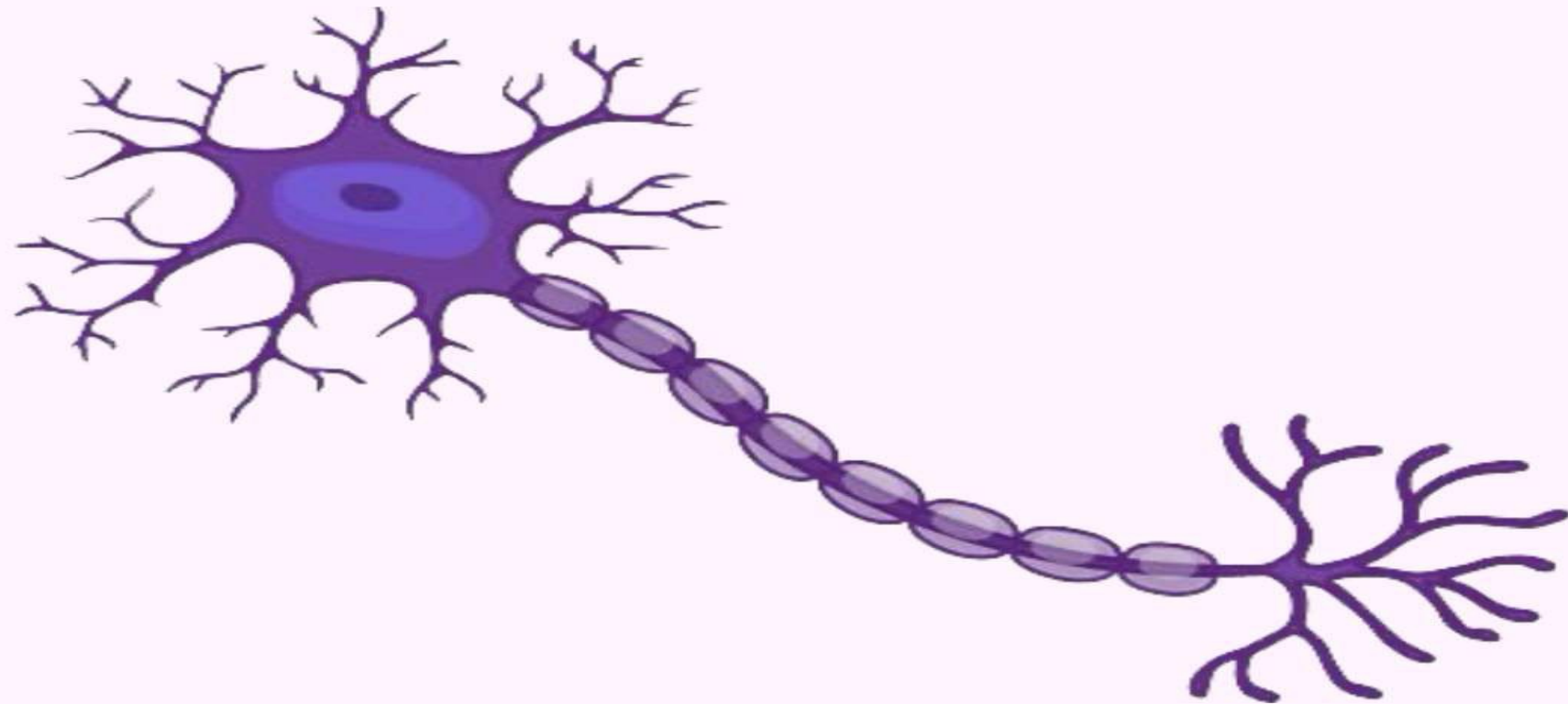


PHYSIOLOGY



LEC NO. : 12

DONE BY : Nour Al-amoush.

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,

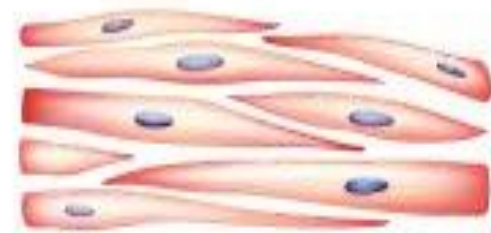
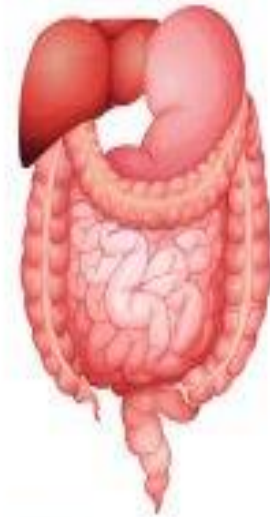
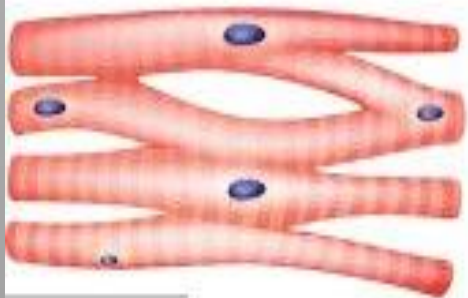
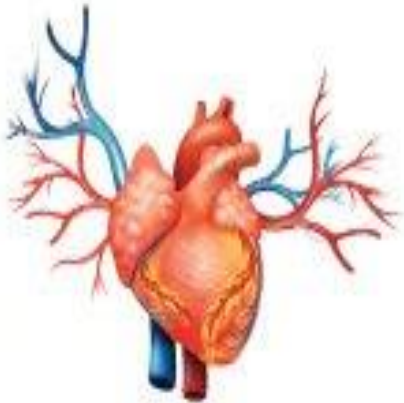
cardiac and skeletal → skelton + Attached to bones.

①
الملساء ← في جدار الأوعية .
(المعدة ، الأمعاء ...)

②
في القلب

③

Types of Muscle




477005433

Cardiac muscle

Skeletal muscle

Smooth muscle

SKELETAL MUSCLE

- 
- Deltoid
- Pectoralis major
- Triceps
- Biceps brachii short head
- Biceps brachii long head
- Serratus anterior
- Brachialis
- External abdominal oblique
- Brachioradialis
- Extensor Carpi Radialis Longus
- Bicipital aponeurosis
- This anatomical illustration shows the right arm and shoulder region from a medial view. The muscles are rendered in a realistic orange-brown color with visible fiber orientation. Black lines connect text labels on the left to specific points on the muscles. The labels include: Deltoid (shoulder), Pectoralis major (chest), Triceps (back of upper arm), Biceps brachii short head and long head (front of upper arm), Serratus anterior (side of torso), Brachialis (front of lower arm), External abdominal oblique (side of torso), Brachioradialis (front of forearm), Extensor Carpi Radialis Longus (back of forearm), and Bicipital aponeurosis (wrist area).

SKELETAL MUSCLE

Skeletal muscle

Characterized by:

مخططة

- ◉ 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). Muscles > muscle fibers > myofibers.

ارادي

Function

Position

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

2-Heat production

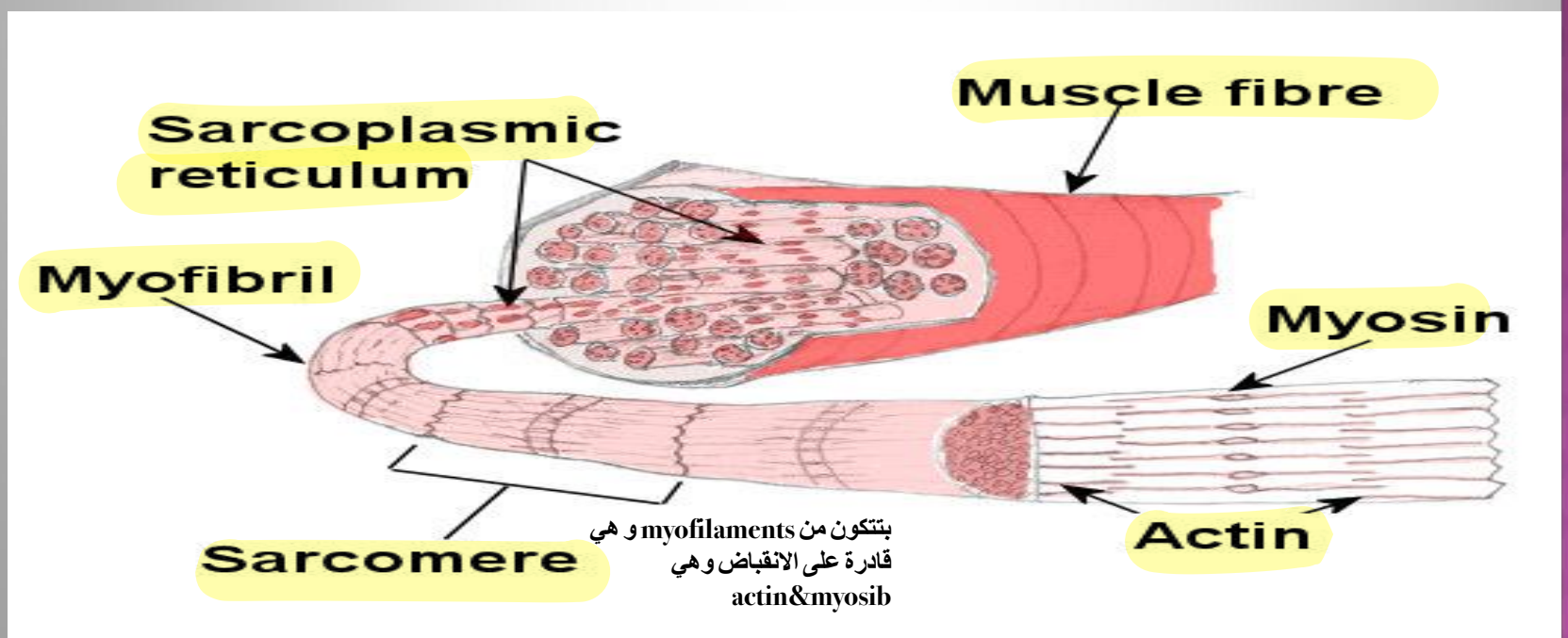
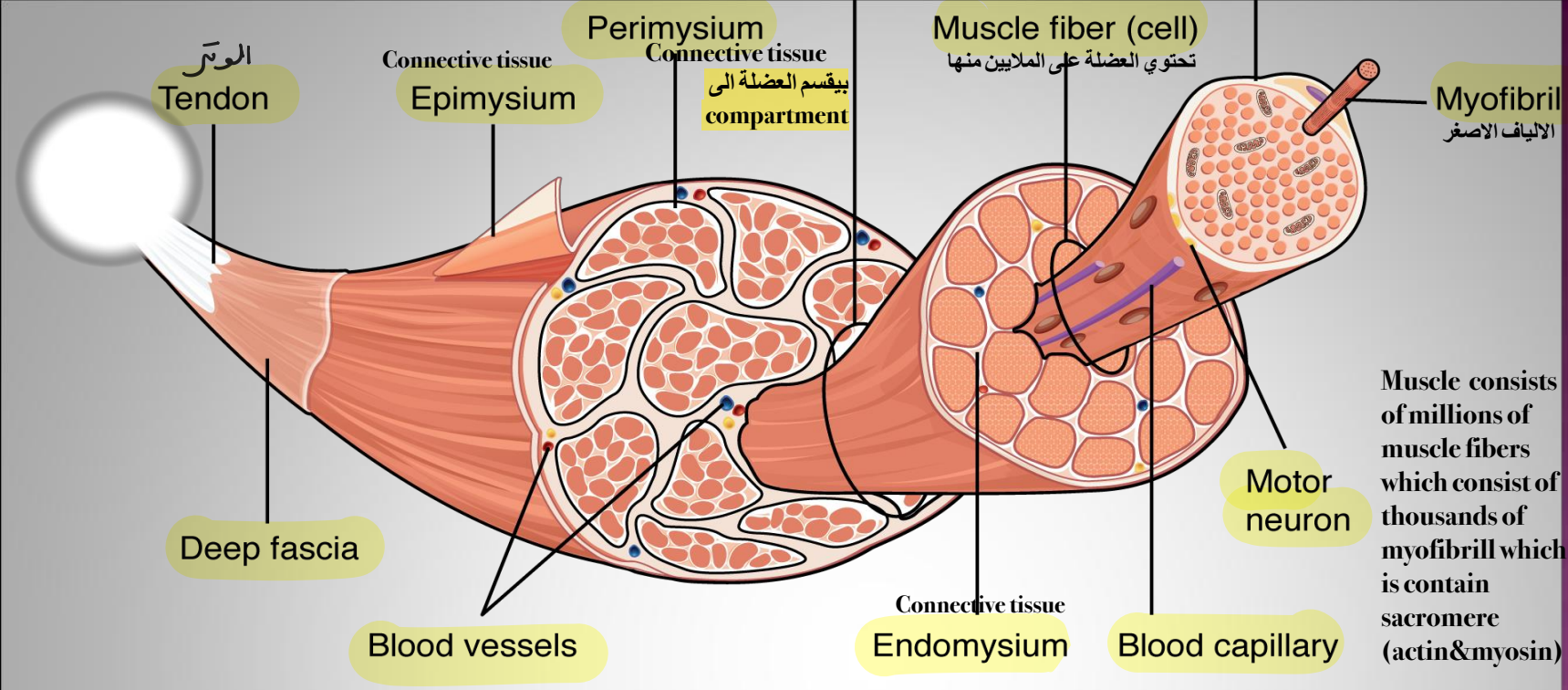
لانه contraction بيولد حرارة عشان هيك لما
نبرد بتصينار جفة عشان تولد الحرارة

3-venous drainage

الاوعية الدموية و اللمفاوية بتكون موجودة داخل العضلات لما العضلة تنقبض بتعصر الاوردة و
الاوعية اللمفاوية وتدفعها لفوق عشان تصب في القلب و الأوعية اللمفاوية تصب في main
lymphatic duct

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. يمتد من بداية العضلة لنهايتها

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

The Myofibrils:

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

length of ms. Fibers. برضو ماسكة من البداية للنهاية

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

من zprotien
transverse sheets called **Z discs** .

موجودة ما بين 2 (z)
lines) و هو عبارة
عن بروتين

The sarcomere

The functional unit of myofibrill
لو حصل فيها تنقبض العضلة يعني
origin & insertion قربوا من بعض

- The sarcomere contains two types of interdigitating
متداخلين

بروتين قابل للانقباض

filaments, which are contractile proteins:

1- Thick myosin filaments.

2 - Thin filaments.

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

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

THE SARCOMERE

يعني ما عنا actin

⊙ **H zone** at the centre of **A band** contains

myosin filaments connected by **M line**.
موجود في m protein

Around z line

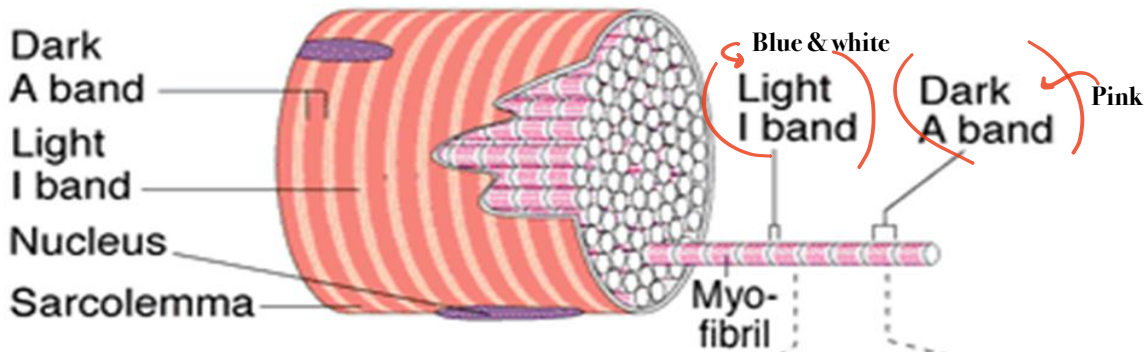
⊙ **The light area (1 band)** : on either side of **Z**

disc contain only actin filaments.

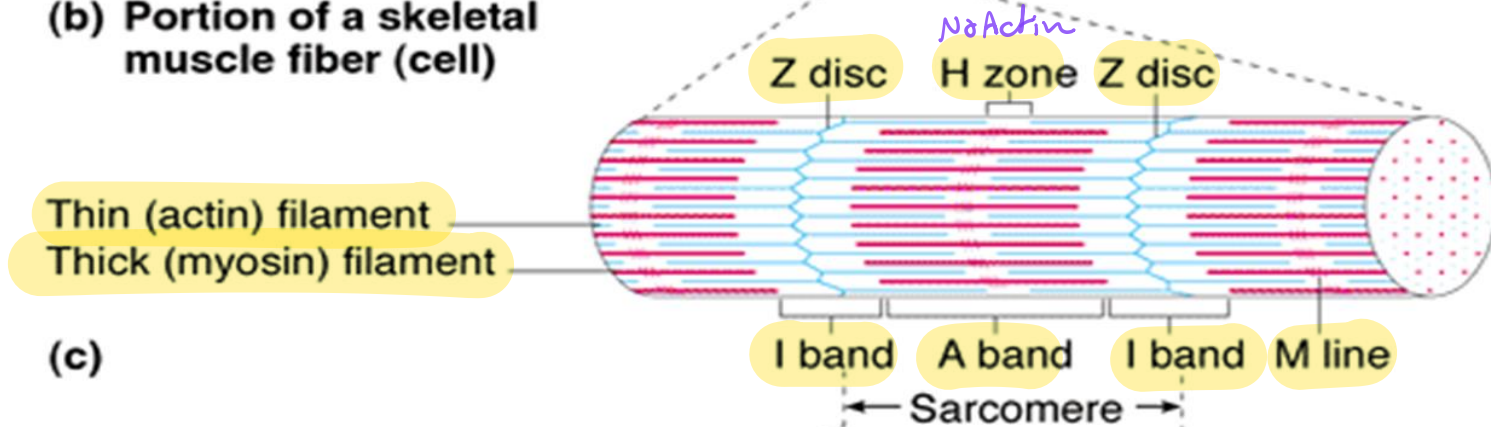
⊙ **Cross bridges project from myosin** towards

the binding sites on actin.

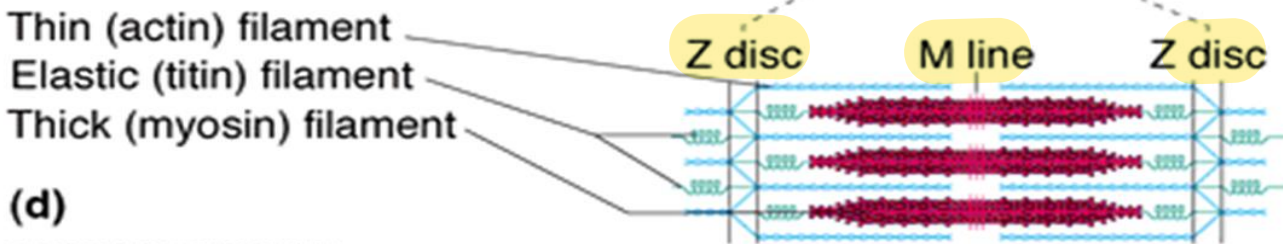
تتحد مع actin عشان يصير contraction of muscle



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

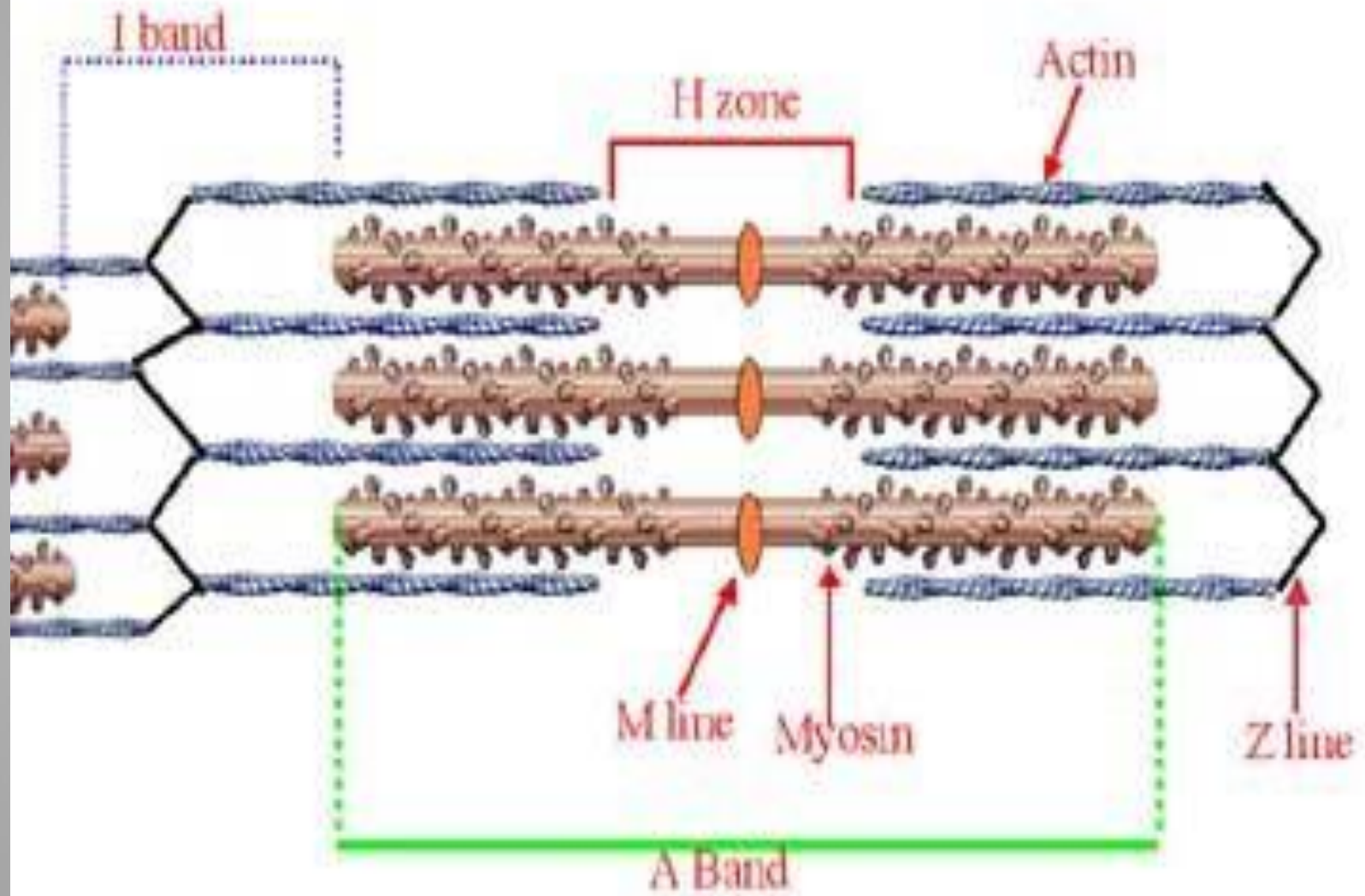


(c)



(d)

Sarcomere



Thick filaments:

- Called **myosin** protein.

- Cross bridges **extends from its surface towards**
the thin filaments.

- Each cross bridge **contains actin binding site &**
طالعة من myosin
يلي المفروض ترتبط مع
binding site
عشان يصير
عنا contraction

- **ATP ase.**
وظيفته يوفر الطاقة لحتى تتم عملية الاتحاد بين cross bridge & actin

Light band

THIN FILAMENTS: INCLUDES THREE PROTEINS

1) Actin: سلسلتين من جزيئات الاكتين عاملين حلزون

○ Formed of ^{Or row} 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.

لازم بتحدّ Binding site مع
عشان يعمل cross bridge
contraction of muscle

2) Tropomyosin:

Binding site during rest

covering عاملهم tropomyosin اسمه في عنا بروتين

لنقم أ صفر

○ Covers the binding sites on actin during relaxation.

و عشان تنقبض العضلة لازم بيعد هاد البروتين، طيب شو يلي ببعده؟ في عنا بروتين تاني اسمه troponin مكون من 3 types في واحد منهم عنده binding مع cross bridge يتحد مع troponin ف بصير عنا تغير شكلي رح يخليه بيعد ف تتحد مع cross bridge
affinity of Ca²⁺ site of actin

3) Troponin:

formed of 3 portions:

بيحب الكالسيوم، ف اول ما يزد الكالسيوم داخل العضلة هيتحد مع troponin c و رح يتحد مع Troponin
tropomyosin ف رح يشده و ببعده عن ال actin

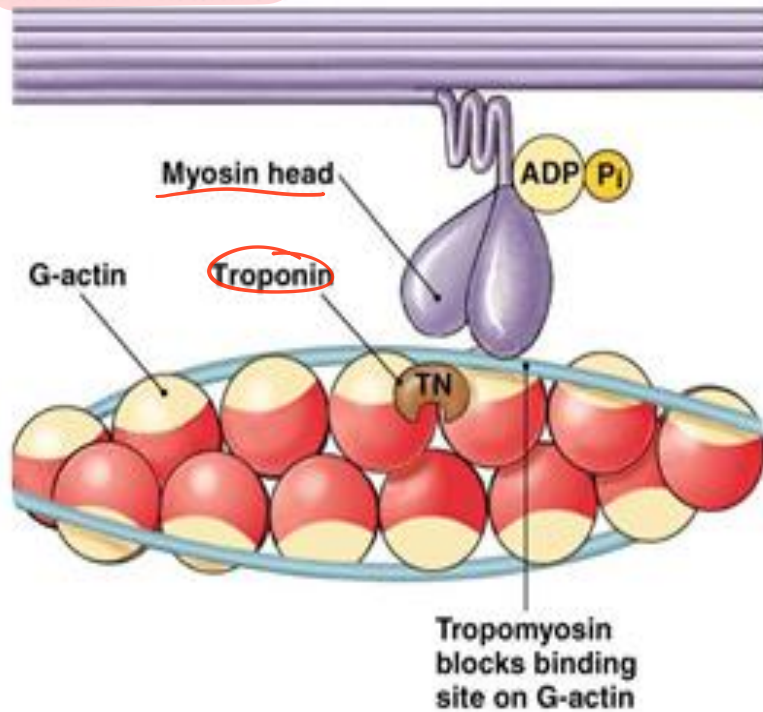
بصير عنا conformational change

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

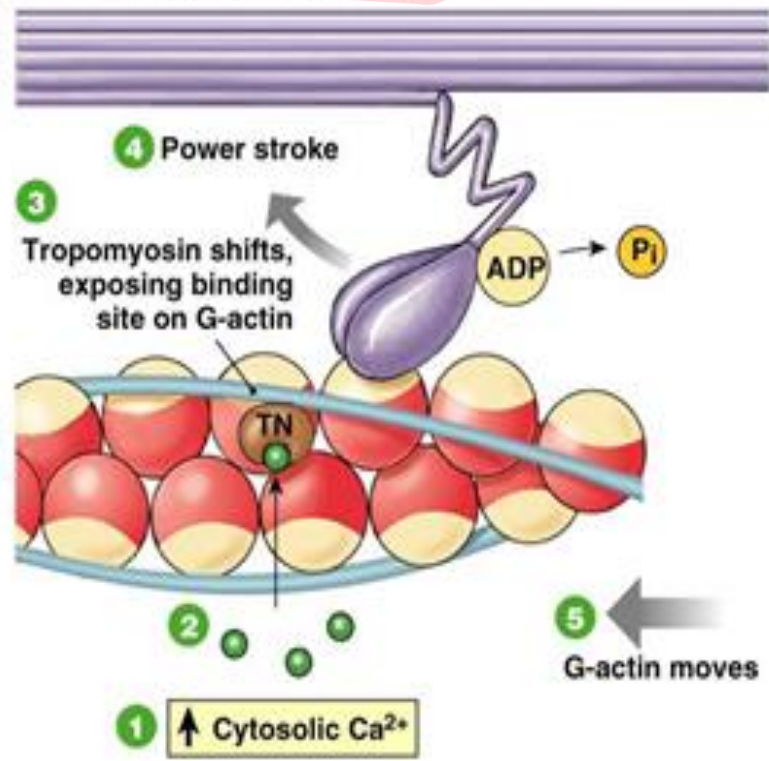
b) **Troponin T**: has strong affinity to bind with tropomyosin.

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.

حاجة مهمة في muscle contraction

The Tubular system موازي للactin & myosin

✂ 1) The transverse (T) tubule:

بيشبه الحفرة ينزل
لتحت على طول
myofibril

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

Function:

- 1) surface area of **sarcolemma many times.** يعني زودت wave of depolarisation
- 2) help movement of **ions and other substances** inside and outside the cell. تسمح بمرور الايونات داخل وخارج الخلية خصوصًا Ca
- 3) Allow **the depolarization wave to pass rapidly inside the**
Muscle
ms. Fiber.

تخزن Ca يلي انا بحاجة للcontraction
طيب كيف بدى اطلعه منها عشان يتحد مع troponin?
لما يصير عنا action potential
على جدار muscle وينزل عن طريق
T tubule

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**.

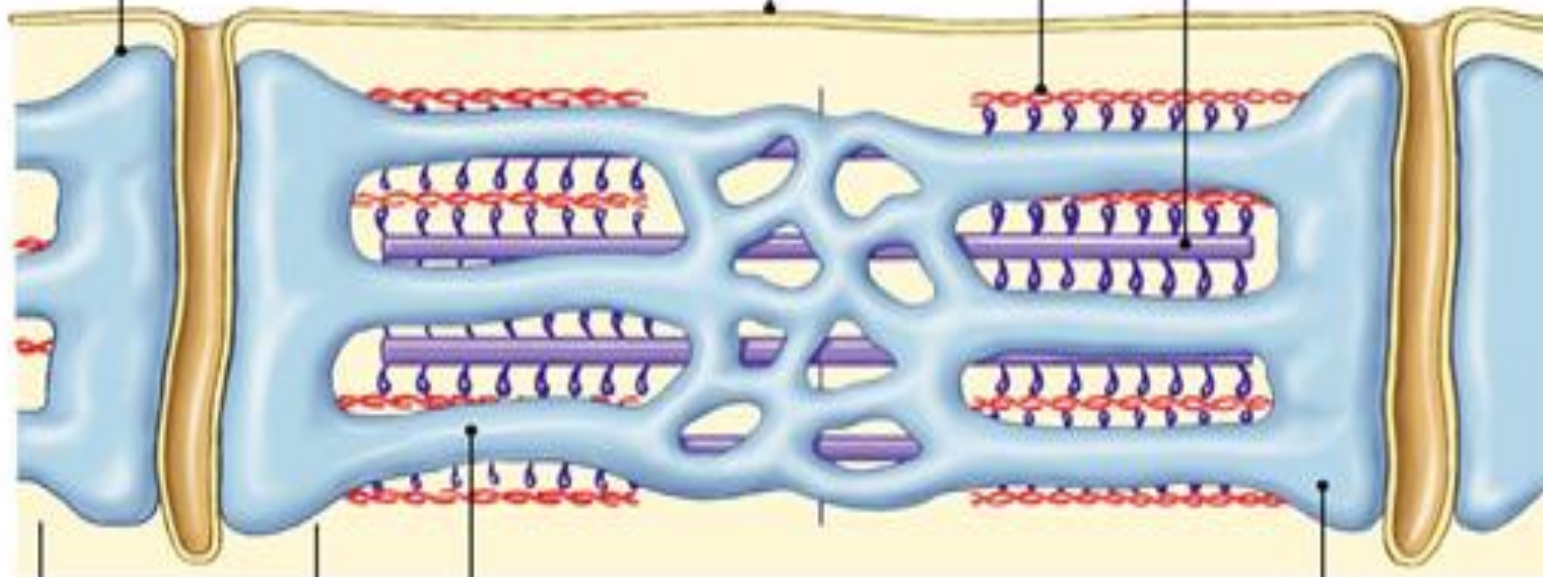
هاد عبارة عن انتفاخ

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

Thin filament

Sarcolemma

Thick filament



Triad

Sarcoplasmic reticulum stores Ca^{2+} .

Terminal cisterna

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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.

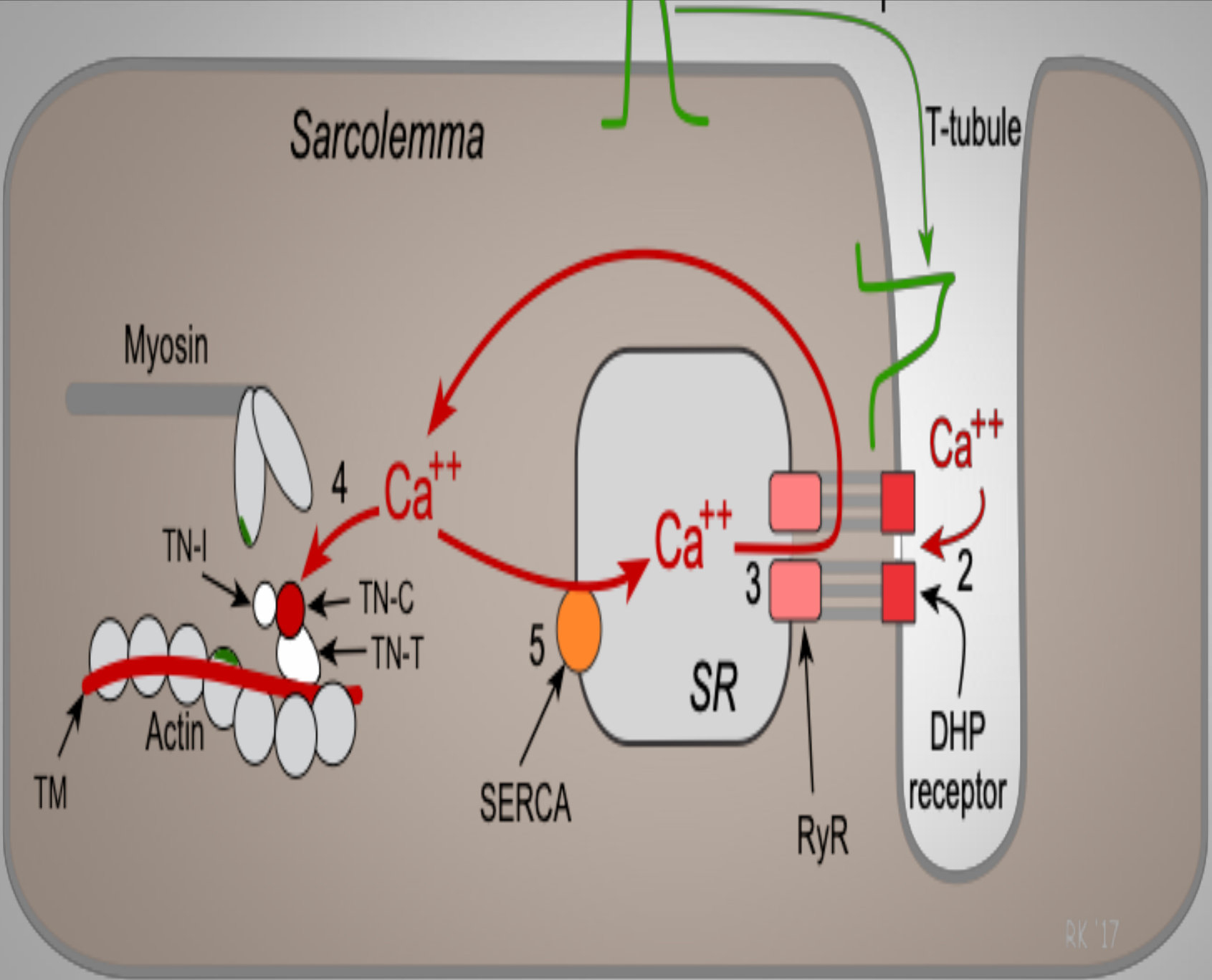
فأكرين لما حكينا عن neuromuscular junction و قلنا انه بصير on the surface of muscle و هاد يمتد الى داخل T tubule لحد sarcoplasmic reticulum لما ينتشر داخل T tubule يسمح بخروج ca عن طريق channels ف يخرج من troponin c و يتحد من sarcoplasmic reticulum يقوم بعمل Troponin c شادد tropomyosin بعيد عن actin filaments ف binding site يبقى exposed ف تيجي ال cross bridge و تتحد معاه

ما بيحصل غير لما تيجي 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 تغير شكلي 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. يعني head of cross bridge من myosin تتحد مع binding site في actin

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. عشان يصير الهانثناء

Is stored in

لازم يبعدوا عن بعض Actin & myosin

c) Detachment: of the cross bridges from actin.

⊙ It needs ATP. If no ATP is available, the thin and thick

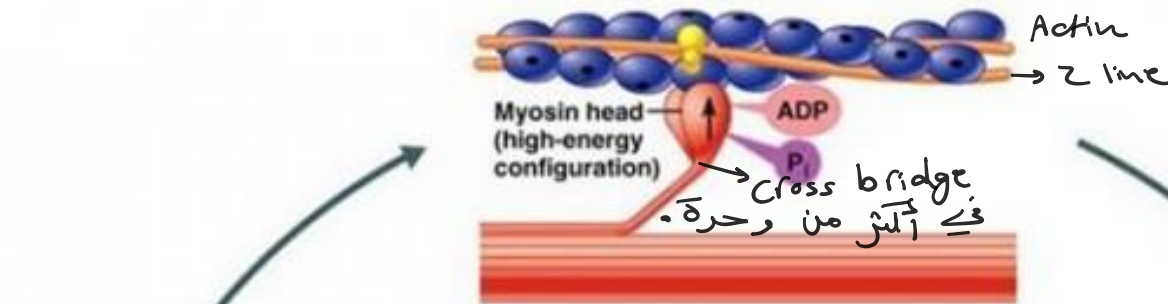
filaments can't be separated (ms. Contracture).

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

⊙ Once here, they can participate in another cycle.

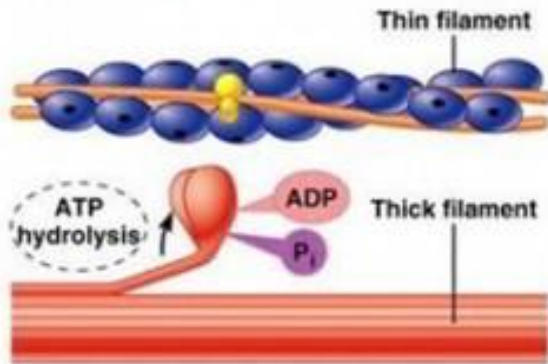
⊙ Cycling continues as long as Ca^{++} is attached to

Troponin. عشان يحصل relaxation لازم Ca^{++} يختفي.



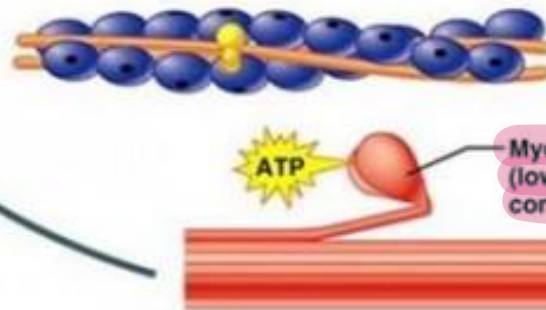
① Myosin head attaches to the actin myofilament, forming a cross bridge.

ال cross bridge طالعة من myosin وتتحد مع binding site من actin هاد اسمه binding يعني بتنعوج و بنستخدم هون atp بتروح تشد actin molecules لجواف z discs بقربوا لبعض و بصير shortning of sacromere



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.

عشان تبعد و يحصل لها ثانية بتحتاج الى طاقة و اللي بساعدها انه هي اول ما تتحد مع atp هي نفسها مارح تقبل ترتبط مع binding site



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

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

Relaxation: لما يختلفي الca بتصير

- Is an active process (needs ATP).
- Occurs when **Ca⁺⁺** moves away from troponin.
To sarcoplasmic Reticulum.
- **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