Chapter 3: Molecules of Life

Organic Compounds

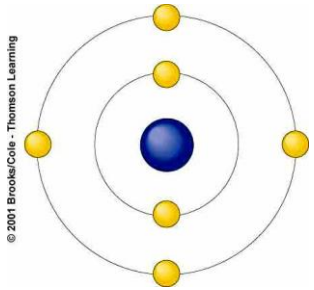
Hydrogen and other elements covalently bonded to carbon

- Carbohydrates
- Lipids
- Proteins
- Nucleic Acids

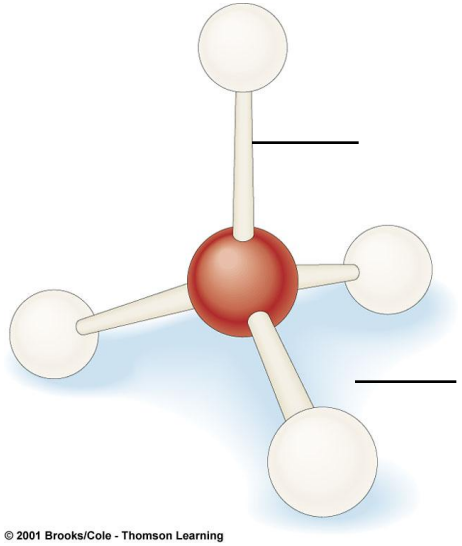
Carbon's Bonding Behavior

Chemistry of Carbon

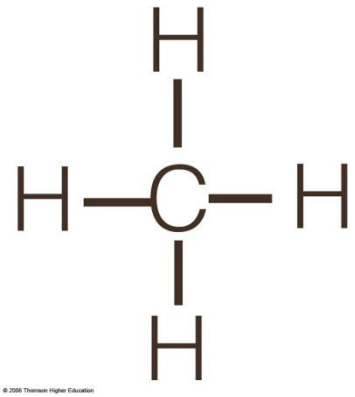
- Outer shell of carbon has 4 electrons; can hold 8



- Each carbon atom can form covalent bonds with up to four atoms

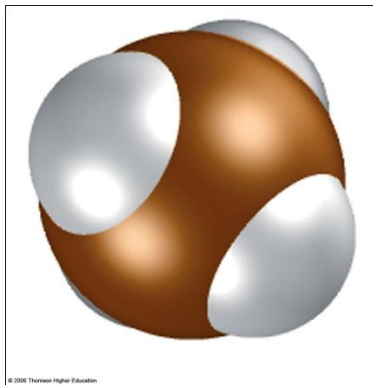


Organic Compounds



structural formula for methane

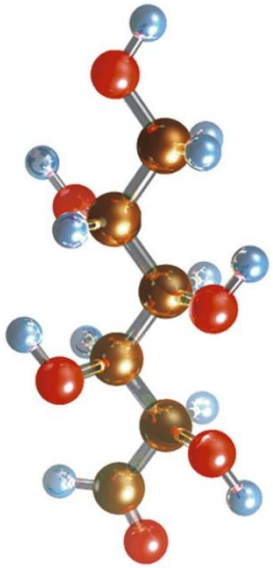
ball-and-stick model

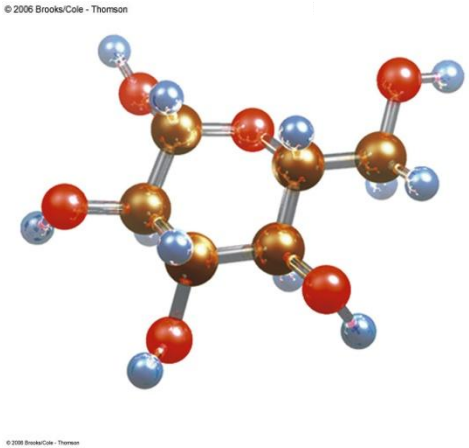


space-filling model

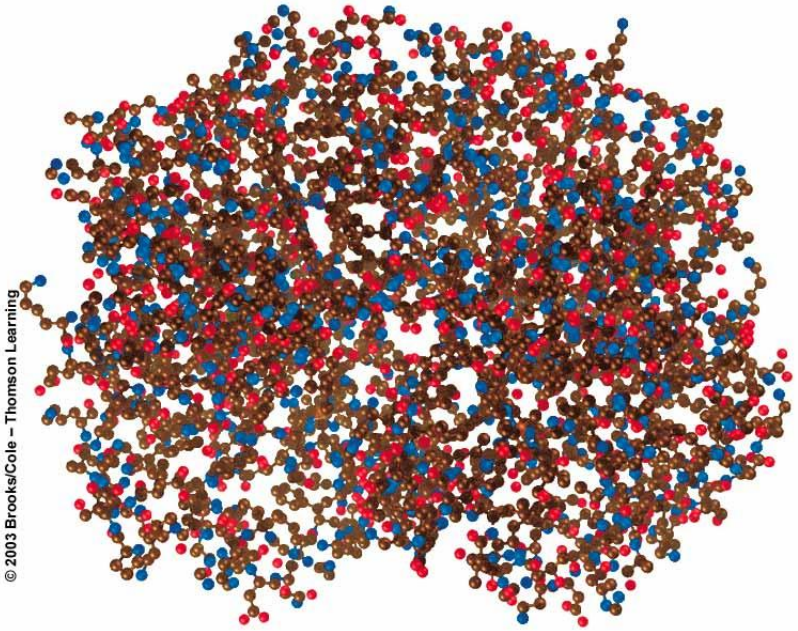
Bonding Arrangements

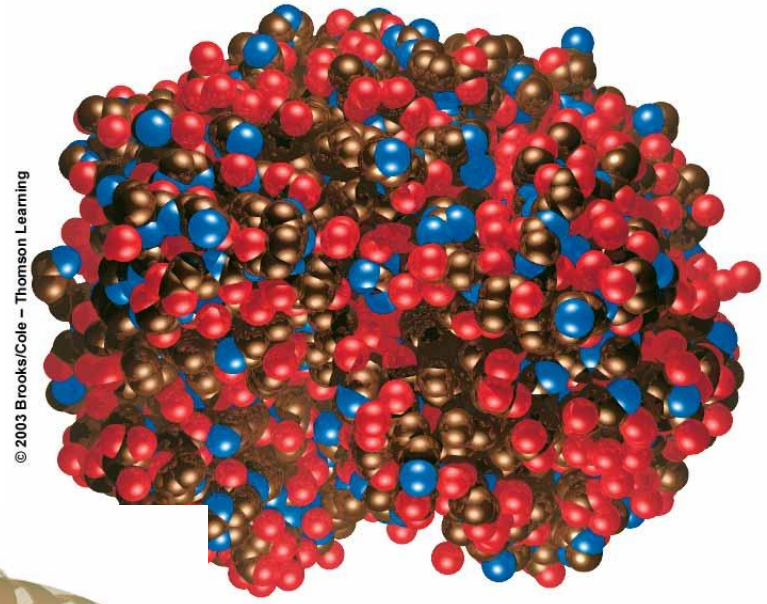
- Carbon atoms can form chains or rings
- Other atoms project from the carbon backbone





Organic Compounds





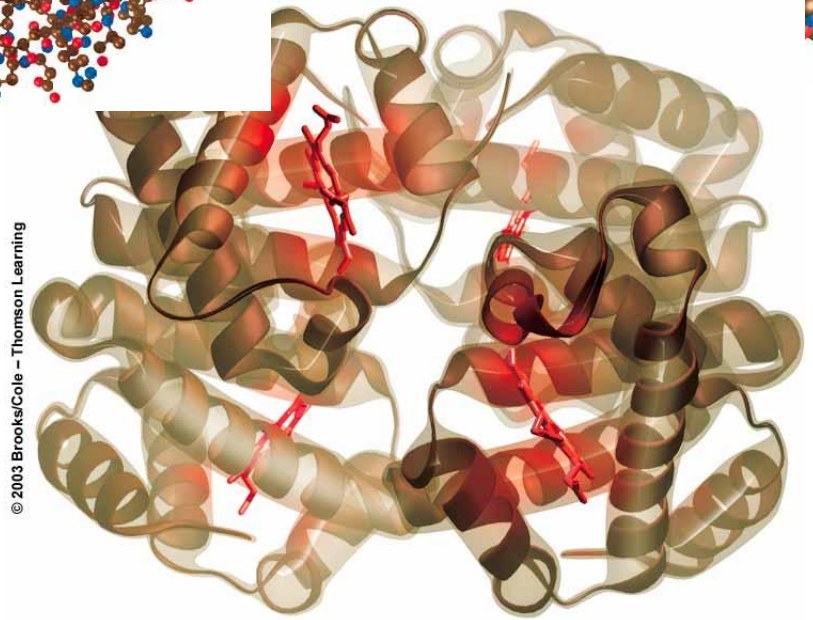


Fig. 3-2, p.35

Examples of Functional Groups

Hydroxyl group	- OH
Amino group	- NH_3^+
Carboxyl group	- COOH
Phosphate group	- PO_3^-
Sulfhydryl group	- SH

Functional Groups

- **Atoms or clusters of atoms that are covalently bonded to carbon backbone**

- **Give organic compounds their different properties**

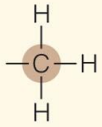
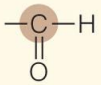
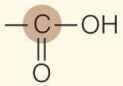
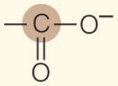
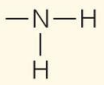
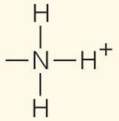
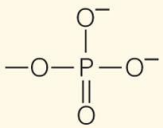
Hydroxyl	—OH		In alcohols (e.g., sugars, amino acids); water soluble
Methyl			In fatty acid chains; insoluble in water
Carbonyl	 —CHO (aldehyde)	 >CO (ketone)	In sugars, amino acids, nucleotides; water soluble. An *aldehyde* if at end of a carbon backbone; a *ketone* if attached to an interior carbon of backbone
Carboxyl	 —COOH (non-ionized)	 —COO^- (ionized)	In amino acids, fatty acids; water soluble. Highly polar; acts as an acid (releases H^+)
Amino	 —NH_2 (non-ionized)	 —NH_3^+ (ionized)	In amino acids and certain nucleotide bases; water soluble; acts as a weak base (accepts H^+)
Phosphate		 icon	In nucleotides (e.g., ATP), also in DNA, RNA, many proteins, phospholipids; water soluble, acidic
Sulfhydryl	—SH	—S—S— (disulfide bridge)	In amino acid cysteine; helps stabilize protein structure (at disulfide bridges)

Fig. 3-4, p.36

Condensation

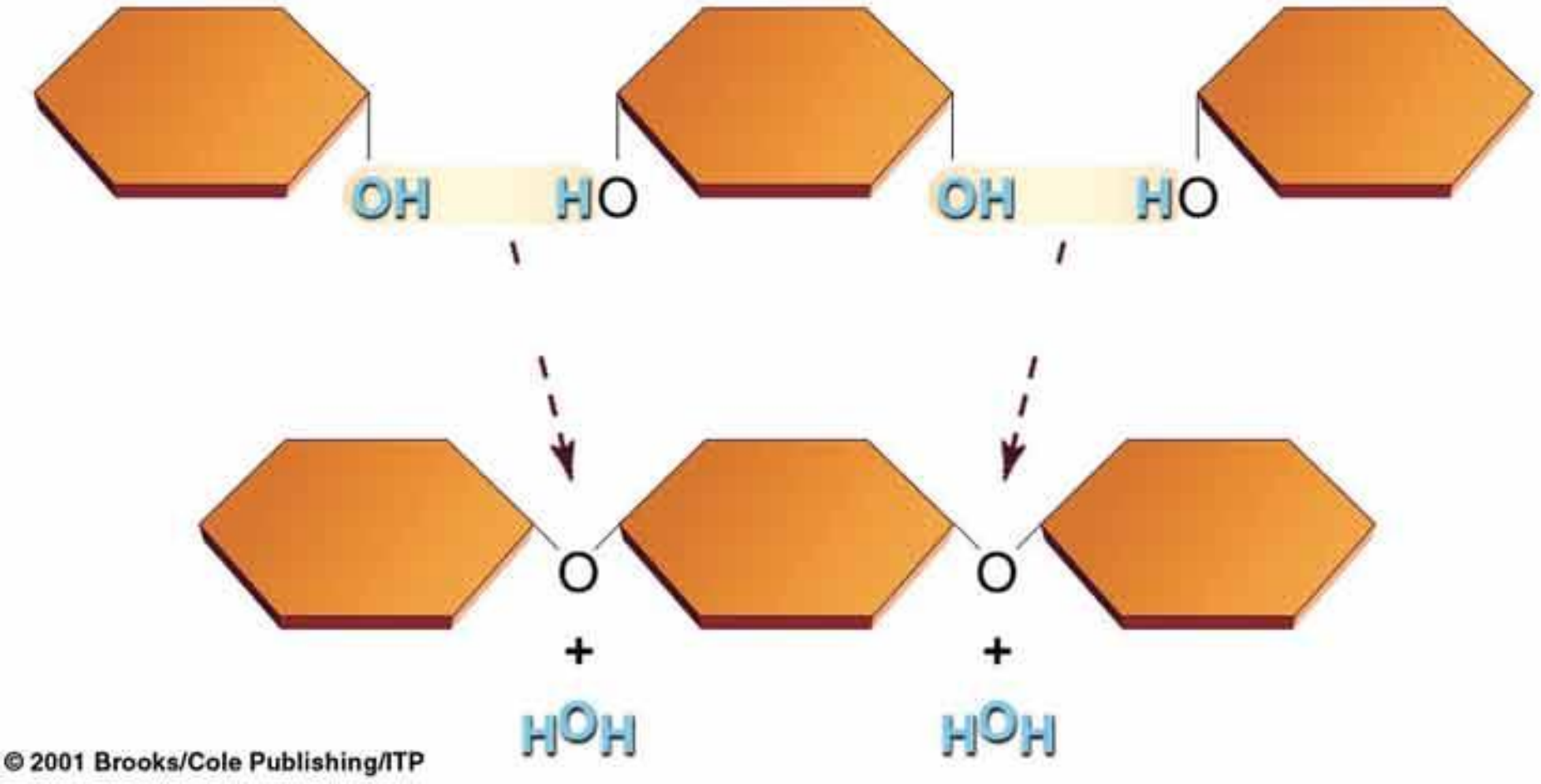


Fig. 3-6a, p.38

Hydrolysis

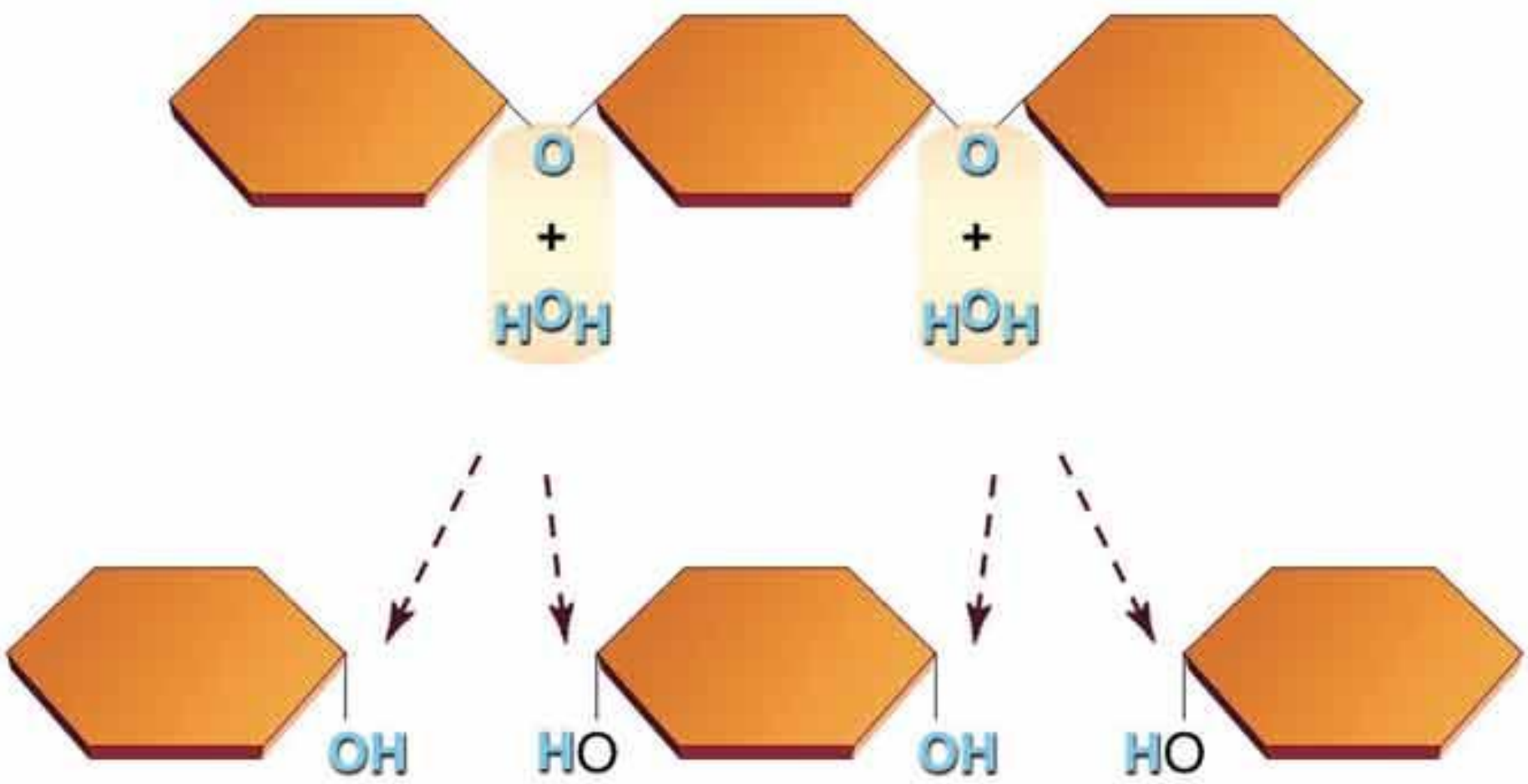


Fig. 3-6b, p.38

Carbohydrates

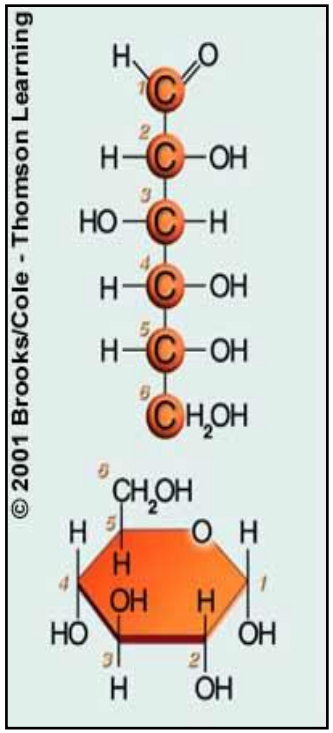
Monosaccharides
(simple sugars)

Oligosaccharides
(short-chain carbohydrates)

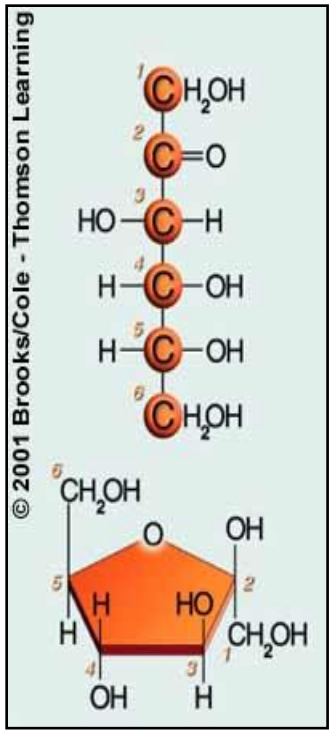
Polysaccharides
(complex carbohydrates)

Monosaccharides

- **Simplest carbohydrates**
- Most are sweet tasting, water soluble
- Most have 5- or 6-carbon backbone
  - Glucose (6 C)
  - Fructose (6 C)
  - Ribose (5 C)
  - Deoxyribose (5 C)



glucose



fructose

Disaccharides

- Type of oligosaccharide
- **Two monosaccharides covalently bonded**
- Formed by condensation reaction

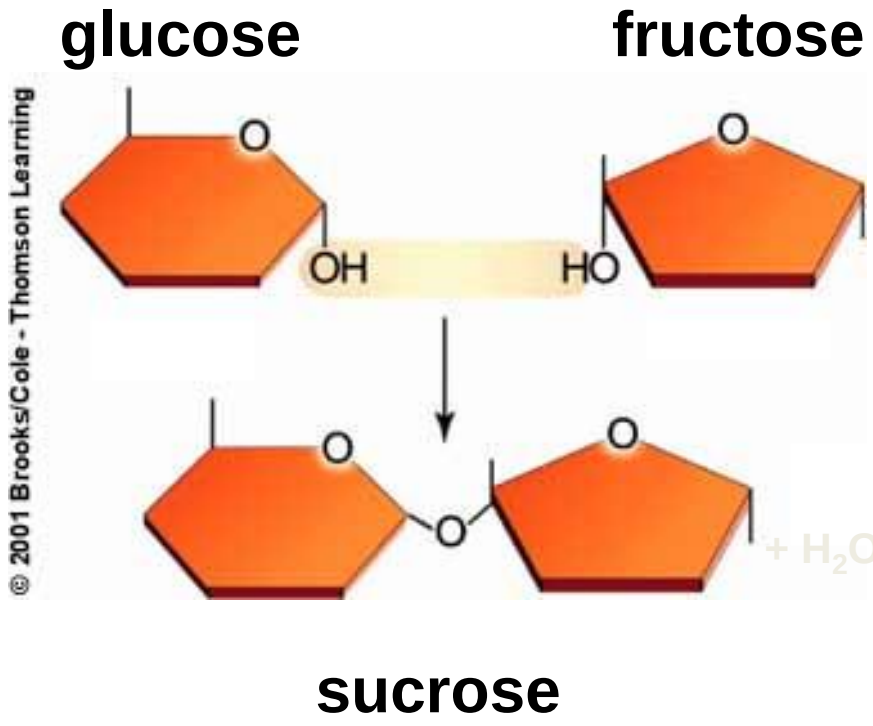


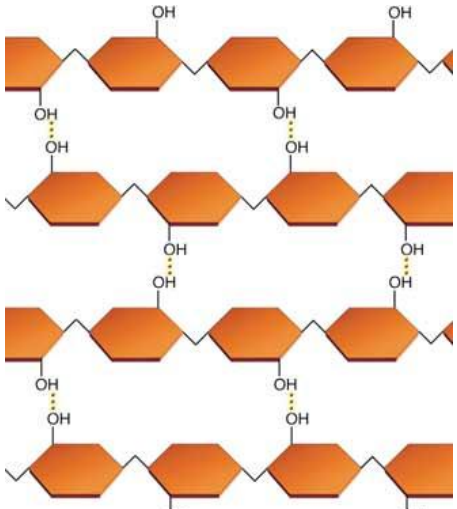
Fig. 3-7b, p.38

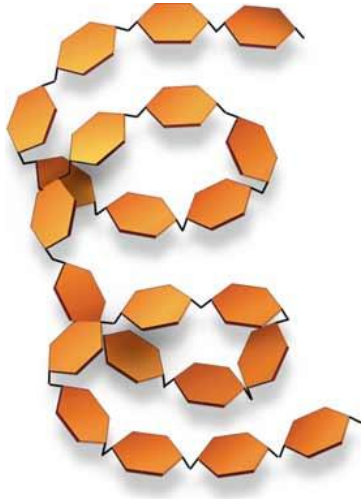
Polysaccharides

- Straight or branched chains of many sugar monomers
- Most common are composed entirely of glucose
  - Cellulose
  - Starch (such as amylose)
  - Glycogen

Cellulose & Starch

- Differ in bonding patterns between monomers
- **Cellulose** - tough, indigestible, structural material in plants
- **Starch** - easily digested, storage form in plants





Glycogen

- Sugar storage form in animals
- Large stores in muscle and liver cells
- When blood sugar decreases, liver cells degrade glycogen, release glucose

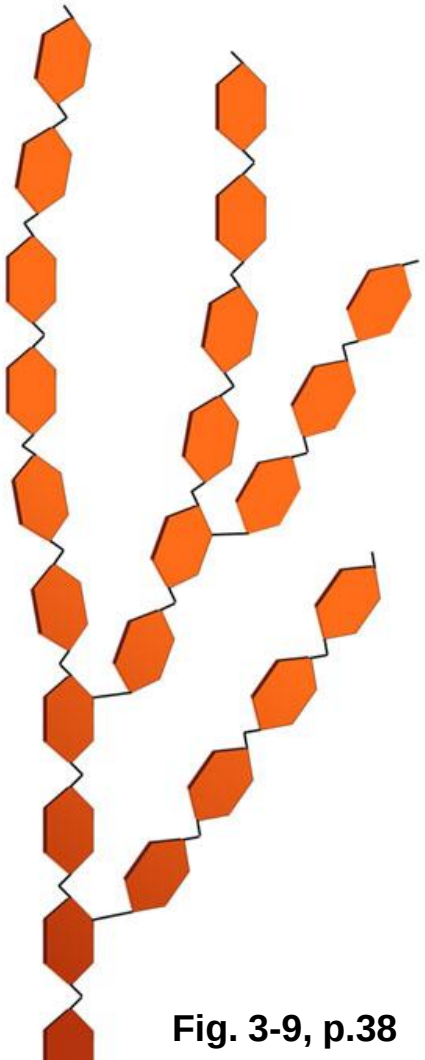


Fig. 3-9, p.38

Lipids

- **Most include fatty acids**
  - **Fats**
  - **Phospholipids**
  - **Waxes**
- Sterols (steriods) and their derivatives have no fatty acids
- Tend to be insoluble in water

Fats

- **Fatty acid(s) attached to glycerol**
- **Triglycerides are the most common fat**

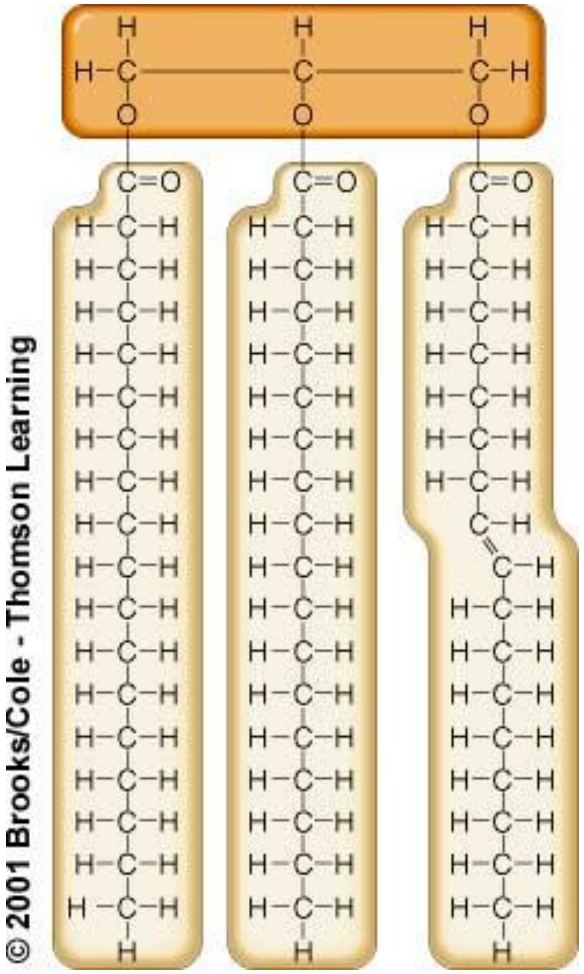
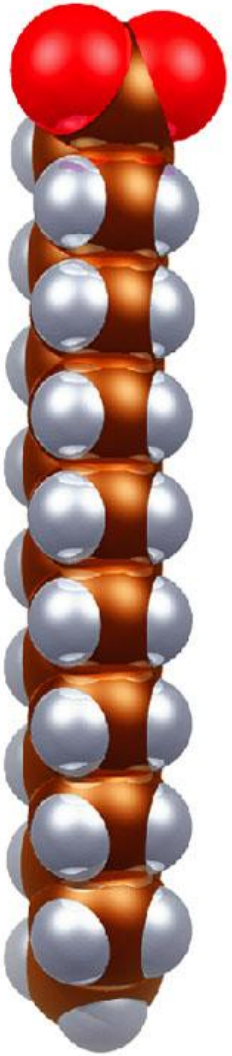
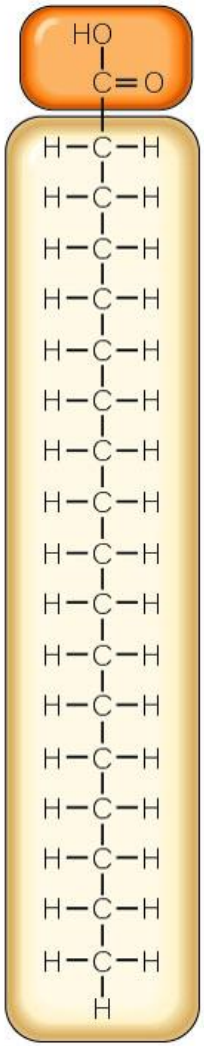
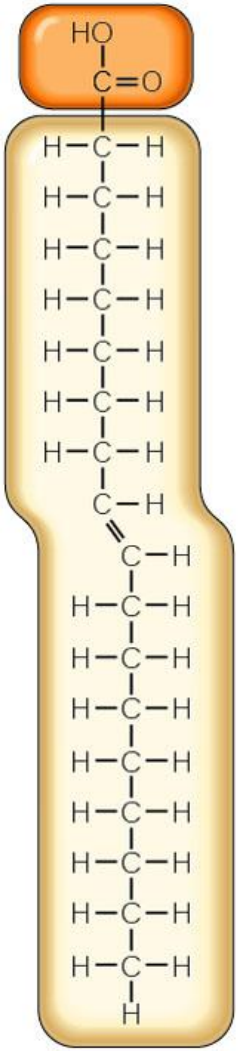


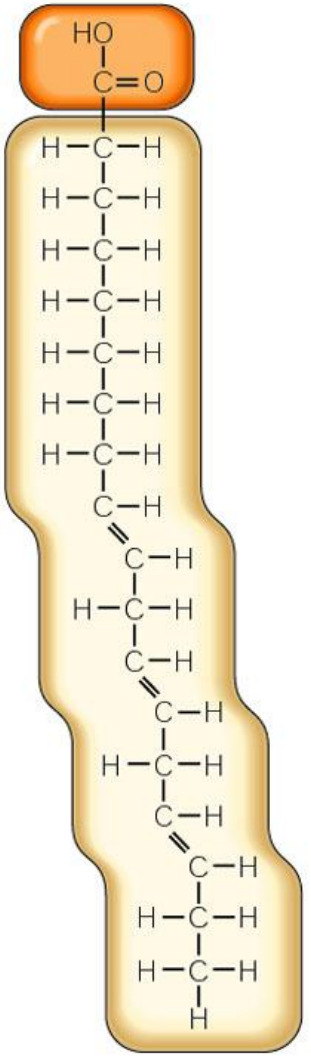
Fig. 3-12, p.40

Three Fatty Acids









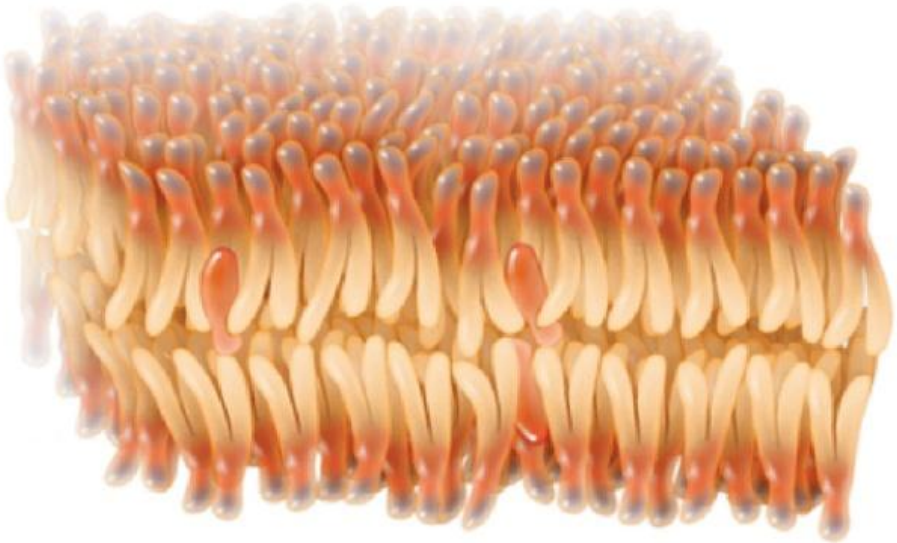
© 2006 Brooks/Cole - Thomson
© 2006 Brooks/Cole - Thomson
© 2006 Brooks/Cole - Thomson

Fig. 3-11, p.40

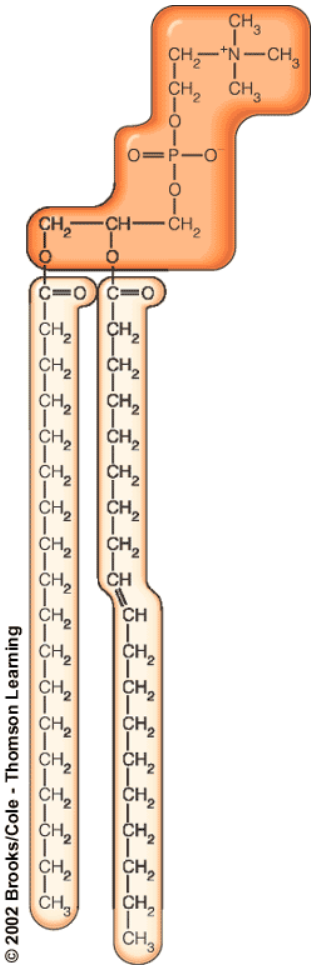
Fig. 3-12a, p.40

Phospholipids

- **Main components of cell membranes**

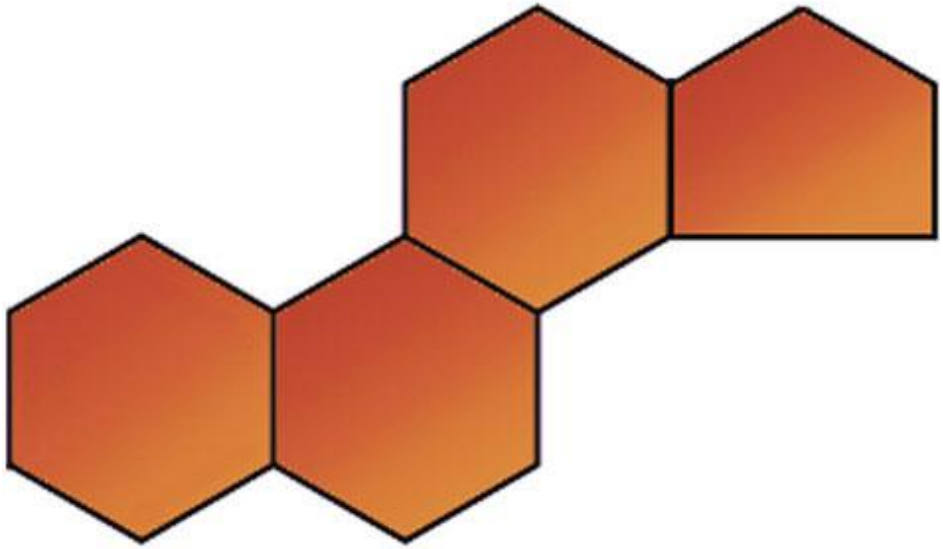


cell membrane section

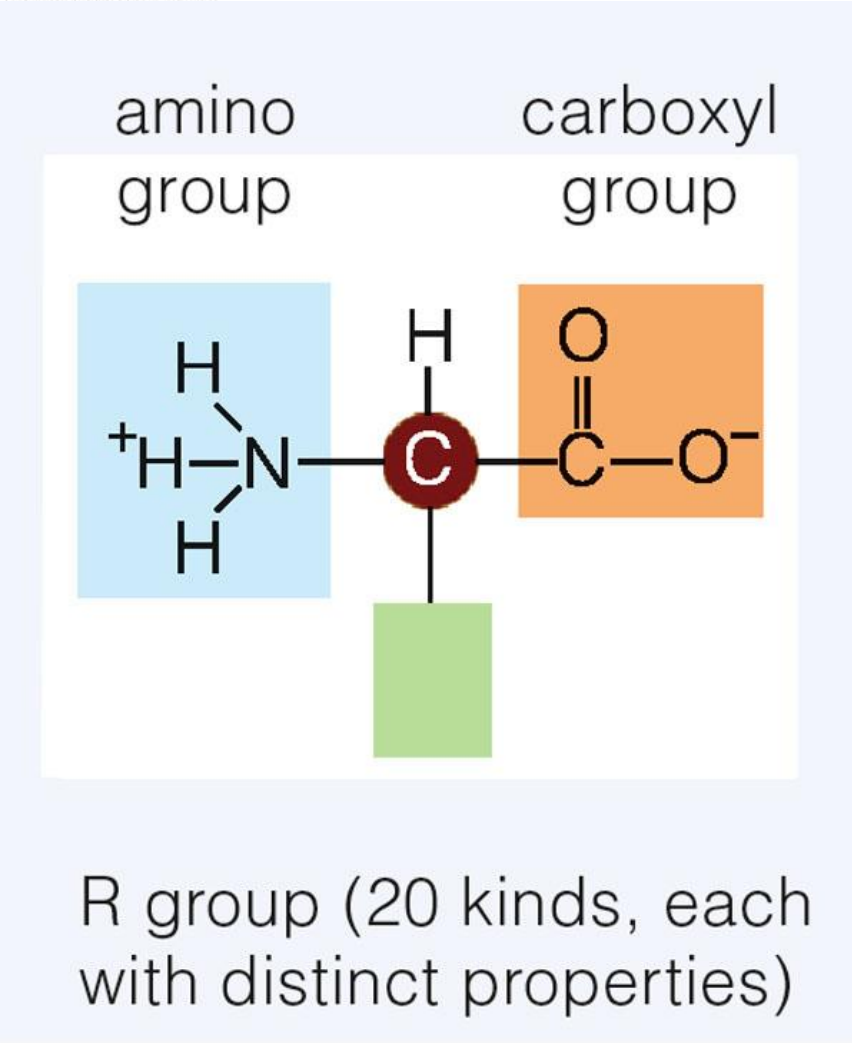


Sterols and Derivatives

- **No fatty acids**
- Rigid backbone of four **fused-together carbon rings**
- **Cholesterol, estrogen, testosterone** - most common type in animals



Amino Acid Structure

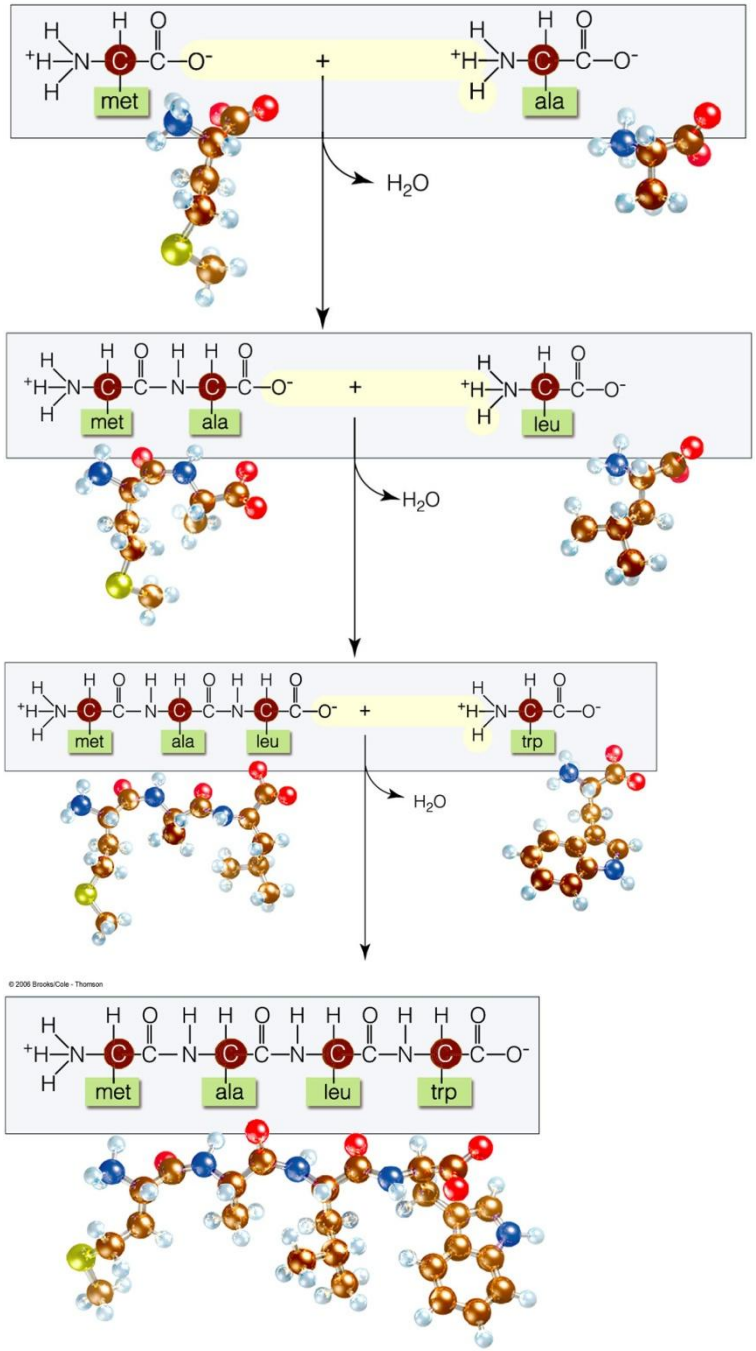


Properties of Amino Acids

- Determined by the **“R group”**
- Amino acids may be:
  - Non-polar
  - Uncharged, polar
  - Positively charged, polar
  - Negatively charged, polar

Protein Synthesis

- **Protein is a chain of amino acids linked by peptide bonds**
- Peptide bond
  - Type of covalent bond
  - Links amino group of one amino acid with carboxyl group of next
  - Forms through condensation reaction



© 2006 Brooks/Cole - Thomson

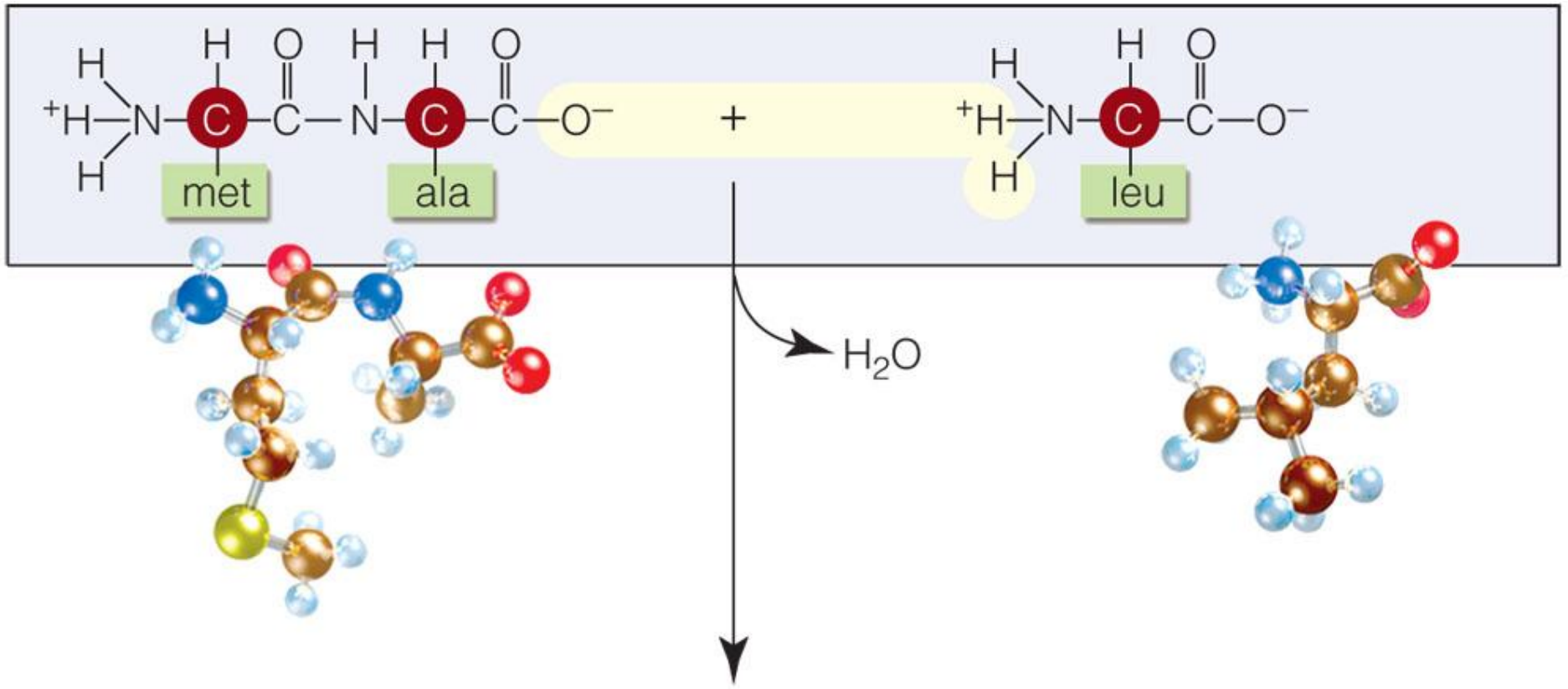


Fig. 3-15c, p.42

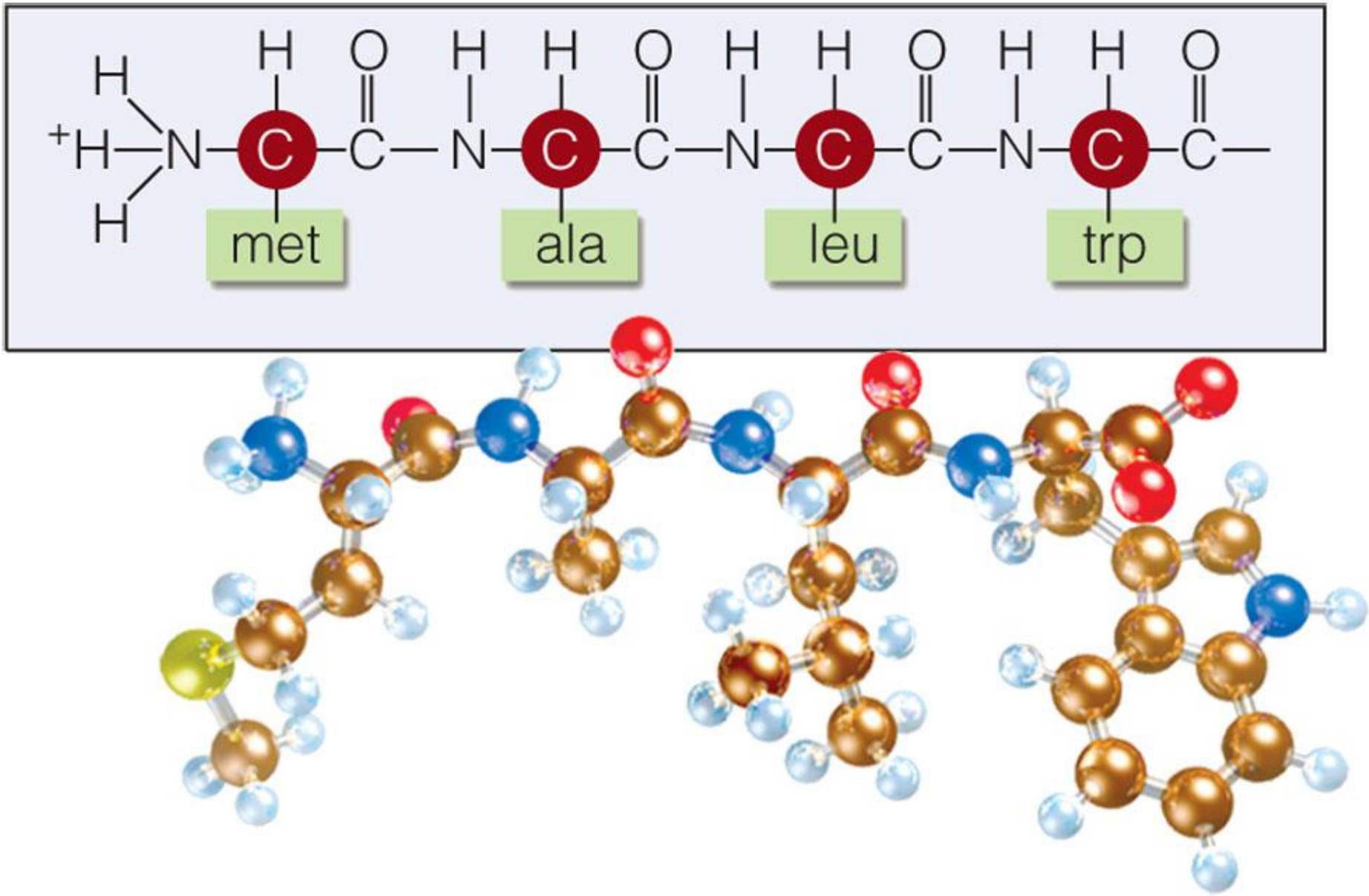
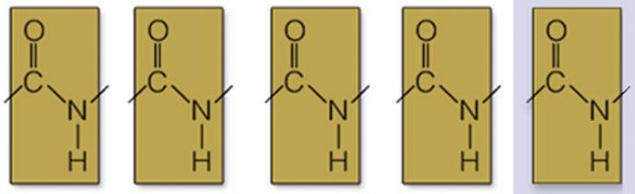


Fig. 3-15e, p.42

Primary Structure

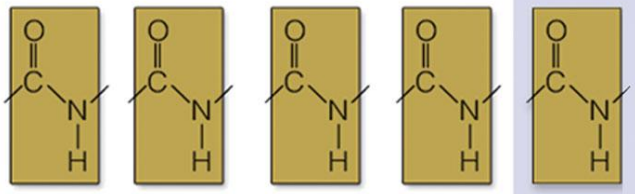
- **Sequence of amino acids**
- **Unique for each protein**
- **Two linked amino acids = dipeptide**
- **Three or more = polypeptide**
- Backbone of polypeptide has N atoms:

-N-C-C-N-C-C-N-C-C-N-



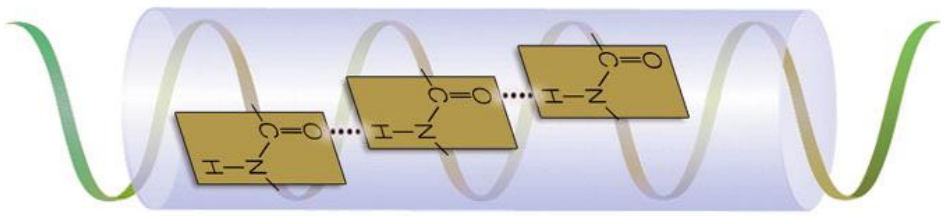
Primary Structure

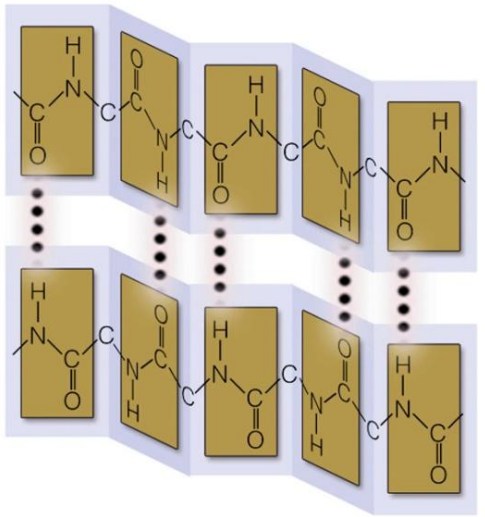
- Primary structure influences shape in two main ways:
  - **Allows hydrogen bonds to form between different amino acids** along length of chain
  - Puts **R groups** in positions that allow them to **interact**



Secondary Structure

- Hydrogen bonds form between different parts of polypeptide chain
- These bonds give rise to **coiled or extended pattern**
- **Helix or pleated sheet**

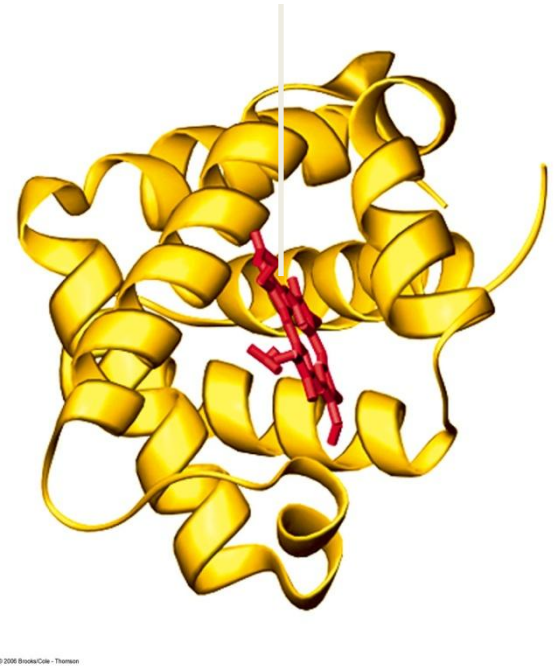




Tertiary Structure

- Folding as a result of interactions between R groups

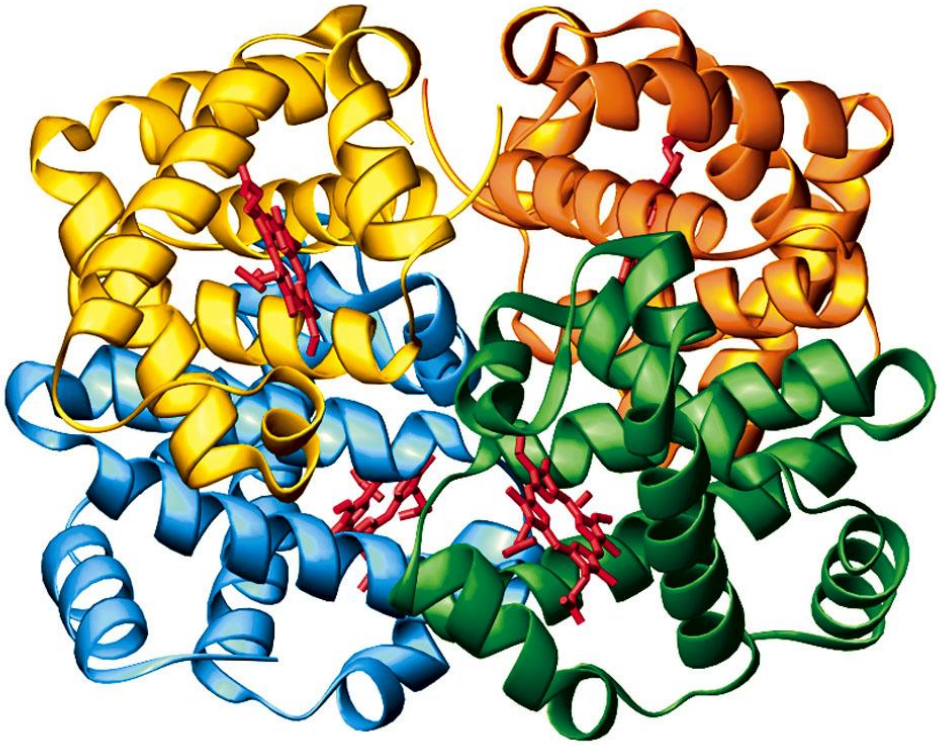
heme group



coiled and twisted polypeptide chain of one globin molecule

Quaternary Structure

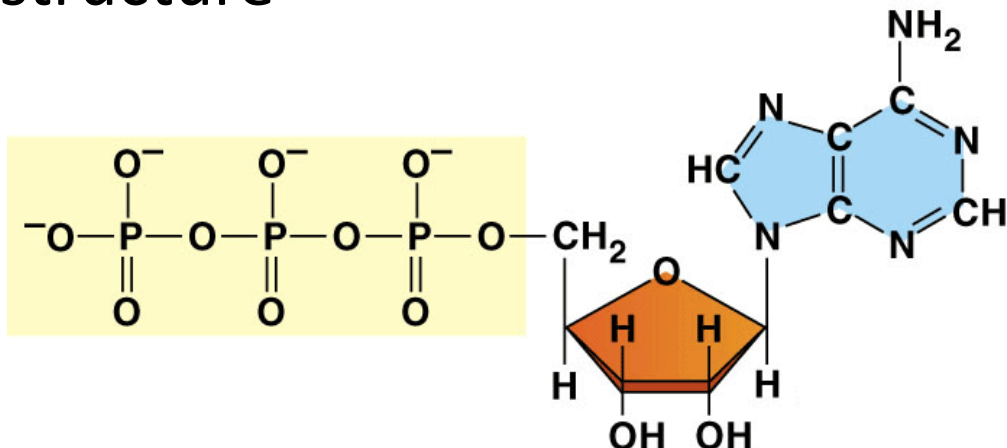
- **Some proteins are made up of more than one polypeptide chain**



Hemoglobin

Nucleotide Structure

- **Sugar**
  - Ribose or deoxyribose
- **At least one phosphate group**
- **Base**
  - Nitrogen-containing
  - Single or double ring structure

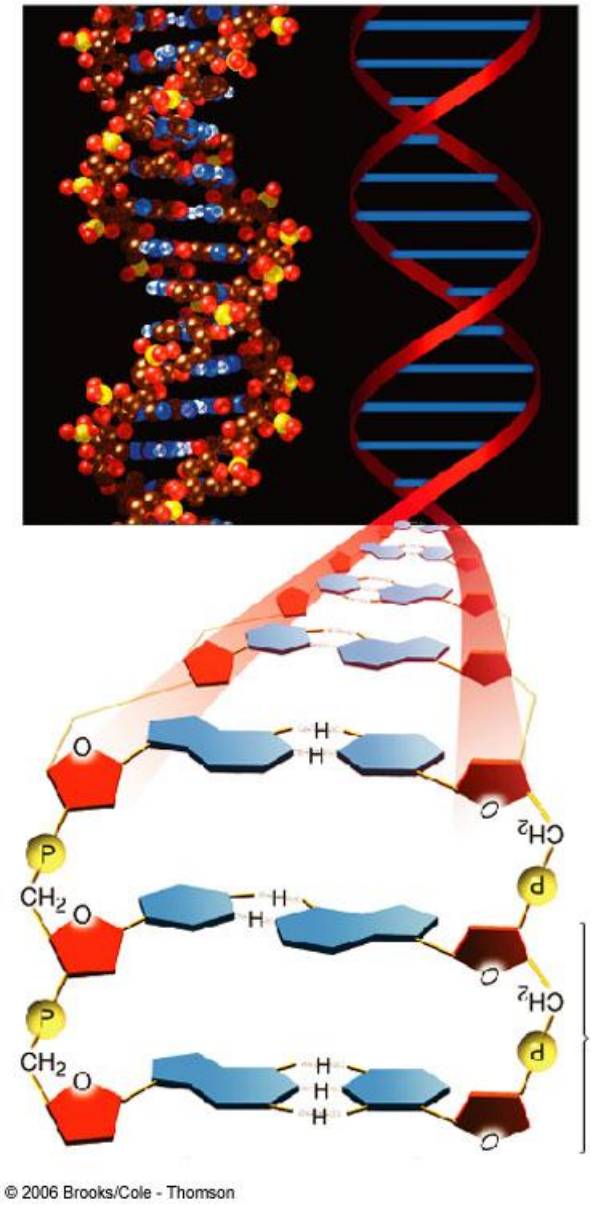


Nucleotide Functions

- Energy carriers
- Coenzymes
- Chemical messengers
- Building blocks for nucleic acids

DNA

- Double-stranded
- Consists of four types of nucleotides
- A bound to T
- C bound to G



RNA

- Usually single strands
- Four types of nucleotides
- Unlike DNA, contains the base uracil in place of thymine
- Three types are key players in protein synthesis