Energy for Contraction:

- ATP supplies the energy needed for the muscle fiber to:
  - move & detach cross bridge
  - pump Ca back to SR
  - pump Na & K back into cell
- When are available stores of ATP depleted in: 4-10 seconds
- What are the energy sources for contraction: ATP ONLY
- ATP Production
  - anaerobic pathway
    - glycolysis
    - lactic acid formation
  - aerobic pathway
- Anerobic pathway
  - Lactic acid and glycolysis formation
  - ATP can be generated by breaking down and using energy stored in glucose
  - Glycolysis

```
GLUCOSE 2 ATP 2 NAD+  
↓                       ↓
GLYCOLYSIS             ↓
PYRUVATE 4 ATP 2 NADH
```

- Glucose breakdown
  - Oxygen required? NOPE
  - Lots of O2 present → mitochondria
  - Aka: aerobic
  - No or less O2 present → lactic
  - Aka: anaerobic

- Aerobic Respiration
  - 95% of ATP during rest to light moderate exercise
  - Slower than anaerobic
  - Occurs in mitochondria and requires oxygen
  - Fuel: 1 glucose
    - 2 fatty acids
Muscle Fatigue

- After 30 min fuel: fatty acids

why? 

- Physiological inability to contract despite continued stimulation
- Occurs where there are: ionic imbalances
  - Levels of K, Ca, Cl can interfere with excitation
  - Prolonged exercise may also damage SR and interfere with Ca^2+ regulation and release
- Lack of ATP is rarely a reason for fatigue, except for severely stressed muscles marathon

For a muscle to return to its pre-exercise state:
  - Oxygen: reserved & replenished
  - Lactic acid: \( \rightarrow \) pyruvic acid
  - Glucose: stored & replace
  - ATP & creatine phosphate: reserved & resynthesized

Factors of Muscle Contraction

- The force of contraction depends on the number of cross bridges attached, which is affected by four factors:
  - 1. \# muscle fibers stimulated
  - Recruitment
  - Relative size of fibers
  - The bulkier the muscle the more tension can develop
  - Muscle cells can \( \uparrow \) in size, hypertrophy with regular exercise
  - 3. Freq of stimulation
  - Higher the freq, greater the force
  - 4. Degree of stretch
  - Muscle fibers with sarcomeres that are 80-120\% of their normal resting length generate more force
  - Less than 80\%, filaments overlap too much and force decrease
  - Greater than 120\%, filaments don't overlap enough so force decrease
Velocity and duration of Contraction

- How fast a muscle contracts and how long it stays contracted is determined by:
  - Muscle Fiber Type
    - Speed of contraction
    - Metabolic pathway
      - Oxidative
      - Glycolytic
        - Slow oxidative
        - Fast oxidative
        - Fast glycolytic
  - Load
  - Recruitment

- 1. Muscle Fiber Type
  - Speed of contraction
    - Slow or fast fibers
      - According to speed myosin ATPase splits ATP
      - Pattern of electrical activity of motor neurons
  - Metabolic pathway used for ATP synthesis
    - Oxidative fibers: aerobic → w/ O2
    - Glycolytic fibers: anaerobic → w/o O2

- Based on these criteria, skeletal muscle is classified
  - Slow oxidative
  - Fast oxidative
  - Fast glycolytic

<table>
<thead>
<tr>
<th></th>
<th>Type I: Slow Oxidative</th>
<th>Type IIA: Fast Oxidative/Glycolytic</th>
<th>Type IIB: Fast Glycolytic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twitch Speed</td>
<td>Slow</td>
<td>Fast</td>
<td>Fast</td>
</tr>
<tr>
<td>Twitch Force</td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td>Resistance to Fatigue</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

- Slow oxidative fibers
  - Oxygen storage: high
  - ATP use: slow
  - Lactic acid build up: none, ATP made
  - Fatigue: resistant
  - Suited for: low-endurance activity
- Fast Oxidative fibers
  - Oxygen storage: high
  - ATP use: fast
  - Lactic acid build up: medium
  - Fatigue: easily short intense
  - Suited for: powerful

- Fast glycolytic fibers
  - Oxygen storage: none
  - ATP use: fast
  - Lactic acid build up: medium
  - Fatigue: easily
  - Suited for: short intense

- 2. Load
  - Muscles contract fastest when: no load
  - Greater the load (2): shorter contraction duration slower contraction

- 3. Recruitment
  - Define: more motor units contracting faster & more prolonged contraction

Adaptation to exercise
- Aerobic exercise:
  - Muscle capillaries
  - Number of mitochondria
  - Myofibrillar synthesis
    - Results in greater endurance, strength and resistance to fatigue
    - May convert fast glycogenic to fast oxidative

- Resistance exercise:
  - Muscle hypertrophy
    - Due to increase in fiber size
    - Increased mitochondria, myofilaments, glycogen storages, and connective tissue
    - Increase muscle strength and size

Clinical: Homeostatic Imbalance
- Muscles must remain active to be active
- Disuse Atrophy:
  - Due to: degeneration loss of mass
○ Can begin: **almost immediately**

- Per day muscle decline: 5%
- Paralyzed muscle may atrophy: ¼ of size
- What replaces lost muscle tissue: impossible
- Rehab?

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**THE END**

Ex 3 prep Brindley  
- Kahoot