

# Muscle Physiology

# Muscular System Functions

- Body movement
- Maintenance of posture
- Respiration
- Production of body heat
- Constriction of organs and vessels
- Heart beat

# Properties of Muscle

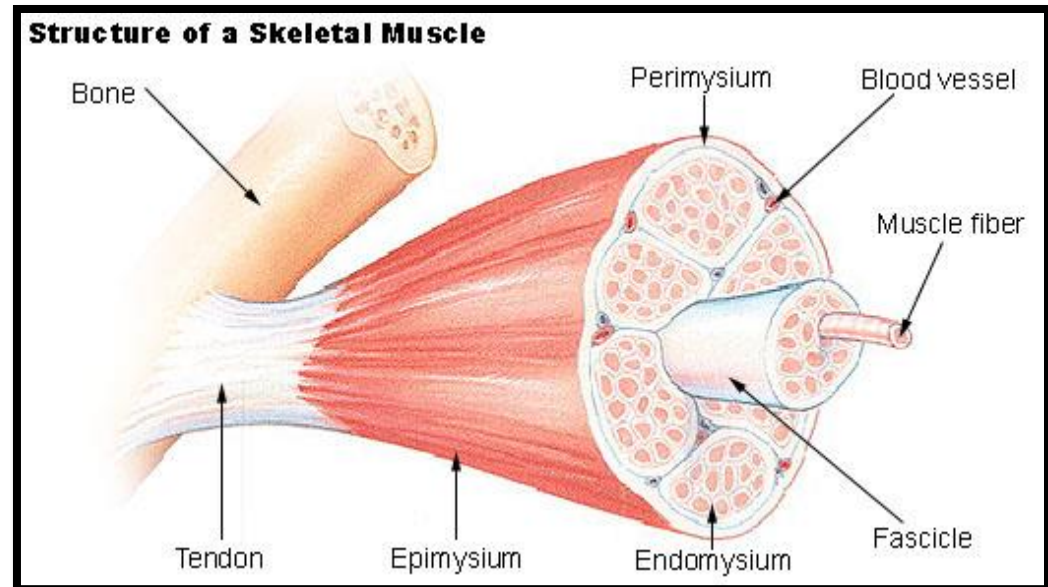
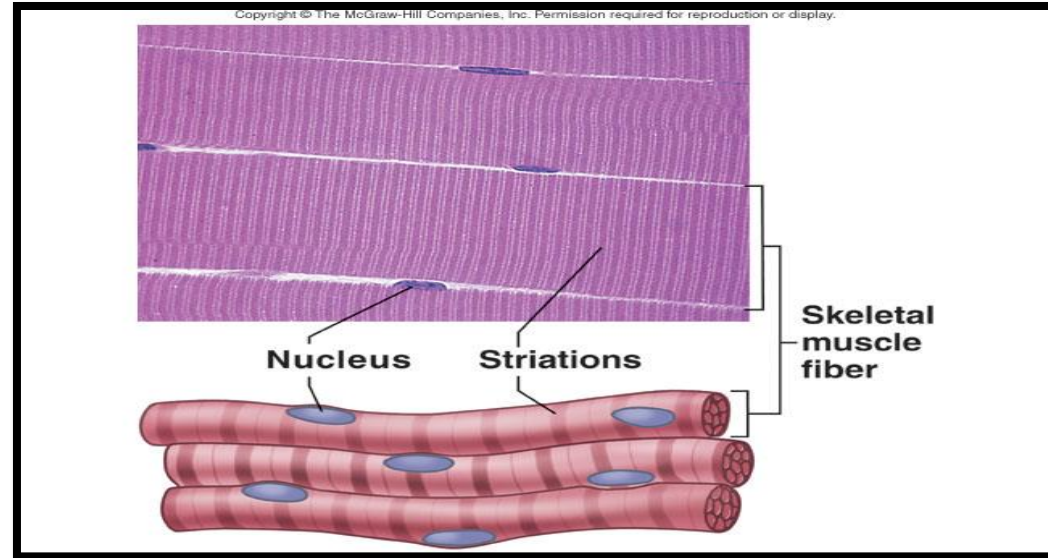
- **Contractility**
  - Ability of a muscle to shorten with force
- **Excitability**
  - Capacity of muscle to respond to a stimulus
- **Extensibility**
  - Muscle can be stretched to its normal resting length and beyond to a limited degree
- **Elasticity**
  - Ability of muscle to recoil to original resting length after stretched

# Characteristics of Muscles

- Muscle cells are elongated  
(muscle cell = muscle fiber)
- Contraction of muscles is due to the movement of microfilaments
- Muscles are responsible for all types of body movement
- Three basic muscle types are found in the body
  - Skeletal muscle
  - Cardiac muscle
  - Smooth muscle

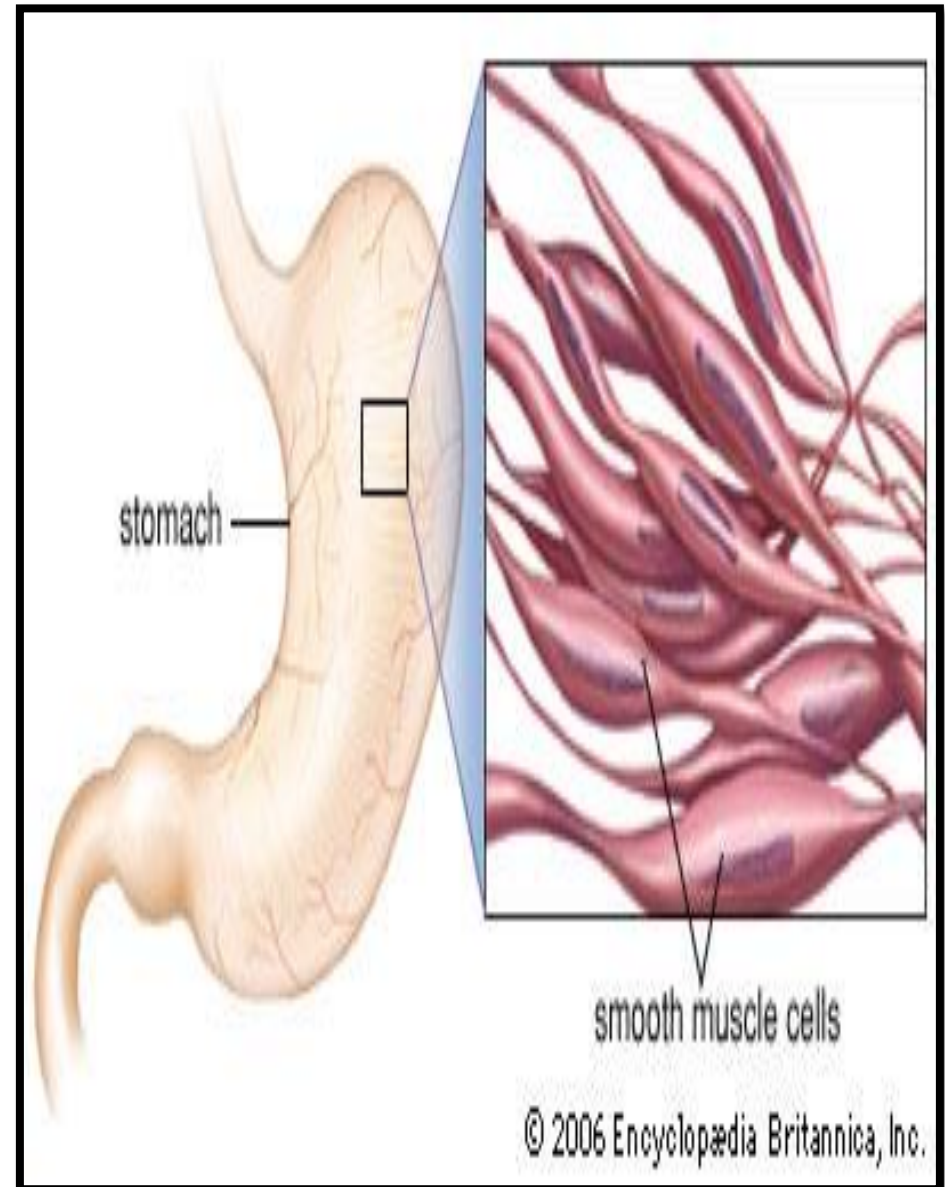
# 1- Skeletal Characteristics

- Attached to bones
- Nuclei multiple and peripherally located
- Striated, Voluntary and involuntary (reflexes)

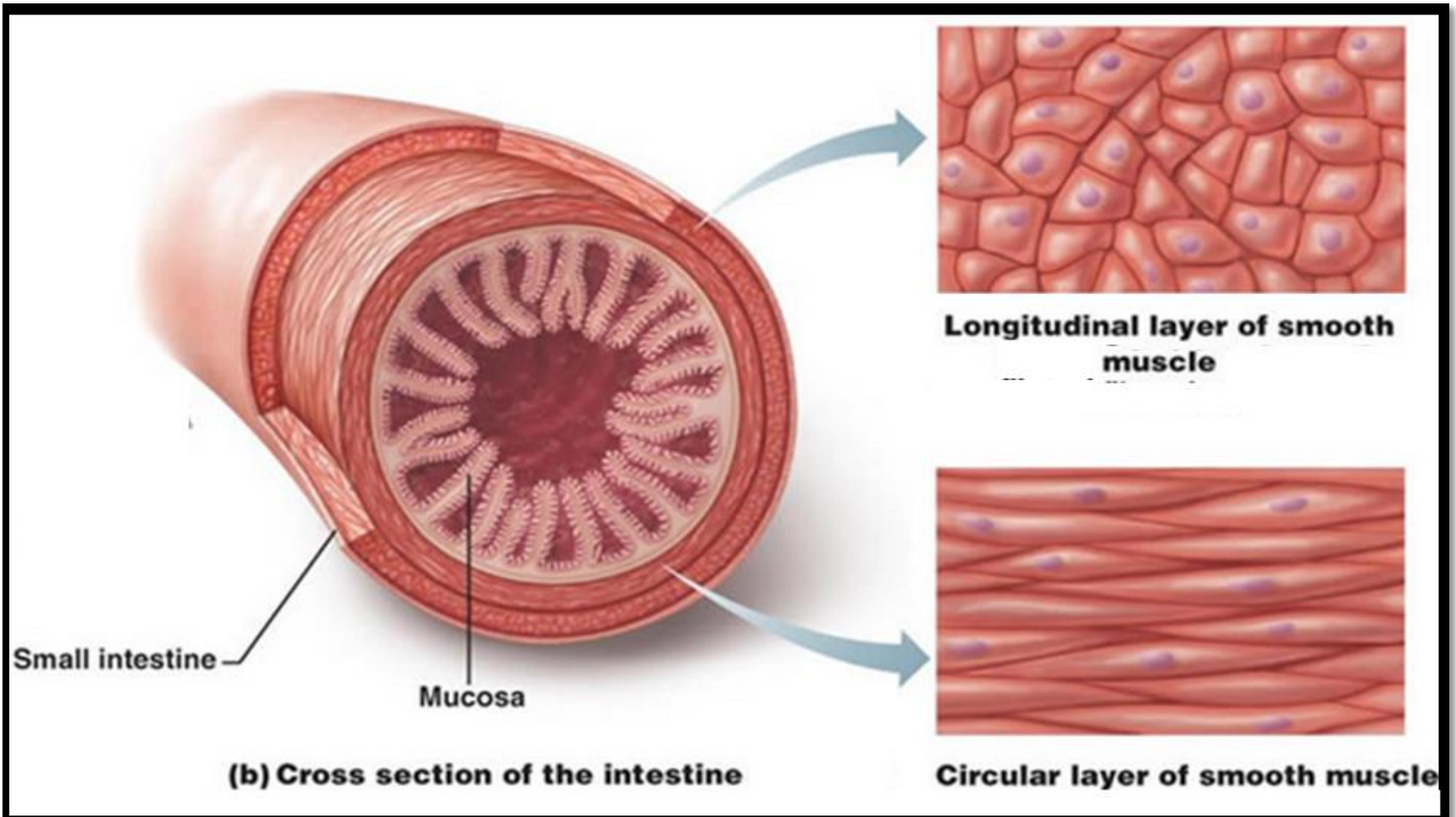


# 2- Smooth Muscle Characteristics

- Walls of hollow organs, blood vessels, eye, glands, skin
- Single nucleus centrally located
- Not striated
- Involuntary
- In visceral smooth

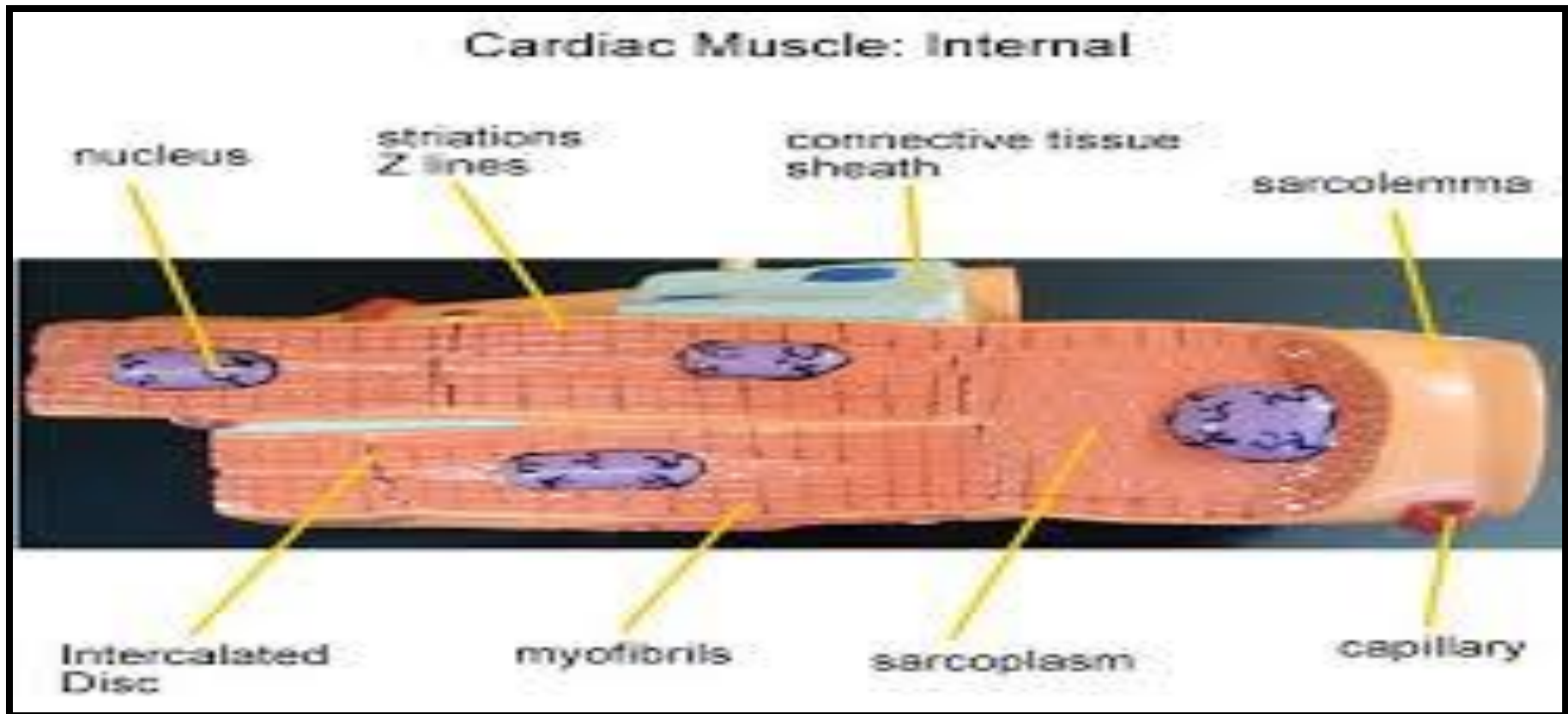
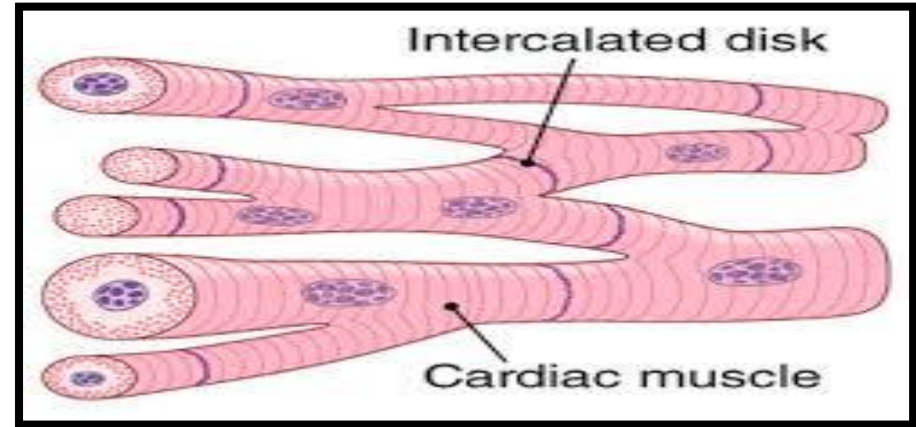


# peristaltic movement by smooth M.



# 3- Cardiac Muscle Characteristics

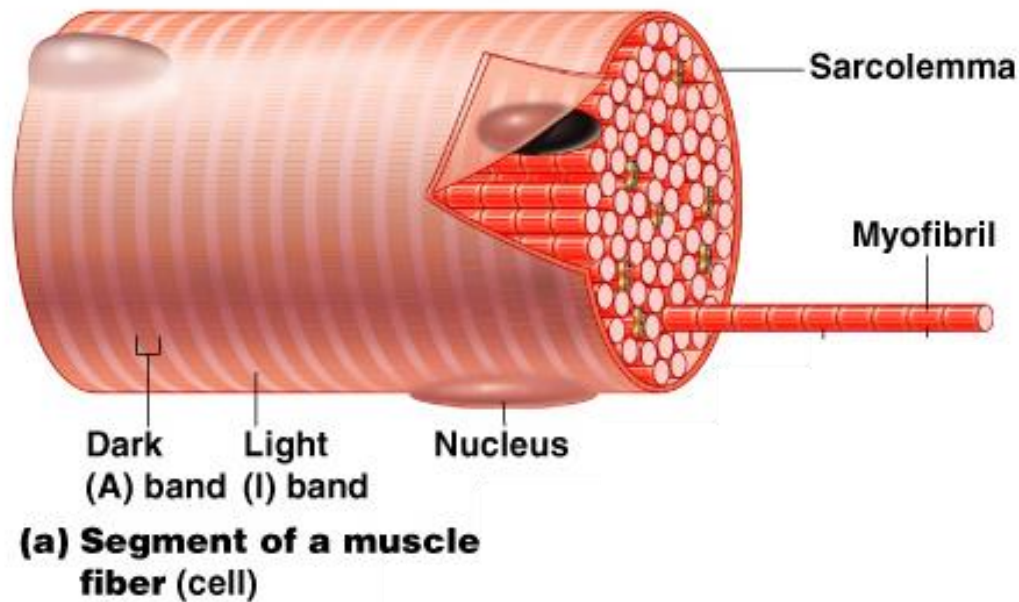
- Heart
- Single nucleus centrally
- Striations
- Involuntary
- Intercalated disks





# Microscopic Anatomy of Skeletal Muscle

- Cells are multinucleate
- Nuclei are just beneath the sarcolemma
- Sarcolemma—specialized plasma membrane



# Properties of Skeletal Muscle Activity

- Irritability – ability to receive and respond to a stimulus
- Contractility – ability to shorten when an adequate stimulus is received

# Sarcomere of Skeletal Muscle

- A **sarcomere** is the basic unit of striated muscle tissue. are composed of **muscle fibers**, called myocytes
- The Muscle fibers are composed of tubular myofibrils which appear under the microscope as **dark** and **light bands**.

# Sarcomeres composed

1- Myosin protein

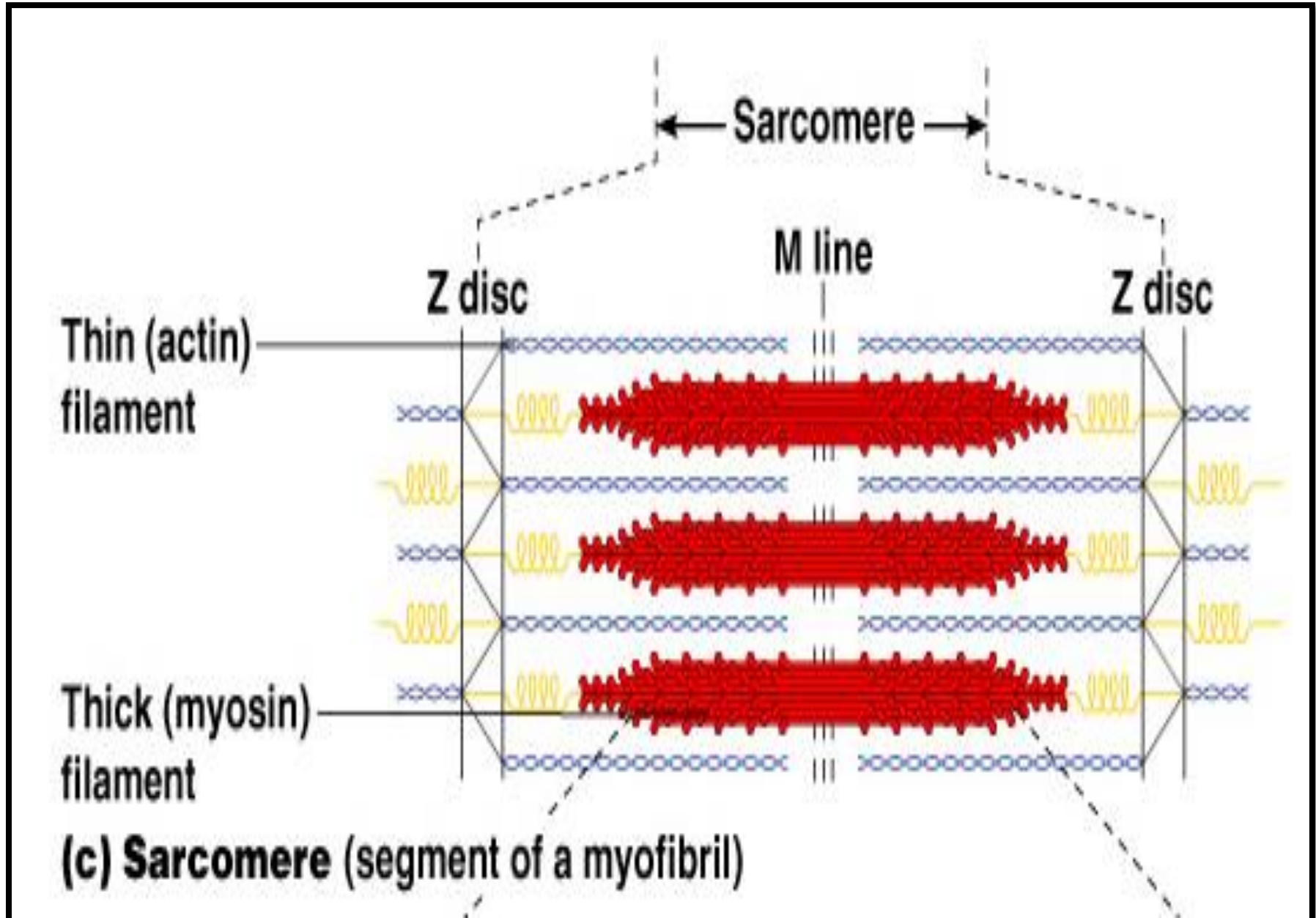
which forms the **thick filament**, has a long, fibrous tail and a globular head. The Myosin can only bind to actin when the binding sites on actin are exposed by calcium ions.

2- Actin protein which forms the **thin filament**.

3- Tropomyosin complex (4 types protein).

Myosin & Actin molecules are bound to the **Z line** (Zwischenscheibe), which forms the borders of the sarcomere. The thin **M-line** (Mittelscheibe), the disc in the *middle* of the sarcomere) formed of cross-connecting elements of the cytoskeleton.

# Sarcomere of Skeletal Muscle



# Types of Muscle Contractions

- Isotonic contractions
  - Myofilaments are able to slide past each other during contractions
- Isometric contractions
  - Tension in the muscles increases
  - The muscle is unable to shorten

# Muscle is Stimulated by Nerve

- Skeletal muscles must be stimulated by a nerve to contract
- Motor unit
  - One neuron
  - Muscle cells stimulated by that neuron

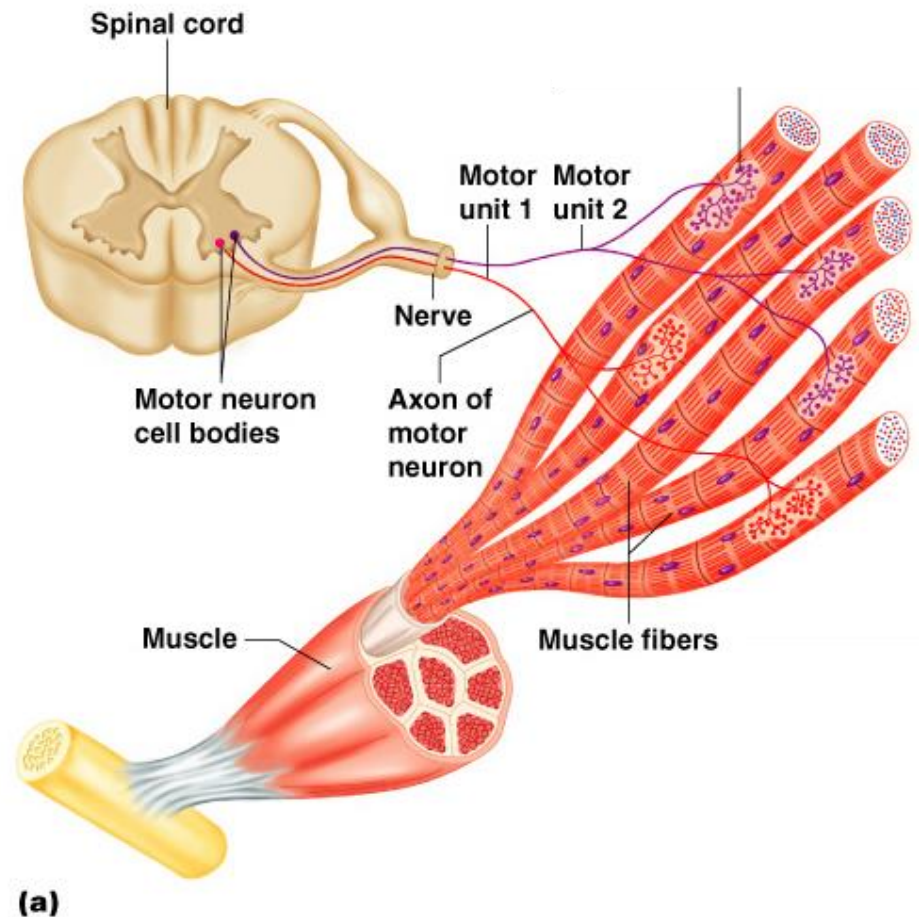


Figure 6.4a

# Transmission of Nerve Impulse

- Neurotransmitter – a chemical released by the nerve upon arrival of nerve impulse
  - The neurotransmitter - **acetylcholine**
- Neurotransmitter attaches to receptors on the sarcolemma
- Sarcolemma becomes permeable to sodium ( $\text{Na}^+$ )
- Sodium enters the cell and generates an action potential
- Once started, muscle contraction cannot be stopped



# The Sliding Filament Theory of Muscle Contraction

- This action causes the myosin to slide along the actin
- The result is shortening of the muscle – a contraction

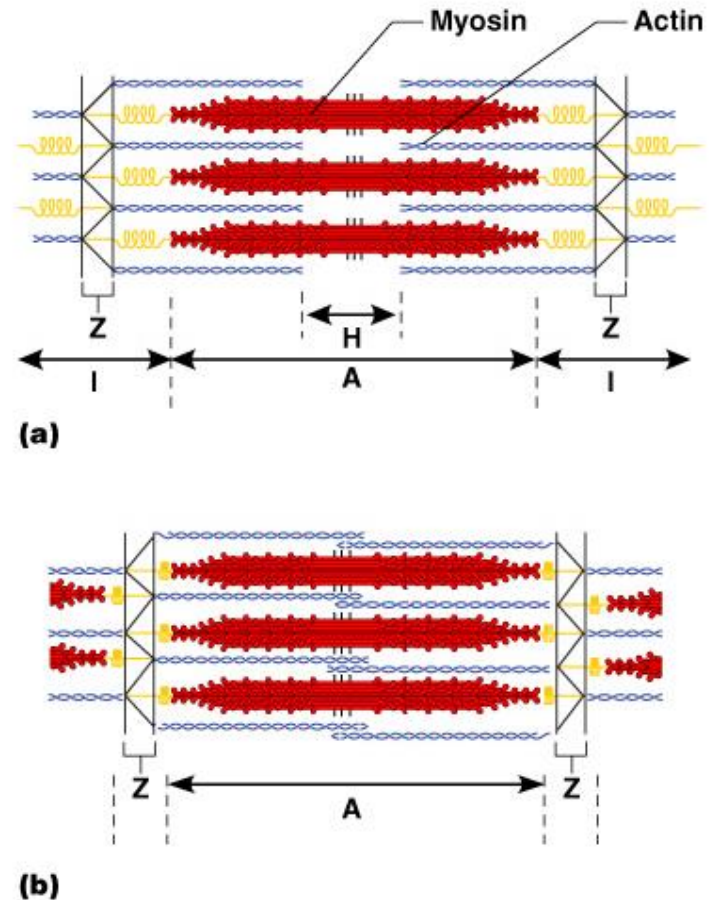


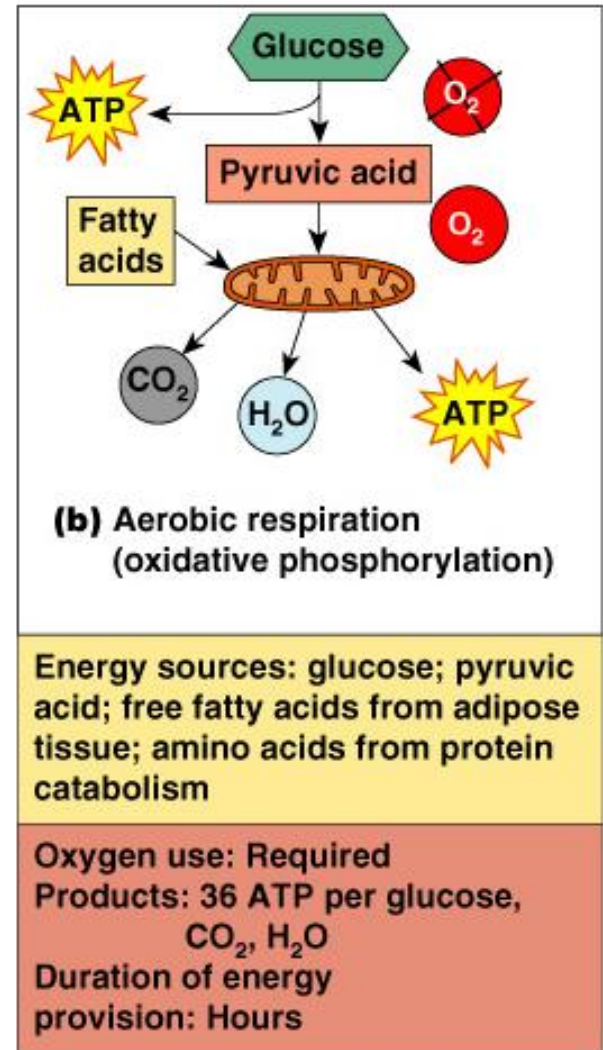
Figure 6.7

# Muscle Response to Strong Stimuli

- Muscle force depends upon the number of fibers that are stimulated
- More fibers contracting results in greater muscle tension
- Muscles can continue to contract unless they run out of energy

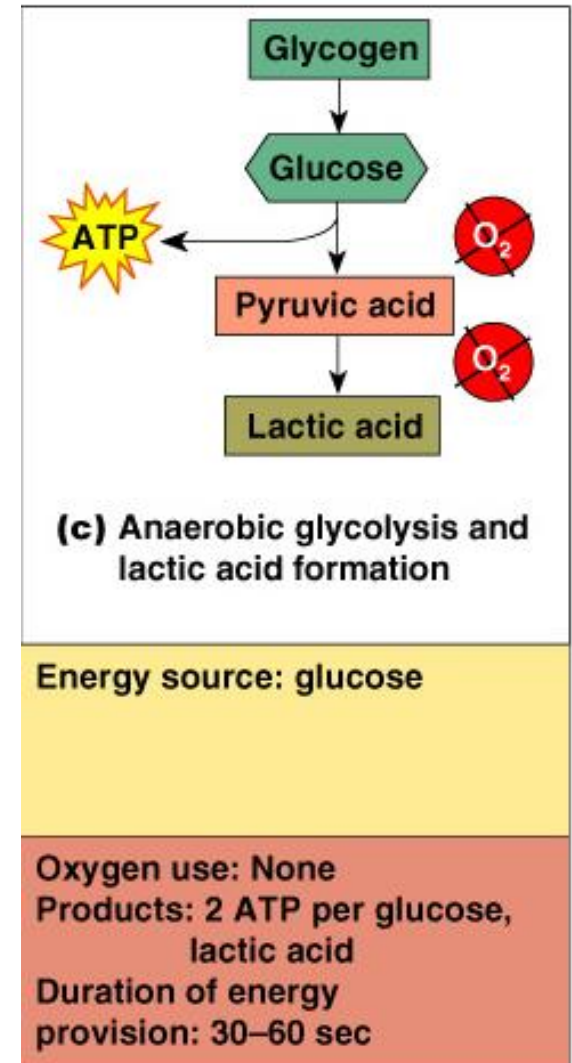
# Energy for Muscle Contraction

- Aerobic Respiration (Cellular respiration)
  - Series of metabolic pathways that occur in the mitochondria
  - Glucose is broken down to carbon dioxide and water, releasing energy
  - This is a slower reaction that requires continuous oxygen



# Energy for Muscle Contraction

- Anaerobic glycolysis
  - Reaction that breaks down glucose without oxygen
  - Glucose is broken down to pyruvic acid to produce some ATP
  - Pyruvic acid is converted to lactic acid



# Muscle Fatigue and Oxygen Debt

- When a muscle is fatigued, it is unable to contract
- The common reason for muscle fatigue is oxygen debt
  - Oxygen must be placed
  - Oxygen is required to rid of accumulated lactic acid
- Increase acidity (from lactic acid) and lack of ATP causes the muscle to contract less