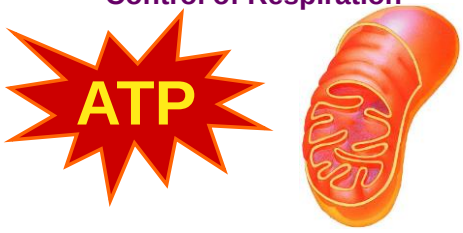
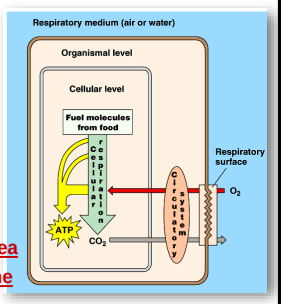
Chapter 9.x

Cellular Respiration: Gas Exchange, Other Metabolites & Control of Respiration



Gas Exchange

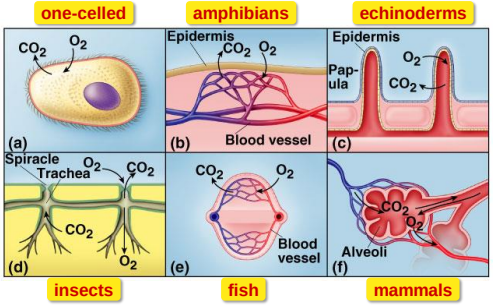
- O_2 & CO_2 exchange
  - provides O_2 for aerobic cellular respiration
  - exchange between environment & cells
    - need high surface area
    - need moist membrane



Optimizing Gas Exchange

- Why high surface area?
  - maximizing rate of gas exchange
  - CO_2 & O_2 move across cell membrane by diffusion
    - rate of diffusion proportional to surface area
- Why moist membranes?
  - moisture maintains cell membrane structure
  - gases diffuse only dissolved in water

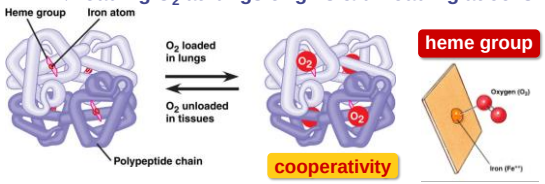
Gas Exchange in Many Forms…



size | water vs. land | endotherm vs. ectotherm

Hemoglobin

- Why use a carrier molecule?
  - O_2 not soluble enough in H_2O for animal needs
    - blood alone could not provide enough O_2 to animal cells
    - hemocyanin in insects = copper (bluish)
    - hemoglobin in vertebrates = iron (reddish)
- Reversibly binds O_2
  - loading O_2 at lungs or gills & unloading at cells

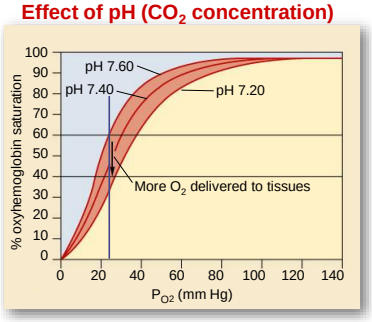


O_2 Dissociation Curve for Hemoglobin

Bohr Shift

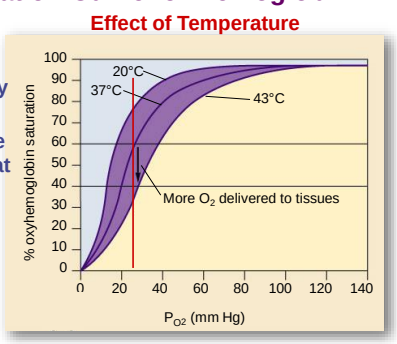
- drop in pH lowers affinity of Hb for O_2
- active tissue (producing CO_2) lowers blood pH (carbonic acid) & induces Hb to release more O_2

Effect of pH (CO_2 concentration)



O_2 Dissociation Curve for Hemoglobin

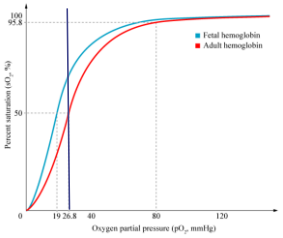
- increase in **temperature** lowers affinity of Hb for O_2
- active muscle produces heat



Fetal Hemoglobin (HbF)

- HbF has greater attraction to O_2 than Hb
  - low O_2% by time blood reaches placenta
  - fetal Hb must be able to bind O_2 with greater attraction than maternal Hb

2 alpha & 2 gamma units

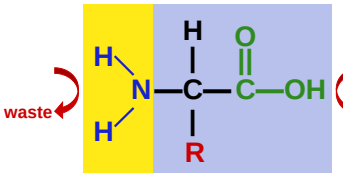


Beyond glucose: Other carbohydrates

- Glycolysis accepts a wide range of carbohydrates fuels
  - polysaccharides → → → glucose (hydrolysis)
    - ex. starch, glycogen
  - other 6C sugars → → → glucose (modified)
    - ex. galactose, fructose

Beyond glucose: Proteins

- proteins → → → → → amino acids (hydrolysis)

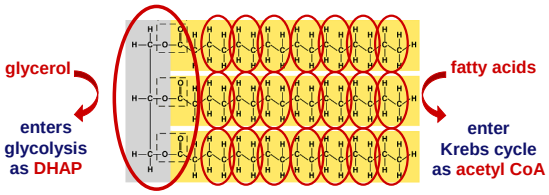


amino group = waste product excreted as ammonia, urea, or uric acid

carbon skeleton = enters glycolysis or Krebs cycle at different stages

Beyond glucose: Fats

- Fats → → → → glycerol & fatty acids (hydrolysis)
  - glycerol (3C) → → DHAP → → glycolysis
  - fatty acids → 2C acetyl groups → acetyl coA → Krebs cycle

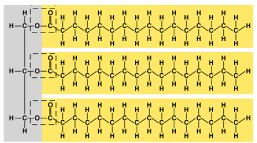


Carbohydrates vs. Fats

- Fat generates 2x ATP vs. carbohydrate
  - more C in gram of fat
  - more O in gram of carbohydrate
    - so it's already partly oxidized

carbohydrate

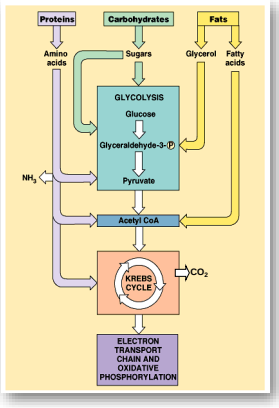
fat



Check the energy per gram listings on the Nutritional Fact sheet on all foods

Metabolism

- Coordination of digestion & synthesis
  - by regulating enzyme
- Digestion
  - digestion of carbohydrates, fats & proteins
    - all catabolized through same pathways
    - enter at different points
  - cell extracts energy from every source



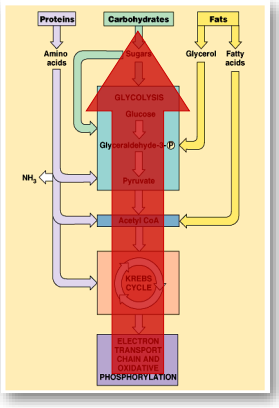
Metabolism

- Coordination of digestion & synthesis
  - by regulating enzymes
- Synthesis
  - enough energy? build stuff!
  - cell uses points in glycolysis & Krebs cycle as links to pathways for synthesis
    - run the pathways "backwards"
      - eat too much fuel, build fat

pyruvate → → glucose

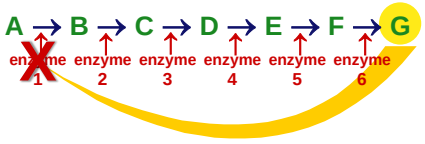
Krebs cycle intermediaries → → amino acids

acetyl CoA → → fatty acids



Feedback Inhibition

- Regulation & coordination of production
  - production is self-limiting
  - final product is inhibitor of earlier step
    - allosteric inhibitor of earlier enzyme
  - no unnecessary accumulation of product



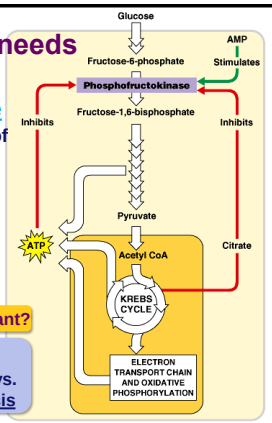
G is an allosteric inhibitor of enzyme 1

Respond to cell's needs

- Key points of control
  - phosphofructokinase
    - allosteric regulation of enzyme
      - "can't turn back" step before splitting glucose
    - ↑ [AMP] & [ADP] stimulate (activators)
    - ↑ [ATP] inhibits
    - ↑ [citrate] inhibits

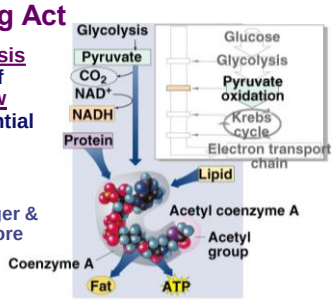
Why is this regulation important?

Balancing act:
availability of raw materials vs. energy demands vs. synthesis



It's a Balancing Act

- Balancing synthesis with availability of both energy & raw materials is essential for survival!
  - do it well & you survive longer
  - you survive longer & you can have more offspring
  - you have more offspring & your genes get to "take over the world!!!"



Acetyl CoA is central to both energy production & synthesis
make ATP or store it as fat