
بسم الله الرحمن الرحيم


رب اشرح لي صدري ويسر لي أمري

The Muscular System

PROF DR / AMR SHALABY

Principles of Animal Physiology

Introduction to the Muscular System

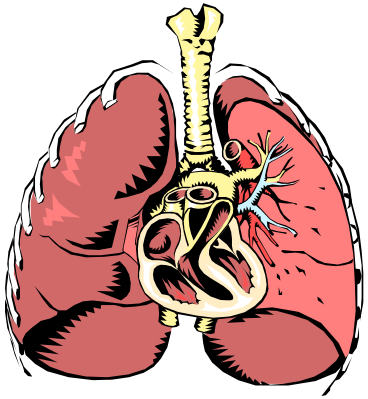
- The ability to use chemical energy to produce force is present to some extent in most living cells, but in muscle cells the chemical apparatus has its greatest development
- Voluntary muscle- are able to control
- Involuntary muscle- can not control

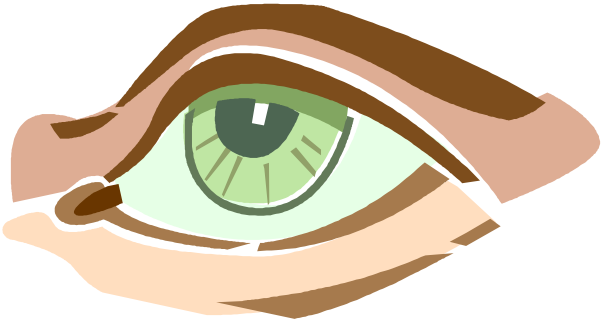
How many muscles do I have?

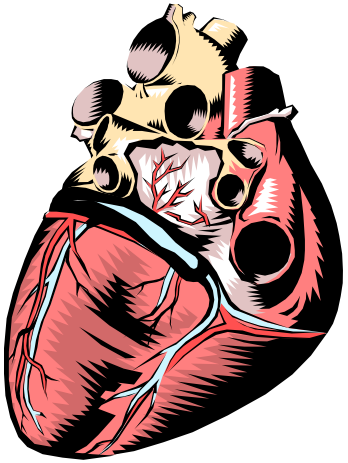
- I have about 650 muscles in my body.
- My muscles make up half of my body weight.
- ??? How much do your muscles weigh?

My muscles are important because they…

- Hold my organs in place
- Hold my bones together so that I can move
- Help me chew my food
- Open and close my eyelids
- Pump my blood
- Allow me to run and play
- Help me to smile!







Did you know?????

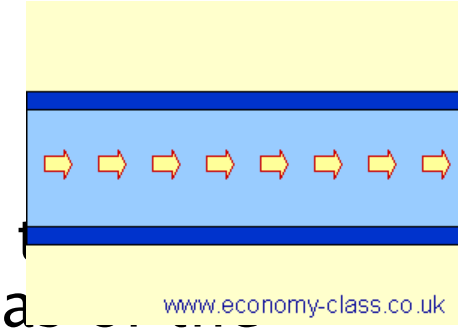
It takes more muscles to frown than to smile?

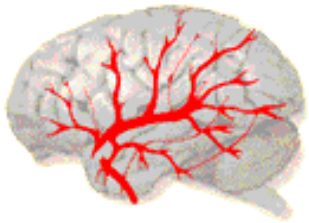
Muscle System Functions

- Provides voluntary movement of body
  - Enables breathing, blinking, and smiling
  - Allows you to hop, skip, jump, or do push-ups
- Maintains posture
- Produces heat

Functions Continued

- Causes heart beat
- Directs circulation of blood
  - Regulates blood pressure
  - Sends blood t… different area… of the body





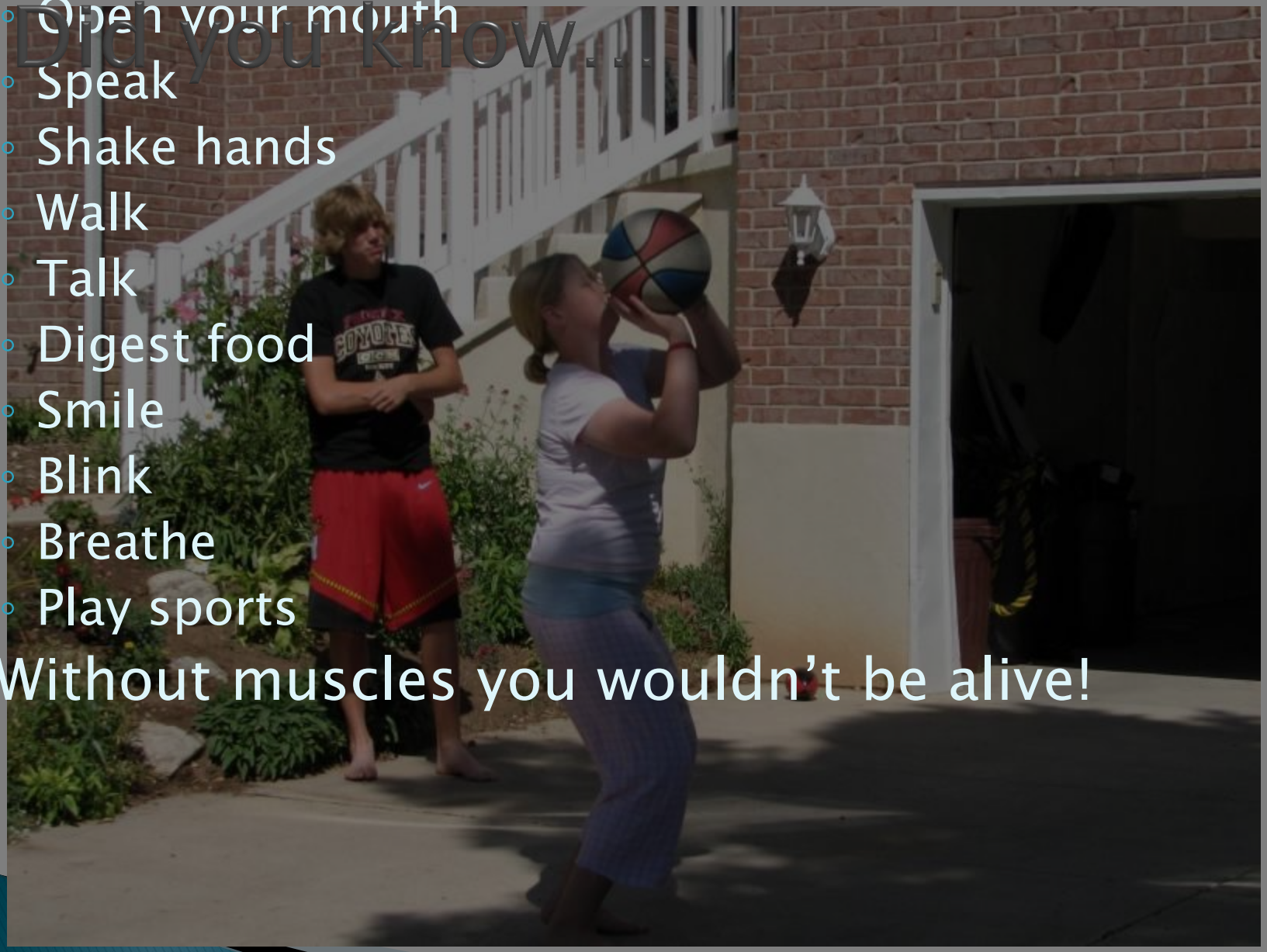
Functions Continued

- Provides movement of internal organs
  - Moves food through digestive tract
  - Enables bladder control
- Causes involuntary actions
  - Reflex actions
  - Adjusts opening of pupils
  - Causes hair to stand on end ( )

Functions of Muscular System

- **Produce movement:** Skeletal muscles for locomotion and manipulation; cardiac muscle responsible for moving blood throughout system; smooth muscles to squeeze and propel substances through hollow organs and tracts.
- **Maintain posture:** Some muscles are continuously activated to enable us to remain erect or seated.
- **Stabilizing joints:** Pull on bones to maintain articulating surfaces.
- **Generating heat:** Tissue most responsible for maintaining body temperature.

- Muscles help you…
  - Open your mouth
  - Speak
  - Shake hands
  - Walk
  - Talk
  - Digest food
  - Smile
  - Blink
  - Breathe
  - Play sports
- Without muscles you wouldn't be alive!



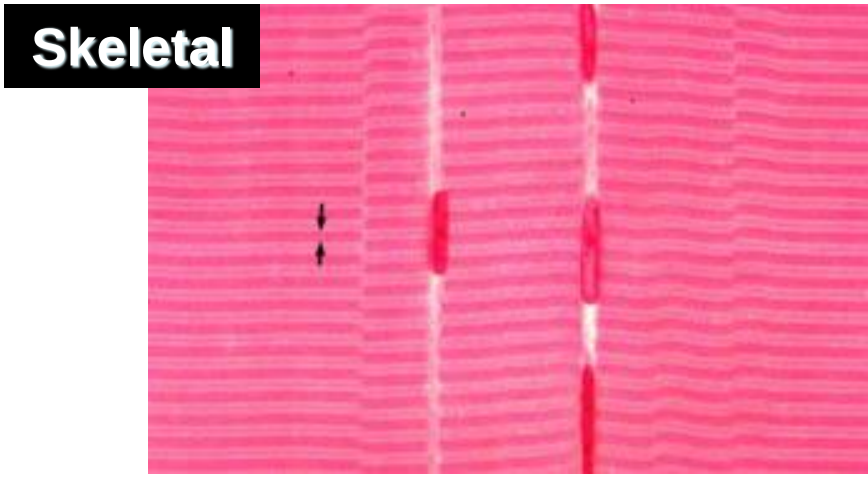
Principles of Animal Physiology

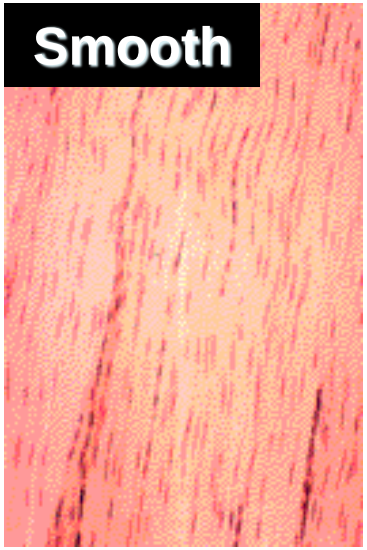
Muscle Physiology

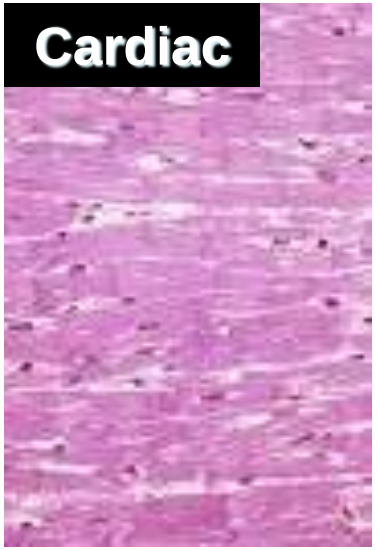
- Functional characteristics of muscles
  - **Excitability**: Ability to receive and respond to a stimulus.
  - **Contractility**: Ability to shorten forcibly when stimulated. Sets muscles apart from other tissues.
  - **Extensibility**: Ability of muscle to be stretched or extended.
  - **Elasticity**: Ability to return to original length after being stretched or after contracting.

Muscle Tissue Characteristics

- Is made up of contractile fibers
- Provides movement
- Controlled by the nervous system
  - Voluntary- consciously controlled
  - Involuntary- not under conscious control
- Examples
  - Skeletal
  - Smooth
  - Cardiac

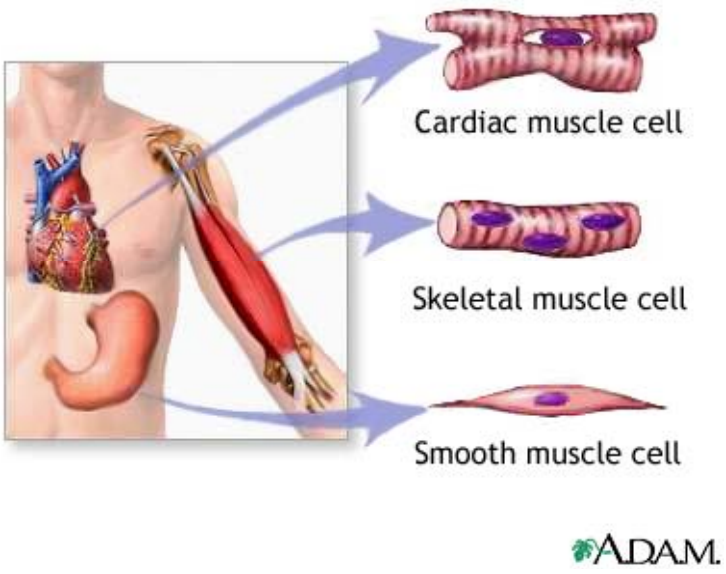


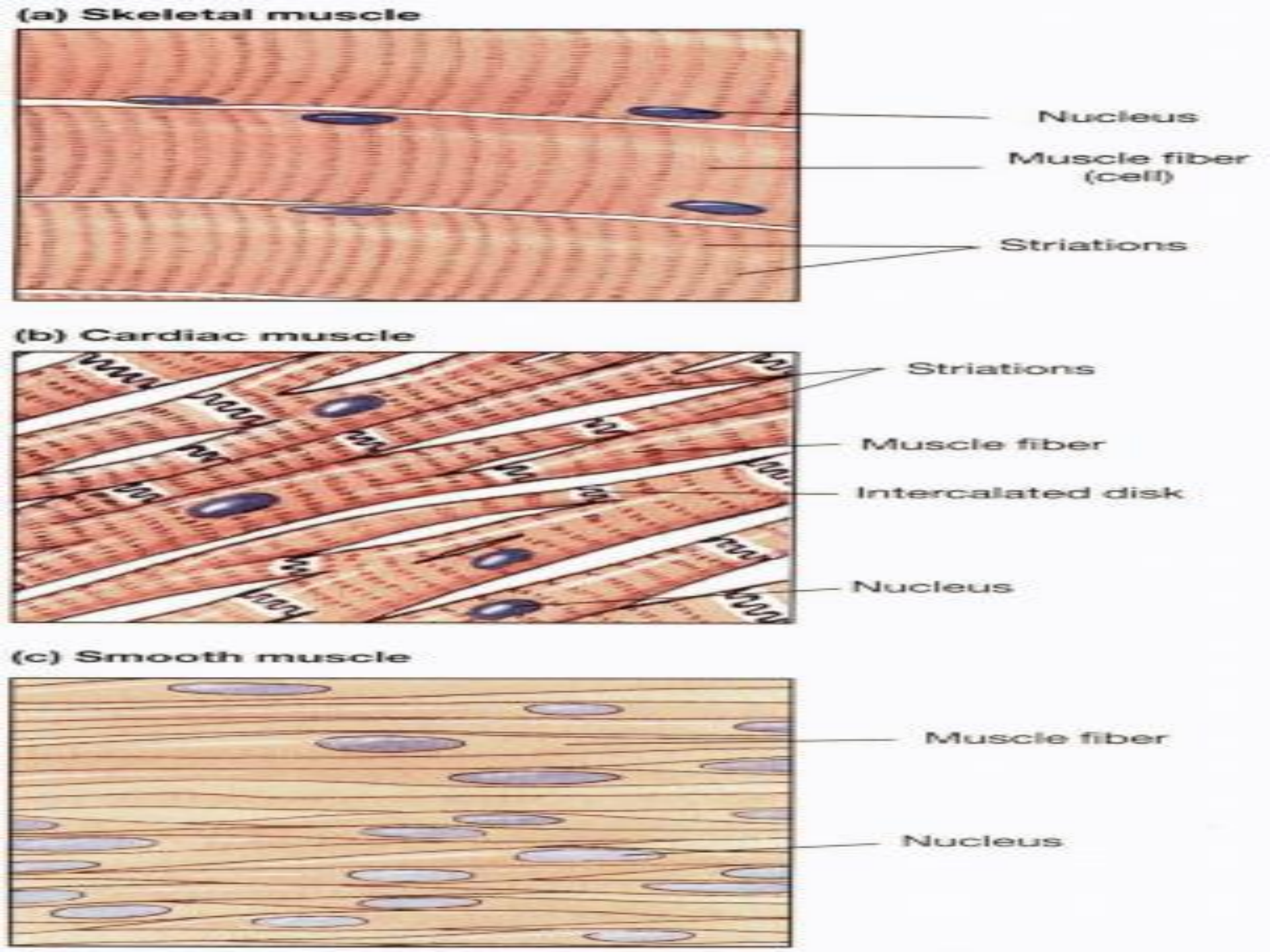




Types of Muscle Tissue

- There are three main types of muscle tissue
  - Skeletal (striated)
  - Cardiac (heart)
  - Smooth (visceral)

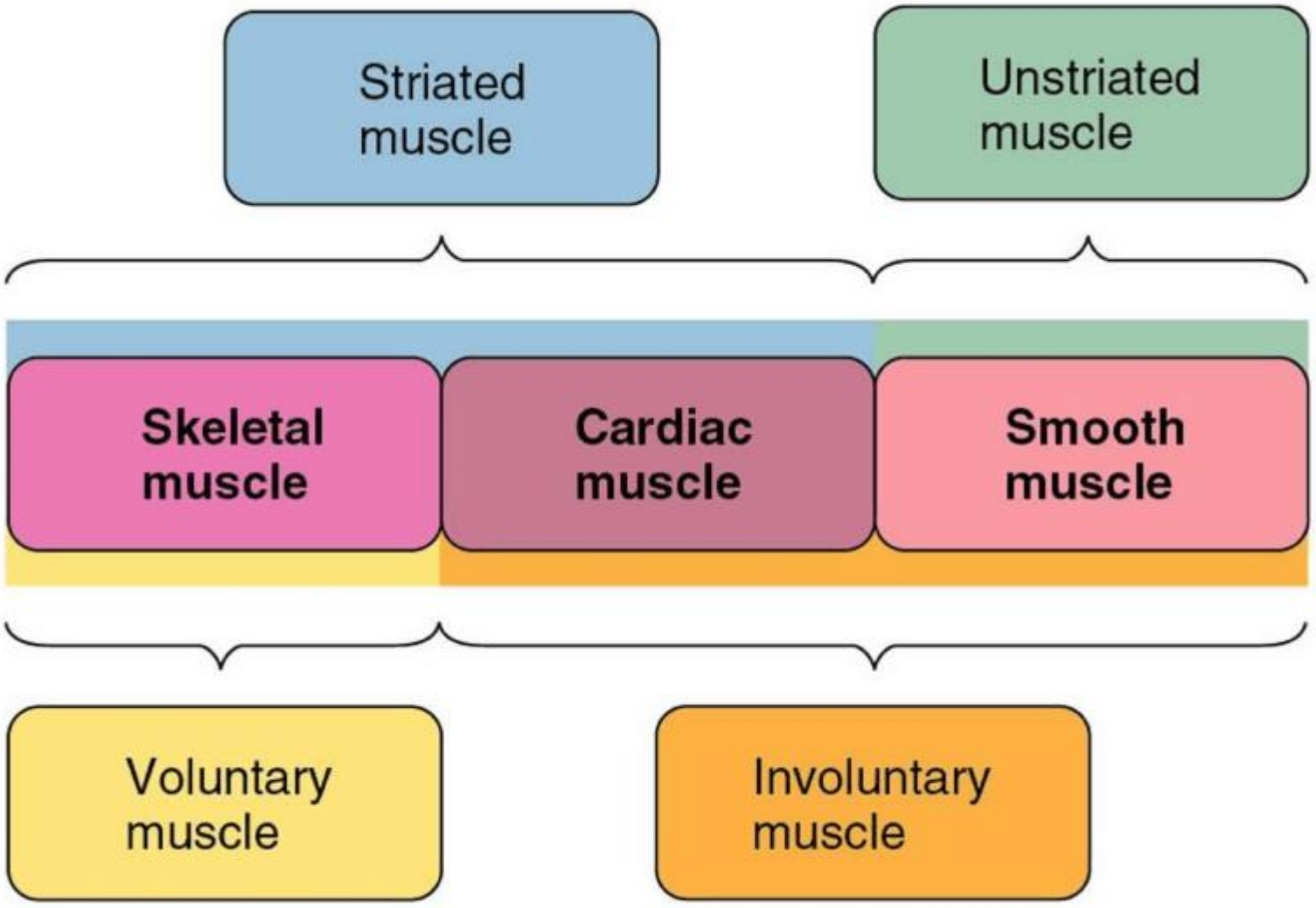



(a) Skeletal muscle
Nucleus
Muscle fiber (cell)
Striations
(b) Cardiac muscle
Striations
Muscle fiber
Intercalated disk
Nucleus
(c) Smooth muscle
Muscle fiber
Nucleus

Principles of Animal Physiology

Muscle Physiology

- Categorization of muscle



Comparison of Muscle Types

Muscle Type	Skeletal	Cardiac	Smooth
Location	Attached to bone	Heart	Walls of internal organs + in skin
Function	Movement of bone	Beating of heart	Movement of internal organs
Control Mode	Voluntary	Involuntary	Involuntary
Shape	Long + slender 	Branching 	Spindle shape 
Characteristics	Striated- light and dark bands Many nuclei	Striated One or two nuclei	Non-striated One nucleus (visceral)

- Muscles can:
  - Perform purposeful locomotors movement of the whole body or parts of the body
  - Manipulate external objects
  - Propel contents through various hollow internal organs
  - Empty the contents of certain organs
  - Produce heat
  - Produce sound

Muscle Physiology

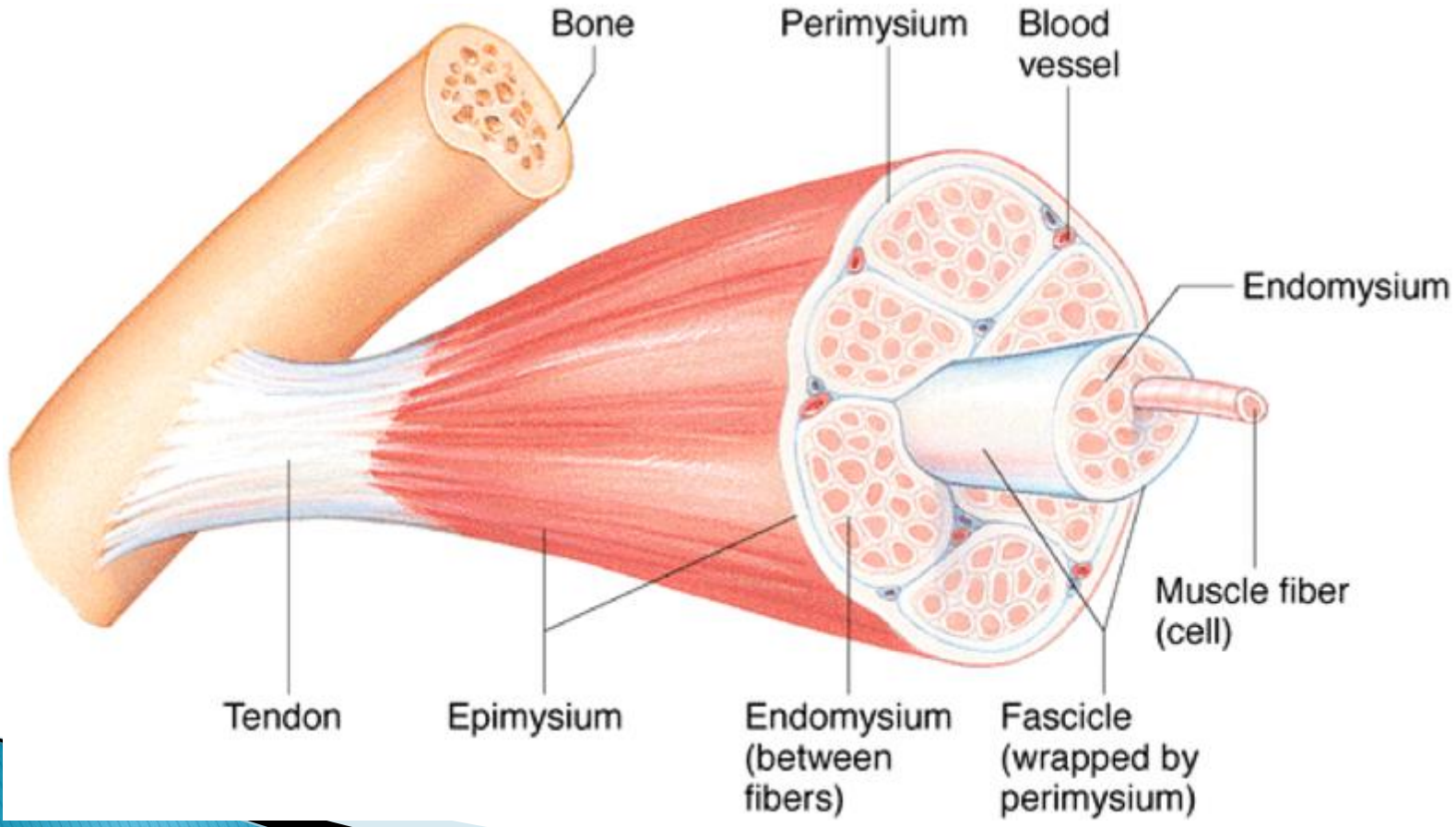
- They differ in cell structure, location, function, and mode of activation.
  - Know how they differ, by:
    - Appearance
    - Fiber arrangement
    - Fiber proteins
    - Control – Nervous control, Hormonal influences
    - Location
    - Morphology
    - Contraction speed
    - Force generated

- Account for at least 40% of body mass (40% in men and 32% in women). Smooth & cardiac muscle account for 10% of total weight.
  - Fish: 20 – 50% muscle
  - Barracudas: 55-65%
- Contains obvious stripes called *striations* and under voluntary control. Made up of muscle fibers, nerves, blood vessels, and connective tissue.

Muscle Physiology

- *Skeletal Muscle*
  - Attached to bones by tendons
    - Origin – closest to body or more stationary bone
    - Insertion – more distal or mobile attachment
    - Joint – flexible connection where two bones meet
    - Flexor – muscle that bring bones closer together
    - Extensor – muscle that move bones away from each other
    - Flexor-extensors pairs are called antagonistic muscle group

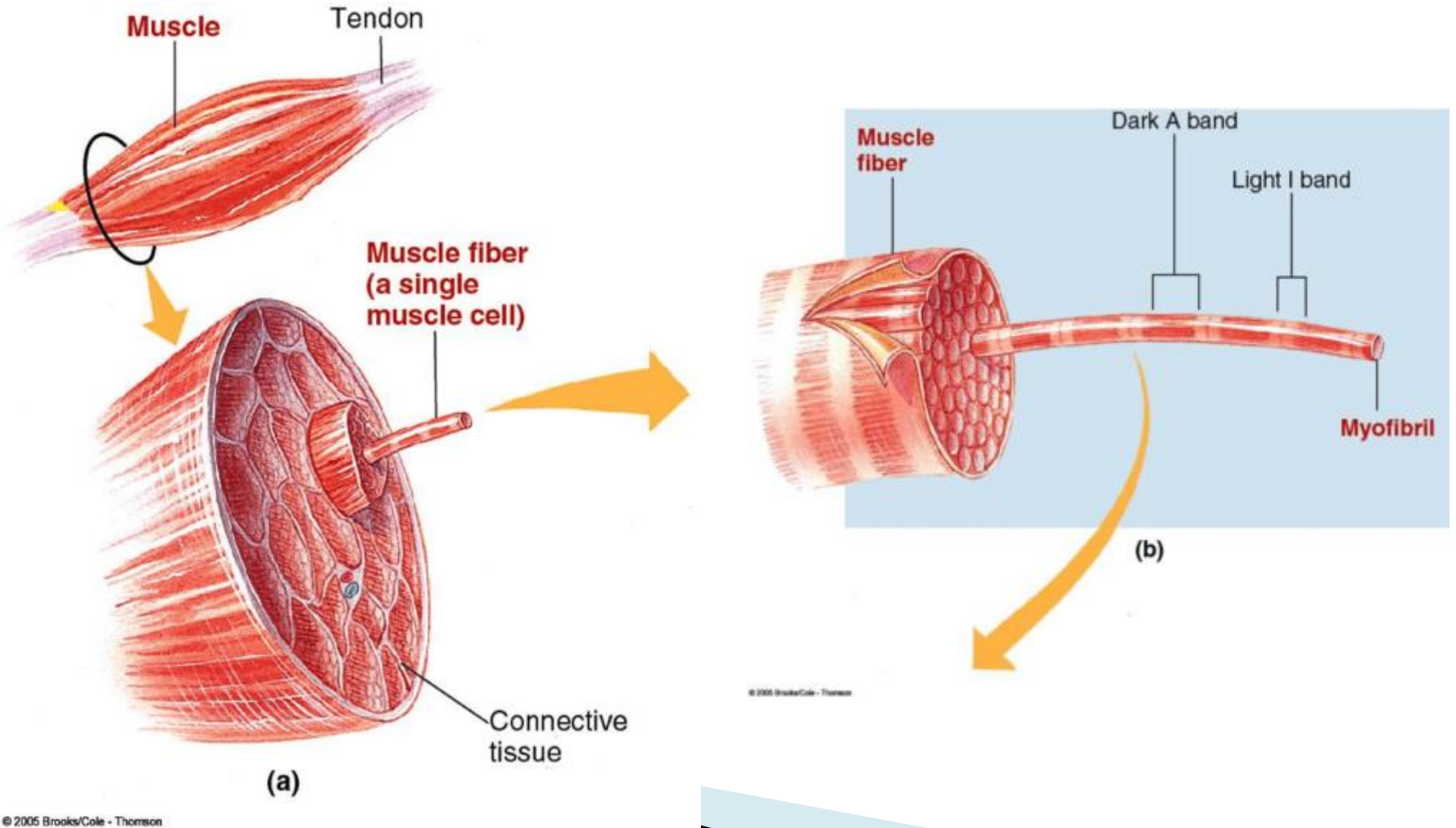
- Organization of skeletal muscle



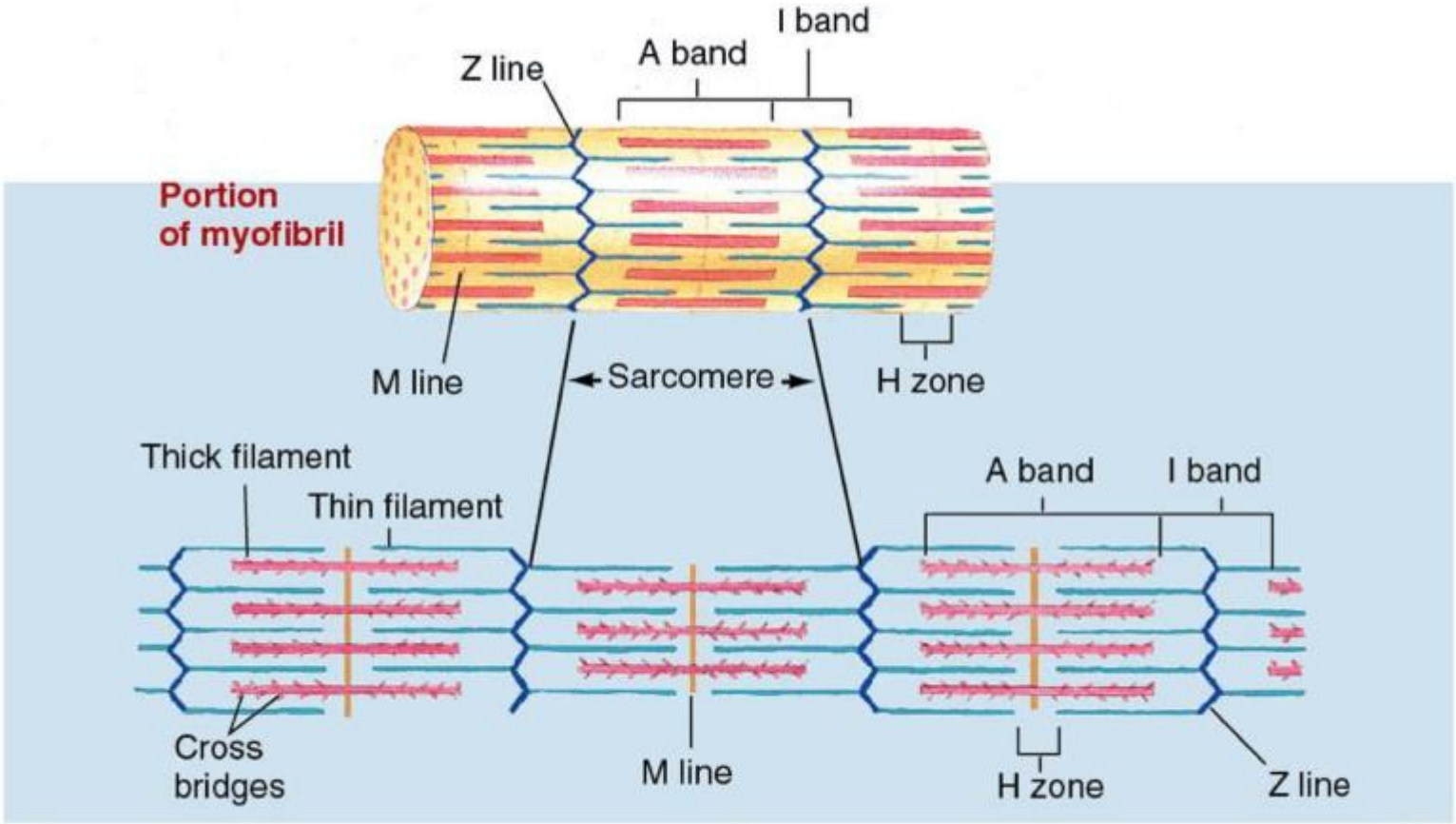
Muscle Physiology

- Organization of cylindrical muscle fibers
- ***Striated muscle***: characteristic **light** and **dark** bands oriented perpendicular to the long axis of the fibers.
- Striated pattern due to cylindrical elements (1–2μ diameter) known as myofibrils.
  - **Muscle fiber** – single skeletal muscle cell
  - **Myoblast** – formed by fusion of undifferentiated, mononucleated cells during development
  - **Muscle** – collection of muscle fibers bound together by connective tissue

- Levels of Organization



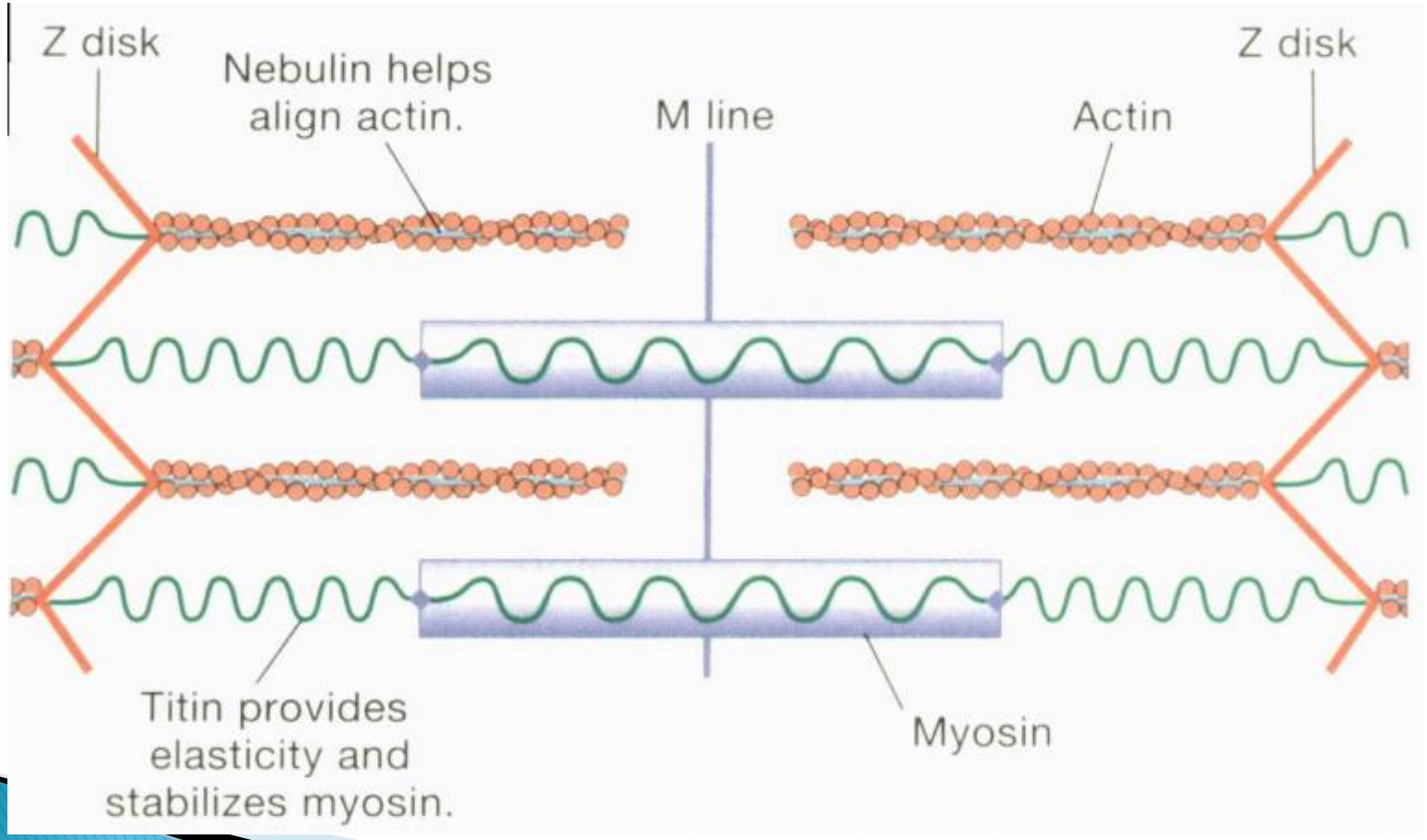
- *Levels of Organization – Myofibril & Sarcomere*



- ***Myofibril*** – composed of thick and thin filaments arranged in a repeating pattern along its length. One of these units is known as a **Sarcomere.**
  - **Thick filaments** – composed entirely of myosin.
  - **Thin filaments** – composed of actin, troponin and troop myosin.
  - **Motor unit** – a motor neuron and all the muscle fibers it controls.

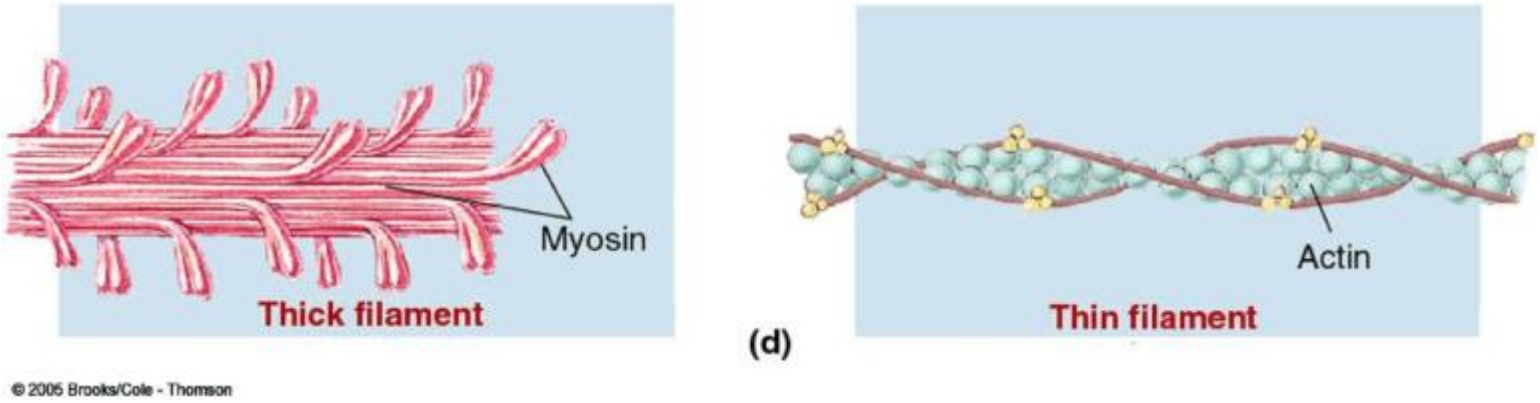
- Titin – huge elastic protein molecule
  - Extends from Z disk to next M line
  - Stabilizes position of the contractile filaments
  - Its elasticity returns stretched muscles to their resting length
- Nebulin – inelastic giant protein
  - Attaches to Z disk
  - Aligns the actin filaments to the Sarcomere

- *Titin – huge elastic protein molecule*

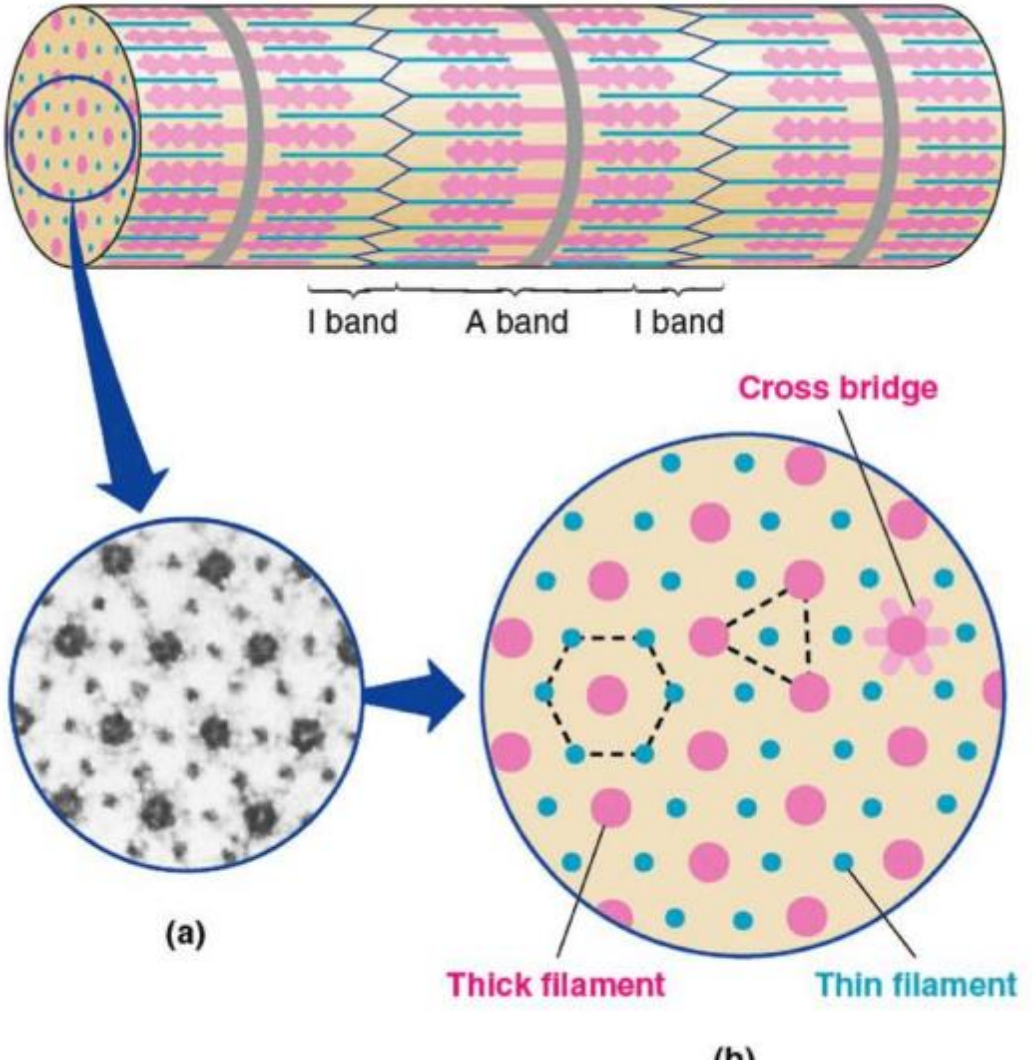


- *Levels of Organization – Internal arrangement*
  - A band
  - I band
  - H zone
  - M line
  - Z line
  - Sarcomere
    - The area between two adjacent Z lines
    - The functional unit of skeletal muscle
    - Smallest component capable of contraction

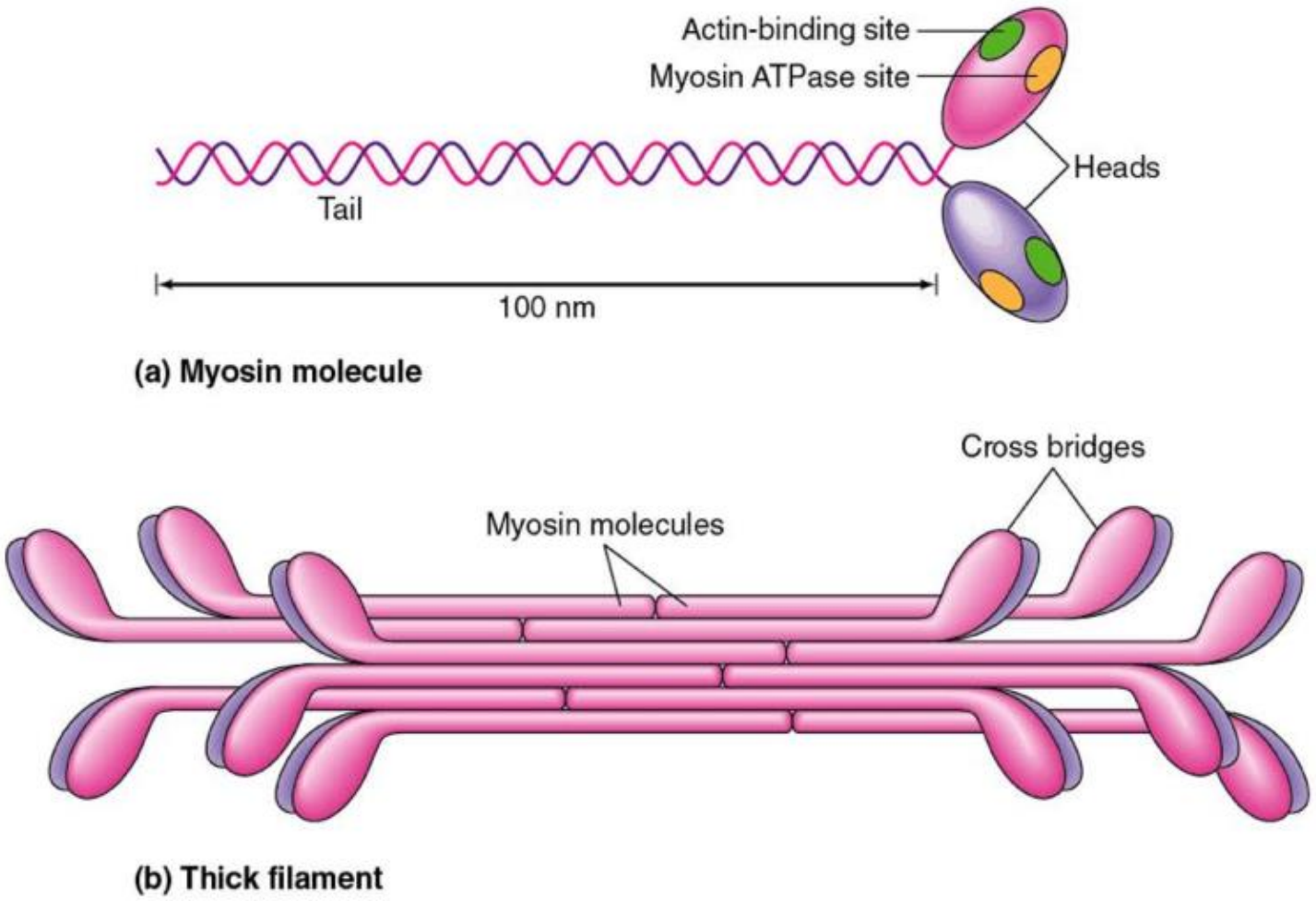
- Levels of Organization – thick & thin filaments



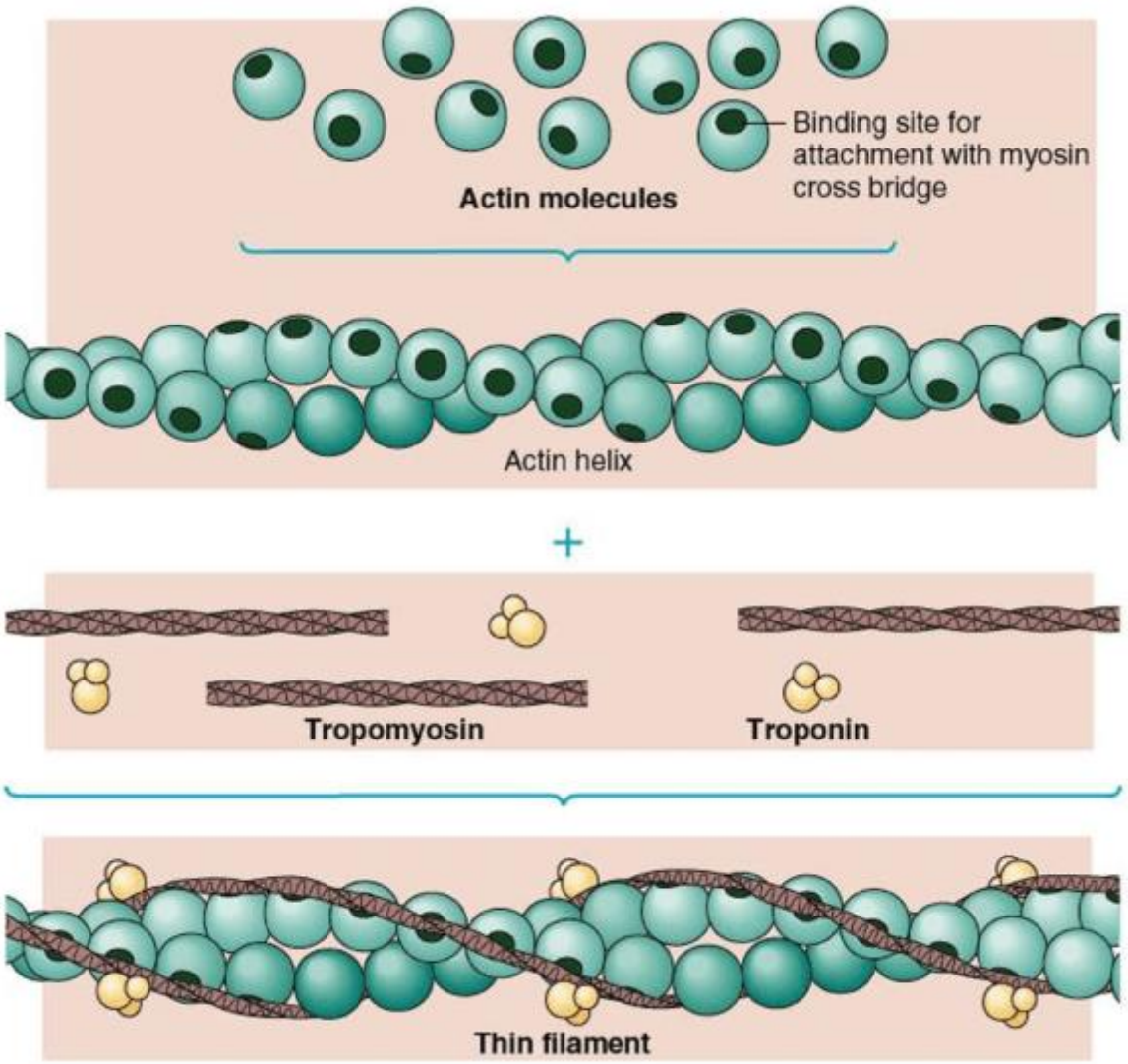
- Levels of Organization – Section of myofibril



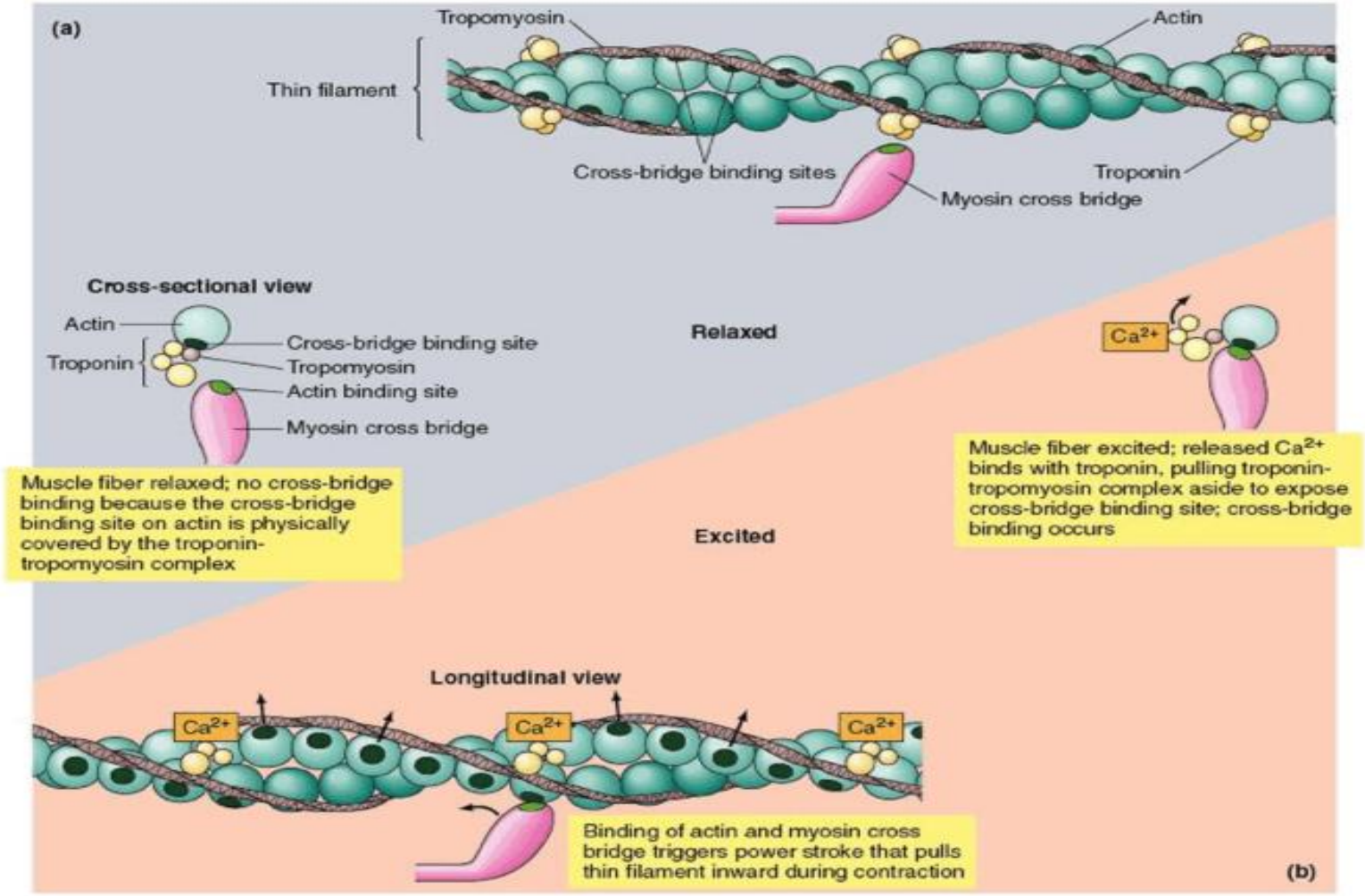
- *Myosin and thick filaments*



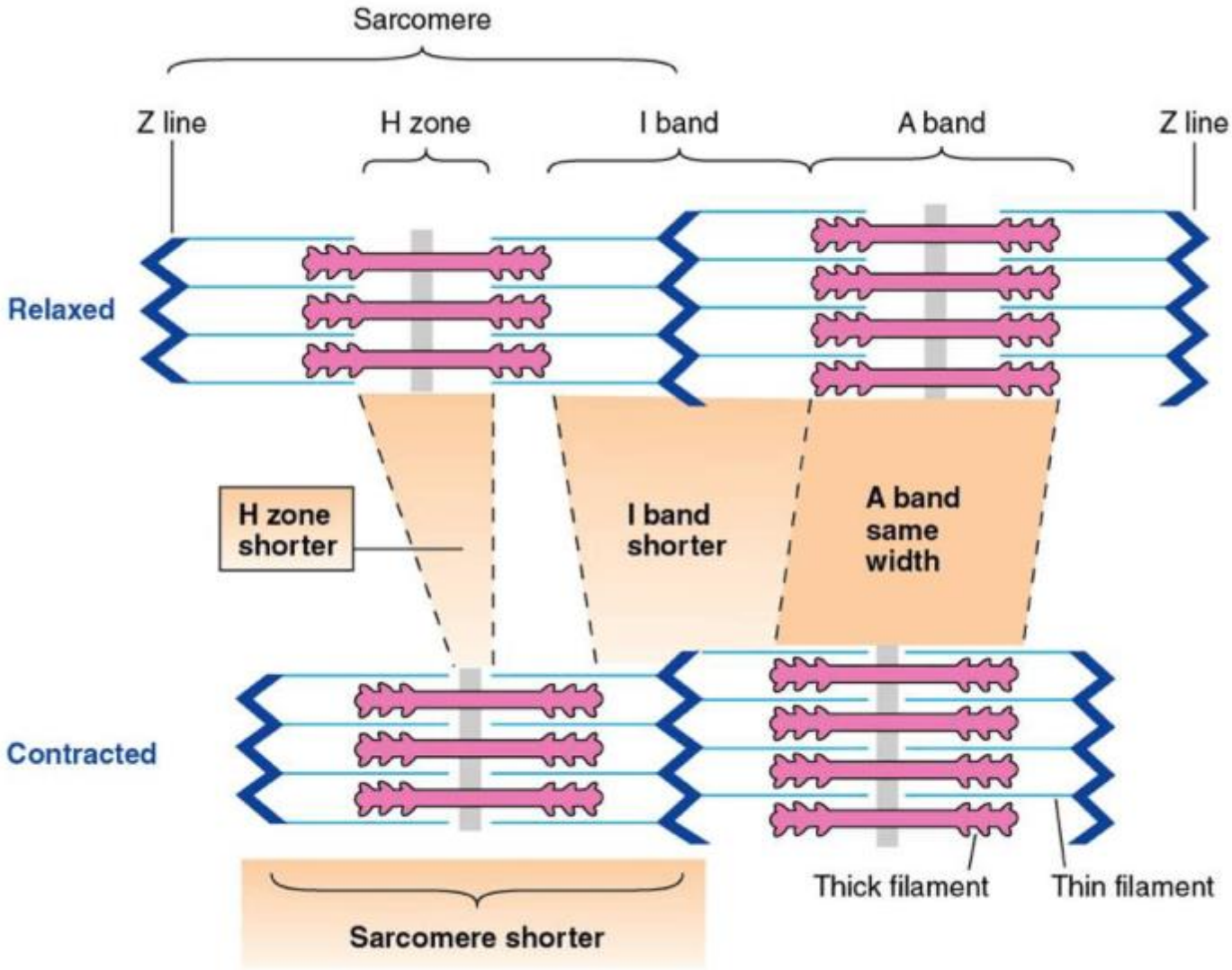
- Thin Filament



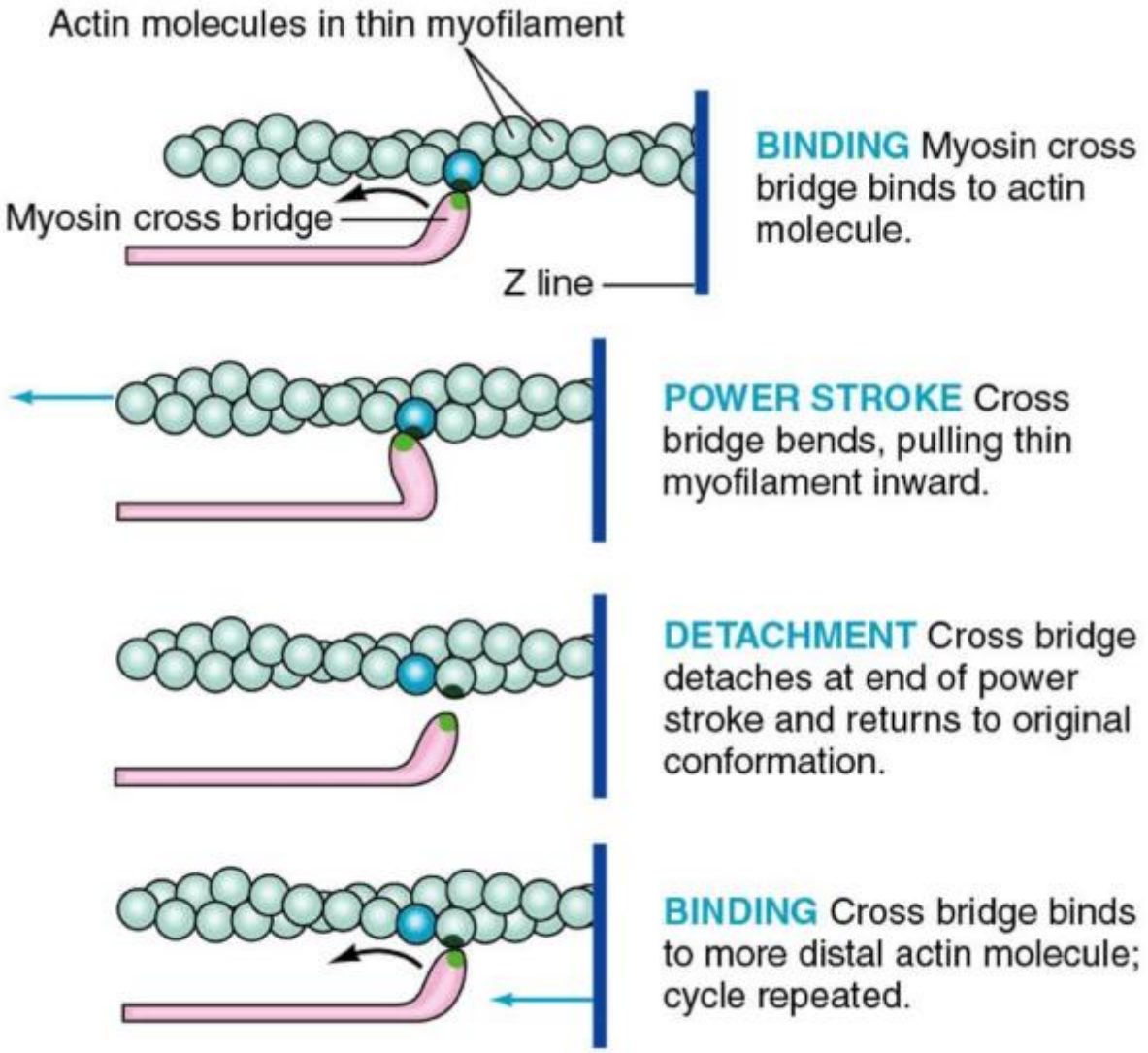
Role of calcium in cross bridging



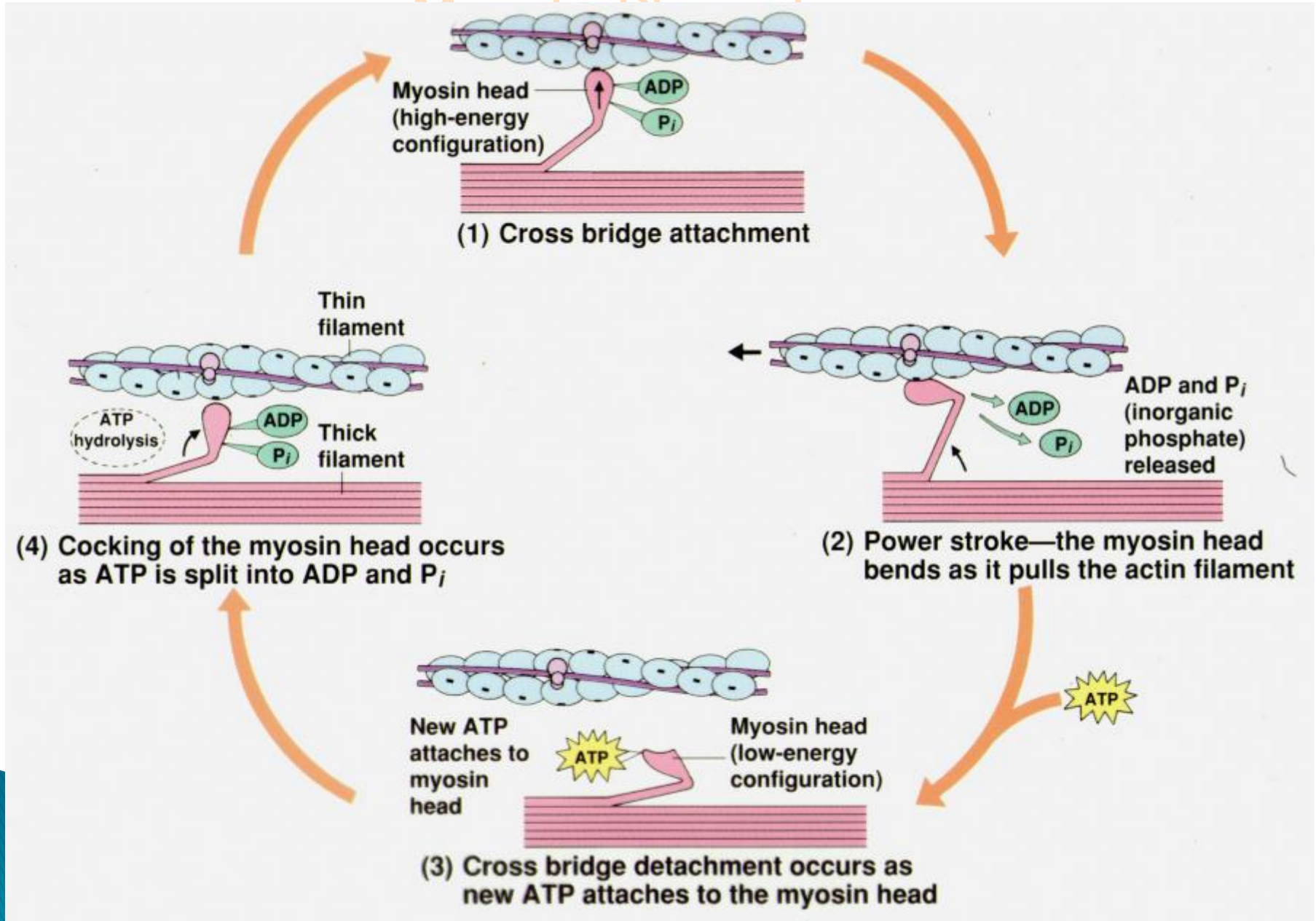
- *Muscle contraction*
  - Sliding-filament mechanism
    - Thin filaments slide toward M line
    - Z discs move closer together
    - Sarcomere shortens
    - H zone becomes smaller and may disappear
    - A band unchanged


Sarcomere
Z line
H zone
I band
A band
Z line
Relaxed
H zone shorter
I band shorter
A band same width
Contracted
Thick filament
Thin filament
Sarcomere shorter
© 2005 Brooks/Cole - Thomson

Cross-bridge activ



Principles of Animal Physiology



Principles of Animal Physiology

- Muscle relaxation
  - No action potentials
  - Degradation of Ach
  - Ca2+-ATPase pump transports Ca2+ into lateral sacs
  - Ca2+-binding proteins lowers its ICF concentration
  - Troponin-tropomyosin complex slips back into its blocking position
  - Actin and myosin no longing bind at cross-bridges
  - Titin helps return sarcomere to its unstimulated conformation
  - Know Table 8-1

Principles of Animal Physiology

Muscle Physiology

- Contraction and Relaxation Summarized
  - Surface membrane of muscle is depolarized
  - AP conducted deep into muscle fiber via T-tubules
  - Signal spreads to sarcoplasmic reticulum
  - Calcium channels open
  - [Ca++] from < 10-7M to 10-6M. Ca++ binds to troponin
  - Tropomyosin molecule moves revealing cross bridge binding site on actin
  - Myosin crossbridges attach to actin filaments causing pull on cross bridge link
  - The sarcomere shortens
  - ATP hydrolyzed, myosin head detaches, may repeat 7 & 8
  - [Ca++], tropomyosin inhibits cross bridge attachment, muscle relaxes

Principles of Animal Physiology

- Contraction activity outlasts the electrical activity
  - Single action potential last 1-2 msec
  - The muscle contraction lags behind
  - Latent period - time required for excitation-contraction coupling
  - Time is also required for cross-bridging
  - Contractile response
    - Contraction time plus
    - Relaxation time

أي أسئلة متعلقة بالدرس؟

جزآكم الله خيرا

د / عمرو شلبي

بالتوفيق أن شاء الله