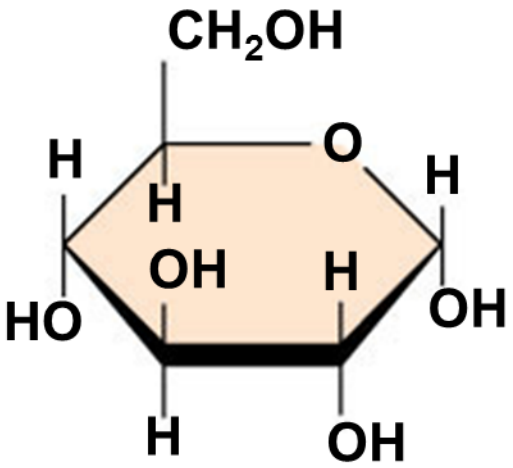
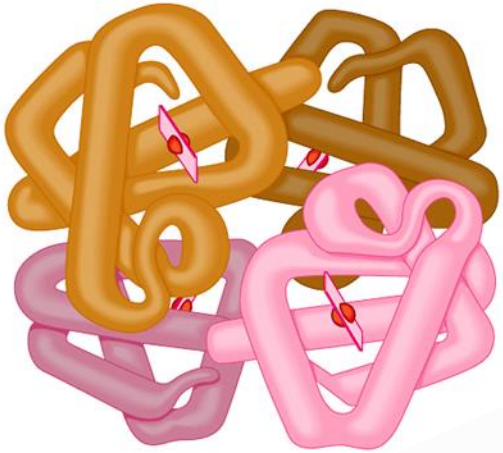
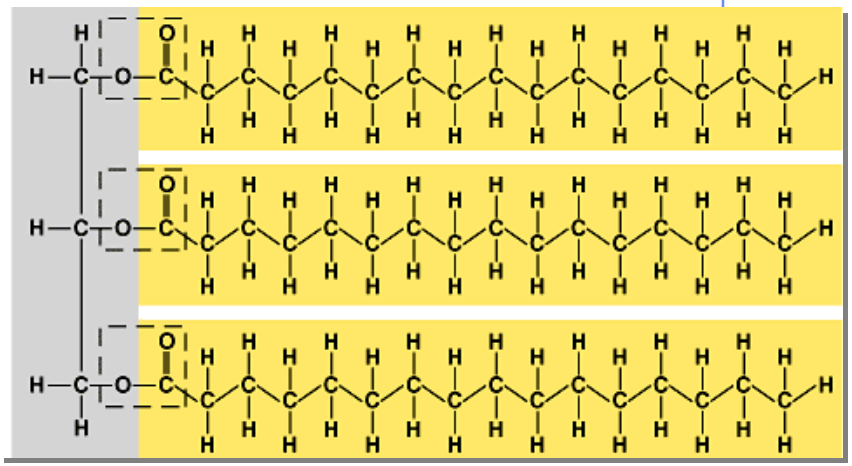
Macromolecules

You are what you eat!

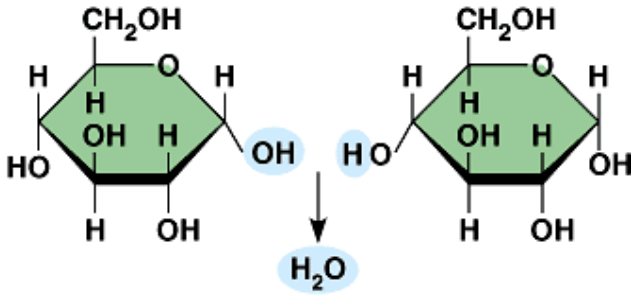






Carbohydrates

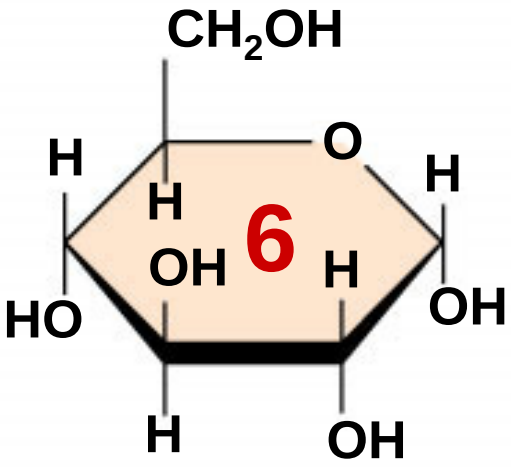
- **Structure / monomer**
  - monosaccharide
- **Function**
  - energy
  - raw materials
  - energy storage
  - structural compounds
- **Examples**
  - glucose, starch, cellulose, glycogen



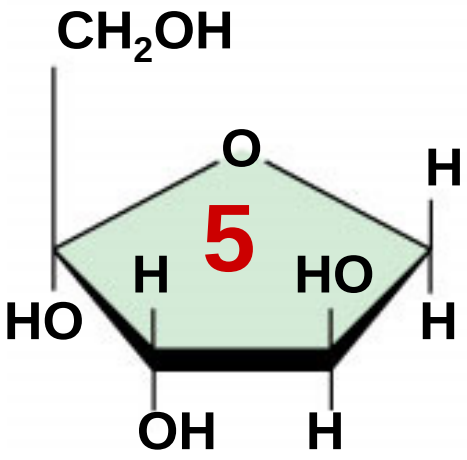
glycosidic bond

Sugars

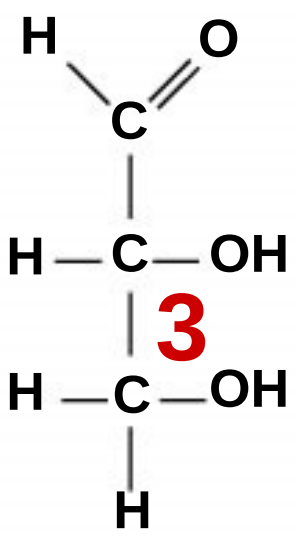
- Most names for sugars end in ***-ose***
- Classified by number of carbons
  - 6C = hexose (glucose)
  - 5C = pentose (ribose)
  - 3C = triose (glyceraldehyde)



Glucose



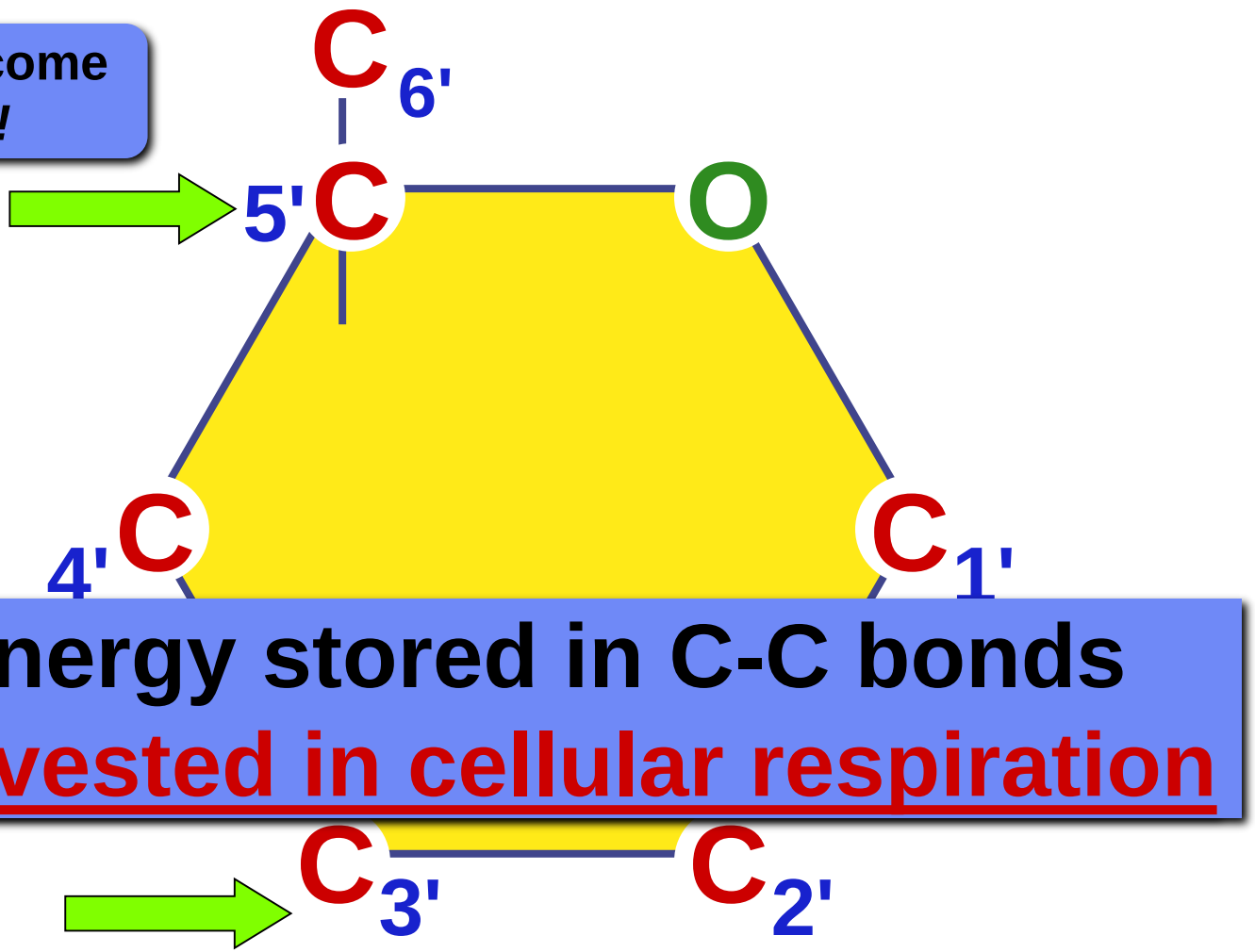
Ribose



Glyceraldehyde

Numbered carbons

These will become important!

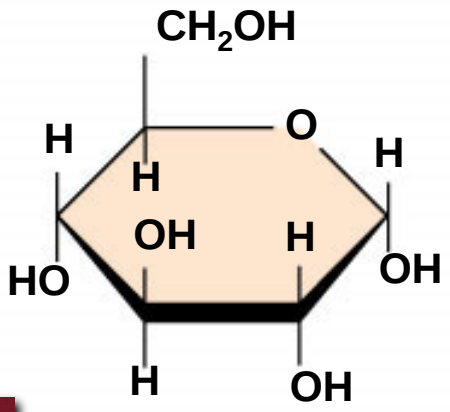


energy stored in C-C bonds

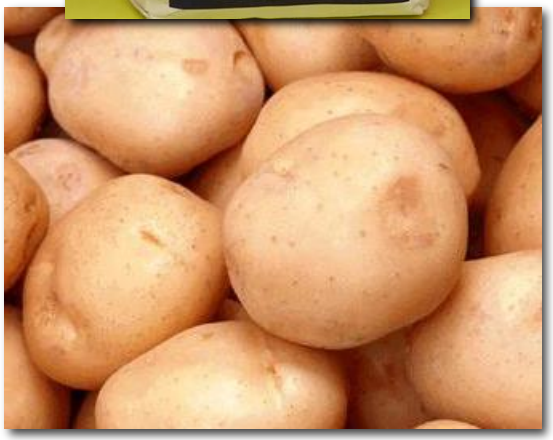
harvested in cellular respiration

Simple & complex sugars

- **Monosaccharides**
  - simple 1 monomer sugars
  - glucose
- **Disaccharides**
  - 2 monomers
  - sucrose
- **Polysaccharides**
  - large polymers
  - starch



Glucose

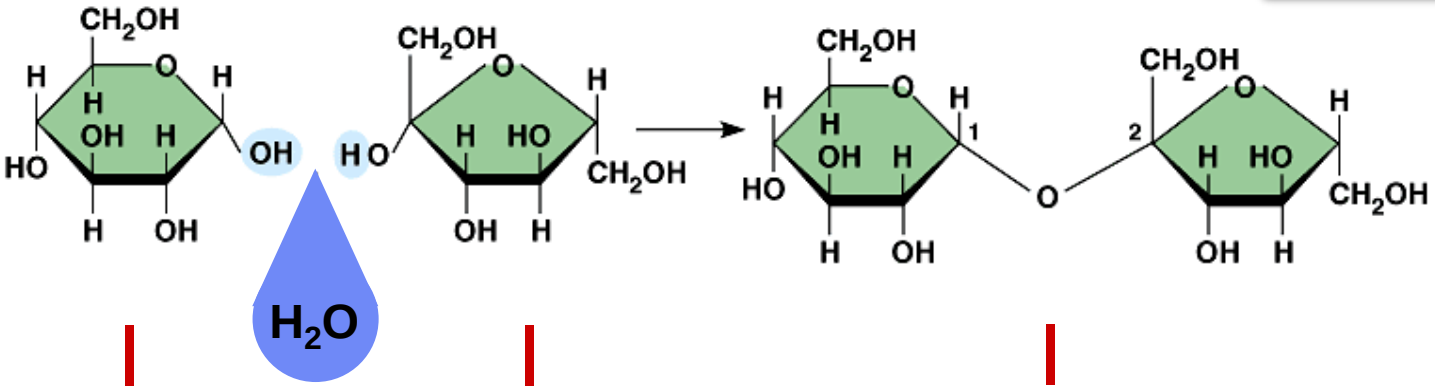


Building sugars

- Dehydration synthesis

monosaccharides

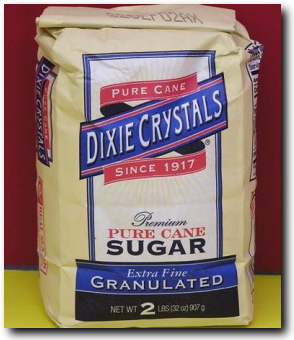
disaccharide



glucose

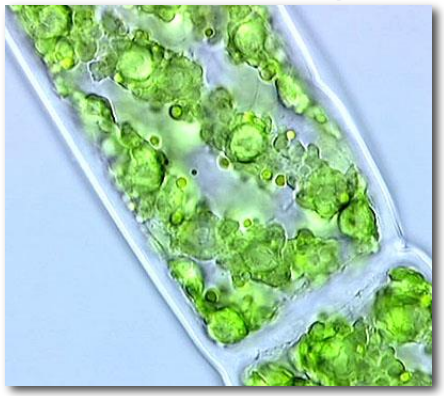
fructose

sucrose (table sugar)



Polysaccharides

- Polymers of sugars
  - costs little energy to build
  - easily reversible = release energy
- Function:
  - energy storage
    - starch (plants)
    - glycogen (animals)
      - in liver & muscles
  - structure
    - cellulose (plants)
    - chitin (arthropods & fungi)



Linear vs. branched polysaccharides

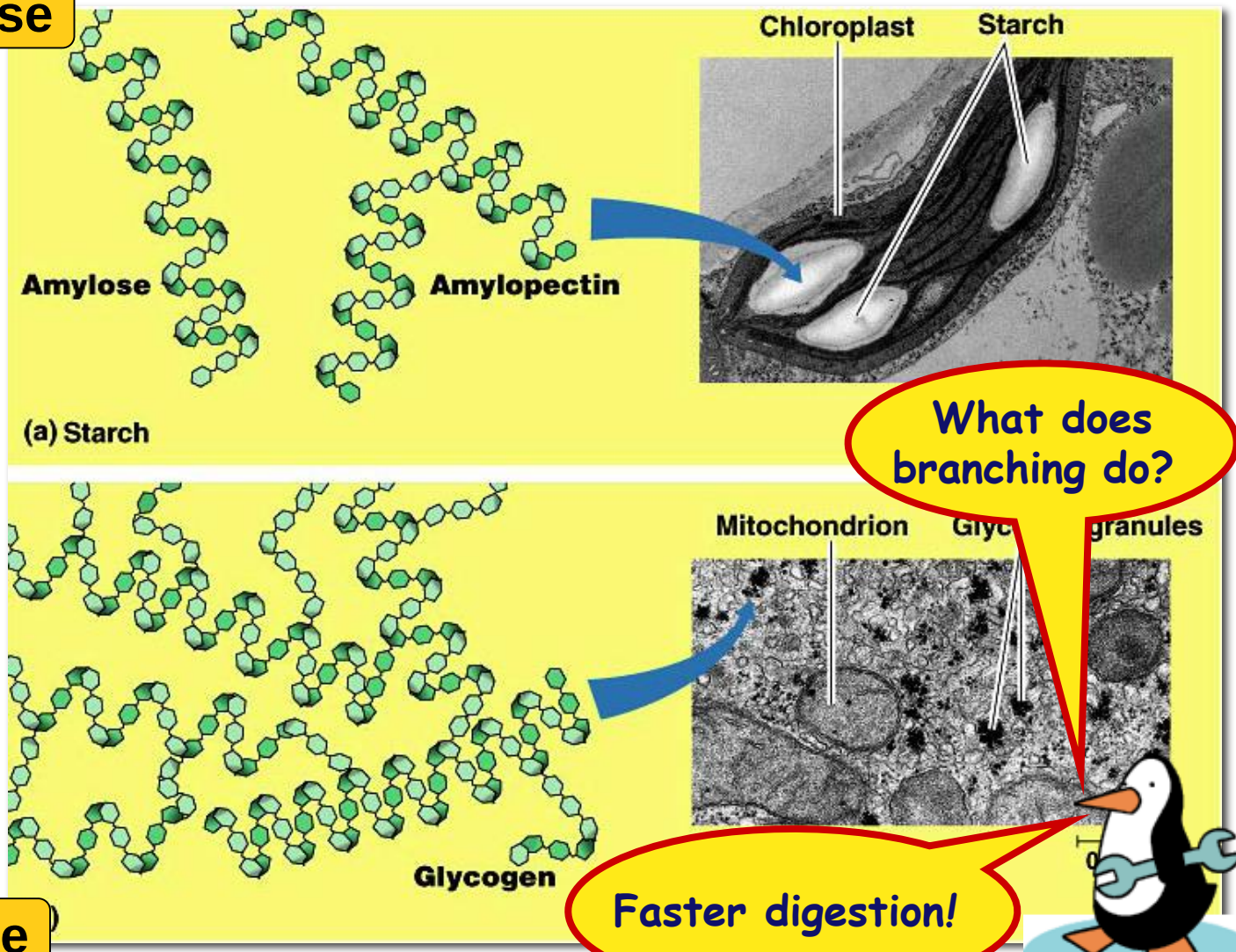
slow release

starch (plant)

energy storage

glycogen (animal)

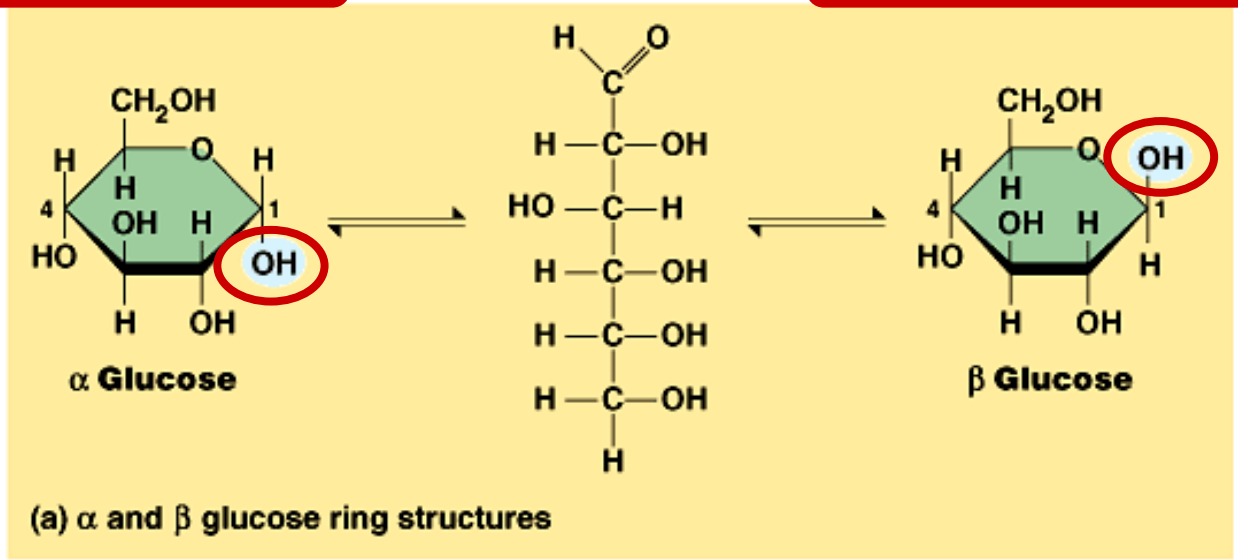
fast release



Polysaccharide diversity

- Molecular structure determines function

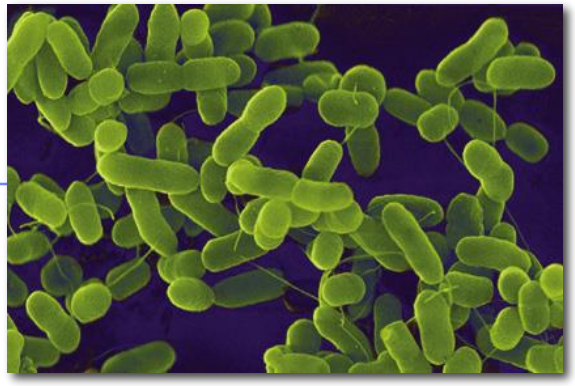
in starch **in cellulose**



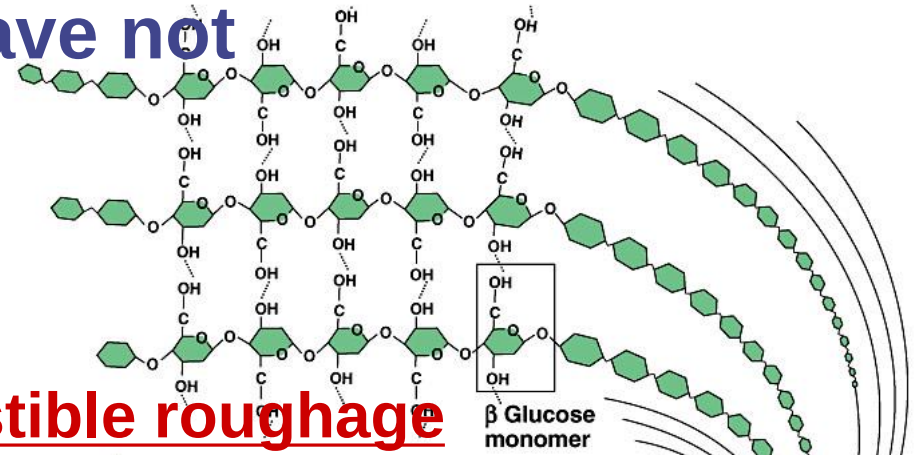
(a) α and β glucose ring structures

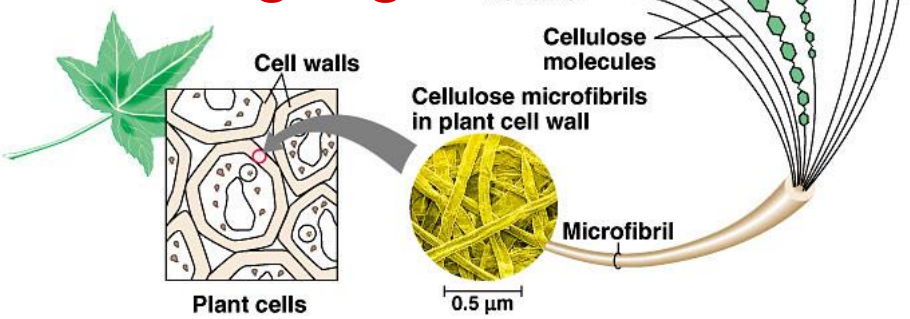
- isomers of glucose
- structure determines function…

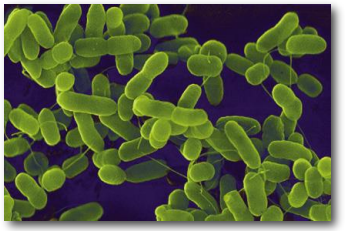
Cellulose



- **Most abundant organic compound on Earth**
  - **herbivores have evolved a mechanism to digest cellulose**
  - **most carnivores have not**
    - **that's why they eat meat to get their energy & nutrients**
    - **cellulose = undigestible roughage**

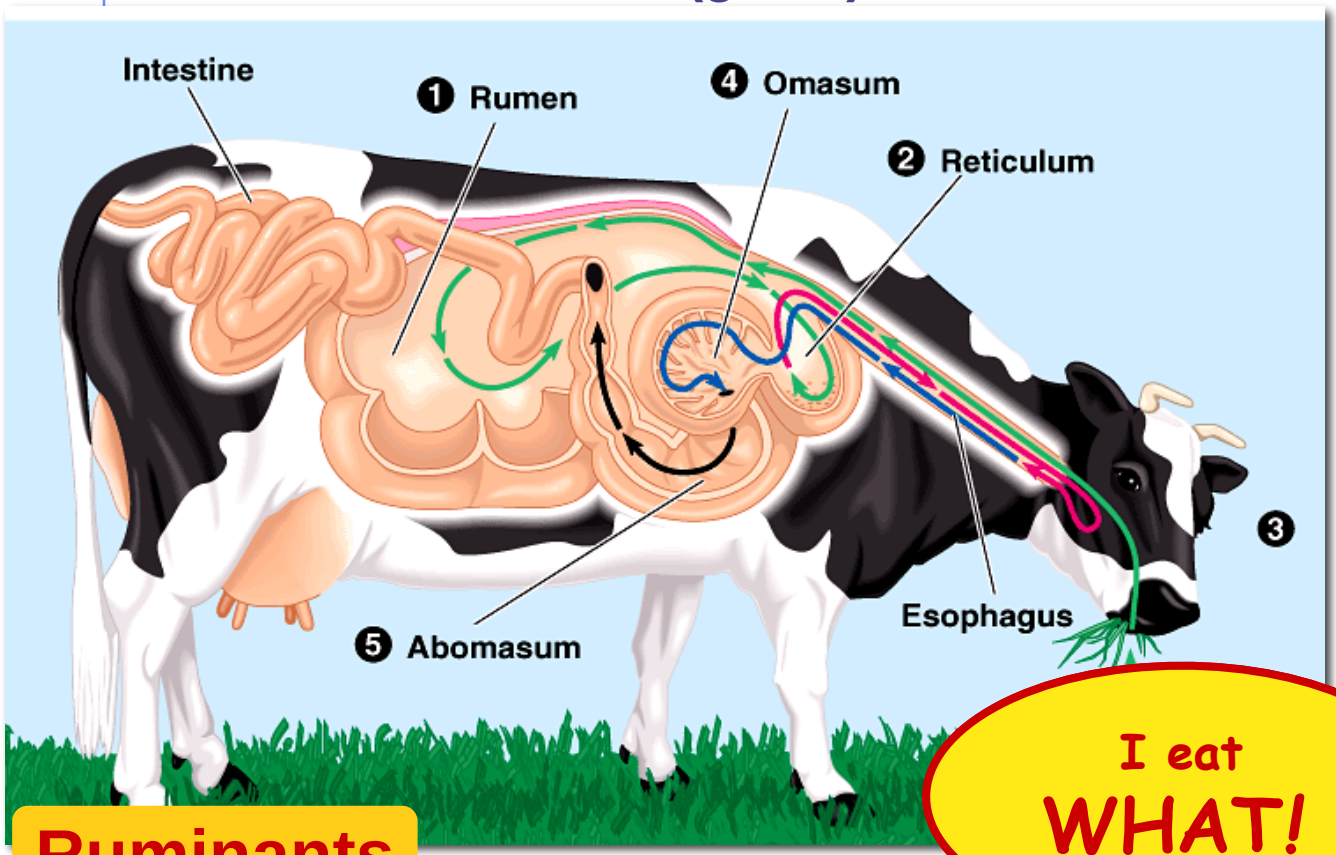




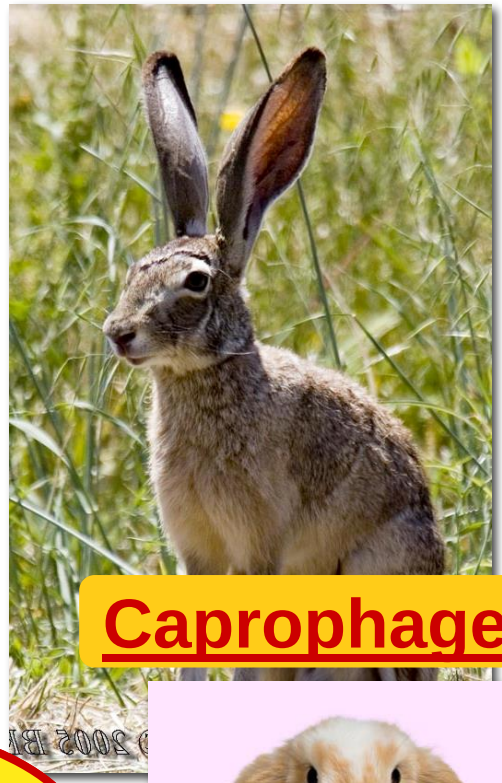


Helpful bacteria

- How can herbivores digest cellulose so well?
  - **BACTERIA** live in their digestive systems & help digest cellulose-rich (grass) meals



Ruminants



Caprophage

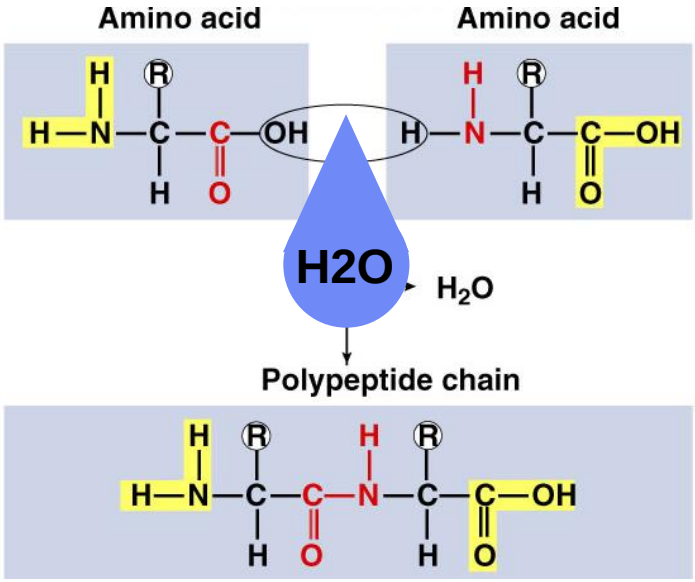
I eat WHAT!

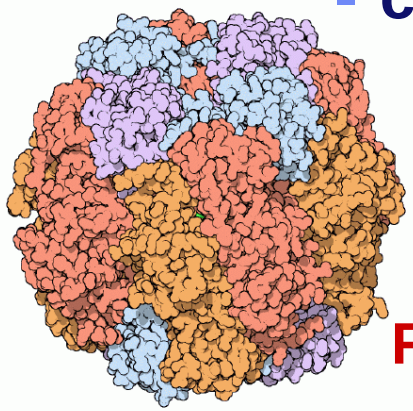
Proteins

- Most structurally & functionally diverse group
- Function: involved in almost everything
  - enzymes (pepsin, DNA polymerase)
  - structure (keratin, collagen)
  - carriers & transport (hemoglobin, aquaporin)
  - cell communication
    - signals (insulin & other hormones)
    - receptors
  - defense (antibodies)
  - movement (actin & myosin)
  - storage (bean seed proteins)

Proteins

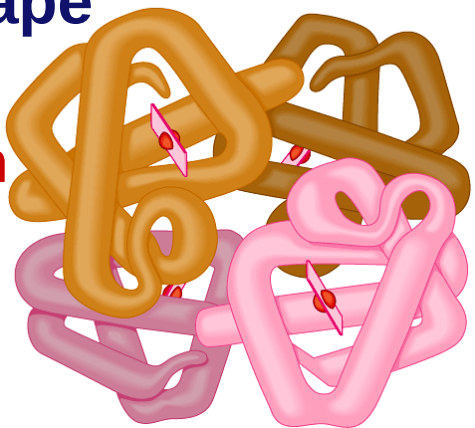
- **Structure**
  - **monomer = amino acids**
    - 20 different amino acids
  - **polymer = polypeptide**
    - protein can be one or more polypeptide chains folded & bonded together
    - large & complex molecules
    - complex 3-D shape

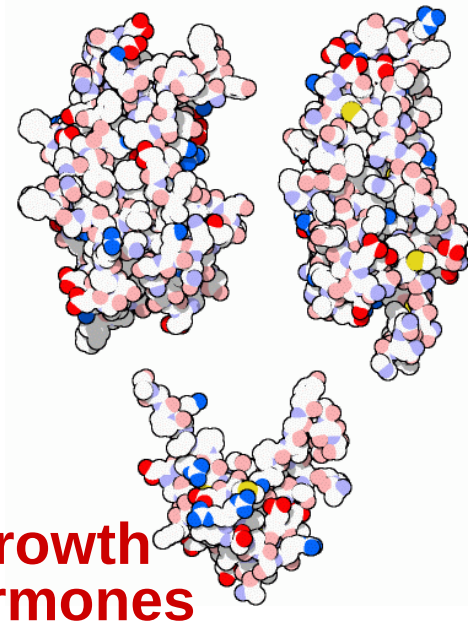




Rubisco

hemoglobin

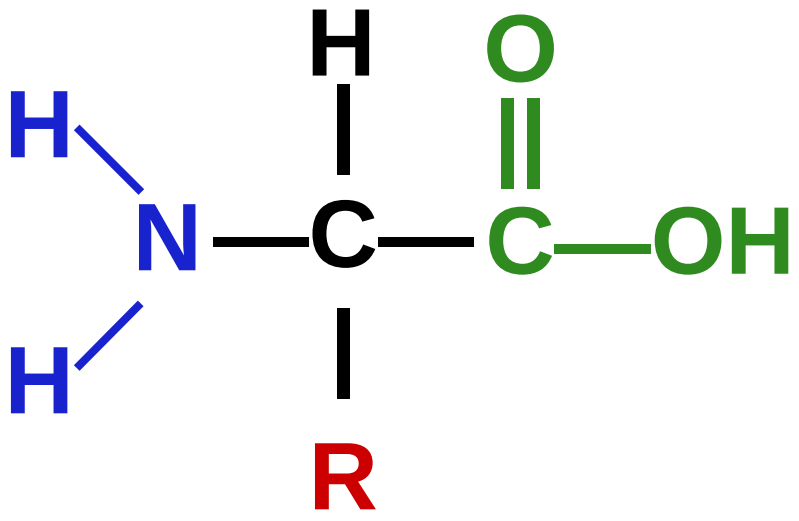


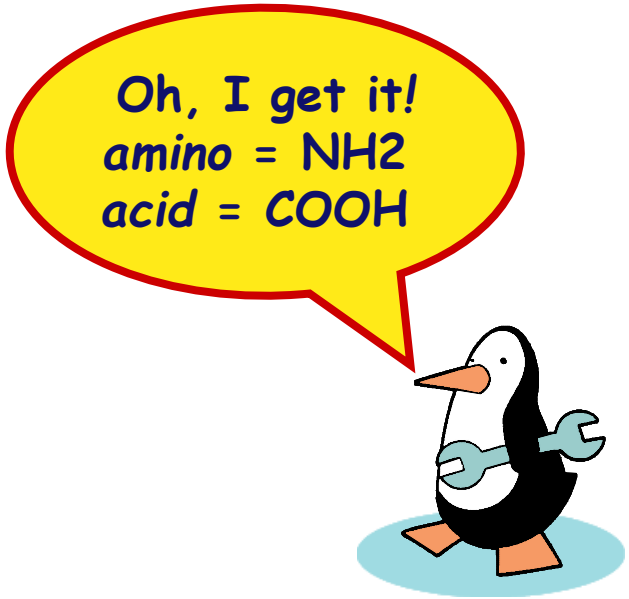


growth hormones

Amino acids

- Structure
  - central carbon
  - amino group
  - carboxyl group (acid)
  - R group (side chain)
    - variable group
    - different for each amino acid
    - confers unique chemical properties to each amino acid
      - like 20 different letters of an alphabet
      - can make many words (proteins)

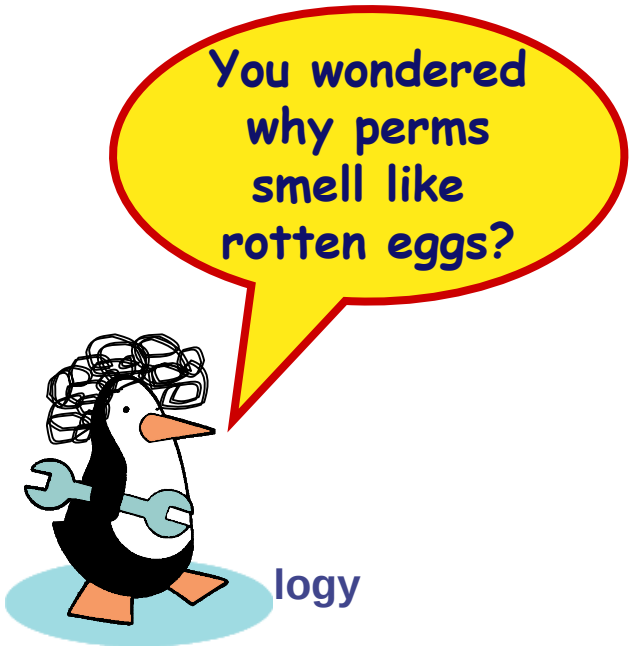




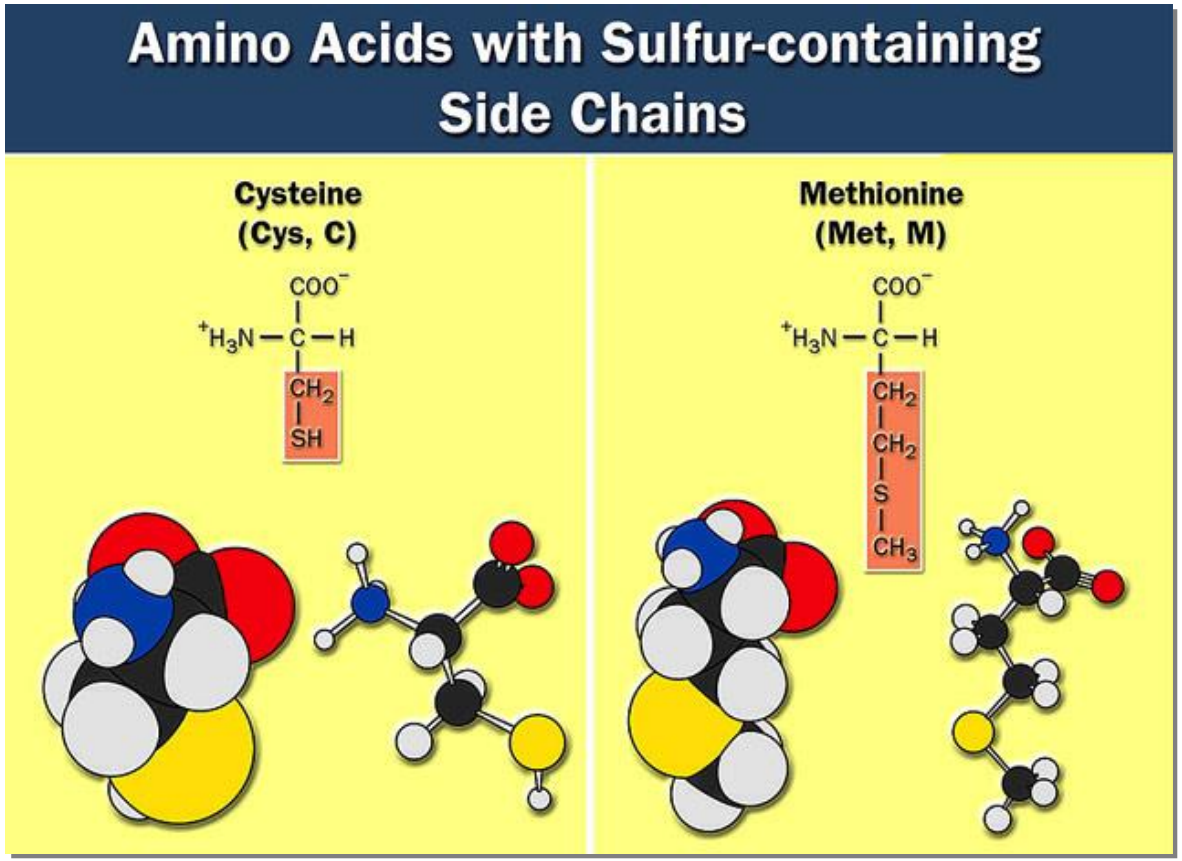
Sulfur containing amino acids

- Form <u>disulfide bridges</u>
  - covalent cross links betweens sulfhydryls
  - stabilizes 3-D structure

H-S – S-H

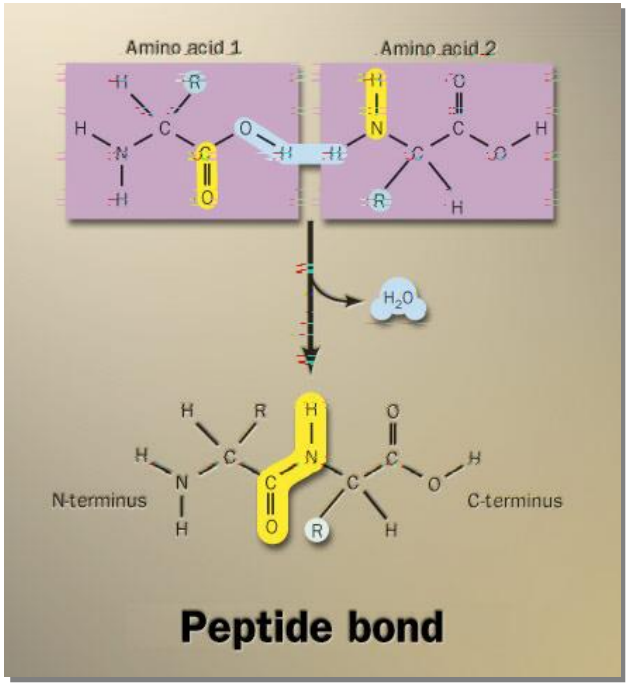


logy

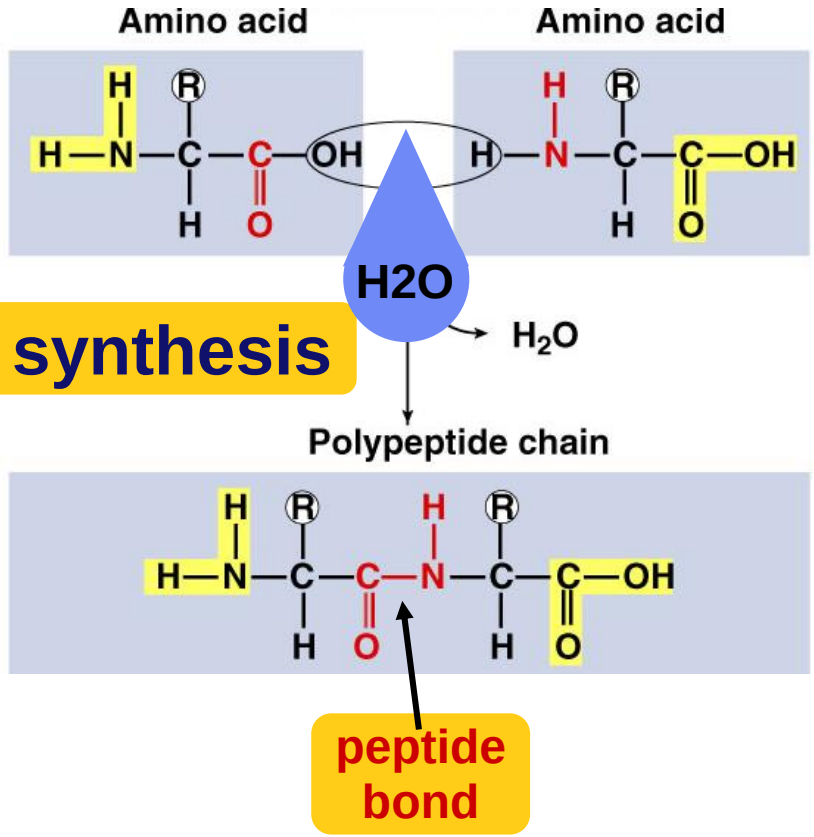


Building proteins

- **Peptide bonds**
  - covalent bond between NH_2 (amine) of one amino acid & COOH (carboxyl) of another
  - C–N bond

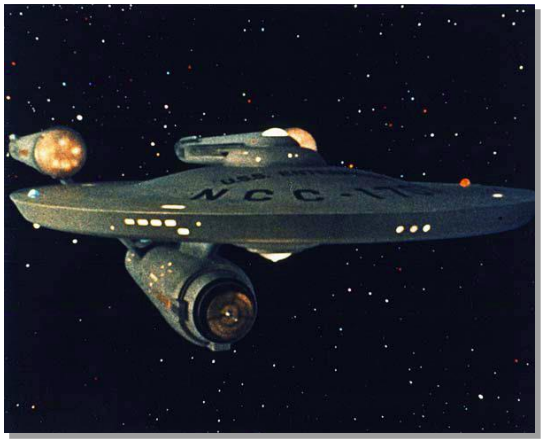


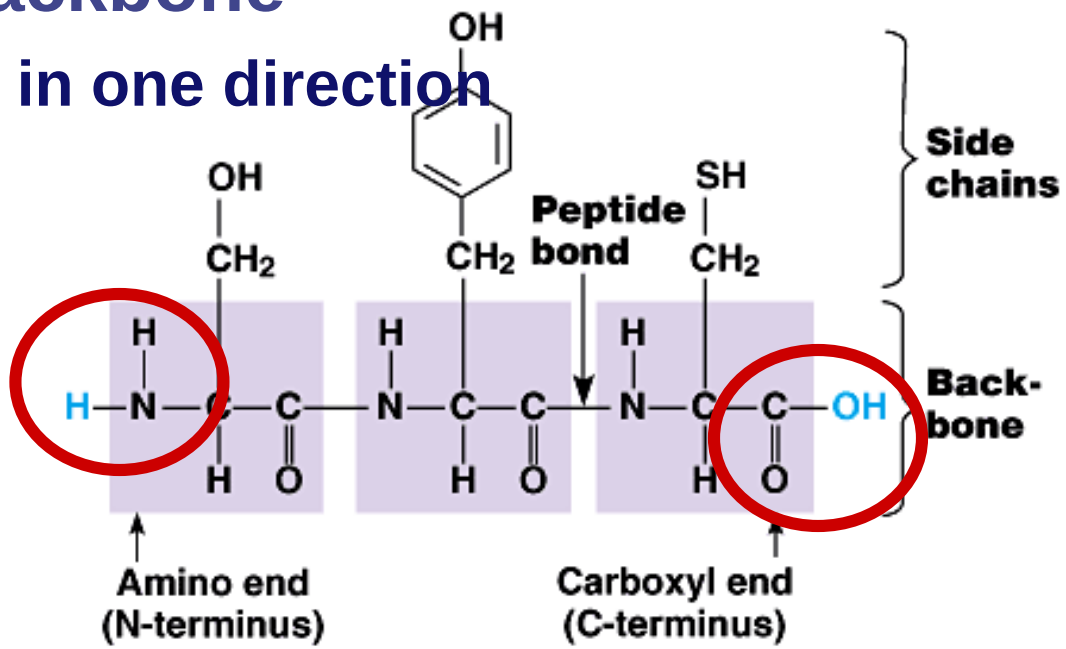
dehydration synthesis



Building proteins

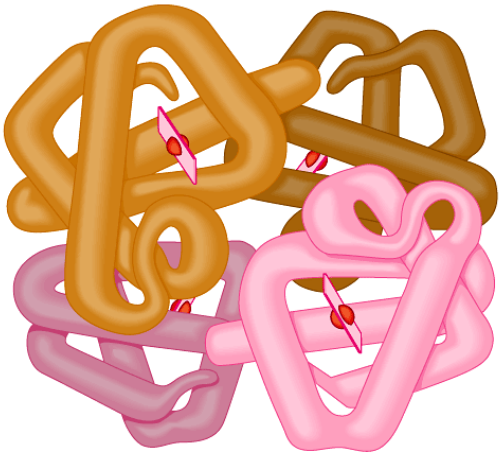
- **Polypeptide chains have direction**
  - **N-terminus = NH_2 end**
  - **C-terminus = COOH end**
  - **repeated sequence (N-C-C) is the polypeptide backbone**
    - **can only grow in one direction**



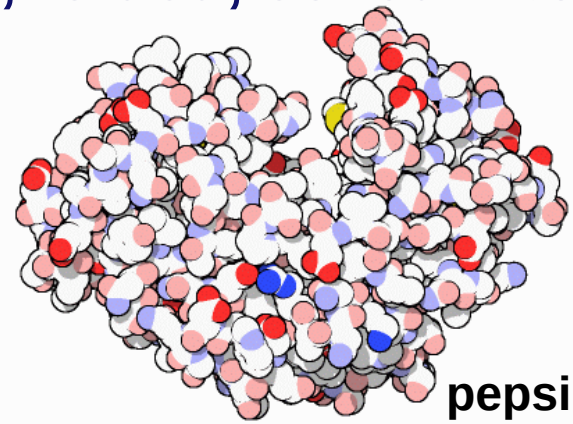


Protein structure & function

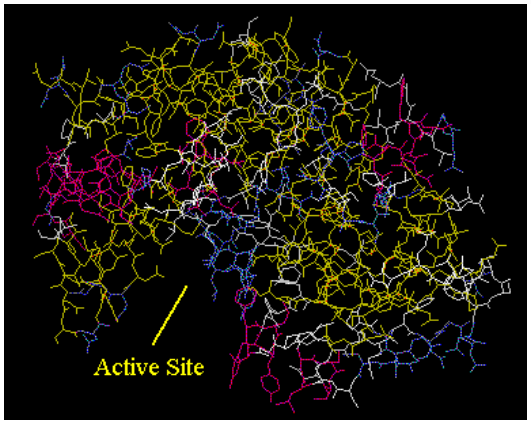
- Function depends on structure
  - 3-D structure
    - twisted, folded, coiled into unique shape

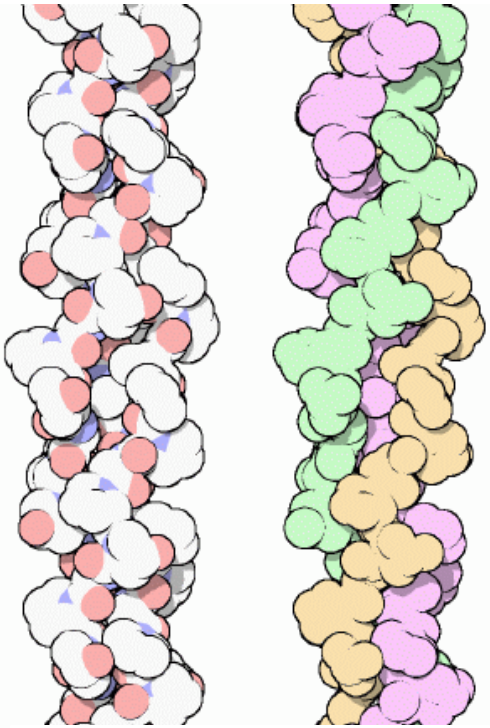


hemoglobin



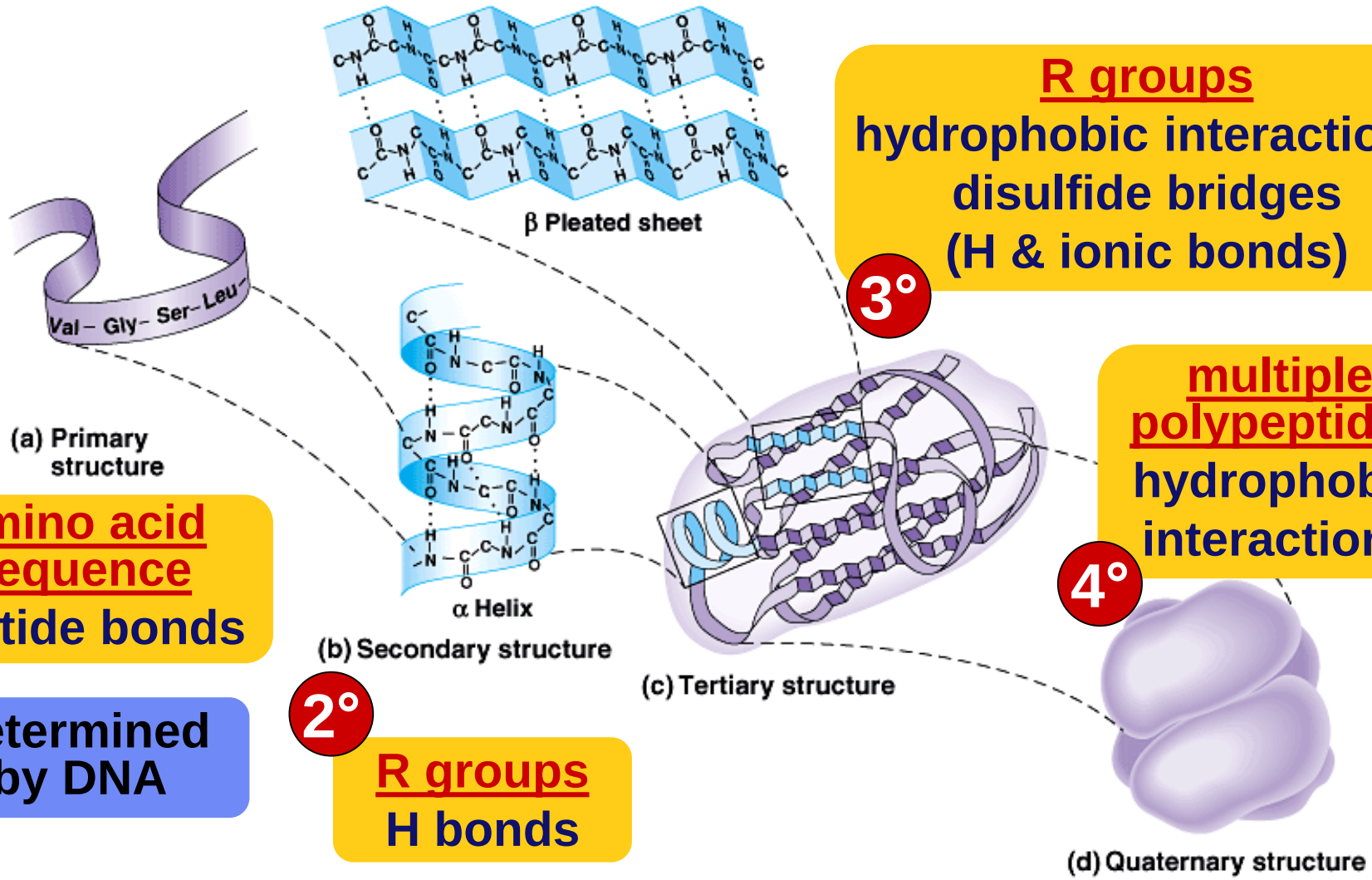
pepsin





collagen

Protein structure



1° **amino acid sequence**
peptide bonds

determined by DNA

2° **R groups**
H bonds

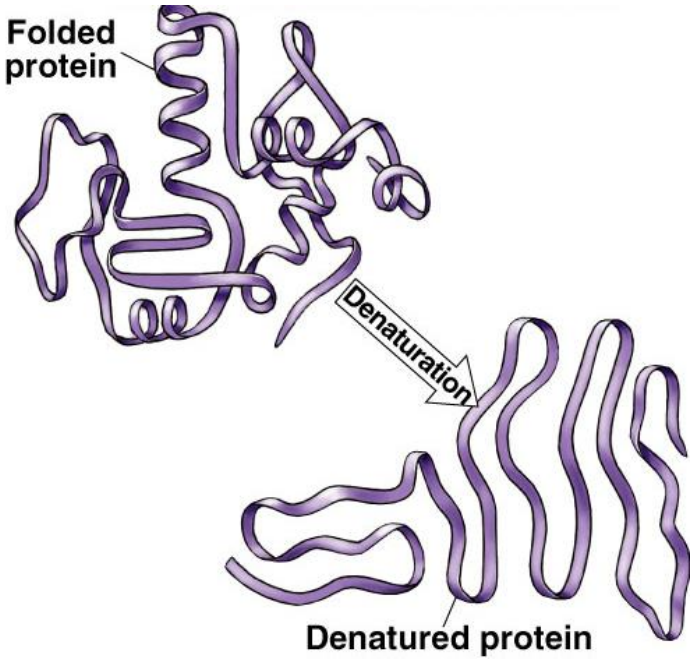
3° **R groups**
hydrophobic interactions
disulfide bridges
(H & ionic bonds)

4° **multiple polypeptides**
hydrophobic interactions

Reg

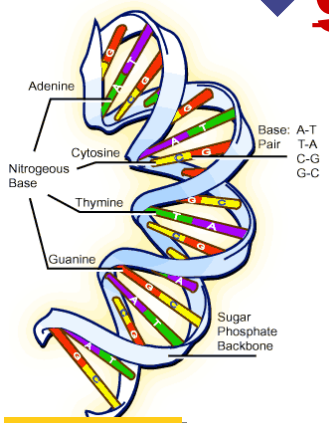
Protein denaturation

- Unfolding a protein
  - conditions that disrupt H bonds, ionic bonds, disulfide bridges
    - temperature
    - pH
    - salinity
  - alter 2° & 3° structure
    - alter 3-D shape
  - destroys functionality
    - some proteins can return to their functional shape after denaturation, many cannot

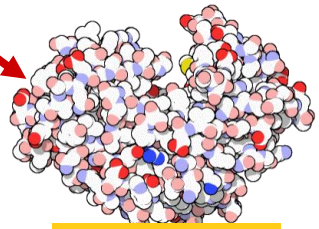


Nucleic Acids

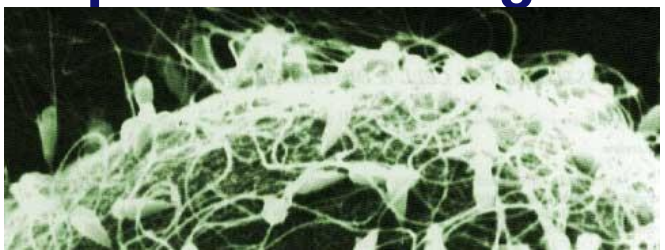
- **Function:**
  - **genetic material**
    - **stores information**
      - genes
      - blueprint for building proteins
        - DNA → RNA → proteins
    - **transfers information**
      - blueprint for new cells
      - blueprint for next generation

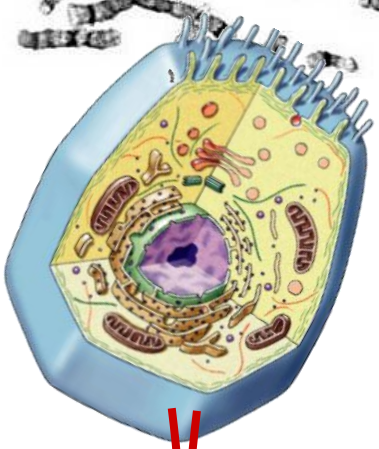


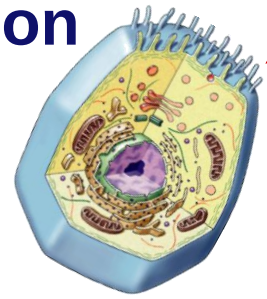
DNA

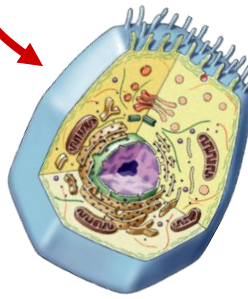


Regen proteins









Nucleic Acids

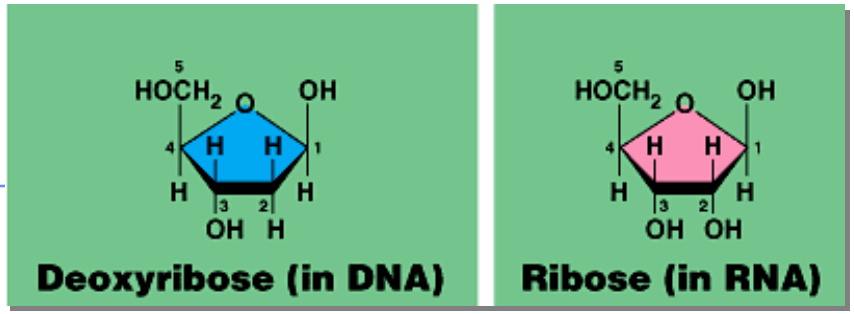
- **Examples:**
  - **RNA (ribonucleic acid)**
    - **single helix**
  - **DNA (deoxyribonucleic acid)**
    - **double helix**
- **Structure:**
  - **monomers = nucleotides**

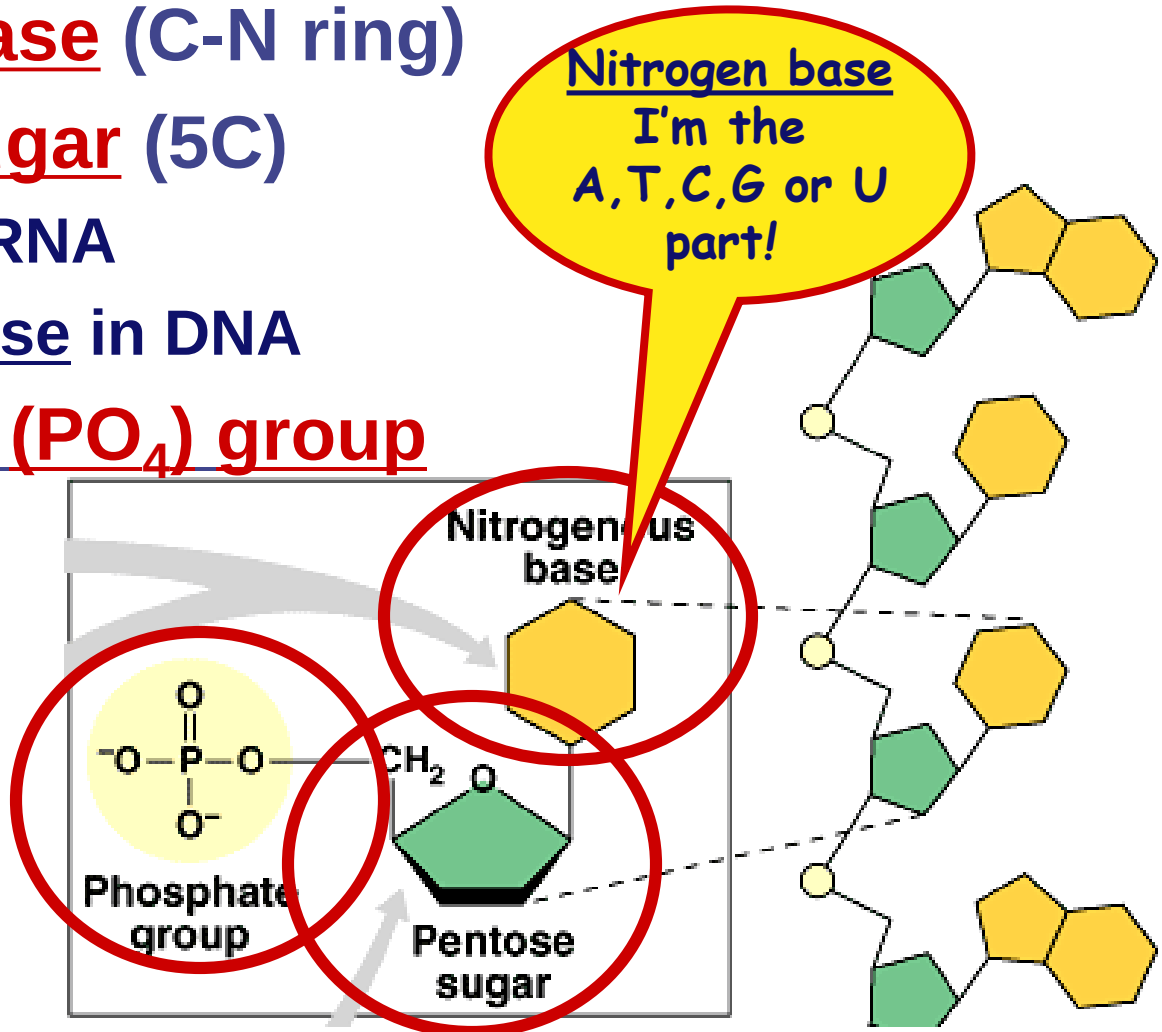
DNA

RNA

Nucleotides

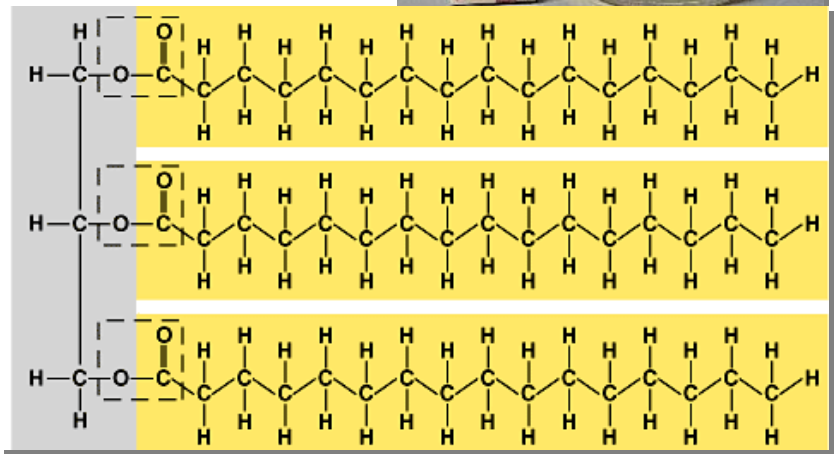
- 3 parts
  - nitrogen base (C-N ring)
  - pentose sugar (5C)
    - ribose in RNA
    - deoxyribose in DNA
  - phosphate (PO_4) group





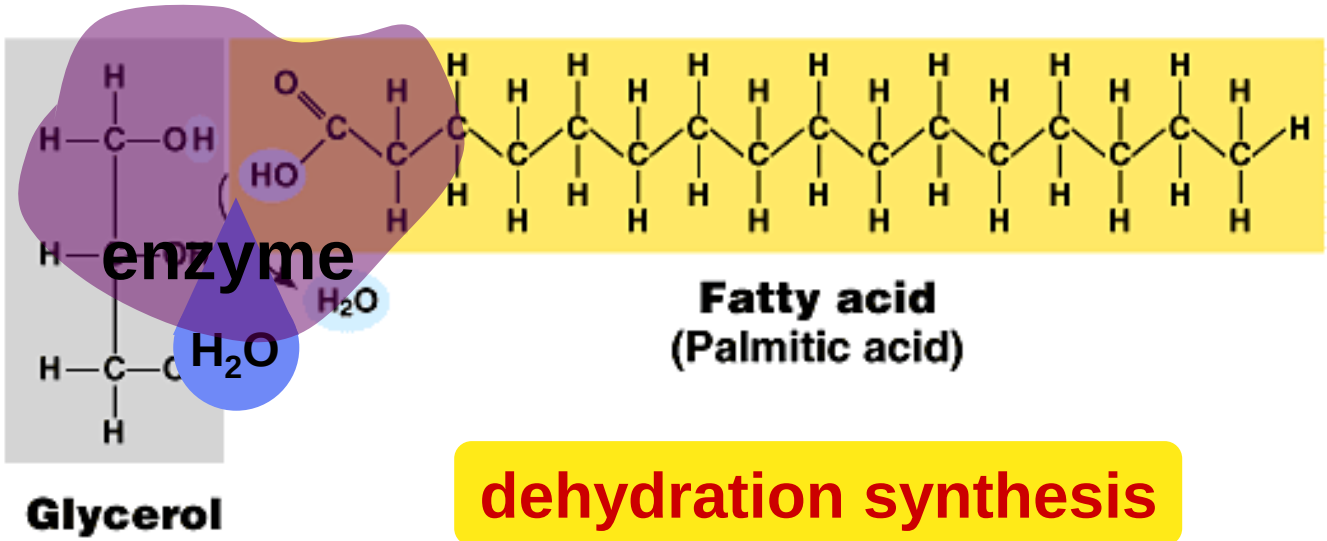
Lipids

- Lipids are composed of C, H, O
  - long hydrocarbon chains (H-C)
- "Family groups"
  - fats
  - phospholipids
  - steroids
- Do not form polymers
  - big molecules made of smaller subunits
  - not a continuing chain



Fats

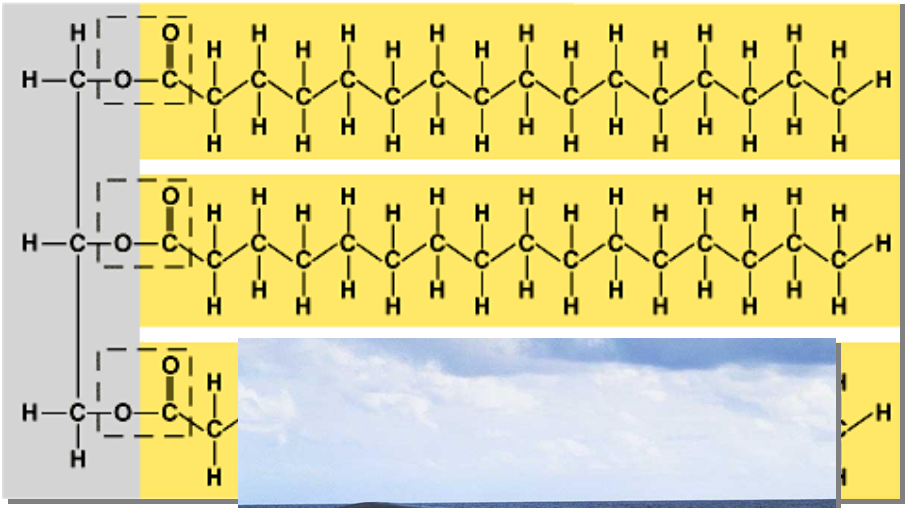
- **Structure:**
  - **glycerol (3C alcohol) + fatty acid**
    - **fatty acid =**
      long HC “tail” with carboxyl (COOH) group “head”



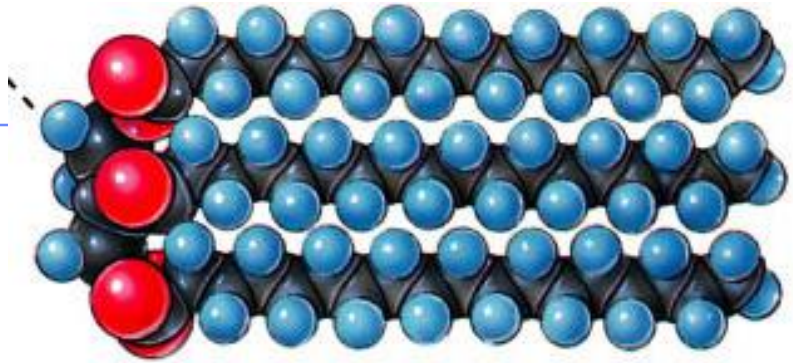
dehydration synthesis

Fats store energy

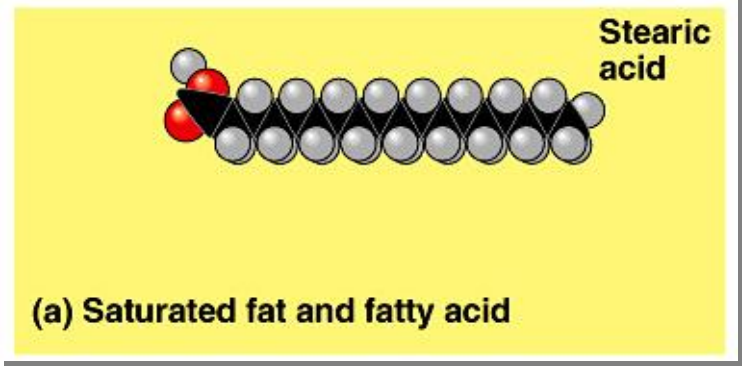
- Long HC chain
  - polar or non-polar?
  - hydrophilic or hydrophobic?
- Function:
  - energy storage
    - concentrated
      - all H-C*!*
    - 2x carbohydrates
  - cushion organs
  - insulates body
    - think whale blubber!



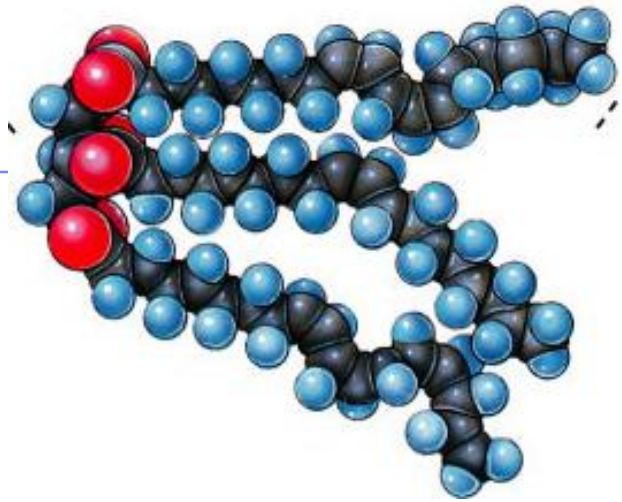
Saturated fats



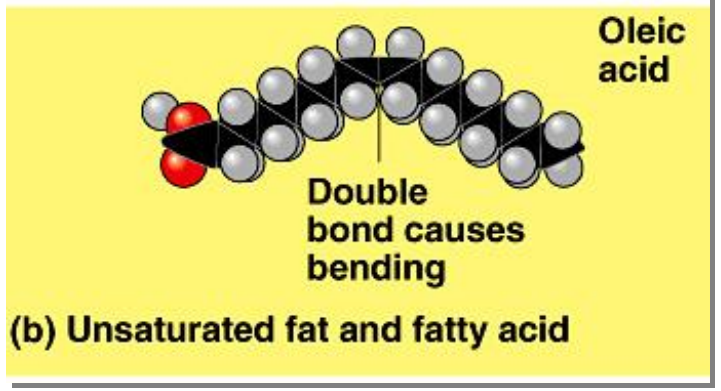
- All C bonded to H
- No C=C double bonds
  - long, straight chain
  - most animal fats
  - solid at room temp.
    - contributes to cardiovascular disease (atherosclerosis) = plaque deposits

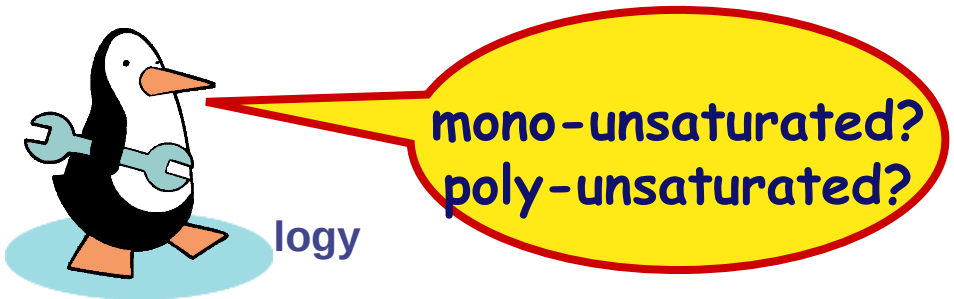


Unsaturated fats



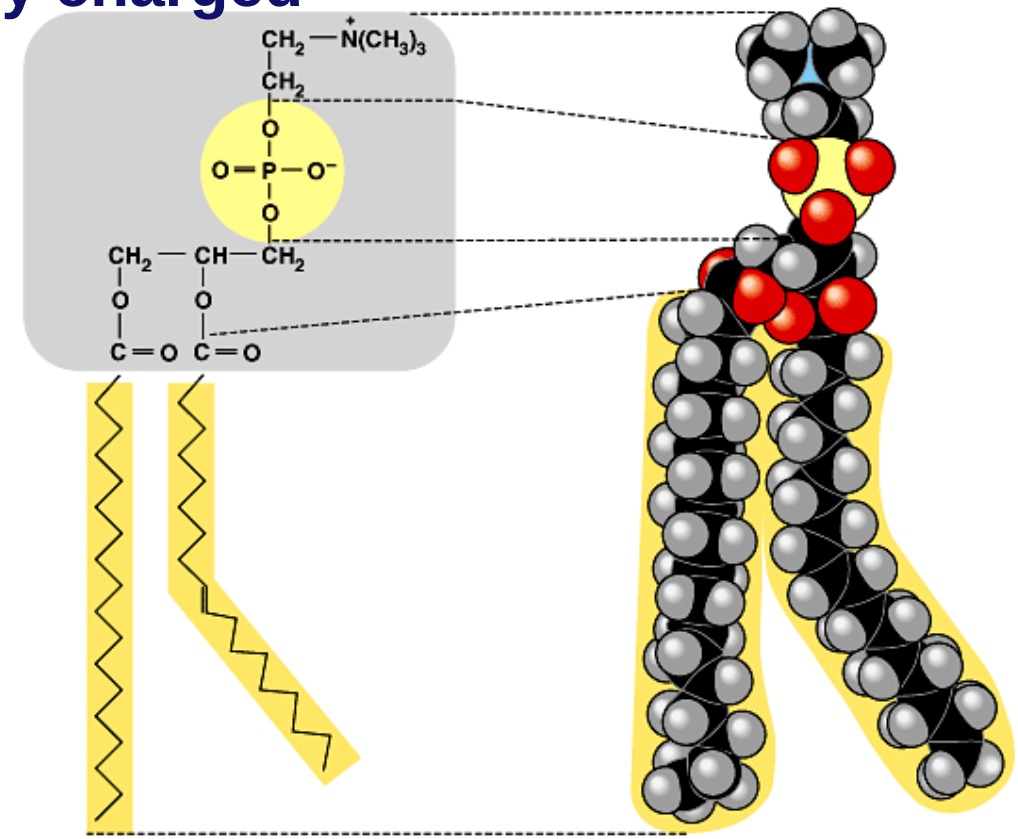
- C=C double bonds in the fatty acids
  - plant & fish fats
  - vegetable oils
  - liquid at room temperature
    - the kinks made by double bonded C prevent the molecules from packing tightly together

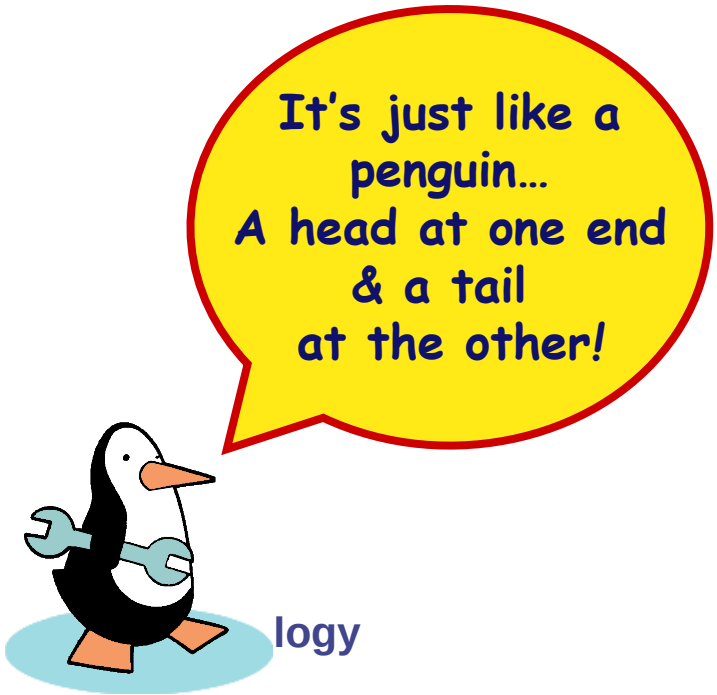




Phospholipids

- **Structure:**
  - glycerol + 2 fatty acids + PO_4
    - PO_4 = negatively charged

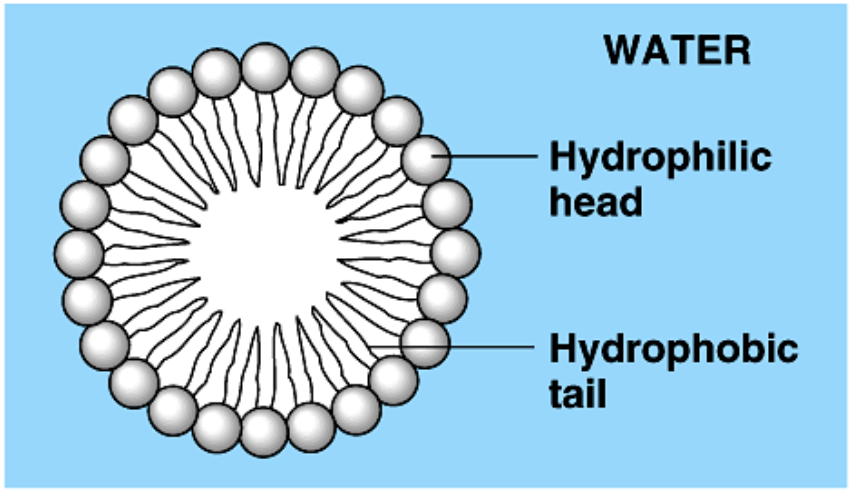


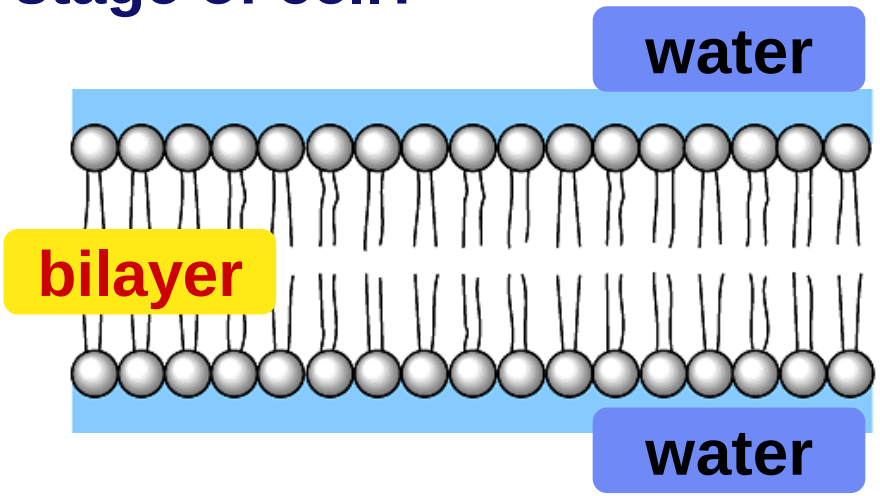


logy

Phospholipids in water

- **Hydrophilic heads "attracted" to H_2O**
- **Hydrophobic tails "hide" from H_2O**
  - can self-assemble into "bubbles"
    - bubble = "micelle"
    - can also form a phospholipid bilayer
    - early evolutionary stage of cell?

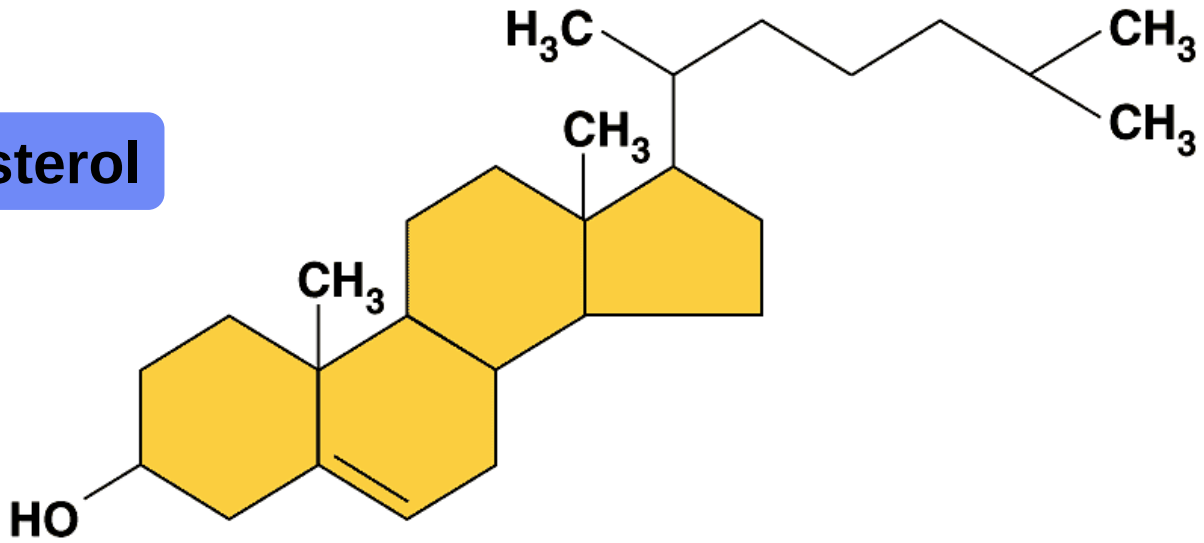




Steroids

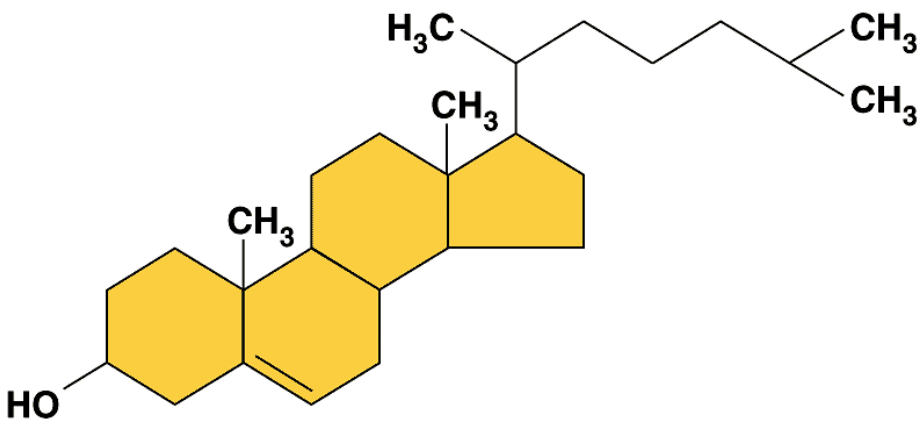
- **Structure:**
  - 4 fused C rings + ??
    - different steroids created by attaching different functional groups to rings
    - different structure creates different function
  - examples: cholesterol, sex hormones

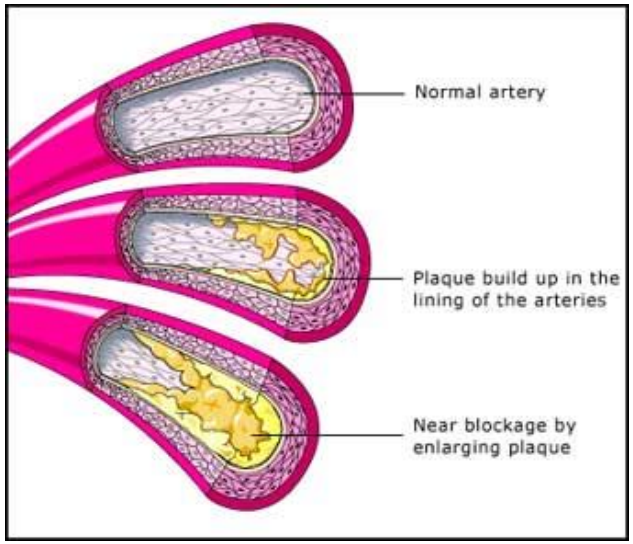
cholesterol



Cholesterol

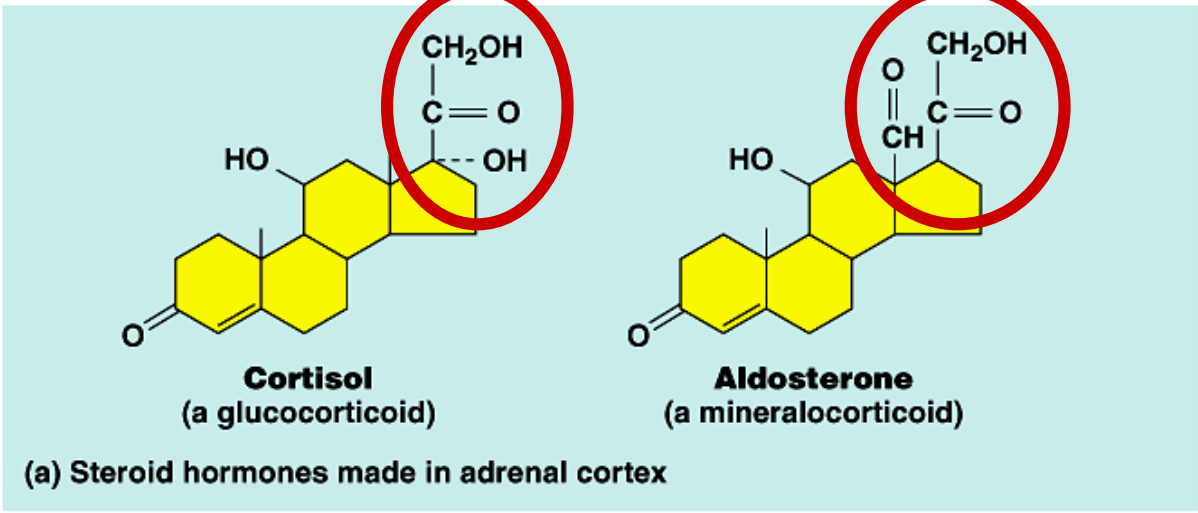
- Important cell component
  - animal cell membranes
  - precursor of all other steroids
    - including vertebrate sex hormones
  - high levels in blood may contribute to cardiovascular disease



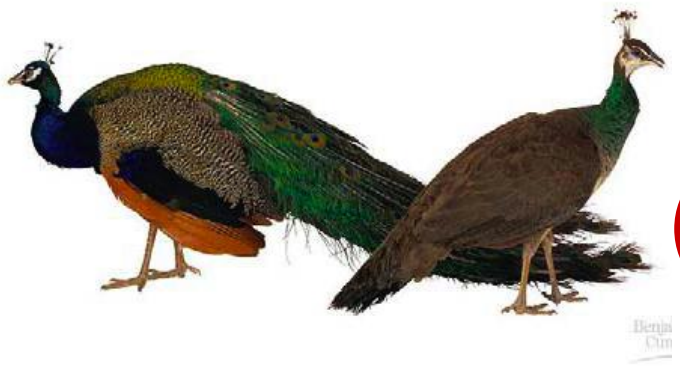


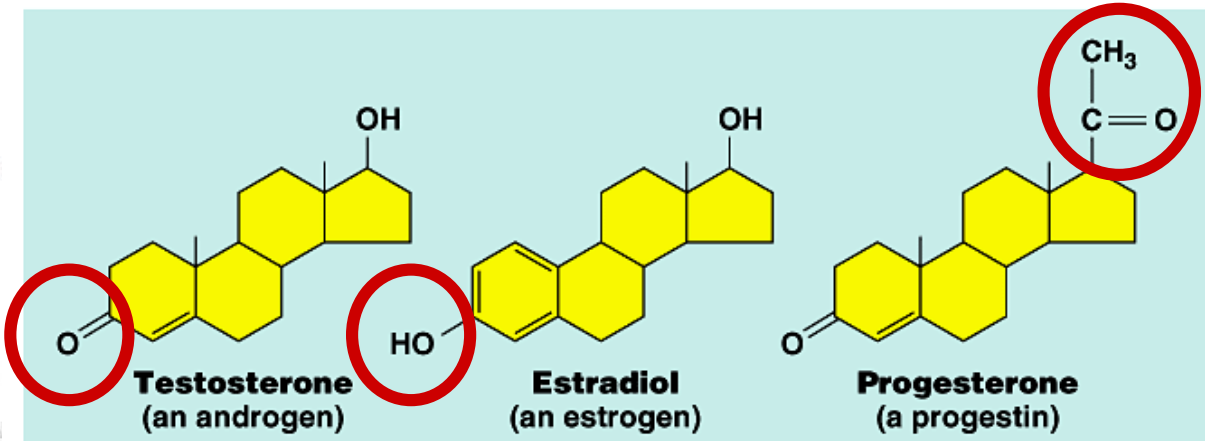
From Cholesterol → Sex Hormones

- What a big difference a few atoms can make!



(a) Steroid hormones made in adrenal cortex





(b) Steroid hormones made primarily in gonads