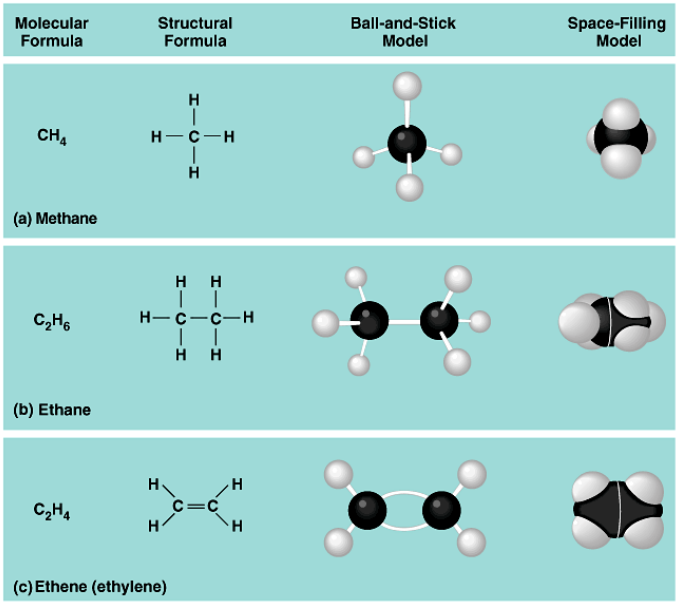
Chapter 3

Molecules of Life

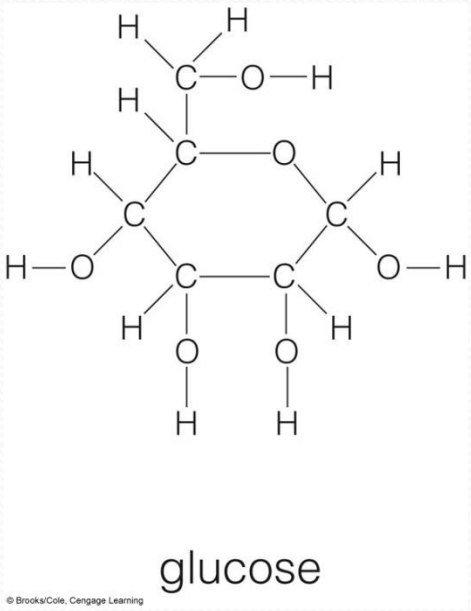
3.1 Organic Molecules

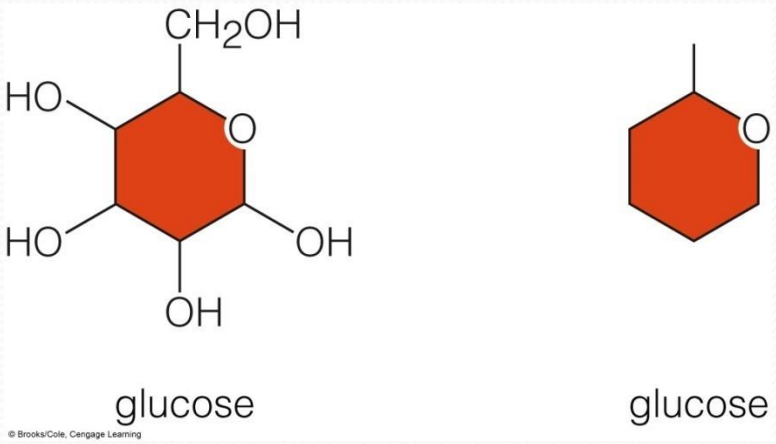
- Living things are made of mostly of carbon, hydrogen and oxygen
- Organic molecule = a molecule made mostly of carbon and hydrogen
- CARBON is the molecule of life
  - Can bond with one, two, three, or four atoms
  - Can form polar or nonpolar bonds
  - Can form chains or rings



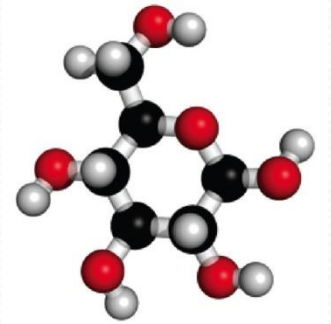
Representing Structures of Organic Molecules

- Structural model of an organic molecule
  - Each line = a covalent bond;
    2 lines = double bonds;
    3 lines =triple bonds
- Carbon ring structures are represented as polygons; carbon atoms are implied



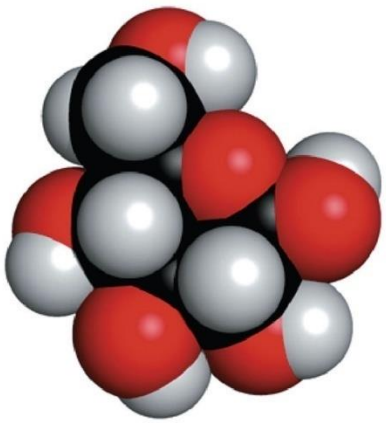


- Ball-and-stick models show positions of atoms in three dimensions; elements are coded by color



glucose

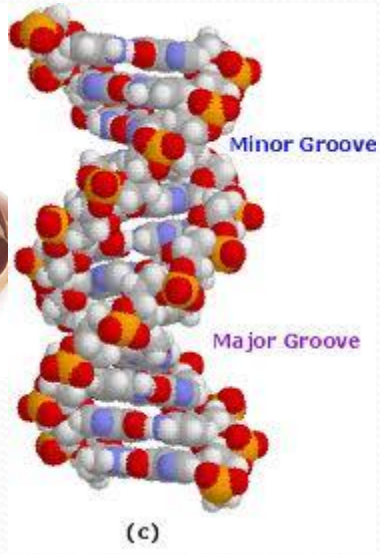
- Space-filling models show how atoms sharing electrons overlap



glucose

Macromolecules

- 4 types in living systems
  - Carbohydrates
  - Lipids (fats)
  - Proteins
  - Nucleic Acids

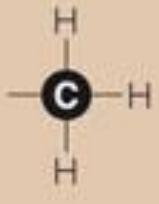
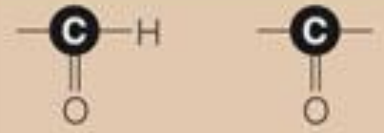


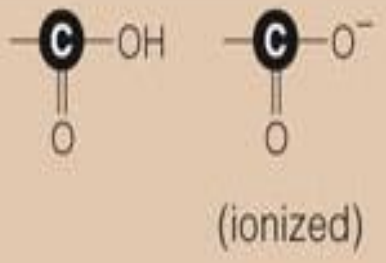
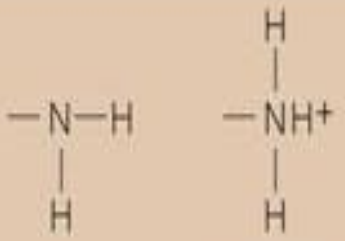
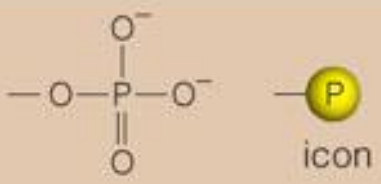
- Made of
  - **Polymers** = a large molecule made of linked monomers
  - **Monomer** = small organic molecules that are used to build larger molecules

3.2 From Structure to Function

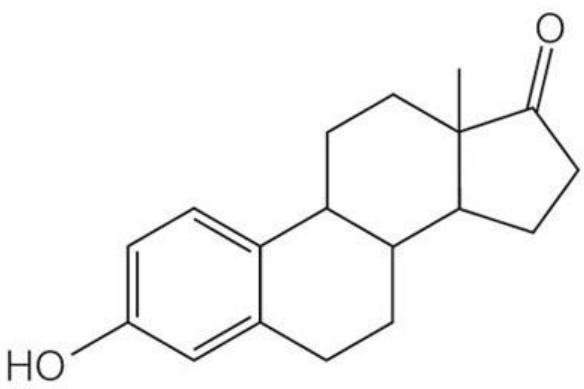
- The function of organic molecules in biological systems begins with their structure
- Most biological molecules have at least one **functional group** = A cluster of atoms that imparts specific chemical properties to a molecule (polarity, acidity)

Functional Groups (you need to know) – pg 38

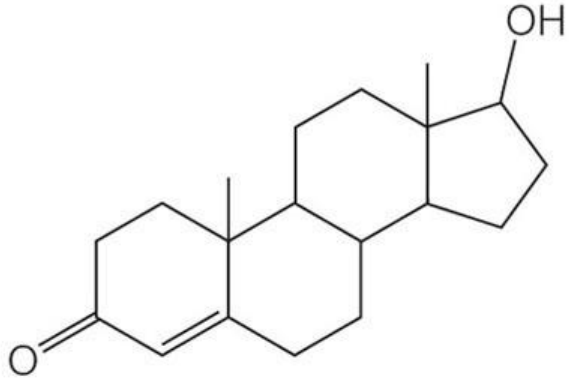
Group	Character	Location	Structure
hydroxyl	polar	amino acids; sugars and other alcohols	—OH
methyl	nonpolar	fatty acids, some amino acids	
carbonyl	polar, reactive	sugars, amino acids, nucleotides	 (aldehyde) (ketone)

carboxyl	acidic	amino acids, fatty acids, carbohydrates	 (ionized)
amine	basic	amino acids, some nucleotide bases	 (ionized)
phosphate	high energy, polar	nucleotides (e.g., ATP); DNA and RNA; many proteins; phospholipids	 icon

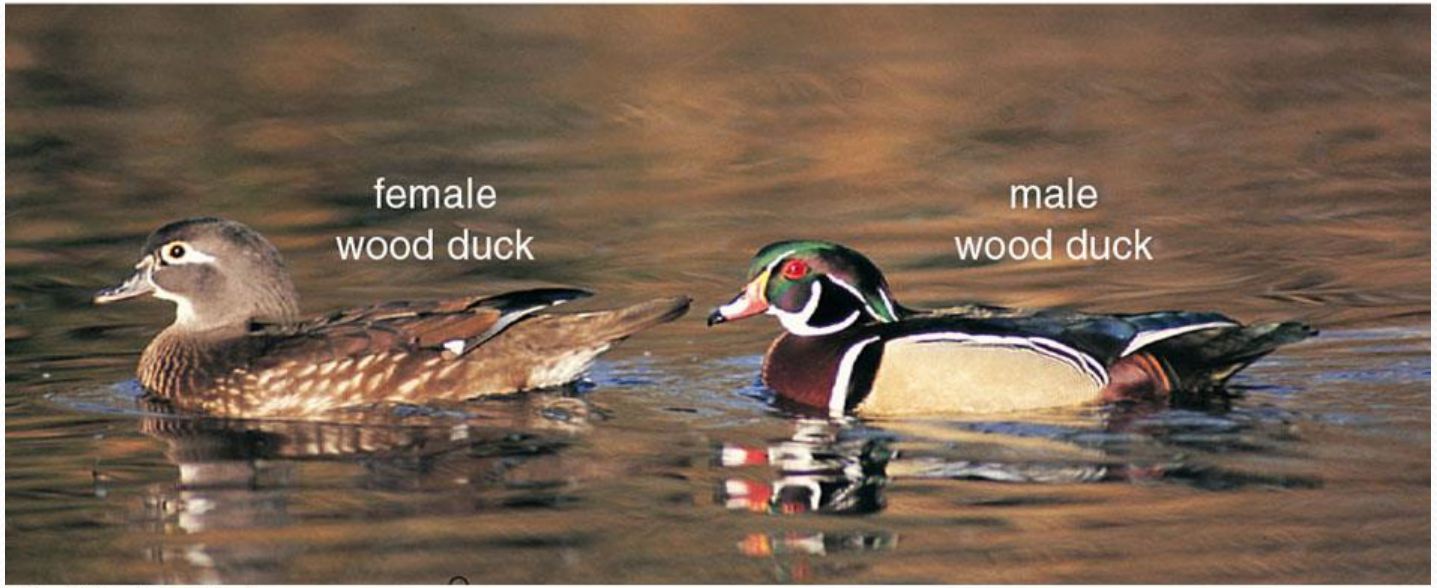
So what's the big deal with functional groups?



one of the estrogens



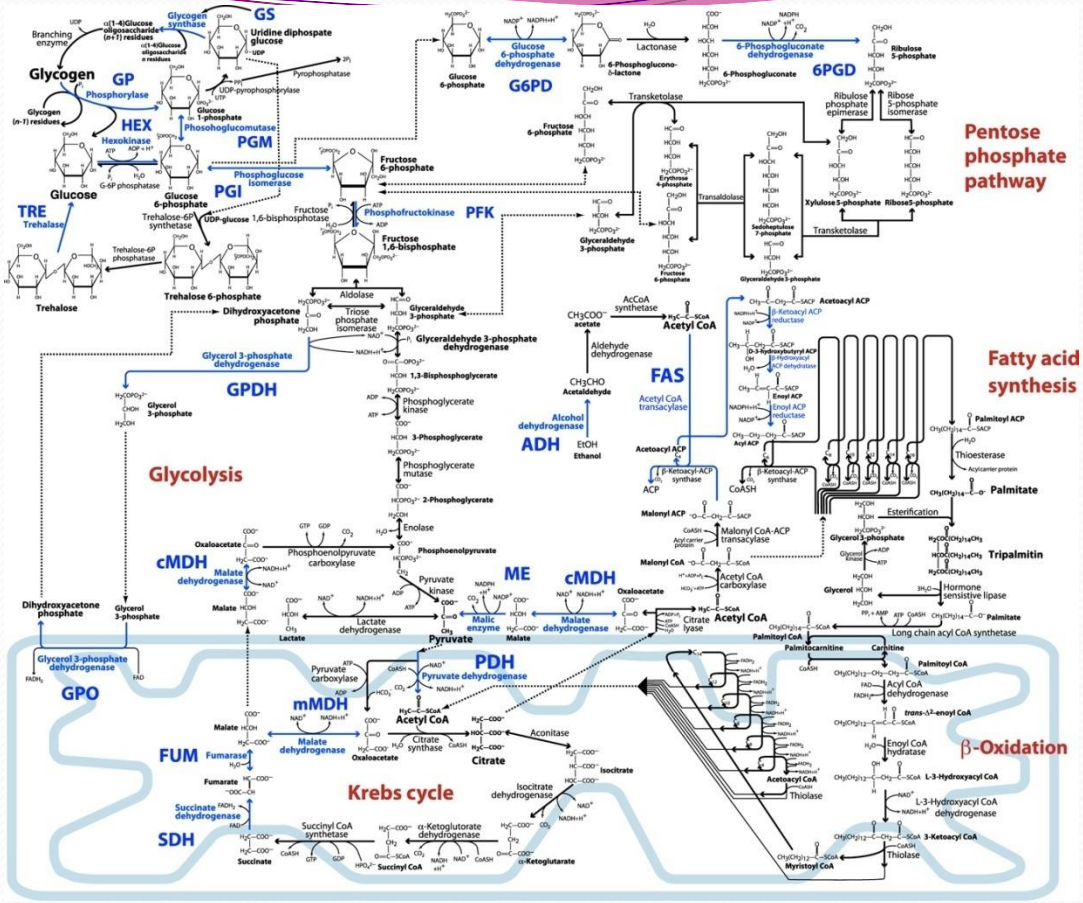
testosterone




YOUR TEACHER TOOK YOUR PHONE?
MINE TOOK MY LEGS

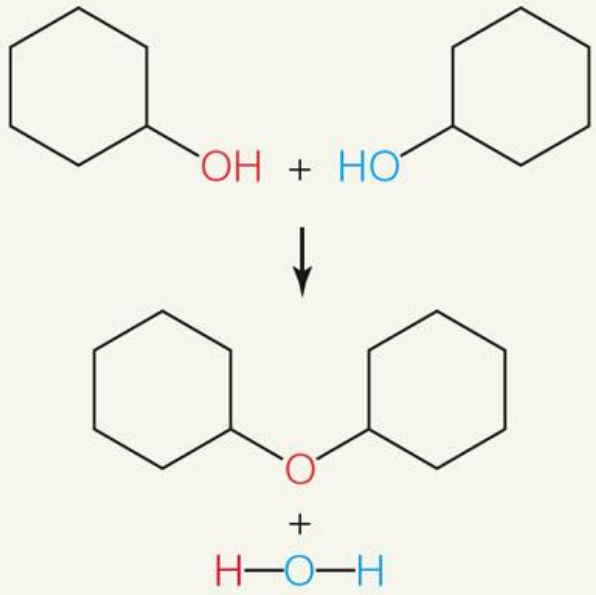
Metabolism

- **Metabolism**
  - Activities by which cells acquire and use energy to construct, rearrange, and split organic molecules
  - Allows cells to live, grow, and reproduce
  - Requires enzymes (proteins that increase the speed of reactions)



Combining molecules

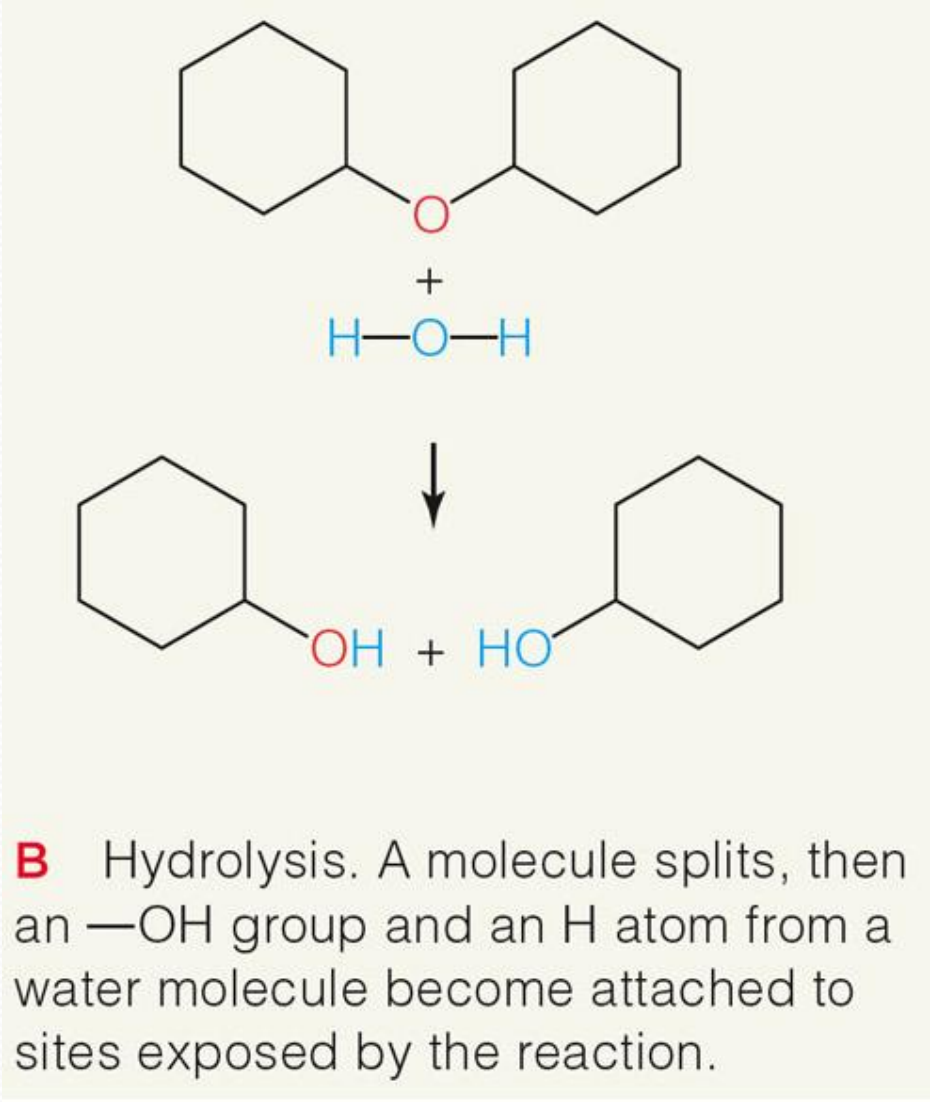
- Combining = Condensation (dehydration synthesis) = 2 molecules covalently bond into a larger molecule
  - Removes an –OH from one molecule and a –H from another making H20



A Condensation. An —OH group from one molecule combines with an H atom from another. Water forms as the two molecules bond covalently.

Separating Molecules

- Splitting molecules = hydrolysis
  - Enzymes break a bond by adding –OH and –H groups from H2O



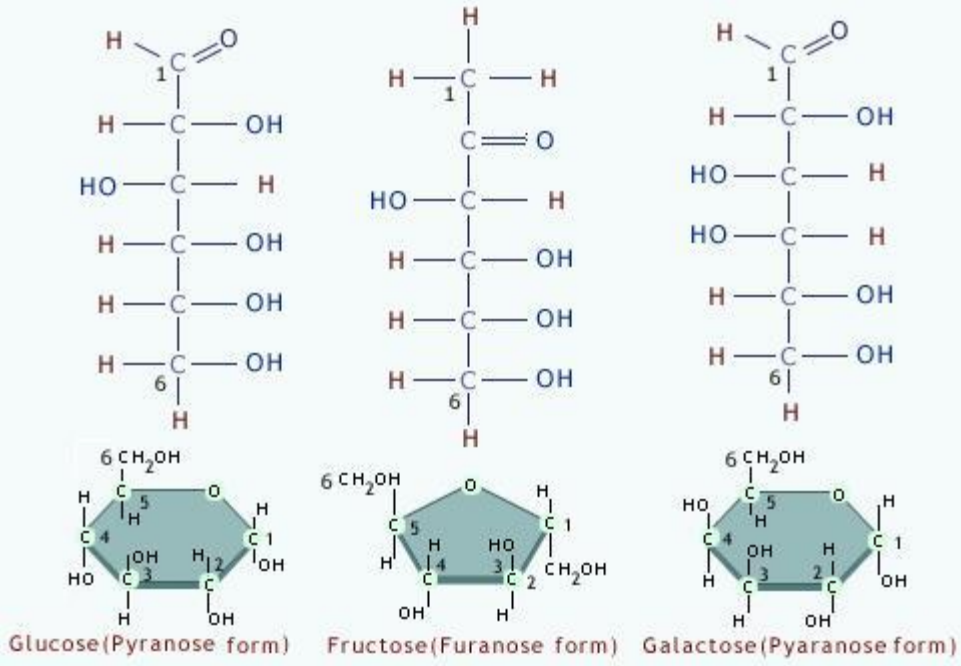
B Hydrolysis. A molecule splits, then an —OH group and an H atom from a water molecule become attached to sites exposed by the reaction.

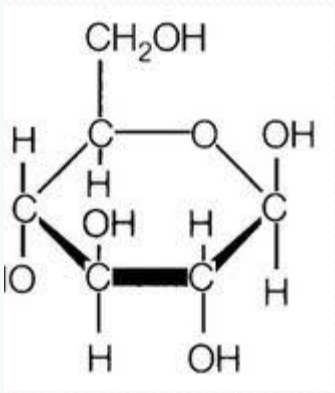
3.3 Carbohydrates

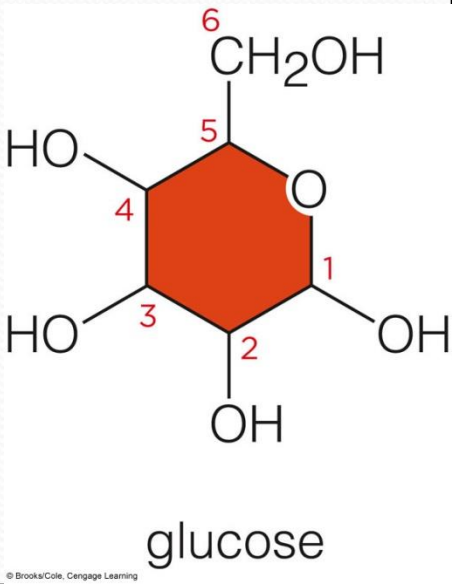
- **Carbohydrates =** Organic molecules that consist of carbon, hydrogen, and oxygen in a 1:2:1 ratio
  - the most plentiful biological molecules in the biosphere
- Used by cells as structural materials and stored or instant energy
- Three types of carbohydrates in living systems (don't write these yet – they are on the next slides!)
  - Monosaccharides (1 sugar = monomer)
  - Oligosaccharides (a few)
  - Polysaccharides (many)

Monosaccharides

- Monosaccharides = the monomer of carbohydrates
  - "simple sugars"
  - 5 or 6 carbon atoms, hydroxyl groups
  - End in -ose

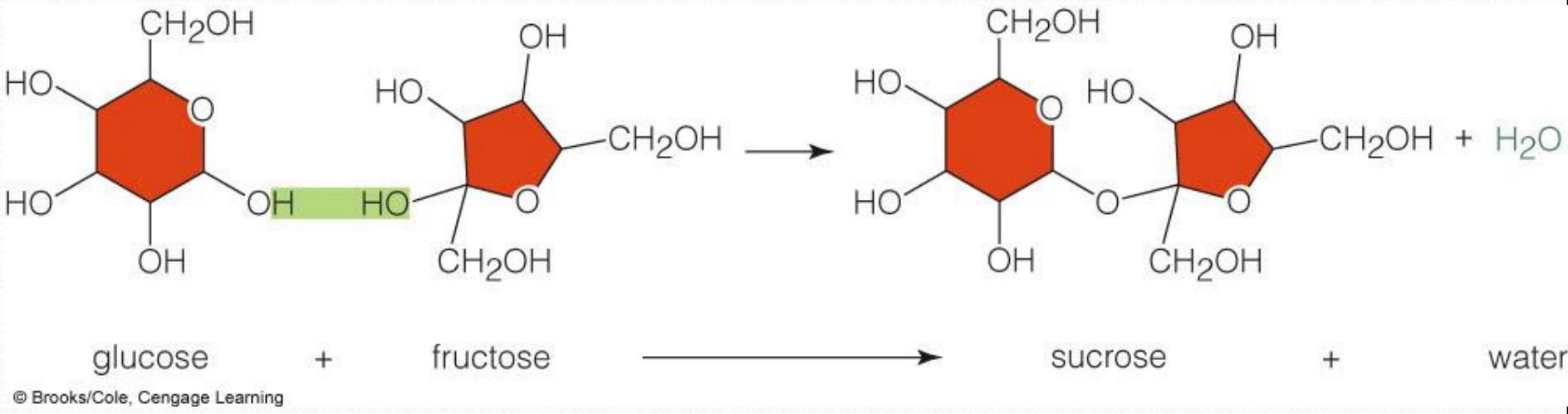






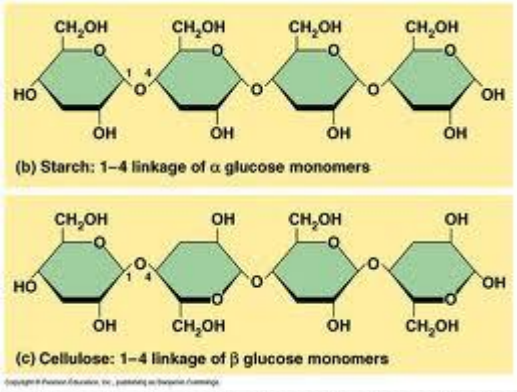
Oligosaccharide

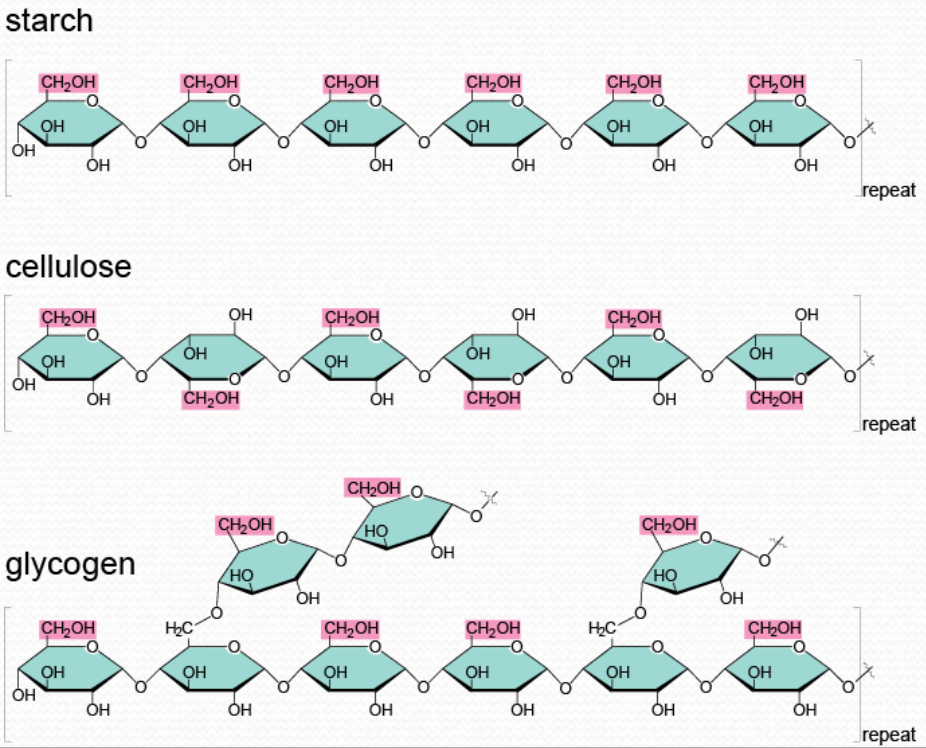
- Oligosaccharide = “a few” short chain of monosaccharides
  - Glucose + galactose = lactose (milk)
  - Glucose + fructose = sucrose (table sugar)



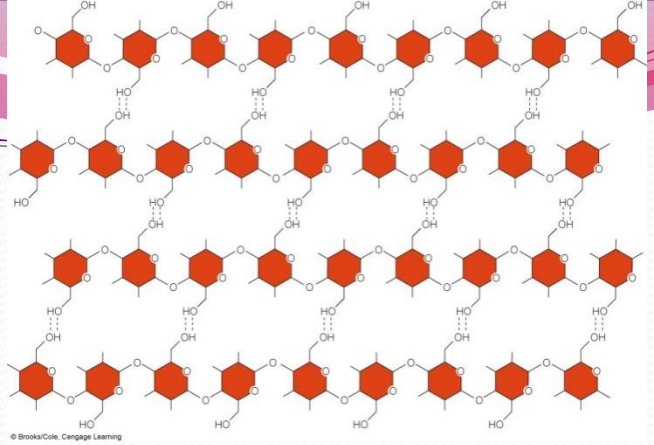
Polysaccharides

- Polysaccharides = many (100s or 1000s) of monomers
  - "complex" carbohydrates
  - Can be straight chained or branched
  - Ex. Starch, glycogen and cellulose are all made of glucose (see next slide)

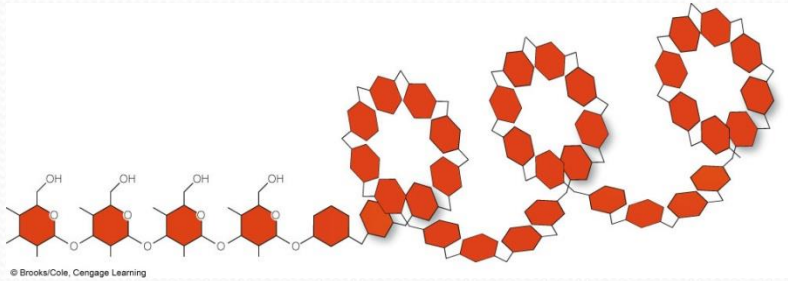




- Cellulose
  - Structure in plants

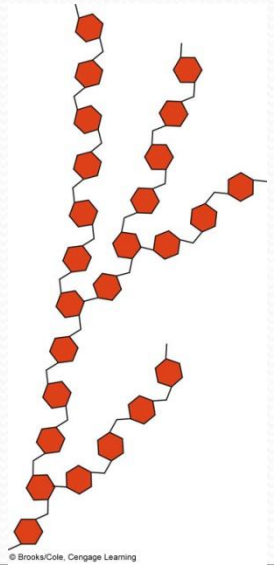


- Starch (amylose)
  - Main energy reserve in plants

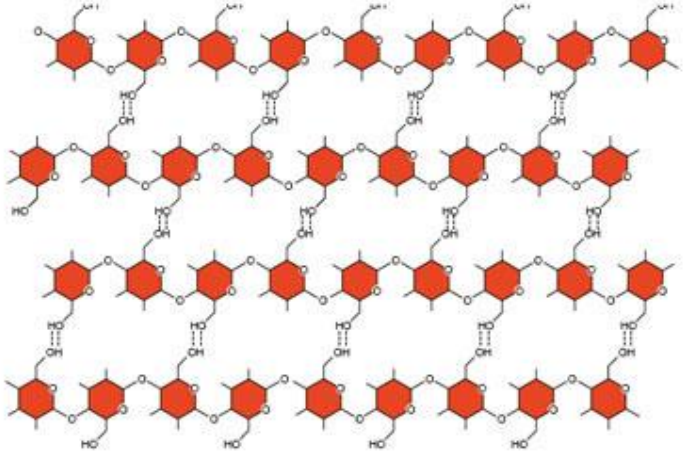


- Glycogen
  - Energy reserve in animals

(found in liver and muscles)

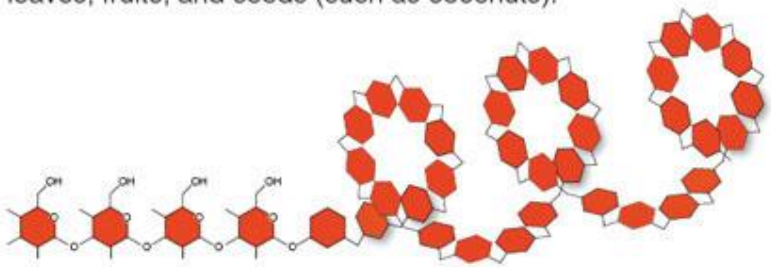


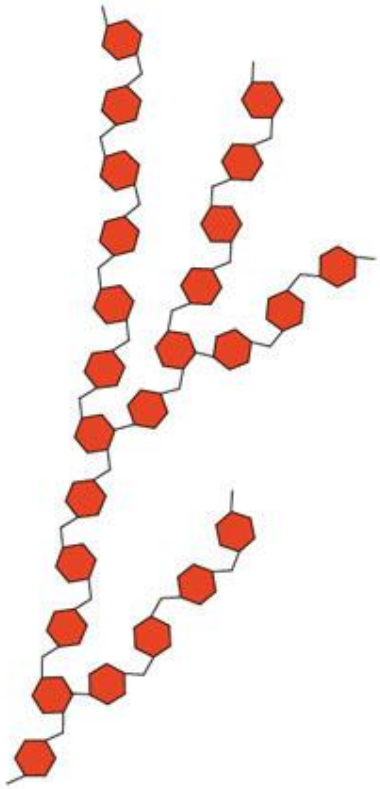
Cellulose, Starch, and Glycogen



a Cellulose, a structural component of plants. Chains of glucose units stretch side by side and hydrogen bond at many —OH groups. The hydrogen bonds stabilize the chains in tight bundles that form long fibers. Very few types of organisms can digest this tough, insoluble material.

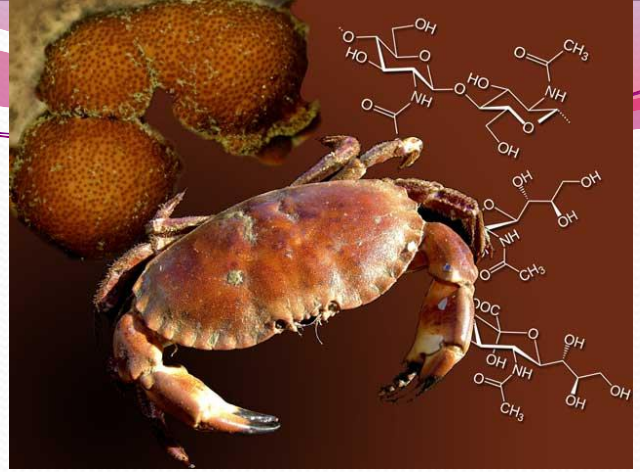
b In amylose, one type of starch, a series of glucose units form a chain that coils. Starch is the main energy reserve in plants, which store it in their roots, stems, leaves, fruits, and seeds (such as coconuts).



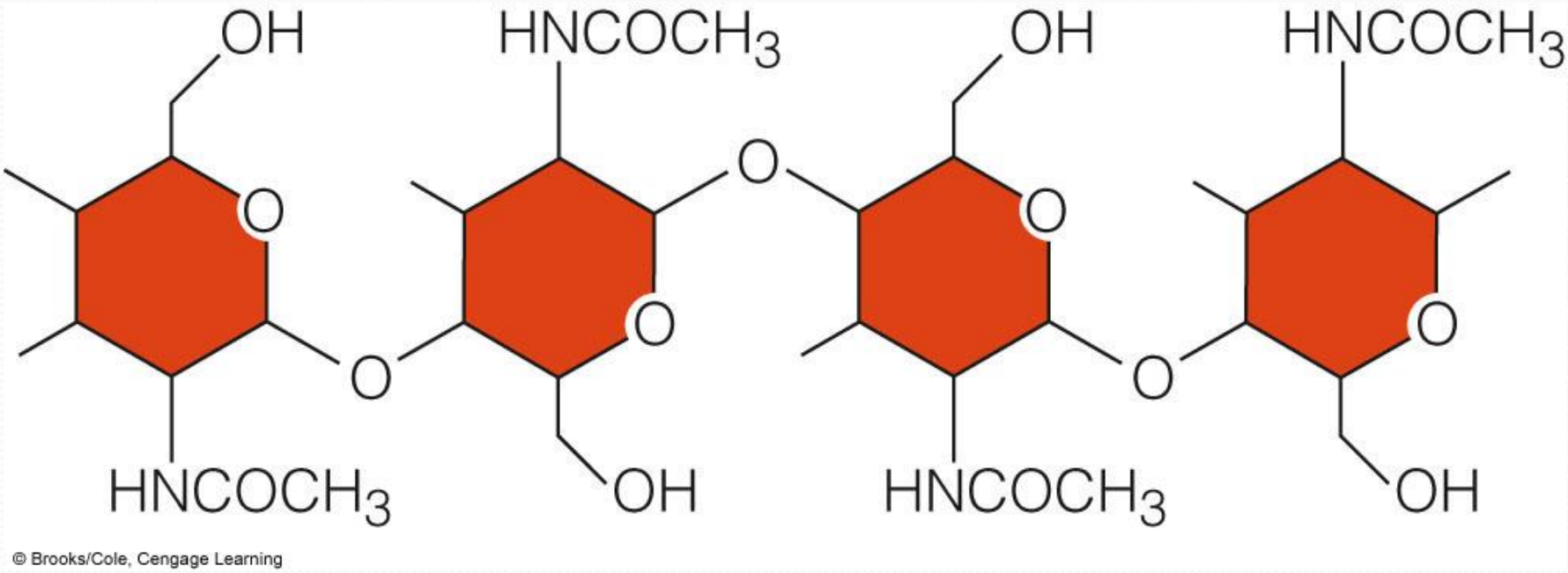


c Glycogen. In animals, this polysaccharide functions as an energy reservoir. It is especially abundant in the liver and muscles of active animals, including people.

Chitin

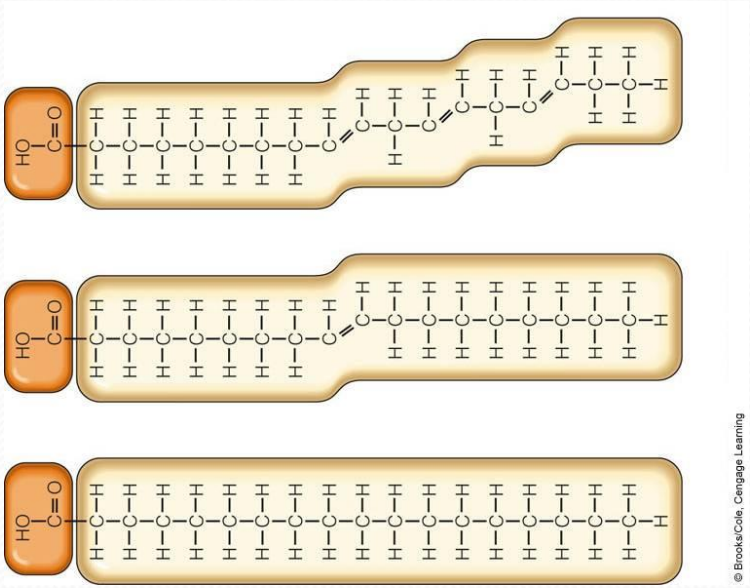


- Chitin =
  - Contains nitrogen
  - strengthens hard parts of animals such as crabs, and cell walls of fungi



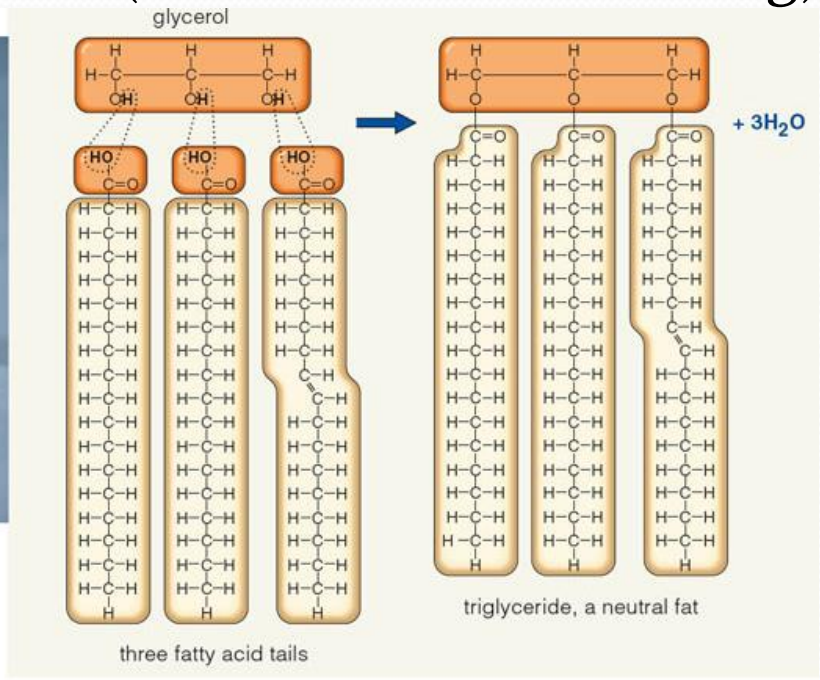
3.4 Greasy, Oily – Must be Lipids

- **Lipids** = fatty, oily or waxy organic compounds that are insoluble in water
- Many lipids are made of **fatty acids**
  - Fatty acids = Simple organic compounds with a carboxyl group joined to a backbone of 4 to 36 carbon atoms



Fats and Triglycerides

- **Fats =** Lipids with one, two, or three fatty acids "tails" attached to glycerol
- **Triglycerides =** Neutral fats with three fatty acids attached to glycerol
  - The most abundant energy source in vertebrates
  - Concentrated in adipose tissues (insulation & cushioning)



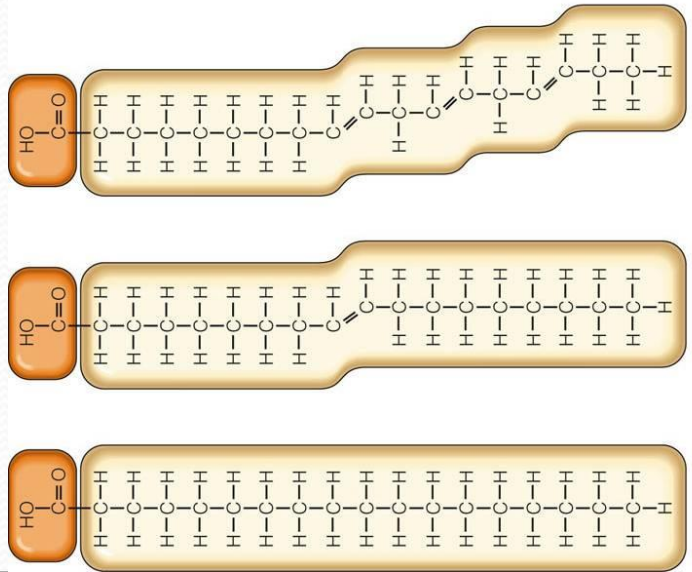
Saturated vs. unsaturated

- Saturated fatty acids – have single bond hydrocarbon tails ("saturated" with Hydrogen)
  - Animal fats – solid at room temperature
  - Straight tails pack tightly
- Unsaturated fatty acids – have 1 or more double bonds
  - Vegetable oils – liquid at room temp
  - Kinked tails don't pack tightly

polyunsaturated

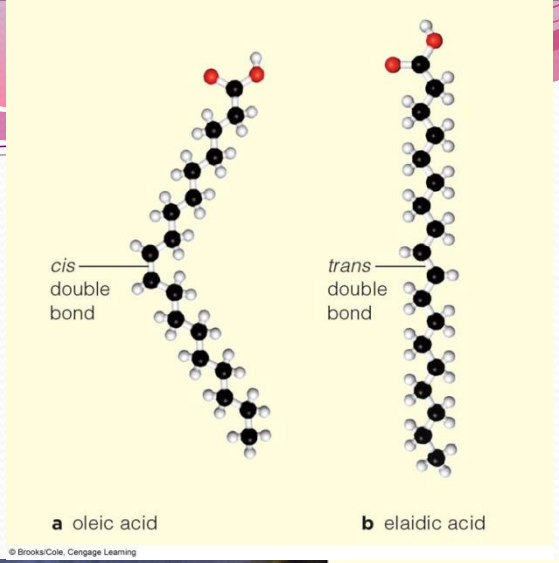
monounsaturated

saturated

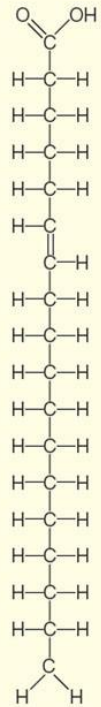


Trans Fats

- Trans fats
  - Partially hydrogenated vegetable oils formed by a chemical hydrogenation process
  - Double bond straightens the molecule
  - Pack tightly; solid at room temperature
  - Raise the level of cholesterol in the blood

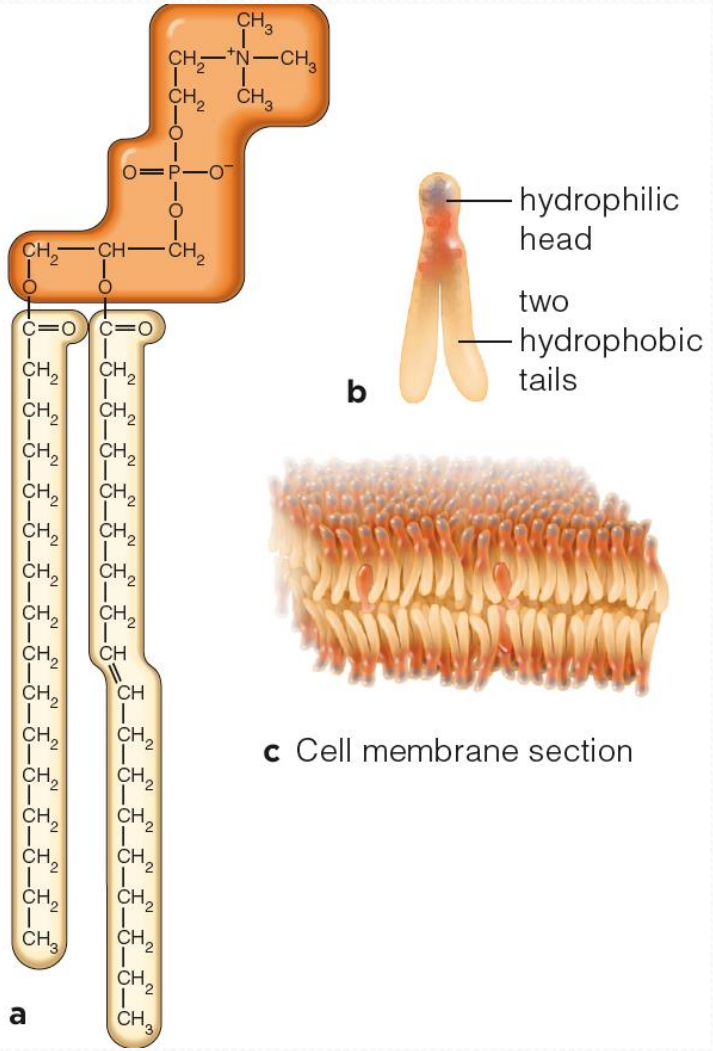



© Brooks/Cole, Cengage Learning



Phospholipids

- Phospholipids = have a polar head with a phosphate and 2 nonpolar fatty acid tails
  - Head = hydrophilic
  - Tail = hydrophobic
  - Most abundant lipid in cell membranes

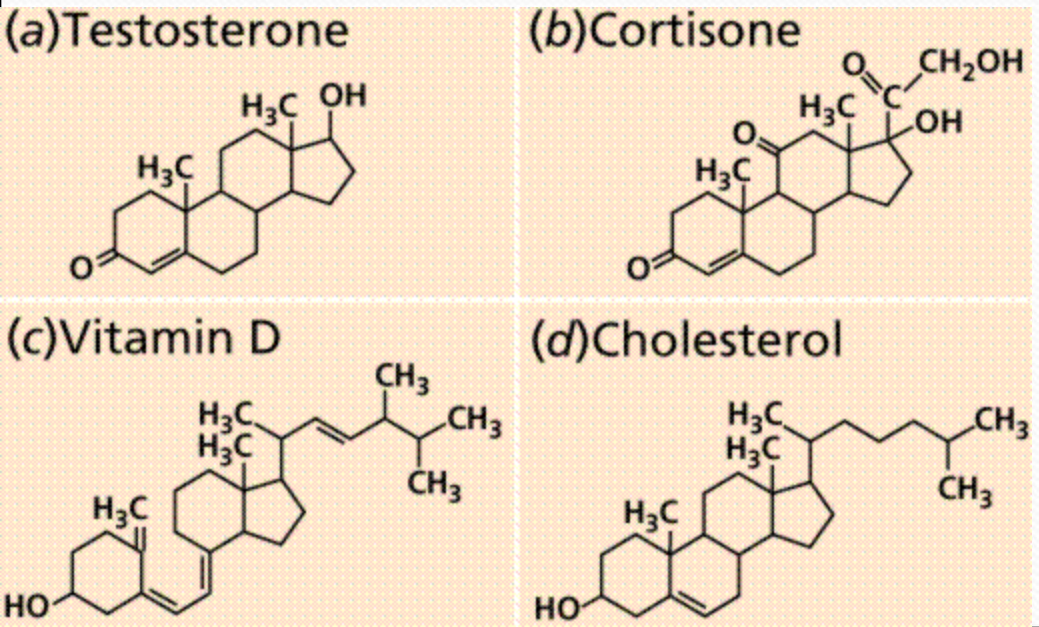


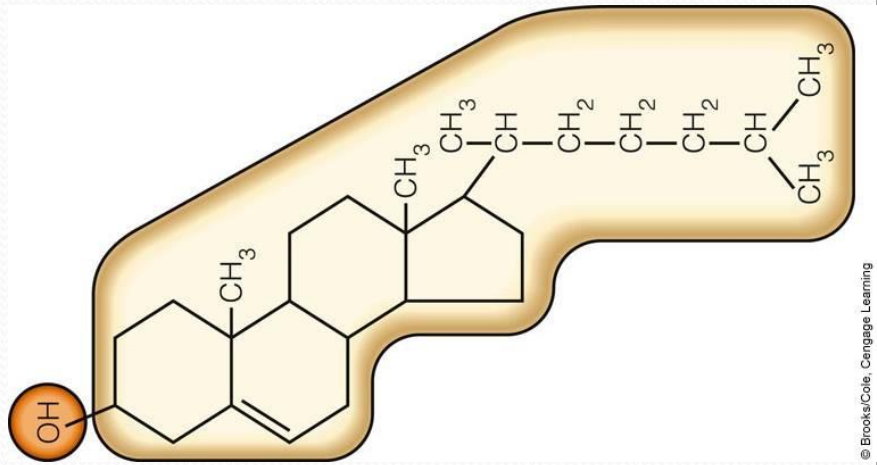
Waxes

- Complex mixtures with long fatty-acid tails bonded to long-chain alcohols or carbon rings
- Protective, water-repellant covering

Steroids

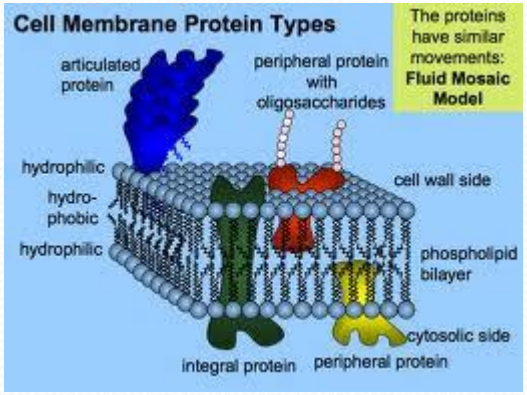
- **Steroids** = Lipids with a rigid backbone of four carbon rings and no fatty-acid tails
- Cholesterol
  - Component of eukaryotic cell membranes
  - Remodeled into bile salts, vitamin D, and steroid hormones (estrogens and testosterone)

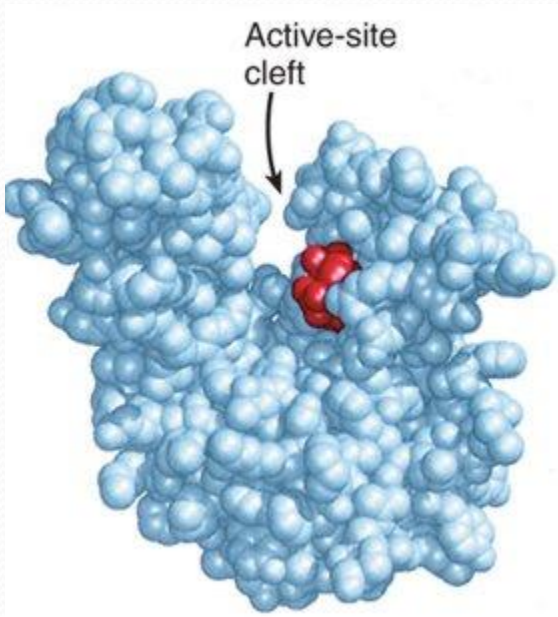




3.5 Proteins

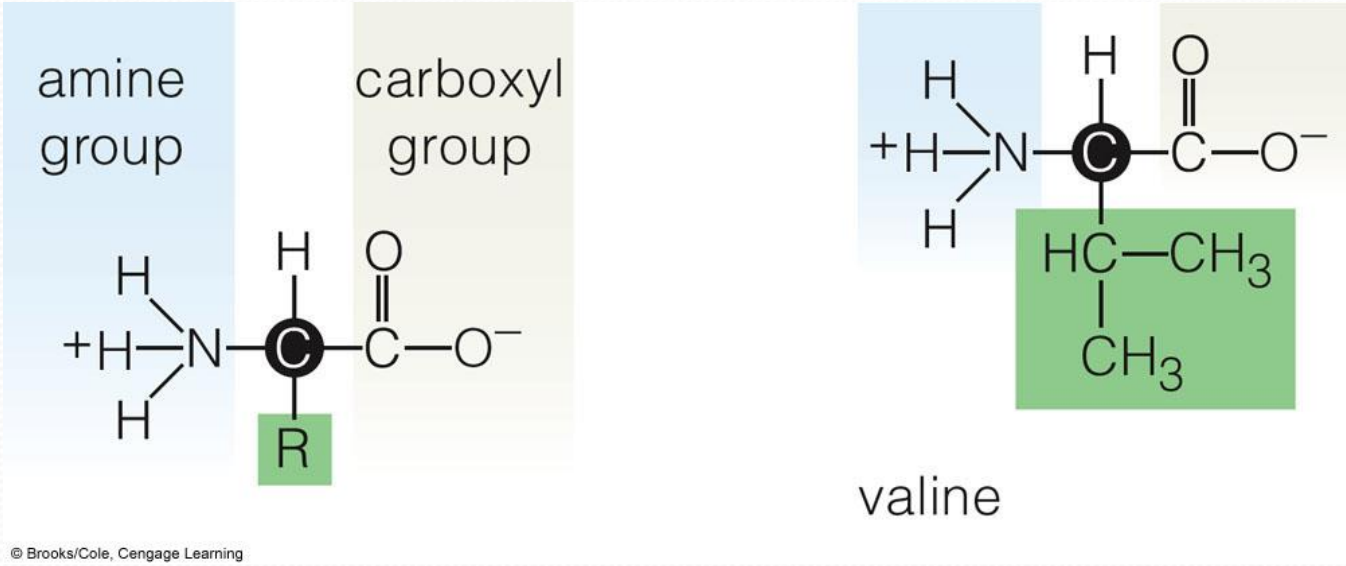
- Proteins = organic compound made of amino acids
- Proteins are the most diverse biological molecule
  - Structure – hair, hoofs, feathers,
  - Enzymes
  - Cell communication – messengers
  - Cellular defense - antibodies
  - Provide energy (seeds, eggs, etc)
  - Cell membranes





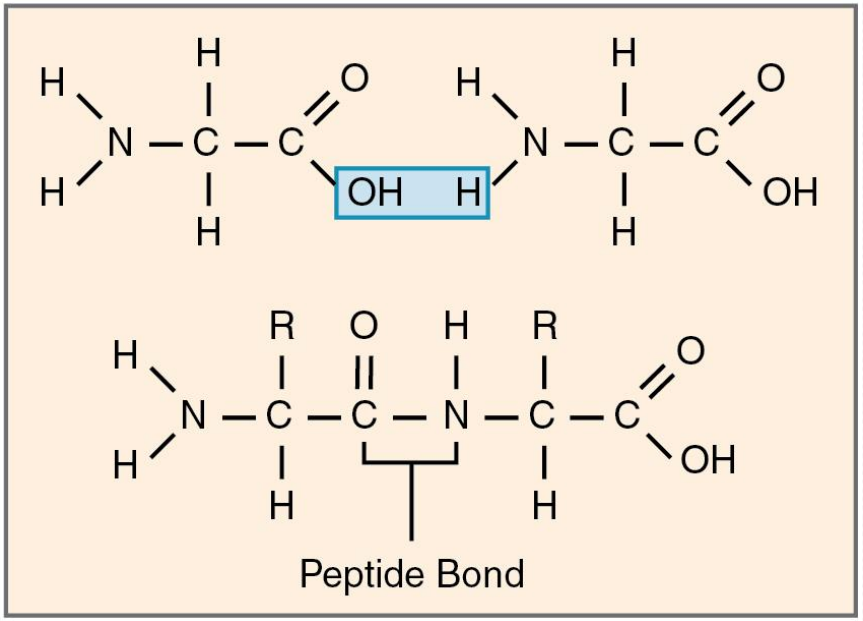
Amino Acids

- Cells build thousands of different proteins by stringing together amino acids in different orders
- Amino acid = an organic compound with an amine, carboxyl, and "R" group

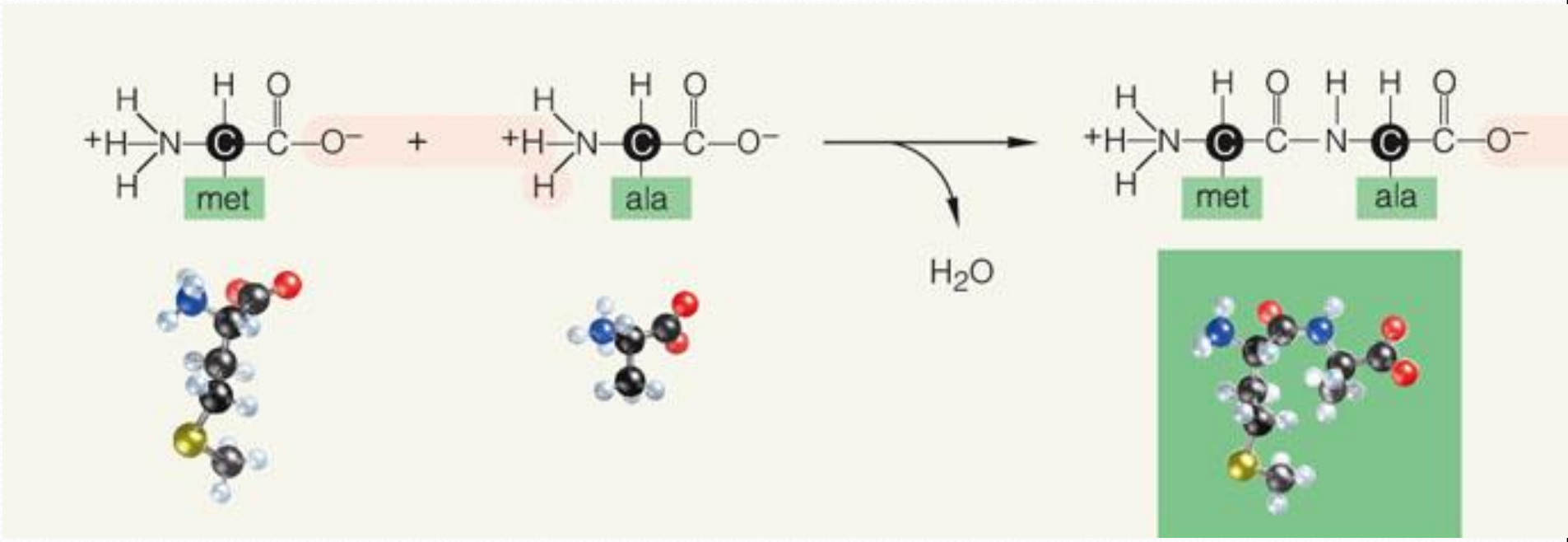


Peptide bonds

- Amino acids combine to form polypeptides
- The bond between amino acids is called a peptide bond
  - Formed through condensation (dehydration synthesis)



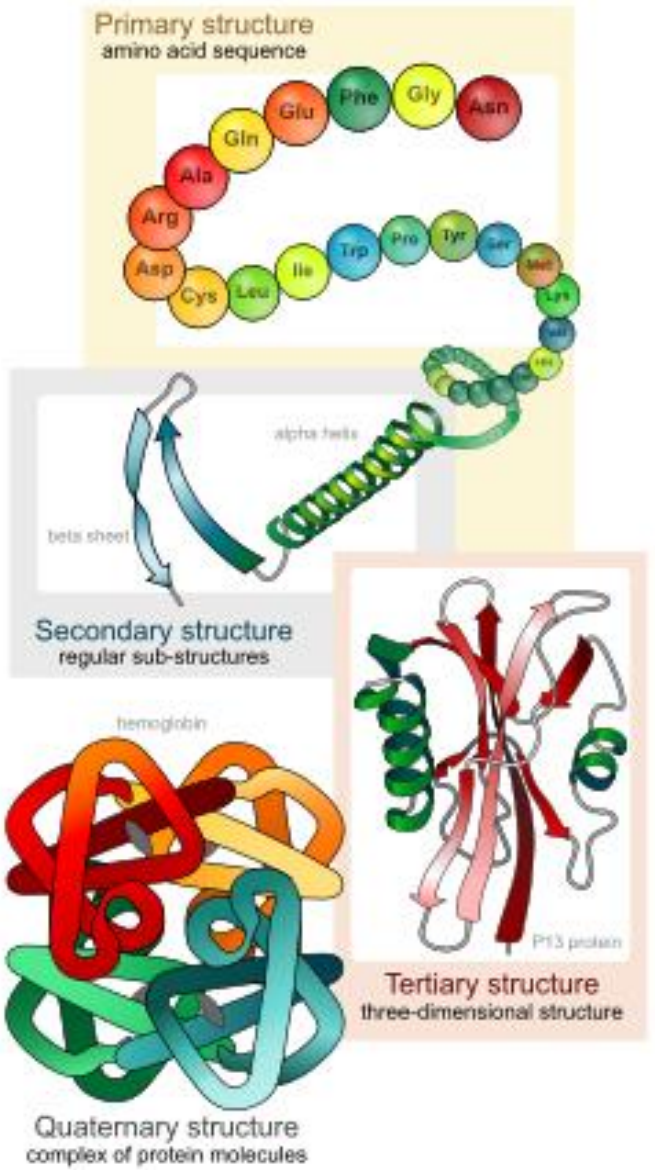
Formation of a peptide bond



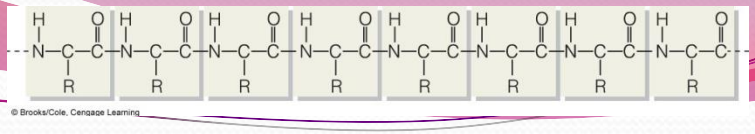

IT'S MONDAY
Don't FORGET
TO BE
AWESOME.

Level of Protein Structure

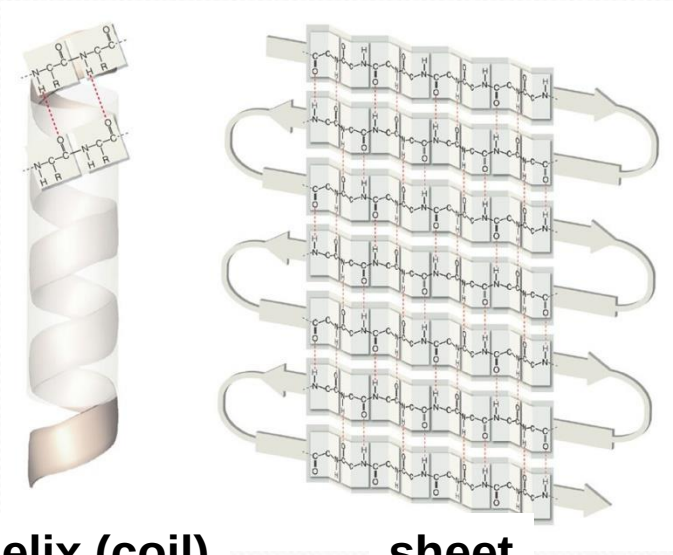
1) Primary – amino acid sequence
2) Secondary – hydrogen bonds between amino acids causes the chains twist, bend, loop and fold
3) Tertiary – the secondary structure coils into compact and stable "domains"
4) Quaternary- 2 or more polypeptide chains associate as one molecule



a) Protein primary structure: Amino acids bonded as a polypeptide chain.

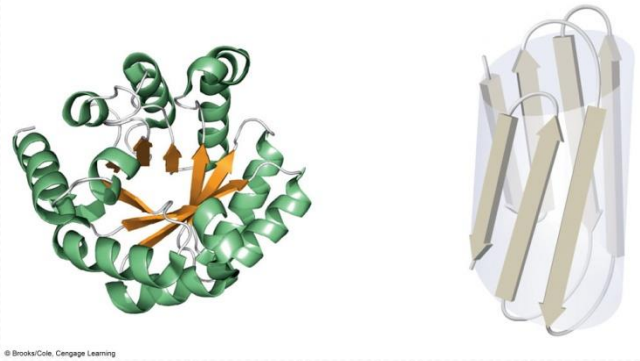


b) Protein secondary structure: A coiled (helical) or sheetlike array held in place by hydrogen bonds (dotted lines) between different parts of the polypeptide chain.



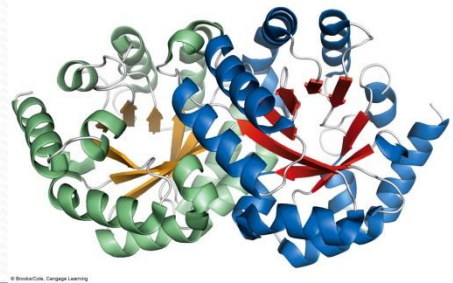
helix (coil) **sheet**

c) Protein tertiary structure: A chain's coils, sheets, or both fold and twist into stable, functional domains such as barrels or pockets.



barrel

d) Protein quaternary structure: two or more polypeptide chains associated as one molecule.

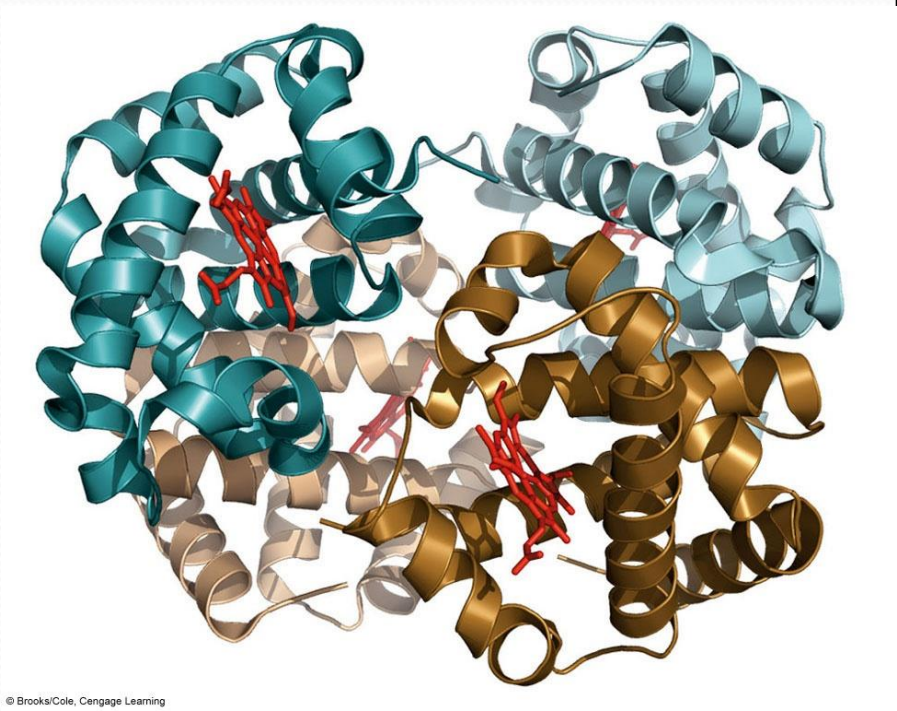


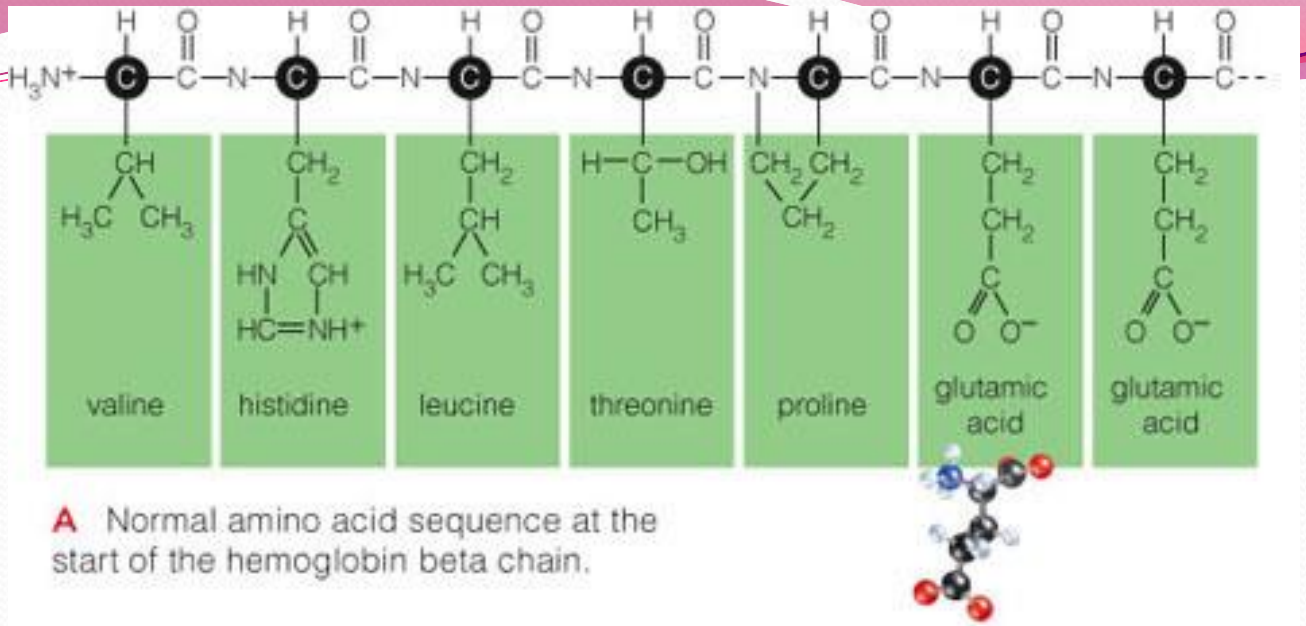
Stepped Art

Fig. 3-17, p. 45

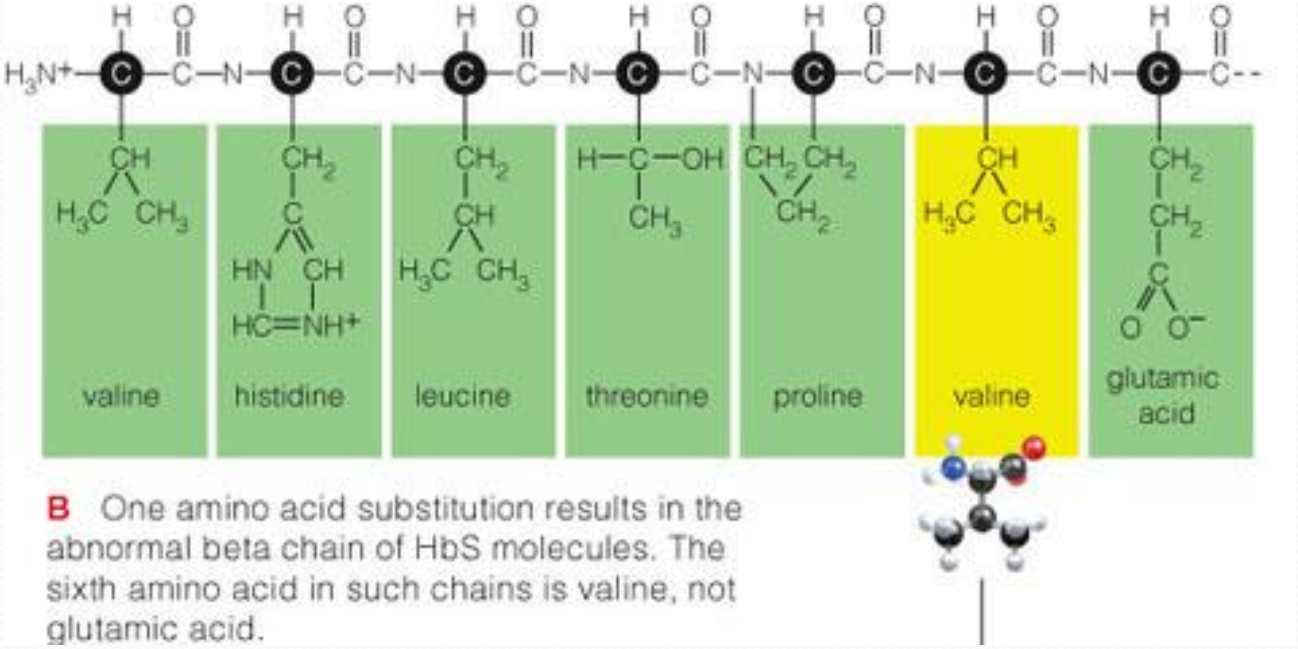
3.6 Why is protein structure important?

- When an protein's amino acid sequence is changed, the protein structure (and function) may also be changed
  - Ex. Sickle cell anemia
    - Hemoglobin contains 4 peptide chains – each bonds 1 oxygen molecule



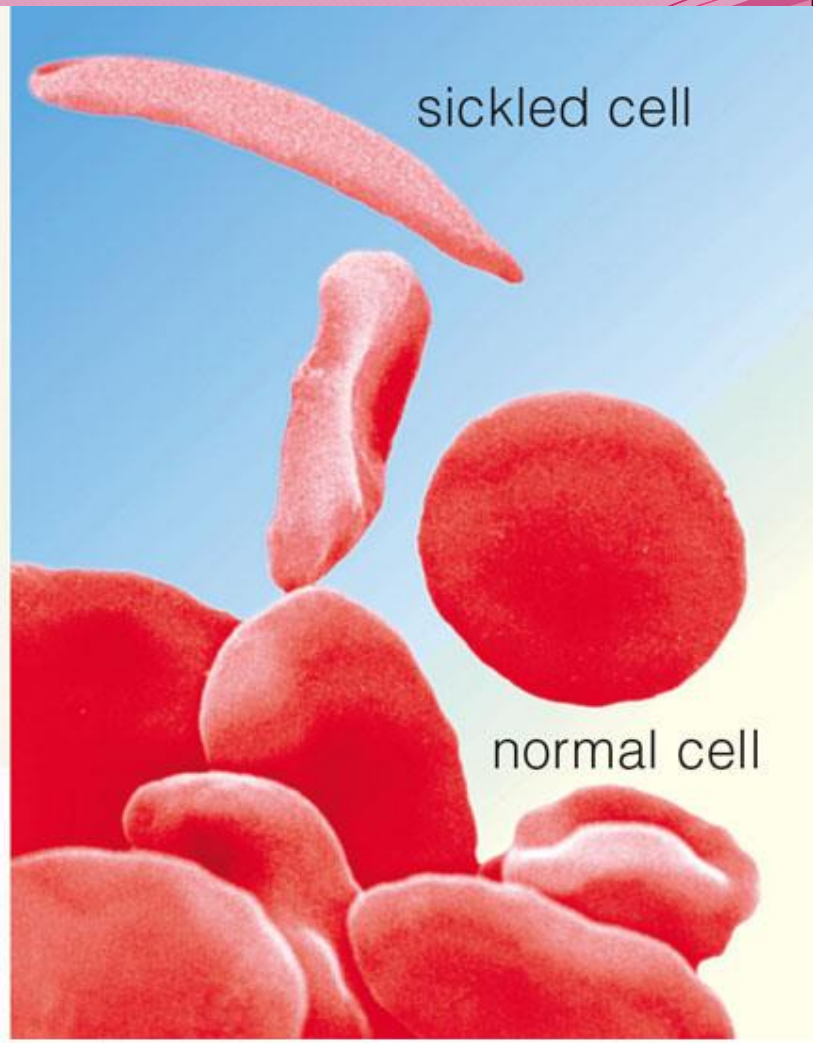


A Normal amino acid sequence at the start of the hemoglobin beta chain.



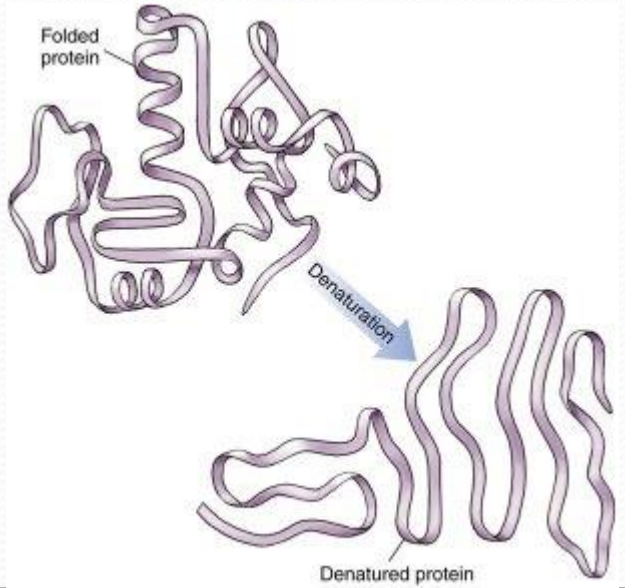
B One amino acid substitution results in the abnormal beta chain of HbS molecules. The sixth amino acid in such chains is valine, not glutamic acid.

C Glutamic acid carries a negative charge; valine carries no charge. This difference changes the protein so it behaves differently. At low oxygen levels, HbS molecules stick together and form rod-shaped clumps that distort normally rounded red blood cells into sickle shapes. (A sickle is a farm tool that has a crescent-shaped blade.)



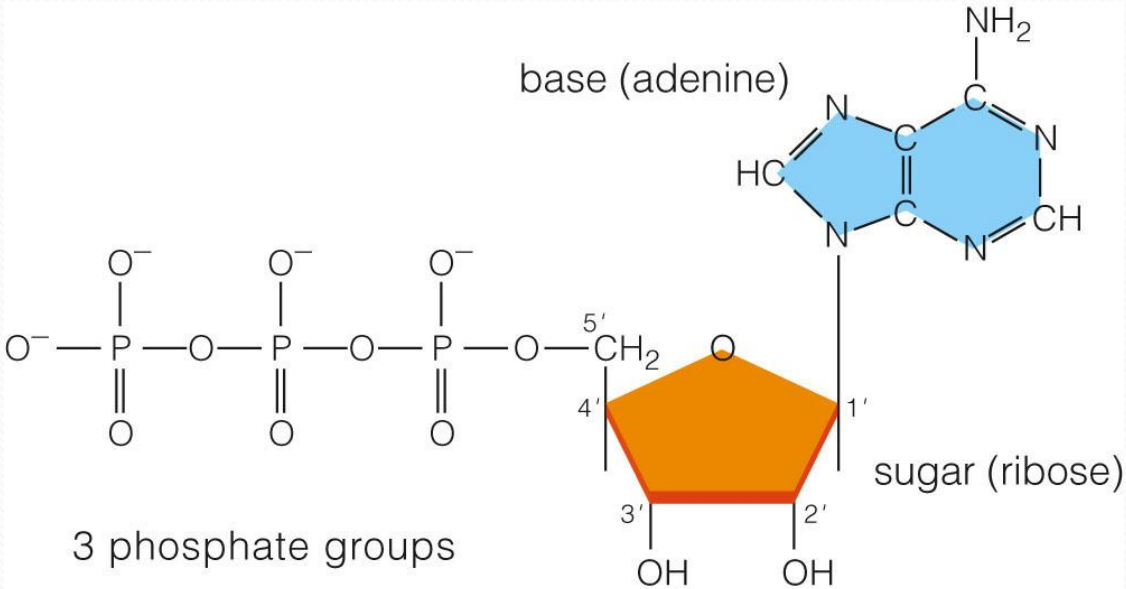
Denaturation

- Proteins function only as long as they maintain their correct 3-D shape
  - When a protein loses its shape and no longer functions, it is **denatured**
  - Heat, changes in pH, salts, and detergents can disrupt the hydrogen bonds that maintain a protein's shape



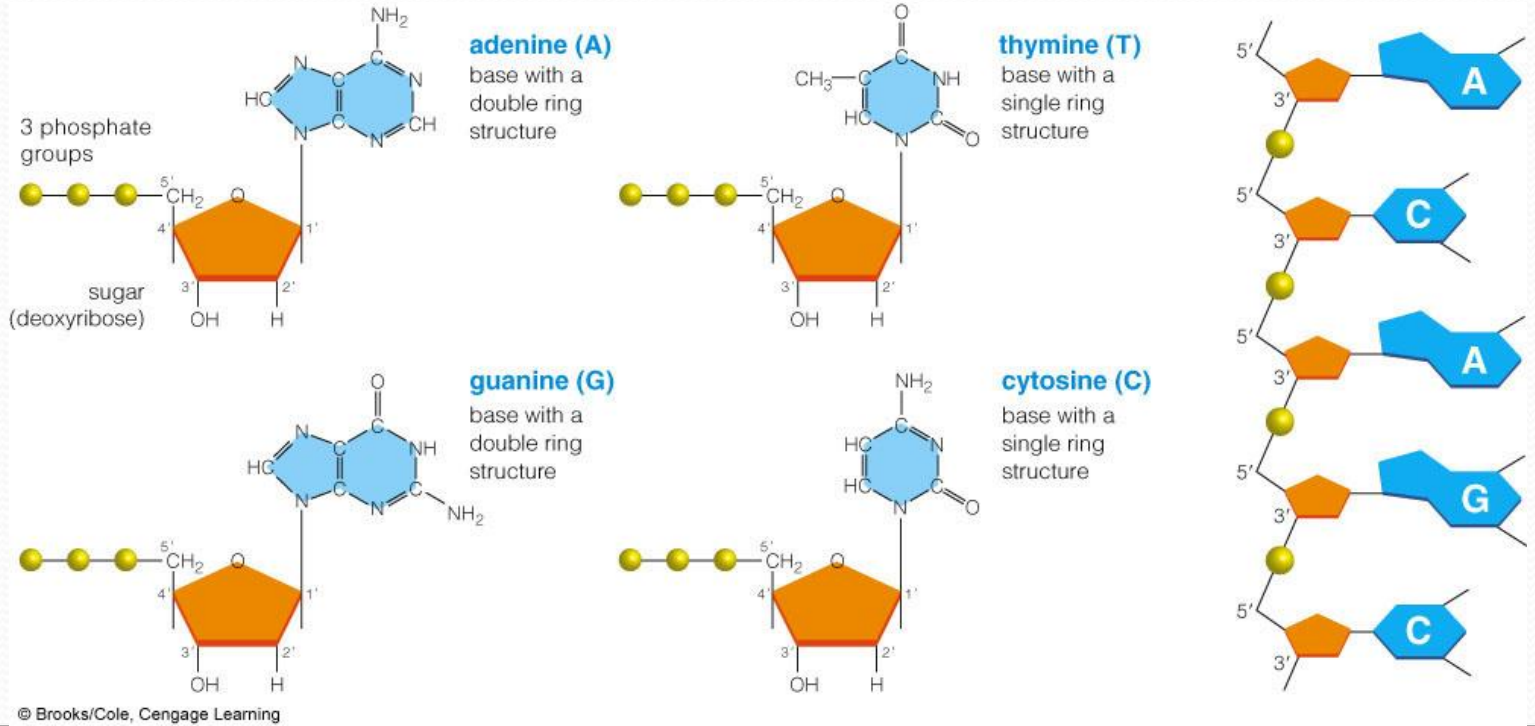
3.7 Nucleic Acids

- **Nucleotide**
  - Consists of a 5-carbon ring sugar, a nitrogen-containing base, and 1 or more phosphate groups
- **ATP**
  - A nucleotide with 3 phosphate groups
  - Important in phosphate-group (energy) transfer



Nucleic acid

- **Nucleic acids**
  - Polymers of nucleotides in which the sugar of one nucleotide is attached to the phosphate group of the next
  - DNA and RNA (next slide)



DNA and RNA

- **RNA (ribonucleic acid)**
  - Contains 4 kinds of nucleotide monomers, including ATP
  - Important in protein synthesis
- **DNA (deoxyribonucleic acid)**
  - Two chains of nucleotides twisted together into a double helix and held by hydrogen bonds
  - Contains all inherited information necessary to build an organism, coded in the order of nucleotide bases