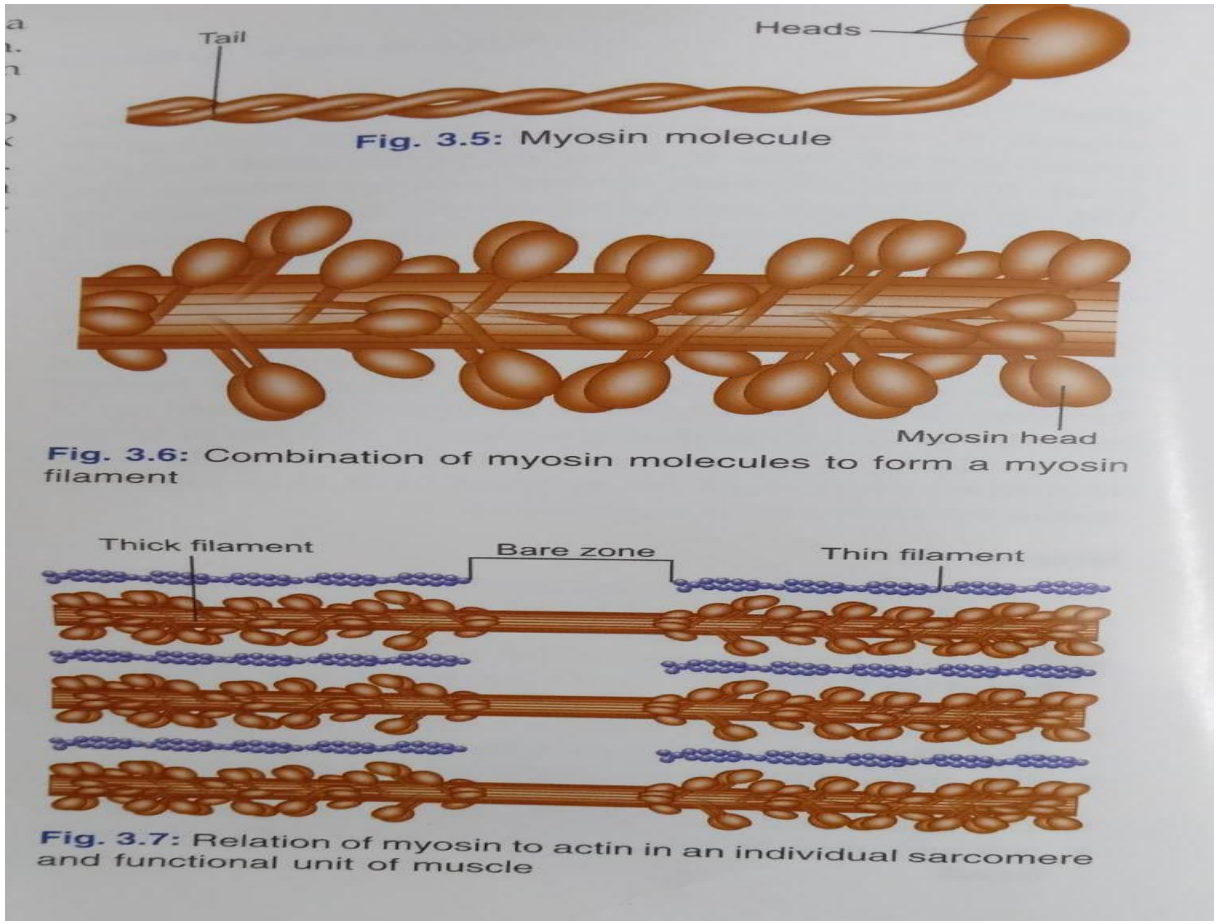
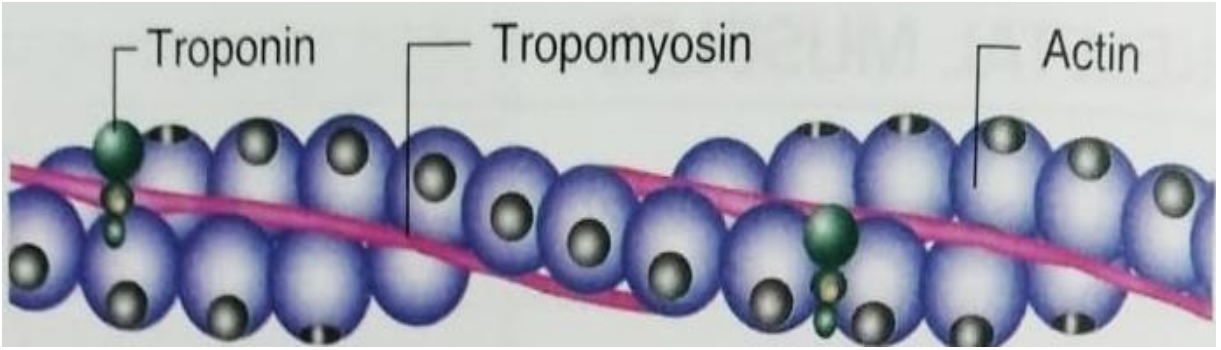


Fig. 3.5: Myosin molecule

Fig. 3.6: Combination of myosin molecules to form a myosin filament

Fig. 3.7: Relation of myosin to actin in an individual sarcomere and functional unit of muscle

- **Actin filament**



- It is made up of 3 proteins –actin, tropomyosin and troponin
- **Actin** -- backbone of actin filament.
  -- double helix made up of F actin, (F actin is formed by polymerization of G actin.)
- **Binding sites** are present on actin.

The bases of actin filaments are attached with z line & ends lie in space between the myosin filaments.

- **Tropomyosin**

  Double stranded protein.

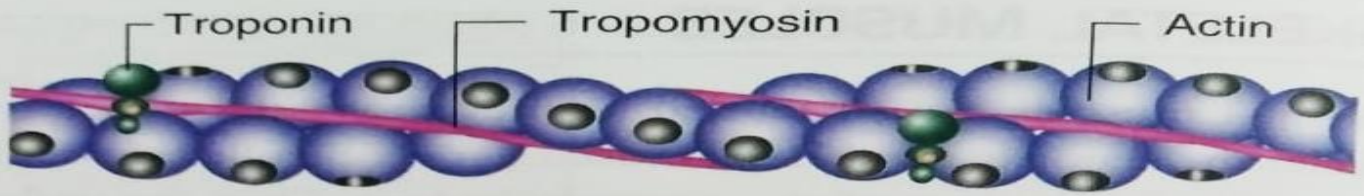
- In resting condition tropomyosin covers the binding site of actin
- **Troponin**

-small globular units located at regular intervals along tropomyosin.

It has 3 subunits ---troponin –T – it binds troponin complex to Tropomyosin

troponin – I- inhibits interaction between actin and myosin

troponin – C- it contains binding site for Ca++



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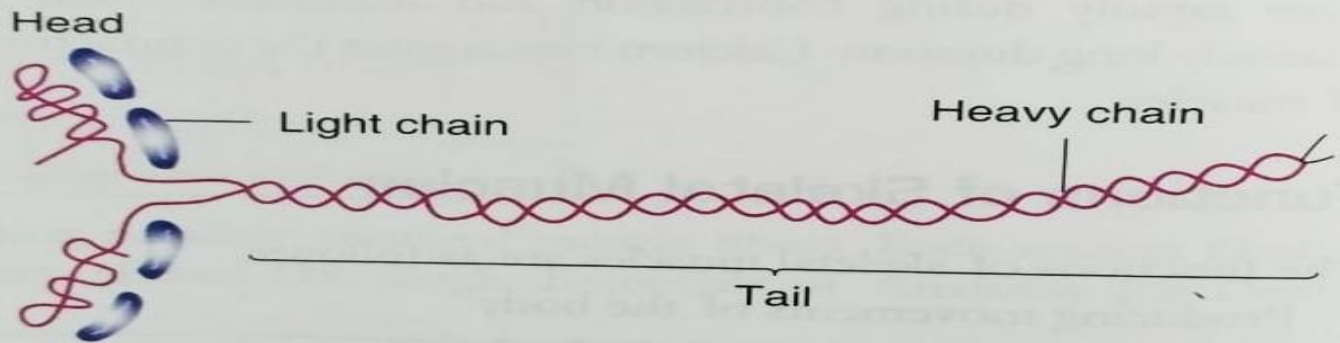

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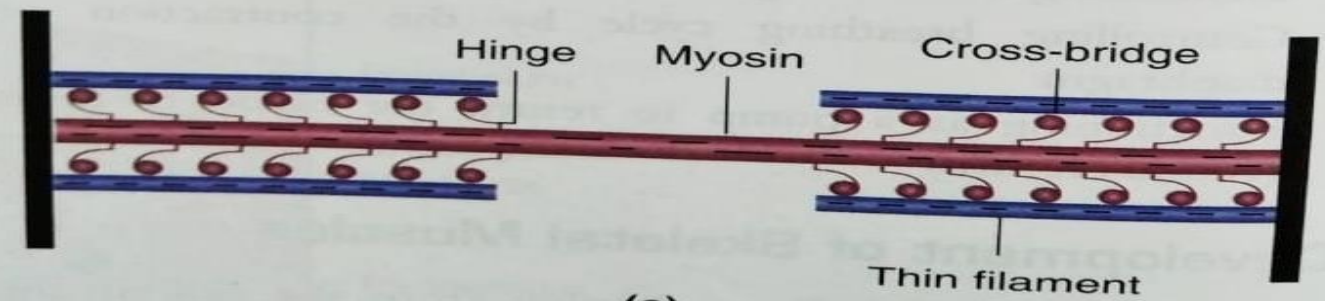


(c)

Figure 17.9 (a) Actin, (b) myosin, and (c) arrangement of actin and myosin.

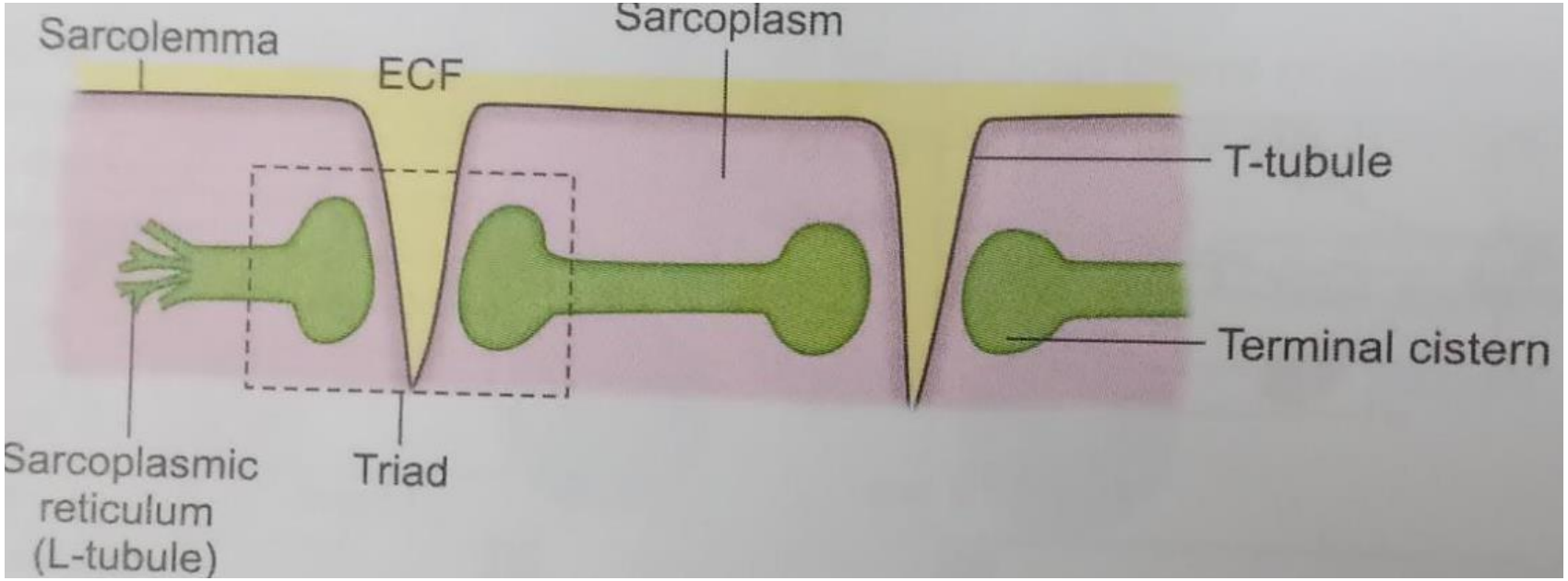
- **Sarcotubular system**

  Tubular system for internal conduction for depolarization

- 2 types--- **transverse tubules** (T tubules)

  longitudinal tubules (L tubules)

1 T Tubule + 2 terminal cisterns on either side = TRIAD



- T tubules--formed by the invagination of sarcolemma into the muscle fibre.

  ----Occurs at AI junction

  --- not closed tubules and contain ECF

- function - rapid transmission of A P from sarcolemma to all deep lying myofibrils
- Receptor - dihydropyridine (V. G Ca channels)

  can act as voltage sensor & can **activate nearby S R**

- **L tubules-**

  --- Lie longitudinal or parallel to the muscle fibre

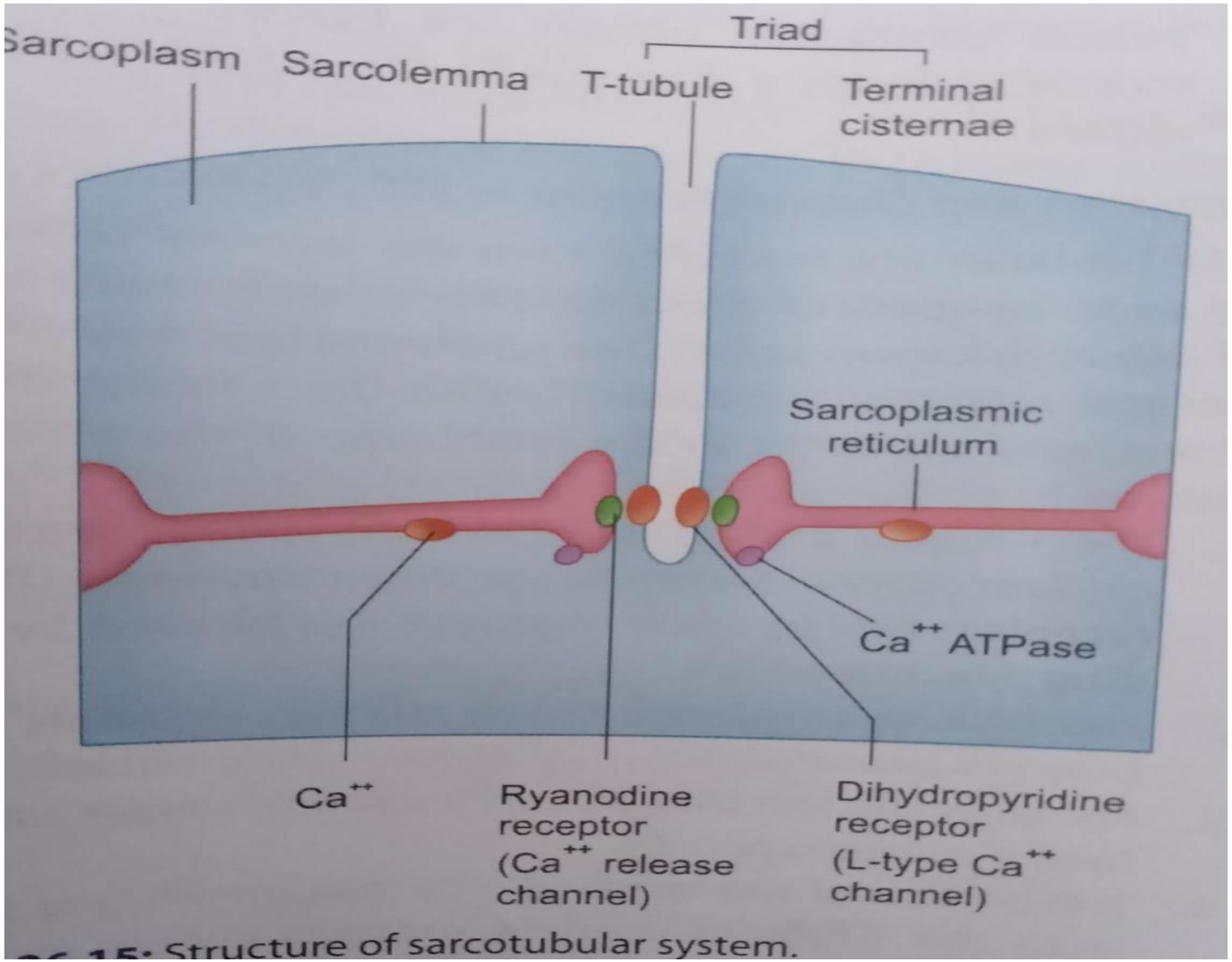
  ----closed tubules and do not contain ECF.

  They have **dilations** near T tubules—terminal cisternae

- L tubules = sarcoplasmic reticulam
- Receptors present ---ryanodine –they are Ca channels
- Function –Ca storage,

  ie, it releases Ca during muscle contraction and restores Ca during relaxation

---calsequestrin present – restore Ca during relaxation



Structure of sarcotubular system.