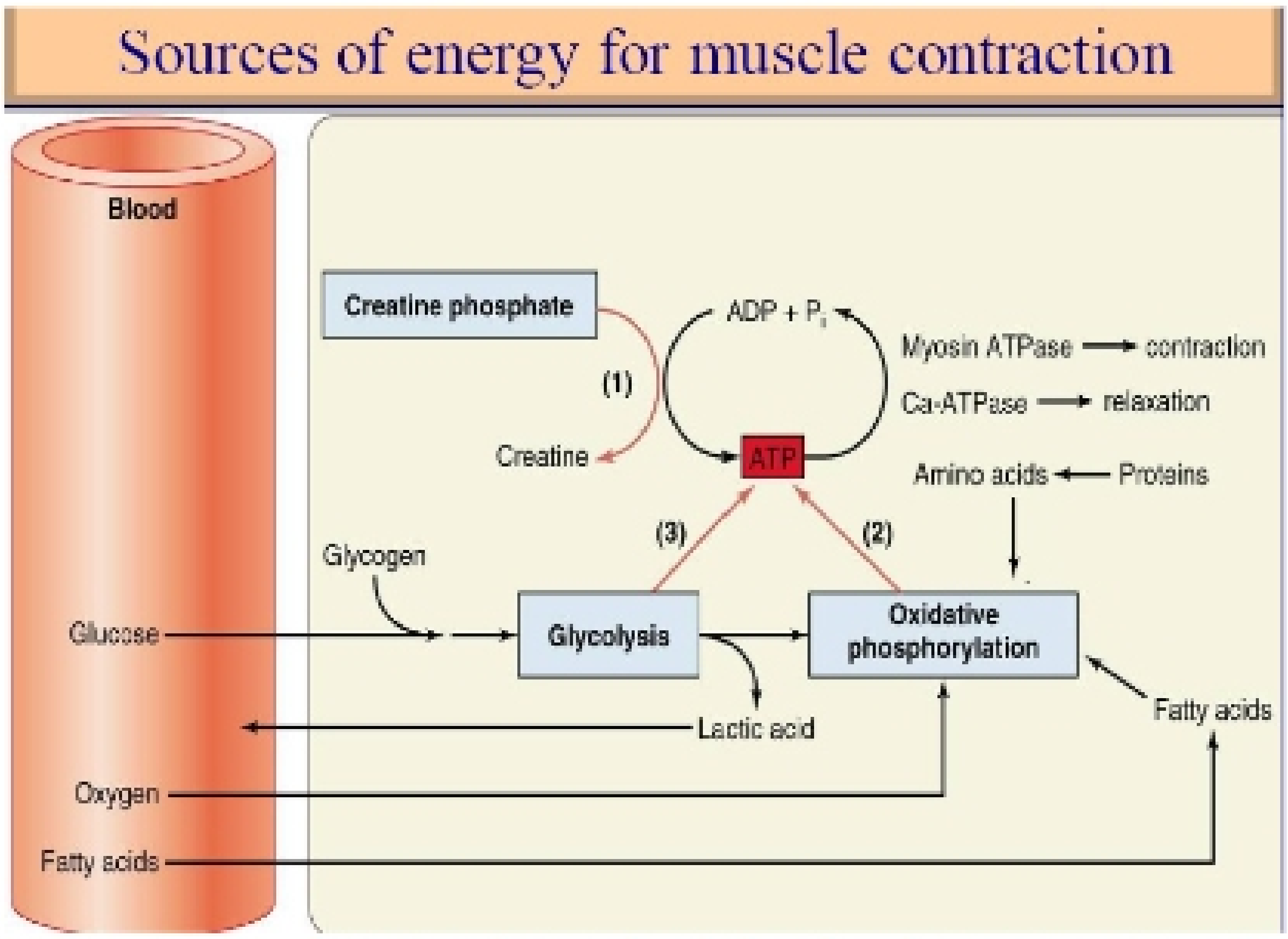
Exam 7 Physiology Study Guide

*Our muscles need a ton of ATP for both movement and relaxation
<u>Muscle Making ATP</u> (2 big categories of making ATP = substrate / oxidative phosphorylation)
(Substrate level (3): Glycolysis, Kreb's, and creatine phosphate)



1. Creatine phosphate via substrate level phosphorylation (1 creatine phosphate => 1 ATP)
    - -Move phosphate attached to creatine to ADP to create (equation 1 in opposite direction)
    - -Initial source of ATP – only takes 1 step to make (vs. glycolysis – 10 steps)
        - -Used to start moving muscle, but quickly gone
    - -Limited supply: we can only have so much creatine phosphate in our muscles
        - -Ex: Body builders who try to pack in creatine phosphate to get more quick muscle movement → changes osmolarity in our muscles (water rushes in)
            - -Get swelling in muscles from water
        - -Too much creatine can become toxic
    - -Supply is replenished during relaxation (creatine → creatine phosphate)
2. Glycolysis – Break down of sugars from blood or glycogen (stores sugar)
        - *Athletes carb load before endurance race – increases glycogen storage
    - -1 sugar → 2 ATP
    - -Used alone during intense/prolonged activity (typically anaerobic)
        - -Used with other processes during aerobic activity too
    - -Can be anaerobic (no oxygen) → produce lactic acid
    - -Components replenished during relaxation → remove lactic acid from muscles
3. Oxidative Phosphorylation (Electron Transport Chain)
    - -1 process → 32-34 ATP
    - -Continued supply during moderate exercise (can't overuse oxygen supply)
    - -ONLY aerobic
4. Kreb's Cycle (ONLY aerobic) – relies on recycling products from oxidative phosphorylation

-1 process → 2 ATP
-Amino acids/fatty acids start in the Kreb's cycle

Whole Muscles

-Contraction produced by cross-bridge cycling by many sarcomeres (contraction ≠shortening)
-Bigger the contraction = more sarcomeres involved
-Generates a mechanical force = **Tension** → from myosin heads pulling on actin fibers
-Allows us to move a load from point A to B (like tug-of-war)
-Opposed by the load that we are moving
-Ex: If bicep being used, load includes weight of forearm (vs. exercise phys)
-Holding a 10 kg weight → load is more than 10 kg

*Muscle shortening depends on **tension** > **load** → necessary for body movement
*Can work muscles without joints changing position/size → contraction ≠shortening

Contractions:

-**Isometric**: same length, no change in length of muscle
-Pushing/pulling on loads that are way too big → contractions still occurring!
Ex: Bronson tries to lift podium which is bolted to floor
-Tension < load = NO shortening

-**Isotonic**: No change in tension → muscle maintains specific level of tension
-Done most often, muscle does shorten (tension just above load)
-Tension > load → shortening
*More tension → more cross bridge cycling → more ATP spent
-Not going to spend more than necessary!

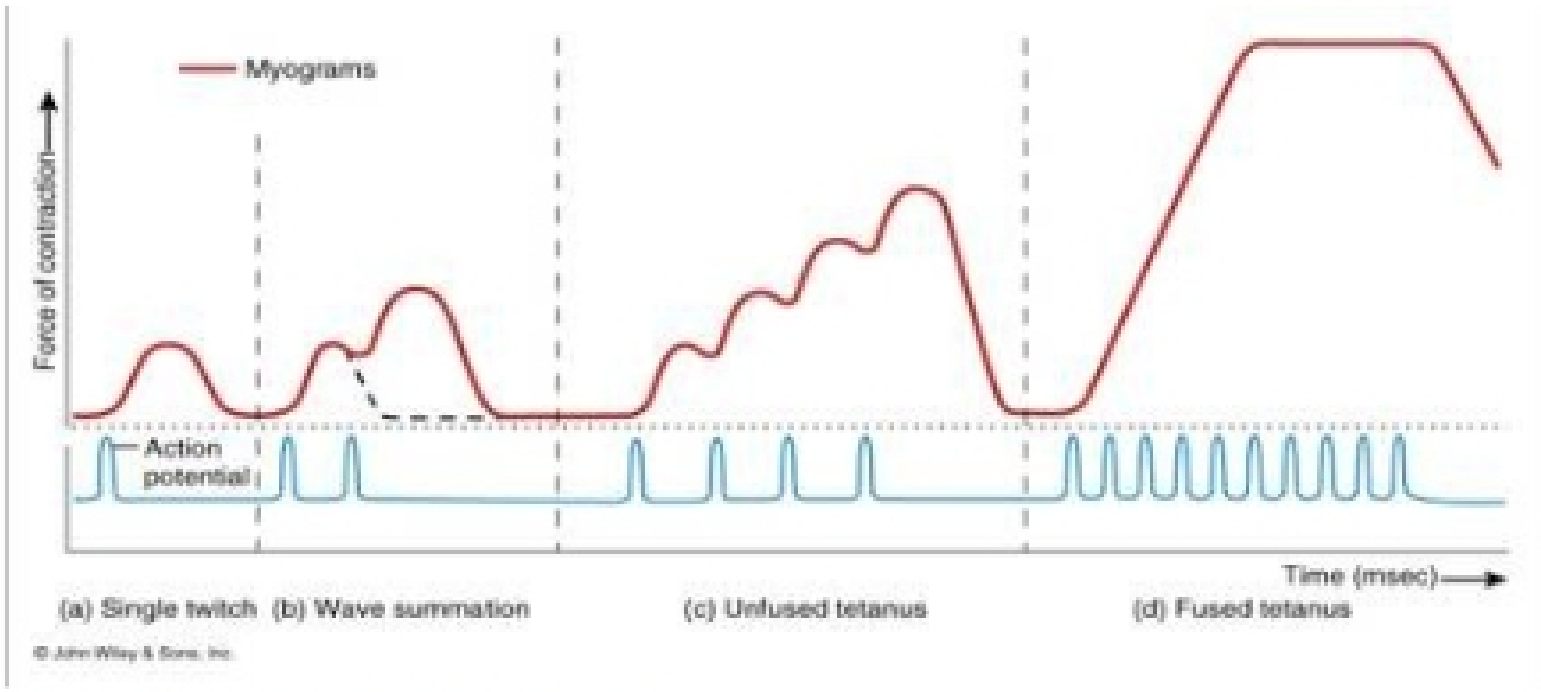
-**Eccentric**: Muscle lengthens
-Muscle must deal with the load present (unlike isometric) b/c its being supported across the muscle (Isometric – load is supported by something other than muscle)
-Load > tension

Isotonic contraction – degree of contraction related to load
-Initial period of isometric contraction → tension < load
-Isometric contraction must happen first → increasing tension
-Ex: initial grunting of large weightlifters before can start moving weight to build enough tension (longer grunting time needed to lift heavier loads)
-Shortening begins after tensions *exceeds* load

*Relationships btw load and isotonic contraction:
-Increase of load: Increase latency (longer isometric contraction)
Decrease velocity (how fast process occurs)
Decrease response (can only fully contract bicep w/ light weight)

Impact of Repeated Stimulus (APs)

-Tension is summed (only if muscle is hit w/ a 2nd stimulus before it reaches "zero")
-Tension builds (like multiple depolarizations hitting postsynaptic cell)
-Maintained contraction = **tetanus**: just a size (not disease)
-Unfused: Partial relaxation between stimuli (lose some tension)
-Fused: no time between stimuli to return calcium → maximum contraction
-ATPase activity can't keep up with calcium present to put some away
*Want to do this when want higher tension levels in muscles



<u>Differences Between Myofibers</u>

1. Speed of contraction of cross-bridge cycle (runners: fast twitch vs. slow twitch)
    a. Fast vs. slow → depends on enzymes used to breakdown ATP (speed differs)
    b. Differ with respect to amount of ATPase activity
    c. Hydrolyzing ATP on cross-bridge
        *Fast contractions deplete ATP more quickly (but create more tension)
        *Slow contraction lasts longer but not as fast (Ex: Prius vs. race car)
2. Mechanism for Making ATP → aerobic vs. anaerobic
    -Oxidative: Maintain oxygen supply → aerobic
        -Vascularized: Many blood vessels around myofiber to keep it oxidated
            Ex: varicose veins – new vessels created (not a fixed system)
        -Oxygen: Small/nonpolar = can cross plasma membrane (want to keep in cell)
            *Must trick the gradient by packing outside or binding oxygen to big amphipathic protein that cant cross PM = **myoglobin** (Stores O_2 in cells)
                -Athletes may target myoglobin levels to increase endurance
    -Glycolytic: Anaerobic (No oxygen)
        -Few mitochondria → why take energy to build them if not used?
        -1 glucose → 2 ATP (20 micrometers of movement)
            *Must have a boatload of glucose (strung together by **glycogen** to help decrease osmolarity - otherwise cell would swell → hypertonic)
                -Ex: Carb-loading sets up body (glucose available for aerobic and also when become anaerobic)

<u>3 Types of Fibers (Dark, light, medium)</u> → from combination of 2 categories above

1. Slow enzyme – oxidative: low ATPase activity/use, high ability to make ATP
    -Tension remains constant over time (but not high level)
    -Ex: Like a 6-figure maker living at poverty level
    -Very sustainable → making tons of ATP and using little
        -Not generating as much tension overall
        -Like a Prius → not fast, but lasts a long time (endurance)
2. Fast enzyme – oxidative (glycolytic occurs first): high ATPase activity
    -Higher tension levels that decrease over time
        -inputs remain the same, but outputs (usage) increasing due to faster cross-bridge cycling occurring → fatigue
3. Fast enzyme – Glycolytic: high ATPase, high glycolytic
    -Most tension created, but drops rapidly