

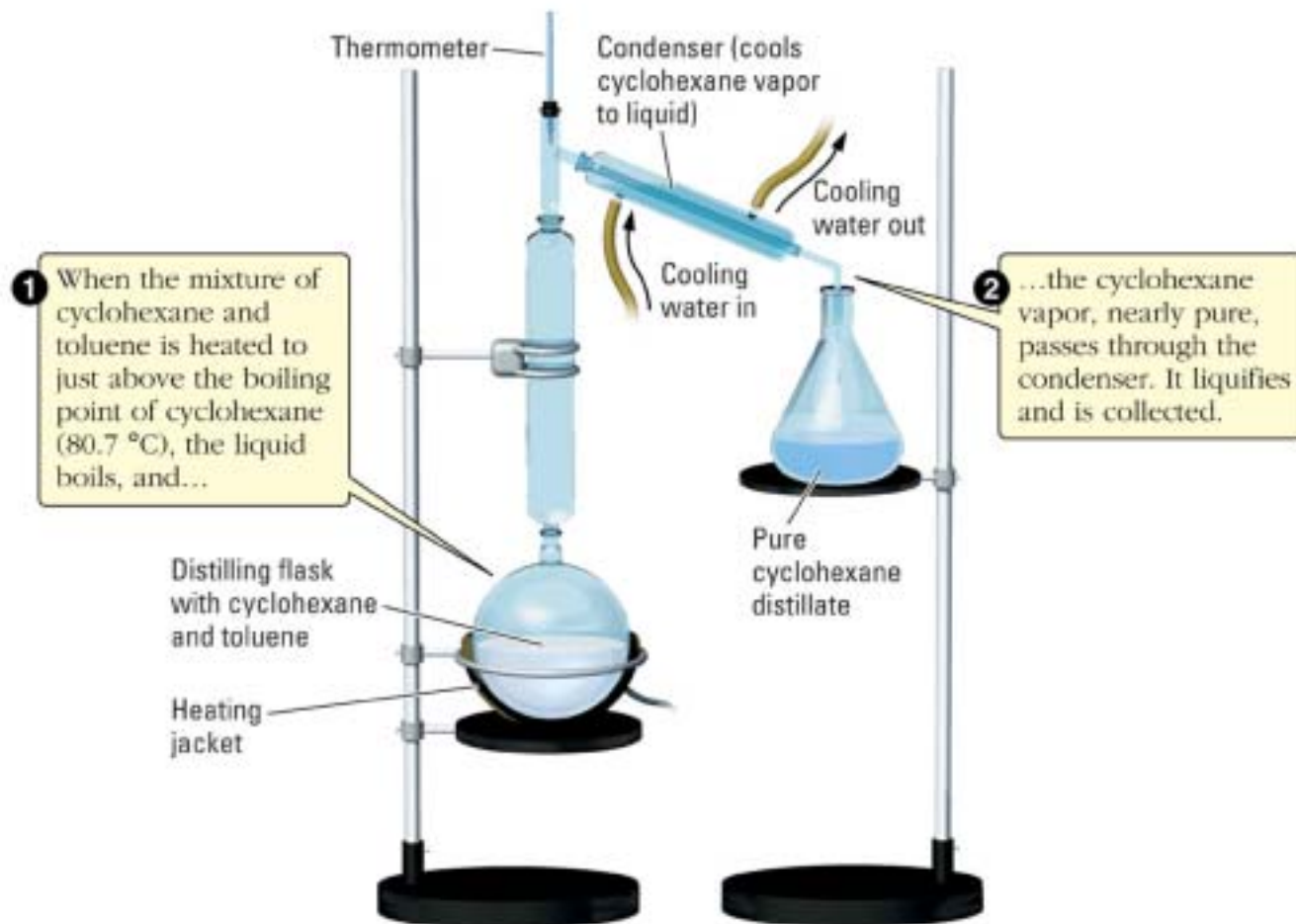
Chapter 12

Fuels, Organic Chemicals, and Polymers

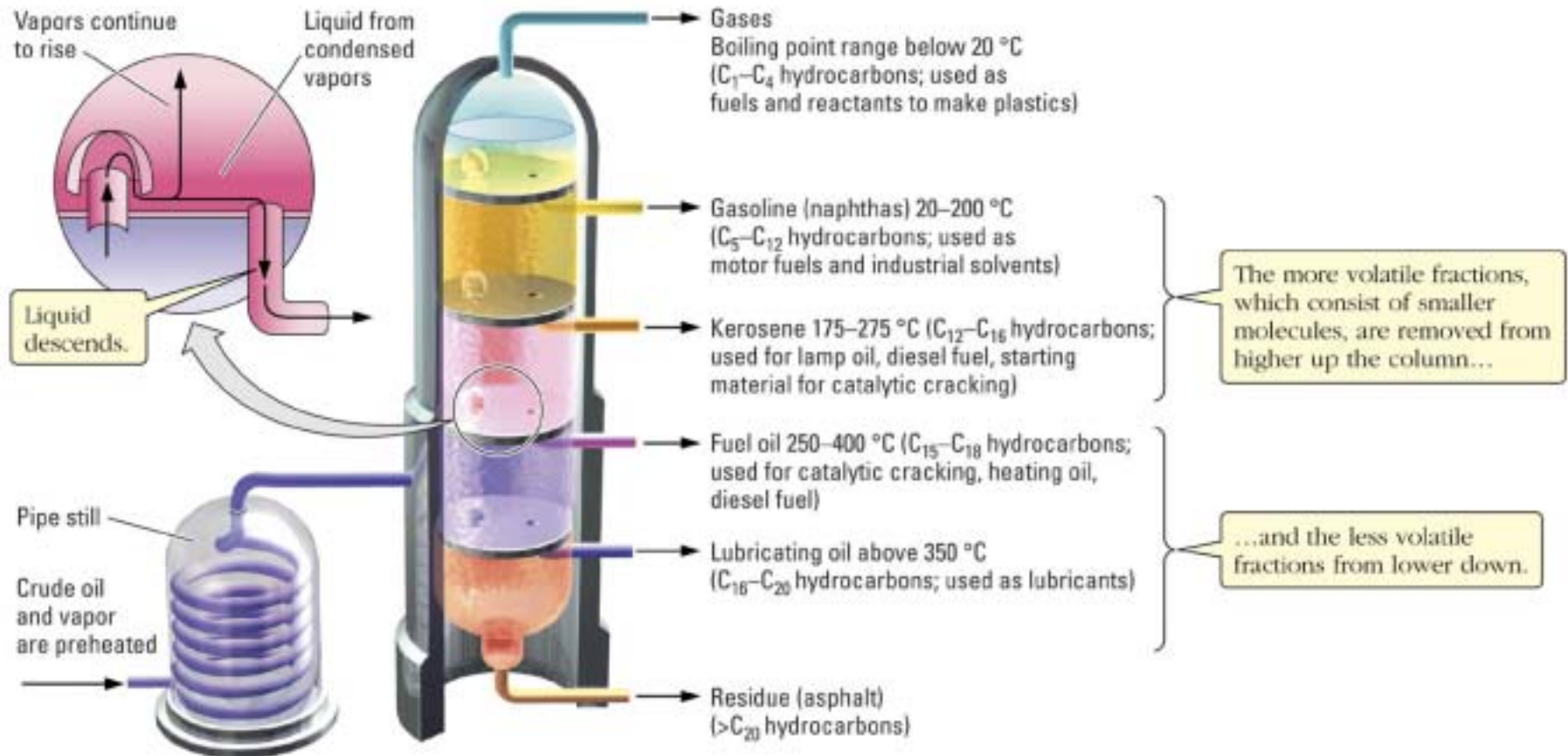
Petroleum

- complex mixture of hydrocarbons including alkanes, cycloalkanes, alkenes, and aromatics
- the mixture varies from one oil field to another depending contributing plants and animals
- range from gases to liquids to solids
- separated by fractional distillation according to their boiling points
- gasoline - fraction with boiling range of 20-200°C, composed of C₅-C₁₂ hydrocarbons

Fractional Distillation



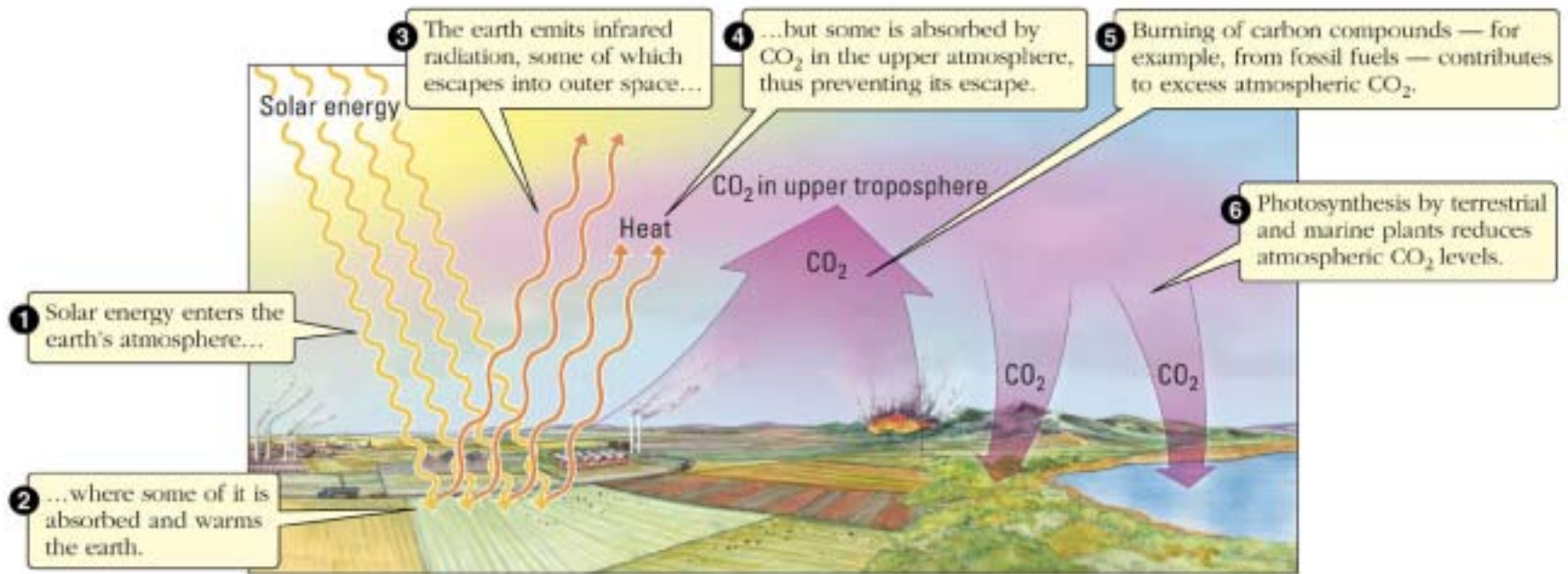
Petroleum Fractional Distillation



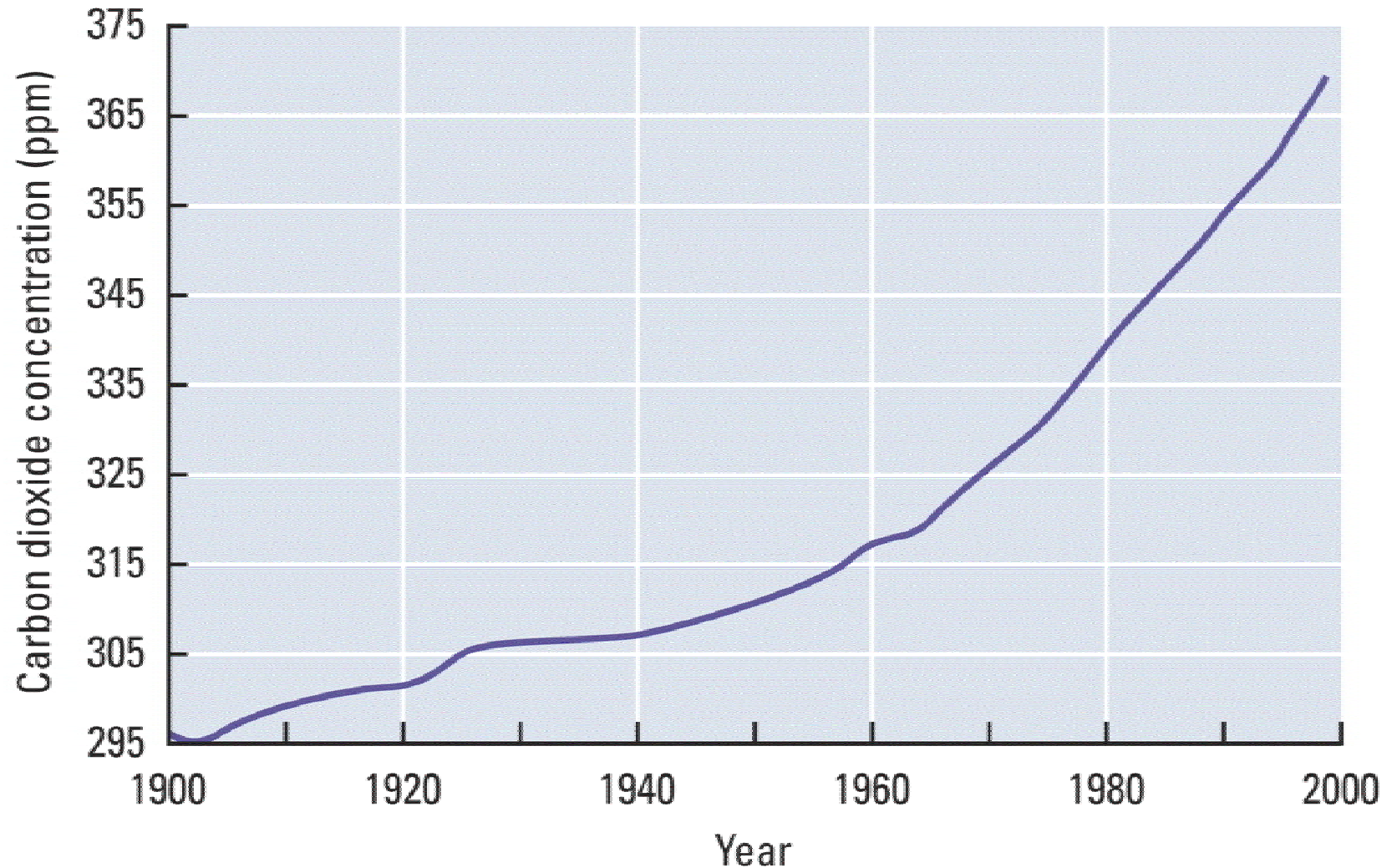
Greenhouse Gases

- carbon dioxide, water vapor, methane, and ozone
- infrared radiation reradiated from the earth into the atmosphere is absorbed by these gases, preventing loss of heat into space

The Greenhouse Effect



Atmospheric CO₂ Concentration



Alcohols and Water

- alcohols are “monosubstituted” water, ROH, hydrocarbon radical, R, substituted for one of the hydrogen atoms in water, HOH
- alcohols form hydrogen bonds to other alcohol molecules, increasing boiling point, and to water, making them very soluble in water

Important Alcohols R-OH

CH_3OH methanol

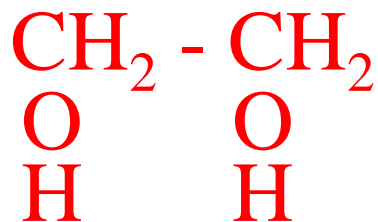
(methyl alcohol)

$\text{CH}_3\text{CH}_2\text{OH}$ ethanol

(ethyl alcohol)

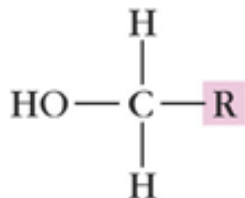
$(\text{CH}_3)_2\text{CHOH}$ 2-propanol

(isopropyl alcohol)

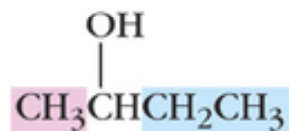
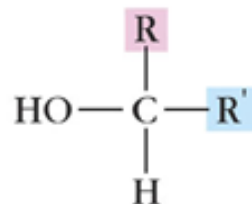
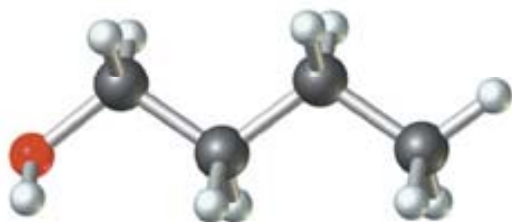


1,2 ethanediol
(ethylene glycol)
("antifreeze")

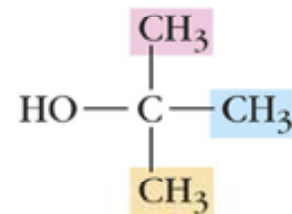
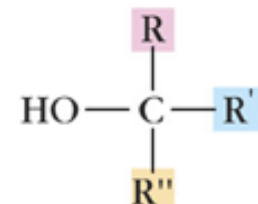
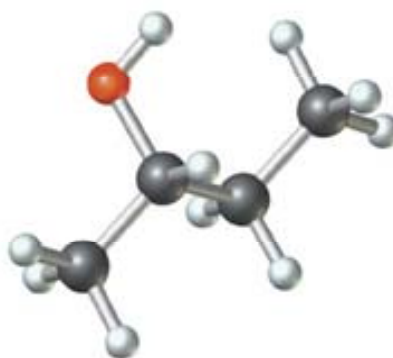
Classes of Alcohols



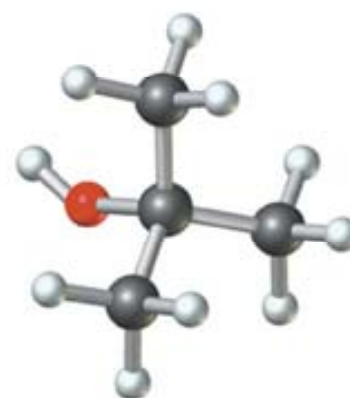
1-butanol,
a primary alcohol



2-butanol,
a secondary alcohol



2-methyl-2-propanol,
a tertiary alcohol



Oxidation of Alcohols

primary alcohol \rightarrow aldehyde \rightarrow carboxylic acids

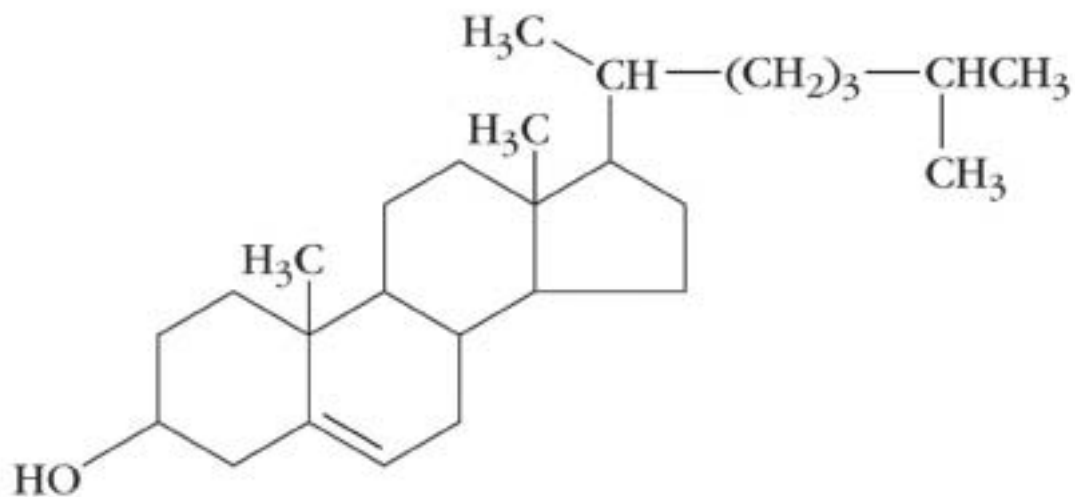


secondary alcohols \rightarrow ketones



tertiary alcohols \rightarrow No Reaction

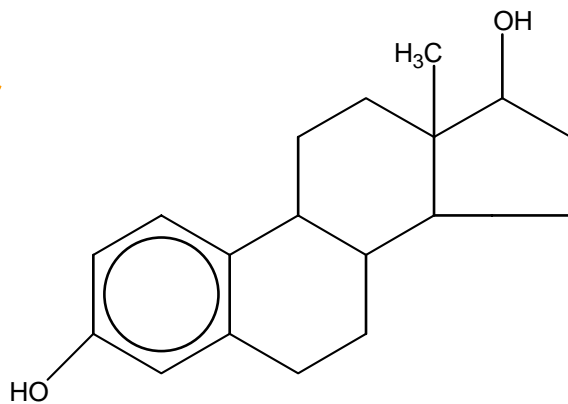
Large Molecules Containing Alcohol Groups



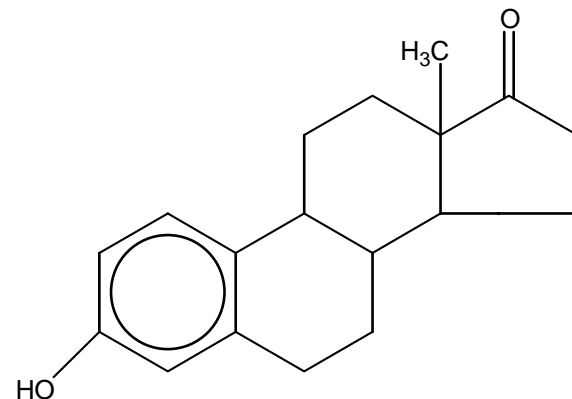
cholesterol



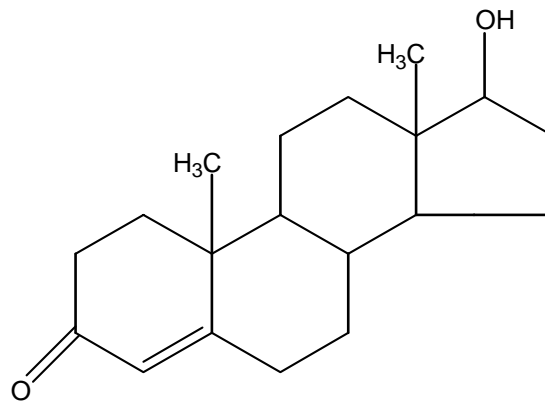
More Large Molecules Containing Alcohol Groups



estradiol
(female hormone,
an estrogen)



estrone
(female hormone,
an estrogen)



testosterone
(male hormone)

Blood Alcohol Level


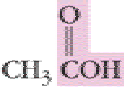
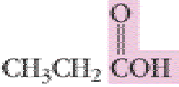

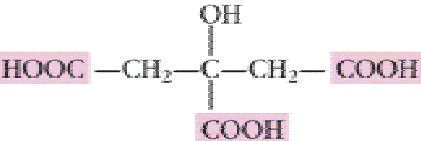
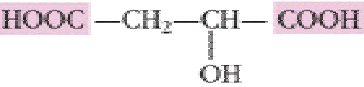
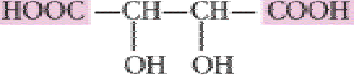
TABLE 12.4

Blood Alcohol
Levels and
Their Effects

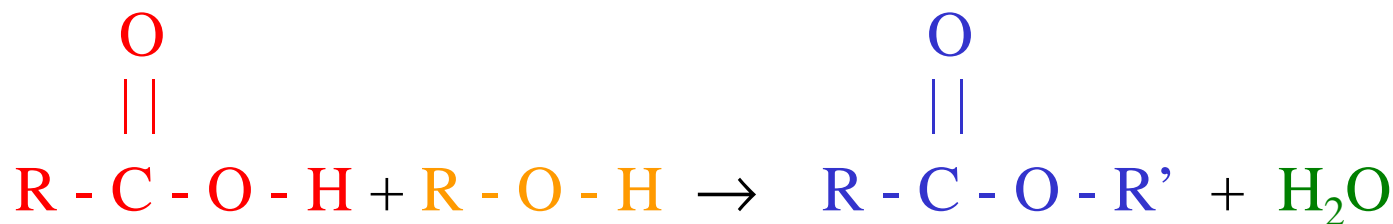
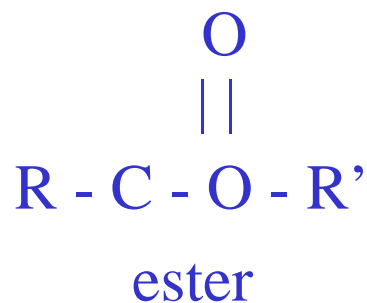
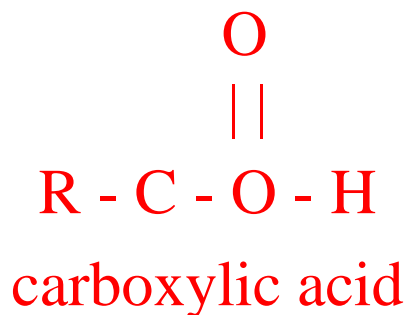
% by Volume	Effect
0.05 – 0.15	Lack of coordination
0.10	Commonly defined point for “driving while intoxicated”
0.15 – 0.20	Intoxication
0.30 – 0.40	Unconsciousness
0.50	Possible death

Carboxylic Acids

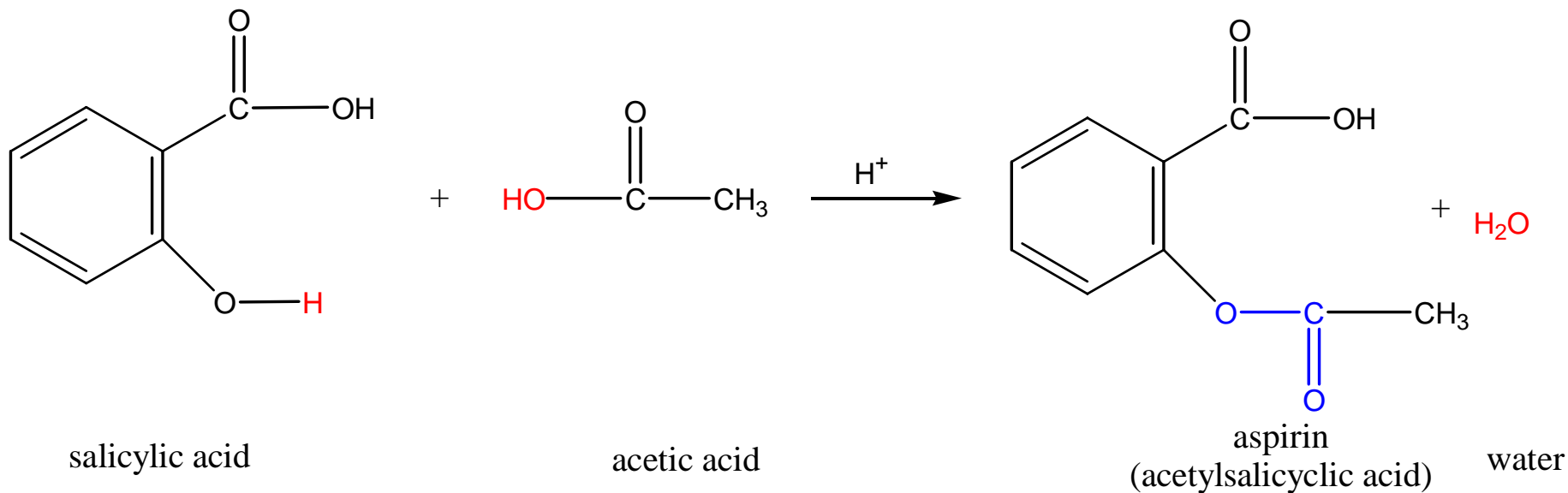
TABLE 12.5 Some Naturally Occurring Carboxylic Acids

Structure	Common name	b.p. (°C)	Natural source
	Formic acid	101	Ants
	Acetic acid	118	Fermented fruit
	Propionic acid	141	Dairy products
	Benzoic acid	250	Berries
<u>m.p. (°C)</u>			
	Citric acid	153	Citrus fruits
	Malic acid	131	Apples
	Tartaric acid	168-170	Grape juice, wine

Carboxylic Acids and Esters



Aspirin



Polymer

- large molecule formed by joining many smaller molecules together via
 - Addition polymerization
 - Condensation polymerization

Monomer

- small molecules which are joined together to form a polymer

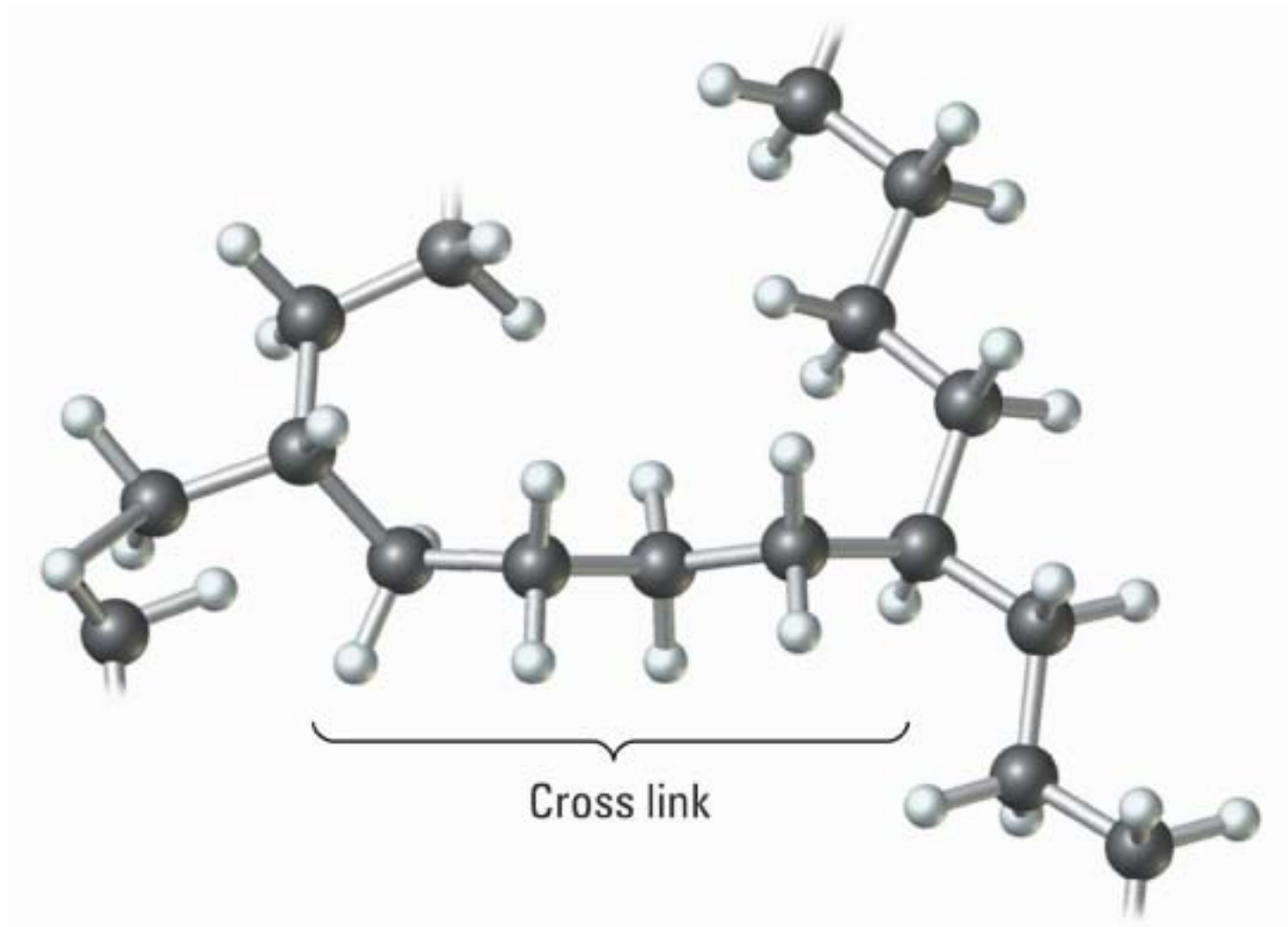
Addition Polymerization

Starts from $\text{CH} = \text{CH}_2$



polyethylene	R	→	H
polypropylene	R	→	CH_3
polyvinylchloride	R	→	Cl
polystyrene	R	→	benzene ring

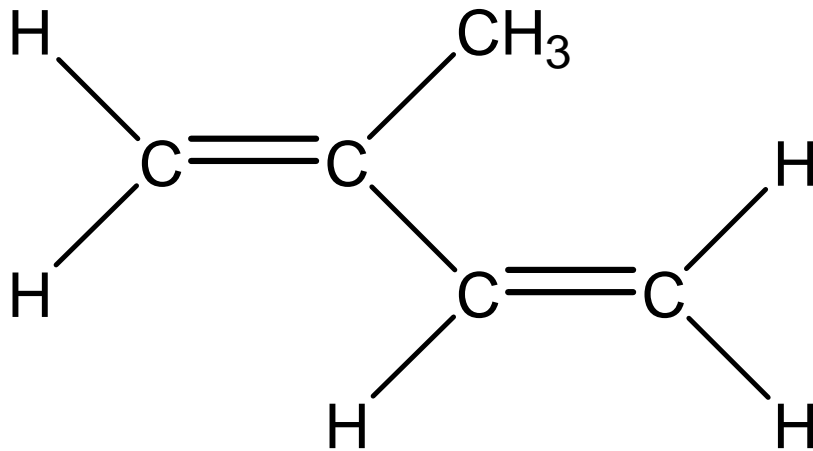
Cross-Linked Polyethylene



Rubber

Natural rubber

Synthetic – polyisoprene (monomer: isoprene)

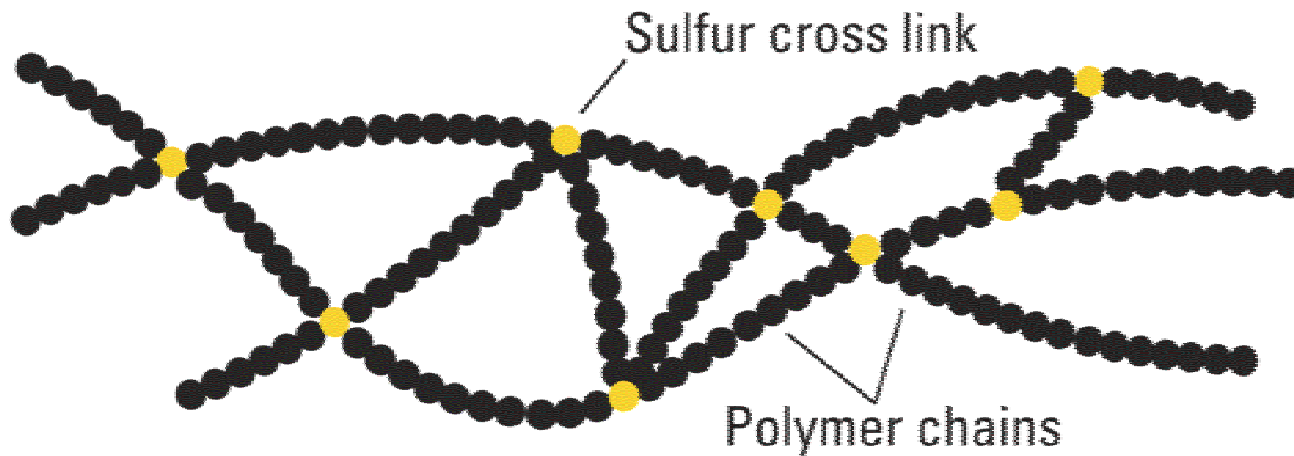


2-methyl-1,3-butadiene (isoprene)

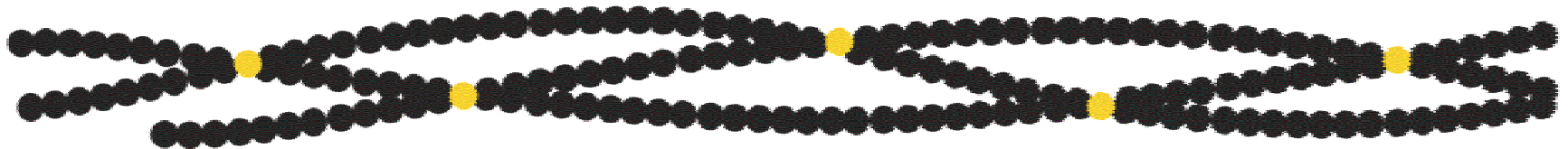
Charles Goodyear, 1839, discovered that the addition of sulfur improved the properties of rubber, a process called vulcanization.

Stretching Rubber

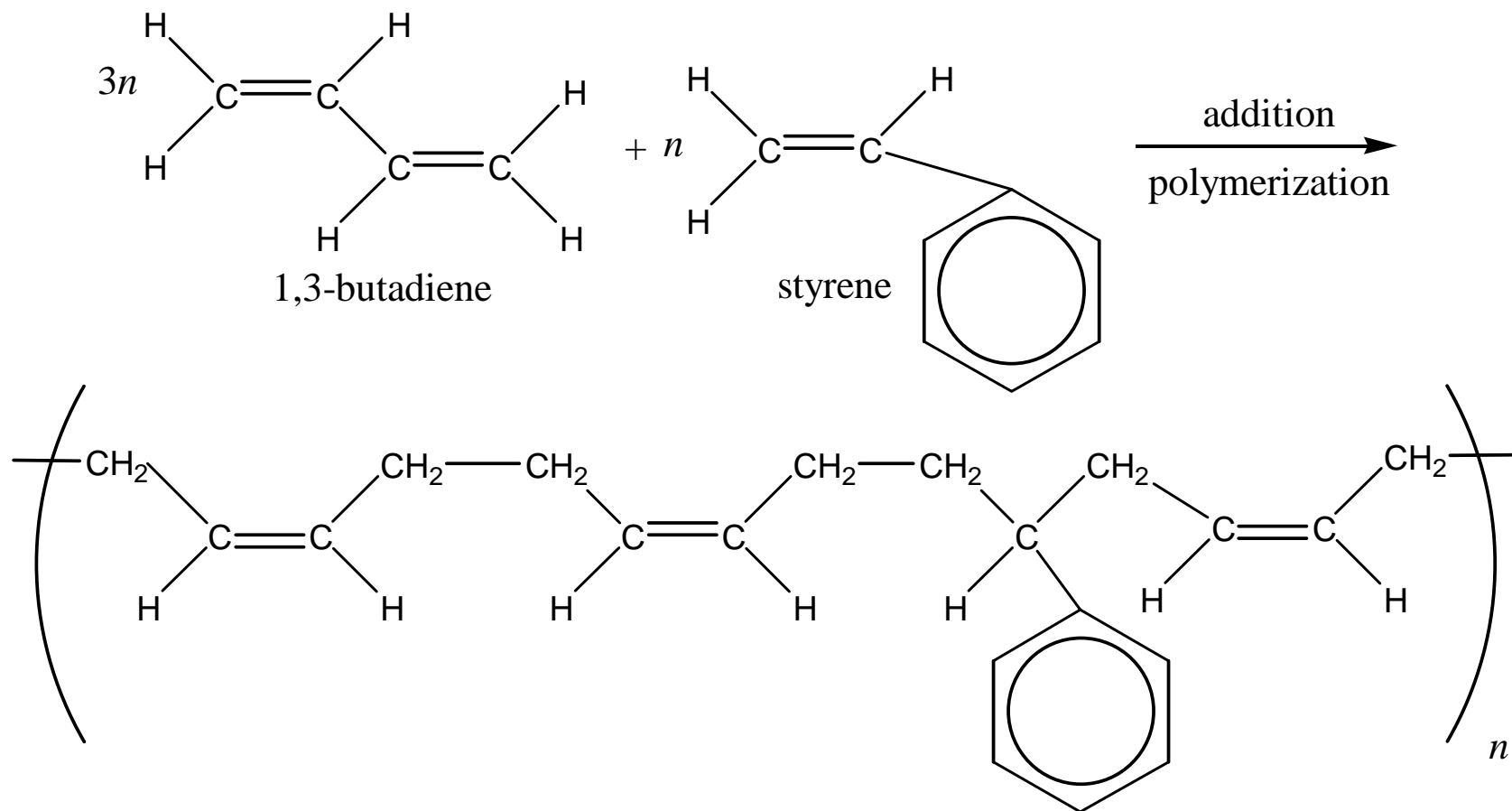
(a) Before stretching



(b) After stretching



SBR Styrene-Butadiene Rubber



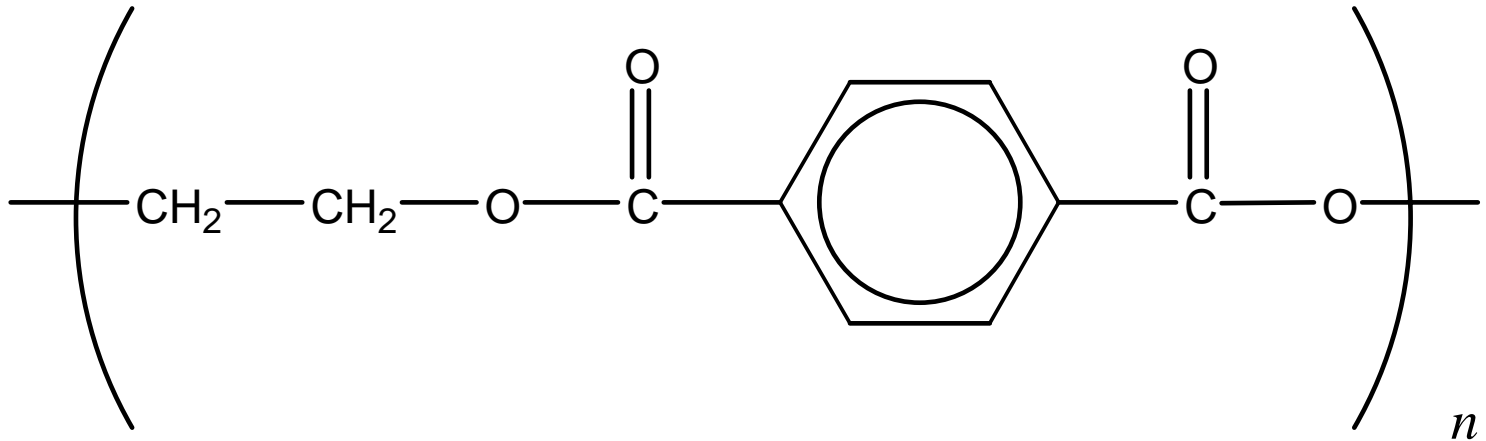
styrene-butadiene rubber (SBR)

Condensation Polymerization

- polymer formed by molecules of two different compounds joining to form the large molecule
- one compound usually has an amine or alcohol functional group
- other molecule has carboxylic acid functional group
- split out water molecule to form peptide or ester linkage

Polyester

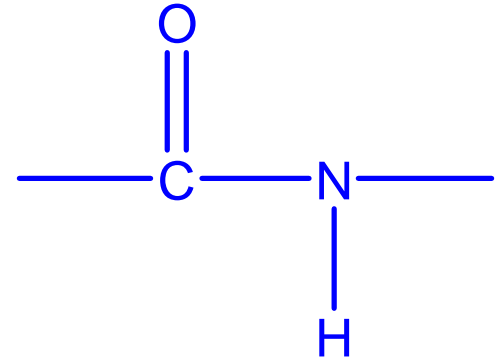
- composed of one molecule with two carboxylic acid functional groups and another molecule with two alcohol functional groups



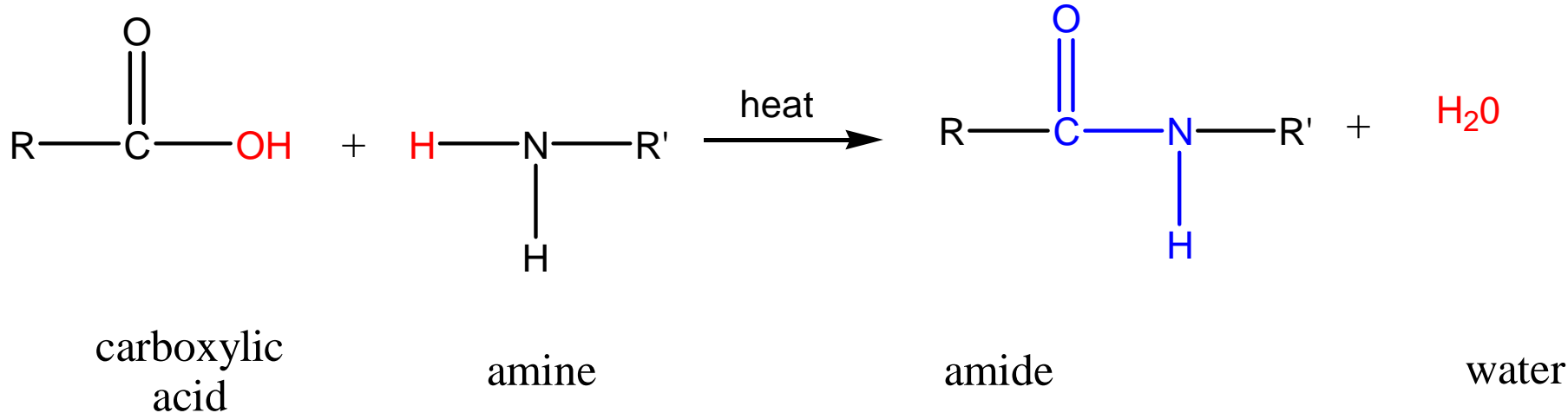
the repeating unit poly(ethylene terephthalate), PET

Amide

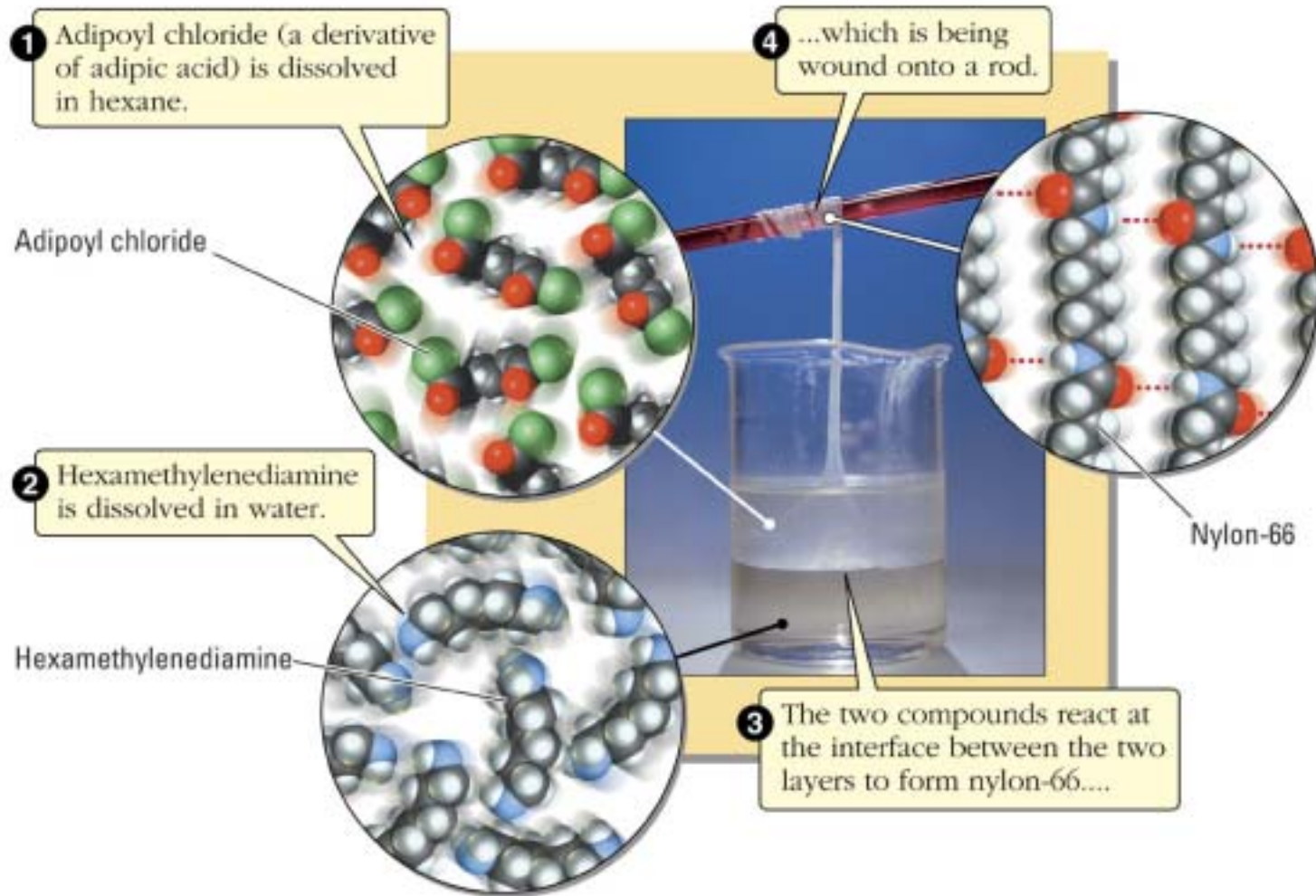
- combination of a carboxylic
- acid and an amine



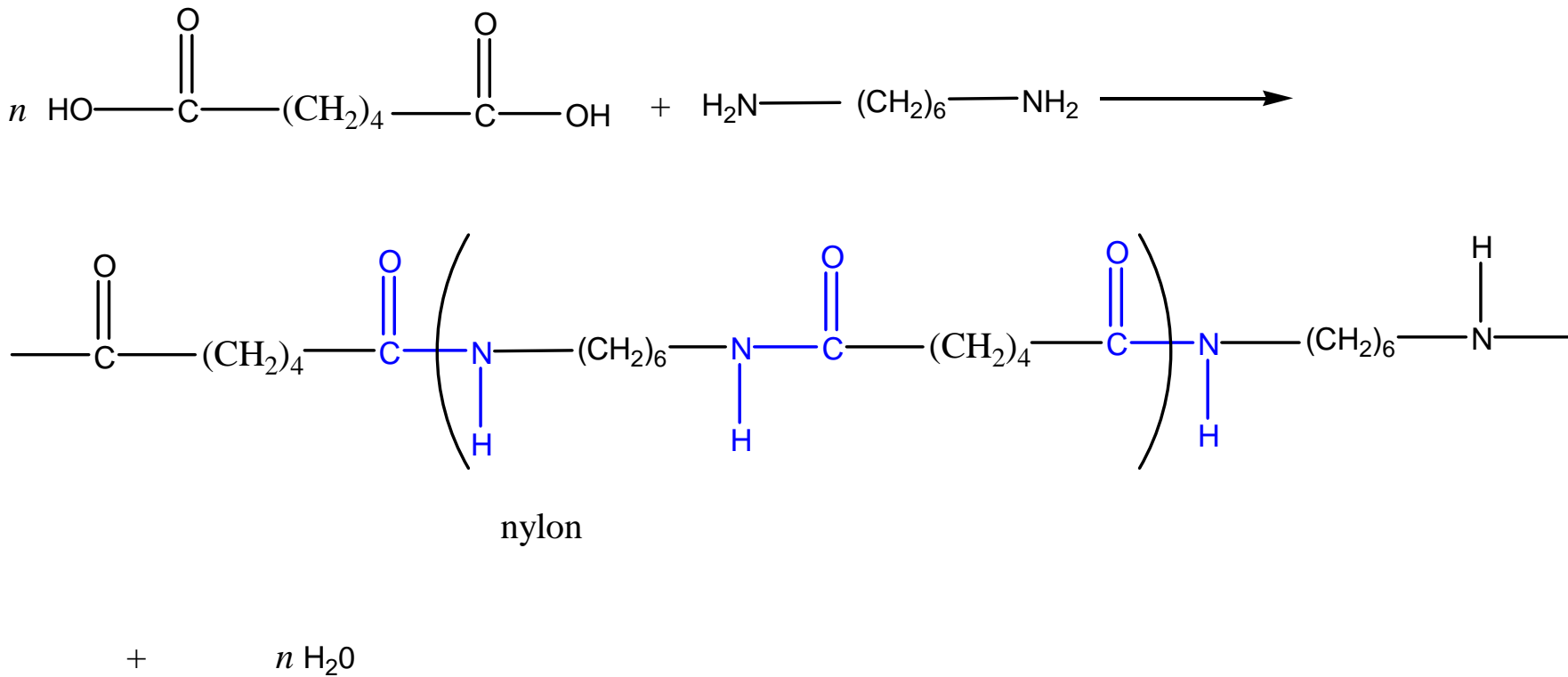
amide linkage



Making Nylon-66

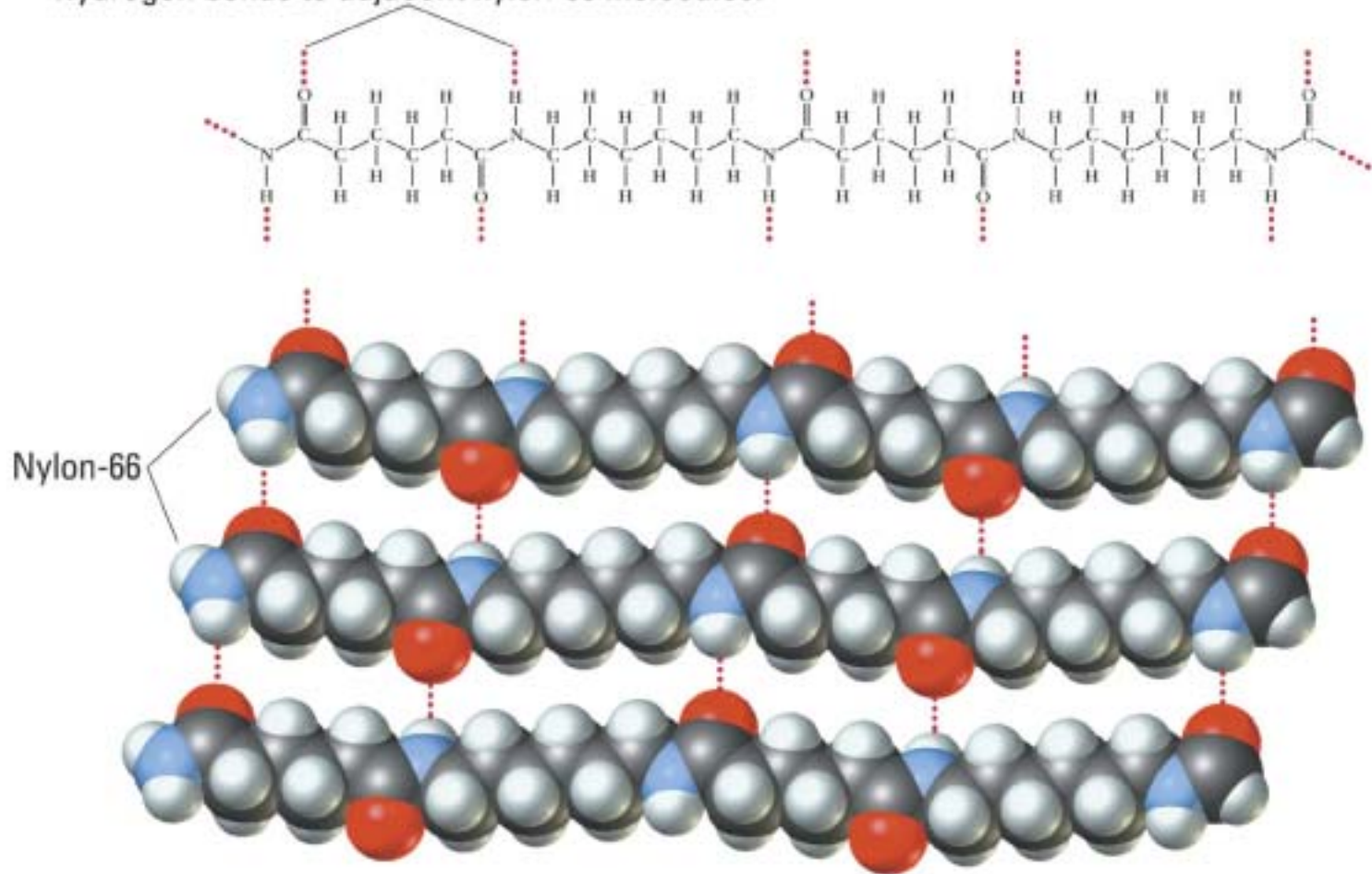


Making Nylon



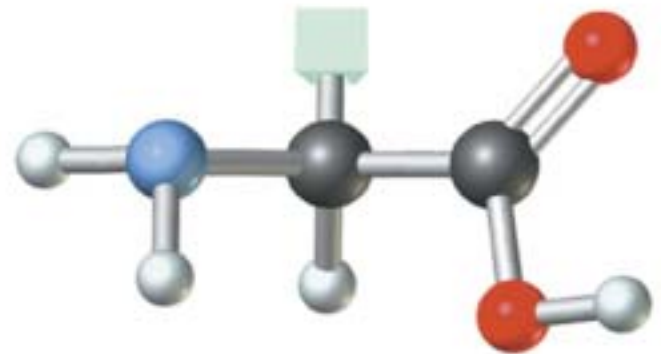
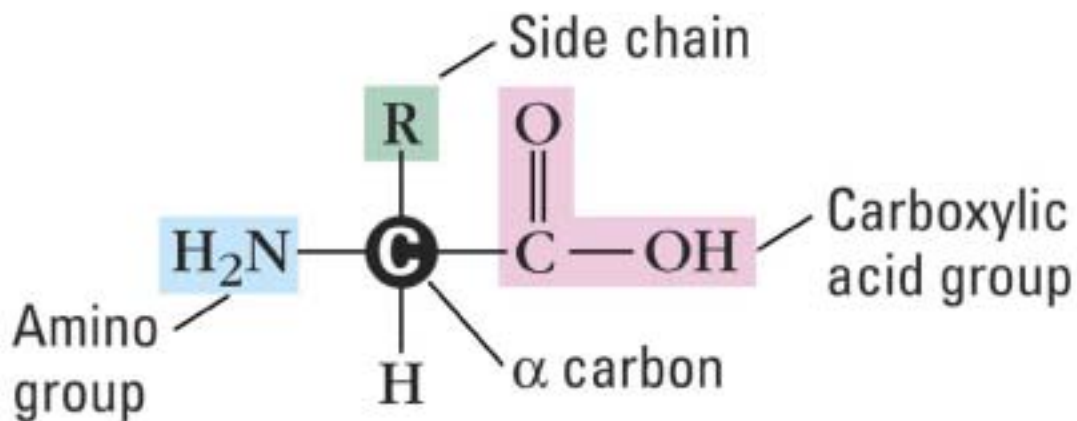
Hydrogen Bonding in Nylon-66

Hydrogen bonds to adjacent nylon-66 molecules.



Amino Acids

- di-functional group compounds, carboxylic acid and amine functional groups
- α -aminocarboxylic acid:
amine functional group is one carbon apart from the carboxylic acid functional group



Common Amino Acids

TABLE 12.8 Common L-Amino Acids Found in Proteins†

Amino Acid	Abbreviation	Structure	Amino acid	Abbreviation	Structure
<i>Nonpolar R groups</i>					
Glycine	Gly	$\text{H}-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	*Isoleucine	Ile	$\text{CH}_3-\text{CH}_2-\underset{\text{CH}_2}{\text{CH}}-\text{CH}-\text{COOH}$
Alanine	Ala	$\text{CH}_3-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	Proline	Pro	$\text{H}_2\text{C}-\underset{\text{H}_2\text{C}}{\underset{\text{N}}{\text{CH}_2}}-\text{CH}-\text{COOH}$
*Valine	Val	$\text{CH}_3-\underset{\text{CH}_3}{\text{CH}}-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	*Phenylalanine	Phe	$\text{C}_6\text{H}_5-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
*Leucine	Leu	$\text{CH}_3-\underset{\text{CH}_3}{\text{CH}}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	*Methionine	Met	$\text{CH}_3-\text{S}-\text{CH}_2\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
			*Tryptophan	Trp	$\text{C}_8\text{H}_7\text{N}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
<i>Polar but neutral R groups</i>					
Serine	Ser	$\text{HO}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	Asparagine	Asn	$\text{H}_2\text{N}-\underset{\text{O}}{\text{C}}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
*Threonine	Thr	$\text{CH}_3-\underset{\text{OH}}{\text{CH}}-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	Glutamine	Gln	$\text{H}_2\text{N}-\underset{\text{O}}{\text{C}}-\text{CH}_2\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
Cysteine	Cys	$\text{HS}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	Tyrosine	Tyr	$\text{HO}-\text{C}_6\text{H}_4-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
<i>Acidic R groups</i>			<i>Basic R groups</i>		
Glutamic acid	Glu	$\text{HO}-\underset{\text{O}}{\text{C}}-\text{CH}_2\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	*Lysine	Lys	$\text{H}_2\text{N}-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
Aspartic acid	Asp	$\text{HO}-\underset{\text{O}}{\text{C}}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	‡Arginine	Arg	$\text{H}_2\text{N}-\underset{\text{NH}}{\text{C}}-\text{NH}-\text{CH}_2\text{CH}_2\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$
			Histidine	His	$\text{C}_5\text{H}_4\text{N}_2-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$

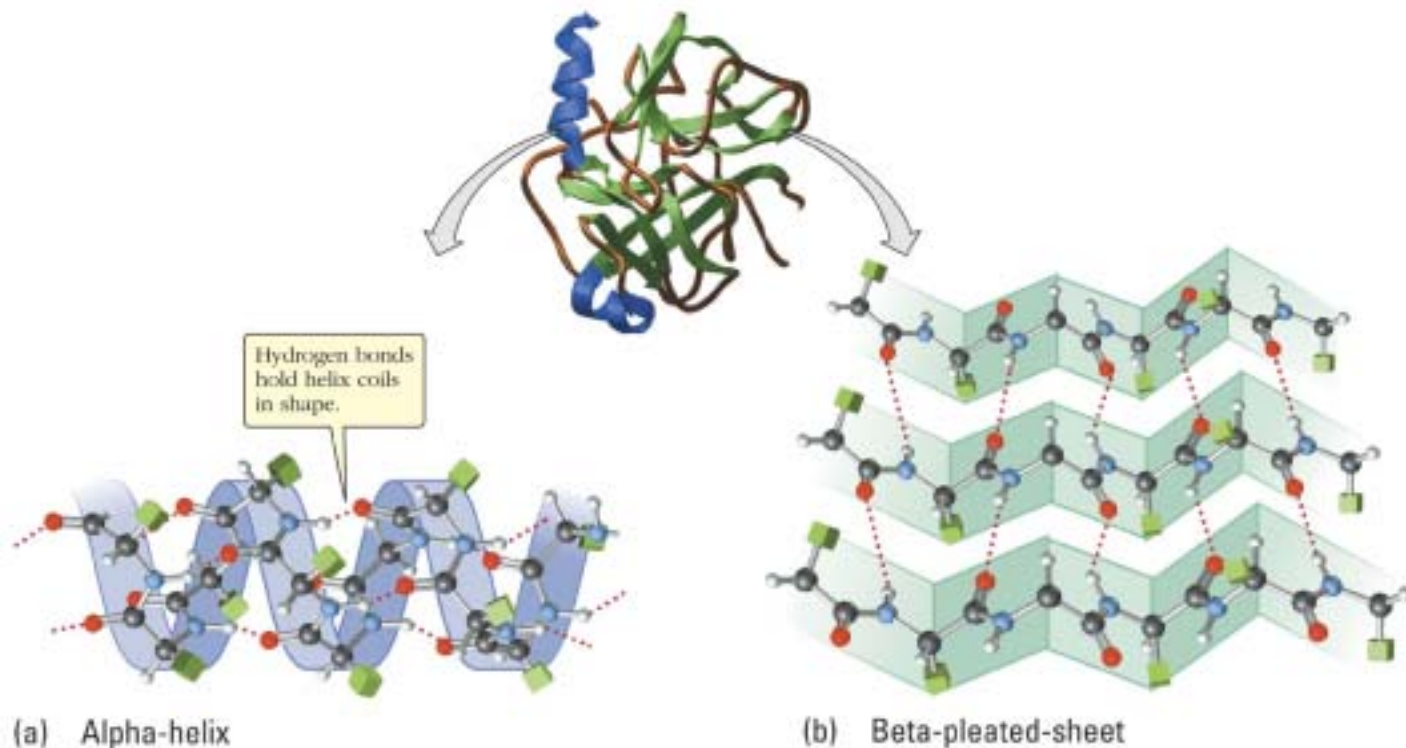
*Essential amino acids that must be part of the human diet. The other amino acids can be synthesized by the body.

†The R group in each amino acid is highlighted.

‡Growing children also require arginine in their diet.

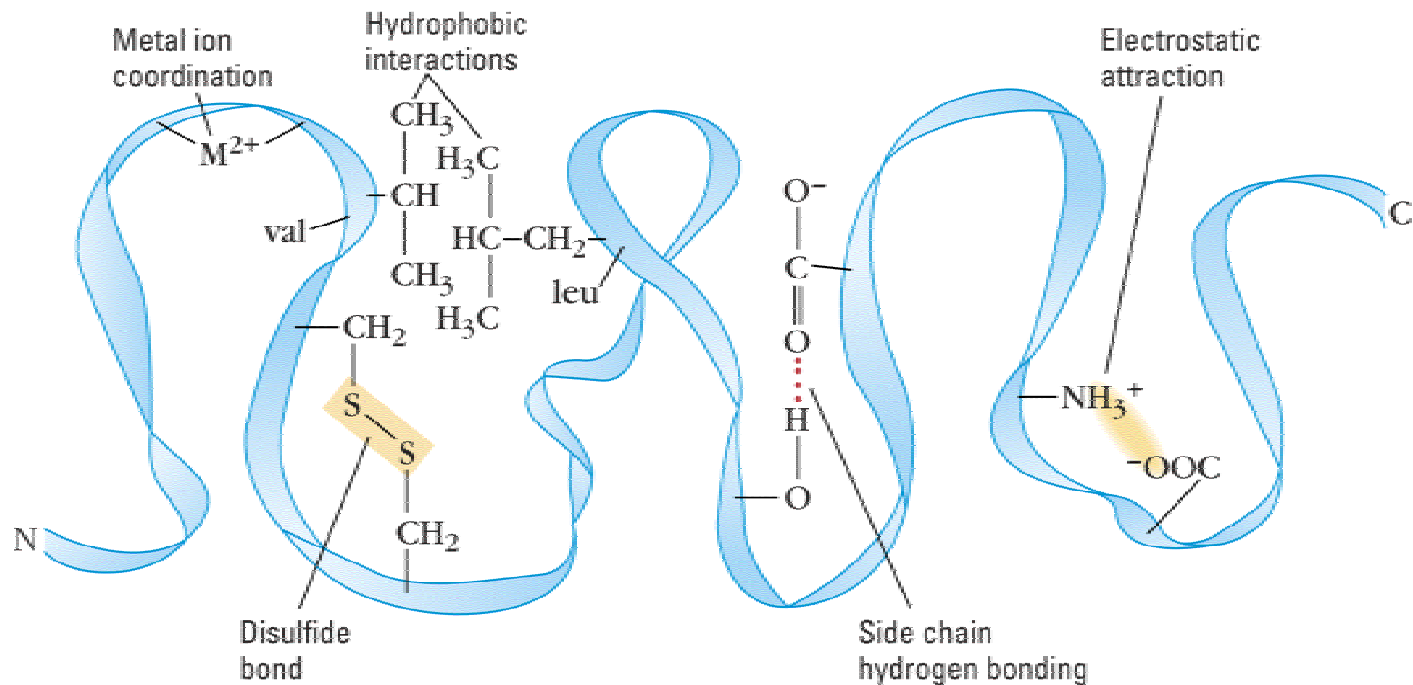
Secondary Structure of Protein

- Regular patterns in the structure created by intramolecular hydrogen bonding



Tertiary Structure of Proteins

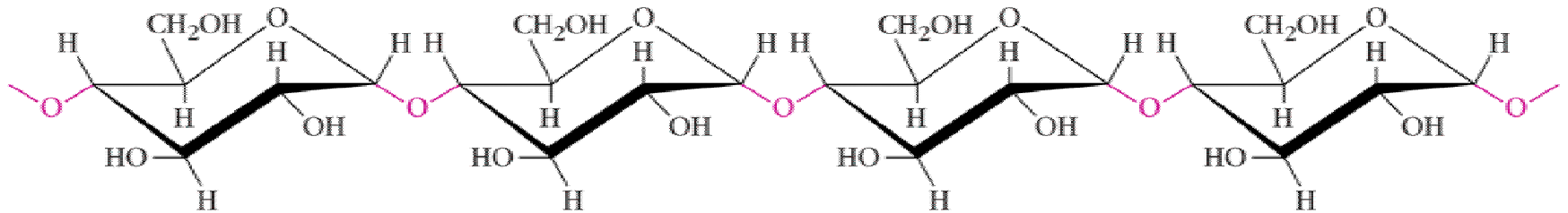
- overall three-dimensional structure of the protein



Sugars

- Saccharide - scientific name for sugar
- Monosaccharide(glucose, fructose) - 1 sugar molecule, acts as monomer in di- and polysaccharide
- Disaccharide(sucrose, maltose) - 2 sugar molecule units may be same or different sugars
- Polysaccharide(starch, cellulose) - polymer of many sugar molecules, starch and cellulose
- glycosidic linkage - link between sugar units

Amylose



Cellulose

