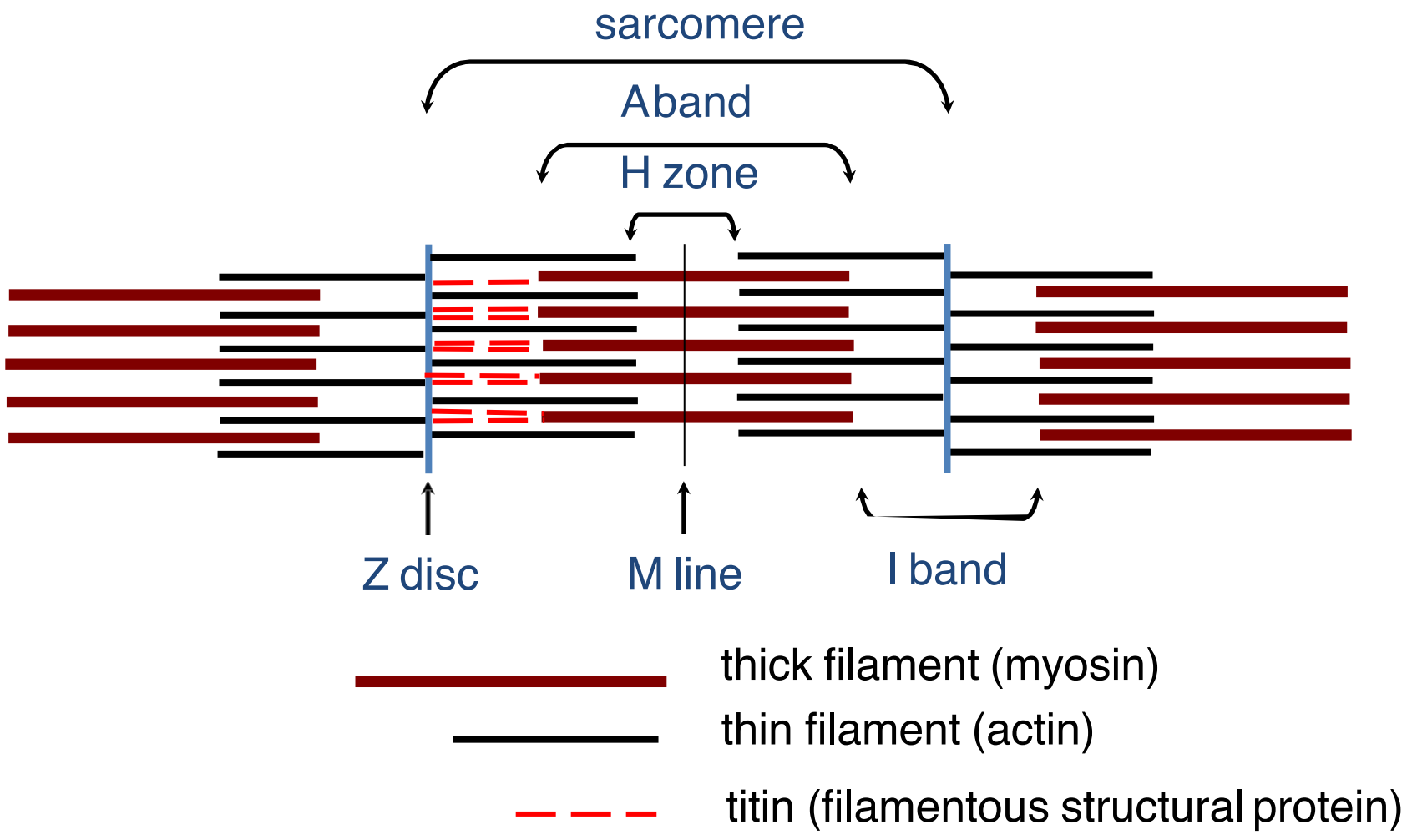
The Sarcomere



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 (zones + overlap)

1 µm long: very uniform,

nebulin forms guide for synthesis

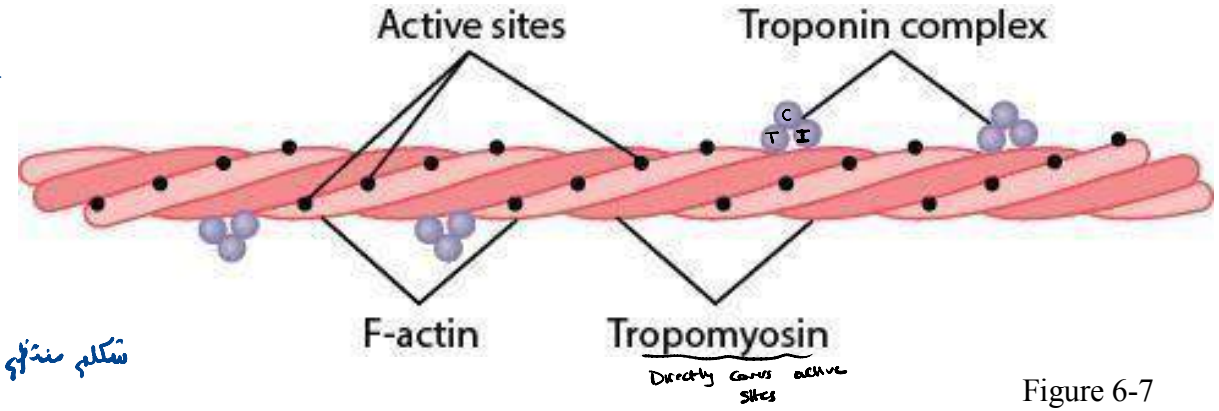


Figure 6-7

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

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

Tropomyosin
- covers active sites
- prevents interaction with myosin

Troponin
- **I** - binds actin
- **T** - binds tropomyosin
- **C** - **binds Ca^{2+}** → Ca^{+2} attaches to troponin C → removes tropomyosin → available sites for contraction

The Myosin filaments and myosin molecule

- 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

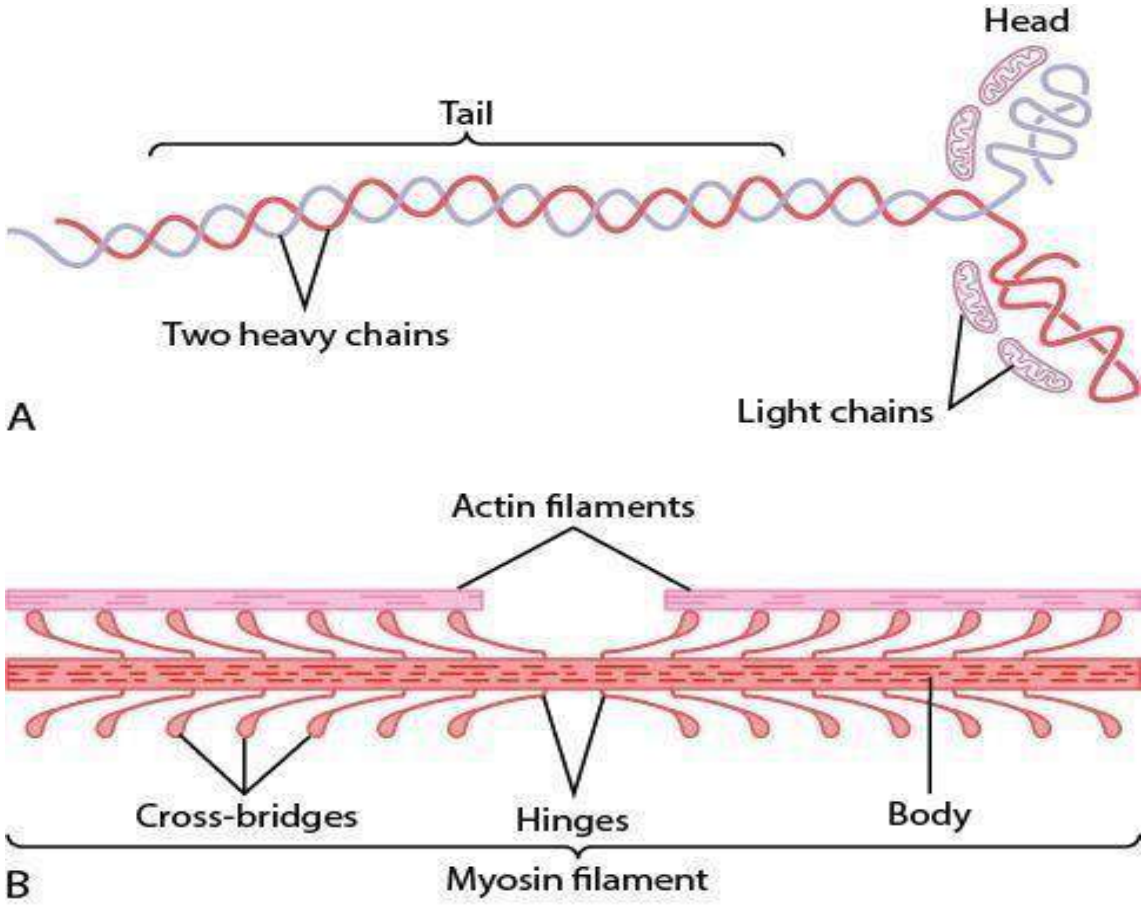
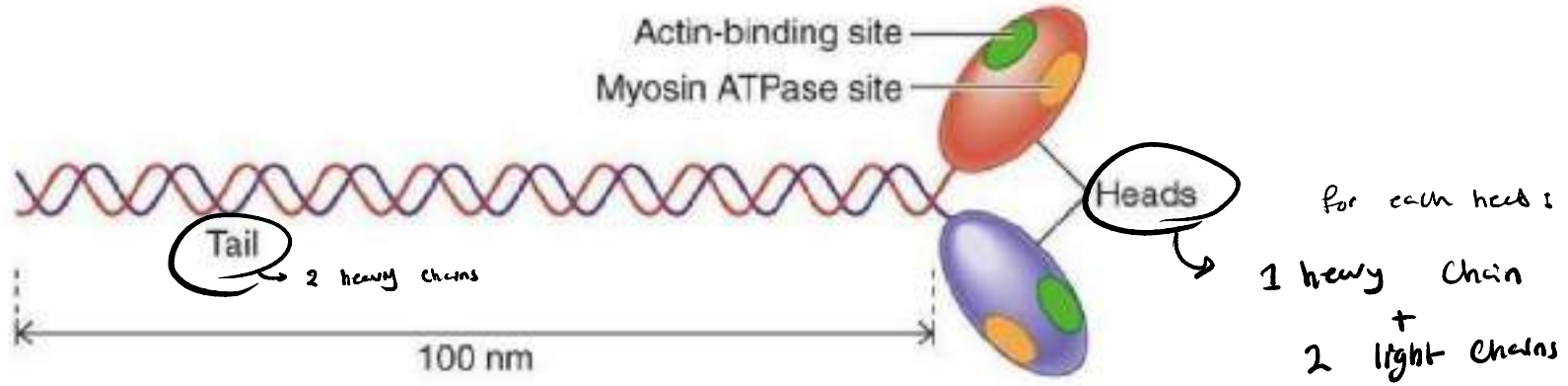


Fig. 6.5

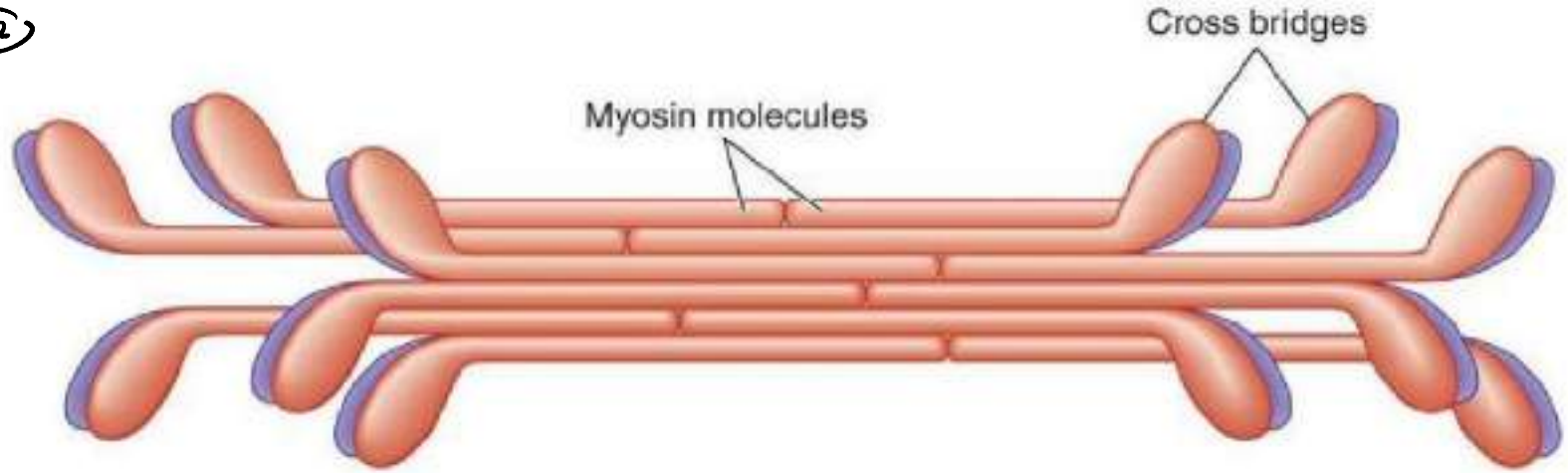
Structure and Arrangement of Myosin Molecules Within Thick Filament

- 2 parts الـ myosin الـ
  - 2 Heads
  - tail
- myosin filament كل
  - 6 protein chains ⇐ منه يتكون
    - light chains → 4
    - heavy chains → 2
- ③ يحتوي كل myosin head * كل
  - أماكن ثلاثة
    - Actin binding site
    - ATP binding site
    - Myosin ATPase site



for each head :
1 heavy chain
+
2 light chains

(a) Myosin molecule

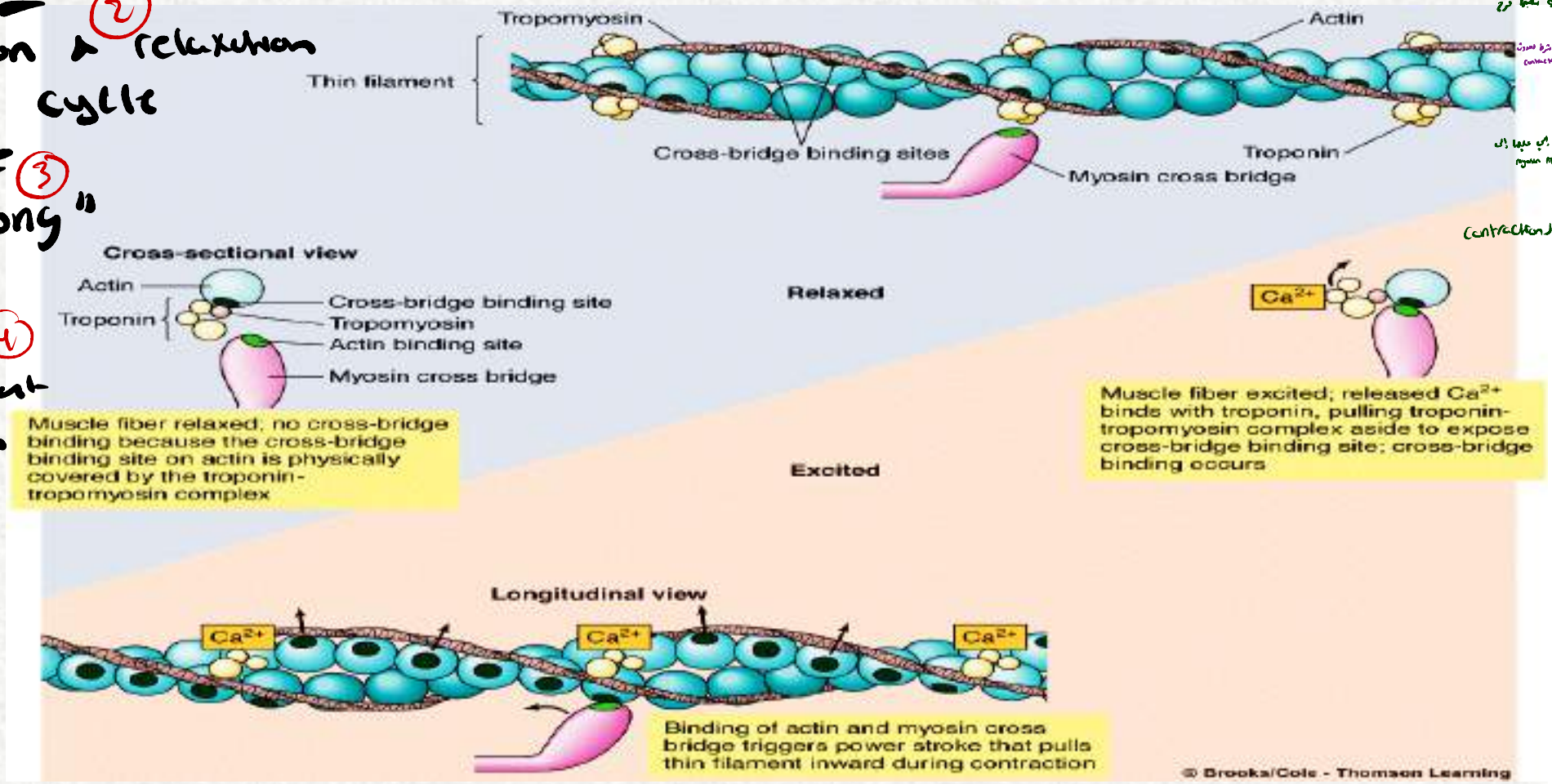


(b) Thick filament

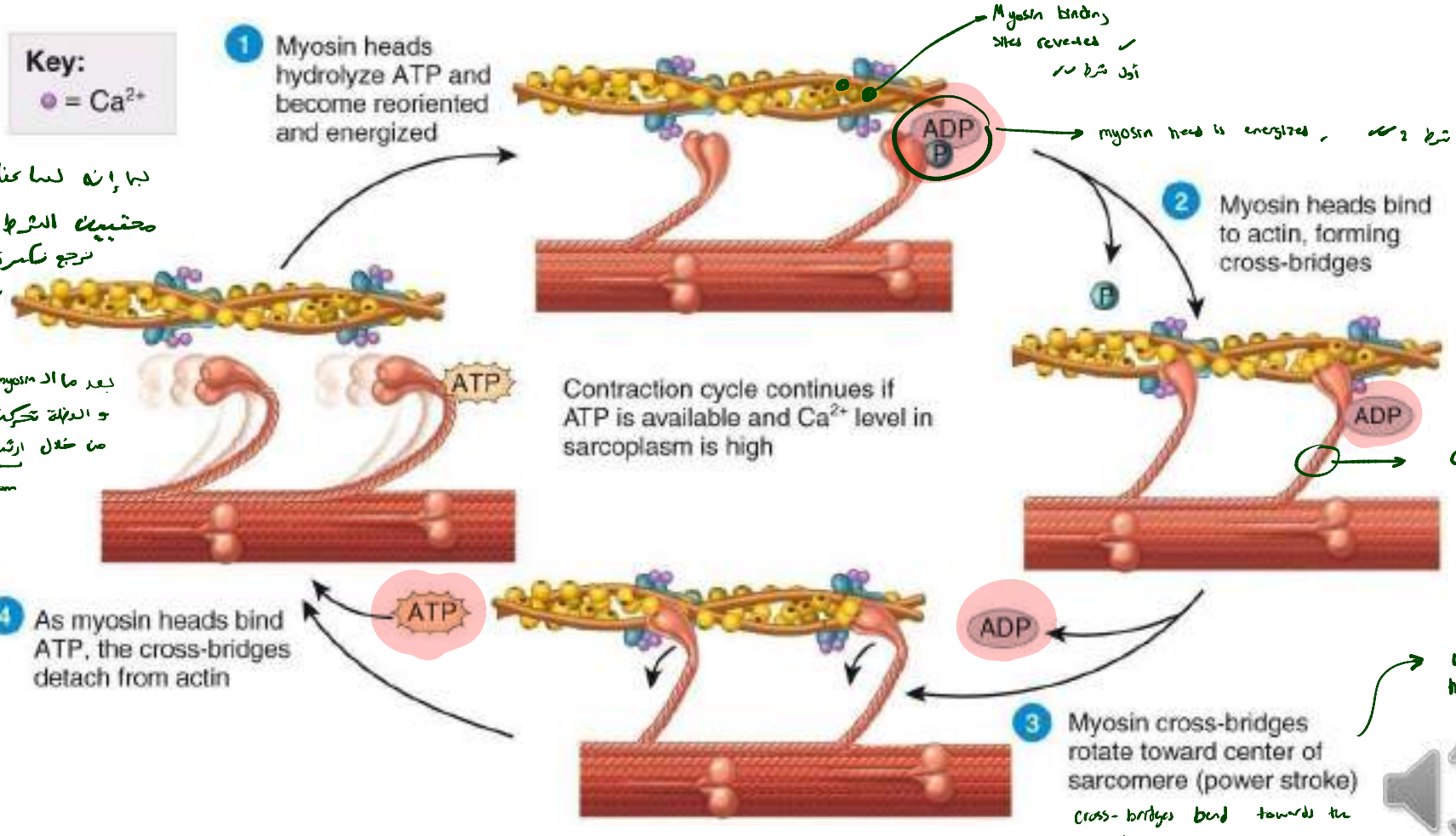
Mechanism of Skeletal muscle Contraction = Contraction & relaxation cycle = "Walk-Along" theory = Sliding filament mechanism

4 names for the same concept

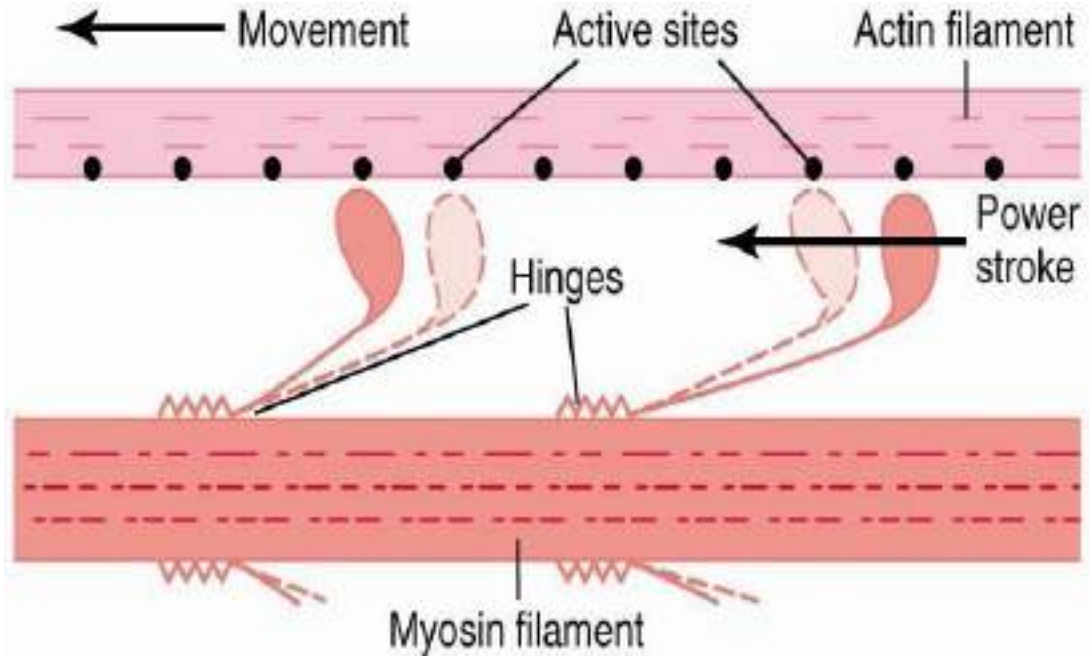
Contraction and relaxation cycle



Contraction and relaxation cycle



“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.*

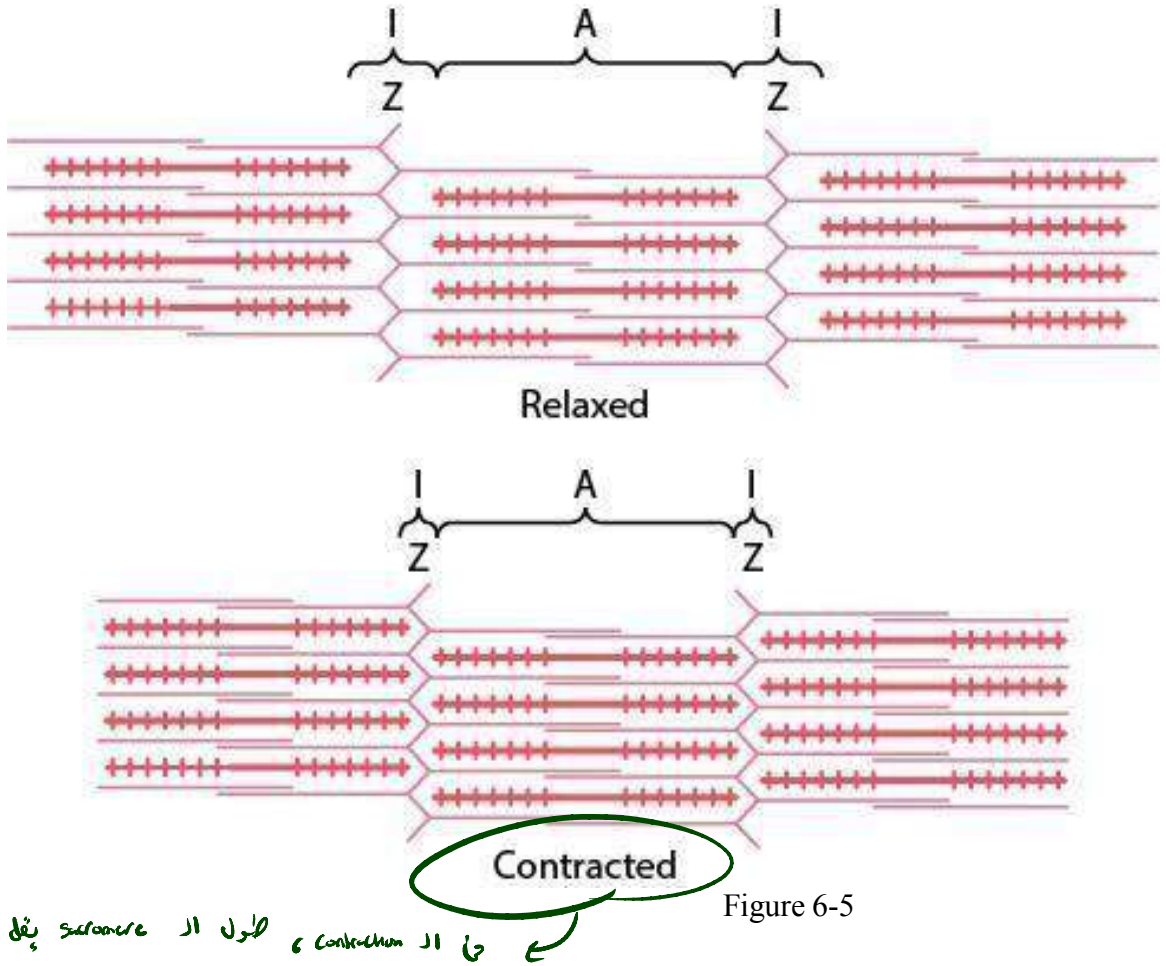


Figure 6-5

important note:

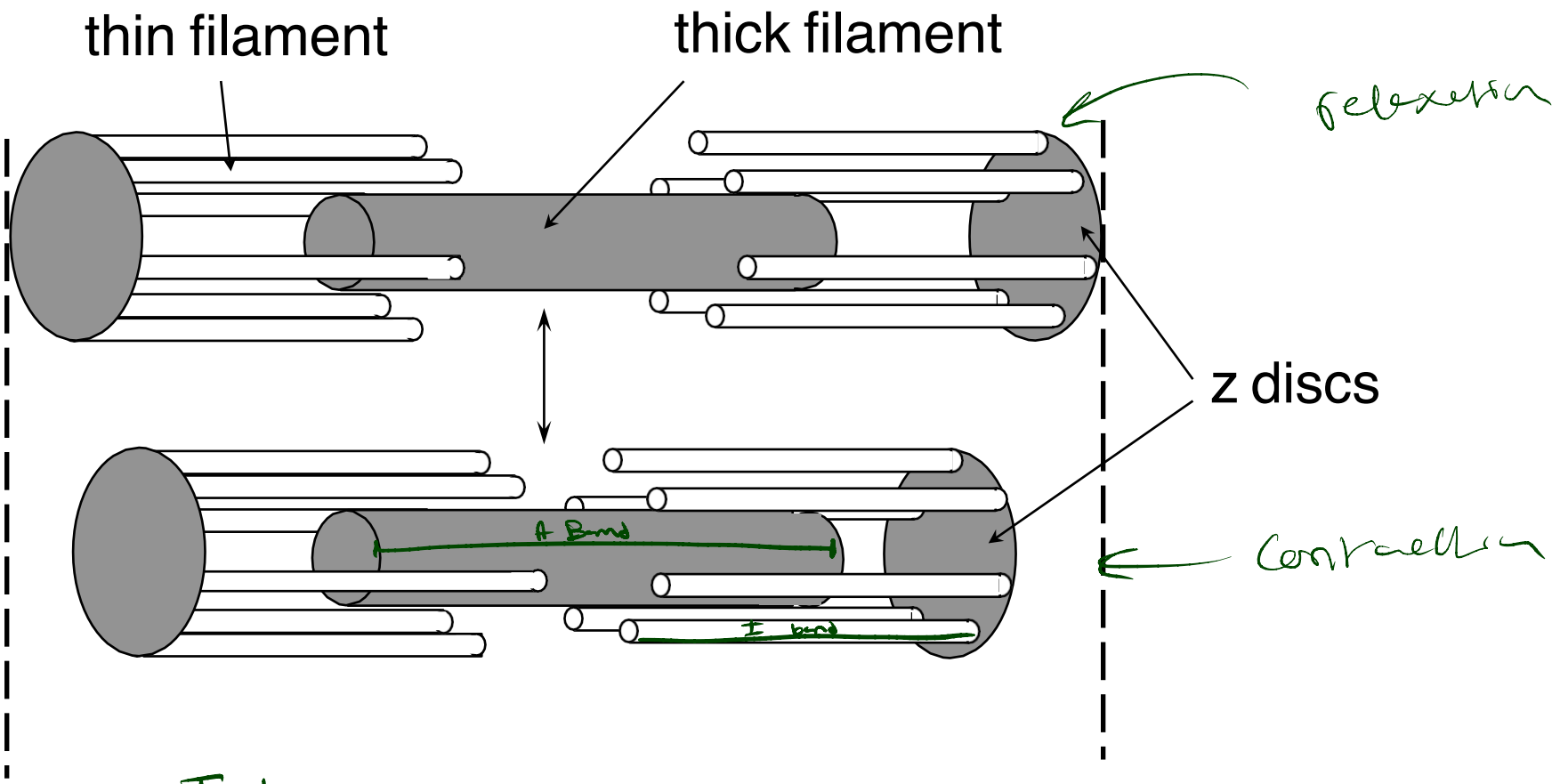
contraction يقل بال actin طول ال

بينما طول ال myosin لا يتغير

Which band shortens - I or A?

actin مناطق ال ← لا يوجد myosin

مناطق ال myosin ← overlap و ال



relaxation

contraction

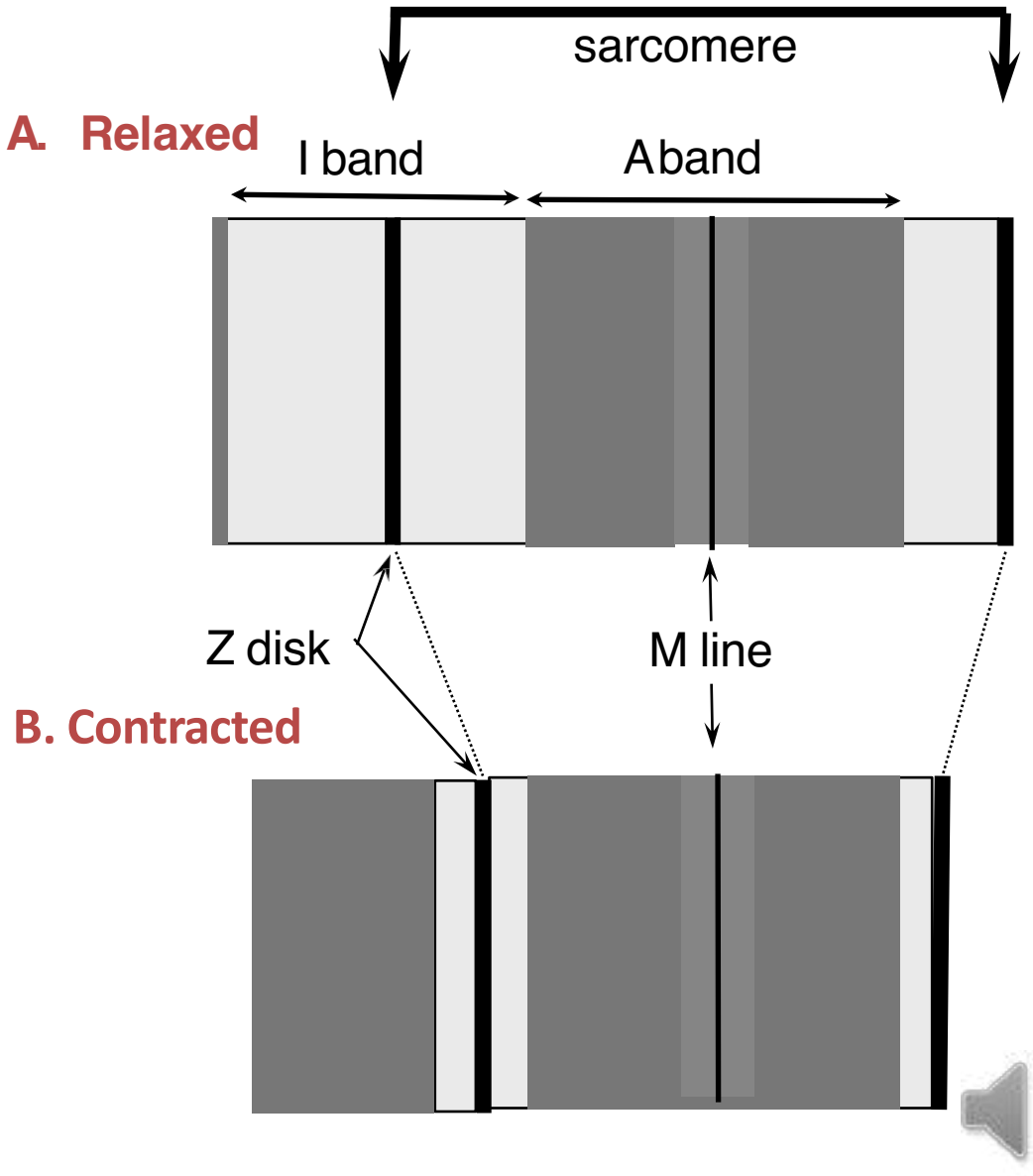
Lengths
- actin → No change
- myosin → no change
- A band → no change
- I band → The only one that shortens

I band ⇒ Shortens in contraction

A band ⇒ no change in length

Which band shortens - I or A?

- The A band appearsdark
- 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.



Role of ATP and Fenn effect

- 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

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

حالة عند الموتى
بعد الوفاة بـ 12 ساعة العضلات
بتخشب لانه عضلاته بتكون contracted

ممكن من خلالها نعرف وقت الوفاة

1. Myosin head attached to actin

ATP

+ NO ATP available to detach heads from actin ⇒ constant contraction

↓

RIGOR

← بتروح لحالة بعد 36–47 h من الوفاة بعد ما تبلش تتحلل بروتينات الجثة.

Rigor mortis:

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

سبب الـ Rigor Mortis

Cytoskeletal Proteins

- Longitudinal cytoskeletal proteins include two large proteins called titin and nebulin
- Titin
  - elastic anchor protein
  - Helps align the thick filament
  - Adds an elastic element to the sarcomere.
    - Titin is anchored at the M-Line, runs the length of myosin, and extends to the Z disc.
- Nebulin
  - stabilizing protein associated with the thin filament
  - None elastic
  - Spans the length of the thick filament
- 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).
- 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

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