Objectives

1. Describe how action potential is initiated in a muscle cell.
2. Describe events in muscle cell contraction.
3. Describe 3 ways in which ATP is regenerated during muscle activity.
4. Define muscle fatigue and oxygen debt
5. Distinguish between types of exercise and the effect on muscles

SKELETAL MUSCLE ACTIVITY

• Properties of muscle:
  – Irritability – ability to receive & respond to stimuli
  – Contractility – ability to shorten upon receipt of stimuli

Definitions

• Motor unit
  – One neuron and all the skeletal muscle cells it stimulates

• Neuromuscular junction
  – Junction between the axon terminal of neuron and sarcolema of muscle

• Synaptic cleft
  – Fluid filled gap between them

A) Nerve Stimulus & Action Potential

• Structure of a neuromuscular junction
  – Axon – long cytoplasmic extensions of the cell body; wrap in protective fatty tissue called myelin sheath
  – Axonal terminals – end branchings of neuron
  – Dendrites – branchings of the cell body that receive stimuli
  – Synaptic cleft – gap between axonal terminals and sarcolema of muscle cell

B) Activities at the Neuromuscular Junction

1. Nerve impulse is received by the dendrites & travels along the neuron reaching the axonal terminals
2. A neurotransmitter called acetylcholine or ACh is released
3. ACh diffuses into the synaptic cleft & attaches to proteins of the sarcolemma
4. Sarcolema becomes temporarily permeable to Na+

http://www.blackwellpublishing.com/matthews/nmj.html
5. Rapid intake of Na+ into the muscle cell causes an excess of positive ions in the cell
6. The electrical condition of the sarcolemma is upset causing a current called the action potential
7. Action potential runs the length of the sarcolemma conducting electrical impulses

8. Once activated by the current the sliding filament theory occurs
9. Cross bridges of thick filaments spin and attach to the thin filaments
10. Thin filaments are pulled inward causing the H zone to disappear
11. This shortens the sarcomere causing a contraction to occur

http://highered.mcgraw-hill.com/sites/0072437316/student_view0/chapter42/animations.html#

- In order for cross bridges to join to thin filaments Ca ions are needed
- Sarcoplasmic reticulum releases stored Ca
- As muscle relaxes Ca is reabsorbed & cell returns to its original length

**Energy Systems**

- As muscles contract ATP is broken down to provide energy
- Muscles only store enough ATP to last 4 - 6 secs; enough to begin contraction
- ATP is continuously regenerated by 3 pathways

1. **Phosphorylation of ADP by Creatine Phosphate**
   - Creatine Phosphate (CP) is found in muscle fibers
   - A high energy phosphate is removed from CP and joined to ADP (adenosine diphosphate) to form ATP
   - Last for about 20 secs

2. **Aerobic Respiration**
   - Used at rest or light activity
   - Break down of glucose using oxygen
   - Glucose is broken down into CO₂ and H₂O
   - Energy that is released is captured in ATP
   - 36 molecules of ATP are generated for 1 glucose
   - Slow process
   - Requires constant supply of oxygen & nutrients
3. Anaerobic Respiration & Lactic Acid Fermentation

- Used during intense activity
- Break down of glucose without oxygen
- Generates 2 ATP for each glucose
- Faster process
- Requires large amounts of glucose and accumulates lactic acid which fatigues muscle

Types of Muscle Contractions

- Isotonic
  - “same tone”
  - Myofilaments successfully slide, sarcomere shortens & movement occurs
  - Bending knee or elbow
- Isometric
  - “same measurement”
  - Myosin heads “spin their wheels” creating tension but no movement
  - Pushing a wall

Muscle Fatigue and Oxygen Debt

- Muscle fatigue- unable to contract; sometimes happens in marathon runners.
- Oxygen debt- occurs to some extent with all activity; causes rapid breathing
- Muscle tone- not voluntarily controlled; some fibers are always contracting
- Flaccidity- loss of muscle tone

Effect of Exercise on Muscles

- Aerobic exercise- stronger, more flexible muscles that resist fatigue (no increase in size)
  - Blood supply increases
  - Mitochondria increase (more O$_2$)
  - Heart enlarges
  - Fat deposits clear from blood vessels
  - Lungs more efficient
  - Jogging, biking, aerobics

Effect of Exercise on Muscles

- Resistance (isometric)- forcing muscles to contract with as much force as possible
  - Muscle cells enlarge (increased muscle size)
  - Connective tissue reinforcement also increases
  - Will not improve endurance