

THE MUSCULAR SYSTEM

BY

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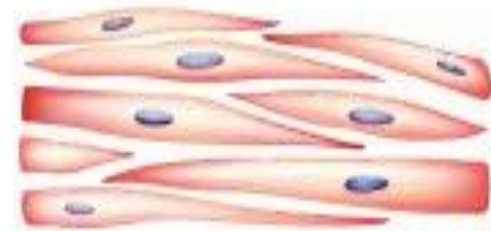
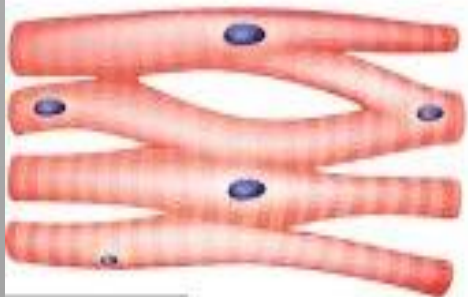
OBJECTIVES

- 1-What are the types of muscles in our body ?
- 2-what is the characters and functions of skeletal muscles?
- 3-What is the functional histology of skeletal muscle?
- 4-What is the tubular system in skeletal muscle?
- 5-what is the mechanism of muscle contraction?
- 6-what is the mechanism of muscle relaxation?

Types of muscle tissue

The body **contains three types of muscle tissue**: smooth, cardiac and skeletal

Types of Muscle



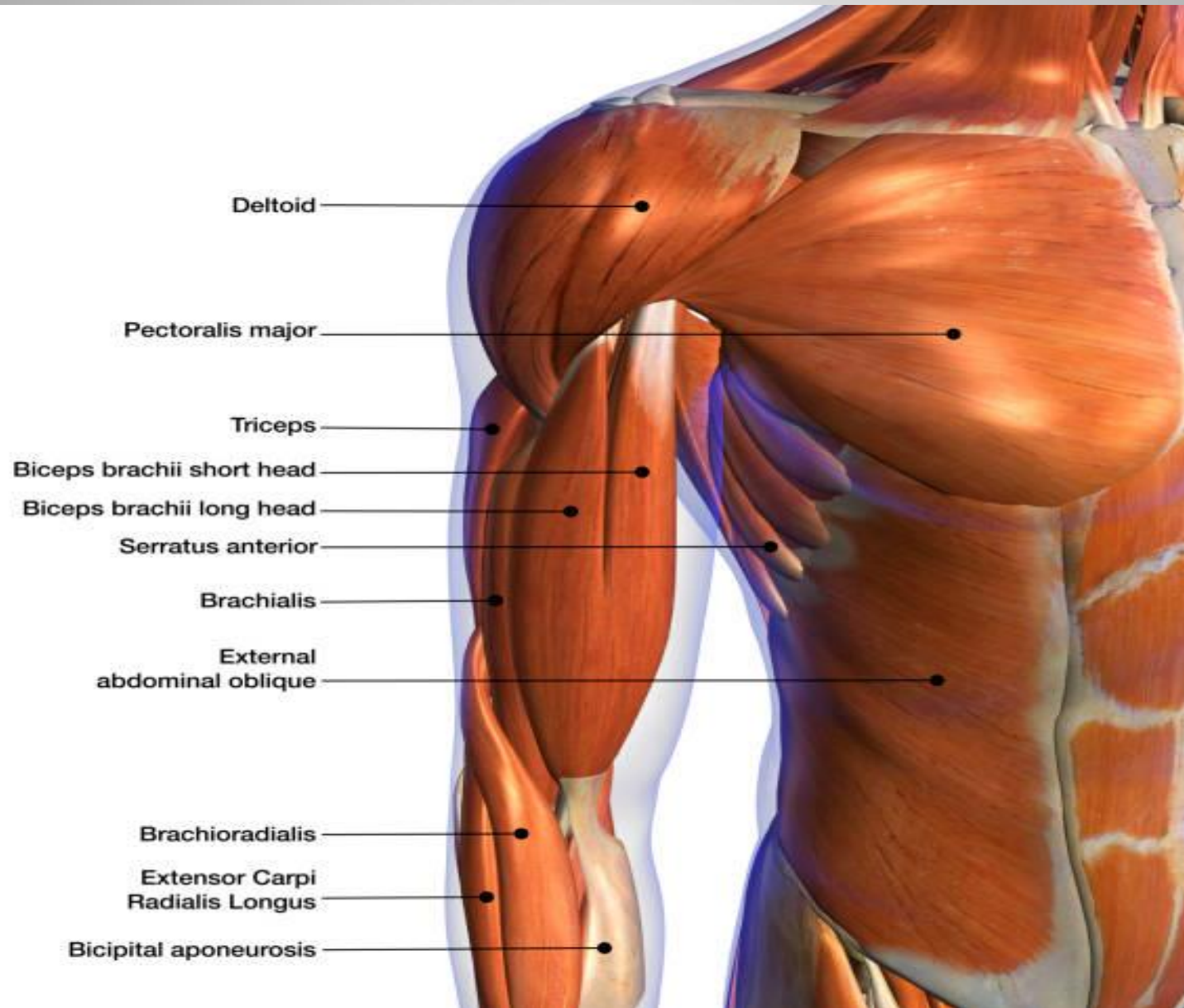
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Cardiac muscle

Skeletal muscle

Smooth muscle

SKELETAL MUSCLE



SKELETAL MUSCLE

Skeletal muscle

Characterized by:

- ⊙ Striated, **striated ms include** also the cardiac ms.
- ⊙ Represent **40 %** of the body weight.
- ⊙ **Under voluntary control.**
- ⊙ The skeletal ms. Consists of millions of ms. Fibers (**myofibers**).

Function

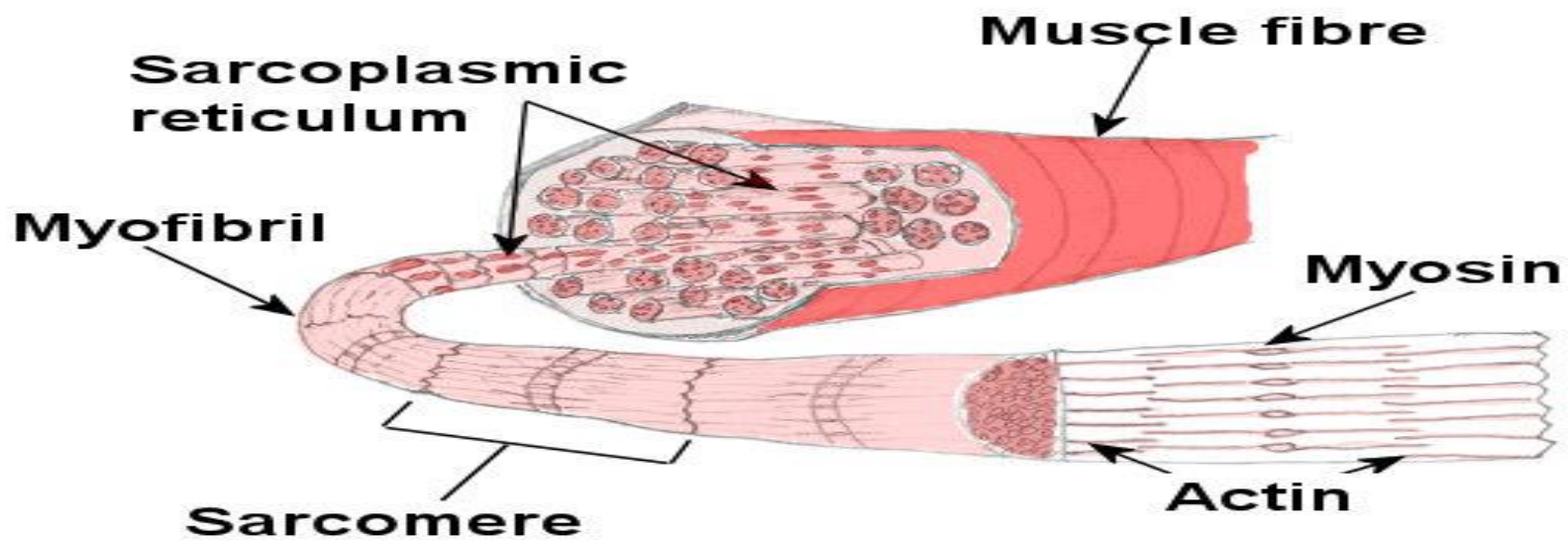
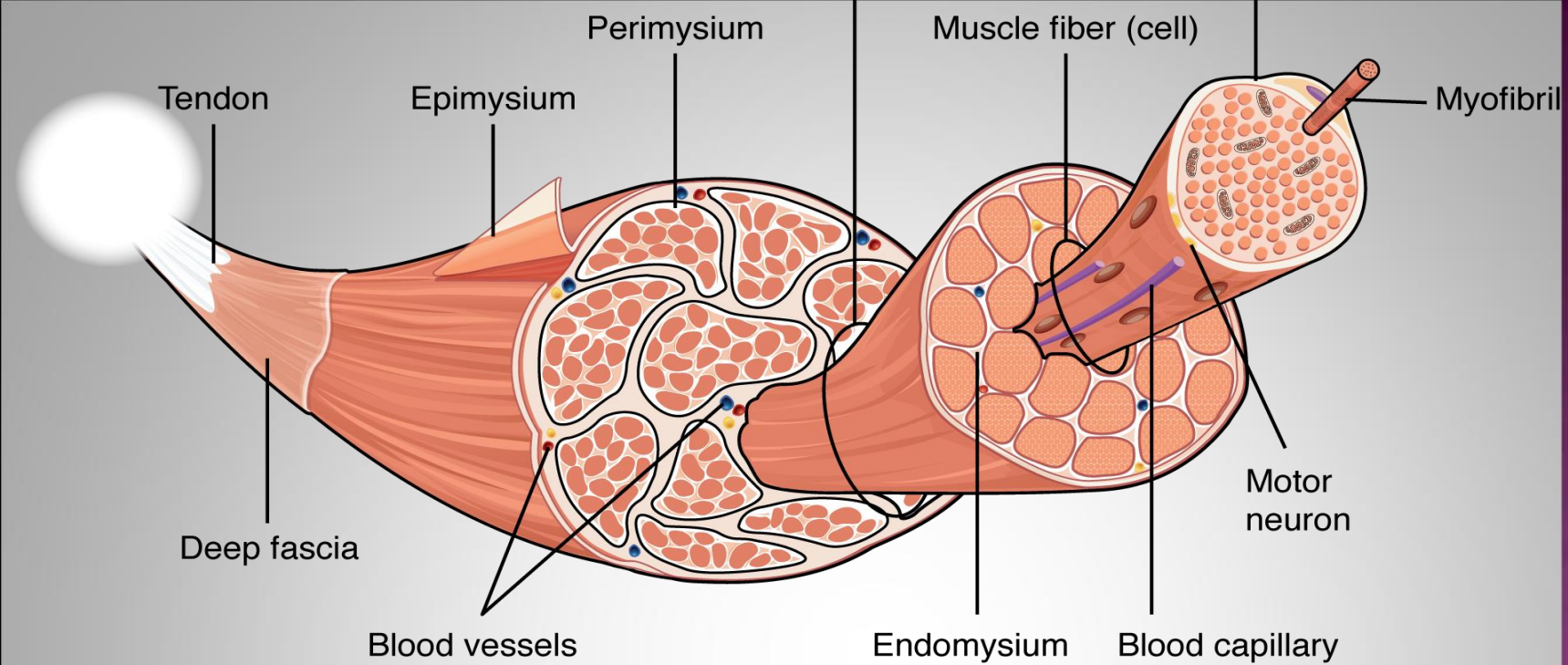
1-Move the **body maintain body posture**

2-Heat production

3-venous drainage

4-lymphatic drainage

5- **maintain body posture**



FUNCTIONAL HISTOLOGY

MUSCLE FIBRES:

- ⊙ Their diameter ranges **between 10 - 100 um.**
- ⊙ They extend through the entire length of the muscle.
- ⊙ - **Each ms. Fiber** consists of thousands of
myofibrils

The Myofibrils:

⊙ **1 μm in diameter** and extend through the entire length of ms. Fibers.

⊙ Divided into **functional units, sarcomeres** by transverse sheets called **Z discs** .

The sarcomere

- The sarcomere contains two types of interdigitating filaments, which are contractile proteins:

1- **Thick myosin filaments.**

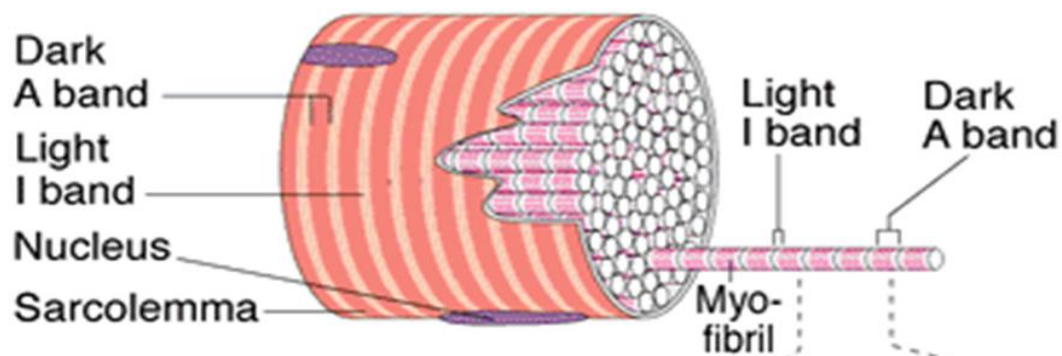
2 - **Thin filaments.**

- The sarcomere contains **dark areas (A band)** and light areas (**I band**).

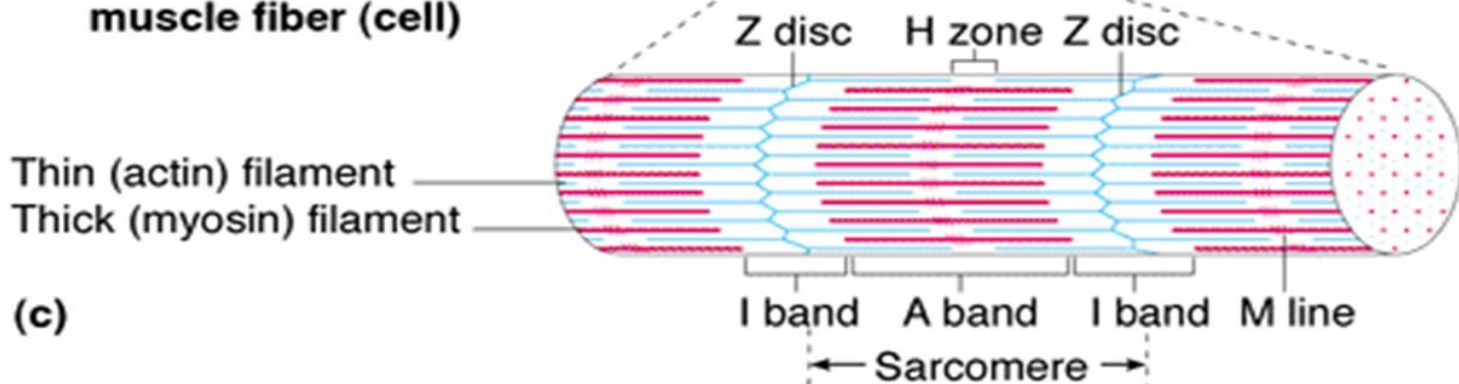
- **The dark area (A band)** : lies at the centre of the sarcomere & contains the **interdigitating myosin and actin filaments.**

THE SARCOMERE

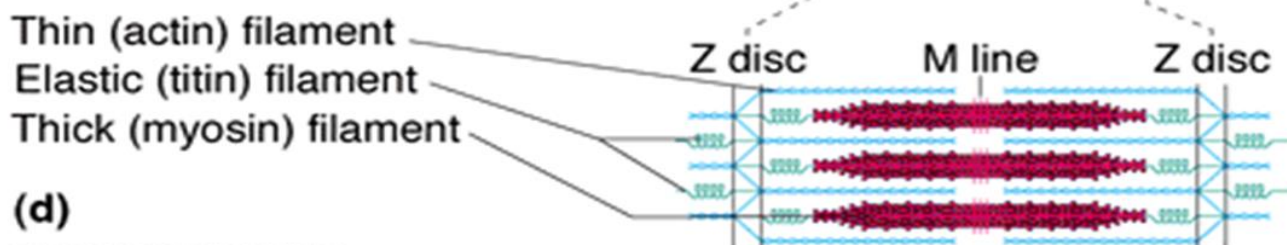
- ⊙ **H zone at the centre of A band** contains myosin filaments connected by M line.
- ⊙ **The light area (I band)** : on either side of **Z disc** contain only actin filaments.
- ⊙ **Cross bridges project from myosin** towards the binding sites on actin.



(b) Portion of a skeletal muscle fiber (cell)

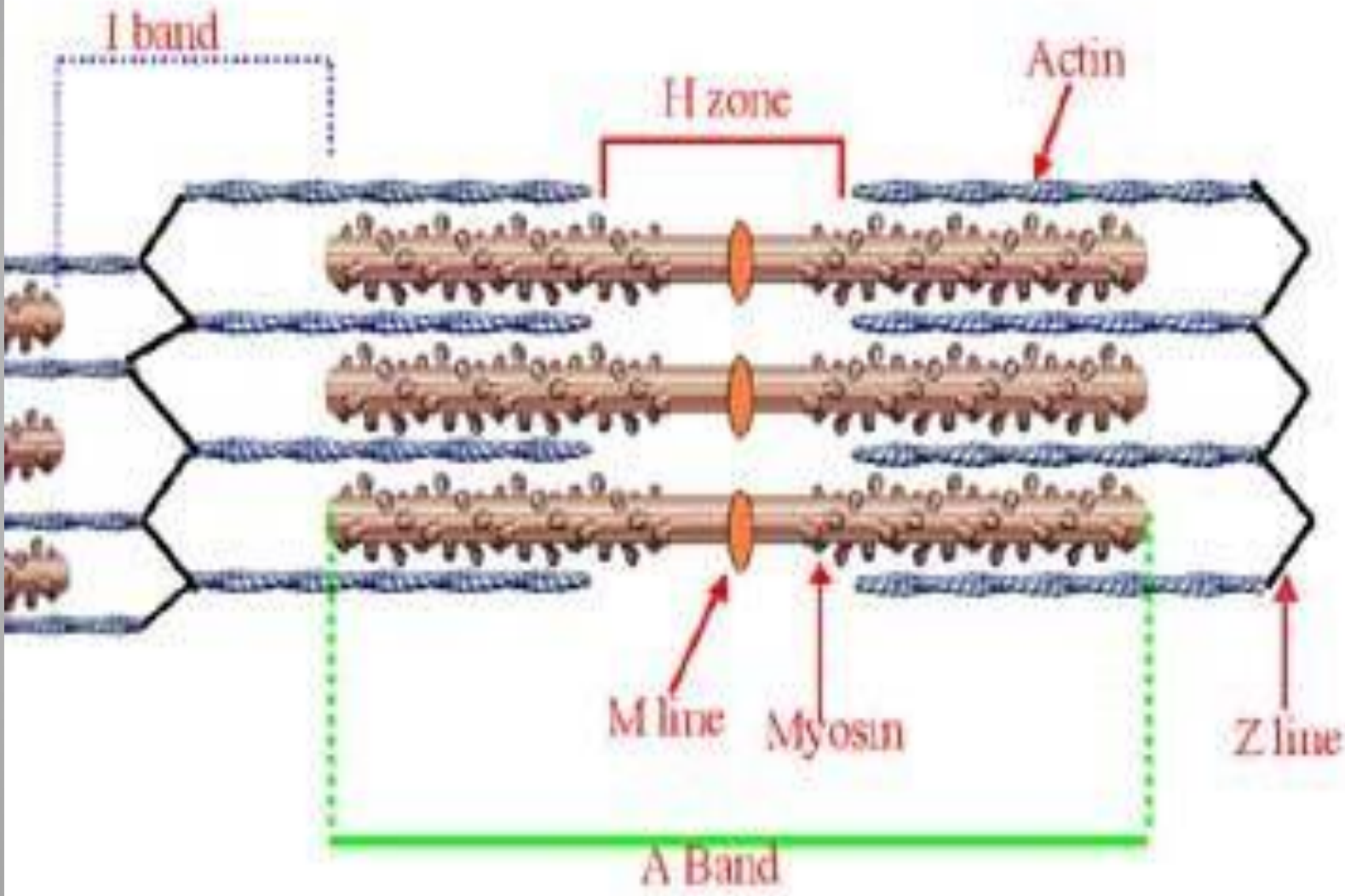


(c)



(d)

Sarcomere



Thick filaments:

- ⊙ Called **myosin** protein.
- ⊙ Cross bridges **extends from its surface towards** the thin filaments.
- ⊙ Each cross bridge **contains actin binding site & ATP ase.**

THIN FILAMENTS: INCLUDES THREE PROTEINS

1) Actin:

- ◉ Formed of **two chains of actin molecules** forming a helix, each actin molecule has specific sites with which **the cross bridge of myosin combine during contraction called binding site.**

2) Tropomyosin:

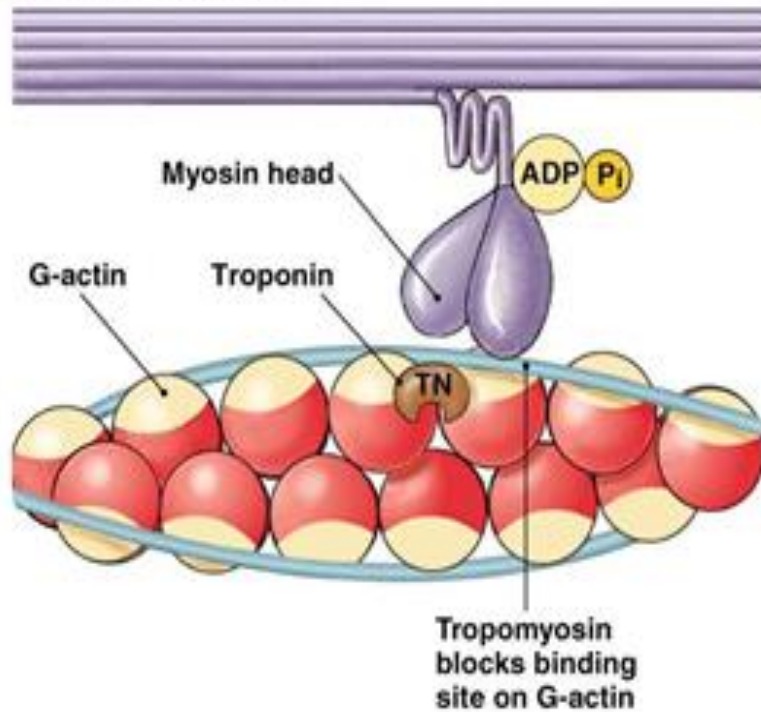
- Covers **the binding sites on actin during relaxation.**

3) Troponin:

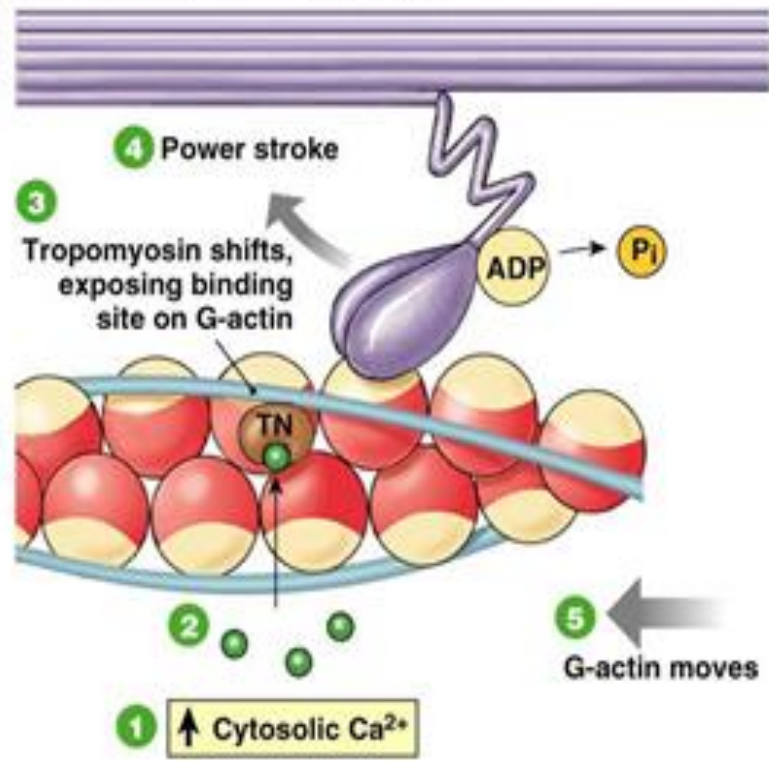
formed of 3 portions:

- Troponin C:** has strong affinity to **bind with calcium.**
- Troponin T:** has strong affinity to bind **with tropomyosin.**
- Troponin I :** has strong affinity to bind **with actin.**

(a) Relaxed state



(b) Initiation of contraction



- | | |
|---|---|
| 1 Ca ²⁺ levels increase in cytosol. | 2 Ca ²⁺ binds to troponin. |
| 3 Troponin-Ca ²⁺ complex pulls tropomyosin away from G-actin binding site. | 4 Myosin binds to actin and completes power stroke. |

Fig:(5) Cross bridges

5 G-actin moves.

The Tubular system

1) The transverse (T) tubule:

- They are **invaginations of the ms. Memb** at the junction of A and I band.

Function:

- 1) surface area of **sarcolemma many times**.
- 2) help movement of **ions and other substances** inside and outside the cell.
- 3) Allow **the depolarization wave to pass rapidly inside the ms. Fiber**.

2) The sarcoplasmic reticulum "SR":

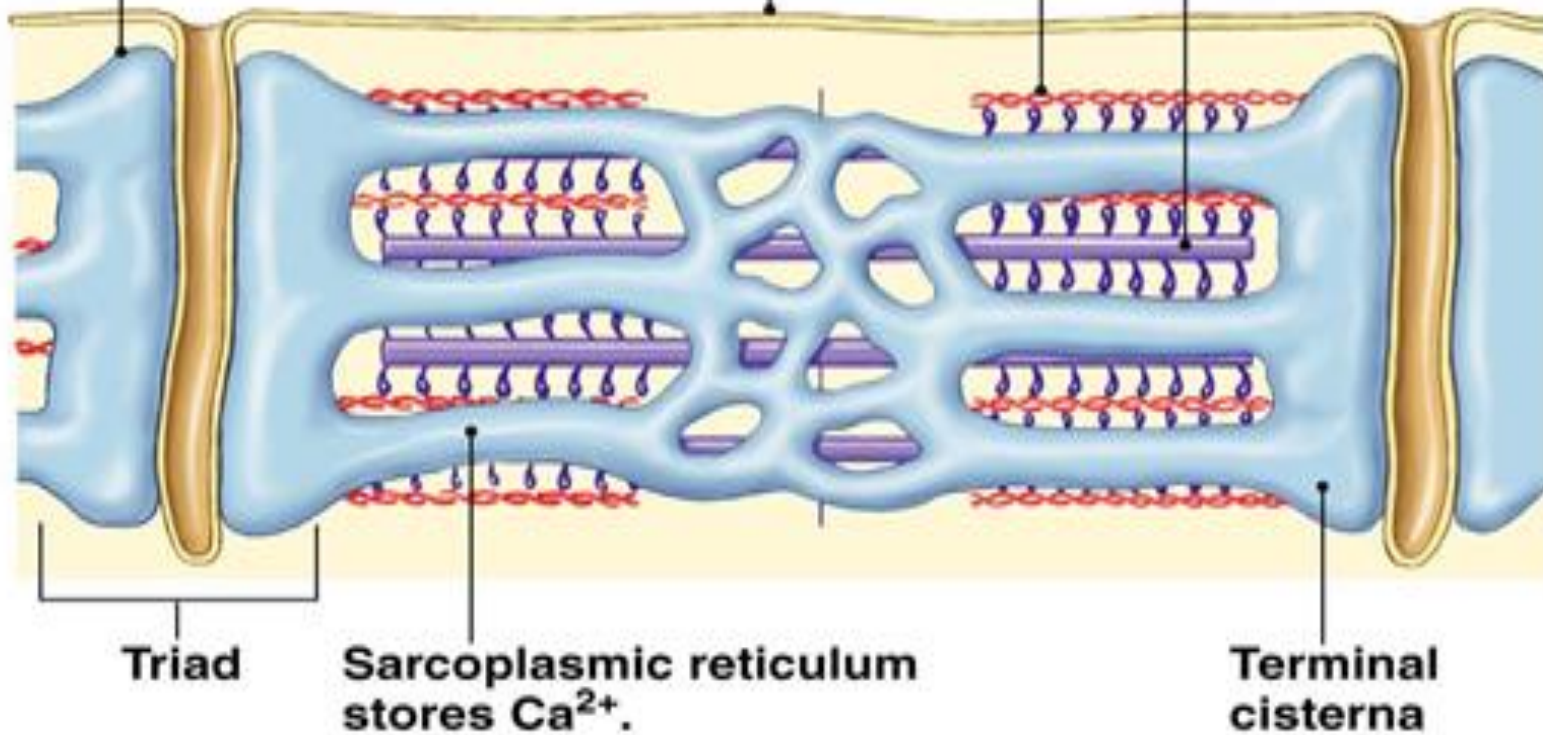
- Formed **of a network of anastomosing longitudinal tubules** which run parallel to the myofibril.
- The dilated ends of **the tubules are called the terminal cisternae**.
- A group of t-tubule + two terminal cisternae on either side is called triad.

T-tubule brings action potentials into interior of muscle fiber.

Thin filament

Sarcolemma

Thick filament



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Fig (4):Muscle structure

THE TUBULAR SYSTEM

Function:

the terminal cisternae:

- **release Ca^{++} ions during ms. contraction.**
- store Ca^{++} ions during ms. relaxation.

Process of muscle contraction

1- binding of cross bridges between actin and myosin:

- Ca is released from the sarcoplasmic reticulum in response to passage of nerve impulse through the T tubules through ca release channels
- The released **Ca⁺⁺ binds to Troponin**, which undergoes conformational change so **that Tropomyosin moves away leading to exposure of the binding sites on actin.**
- The exposed **actin binding sites immediately bind to the cross bridges of myosin.**

Sarcolemma

T-tubule

Myosin

4

Ca⁺⁺

TN-I

TN-C

TN-T

Ca⁺⁺

Ca⁺⁺

3

2

DHP receptor

TM

Actin

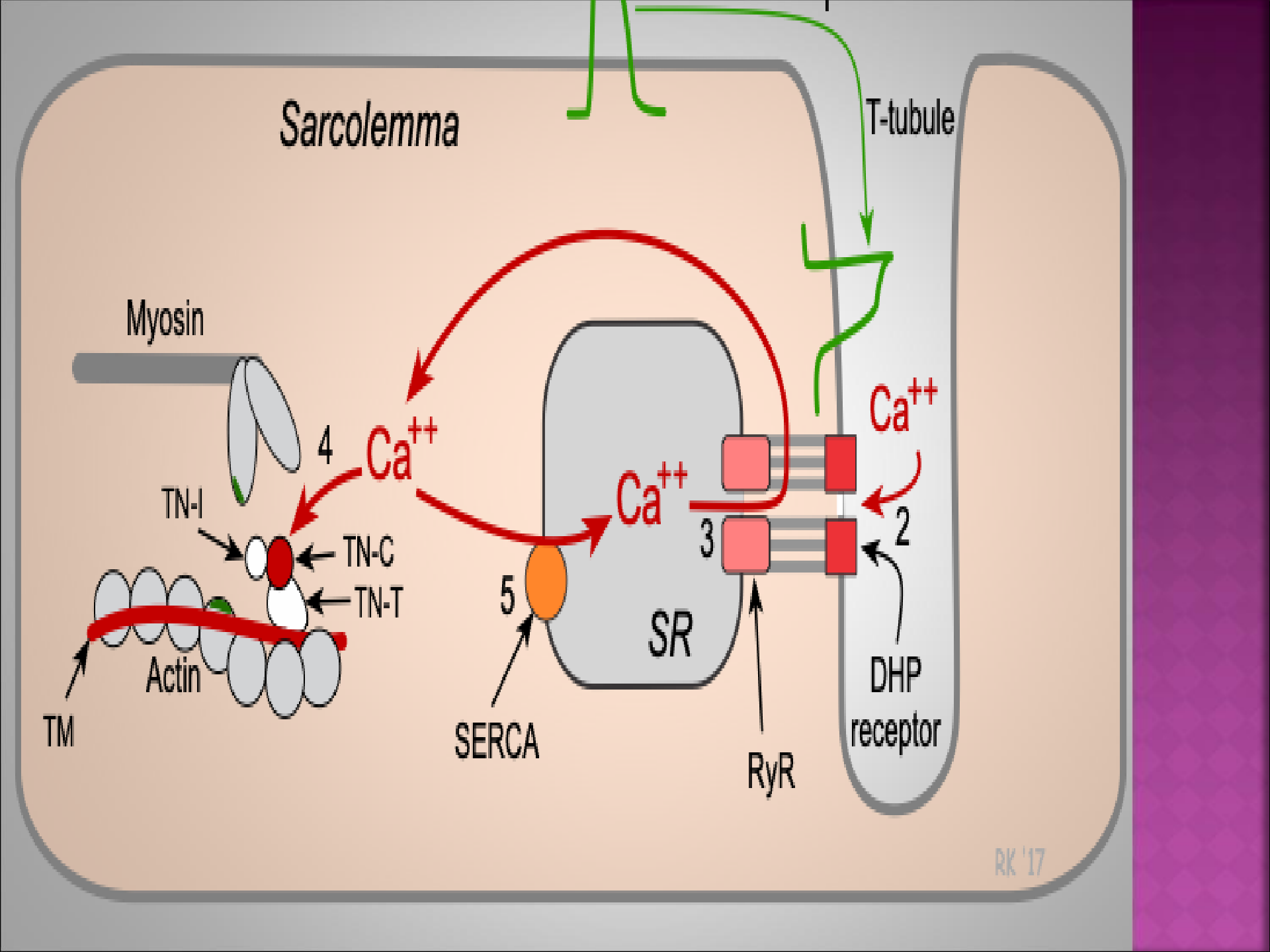
SERCA

SR

RyR

5

RK '17



2- Cross-bridge cycling: the cycling occurs by the following steps:

a) Binding: of actin and myosin.

b) Bending: of the cross bridges ~ sliding of actin over myosin.

- ⊙ **The force of bending is transmitted through actin to Z discs causing shortening of the sarcomere .**
- ⊙ **ATP is needed, Both ATP and ATP ase are attached to the cross bridges i.e. energy is needed for bending.**

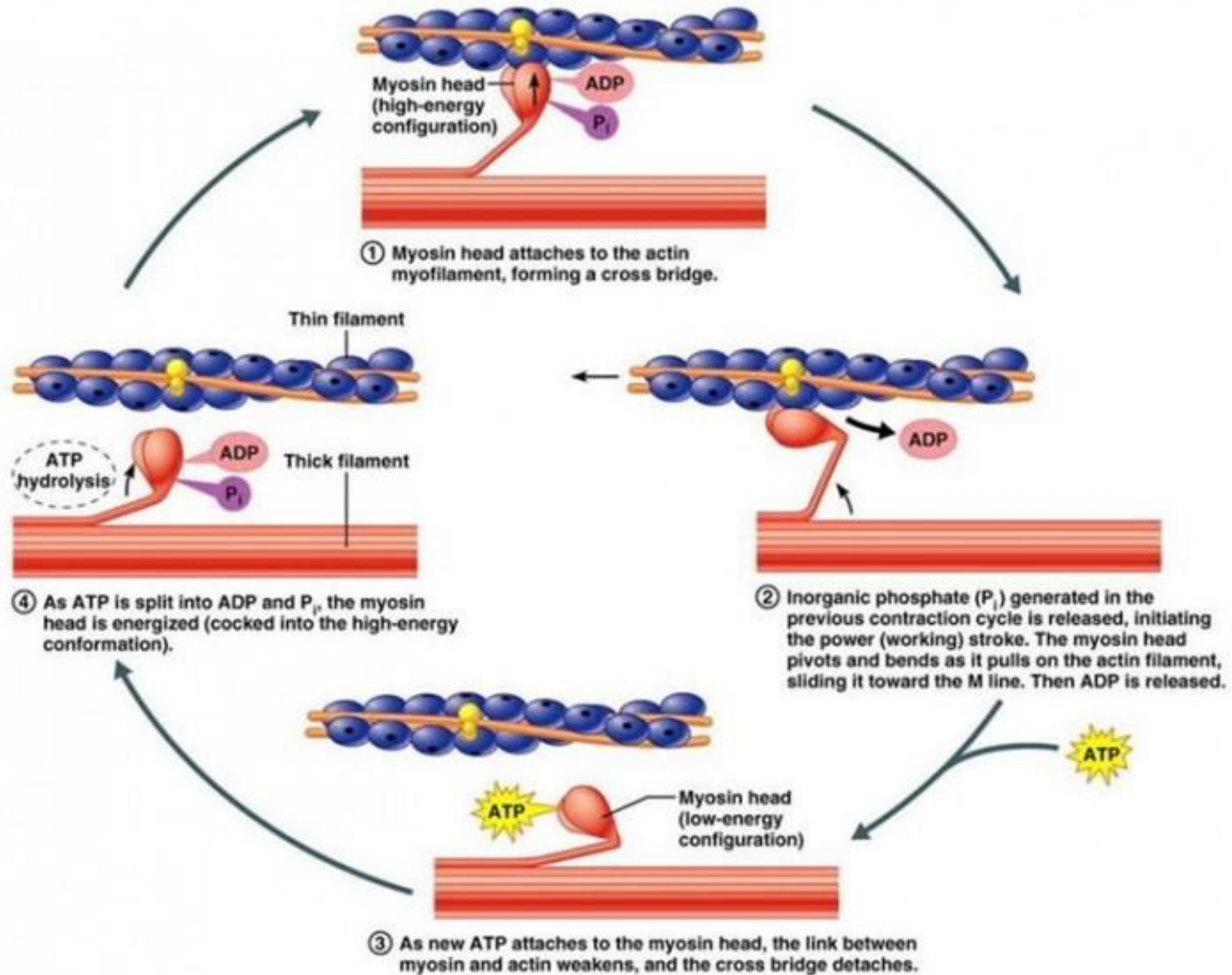
c) Detachment: of the cross bridges from actin.

⊙ **It needs ATP. If no ATP is available, the thin and thick filaments can't be separated (ms. Contracture).**

3- Return of the cross bridges to the original position:

⊙ **Once here, they can participate in another cycle.**

⊙ **Cycling continues as long as Ca^{++} is attached to Troponin.**



Relaxation:

- ⊙ Is an active process (needs ATP).
- ⊙ Occurs when **Ca⁺⁺ moves away from troponin.**
- ⊙ **Active ca uptake by ca pump (Ca⁺⁺ atpase)** by terminal cistern
- as a result **troponin returns to its original state** & tropomyosin returns to cover the binding sites of actin so cycling stops.

SUMMARY

1-There are 3 types of muscles in our body :

- a) Skeletal.
- b) Smooth.
- c) Cardiac.

2-Skeletal muscle functions include:

- a) Movement and posture.
- b) Help venous return .
- c) Help lymphatic drainage.
- d) Maintain body temperature.

SUMMARY

3-Functional histology of skeletal muscles:

- a) The sarcomere is the functional unit.
- b) The sarcomere contain dark and light bands.
- c) The dark band is formed mainly by myosin filaments.
- d) The light band is formed mainly by actin filaments.

4-Skeletal muscle contraction:

- a) Is triggered by ca release.

SUMMARY

b) Is caused by the process of cross bridge cycling.

c) Contraction causes approximation of the 2 Z lines and shortening of the sarcomere.

5-Relaxation :

a) Is caused by active reuptake of Ca into the sarcoplasmic reticulum.

b) And return of the tropomyosin to cover the active sites of the actin molecules.

c) And stoppage of cross bridge cycling.

MCQ

Which of these structures is considered the functional unit of the skeletal muscle?

- a) The dark band.
- b) The sarcomere.
- c) The sarcoplasmic reticulum.
- d) The T tubules.
- e) The I band.

MCQ

Which of these proteins covers the active sites of the actin molecules of the skeletal muscle fibre filaments during rest?

- a) The myosin protein.
- b) The actin protein.
- c) The tropomyosin .
- d) The troponin.
- e) The Z line protein.

MCQ

The skeletal muscle contraction is triggered by release of which of these ions?

- a) Mg ion.
- b) Ca ion.
- c) Na ion.
- d) K ion.
- e) Cl ion.

WHICH IS THE TYPE OF PROTEIN PRESENT IN THICK FILAMENTS OF MUSCLE FIBERS?

- a) Actin
- b) Tropomyosin
- c) Troponin
- d) M protein
- e) myosin

TROPONIN IN MUSCLE FIBRILS HAS STRONG AFFINITY TO WHICH OF THESE IONS?

- a) Na^+
- b) K^+
- c) Ca^{++}
- d) Mg^{++}
- e) Cl^-

TROPONIN T IN MYOFIBRILS HAS STRONG AFFINITY TO WHICH OF THESE SUBSTANCES?

- a) Tropomyosin
- b) Ca^{++}
- c) Actin
- d) Myosin
- e) Titin

TROPONIN I IN MYOFIBRILS HAS STRONG AFFINITY TO WHICH OF THESE SUBSTANCES?

- a) Myosin
- b) Actin
- c) Tropomyosin
- d) Ca^{++}
- e) Titin

SHORT ESSAY QUESTIONS

1. Mention functions of skeletal muscles
2. Discuss mechanism of skeletal muscle contraction and cross bridge cycling
3. Mention components of tubular system of skeletal muscle and describe its functions
4. Describe mechanism of skeletal muscle relaxation
5. Mention protein making up the actin filaments of myofibrils

THANK

You