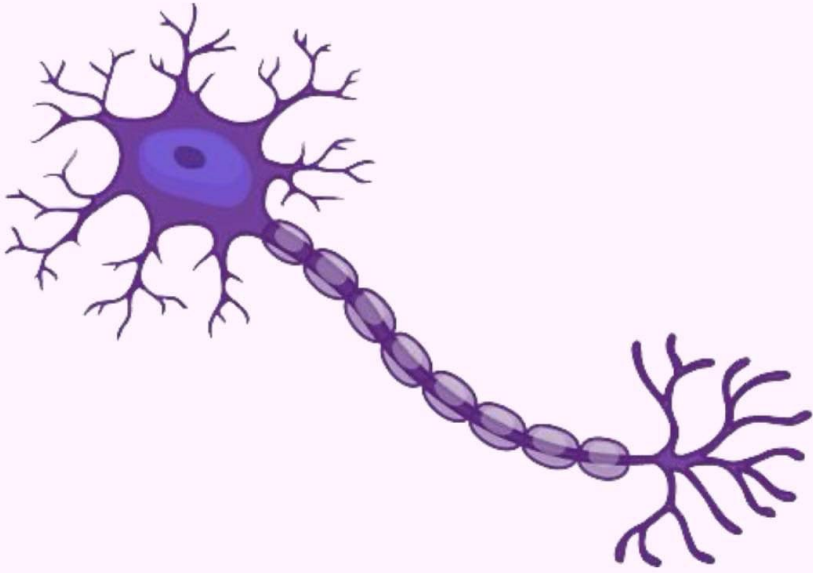




PHYSIOLOGY



LEC NO. : 12

DONE BY : Asia Al-wafyan.

وَقُلْ رَبِّ زِدْنِي عِلْمًا

الجهاز العصبي .

THE MUSCULAR SYSTEM



BY

⦿ **D. Gehan
Elwakeel**

⦿ **A. Professor of
physiology**

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

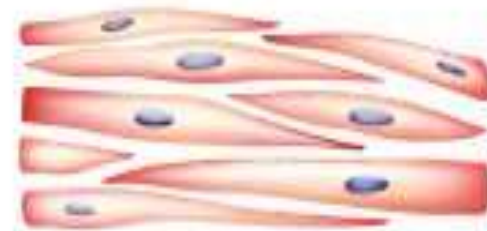
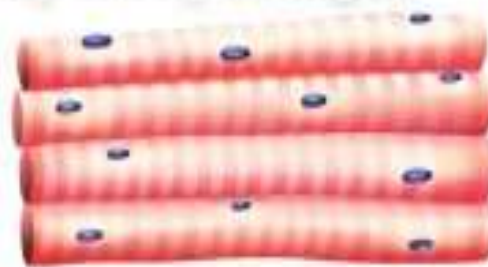
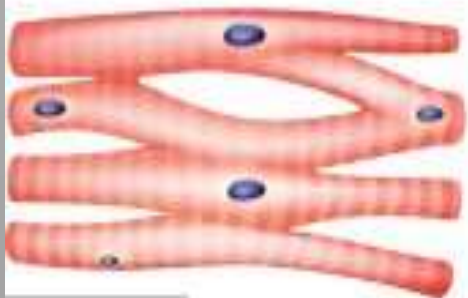
موجوده في جدار الاحشاء ،
العضلات الي انا ما بقدر اتحكم
(involuntary) فيها بارادتي

Types of Muscle

عضلة القلب



العضلات الي متصله بالعظام



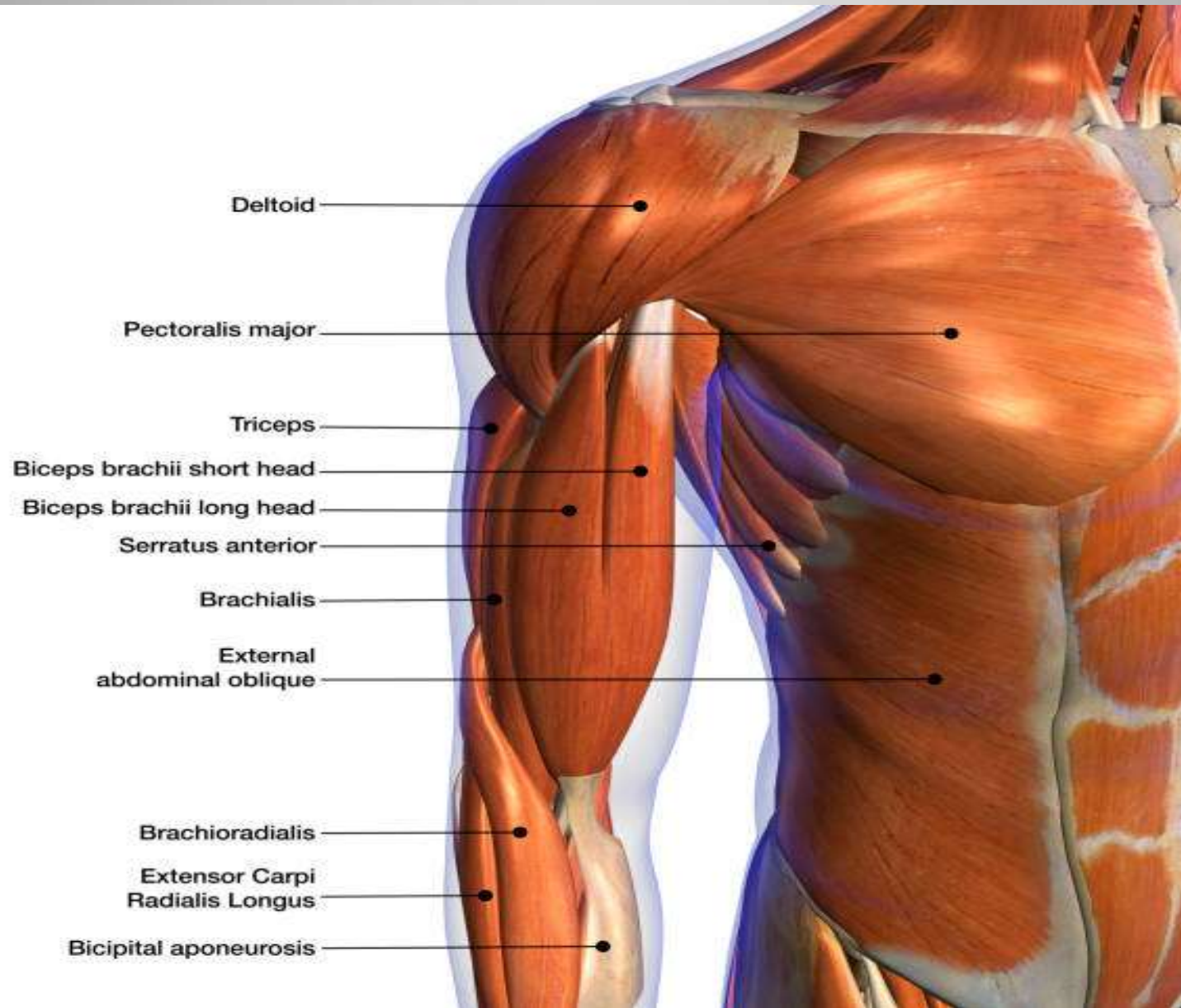
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Cardiac muscle

Skeletal muscle

Smooth muscle

SKELETAL MUSCLE



SKELETAL MUSCLE

Skeletal muscle

Characterized by:

محرزة و مقسمة الى اجزاء

⊙ 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**).

الmuscles تتكون من muscle fibers و ال muscle
fibers تتكون من myofibren و ال myofibril تتكون من
myofiren

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Function

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

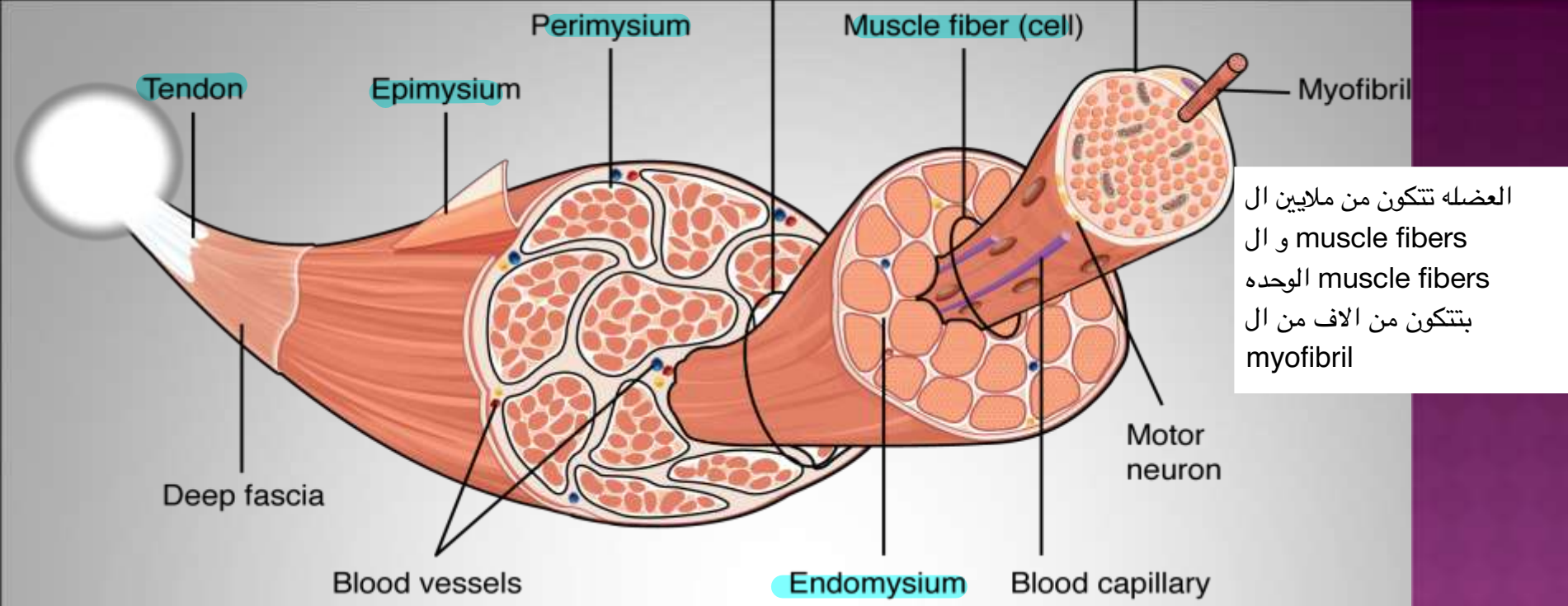
2-Heat production (contraction) عن طريق الانقباضات تبعت العضلات

3-venous drainage

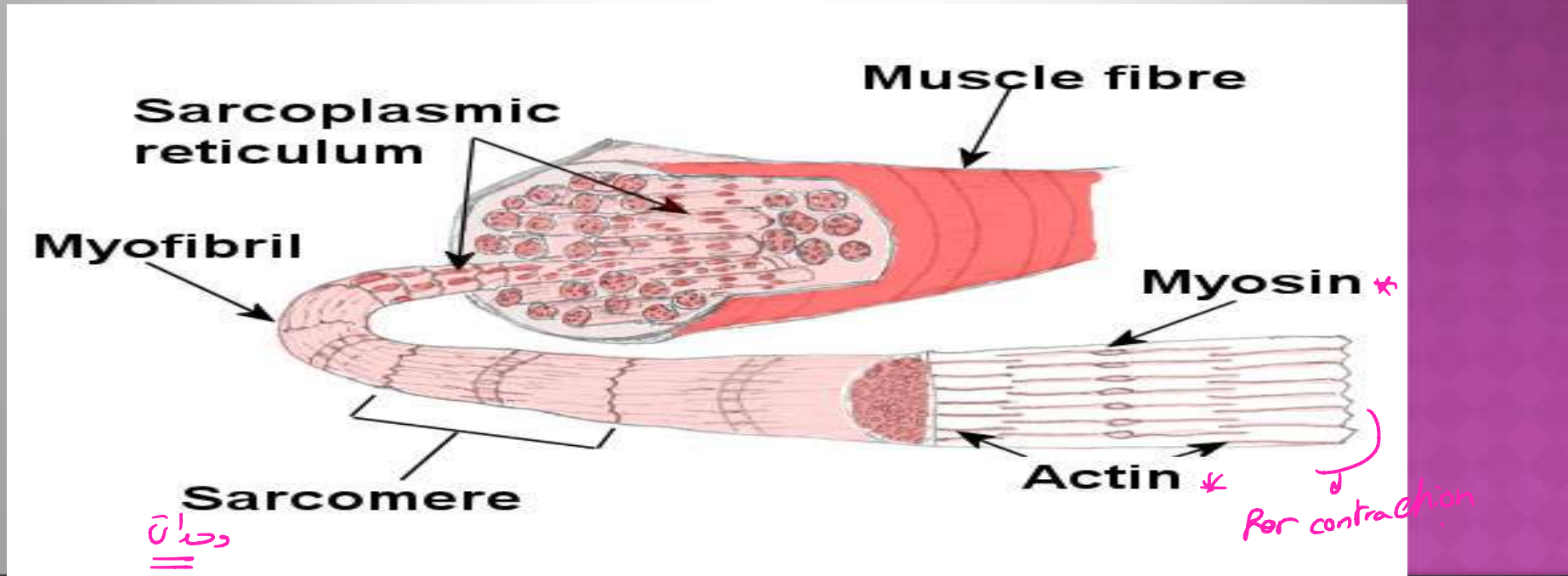
الاورده و الاوعية الدمويه و اللمفاويه موجودة داخل العضلات فلما العضله بتتقبض بتروح بتدفع الاكل lymph لفوق عشان تصب في الاوعية اللمفاويه و بعدين في القلب ، و بتدفع الدم لفوق عشان يصب في القلب

4-lymphatic drainage

5- **maintain body posture**



العضله تتكون من ملايين ال muscle fibers و ال muscle fibers الوحده بتتكون من الاف من ال myofibril



FUNCTIONAL HISTOLOGY

MUSCLE FIBRES:

⊙ Their diameter ranges **between 10 - 100 um.**

من بداية العنقبة لغاية نهايتها .

⊙ They extend through the **entire length** of the muscle.

⊙- **Each ms. Fiber** consists of **thousands** of **myofibrils**

The Myofibrils:

سورة 1/2

⊙ **1 μm in diameter** and extend through the entire

من بيوت ال muscle fiber حتى لفانها .

length of ms. Fibers.

⊙ Divided into **functional units, sarcomeres** by

الوحدة الساركو مير للميوفبريل

transverse sheets called **Z discs** .

الساكرومير موجوده بين بروتين اسمو z protein

يكونلي اشبي اسمو z disc

The sarcomere

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

مترابطين

له برد سين حاصر مع الاتعباضه .

1- **Thick myosin filaments.**

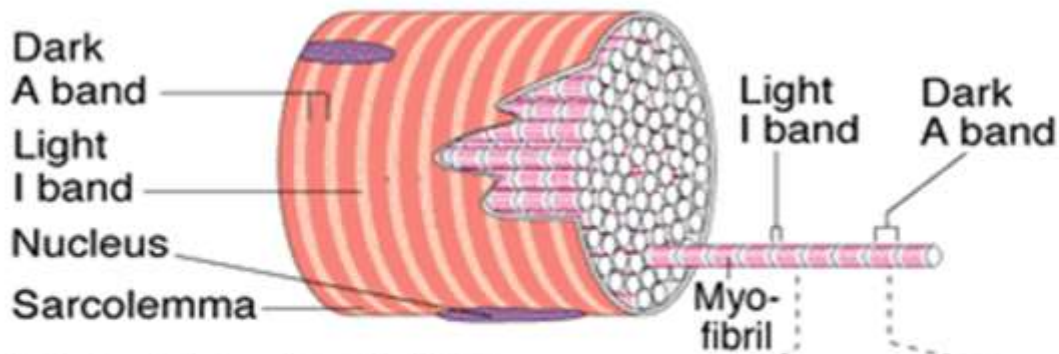
2- **Thin filaments.**

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

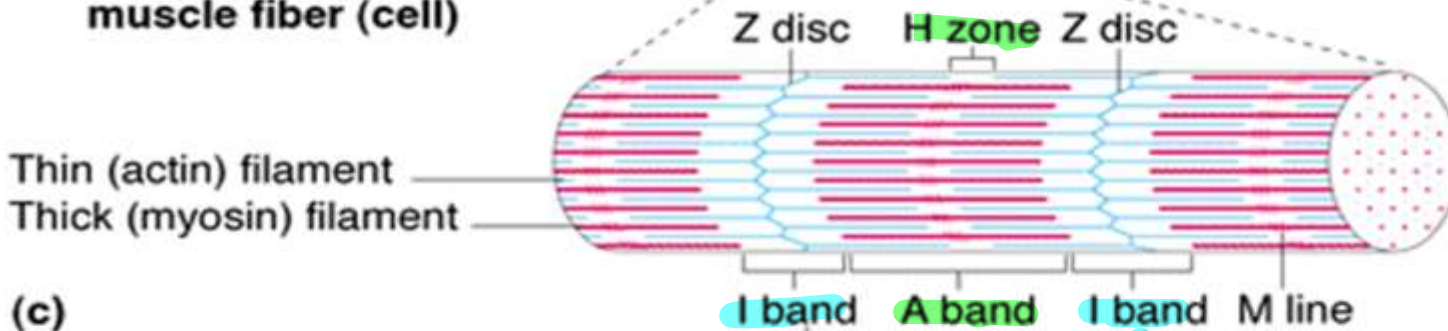
- **The dark area (A band)** : lies at the **centre of the sarcomere** & contains the **interdigitating myosin and actin filaments.**

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)

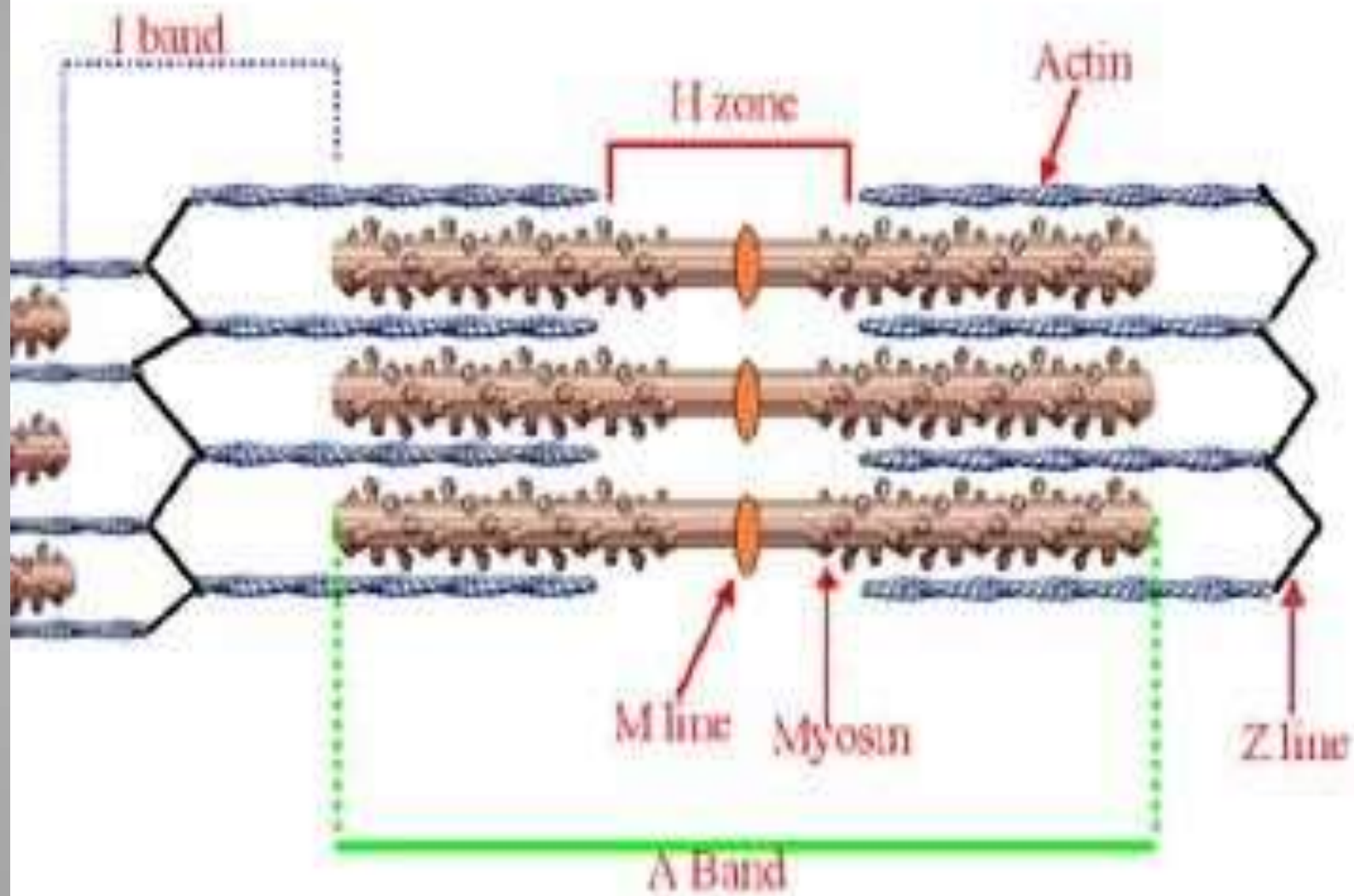


(c)



(d)

Sarcomere



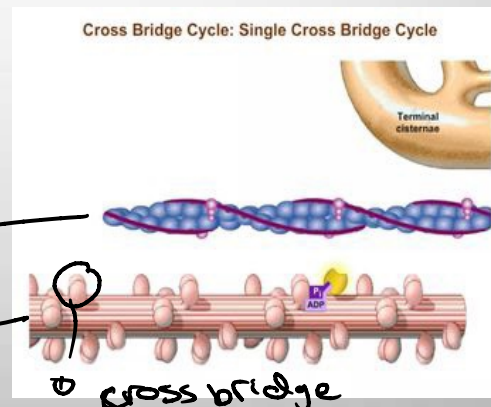
Thick filaments:

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

ATP ase.

عملية الاتحاد بين ال cross bridge و
ال actin filament تحتاج لطاقة فال
atp ase بكسر ال atp و يطلعي
energy بتساعد في عملية ال
contraction

Actin
myosin



THIN FILAMENTS: INCLUDES THREE PROTEINS

1) Actin: هيه عبارہ عن cell filament

Formed of **two chains of actin molecules**

سے مل کر طرز میں .

forming a helix, each actin molecule has

specific sites with which **the cross bridge of**

myosin combine during contraction called

binding site.

ایک طرف سے ال Actin دوسری طرف سے ال cross bridge جس سے ال myosin
ملتا ہے جس سے contraction ہوتا ہے .

عند وجوده ما بقدر ال binding site يتحد مع ال cross bridge فما بصير اصلا contraction for the muscle

2) Tropomyosin:

during rest.

- Covers the binding sites on actin during relaxation.

3) Troponin:

3 الأنواع

formed of 3 portions:

لما يصير للعضلة contractio, troponin C بحب الكالسيوم فاول ما يزيد نسبة الكالسيوم داخل العضله يتحد مع بروتين اسمو troponin C, بعدين بروح ال tropomyosin يتحد مع ال troponin T و بشيل ال tropomyosin و ببعدهو عن الاكتين فيليمانت، و بعدين بييجي اخر نوع troponin I يتحد مع ال actin filament

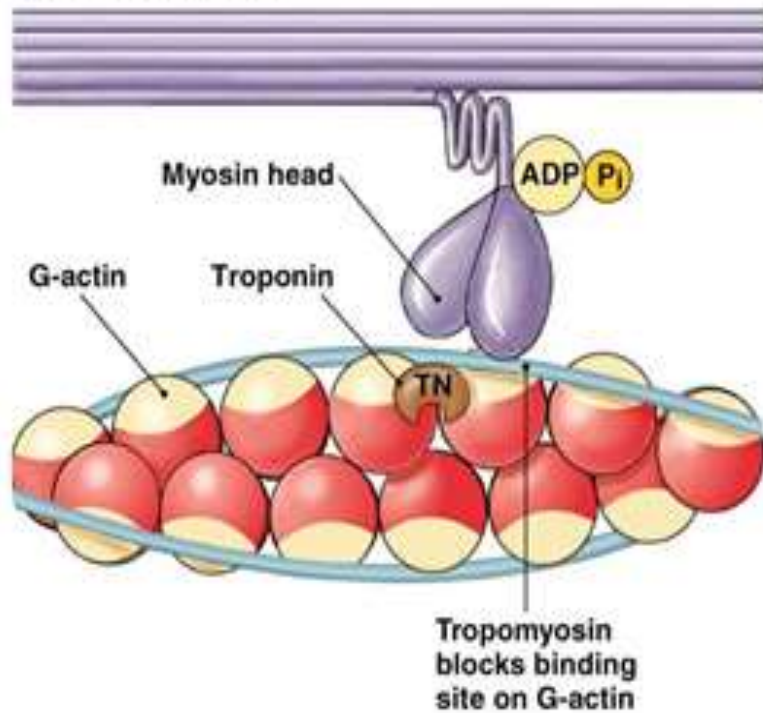
كل هاي العمليه عشان بييجي ال cross bridge و يرتبط نع ال binding site و يعملو انقباض

a) **Troponin C:** has strong affinity to bind with calcium.

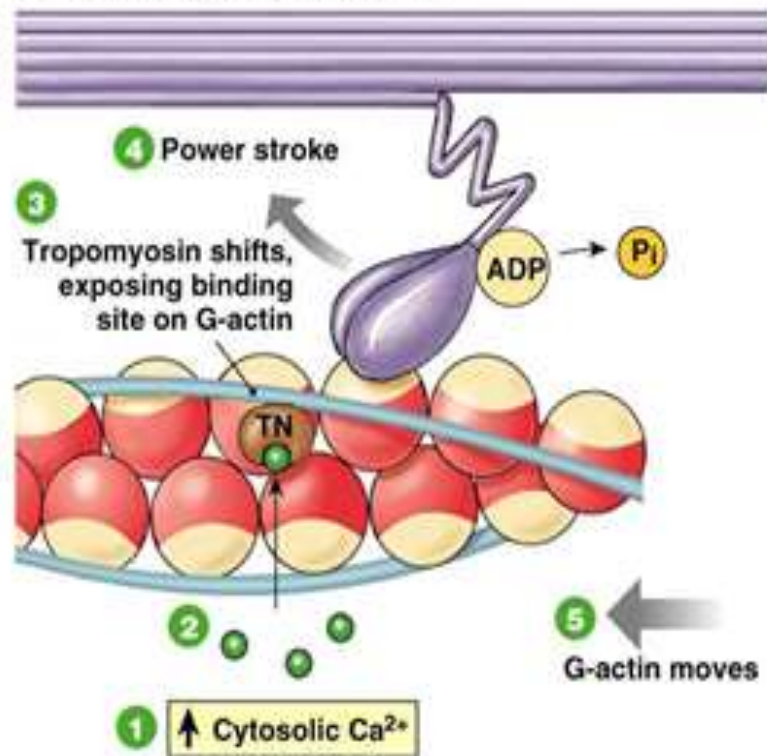
b) **Troponin T:** has strong affinity to bind with tropomyosin.

c) **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:

صغرة

- 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":

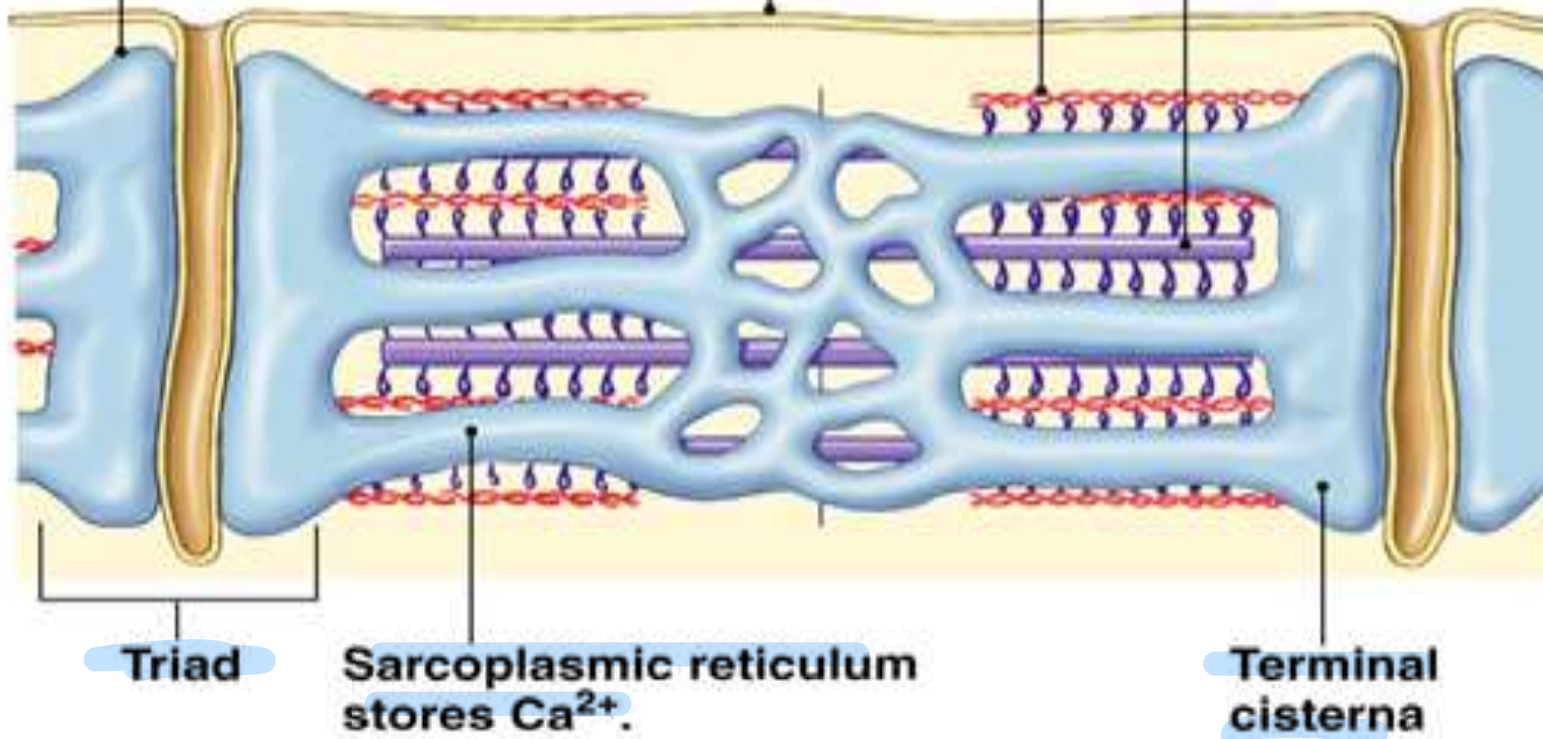
- Formed of a network of anastomosing longitudinal tubules which run parallel to the myofibril.
- The dilated ends of the tubules are called the terminal cisternae.
- A group of t-tubule + two terminal cisternae on either side is called triad.

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.**

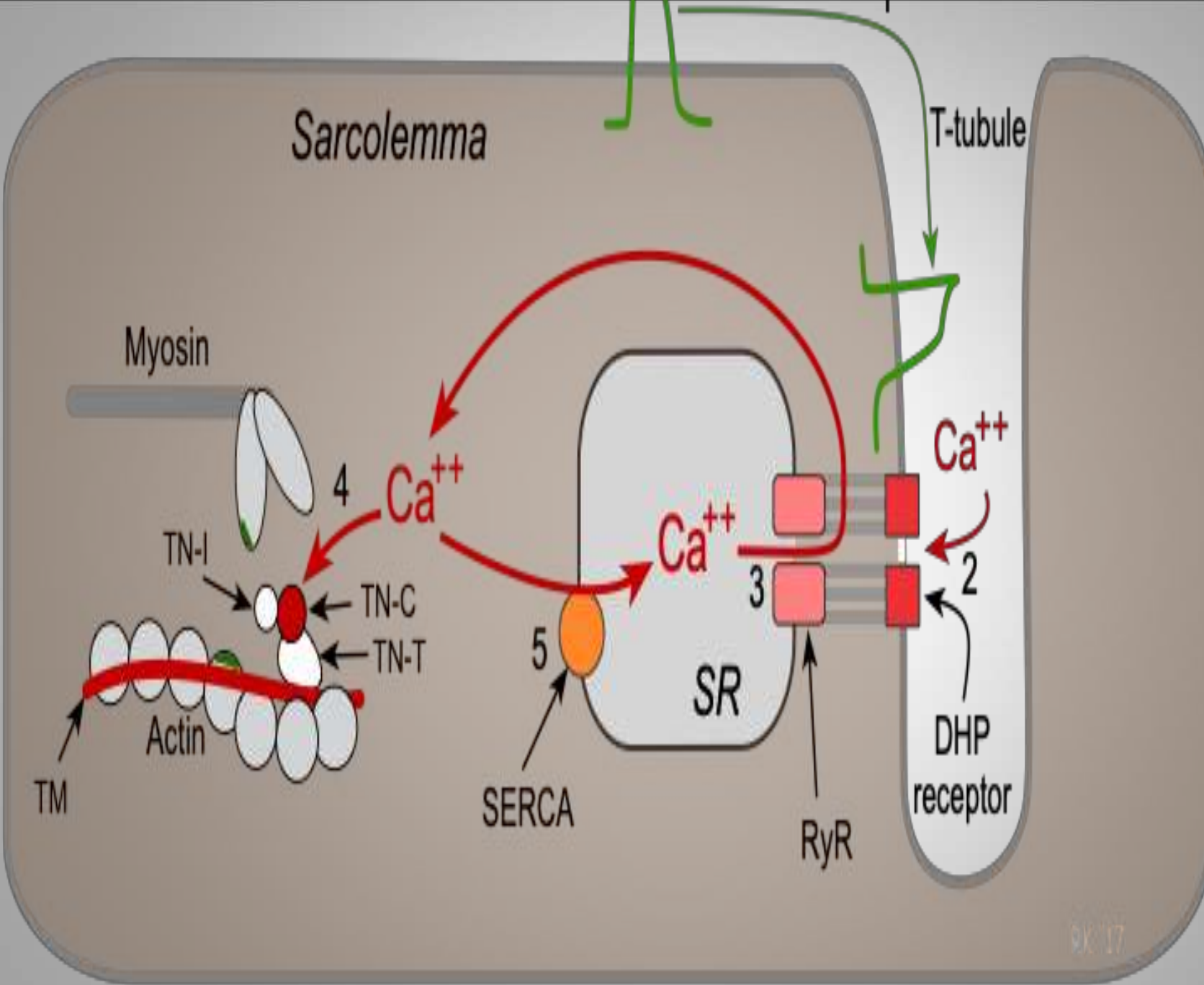
نور وجود nerve impulse

✓

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**.



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:

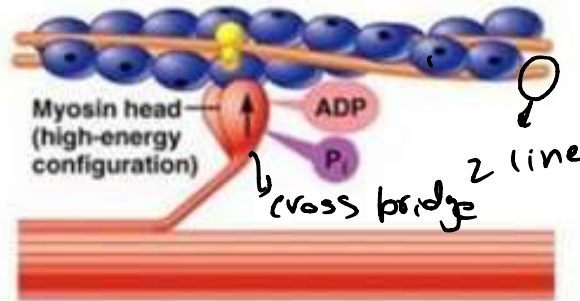
⊙ **Once here, they can participate in another cycle.**

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

Troponin.

Binding:

ارتباط ال cross bridge مع ال binding site

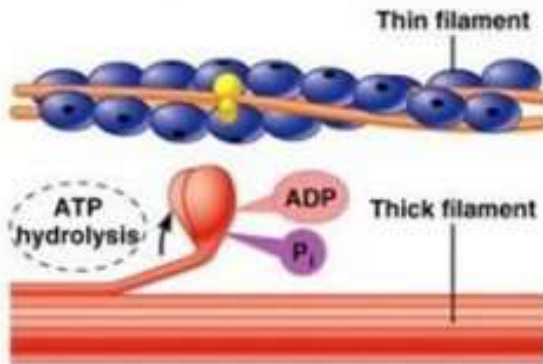


① Myosin head attaches to the actin myofilament, forming a cross bridge.

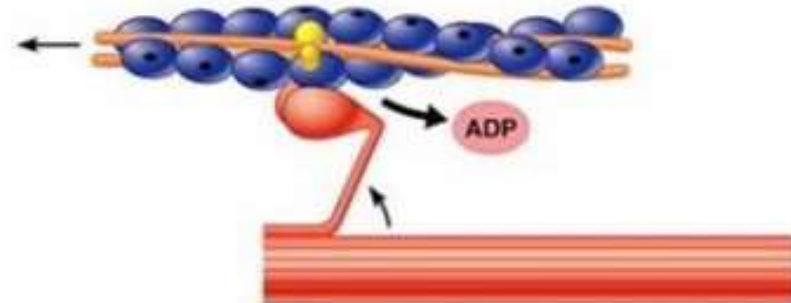
Bending:

بعد الارتباط هاد بصير عندي انواع لل cross bridge ال بييجي الاكتين يدخل لجوا لما يدخل لجوا رح يشد ال shorting of disk sacromere و يصير لها

كل وحده cross bridge بصير لها bending و بتشد ال الاكتين و هون يستهلك طاقه



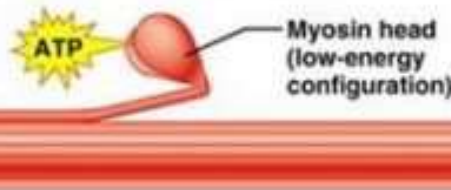
④ As ATP is split into ADP and P_i , the myosin head is energized (cocked into the high-energy conformation).



② Inorganic phosphate (P_i) generated in the previous contraction cycle is released, initiating the power (working) stroke. The myosin head pivots and bends as it pulls on the actin filament, sliding it toward the M line. Then ADP is released.



③ As new ATP attaches to the myosin head, the link between myosin and actin weakens, and the cross bridge detaches.



Detachment:

ال atp molecule رح تتحد مع ال cross bridge cycle فرح تمنعوا نو يرتبط مع الاكتين

ATP

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