Muscle (myology - the study of muscle)

Types – Smooth, skeletal, cardiac
Functions –
Motion within
Regulate organ volume
Movement
Stabilized position
Heat Production
Characteristics
Excitability - able to receive/respond to stimuli
Contractibility - the ability to shorten
Extensibility - the ability to lengthen
Elasticity - the ability to return to original size

Skeletal Muscle

Connective tissue

1. Fascia (fibrous connective tissue under skin or around organs) superficial / under skin
   deep -- endomysium (fascia around a single muscle fiber)
   perimysium (fascia around a bunch of muscle fibers)
   epimysium (fascia around the entire muscle)

Muscle structure

1. Muscle → bundle of muscle fibers (fascicle) → muscle fiber -- (single cell covered by a sarcolemma - plasma membrane / filled with sarcoplasm – cytoplasm / has lots of mitochondria for ATP) → myofibril made of sarcomere sections which have a thick filament (w/ the protein myosin and its crossbridges) and a thin filament (w/ actin, troponin and tropomyosin)
2. A myofibril does not run the entire length of the muscle fiber. They run parallel to each other to run the length of the cell. This increases the effect of their contraction.

Muscle Types

Slow twitch	**Fast twitch**
Efficient in using O2	Does not use O2
Delayed muscle firing	Fast to fire
Do not fatigue easily	Tires quickly
Best for – endurance sports	Best for – sprints, pole vaulting etc

Muscular contraction and nervous impulses

A. Events

1. The sequence of events that result in the contraction of an individual muscle fiber begins with a signal—the neurotransmitter, ACh—from the motor neuron innervating that fiber. The local membrane of the fiber will depolarize as positively charged sodium ions (Na^{+}) enter, triggering an action potential that spreads to the rest of the membrane.
2. This triggers the release of calcium ions (Ca^{++}) from storage in the sarcoplasmic reticulum (SR).
3. The Ca^{++} then binds to the troponin to initiates contraction, which is sustained by ATP. The binding of the Ca^{++} unshields the actin binding sites from the myosin. When the actin binding sites are uncovered the myosin crossbridges are free to bind and, with the help of ATP, move the actin filament.
4. One movement is called a power stroke.
5. As long as Ca^{++} ions remain in the sarcoplasm to bind to troponin, which keeps the actin-binding sites "unshielded," and as long as ATP is available to drive the cross-bridge cycling and the pulling of actin strands by myosin, the muscle fiber will continue to shorten to an anatomical limit.
6. Muscle contraction usually stops when signaling from the motor neuron ends, which repolarizes the sarcolemma and T-tubules, and closes the voltage-gated calcium channels in the SR. Ca^{++} ions are then pumped back, using ATP, into the SR, which causes the tropomyosin to reshield (or re-cover) the binding sites on the actin strands.
7. A muscle also can stop contracting when it runs out of ATP and becomes fatigued

B. Rigor mortis results when death leads to a leaking out of the Ca^{+2} ions from the sarcoplasmic reticulum into the sarcoplasm of the muscle cell. This causes the troponin to uncover the myosin binding sites and a power stroke to occur. However, since the person is dead, there is no ATP available to detach the myosin cross bridges. This leads to a sustained contraction - stiff

C. Energy

1. ATP - there is enough stored for 5 seconds of contraction
2. Creatine phosphate - there is enough stored for 15 seconds of contraction

3. Anaerobic respiration (glycolysis) - the breakdown of stored glucose stored as glycogen, to create pyruvic acid and ATP - enough energy for 30 seconds
4. Aerobic respiration uses pyruvic acid and oxygen to create ATP. This can provide energy as long as oxygen and nutrients last. Aerobic is the muscle's preferred choice since it can last the longest.

D. All or none principle

1. In order to contract, muscles need a certain level of stimulus, the threshold, from a nerve. If the impulses is not up to the level, the muscle will not contract at all.
2. Muscle fibers do not partially contract. If there is a weak muscular action, it is not because the fibers contracted weakly. Muscles fibers always contract to their full ability. A weak muscle action is because only a few muscle fibers contracted. It's a number thing.

E. Homeostasis

1. Oxygen debt - the amount of oxygen necessary to return body systems to normal after heavy exercise. Lactic acid accumulation in muscle tissue causes the hard breathing needed to pay the debt
2. Muscle fatigue - the inability of a muscle to sustain its contractile strength. Sustained contraction leads to a body depletion of oxygen and glycogen. The inability of muscle to "go on" causes them to stop, so that oxygen and glycogen levels can be returned to normal.
3. Heat - 85% of the energy in muscles can be released as heat to cool the body. When the body is cold, shivering will generate heat to warm it back up

F. Contraction types - depends of stimulation frequency

1. Twitch - a brief contraction of all fibers in a motor unit from a single action potential
   - Latent period
   - Contraction period
   - Relaxation period
   - Refractory period
2. Tetanus - a sustained contraction or short relaxation period. Comes from multiple action potentials arriving near the end of, or after the refractory period. Most voluntary movements are of this type
3. Isotonic - when a muscle contracts and pulls on another structure to create motion

4. Isometric - when a muscle contracts and pulls on another structure, but no motion occurs. EX - Pushing with all your strength against a building

G. Muscle tone

1. A sustained partial contraction, no motion. Some, but not many, muscle fibers are contracting at a time. EX - posture

H. Abnormalities

1. Hypotonia - decreased muscle tone, flaccid
2. Hypertonia - increased muscle tone, rigid

I. Muscular size

1. Muscular atrophy - wasting away of muscle tissue. Caused by inactivity. Complete atrophy can be caused by a loss of the nerve supply to the muscle. This will cause atrophy and the muscle tissue will be replaced by fibrous tissue. This is an irreplaceable loss
2. Muscular hypertrophy - increase in muscle size due to an increase in use. Muscles do not increase in number after birth. Therefore Pee Wee Herman can NEVER get as muscular as Mr. Universe no matter how much he lifts weights. Conversely, Mr Universe could never become Pee Wee Herman size, since he has more muscle

Cardiac Muscle

A. Characteristics

1. Involuntary 2. Branching 3. Striated striped
4. Shorter, thicker, more square shaped than skeletal

B. Arrangement

1. The atria have one network (a branching and interconnection of muscle fibers), while the ventricles have a 2nd.
2. Fibers within a network are connected by intercalated discs which have a gap junction to speed along impulses.

C. Differences

1. Cardiac tissue beats continuously, we hope, so needs a constant energy supply
2. Cardiac tissue causes its own contractions, its own nervous impulses, in the pacemaker. This is called autorhythmicity .
3. Cardiac tissue has a long refractory period. This reduces the possibility of tetanus - a stopped, contracted heart.

Smooth Muscle

A. Characteristics

1. Involuntary 2. Found in organs 3. Not striped
4. Flexible

B. Types
    1. Visceral
        a. Large sheets that form a continuous network of muscle
        b. The whole sheet responds to a single impulse, not singly like skeletal muscle
        c. Found in small blood vessels, stomach, intestines, uterus, bladder.
        d. More common type of smooth muscle
    2. Multiunit smooth muscle
        a. Acts like skeletal with individual fibers contracting individually.
        b. Found in large blood vessels, large lung airways, arrector pili muscles (hair)

C. Differences
    1. Longer contractile periods than skeletal
    2. Can sustain a contraction longer = more tone
    3. Can be stimulated by nervous impulses, hormones, pH, gas levels, temperature.
    4. More extensible

How Movement is Produced

A. Origin and insertion
    1. Skeletal muscles pull on bones through tendons. Muscles are attached at both ends to bone. The tendon attached to the stationary bone is called the origin. The other tendon, attached to the moving bone, is called the insertion.
    2. The middle part of the muscle is called the belly.

B. Actions
    1. Antagonistic – muscles are paired in an antagonistic relationship. EX. Biceps pull the forearm up and triceps pull it back.
    2. Types
        a. Agonist – the primary muscle causing the action – bicep flexing the elbow
        b. Antagonist – relaxed during the motion of the agonist, but contracts to return the moved part to its original position – tricep extending out the elbow.
        c. Synergist – assists the agonist – the anconeus muscle helps the

bicep

d. Fixators – stabilizes the agonist - the rotator cuff muscles stabilize the bicep's motion

Naming Skeletal Muscles

Muscle can be named using a variety of parameters.

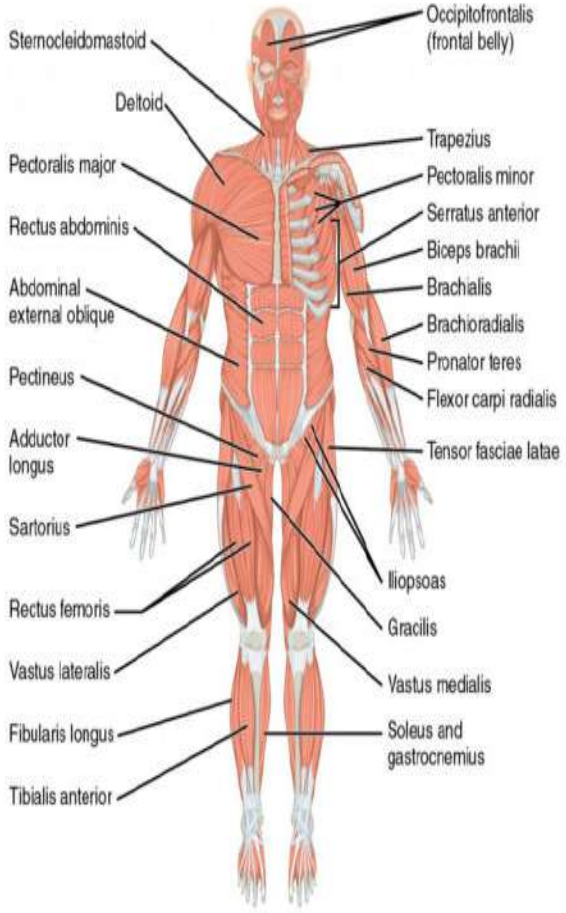
Naming Skeletal Muscles

Named according to a number of criteria:

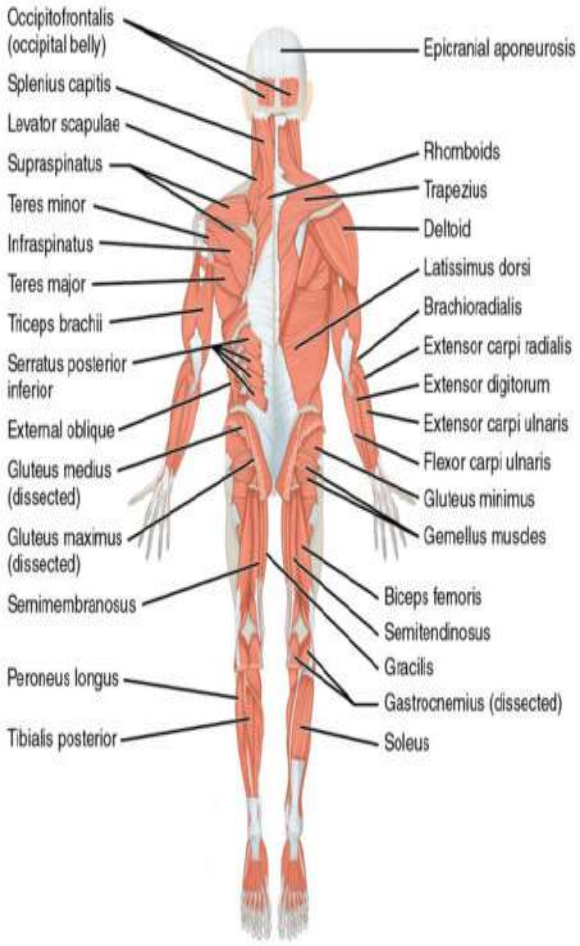
- **Direction of muscle fibers relative to longitudinal axis of the muscle**
  - **Rectus:** Fibers oriented straight with respect to longitudinal axis
  - **Oblique**: Fibers run at an angle to the longitudinal axis
  - **Orbicularis:** Fibers run in a circular path
- **Relative size**
  - **Major** for bigger and **minor** for smaller;
  - **Maximus** for biggest, **intermedius** for middle and **minimus** for smallest
  - **Longus** for longest and **brevis** for shortest.
- **Location**
  - **Pectoralis major** is found in the chest region
  - **Rectus femoris** is found near the femur
- **Location of the origin and insertion**
  - **Brachioradialis** attaches to the humerus (**origin**) and the radius (**insertion**)
- **Number of origins**
  - **Biceps** means two heads
  - **Triceps** means three heads
- **Shape**
  - **Deltoid** means triangular in shape.
  - **Trapezius** is shaped like a trapezium or kite
- **Action**
  - **Flexor** and **extensor**
  - **Adductor** and **abductor**

Muscle you should know – see next page

Major Muscles of the Body



Anterior view
Right side: superficial; Left side: deep



Posterior view
Right side: superficial; Left side: deep