

Physiology Team

430

Musculoskeletal Block

7st lecture

muscle contraction

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* هذا العمل شامل لجميع نقاط المحاضرة مع بعض الإضافات للتوضيح

The Muscle Action Potential

- * Muscle RMP = -90 mV (**same** as in nerves) .
- * Duration of AP = 1-5 ms (**longer** duration than nerve AP , which is usually about 1 ms) .
- * Conduction velocity = 3-5 m/s (**slower** than big nerves) .

Muscle Contraction

There are 2 groups that have **4** important muscle **proteins** :

Group	Proteins	Action
contractile proteins	Actin	slide upon each other during contraction
	Myosin	
regulatory proteins	Troponin	excitatory to contraction
	Tropomyosin	inhibitory to contraction

**** Each muscle cell (fiber)** is 10 -80 micrometer long & is covered by a cell membrane **called Sarcolemma**.

**** Each cell** contains between hundreds to thousands **Myofibrils**.

**** Each Myofibril** contains **3000 Actin filaments** & **1500 Myosin filaments** .

**** Each myofibril is striated** consisting of :

1) dark bands (A-bands): consist mainly of **Myosin & Actin**

2) light bands (I-bands): consist of **Actin**.

**** The ends of Actin** are attached by **Z-Discs(Z-lines)**.

**** Myofibril lying** between **two Z-discs** is called **Sarcomere** . It is about 2 mcrometers .

**** When contraction** takes place Actin & Myosin slide upon each other and the distance between two z-discs **decreases** :
This is called Sliding Filament Mechanism (will be discussed later)

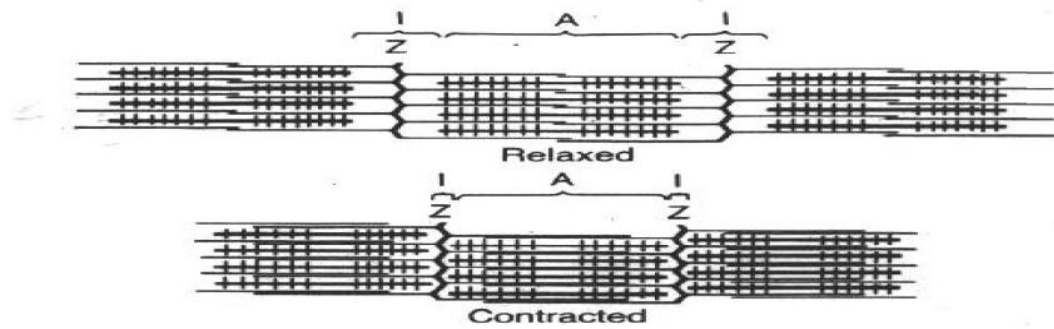
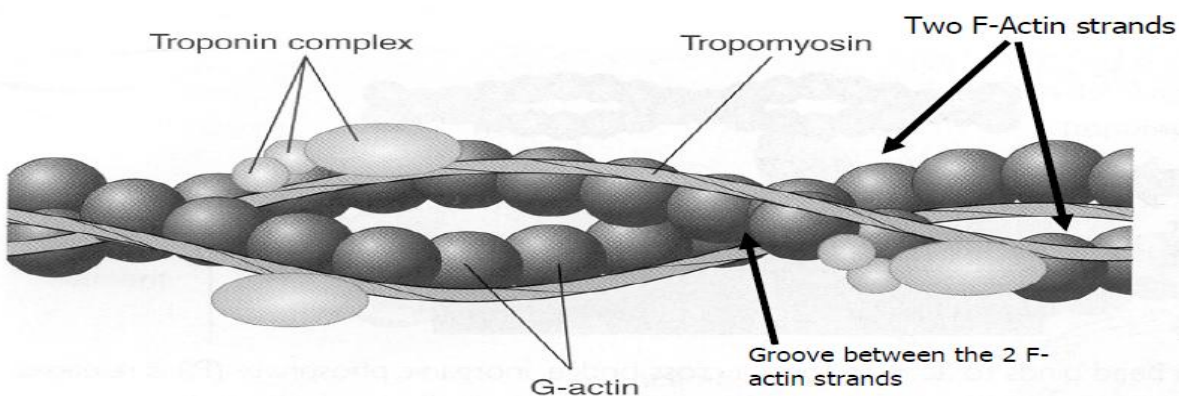


Figure 6-4 The relaxed and contracted states of a myofibril, showing sliding of the actin filaments (black) into the spaces between the myosin filaments (red).

- * **Actin Filament** consists of **Globular protein (G-actin)** بروتين كروي molecules that are attached together to form a chain
- * **Each two chains** like a **double helix** wind together .
- * **Each G-Actin** molecule has a binding site for **Myosin head** (called **actin active sites**)
- * **These active sites** are covered and hidden from the Myosin head by **the inhibitory protein Tropomyosin**
- * **When Troponin is activated by Ca^{++}** it will **move the Tropomyosin** away from these sites and expose them for Myosin.
- * **then myosin** immediately gets attached to them .
- * when the **myosin head attaches to actin** it forms a “ **cross-bridge**”



*** Each Myosin molecule has :**

Head , Hinge (joint) , Tail

*** Each myosin head contains :**

1) ATP-binding site .

2) ATP-ase enzyme .

الرأس فيه موقع لضم الـ ATP و ايضا الأنزيم ATPase الذي يكسر هذا الـ ATP و كنتيجة لذلك يطلق منه طاقة تتم الاستفادة منها في عملية تحرك و انزلاق الميوسين على الأكتين

*** Each 200 myosin molecules** aggregate to form a myosin filament , from the sides of which project myosin heads in all directions .

تتجمع كل مائتي جزيء ميوسين لتلتف مع بعضها مكونة حزمة ميوسين Myosin Filament و من علي كل جانب من حزمة الميوسين تبرز رؤوس الجزيئات لتلتصق بالأكتين عند الانقباض

*** The EPP (end-plate potential)** triggers a muscle AP

Mechanism :

The muscle AP spreads down inside the muscle through the Transverse Tubules (T-tubules) → reach the Sarcoplasmic Reticulum (SR) .

In the SR :

the muscle AP opens **calcium channels (in the walls of the SR)** → calcium passively flows out (by concentration gradient) of the SR into muscle cytoplasm → **Ca⁺⁺ combines with Troponin** .

When Troponin is activated by Ca⁺⁺ → it will move the Tropomyosin away from the myosin binding sites on actin and expose them for Myosin .

then myosin head will immediately attach to these actin active sites . it forms a " cross-bridge"

This binding **activates the enzyme ATPase in the Myosin Head** → breaks down ATP releasing energy → used in the "Power Stroke " to move the myosin head → leadin to pulling & dragging of actin → sliding of actin on myosin

Power Stroke : tilting of the cross-bridge head (myosin head) and dragging (pulling) of actin filament

سحب و جر : pulling & dragging

انزلاق : sliding

ميلان : Tilting

Summary

- (1) Muscle AP spreads through T-tubules
- (2) it reaches the sarcoplasmic reticulum where _ opens its Ca^{++} channels _ calcium diffuses out of the sarcoplasmic reticulum into the cytoplasm _ increased Ca^{++} concentration in the myofibrillar fluid .
- (3) Ca^{++} combines with Troponin , activating it
- (4) Troponin pulls away Tropomyosin
- (5) This uncovers the active sites in Actin for Myosin
- (6) Myosin combines with these sites
- (7) This causes breakdown of ATP and release of energy which will be used in Power Stroke
- (8) Myosin and Actin slide upon each other _ contraction
- (9) A new ATP comes and combines with the Myosin head . This causes detachment of Myosin from Actin .
- (10)ATP is needed for 3 things :
 - (1) Power stroke .
 - (2) Detachment of myosin from actin active sites .
 - (3) Pumping Ca^{++} back into the Sarcoplasmic reticulum .