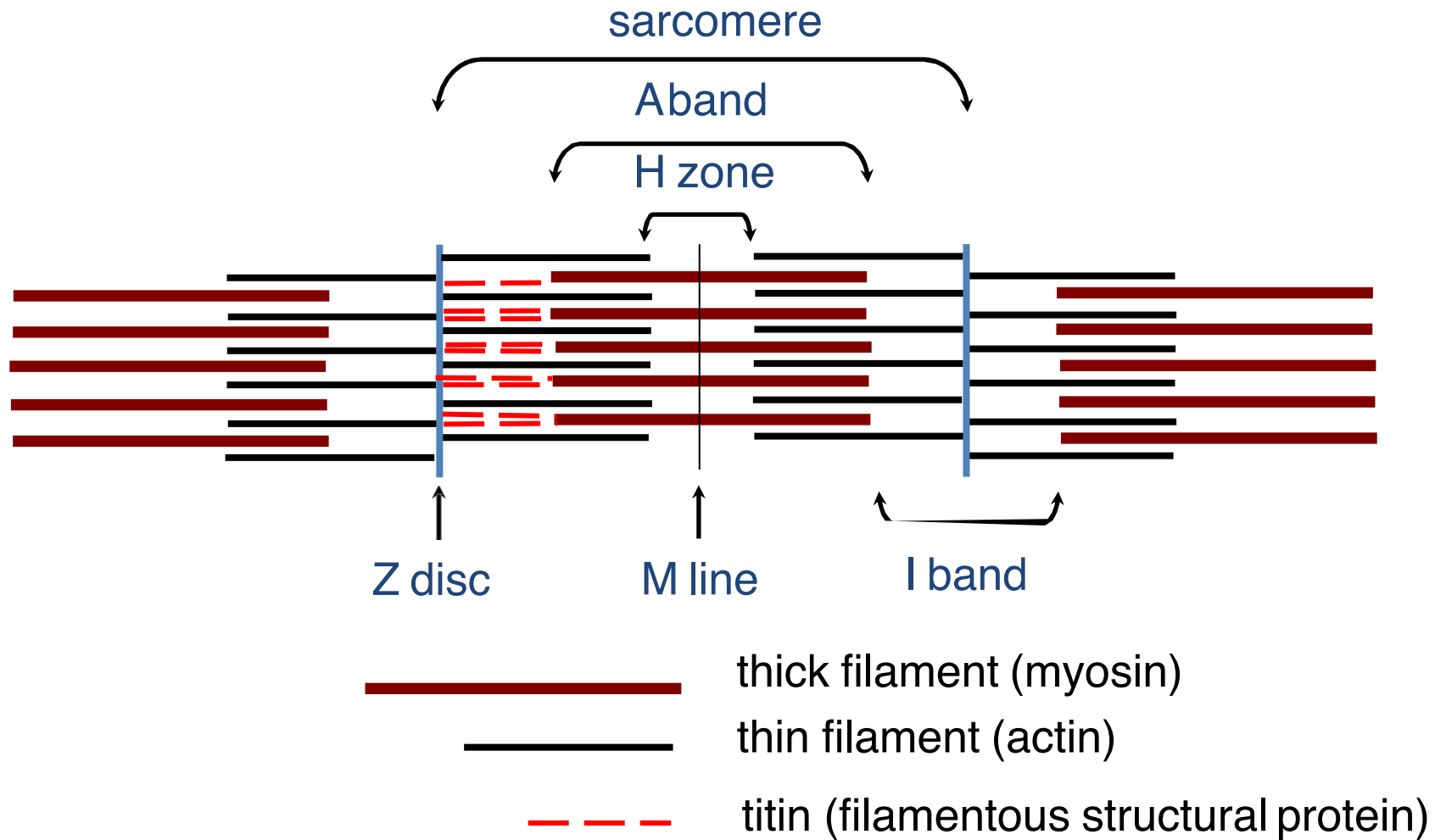


The Sarcomere



The Actin Filament

thin filaments

Form the **I band** - Anchored at one end to Z disc
 Overlap with myosin filament in a portion of the A band (Zone + overlap)
 1 μm long: very uniform, **nebulin** forms guide for synthesis

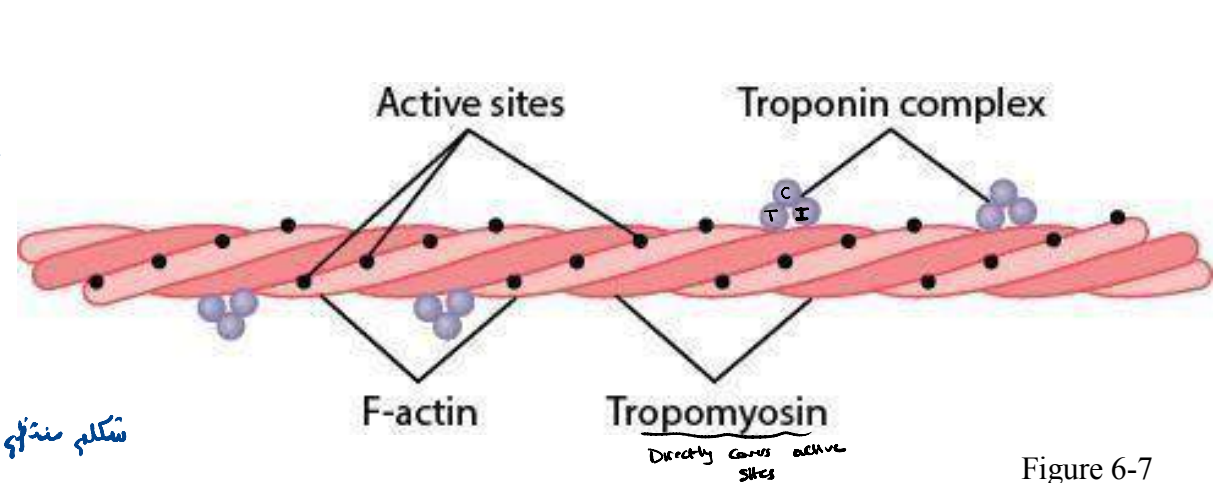


Figure 6-7

البروتين الذي يساعد في تشكيل actin

F-actin is The backbone of the actin filament is a double-stranded *F-actin protein molecule*

double strand helix

- composed of polymerized G-actin
- **ADP** bound to each G-actin (active sites)
- myosin heads bind to active sites

G-protein يكون مرتبطة عليه ADP، و هو متعلق الارضية بال ADP بنسبته Active sites = myosin binding sites

Tropomyosin

لم الغشاء الاول

- covers active sites
- prevents interaction with myosin

وظيفة تغطية ال myosin binding sites

Troponin

بعض الغشاء الثاني 3 types

- **I** - binds actin
- **T** - binds tropomyosin
- **C** - binds Ca^{2+}

Ca^{2+} attaches to troponin C → removes tropomyosin

available sites for contraction

عدد عبارة عن ال contraction وهي هو ارتباط ال actin بال myosin

في الوهم الطبيعي → The Myosin filaments and myosin molecule
ما يكون (relaxation)

عنا Union ال myosin+actin

- Present in the A band
- Myosin Filaments are composed of multiple myosin molecules which is six polypeptide chain
- Two **heavy chains** Spirally around each other to form the tail
- The four light chains are also part of the myosin head, two to each head. .
- Thus each myosin molecule has two "heads" attached to a single "tail"
- "head" region - site of **ATPase** activity

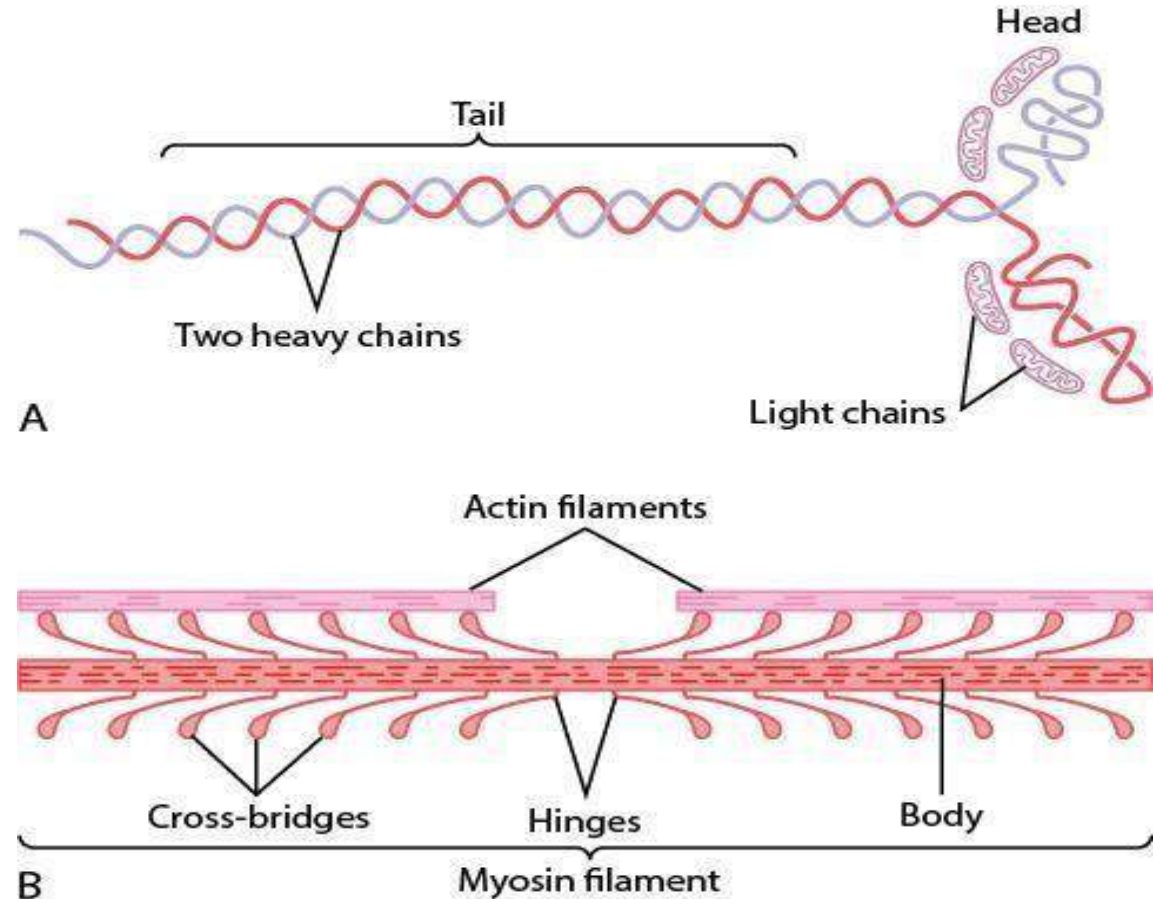


Fig. 6.5

Structure and Arrangement of Myosin Molecules Within Thick Filament

2 parts of myosin •
 2 Heads
 tail

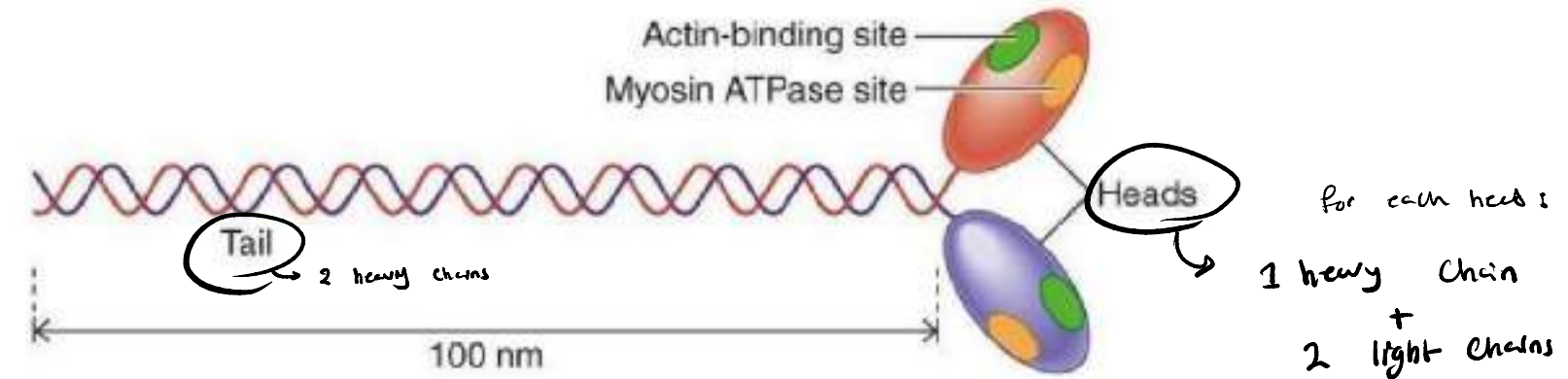
myosin filament •

6 protein chains ← 2 heads

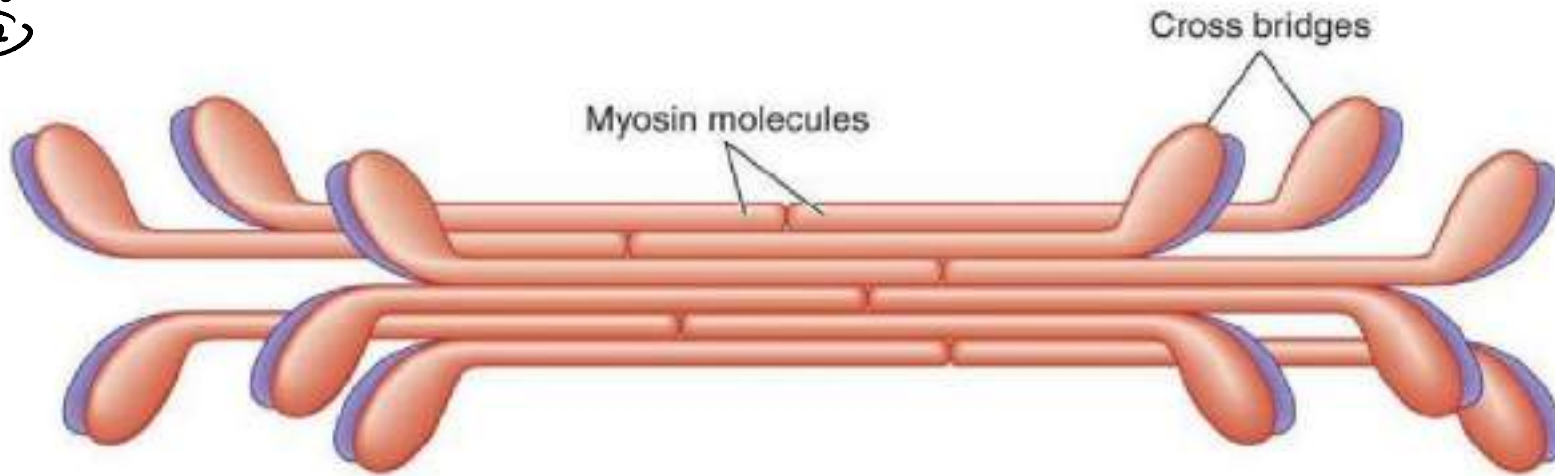
light chains → 4
 heavy chains → 2

3 myosin heads •

Actin binding site
 ATP binding site
 Myosin ATPase site



(a) Myosin molecule



(b) Thick filament



Contraction and relaxation cycle

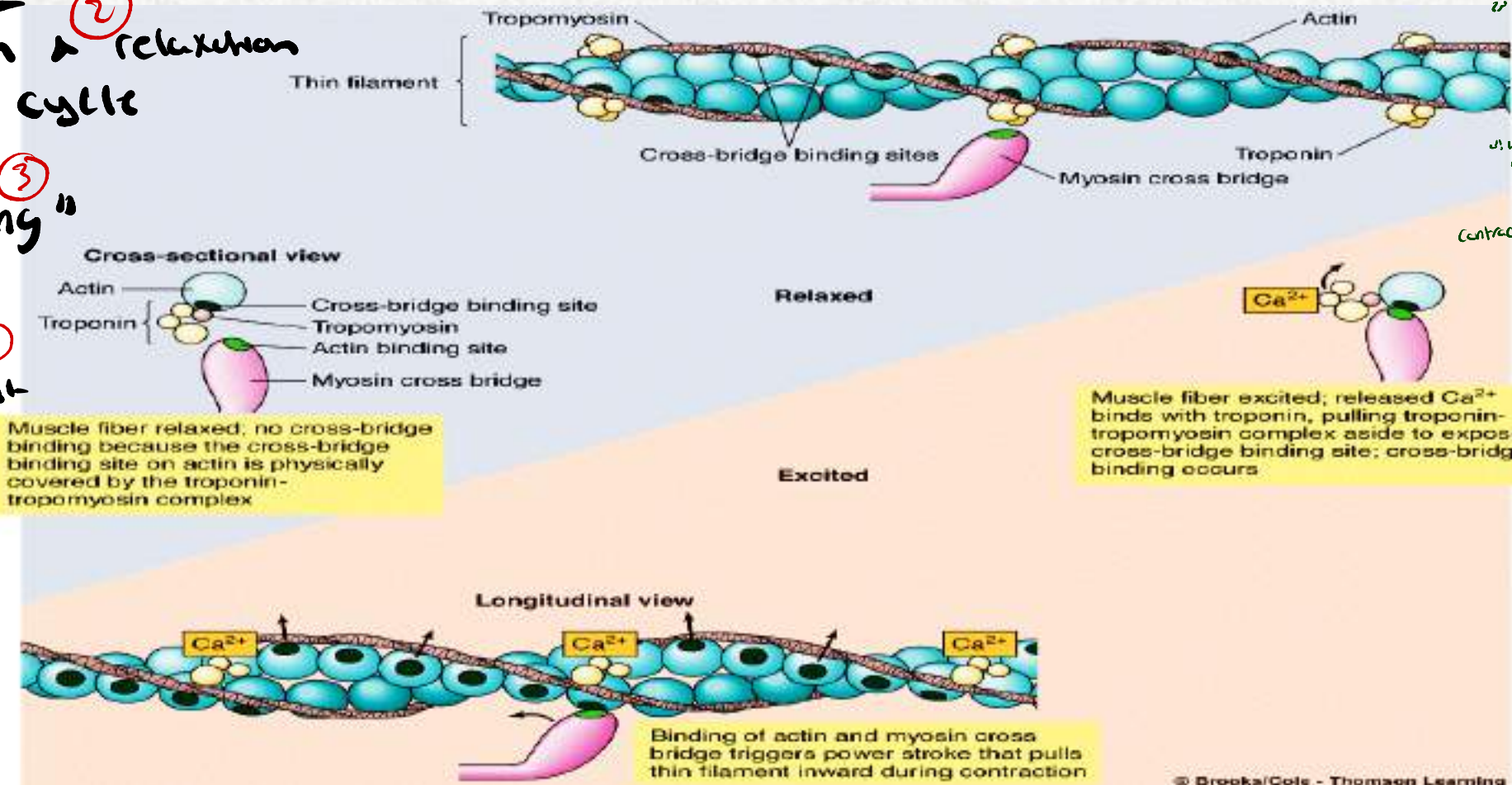
Mechanism of skeletal muscle contraction

= Contraction & relaxation cycle

"Walk-Along" theory

= Sliding filament mechanism

4 names for the same concept



① بداية لا contraction تكون بخروج Ca^{2+} من الأخراف الـ Sarcoplasmic reticulum

② Ca^{2+} binds to troponin C وينتج Troponin C كامل Ca^{2+} بصبه كل

لما يصبه على الـ Troponin C ما تفسر يكون تغطيه الـ Tropomyosin فأيها يصبه من قبل الـ Ca^{2+} Ca^{2+} releases Troponin & Tropomyosin from myosin binding sites.

دها إن الأهمية الـ بتتغير في الـ Myosin (موسين) في بصبه فرج وتكلم الـ PMS في أول مرة تحدث الـ contraction

بشرط التخلي لحدوث الـ contraction: Ca^{2+} من طريق تكبير الـ ATP في دهيا الـ Myosin heads $ADP + P_i$ من طريق ATP من

بعد توازن الشرطين يبدأ الـ contraction

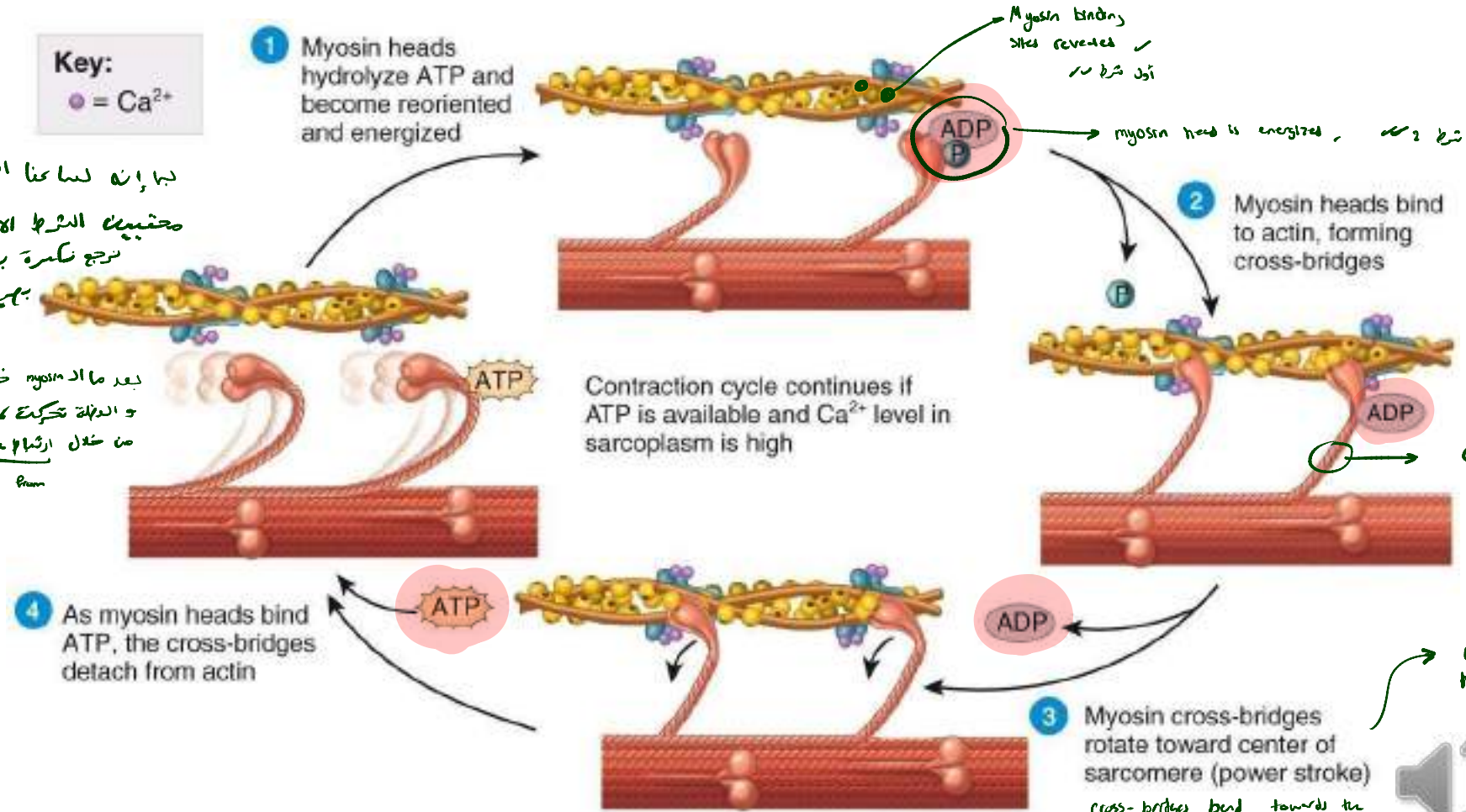
Contraction and relaxation cycle

* كل ما زاد ارتباط ال myosin heads
 بال actin كل ما زاد ال tension
 المقبول في العجلة

Key:
 ● = Ca^{2+}

لما انا لسا هنا ال myosin binding sites
 محتبين الشرط الاول و بتوازن ال ATP
 نرجع نكمرة بنحقق الشرط الثاني و مرة ثانية
 بغير هنا contraction.

بعد ما ال myosin خلعت ال binding و عجلت ال power generation
 و الدفعة تتحرك، هار لازم تفك عن ال actin كمين؟
 من خلال ارتباط molecule ال ATP على ال myosin head
 course myosin to detach from actin

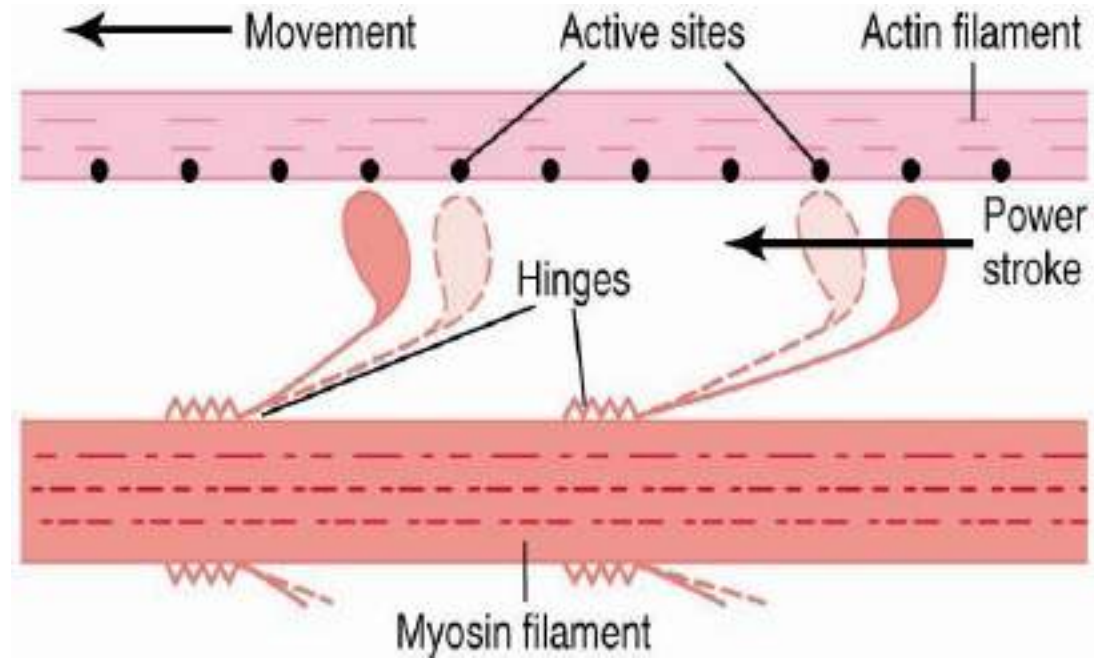


ارتباط ال myosin heads بال actin بعجلتي
 cross bridge

when myosin bridges bend, the generates a power stroke
 ال قوة ال العجلة تتحرك

cross-bridges bend towards the M line

“Walk-Along” Theory



The new alignment of forces causes the head to tilt toward the arm and to drag the actin filament along with it. This tilt of the head is called the *power stroke*.

The heads of the cross-bridges bend back and forth and step by step walk along the actin filament, pulling the ends of two successive actin filaments toward the center of the myosin filament

The greater the number of cross-bridges in contact with the actin filament at any given time, the greater the force of contraction.

The Sliding Filament Mechanism

Relaxed and Contracted States of sarcomeres

Contraction results from the sliding action due to engagement and coupling of actin and myosin filaments. It shows the relaxed state of a sarcomere (top) and the contracted state (bottom). In the relaxed state, the ends of the actin filaments extending from two successive Z disks barely overlap one another.

Conversely, in the contracted state, these actin filaments have been pulled inward among the myosin filaments, so their ends overlap one another to their maximum extent. Also, the Z disks have been pulled by the actin filaments up to the ends of the myosin filaments. Thus, muscle contraction occurs by a *sliding filament mechanism*.

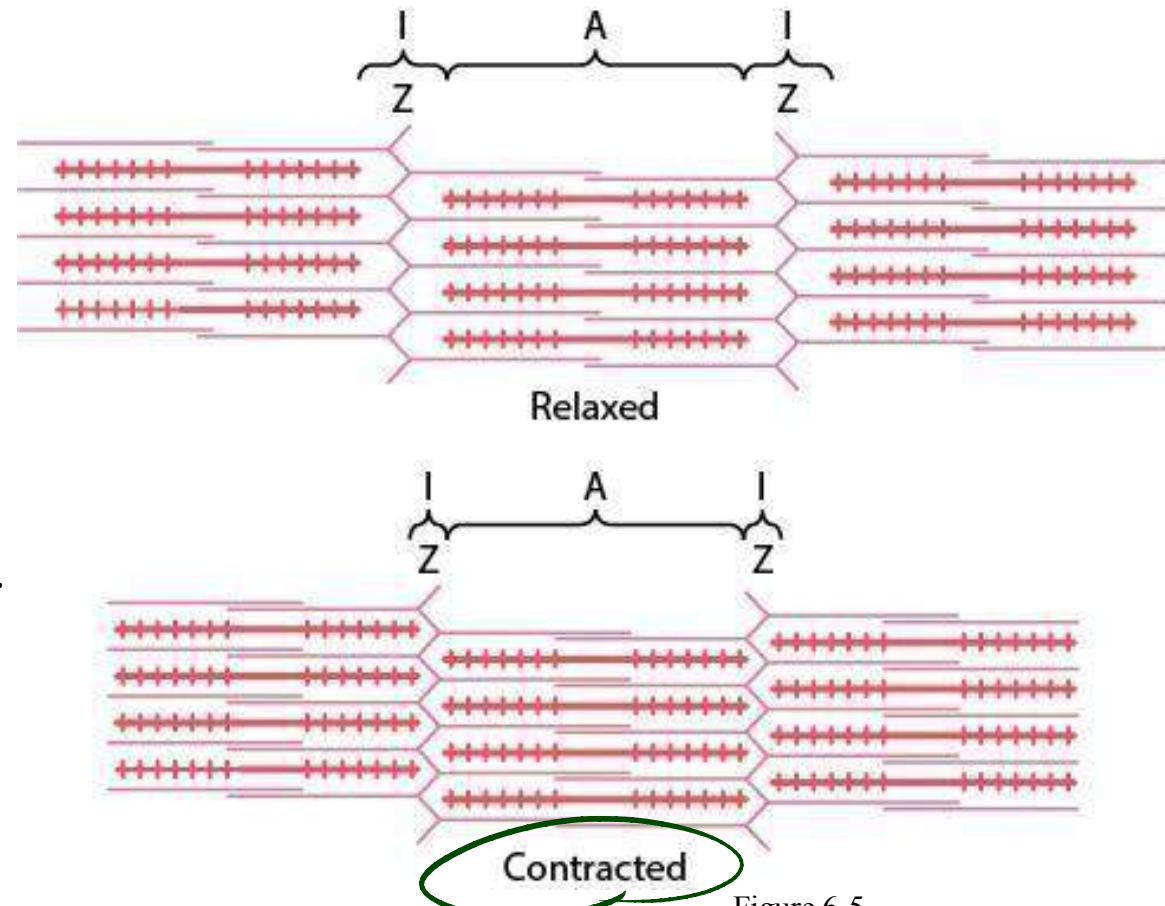


Figure 6-5

في ال contraction و طول ال sarcomere يقل
 في ال cross bridge تم سحب ال myofibrils

important note:

طول ال actin با contraction
بينما طول ال myosin لا يتغير

Which band shortens - I or A?

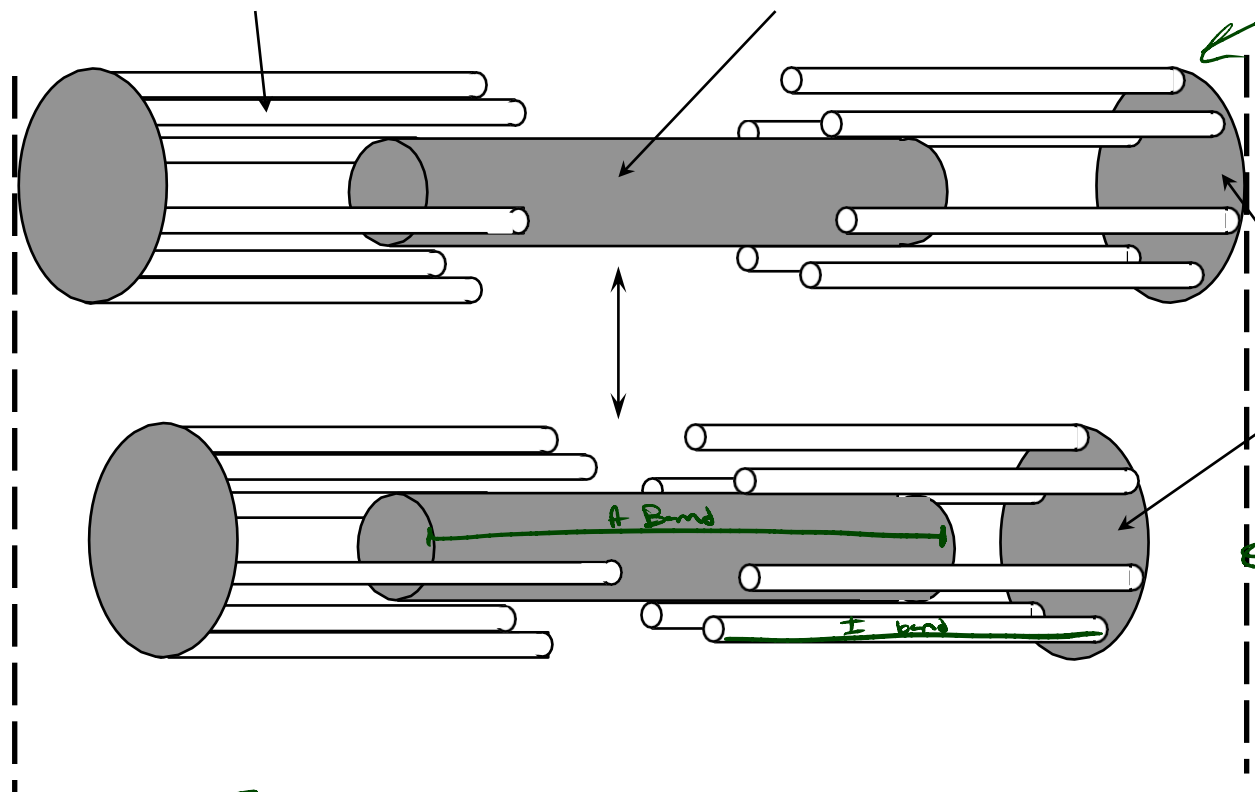
actin
myosin

myosin overlap

flexation

thin filament

thick filament



z discs

contraction

Lengths

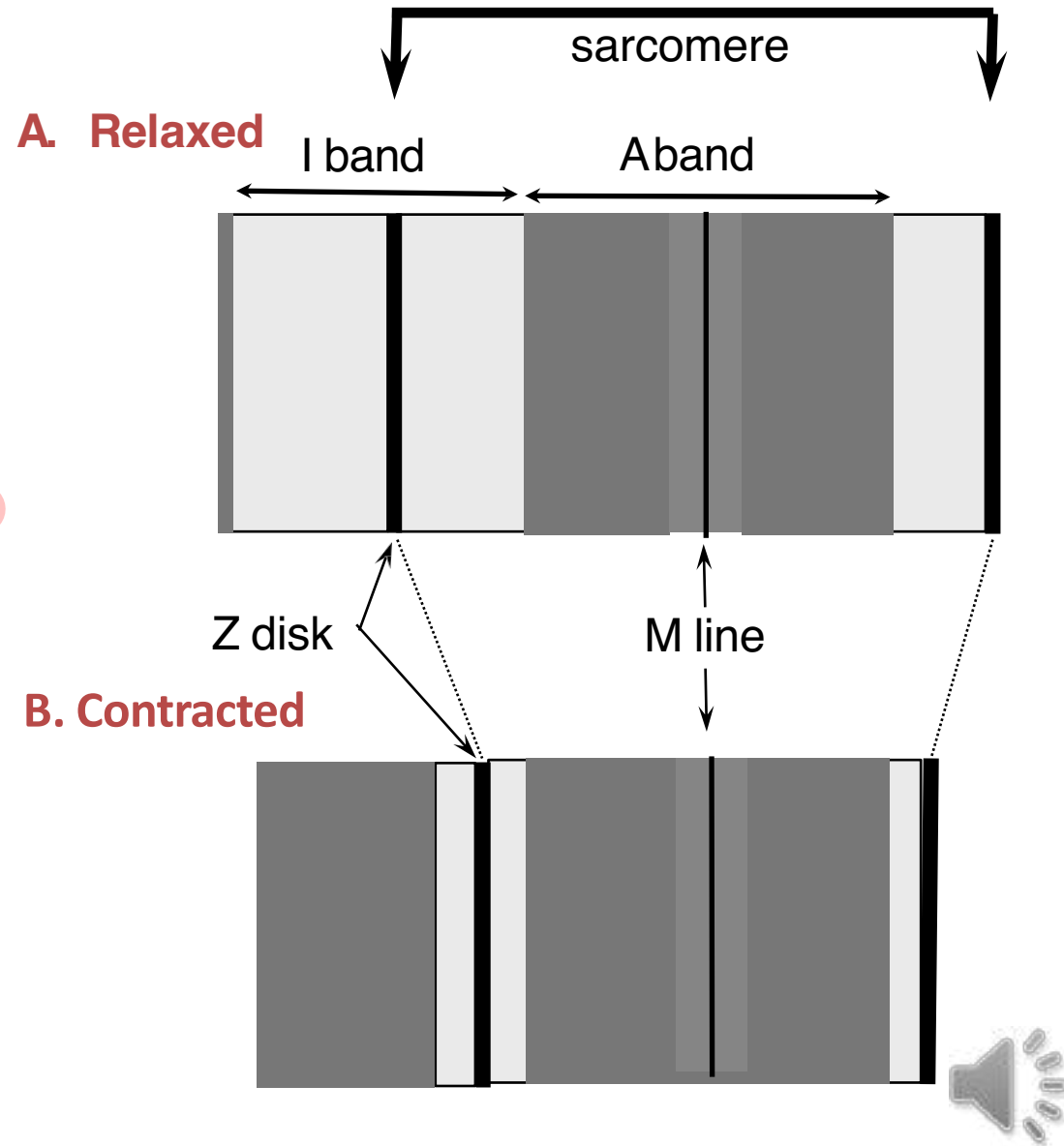
- actin → No Change
- myosin → no change
- A band → no change
- I band → The only one that shortens

I band ⇒ Shortens in contraction

A band ⇒ no change in length

Which band shortens - I or A?

- The A band appears dark
- The I band appears light
 - So, when the I band filament is pulled into the A band, the I band is obscured!
- **The I band appears to shorten.**



موتى تفتلى ال myosin binding sites
لما ال Ca²⁺

يفك ويرجع ذى

Sarcoplasmic reticulum

Role of ATP and Fenn effect

العلاقة تبتم على ال myosin head
بجاسته ال myosin ATPase

- Large amounts of ATP are cleaved to form ADP during the contraction process, and the greater the amount of work performed by the muscle, the greater the amount of ATP that is cleaved; this phenomenon is called **the Fenn effect**
- Before contraction begins, the heads of the cross bridges bind with ATP. The ATPase activity of the myosin head immediately cleaves the ATP but leaves the cleavage products, ADP plus phosphate ion, bound to the head. In this state, the conformation of the head is such that it extends perpendicularly toward the actin filament but is not yet attached to the actin
- When the troponin-tropomyosin complex binds with calcium ions, active sites on the actin filament are uncovered and the myosin heads then bind with these sites
- When Cross bridges formed the energy previously stored by cleavage of ATP in the relaxed state is used for the power stroke

If more tension is wanted, then more ATP will be used

لكون كمال
myosin head is energized

Role of ATP : Continue

- Once the head of the cross-bridge tilts, release of the ADP and phosphate ion that were previously attached to the head is allowed.
- At the site of release of the ADP, a new molecule of ATP binds. This binding of new ATP causes detachment of the head from the actin.
- After the head has detached from the actin, the new molecule of ATP is cleaved to begin the next cycle, leading to a new power stroke.
- That is, the energy again “cocks” the head back to its perpendicular position ready to begin the new power stroke cycle

Rigor Mortis

يمكن من خلالها التعرف وقت الوفاة

حالة عند الموتى بعد الوفاة بـ 2 إلى ساعة اليريقا
بخصيص لان عضلاته يتكون contracted

1. Myosin head attached to actin



+ No ATP available to detach heads from actin => constant contraction

RIGOR

← يترواح كساي الحالة بعد 36-48 h من الوفاة بعد ما تبلى تشكل بروتينات الجئة.

Rigor mortis:

- state of contracture that occurs following death
- due to loss of ATP

Rigor mortis سبب ار

Cytoskeletal Proteins

other proteins that are found in the skeletal muscles that have a role in contraction or the health of muscle.

thin → actin
thick → myosin

①

Longitudinal cytoskeletal proteins include two large proteins called titin and nebulin

Titin

M-line من الـ Z disc
يعتمد من الـ Z disc

- elastic anchor protein
- Helps align the thick filament → تثبيت الـ thick filament (myosin) في أماكنهم
- Adds an elastic element to the sarcomere. → جعطي الـ sarcomere المرونة
- Titin is anchored at the M-Line, runs the length of myosin, and extends to the Z disc.

Nebulin

مع الـ actin

- stabilizing protein associated with the thin filament
- None elastic
- Spans the length of the thick filament

موجود بين myosin

Myomesin plays an important in the structure of sarcomeres. They are found in the M-band region of the sarcomere, between the thick filaments (myosin).

يعتمد من الـ Z disc
لحد الـ M-line
و لحد جعطي المرونة للـ sarcomere.

It's main purpose in this setting is to provide structural integrity by linking the antiparallel myosin fibers and titin filaments which are connected to the Z-discs

Cytoskeletal Proteins : Transverse cytoskeletal proteins

- ② Transverse cytoskeletal proteins link thick and thin filaments, forming a “scaffold” for the myofibrils and linking sarcomeres of adjacent myofibrils
- A system of intermediate filaments holds the myofibrils together, side by side



Dystrophin: An acting binding protein which anchors the entire

- myofibrillar array to the cell membrane
- In patients with muscular dystrophy, dystrophin is defective or absent

صحتن سكر العجلة
بنيغ

