

# MUSCULAR SYSTEM

## 3 Types Muscle Tissue (40-50% of body weight)

### 1) Cardiac

- Involuntary
- Striated
- Contains intercalated disks
- Found in heart

### 2) Smooth (visceral)

- Involuntary
- No striations
- Found in internal organs

### 3) Skeletal

- Voluntary
- Striated
- Attached to bones by tendons
- Primary muscle of system

## 4 Characteristics

- Excitability—
- Contractility—
- Extensibility—
- Elasticity--

## Functions

### 1) Movement (Contraction)

- Prime movers—
- Antagonists—
- Synergists—

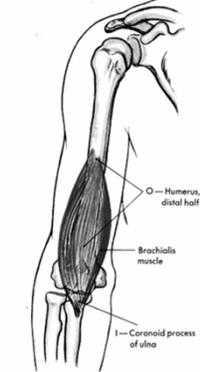
### Prime Mover

- the muscle that provides most of the movement



### Synergist

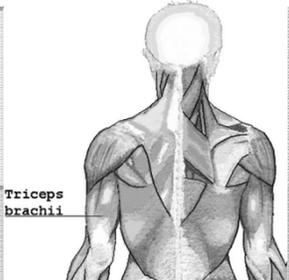
- muscle that assists the prime mover



Brachialis muscle. O. Origin. I. Insertion.

### Antagonist

- the muscle that opposes the action of the prime mover



### 2) Posture

- Tonic contraction—
- Counteracts the force of gravity

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### 3) Heat Production

- 85% of body heat comes from muscle contraction

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### GROSS ANATOMY OF SKELETAL MUSCLE

- Composed of striated muscle cells and connective tissue
- Involves 2 bones with an articulation between them

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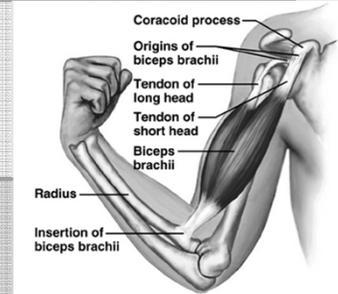
## STRUCTURE (CONT.)

- 1) Origin—
- 2) Insertion—  
 \*\*Insertion always moves toward origin\*\*
- 3) Tendons—
- 4) Bursa—
- 5) Synovial Memb./Fluid—
- 6) Tendon sheaths--

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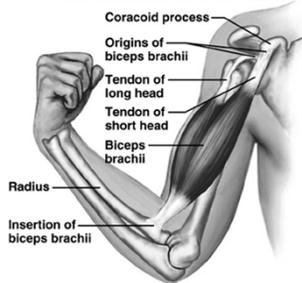
## Origin

- The location where the muscle is attached to the relatively immovable end of the bone



## Insertion

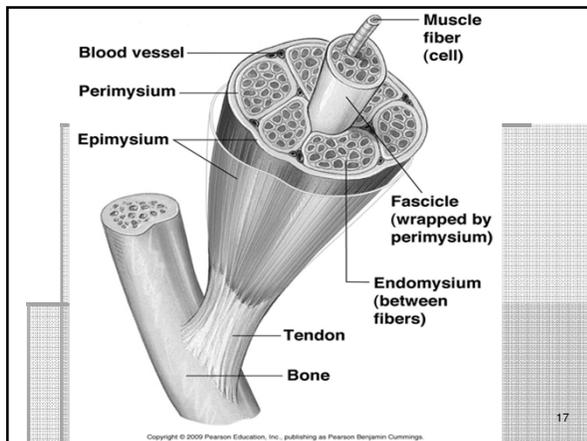
The end of the muscle that is attached to the movable bone



## Microscopic Structure

- Muscle cells are called muscle fibers
- Bundles of muscle fibers are called fascicles.

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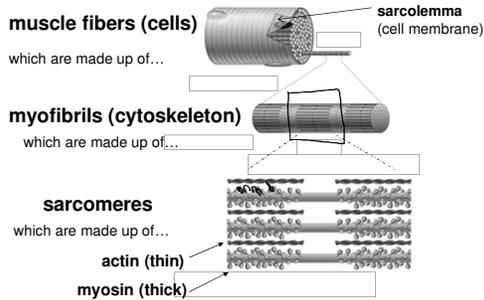
## Connective Tissue Components

- 1) Epimysium—
- 2) Perimysium—
- 3) Endomysium--

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## What are muscles made of?

Skeletal muscle tissue is made up of...



## Parts of Muscle Fibers (cells)

- 1) Sarcolemma—
- 2) Sarcoplasm—
- 3) Sarcoplasmic Reticulum—
- 4) Many mitochondria
- 5) Several nuclei
- 6) Myofibrils/myofilaments

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▪ 4 kinds of protein:

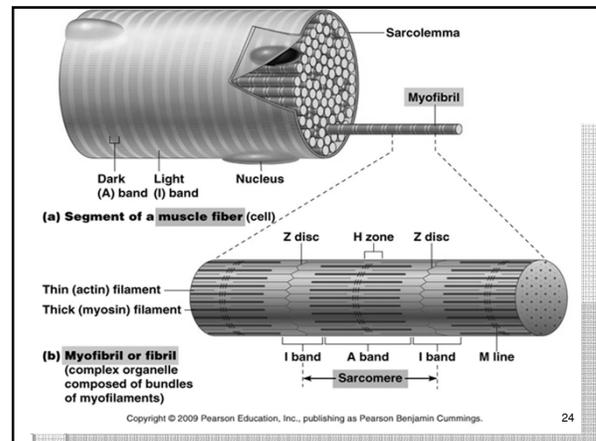
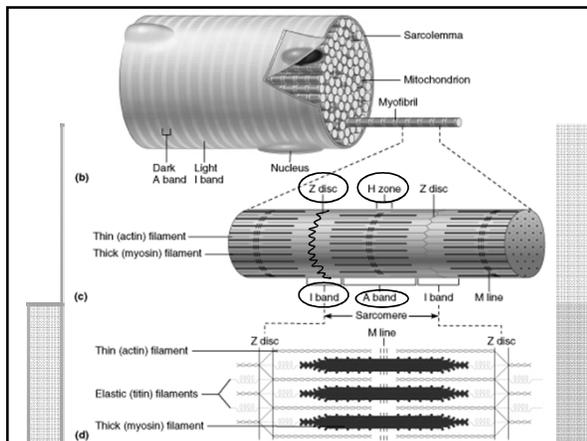
- Myosin—**THICK**
  - Actin
  - Tropomyosin
  - Troponin
- THIN**

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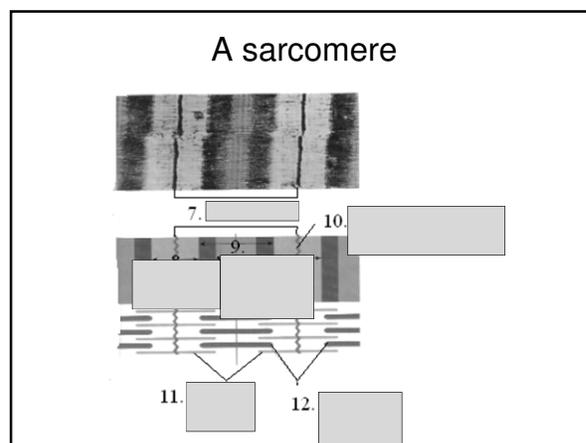
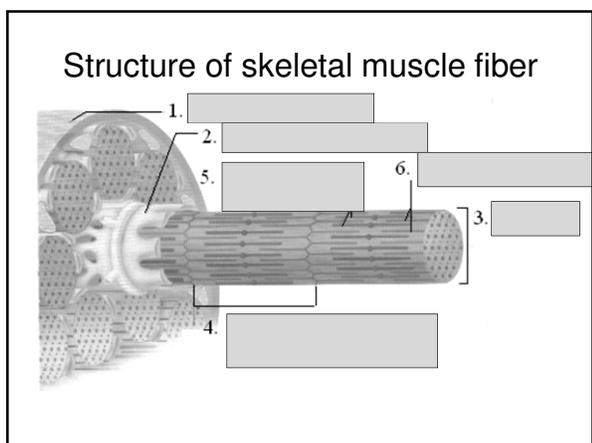
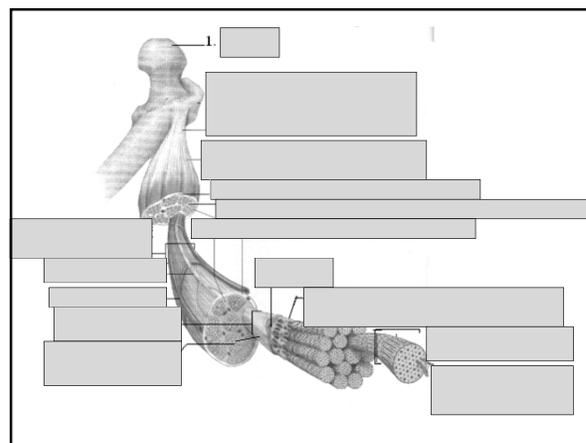
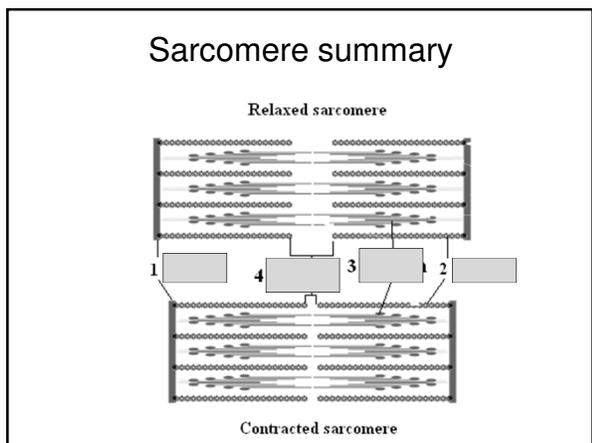
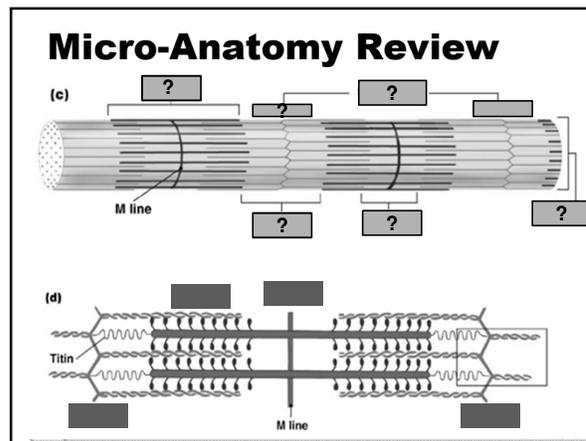
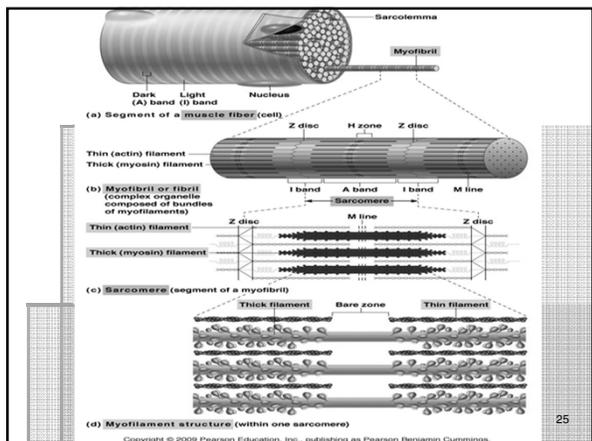
7) Sarcomere—part of myofibril; contractile unit; area between 2 Z-bands; Parts of sarcomere:

- A-bands—
- I-bands—
- H-zone—

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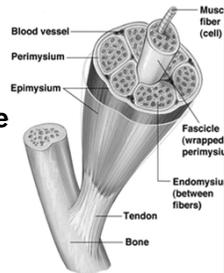
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## Twizzlers Analogy

Use the following terms to create an analogy between packs of Twizzlers and skeletal muscle organization:

epimysium    myofibrils  
perimysium    whole muscle  
fascicle  
muscle fiber (cell)



## Contraction(Read only)

- In a relaxed state, actin & myosin partially overlap.
- During contraction, myosin attaches to actin causing them to move toward each other. This is called the sliding filament theory.
- This shortens the sarcomere, which shortens the muscle fiber.

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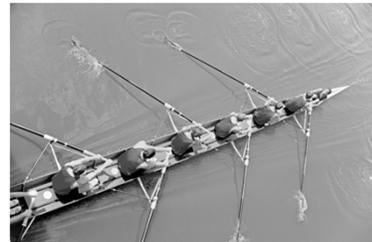
## Contraction (cont.) [Read only]

- When enough muscle fibers contract, the entire muscle will contract.
- 3 requirements:
  - Nerve impulse
  - Calcium
  - ATP

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## The Sliding Filament Theory

Myosin filaments act similarly to a rowing team: the oars (cross bridges) must move in unison to create smooth movement



## Sliding Filament theory

- Boat = Myosin (thick filament)
- Oar = Myosin side arm/heads
- Water = Actin (thin filament)
- Life ring = Calcium

## Process of Contraction

- 1) Nerve impulse (acetylcholine) is received.
- 2)  $Ca^{++}$  released from SR into sarcoplasm.
- 3)  $Ca^{++}$  combines with troponin. This allows myosin heads to attach to actin.
- 4) Filaments pull to center and sarcomere shortens.

\*\*If majority of muscle fibers shorten, then contraction occurs.

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## Relaxation

- Opposite of contraction
- 1) Nerve impulse (acetylcholinesterase) is received.
- 2)  $Ca^{++}$ /troponin complex breaks up.
- 3) This prevents myosin from binding to actin
- 4) Filaments slide apart

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## More Realistic Animation of Muscle Contraction

3-D look into the muscle cell:

(myosin is pink, actin is yellow)

<http://www.dnatube.com/video/1308/Muscle-Contraction>

**Watch it in action**

## The “All-or-None” Principle

Applies ONLY to **individual muscle fibers...NOT** to the entire muscle!

→ If a single muscle cell receives enough stimulus from a neuron, then every sarcomere in that fiber will contract



## All-or-None Principle

- A muscle fiber will contract fully or not at all. There is no partial contraction of a muscle fiber/cell.
- Entire muscles CAN partially contract.
- Threshold stimulus—
- Subthreshold stimulus—

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## MOTOR UNIT (Nervous Tissue Component)

- 1) Motor Neuron
  - Dendrites, Cell body, Axon
- 2) Muscle Fibers
- 3) Neuromuscular Junction — space b/t neuron & muscle fiber

**\*\*KNOW DRAWING!!!!**

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## FATIGUE

- Strength of contraction decreases (no longer respond to ACh)
- Uses up ATP and oxygen
- Creates an oxygen debt & lactic acid build-up

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## Muscle Fatigue

- When a muscle is unable to contract even when stimulated.
- Caused by an **oxygen deficit** from prolonged activity → unable to take in the needed oxygen to supply enough ATP for muscle use



## TYPES OF CONTRACTIONS

- **Twitch**—single stimuli w/ short relax period between
- **Tetanus**—many rapid stimuli w/ no relax
- **Isotonic**—
- **Isometric**—
- \*\***Flaccid**—loss of muscle tone

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## Types of Contractions

- Isotonic → muscle shortens & generates movement



- Isometric → muscle stays long w/ no movement



## EFFECTS OF EXERCISE

- Negative:
  - **Atrophy**
- Positive:
  - **Hypertrophy**—increase in muscle size; helped by **strength training** (isometrics & weights)
  - **Endurance training** —long-term benefit; increases blood flow & # of mitochondria in cell (more ATP)

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## Hypertrophy vs Atrophy

(Muscle growth)      (Muscle shrinkage)

