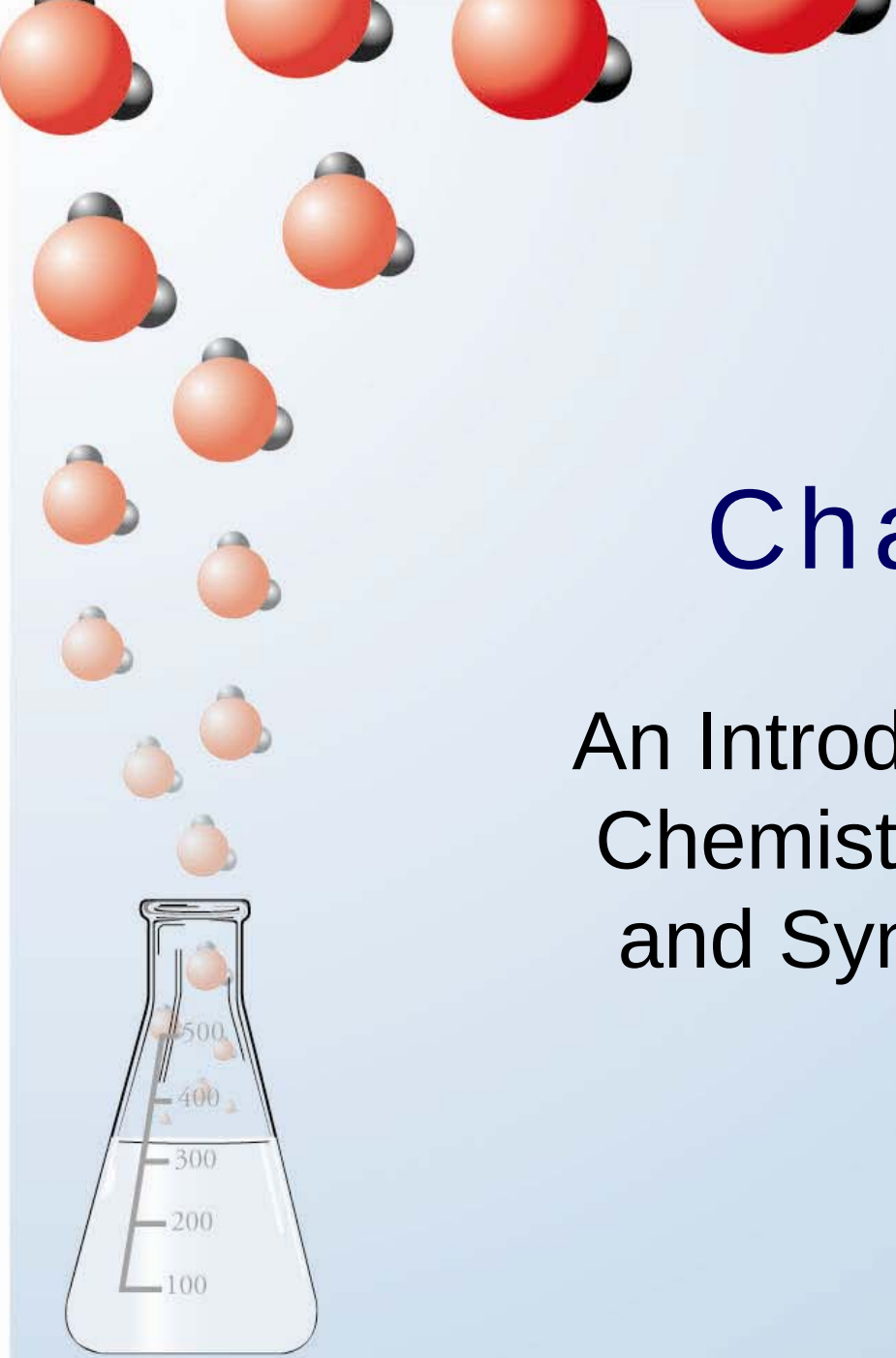
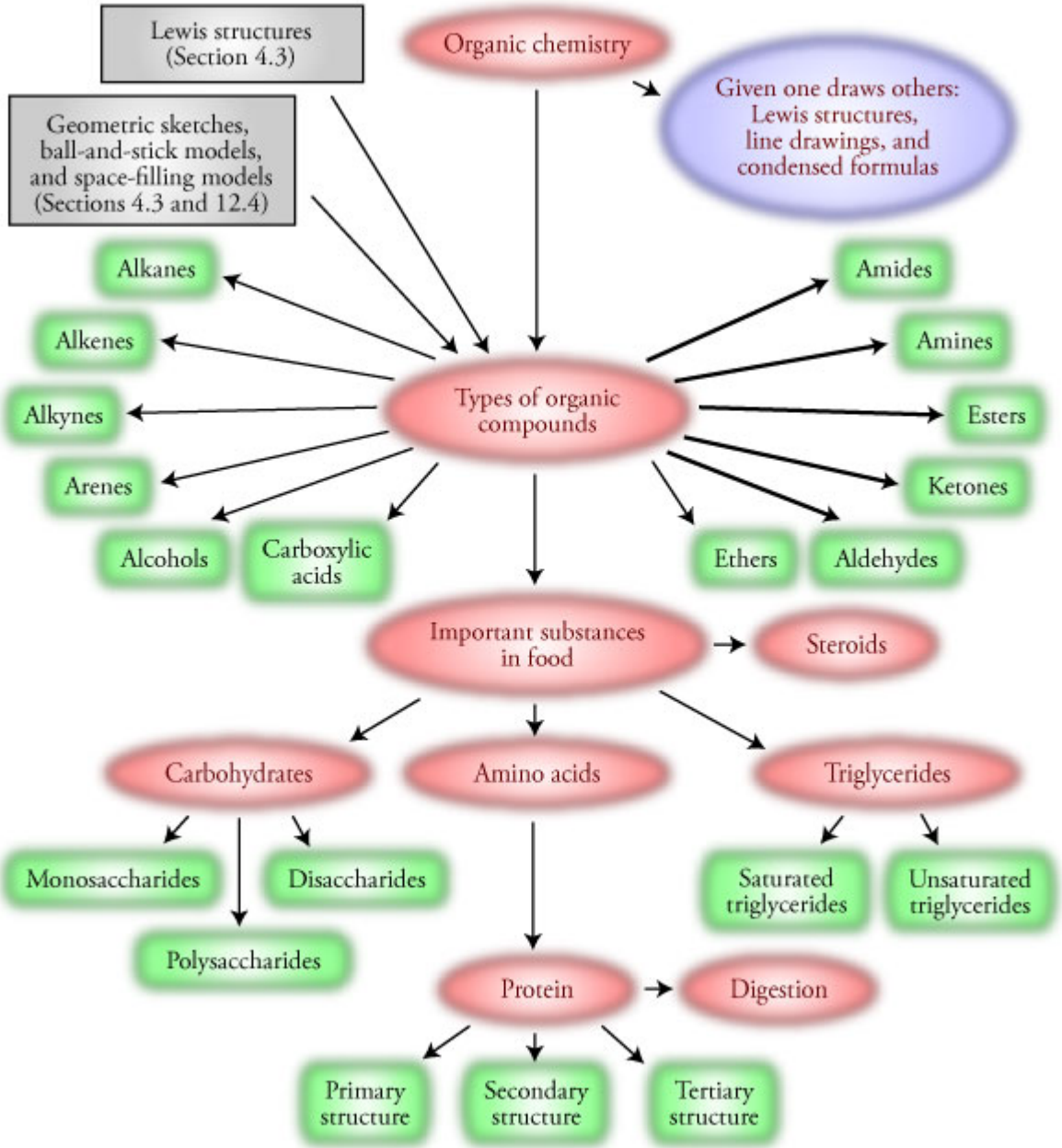


Chapter 17

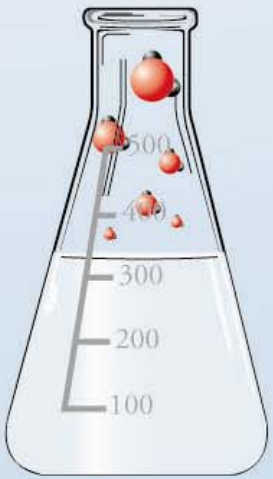
An Introduction to Organic Chemistry, Biochemistry, and Synthetic Polymers

Chapter Map


Lewis structures (Section 4.3)
Organic chemistry
Given one draws others: Lewis structures, line drawings, and condensed formulas
Geometric sketches, ball-and-stick models, and space-filling models (Sections 4.3 and 12.4)
Alkanes
Alkenes
Alkynes
Arenes
Alcohols
Carboxylic acids
Amides
Amines
Esters
Ketones
Ethers
Aldehydes
Types of organic compounds
Important substances in food
Steroids
Carbohydrates
Amino acids
Triglycerides
Monosaccharides
Disaccharides
Polysaccharides
Saturated triglycerides
Unsaturated triglycerides
Protein
Digestion
Primary structure
Secondary structure
Tertiary structure

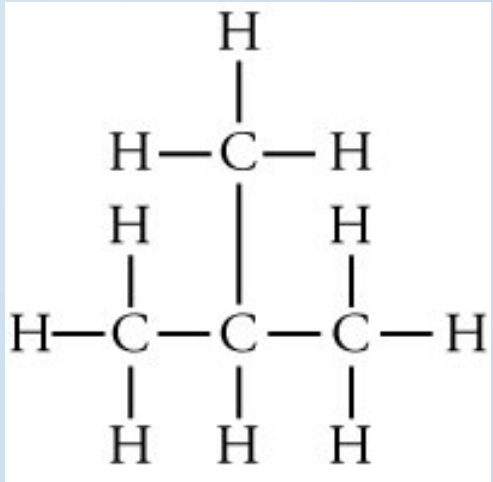
Organic Chemistry

- **Organic chemistry** is the chemistry of carbon-based compounds.
- There are two reasons why there are millions of organic chemicals.
  - Carbon atoms can form strong bonds to other carbon atoms and still form bonds to atoms of other elements.
  - There are many different ways to arrange the same atoms in carbon-based compounds.



Ways to Describe Organic Compounds

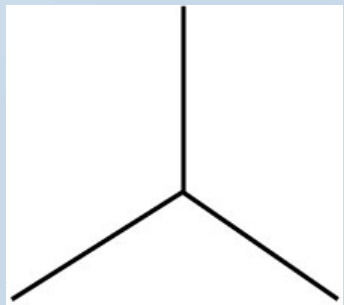
- Lewis structures

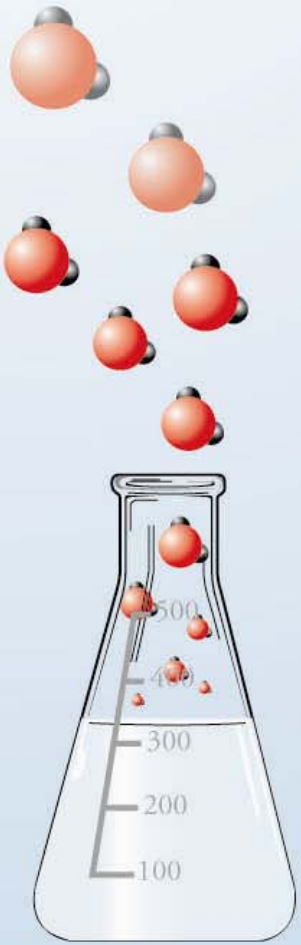


- Condensed Formulas

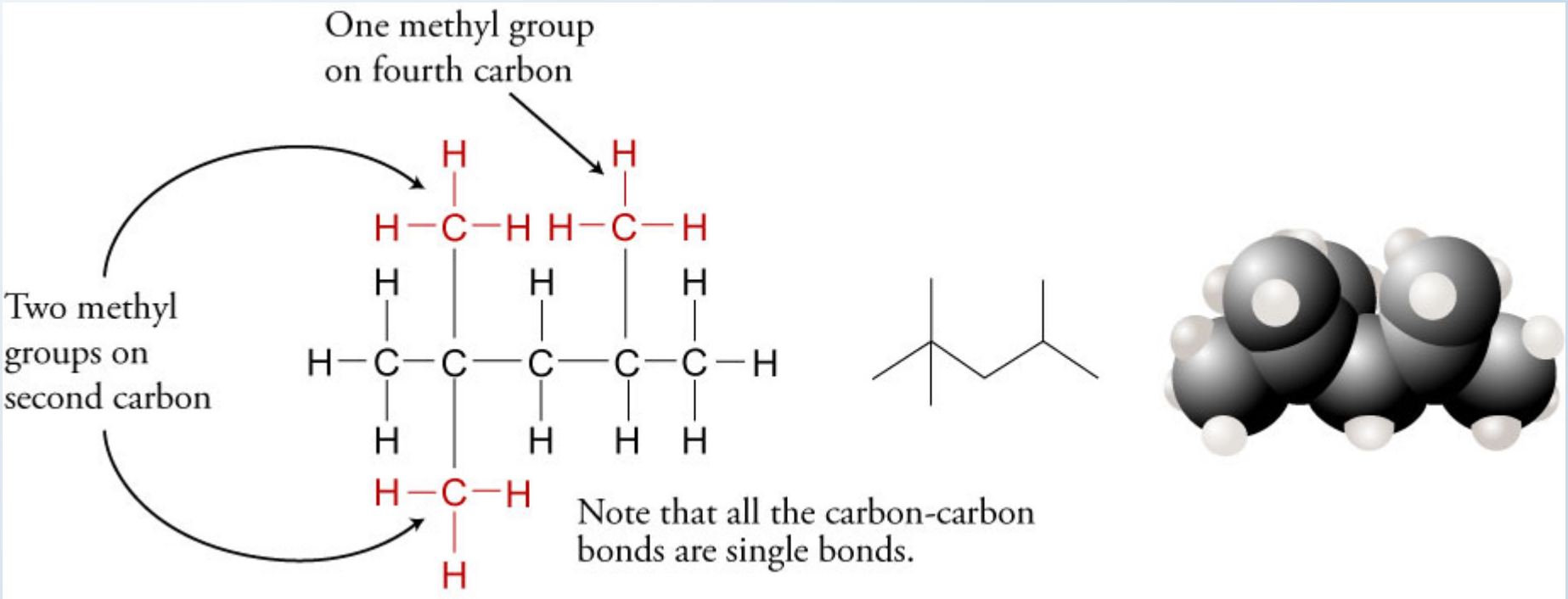
$CH_3CH(CH_3)CH_3$

- Line Drawings



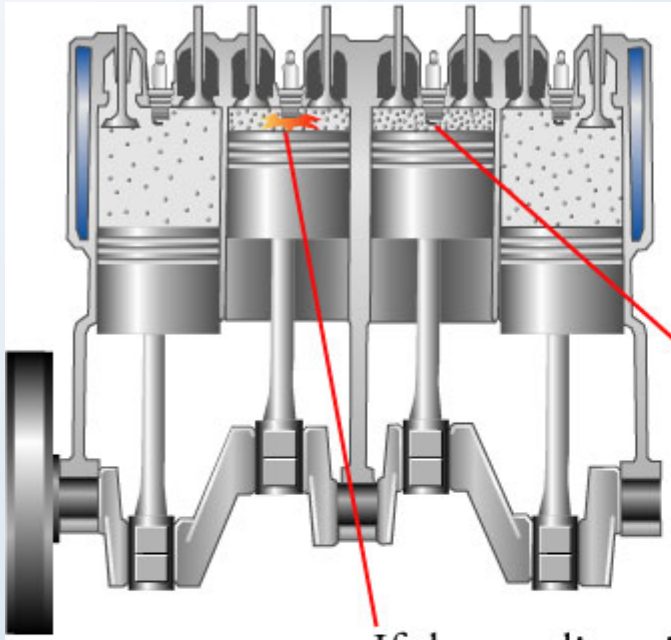


Alkanes - Hydrocarbons (compounds composed of carbon and hydrogen) in which all of the carbon-carbon bonds are single bonds



2,2,4-trimethylpentane, $CH_3C(CH_3)_2CH_2CH(CH_3)CH_3$

Pre-ignition Knock and Octane Rating



If the gasoline-air mixture ignites too soon, before the peak of the stroke of the piston, the piston pushes the crankshaft in the opposite direction, causing a vibration or "pre-ignition knock".

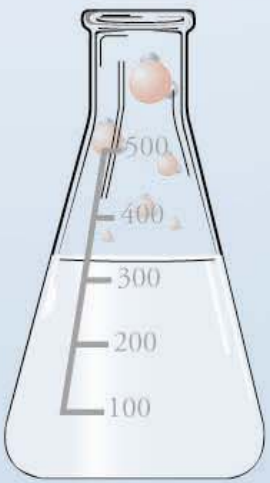
If the gasoline-air mixture ignites at (or just past) the peak of the stroke of the piston, the crankshaft is turned, which ultimately turns the wheels.

Straight-chain hydrocarbons are more likely to pre-ignite, so a gasoline that has a high percentage of straight-chain hydrocarbons has a low octane rating.

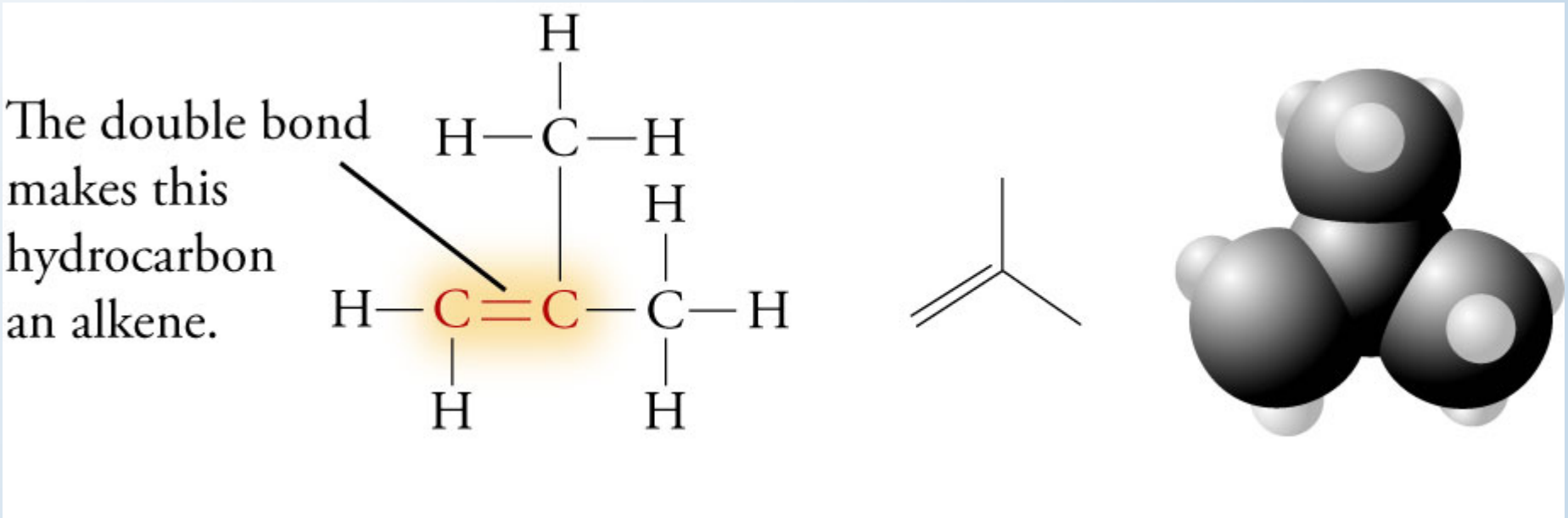
Branched-chain hydrocarbons are less likely to pre-ignite, so a gasoline that has a high percentage of branched-chain hydrocarbons has a high octane rating.

Steps to Octane Rating

- Measure efficiency and degree of vibration for a test engine running on various percentages of heptane (a straight-chain hydrocarbon) and 2,2,4-trimethylpentane (a branched-chain hydrocarbon).
- Run the same test engine with the gasoline to be tested, and measure its efficiency and degree of vibration.
- Assign an octane rating to the gasoline based on comparison of the efficiency and degree of vibration of the test engine with the gasoline and the various percentages of 2,2,4-trimethylpentane (octane or isooctane) and heptane. For example, if the gasoline runs the test engine as efficiently as 91% 2,2,4-trimethylpentane (octane or isooctane) and 9% heptane, it gets an octane rating of 91.



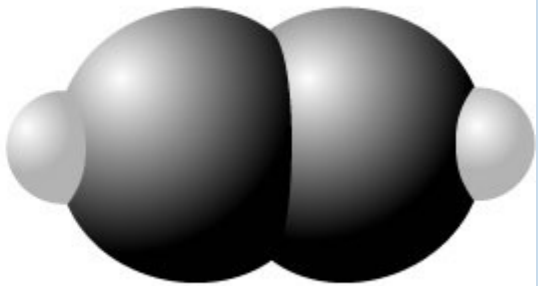
Alkenes - Hydrocarbons that have one or more carbon-carbon double bonds



2-methylpropene (isobutene), $CH_2C(CH_3)CH_3$

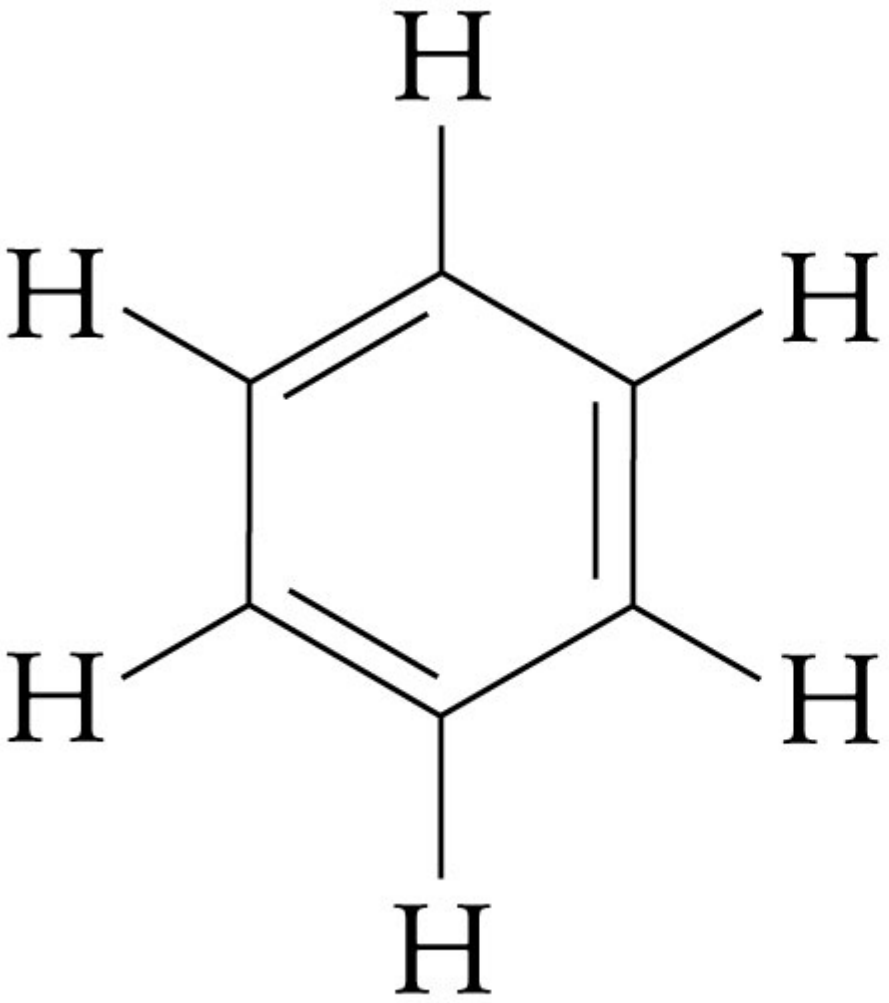
Alkynes - Hydrocarbons that have one or more carbon-carbon triple bonds

The triple bond makes this hydrocarbon an alkyne.

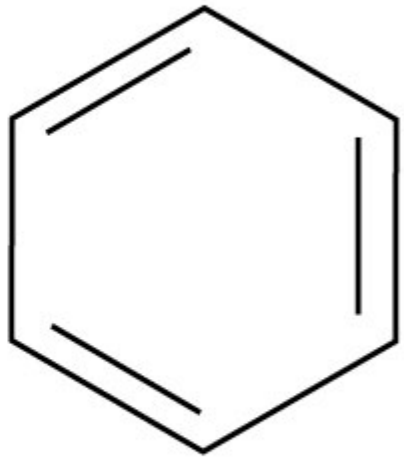


Ethyne (acetylene), HCCH

Benzene

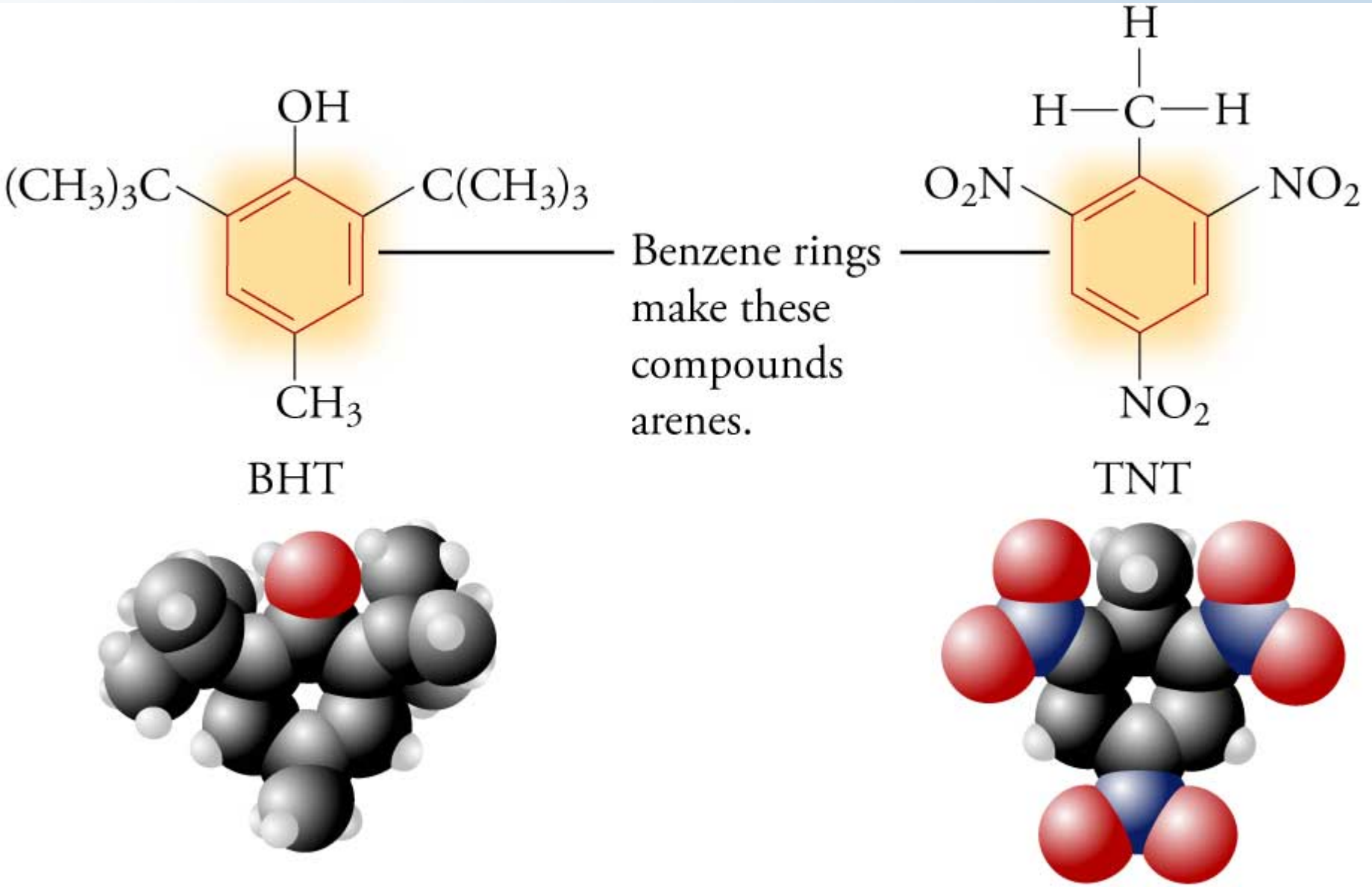


or

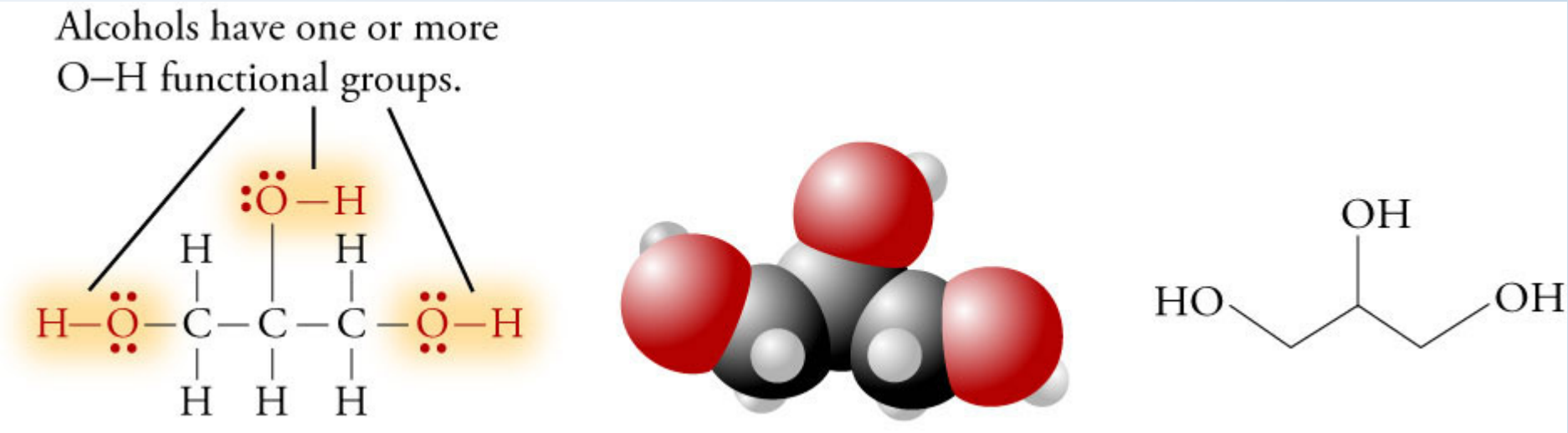


Benzene

Arenes (or Aromatics) - Compounds that contain the benzene ring

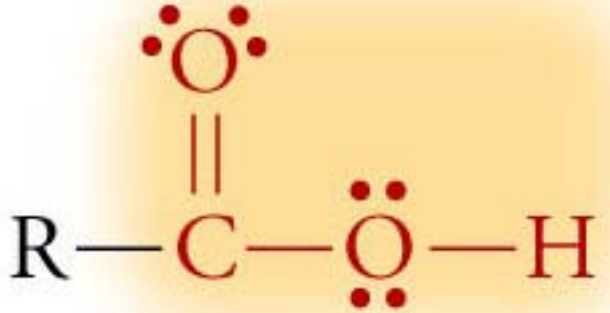


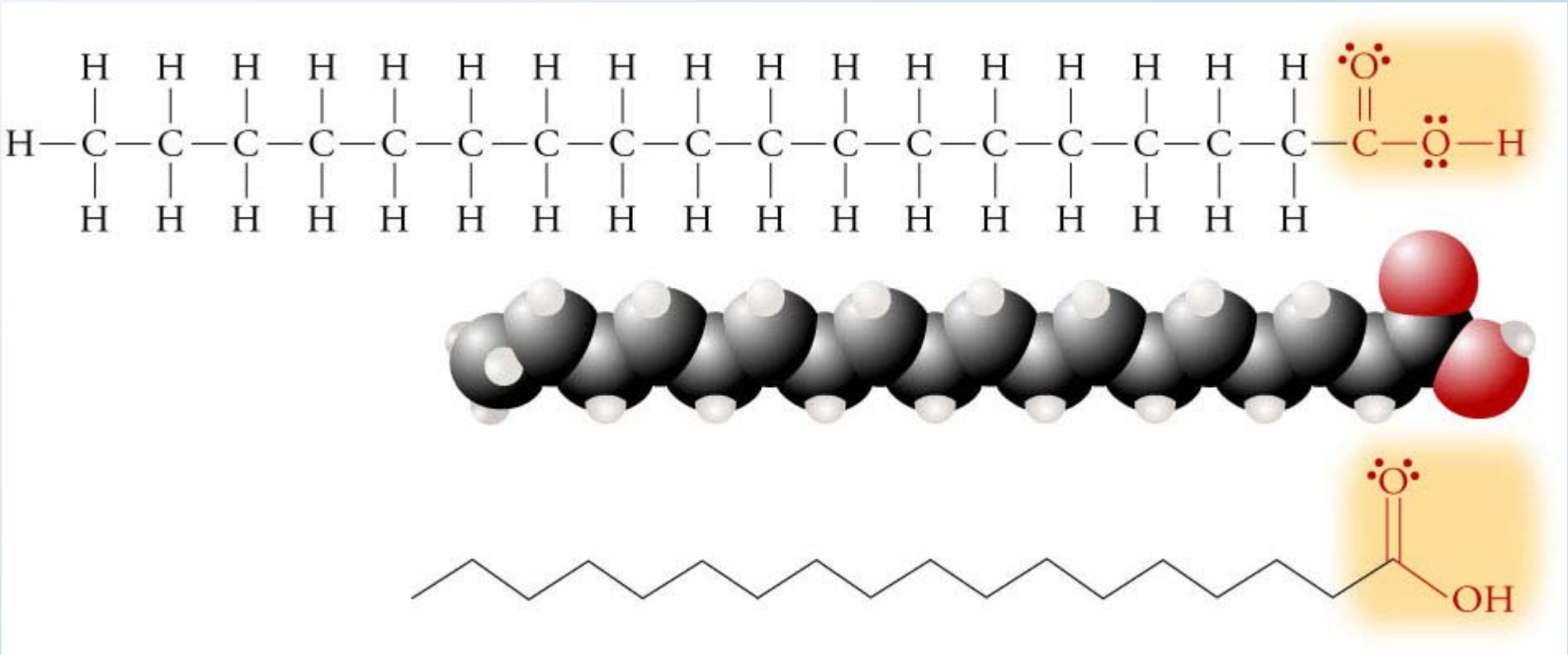
Alcohols - compounds with one or more -OH groups attached to a hydrocarbon group



Glycerol, $HOCH_2CH(OH)CH_2OH$

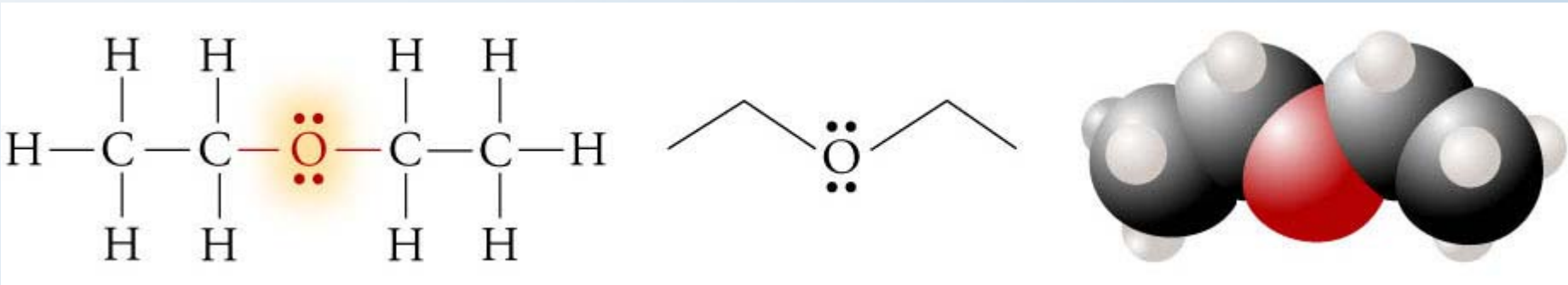
Carboxylic Acids





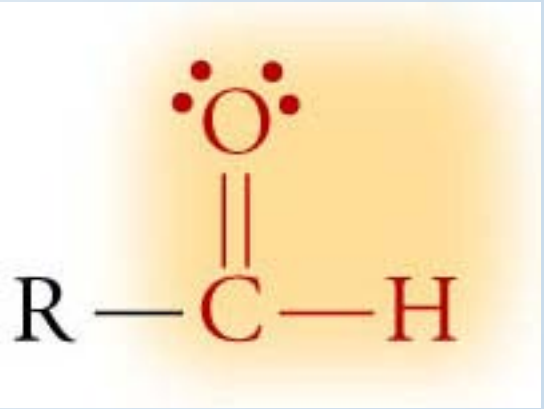
Stearic acid, $CH_3(CH_2)_{16}CO_2H$

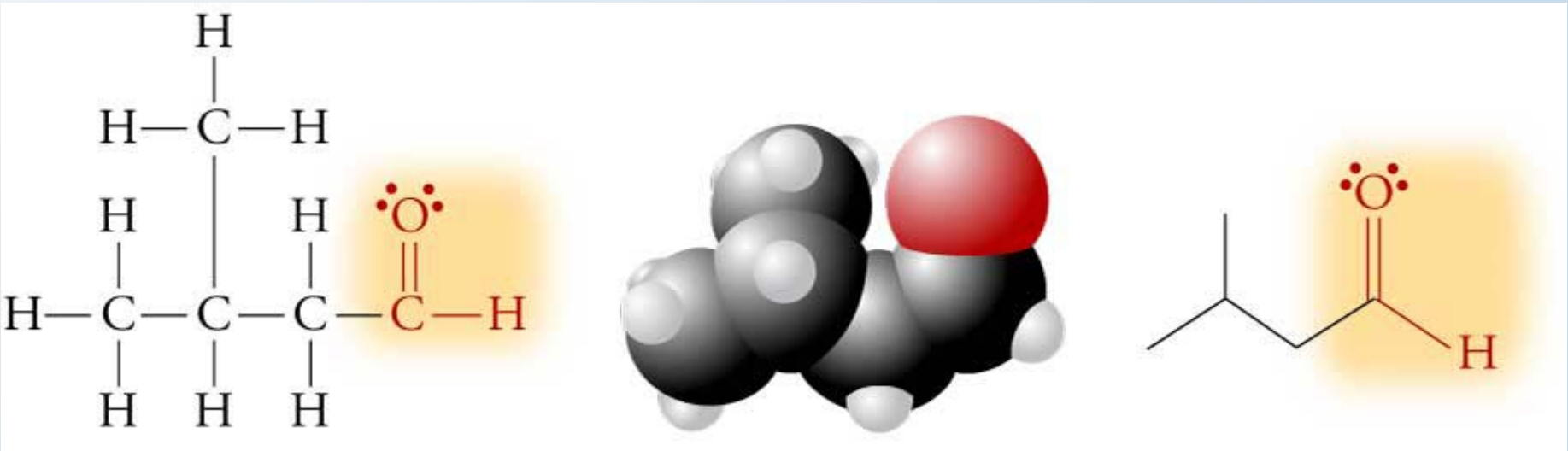
Ethers - two hydrocarbon groups surrounding an oxygen atom



Diethyl ether, $CH_3CH_2OCH_2CH_3$

Aldehyde

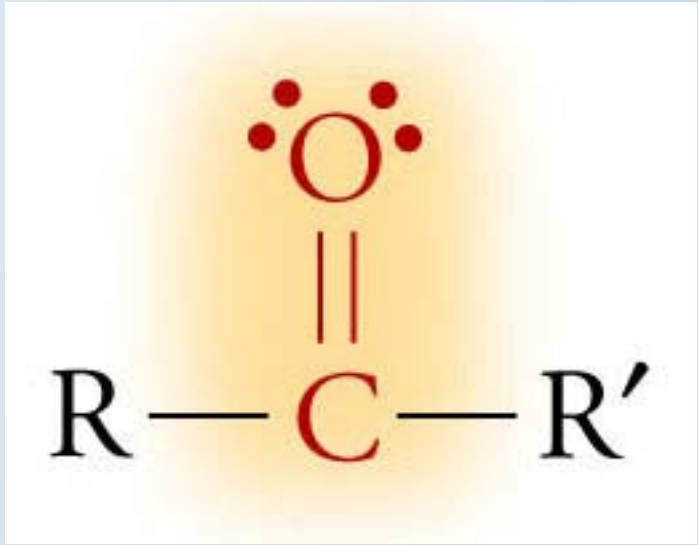


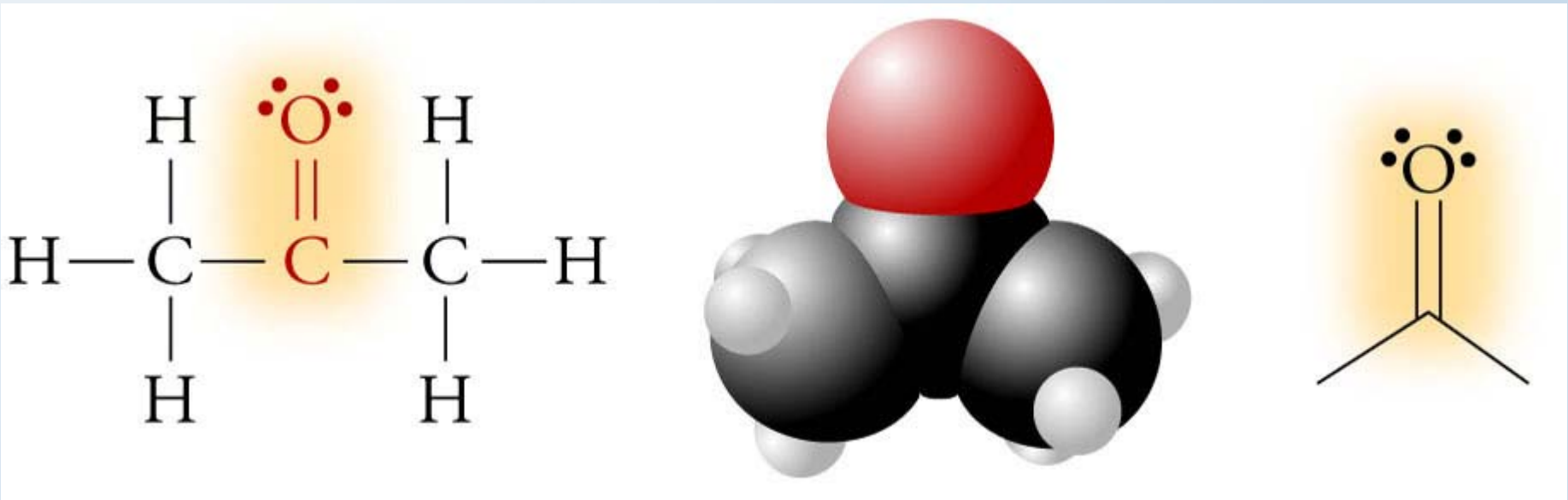


2-methylbutanal, $CH_3CH(CH_3)CH_2CHO$

Ketones

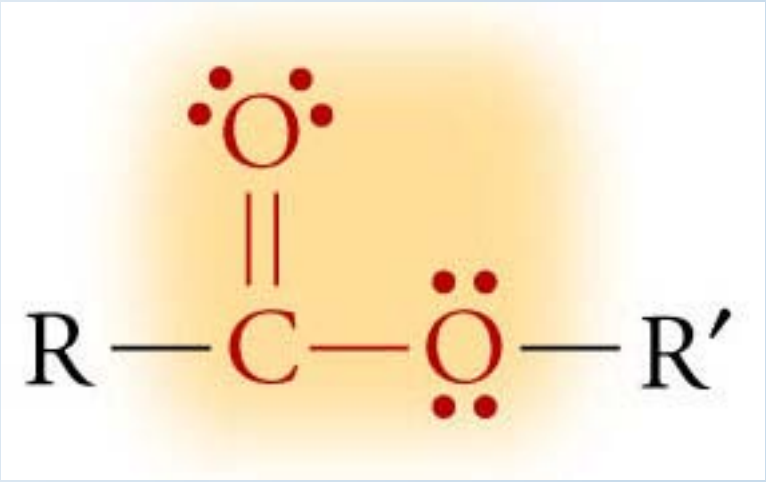
The R's must be hydrocarbon groups. They cannot be hydrogen atoms.



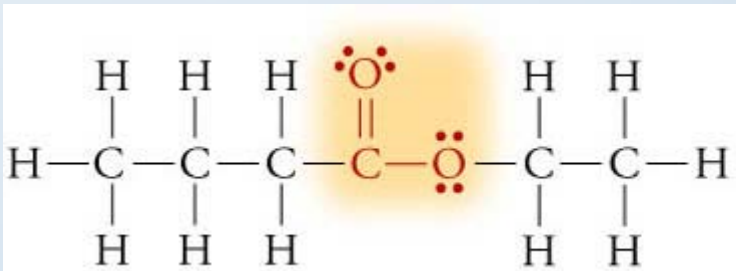


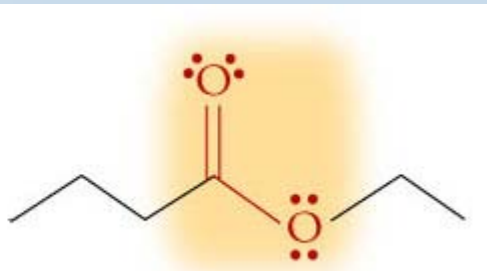
2-propanone (acetone), CH_3COCH_3

Esters



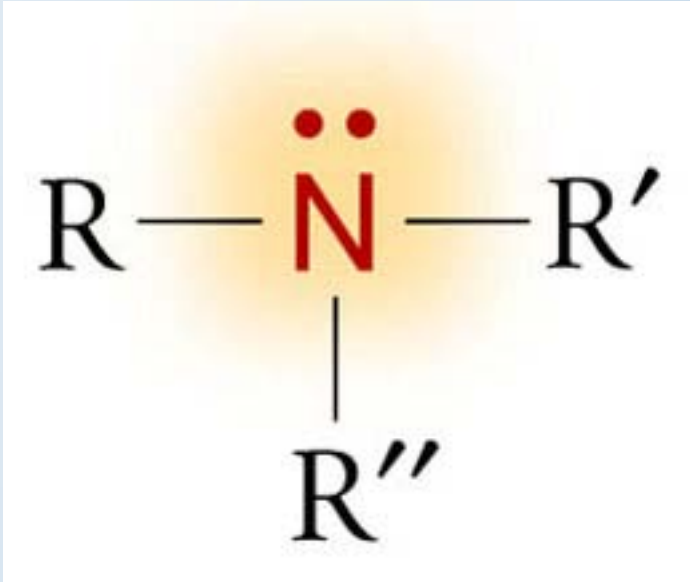
The R’ must be a hydrocarbon group. It cannot be a hydrogen atom.

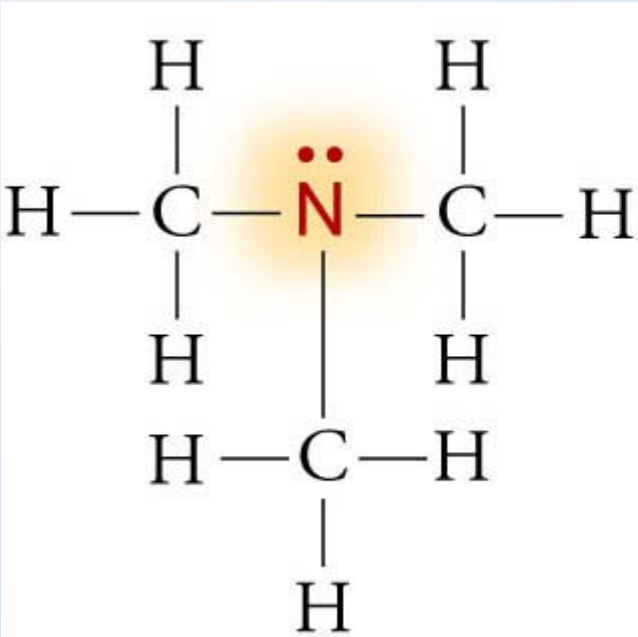


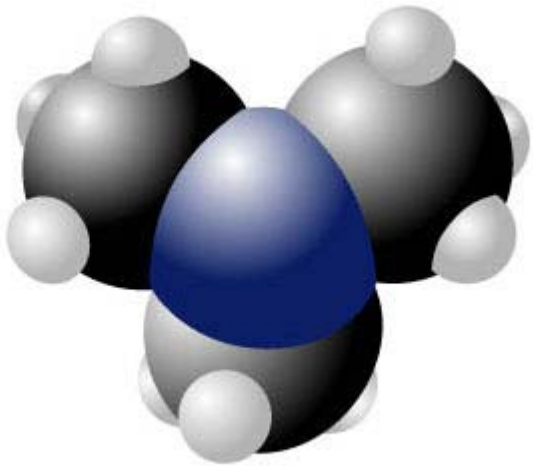


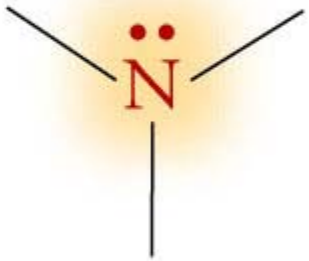
Ethyl butanoate, $CH_3CH_2CH_2CO_2CH_2CH_3$

Amine



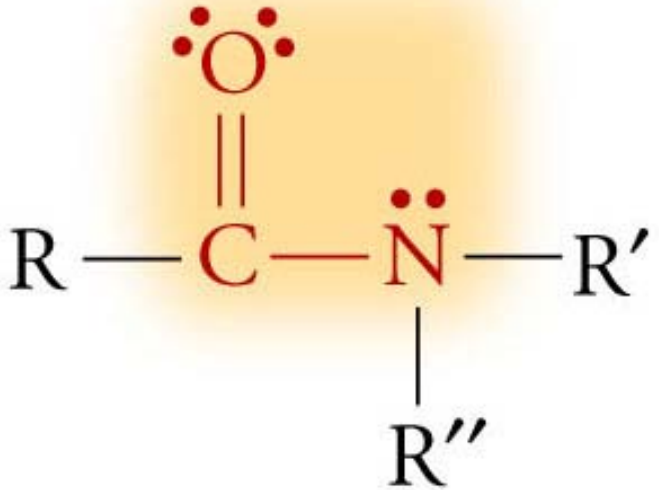


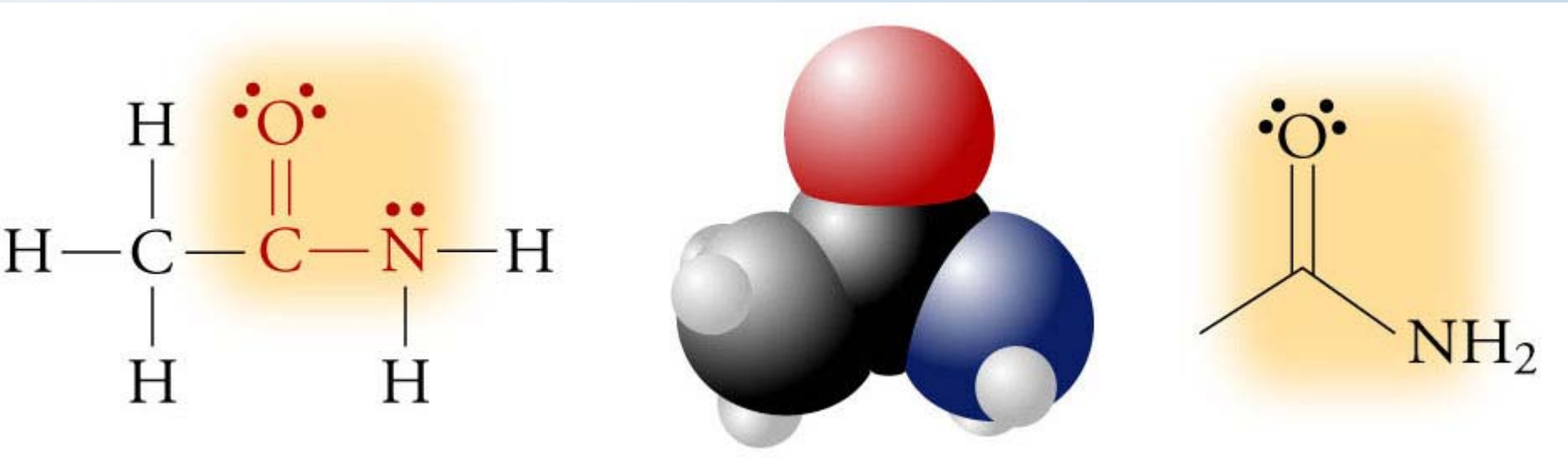




Trimethylamine, $(CH_3)_3N$

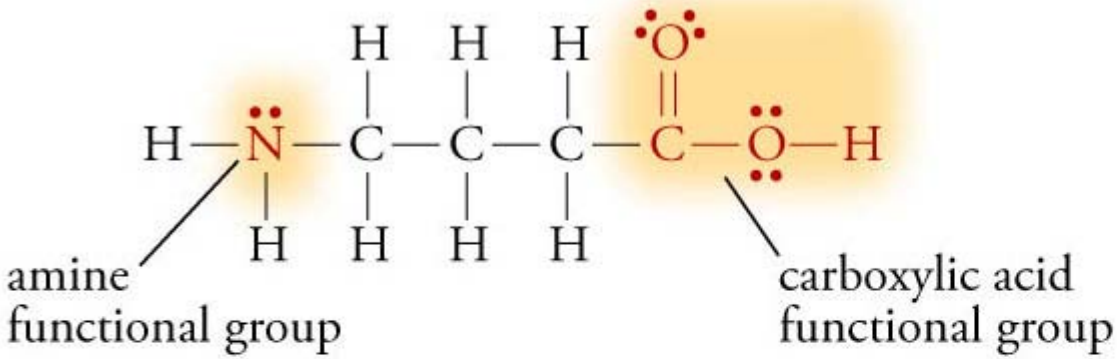
Amides

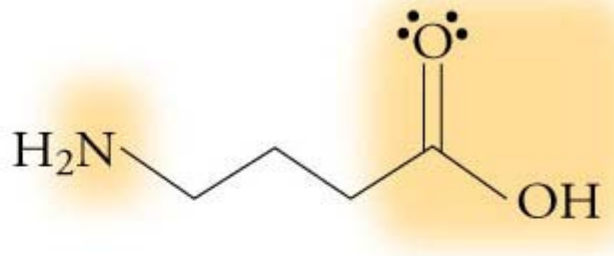


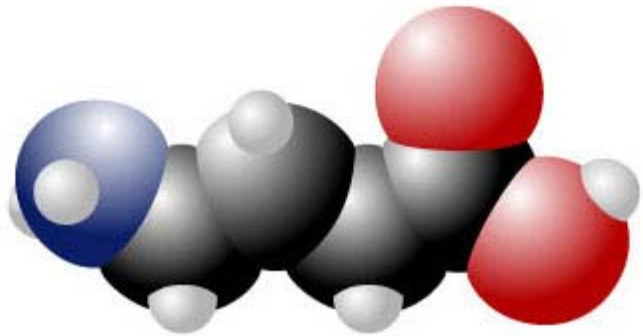


Ethanamide (acetamide), CH_3CONH_2

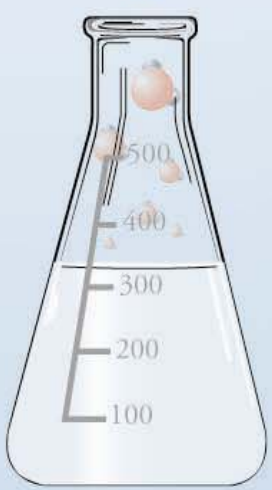
Difunctional Compounds - GABA





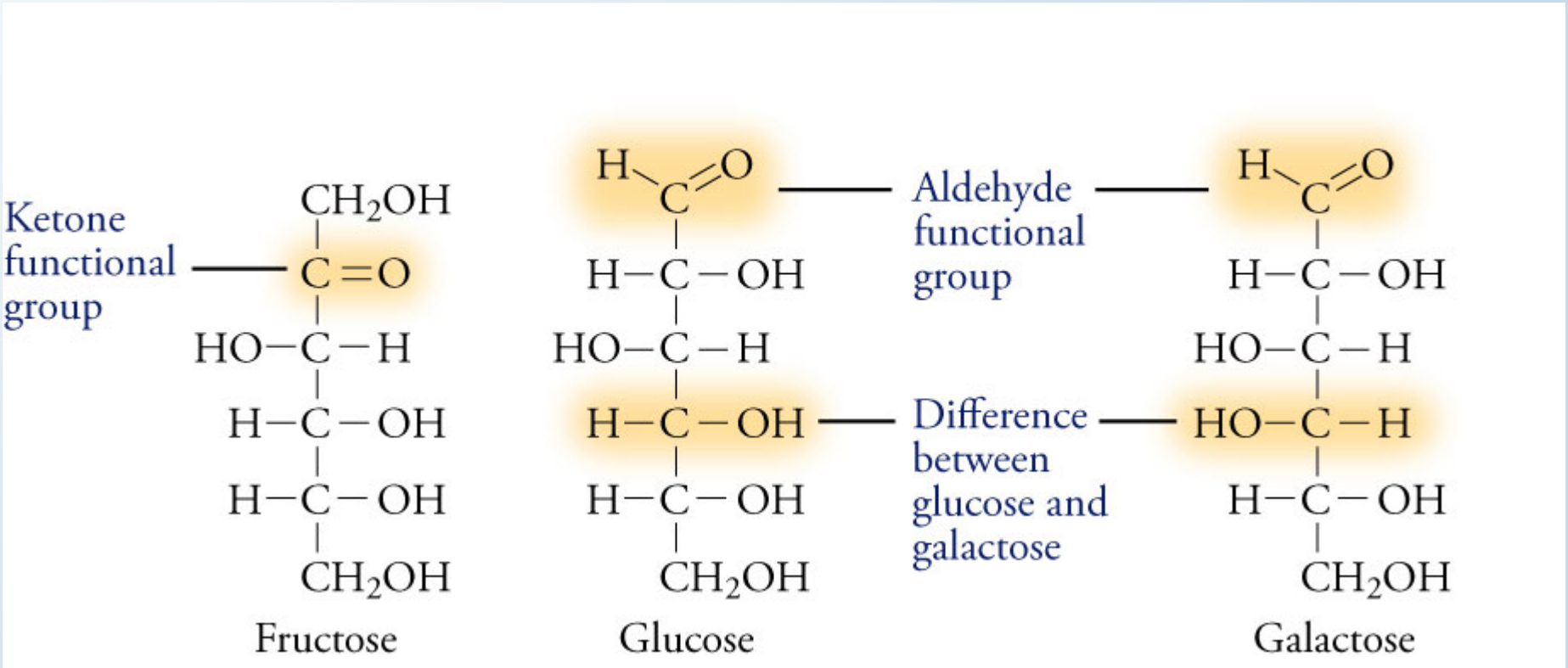


Types of Biomolecules

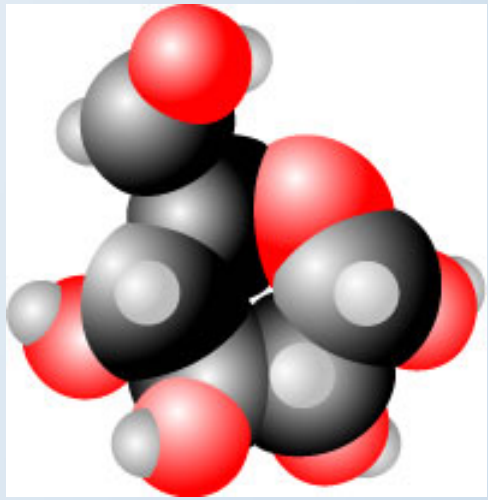


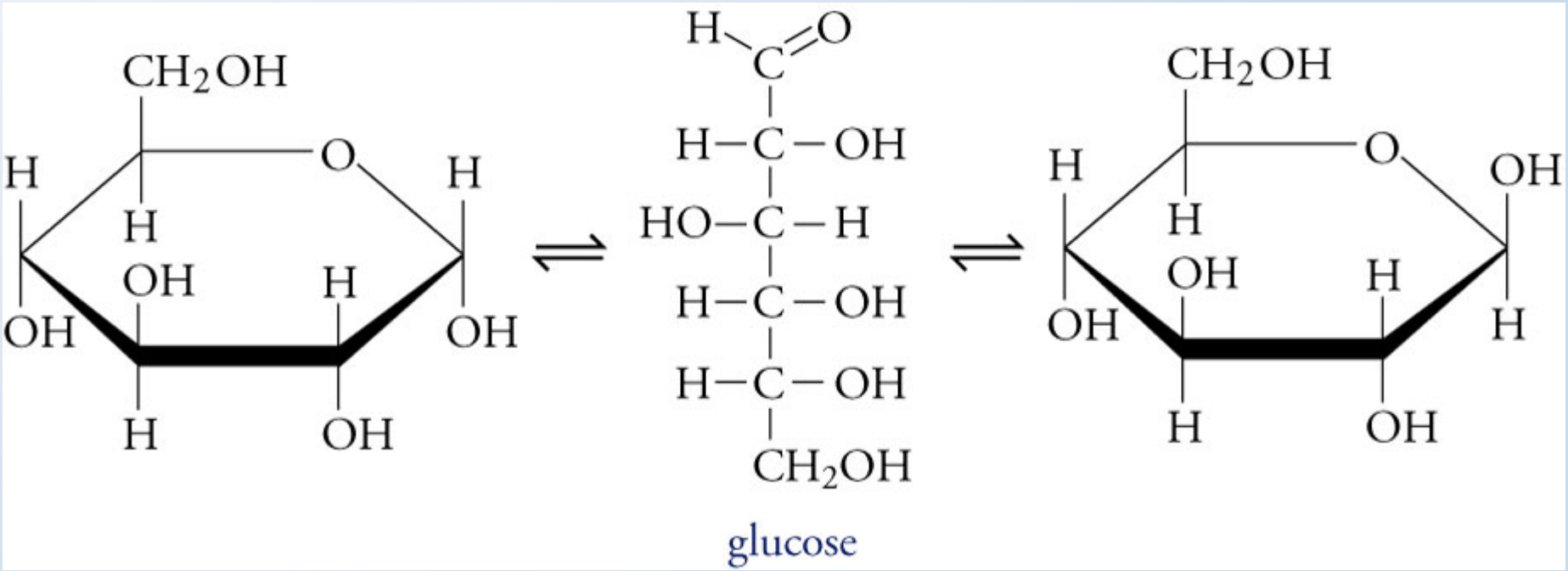
- **Carbohydrates**
  - Monosaccharides (glucose and fructose)
  - Disaccharides (maltose, lactose, and sucrose)
  - Polysaccharides (starch and cellulose)
- **Amino Acids** and **Proteins**
- **Triglycerides**
- **Steroids**

Monosaccharides



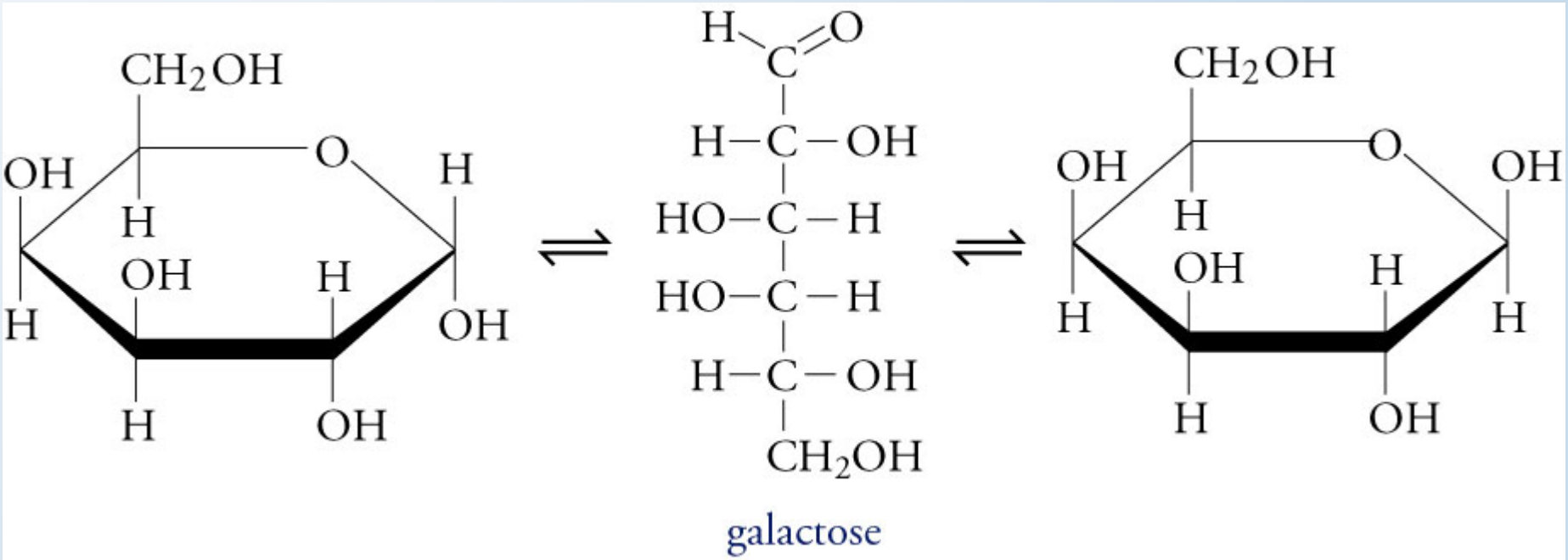
Glucose





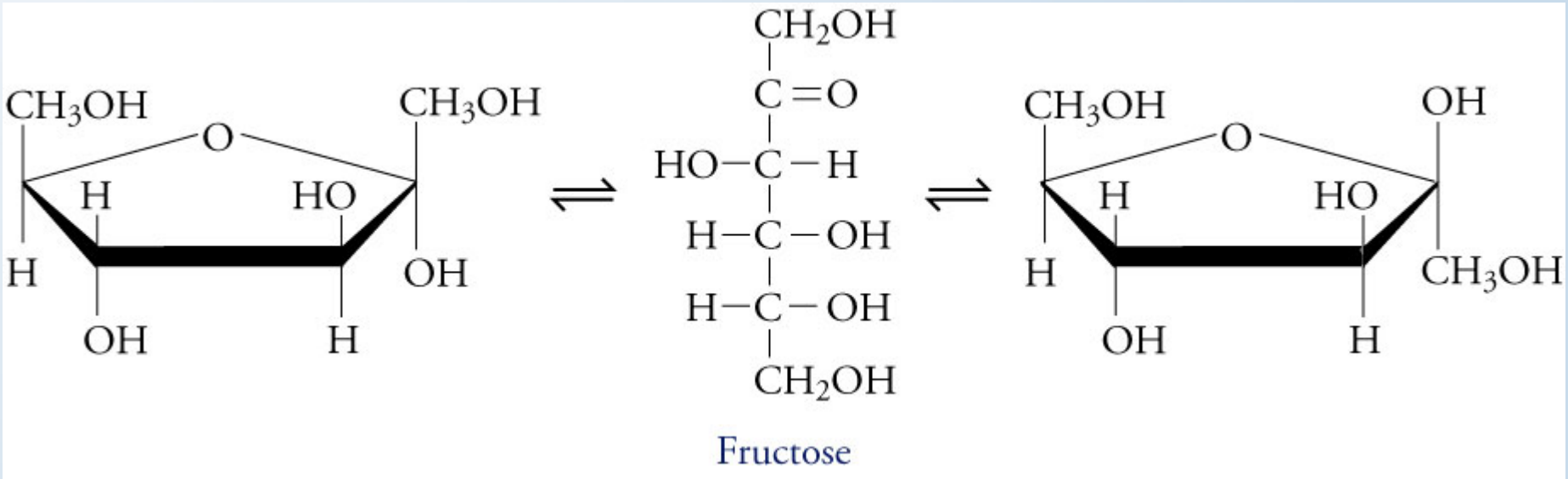
glucose

Galactose



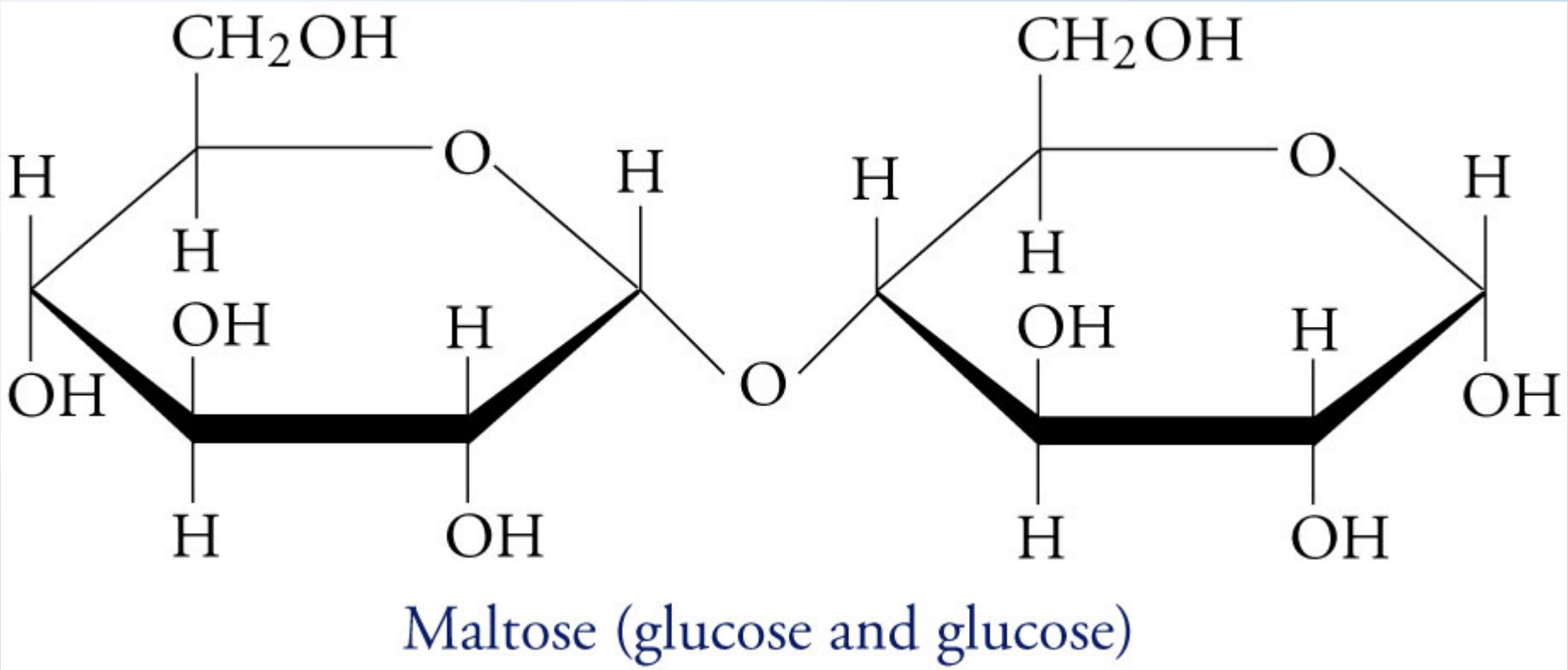
galactose

Fructose



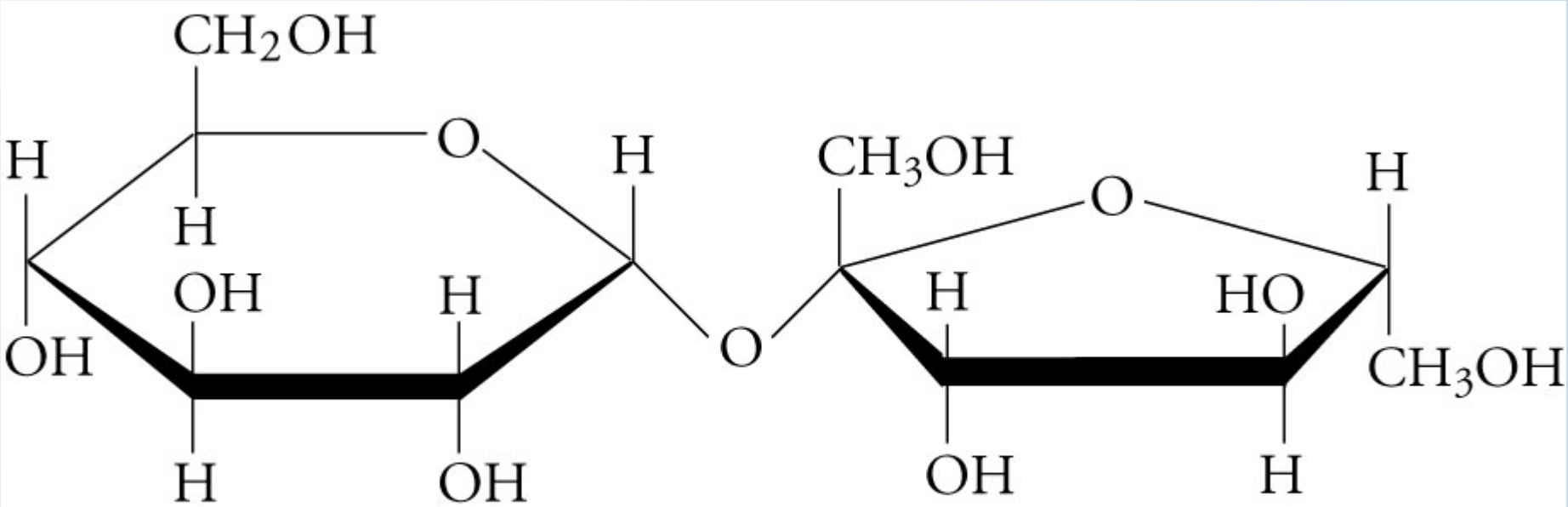
Fructose

Maltose



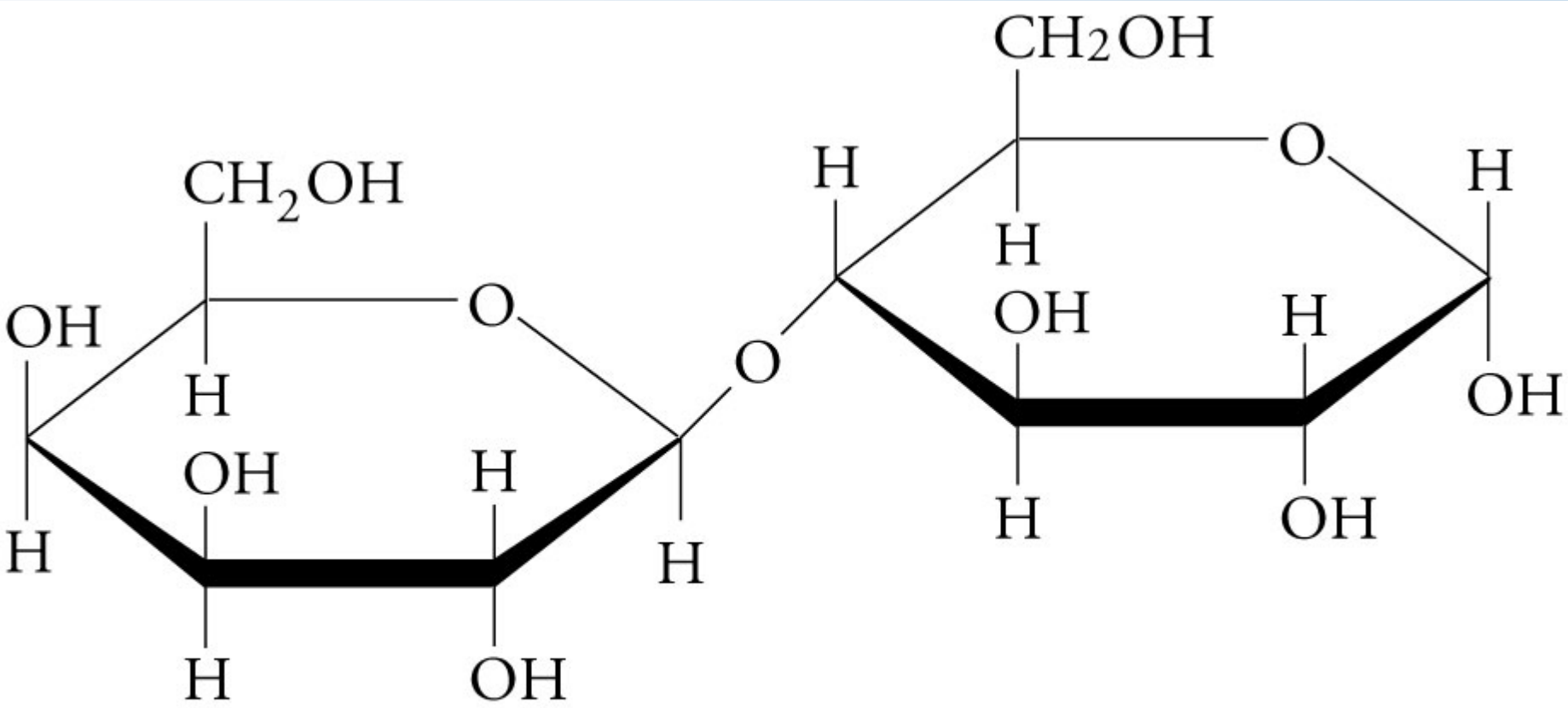
Maltose (glucose and glucose)

Sucrose



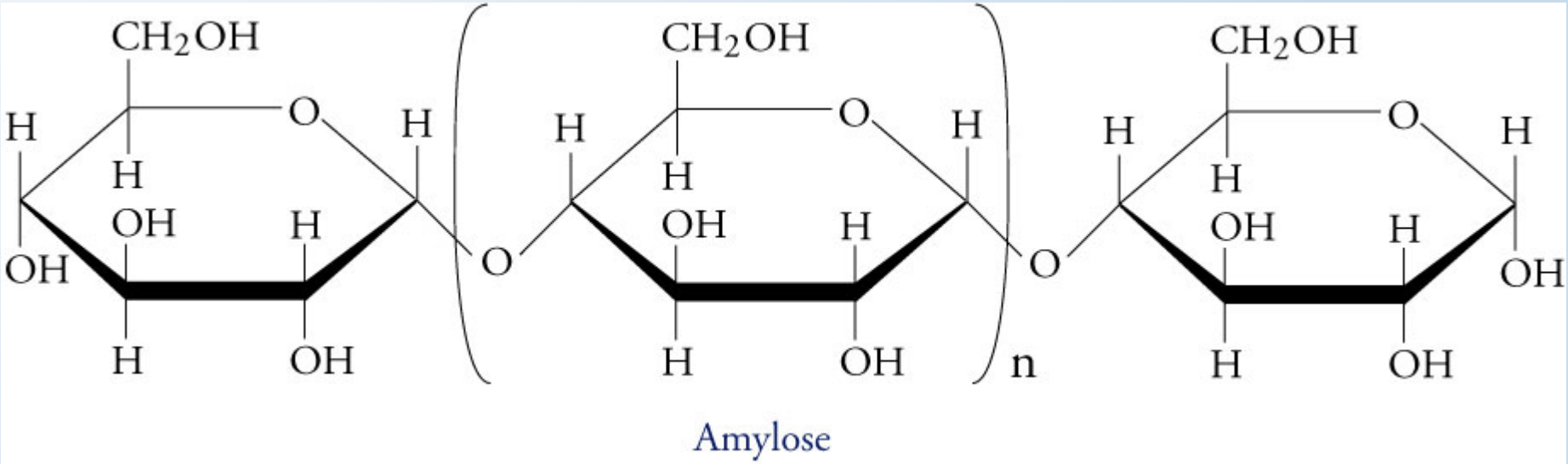
Sucrose (glucose and fructose)

Lactose

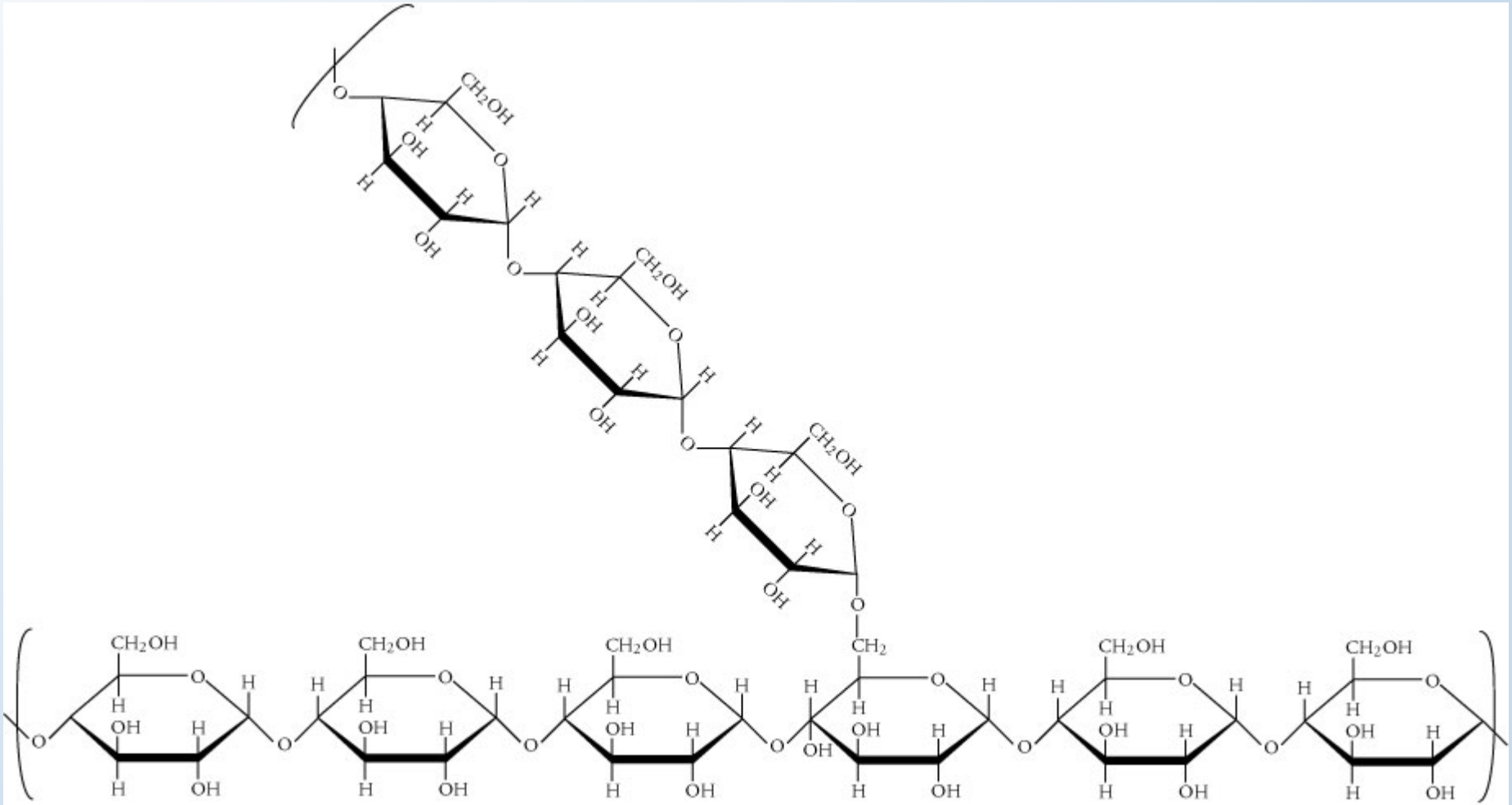


Lactose (galactose and glucose)

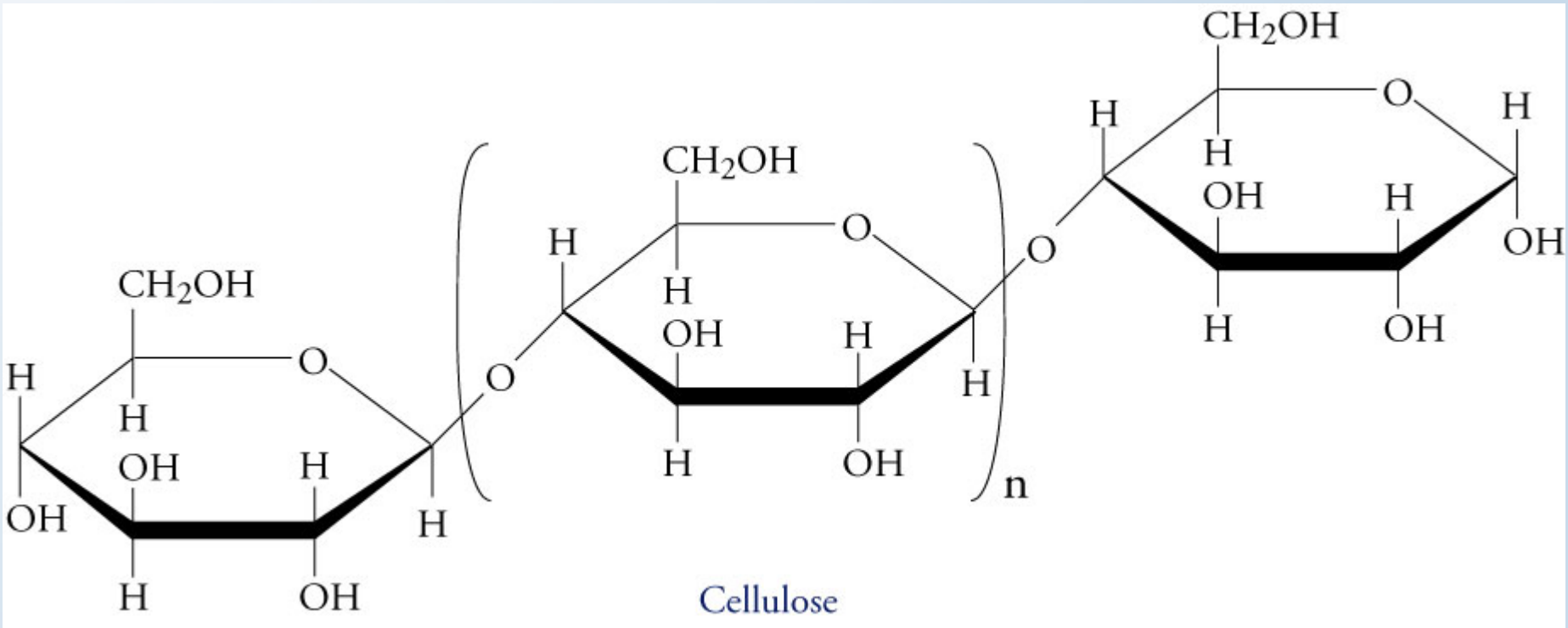
Amylose



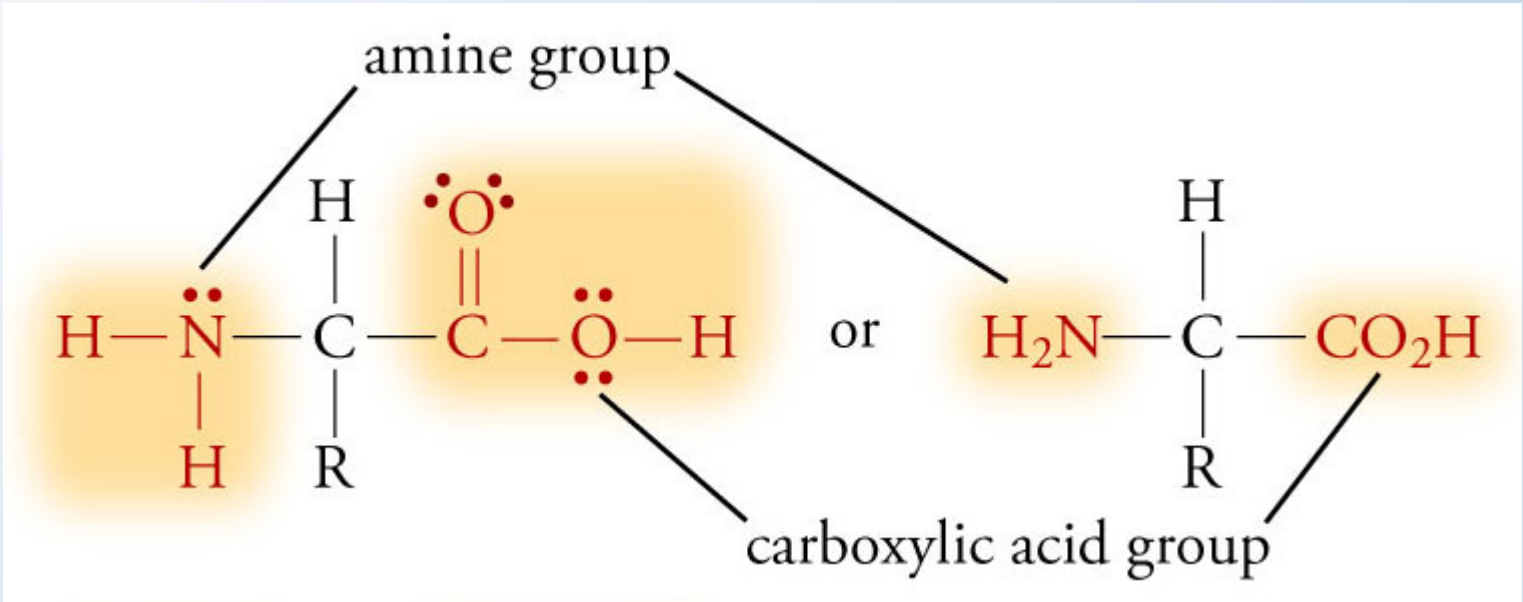
Amylopectin or Glycogen



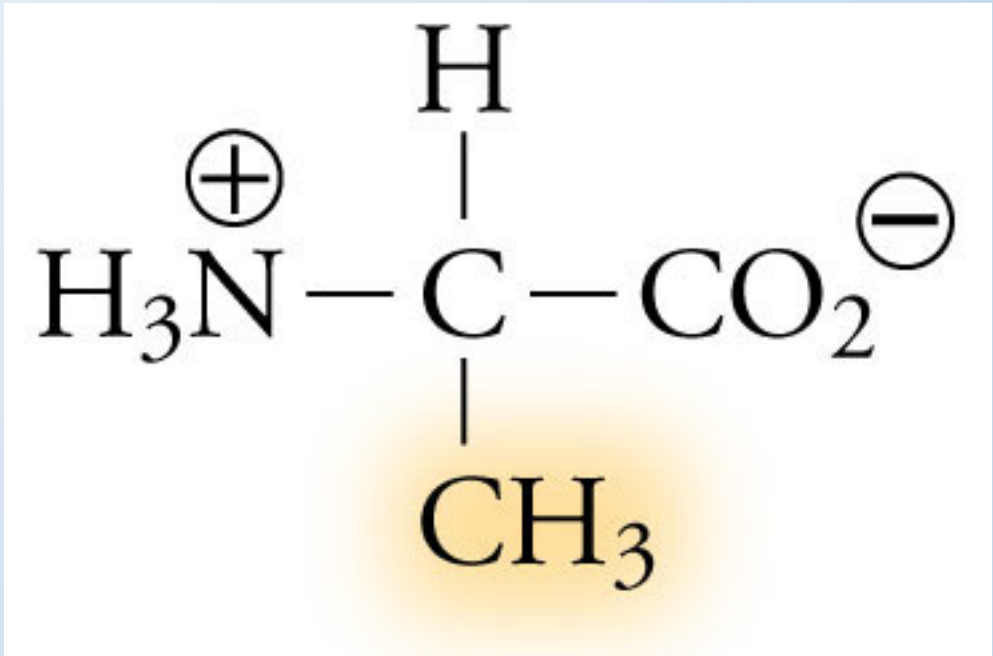
Cellulose

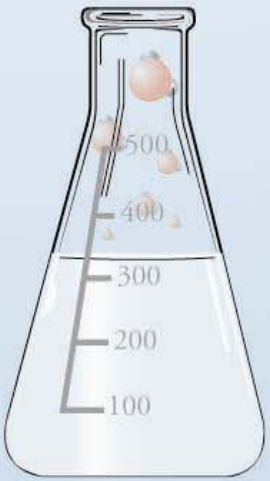


Amino Acids

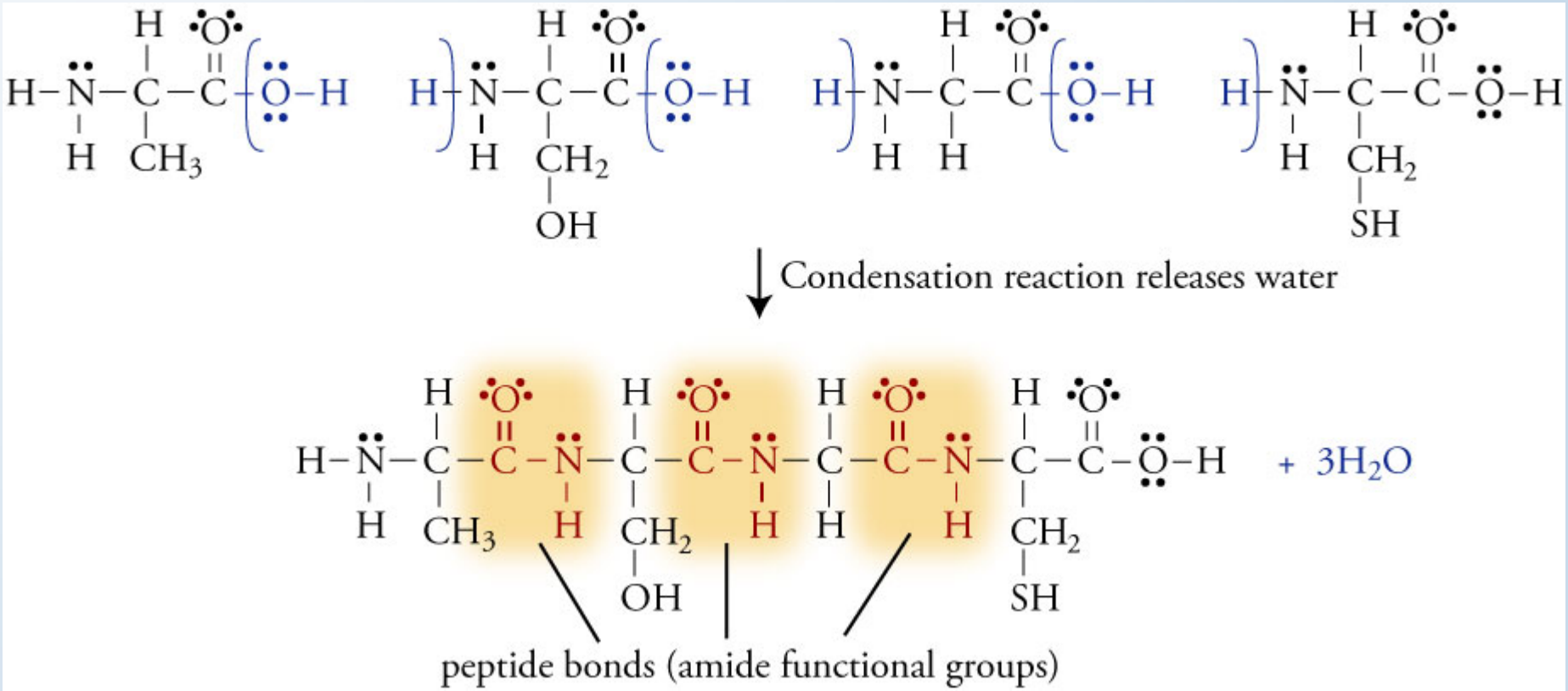


Alanine

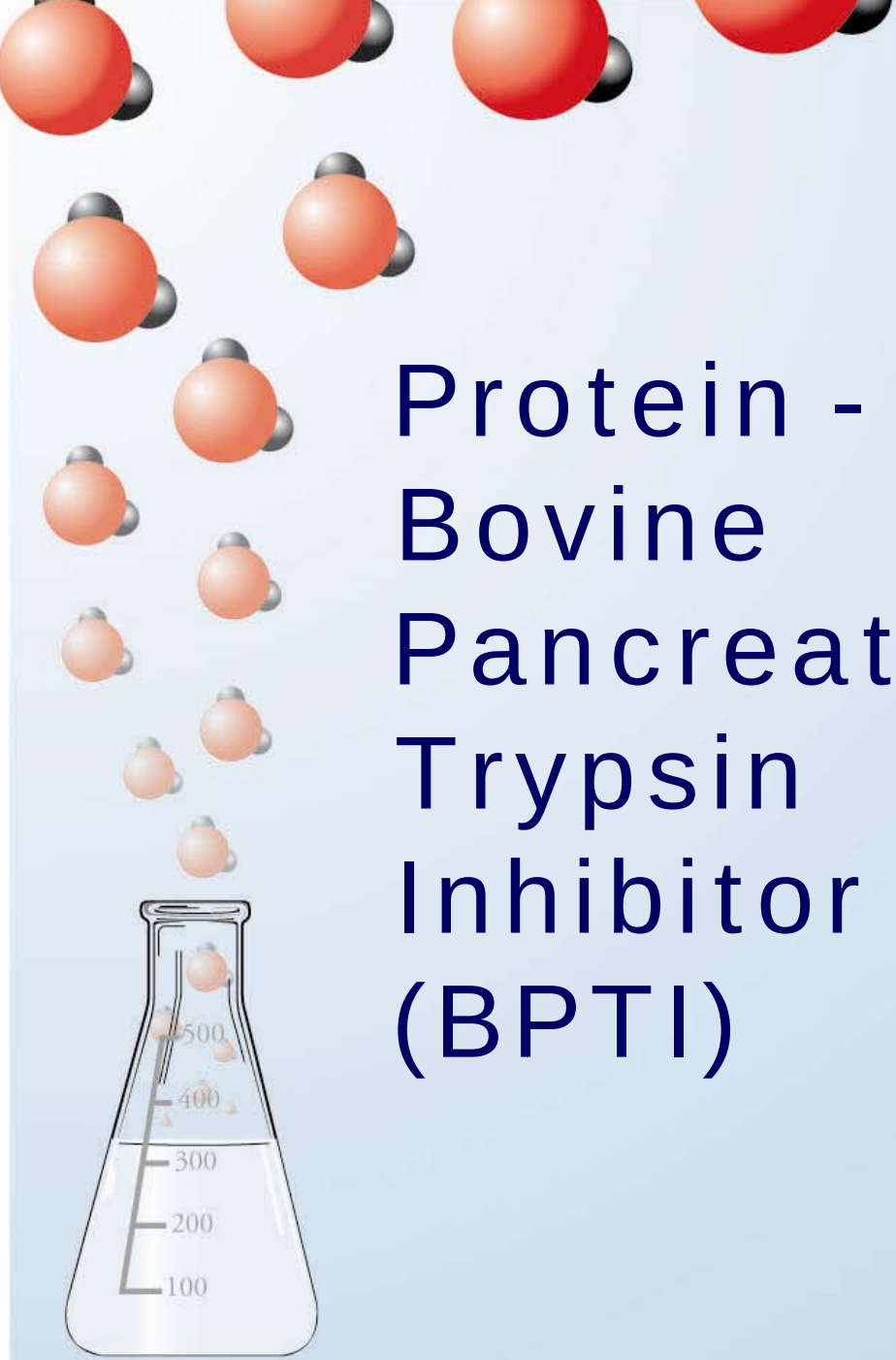


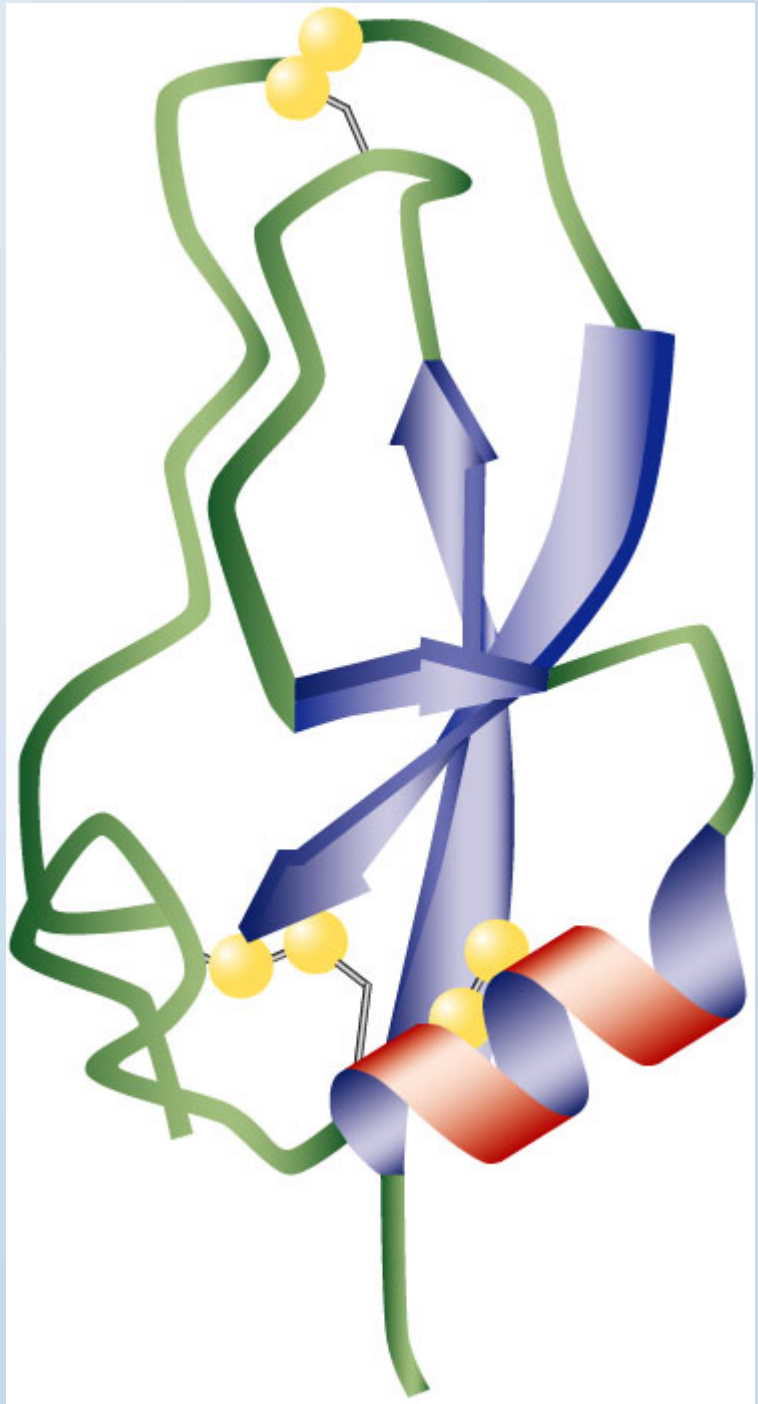


Formation of Ala-Ser-Gly-Cys

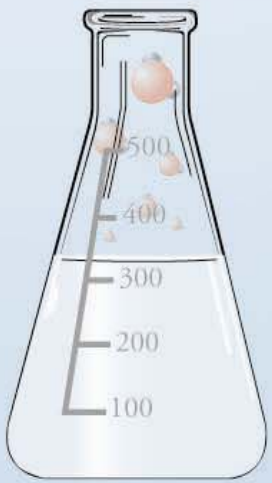


Protein - Bovine Pancreatic Trypsin Inhibitor (BPTI)





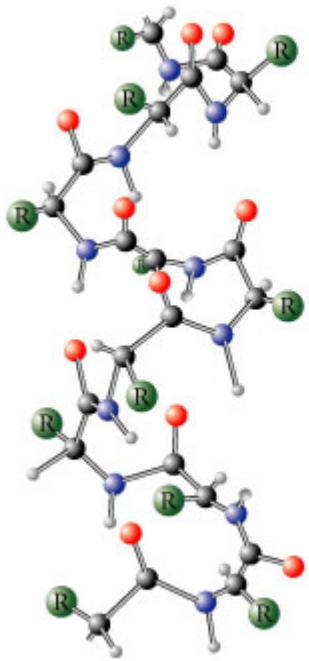
Primary and Secondary Protein Structures



- ***Primary Structure*** = the sequence of amino acids in the protein
- The arrangement of atoms that are close to each other in the polypeptide chain is called the ***secondary structure*** of protein.
  - Three types
    - α-helix
    - β-sheet
    - irregular

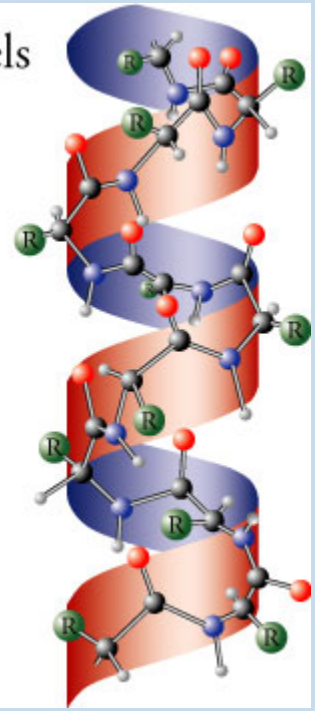
α-helix - Secondary Structure

Ball-and-stick model of a portion of the α-helical secondary structure of a protein molecule

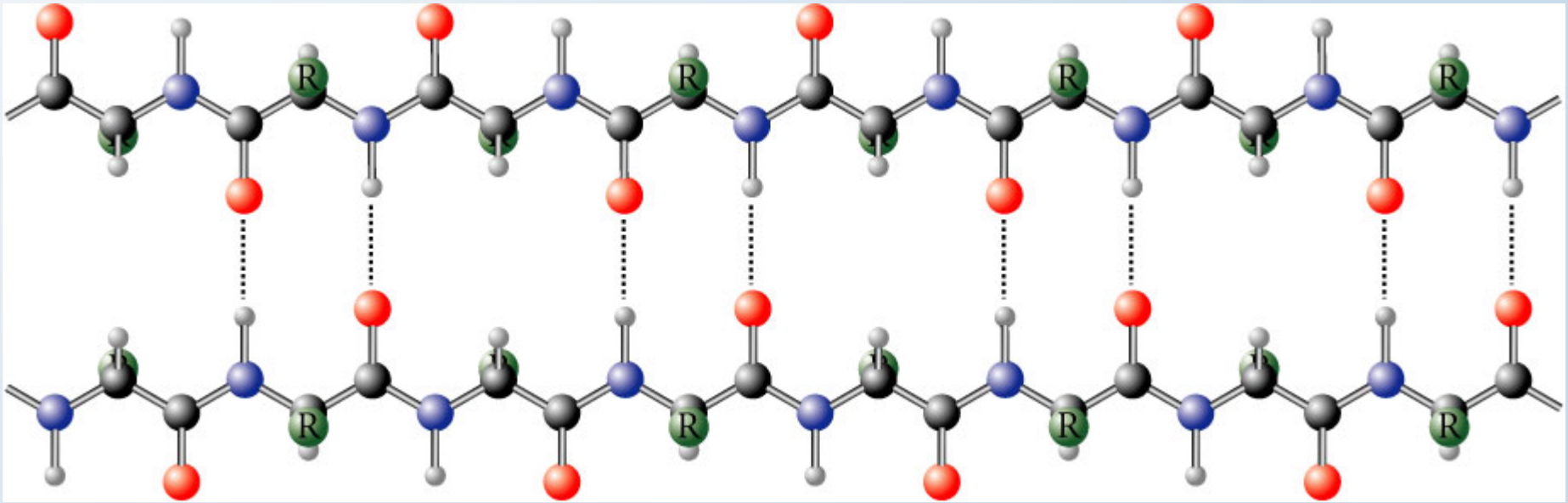


This ribbon model shows the general arrangement of atoms in a portion of the α-helical secondary structure of a protein molecule.

The two models superimposed

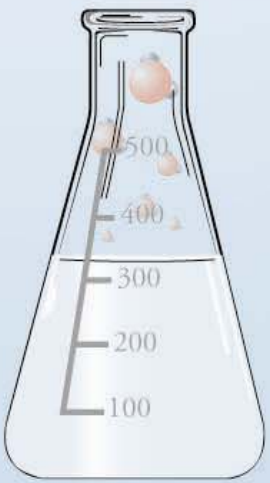


β-Sheet Secondary Structure

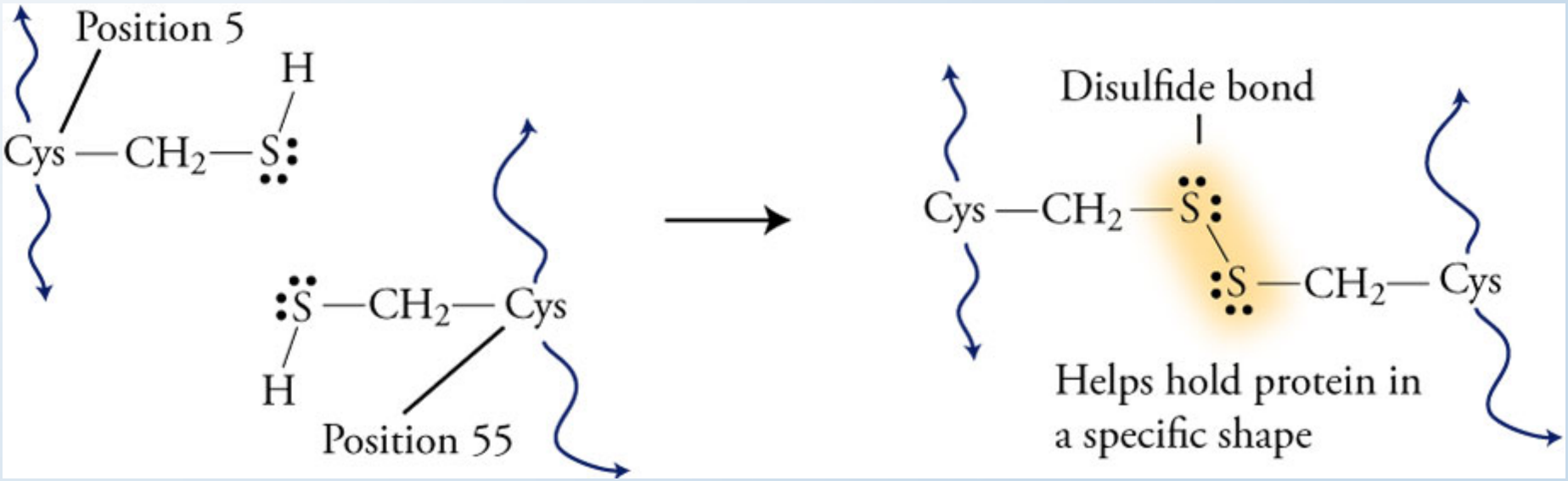


Tertiary Protein Structure

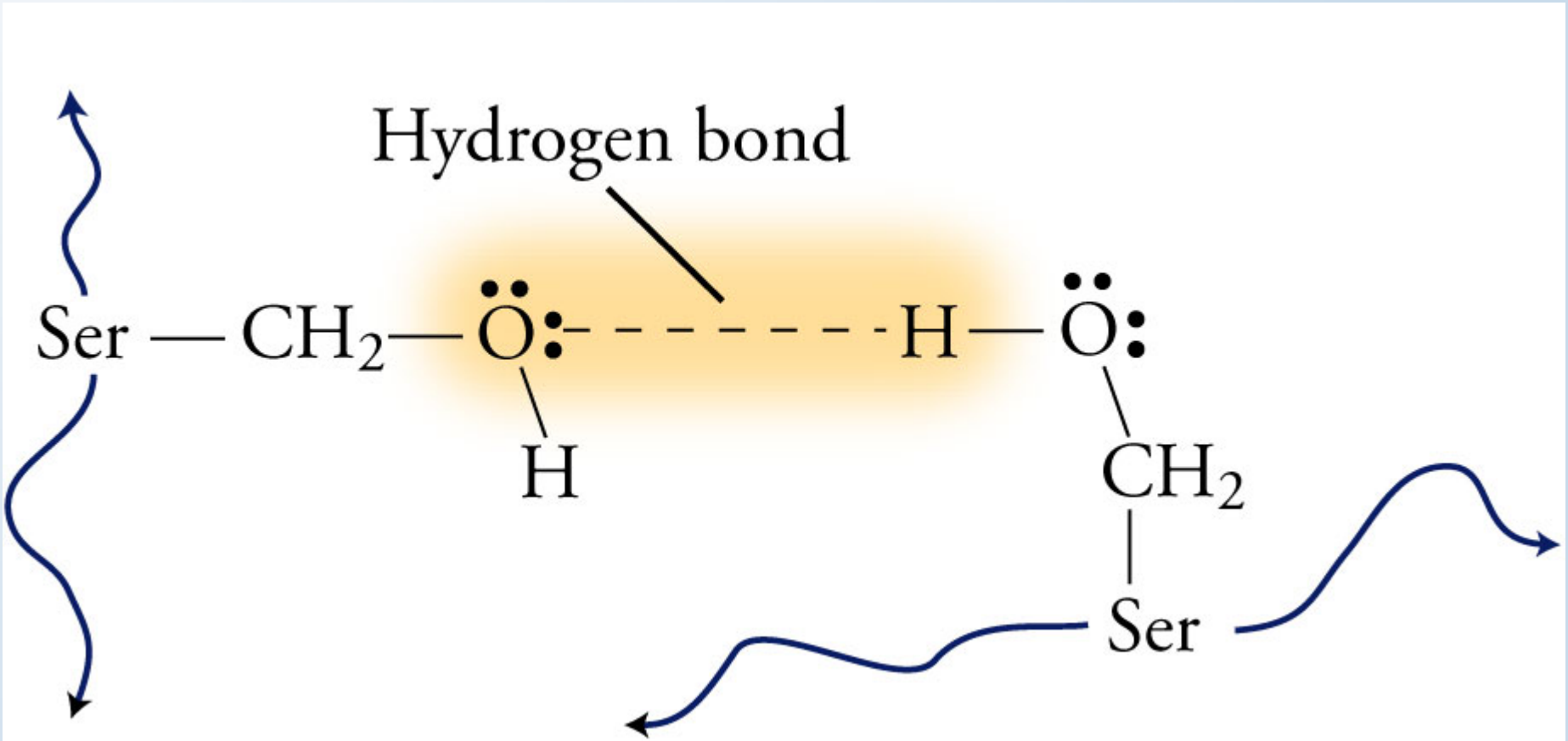
- The very specific overall shape of the protein called its ***tertiary structure***.
- The protein chain is held in its tertiary structure by interactions between the side chains of its amino acids.
  - Disulfide bonds
  - Hydrogen bonds
  - Salt bridges

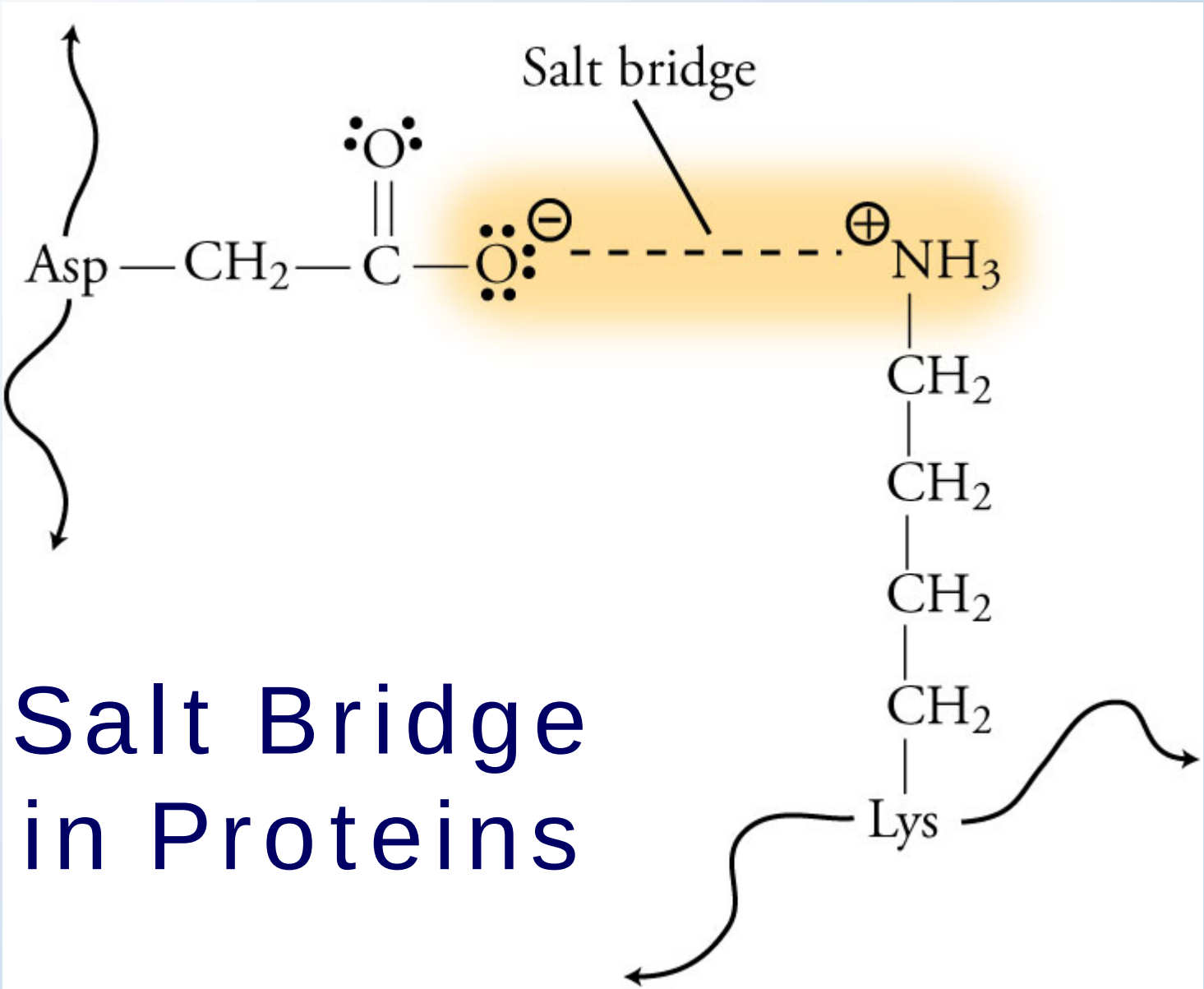


Disulfide Bonds in Proteins



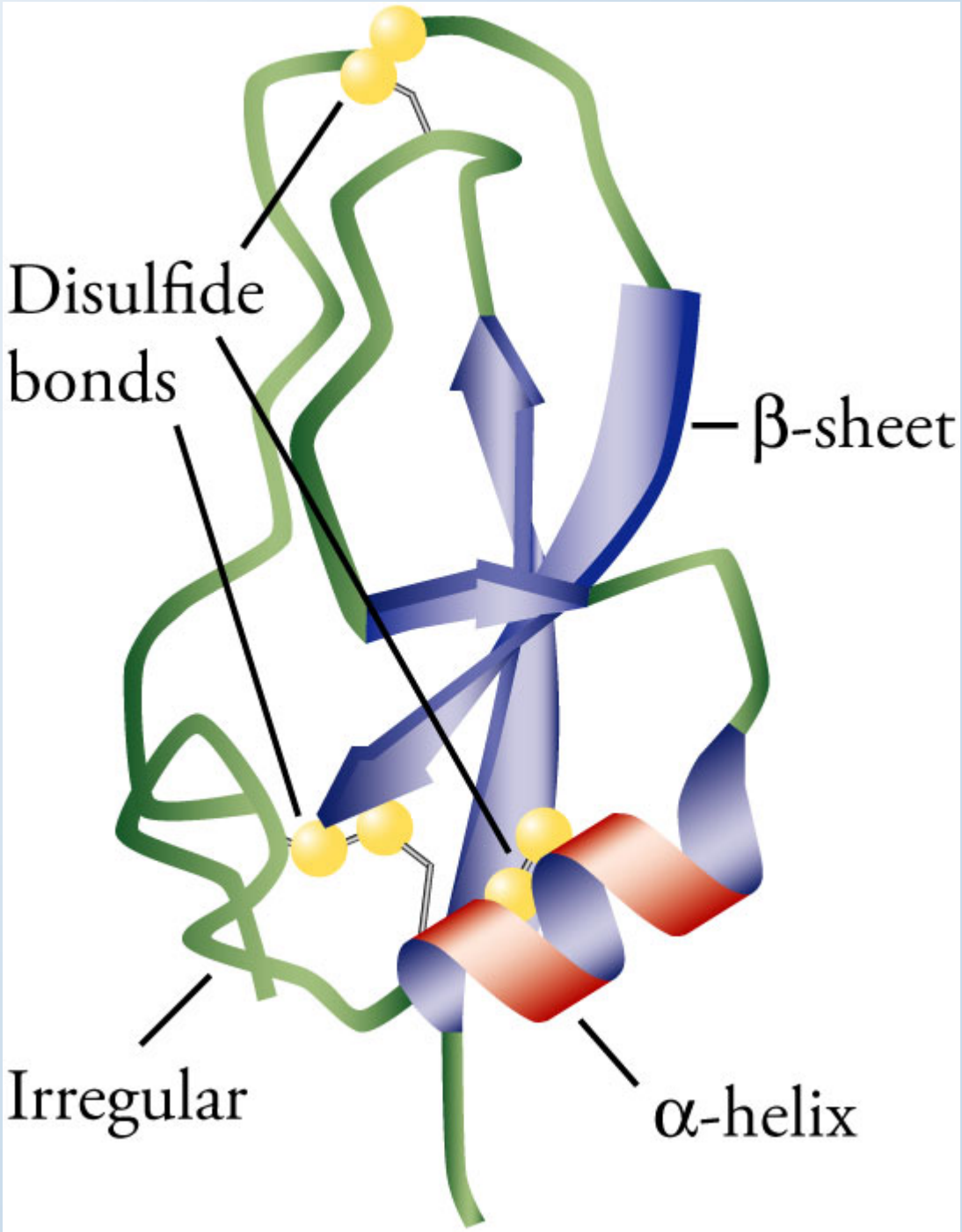
Hydrogen Bonding in Proteins



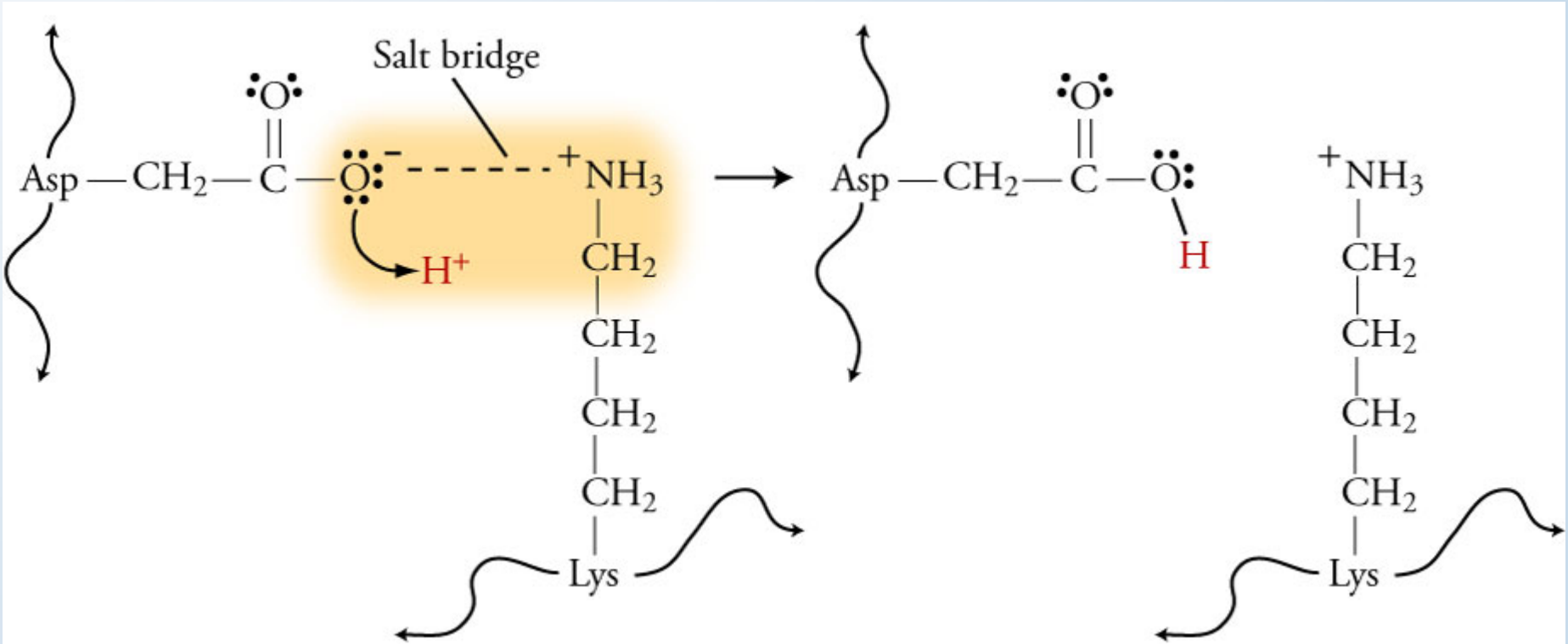


Salt Bridge in Proteins

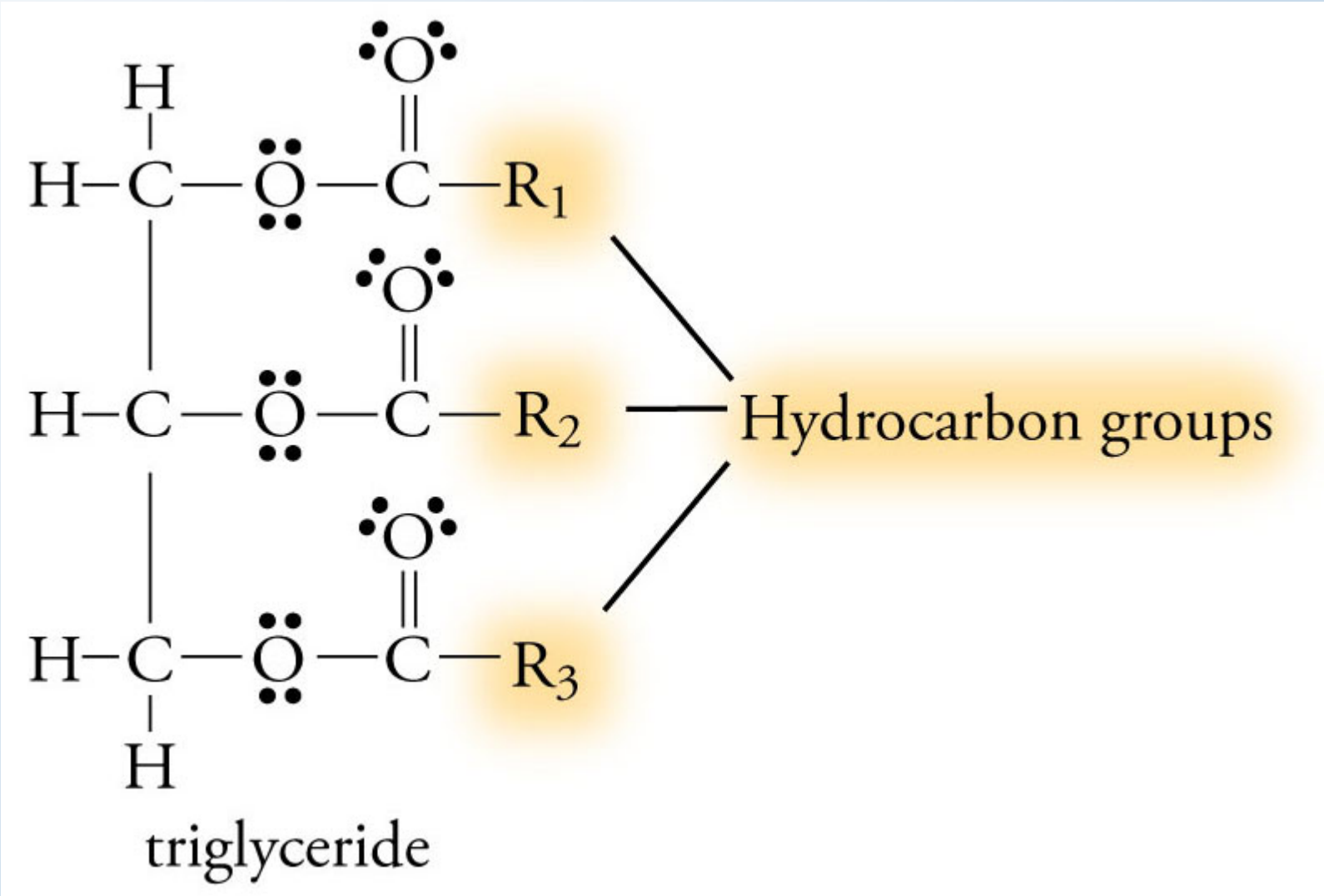
The Ribbon Structure of the Protein BPTI



Disruption of Salt Bridge

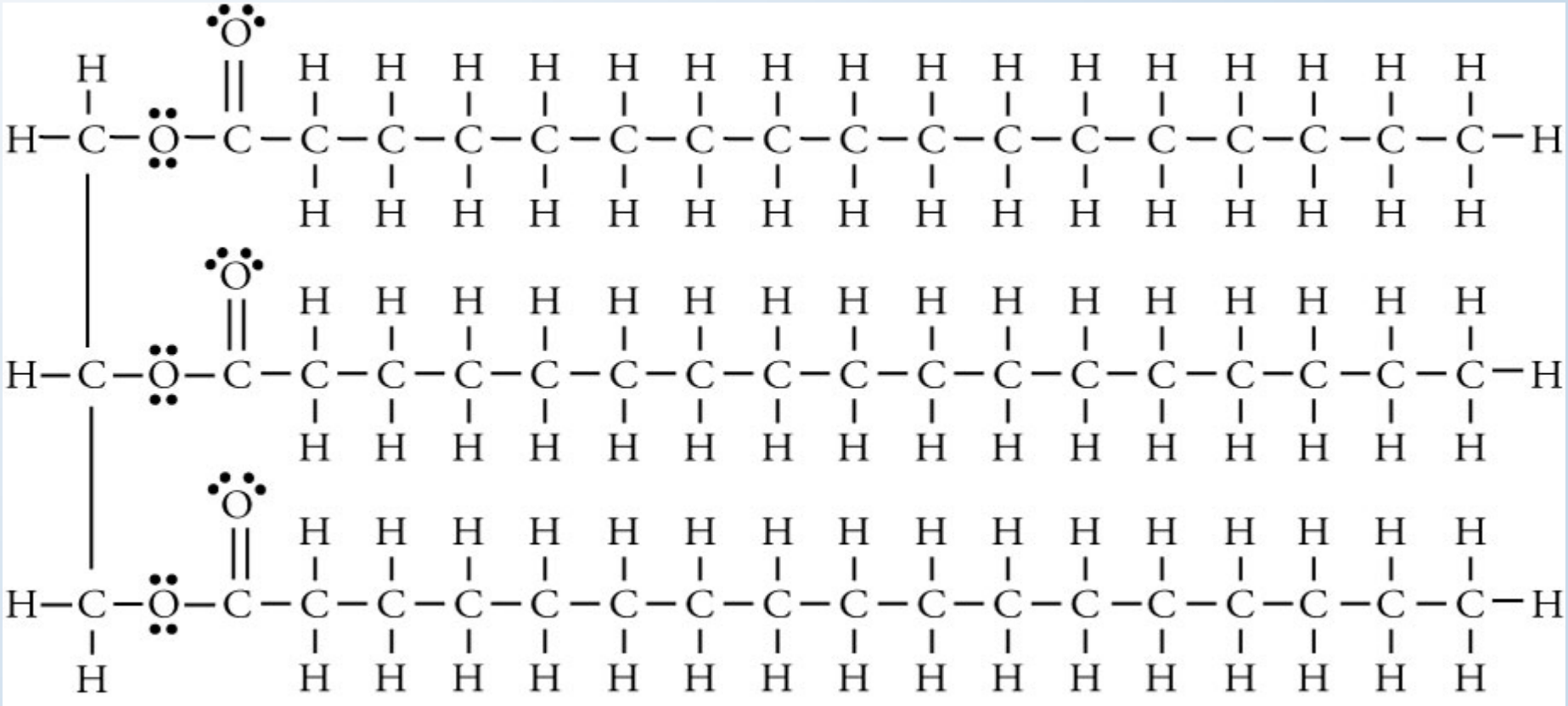


Triglycerides (Fats and Oils)

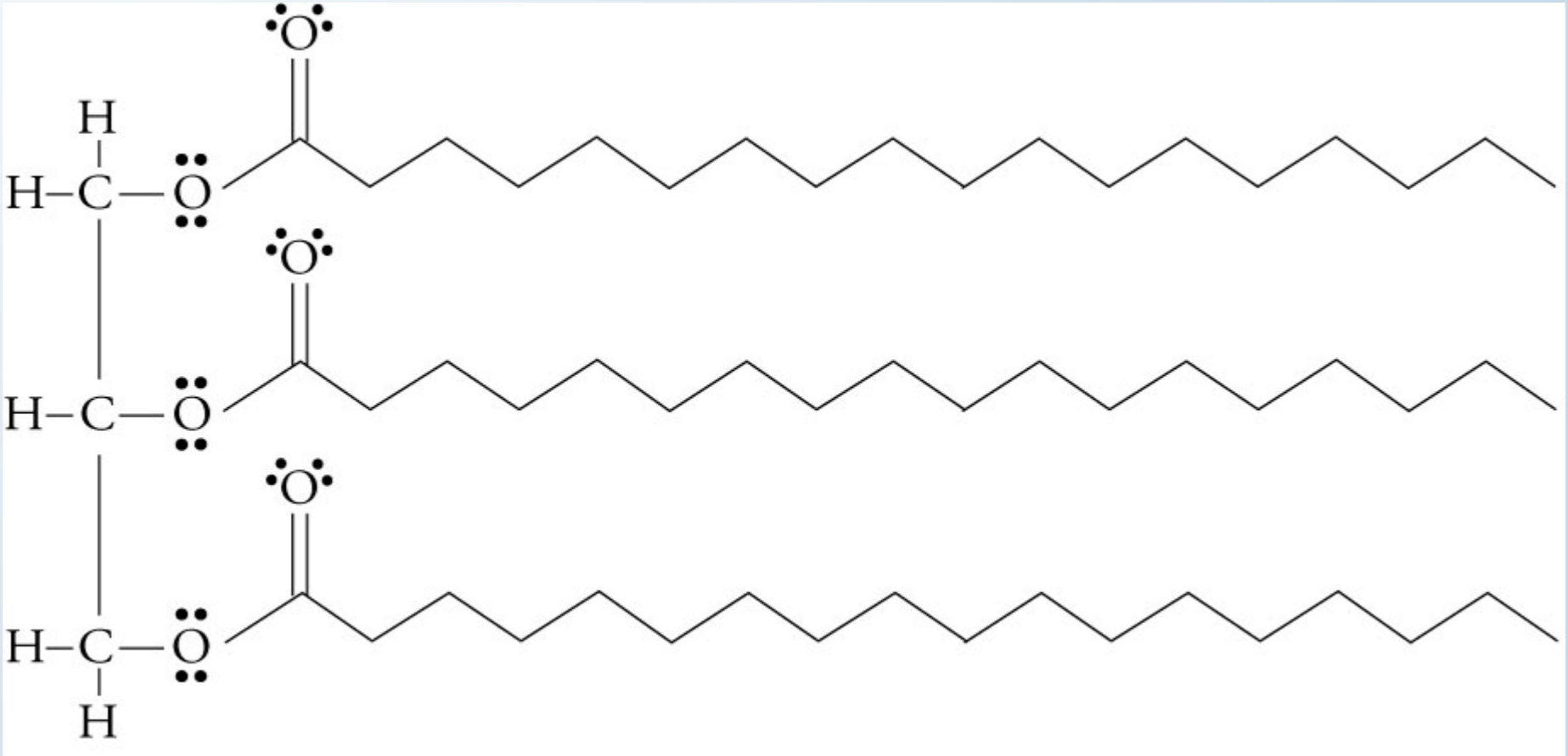


triglyceride

Saturated Triglyceride - Tristearin

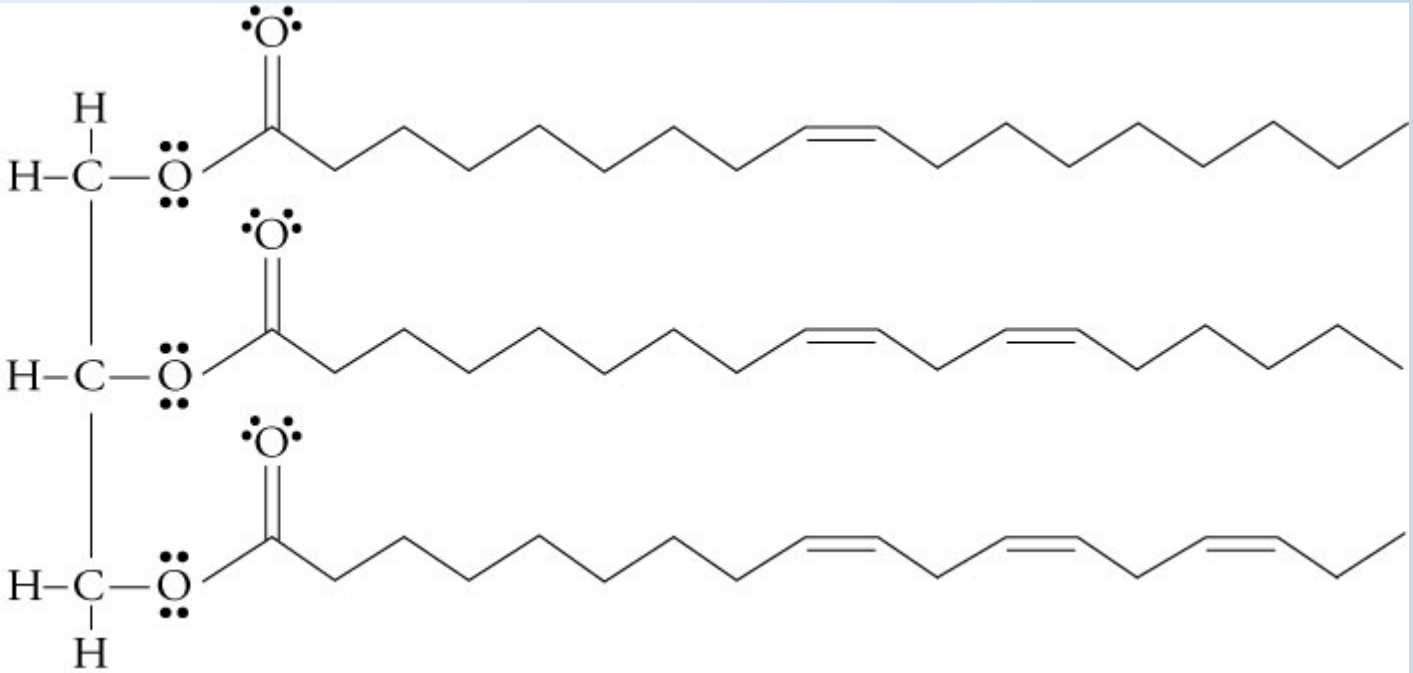


Tristearin – Line Drawing



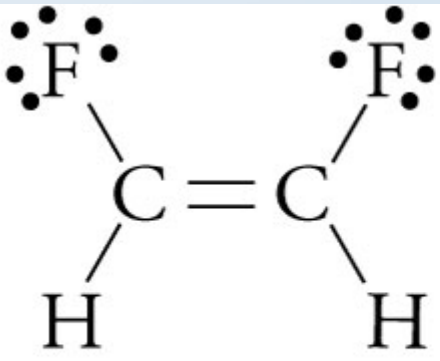
Unsaturated Triglyceride

Liquid triglycerides are rich in carbon-carbon double bonds.

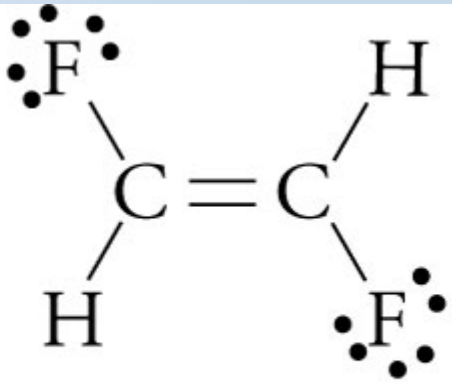


Cis and Trans

- When there is a double bond between two carbons and when like groups are on different carbons and the same side of the double bond the arrangement is called ***cis***.
- When the like groups are on opposite sides of the double bond the arrangement is called ***trans***.

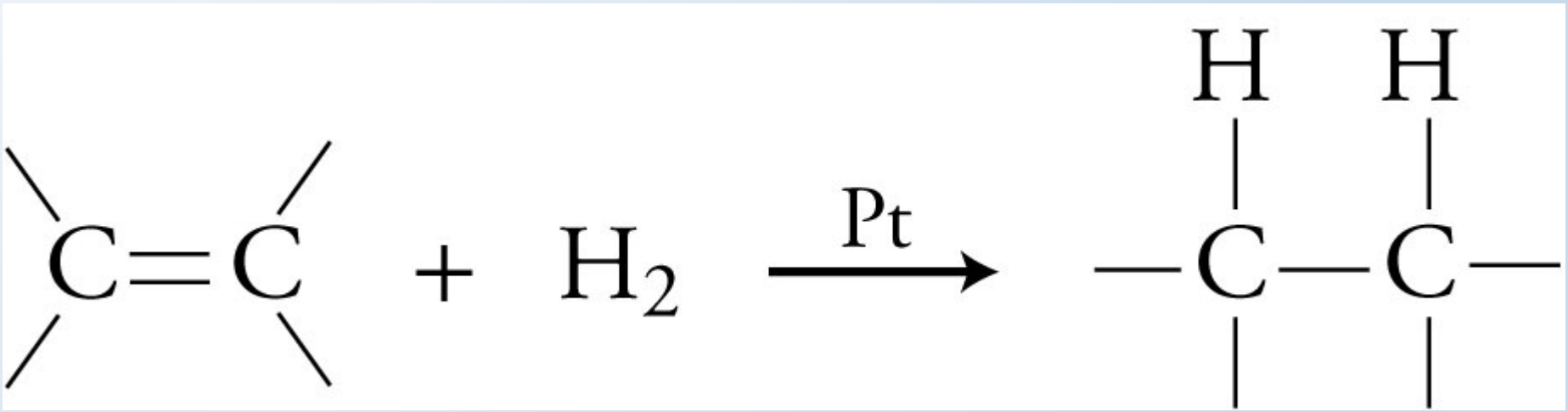


cis-1,2-difluoroethene

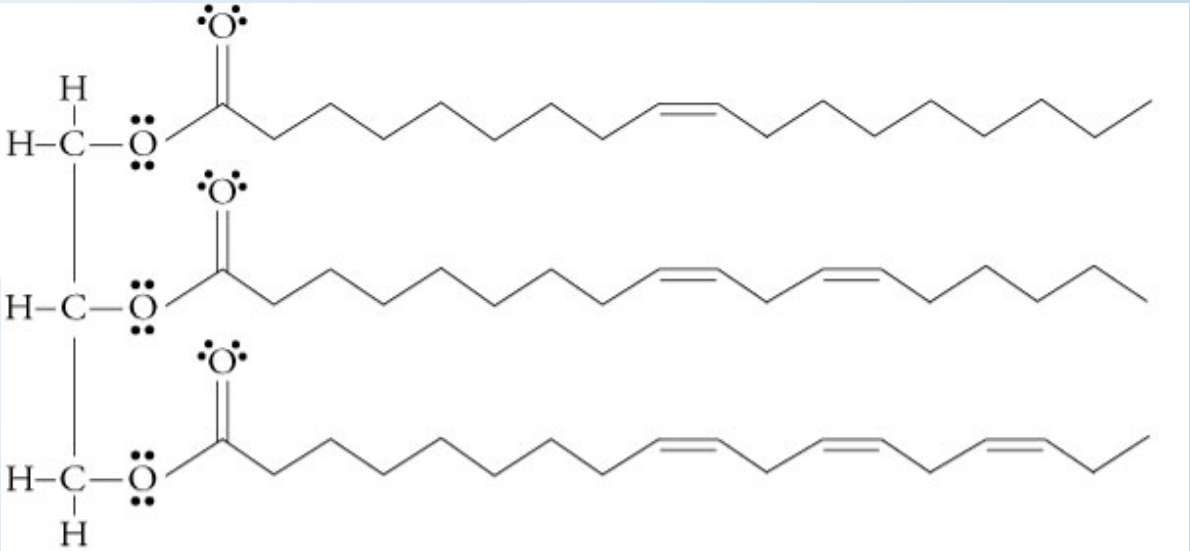


trans-1,2-difluoroethene

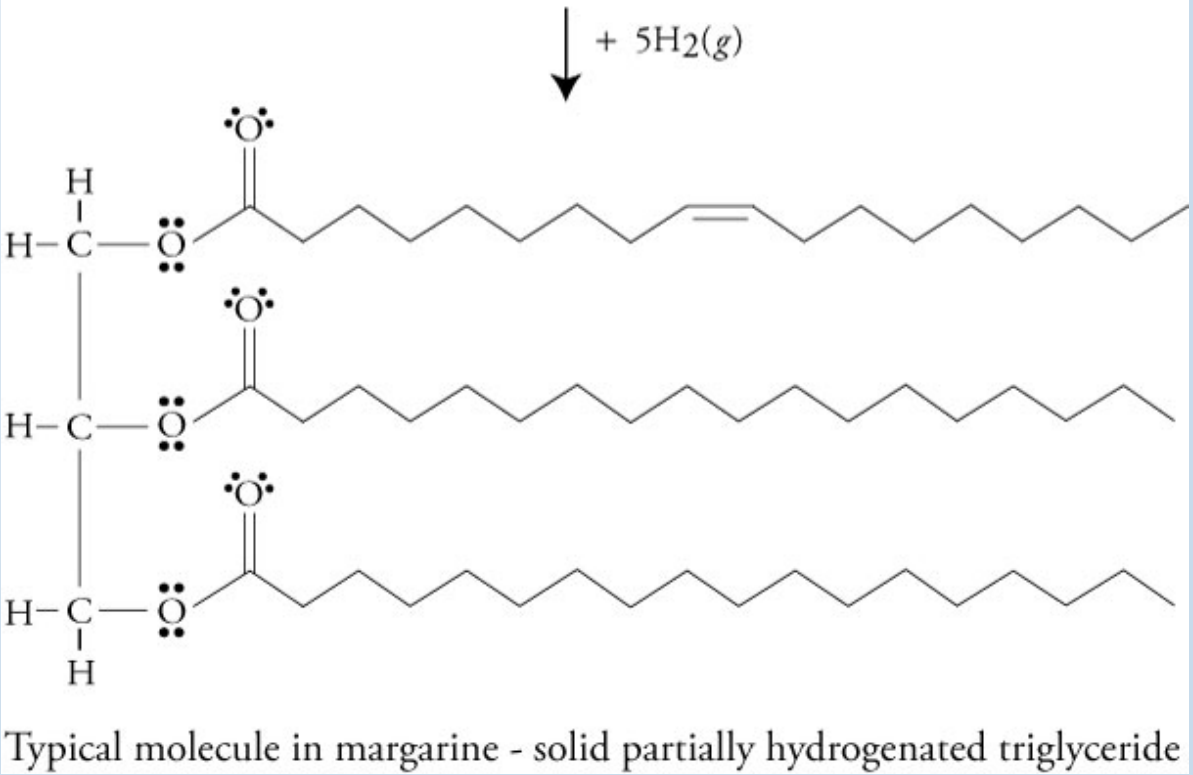
Hydrogenation



Hydrogenation - Example



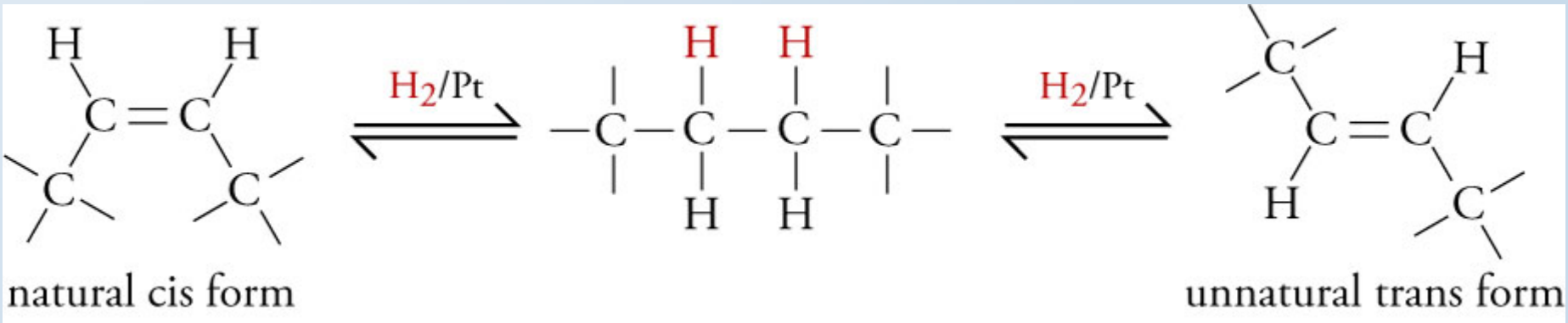
Typical vegetable oil molecule - liquid unsaturated triglyceride



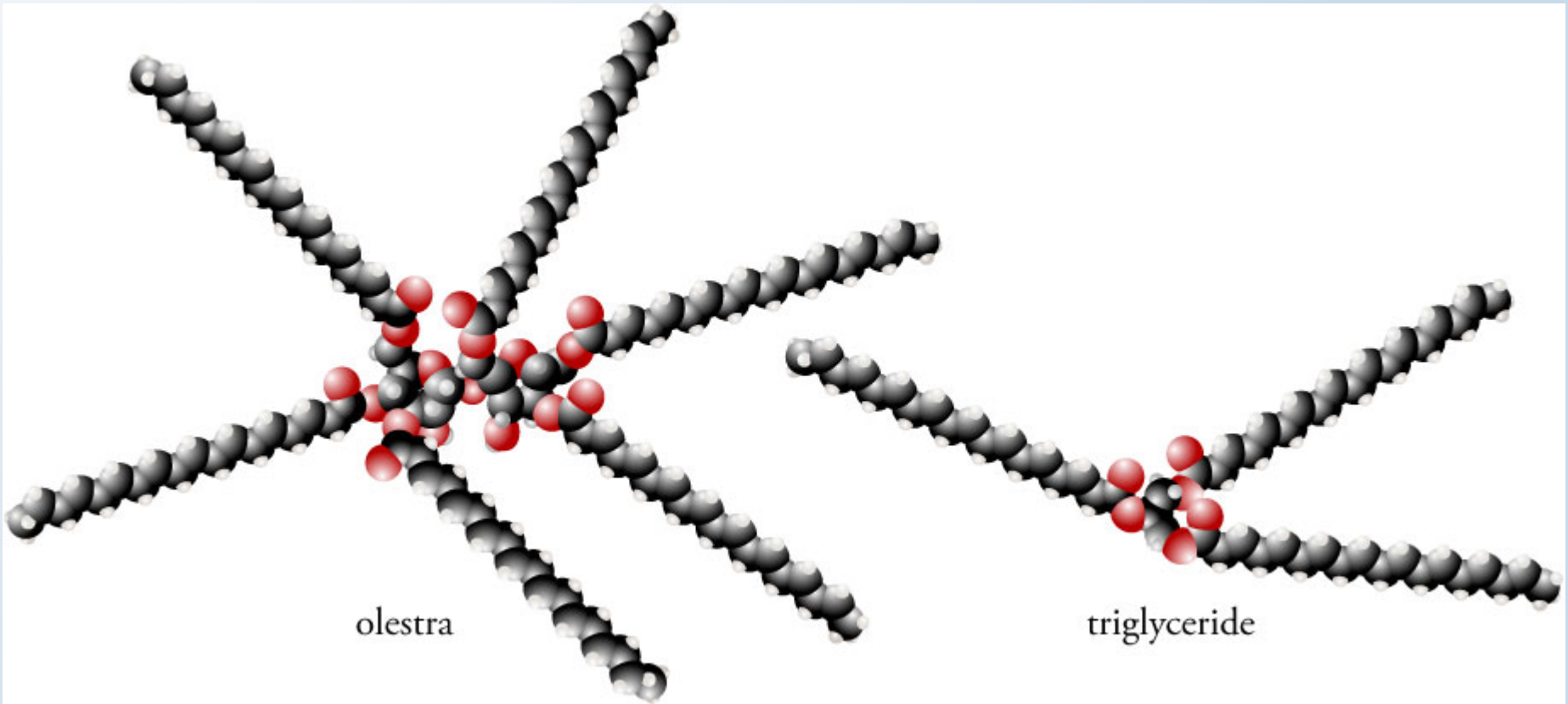
Typical molecule in margarine - solid partially hydrogenated triglyceride

Trans Fats

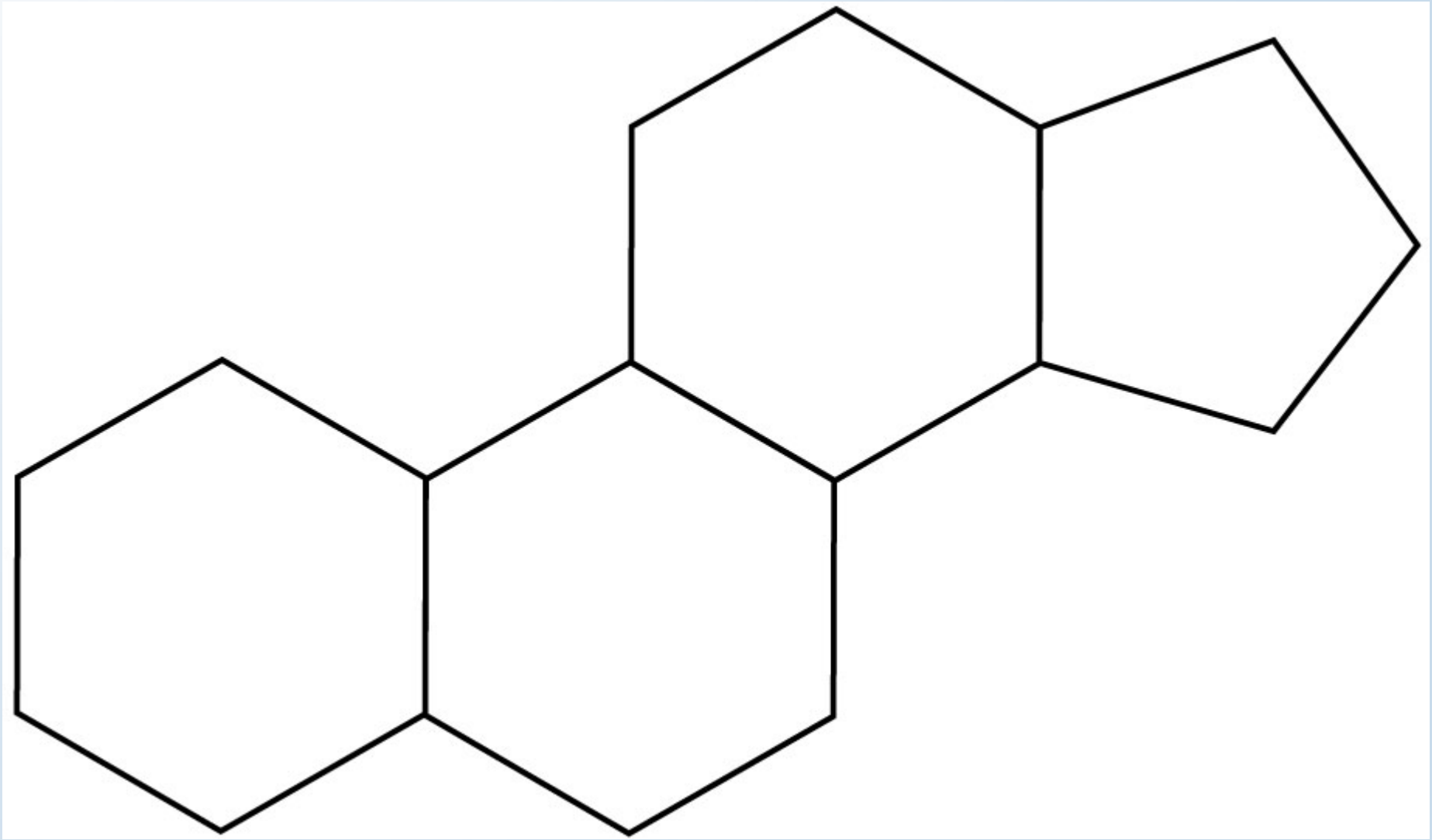
- Hydrogenation is reversible.
- When the double bond is reformed, it is more likely to form the more stable trans form than the less stable cis form.
- Therefore, partial hydrogenated vegetable oils contain trans fats, which are considered to be damaging to your health.



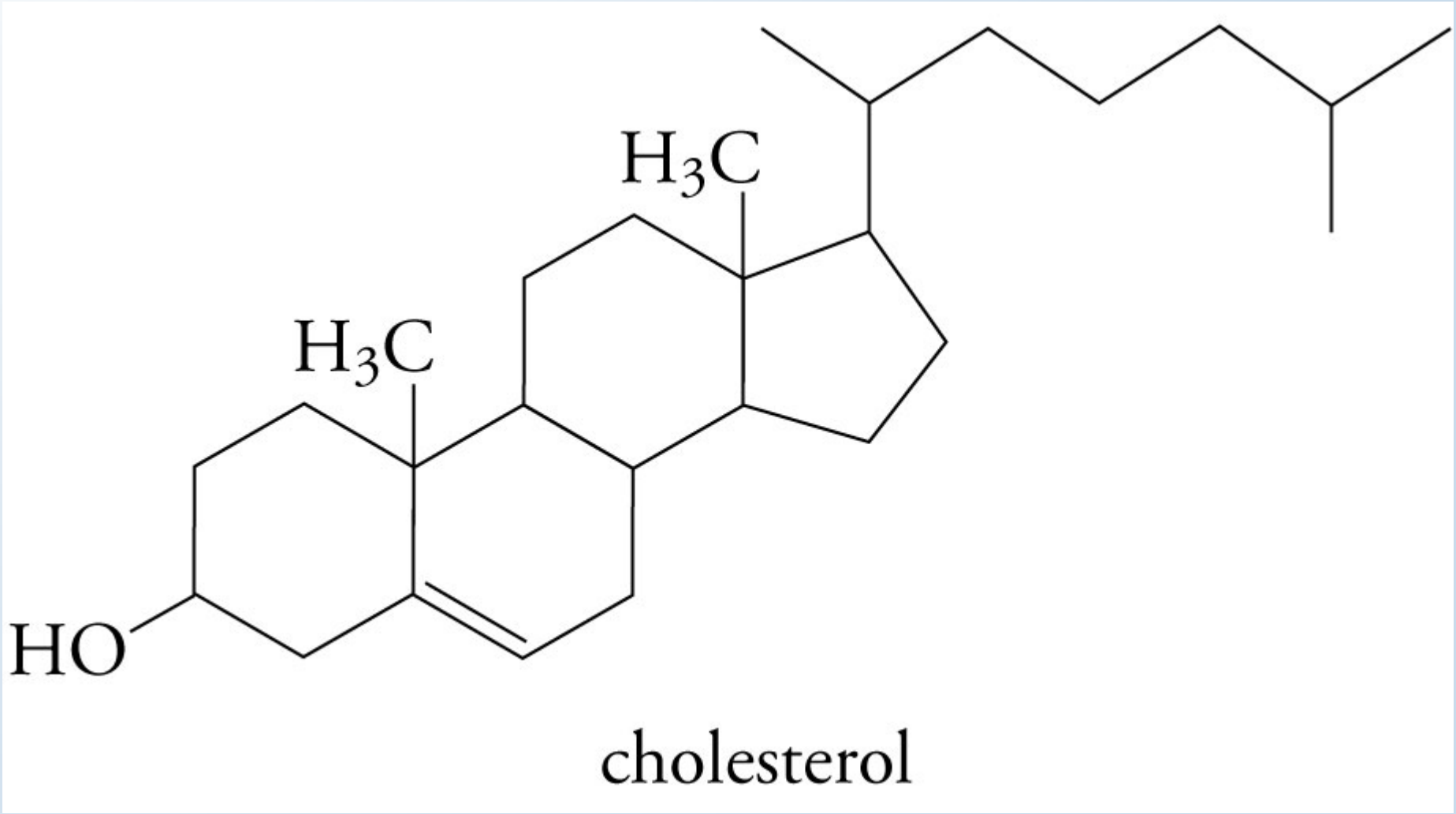
Olestra - a Fat Substitute



Steroid Skeleton

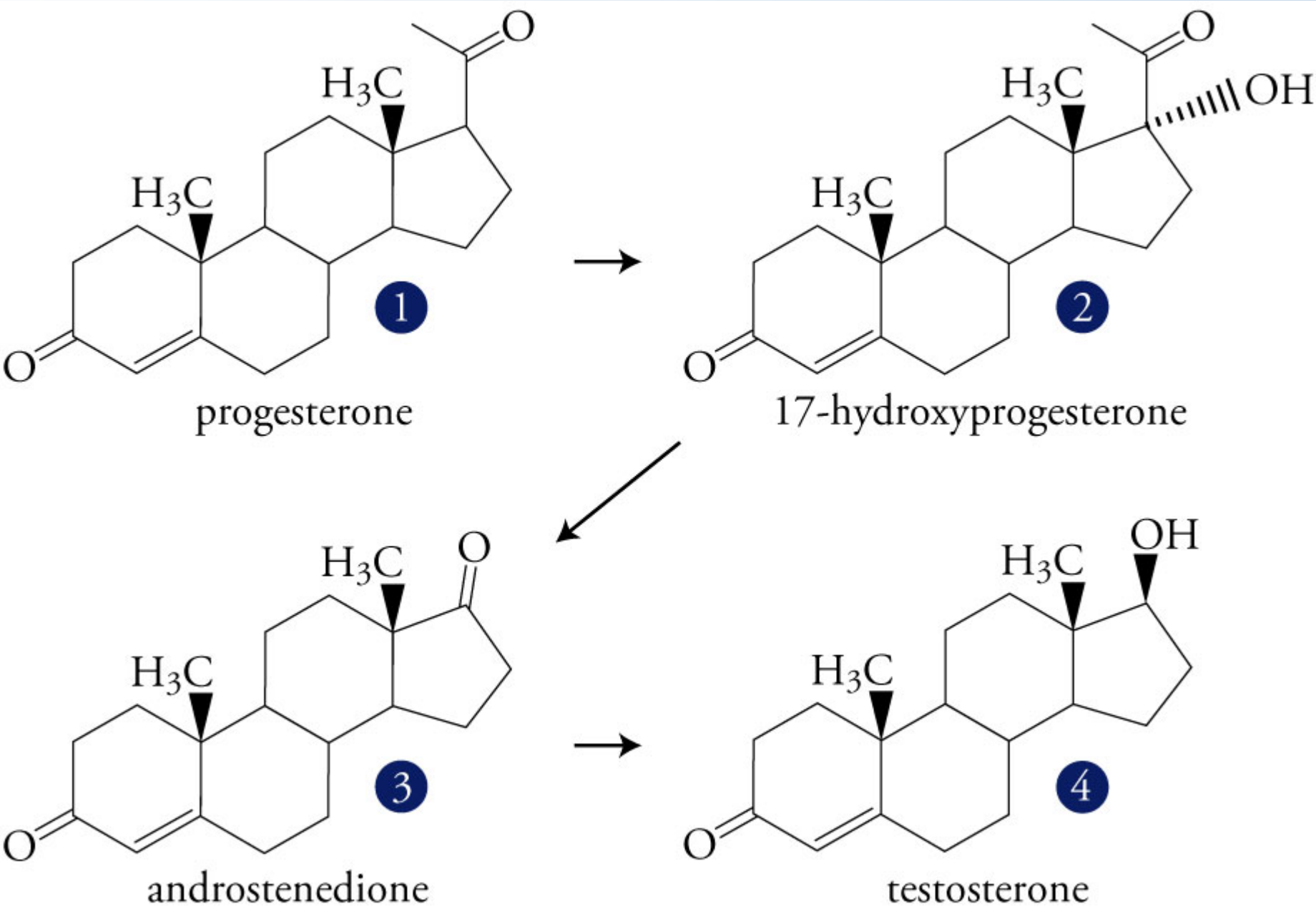


Cholesterol

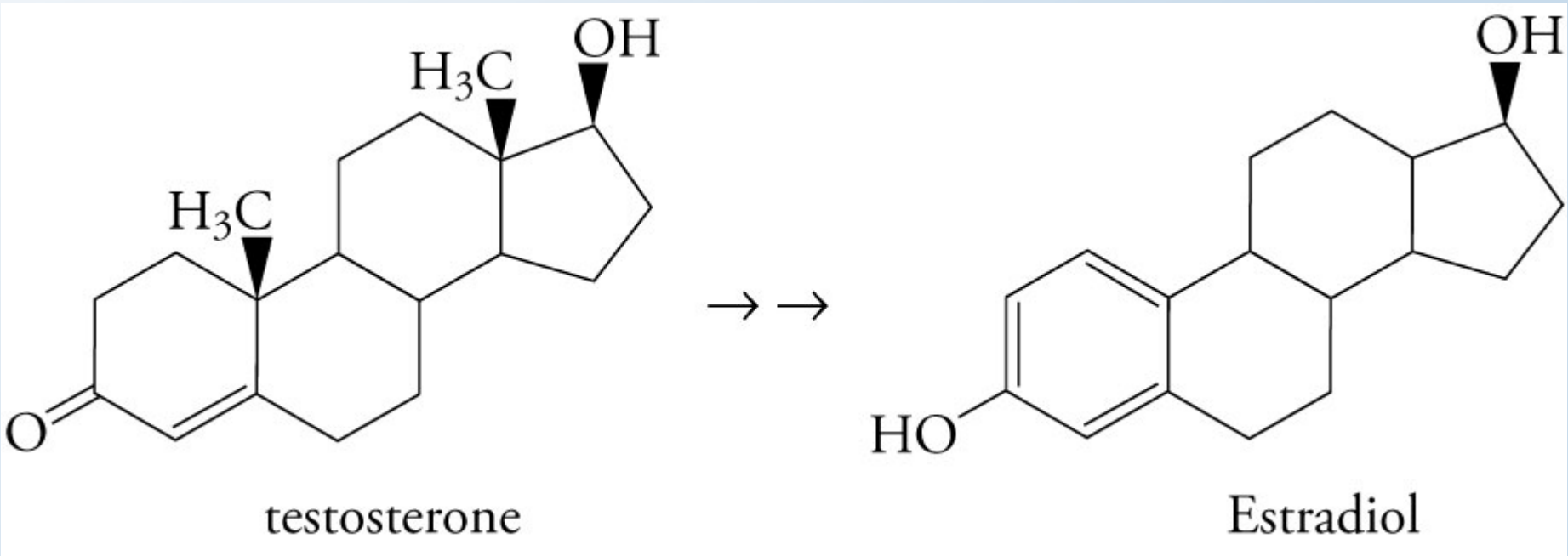


cholesterol

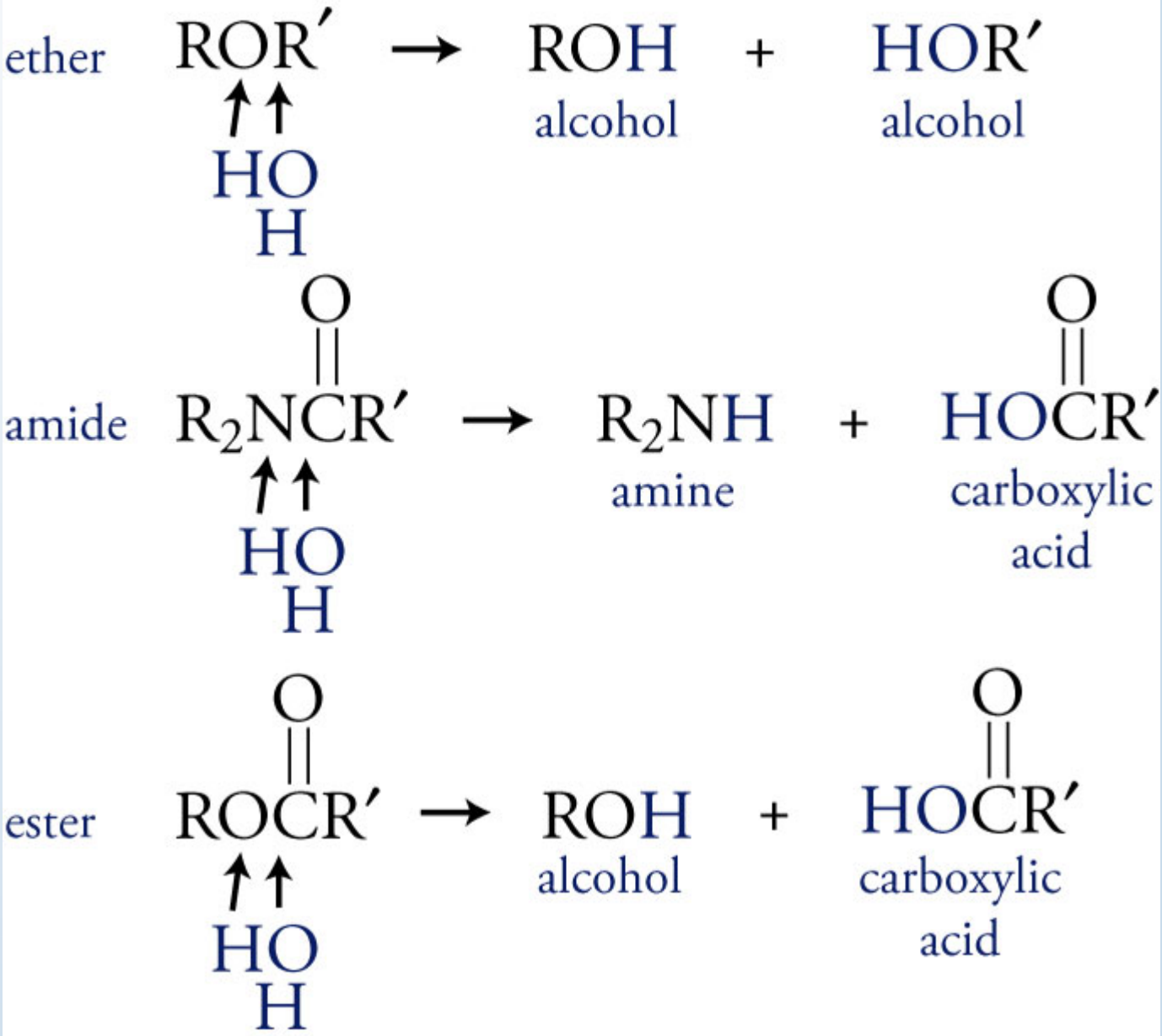
Testosterone Formation



Estradiol



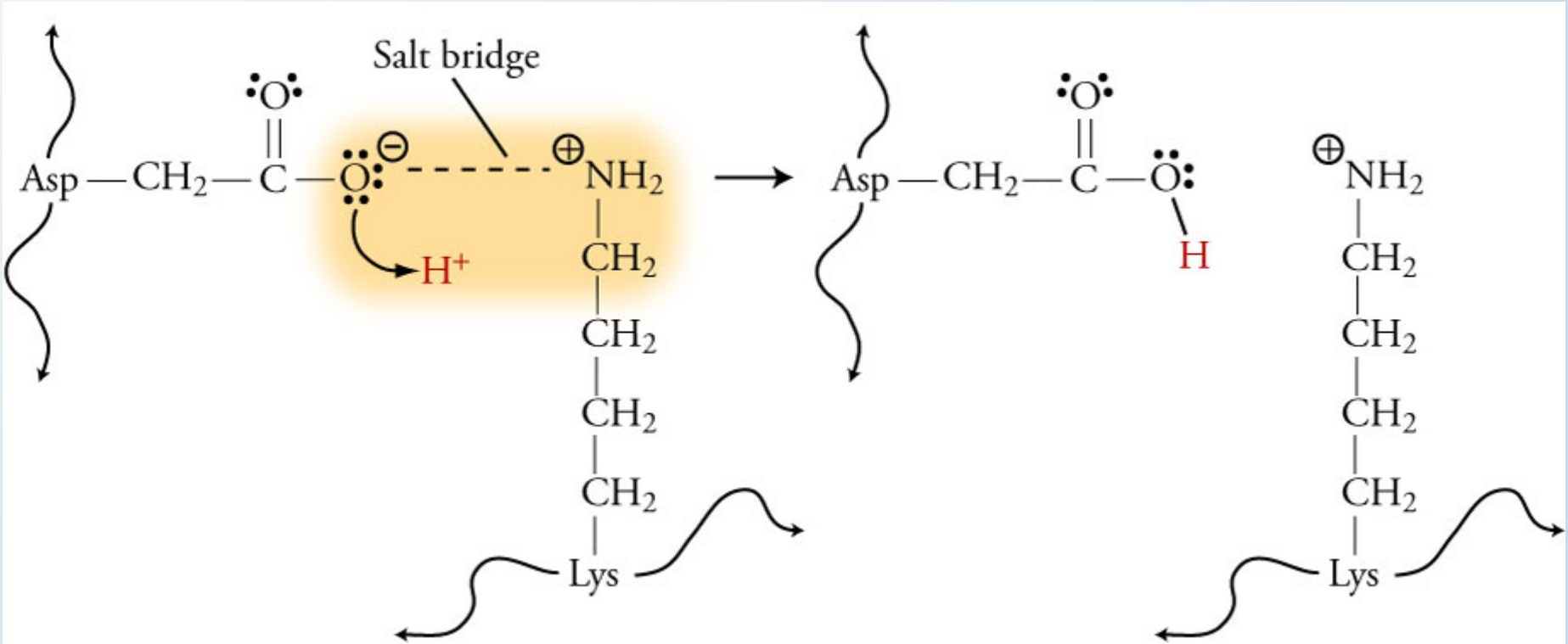
Hydrolysis Reactions



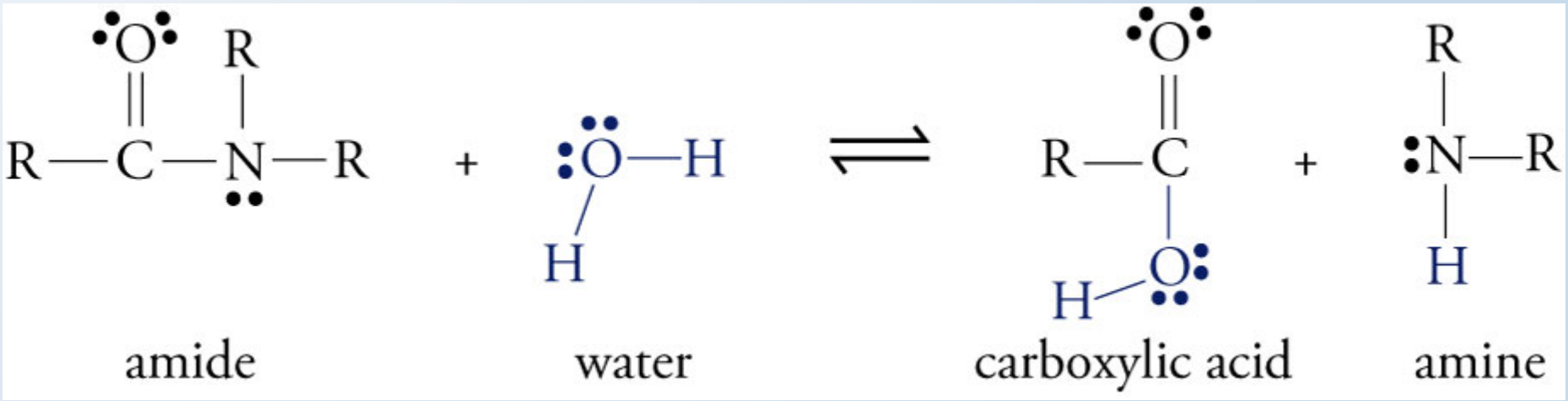
Digestion Products

Substance in Food	Products of Digestion
disaccharides	monosaccharides
polysaccharides	glucose
protein	amino acids
Triglycerides (fats and oils)	glycerol and fatty acids

Disruption of Salt Bridge

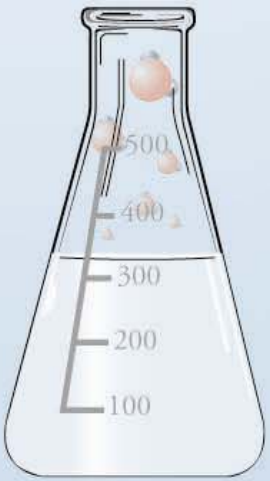


Amide Hydrolysis



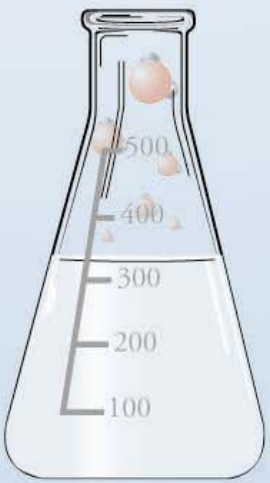
Enzymes

- Enzymes are naturally occurring catalysts. ***Catalysts*** speed chemical changes without being permanently altered themselves.
- The chemicals that they act on are called ***substrates***.
- Very specific due to
  - Shape – “Lock and Key”
  - Positions of binding groups, which attract substrates to the active site, the portion of the enzyme where the reaction occurs.
  - Positions of the catalytic groups that speed the reaction.

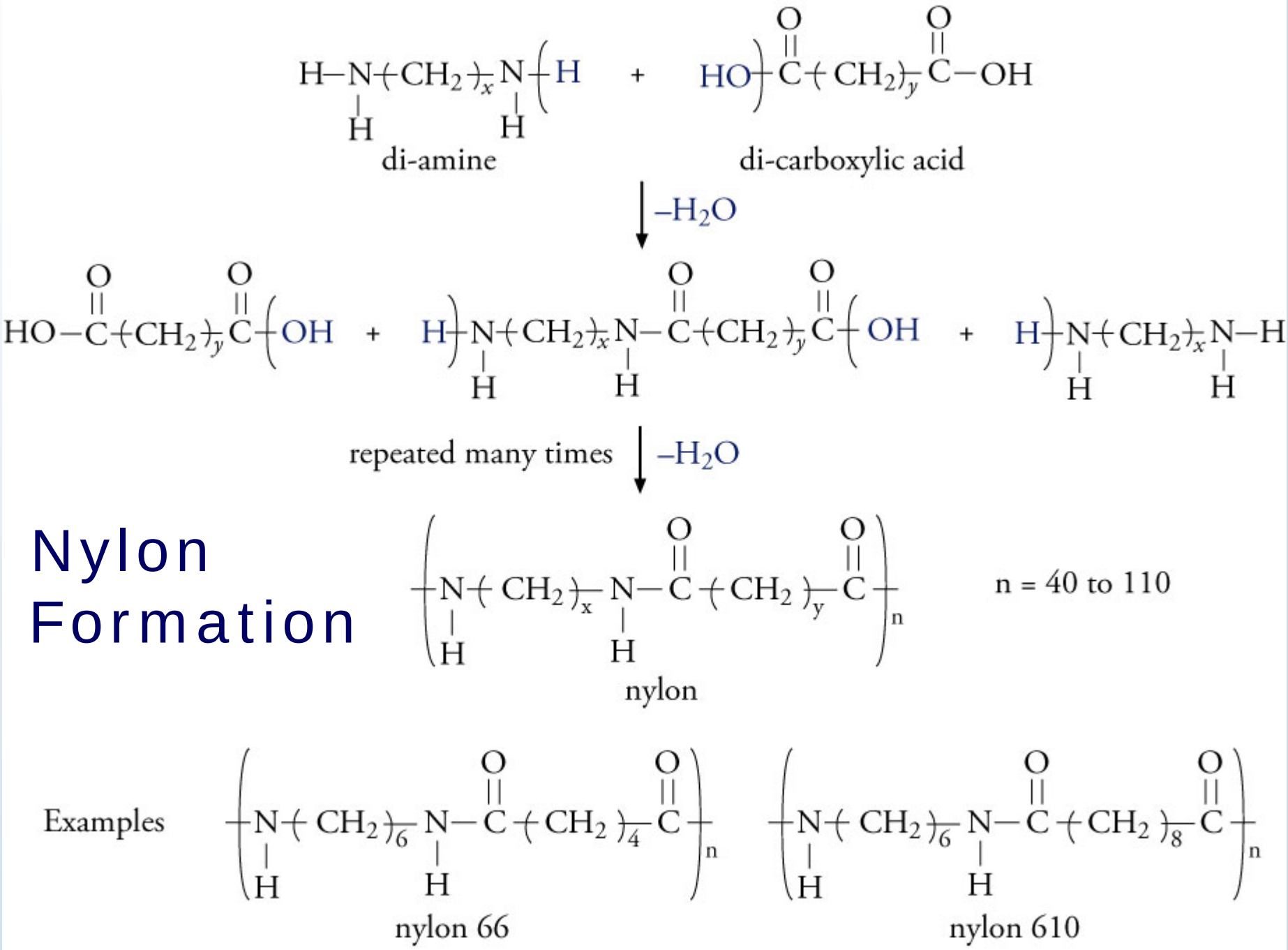


Enzymes Speed Chemical Reactions

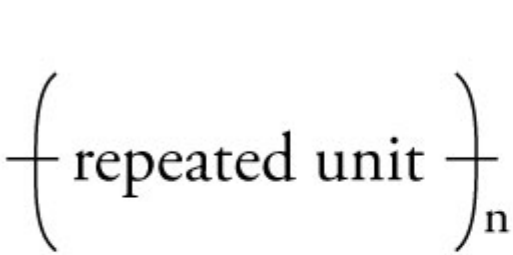
- Provide a different path to products that has more stable intermediates and therefore requires less energy.
- Give the correct orientation every time.



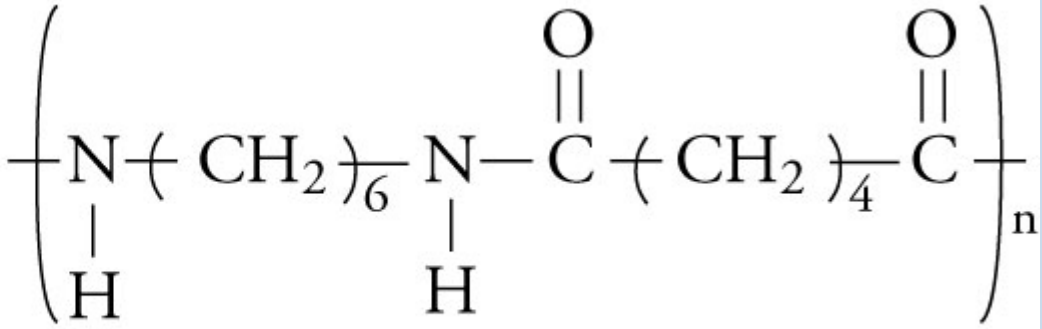
Nylon Formation



Nylon-66

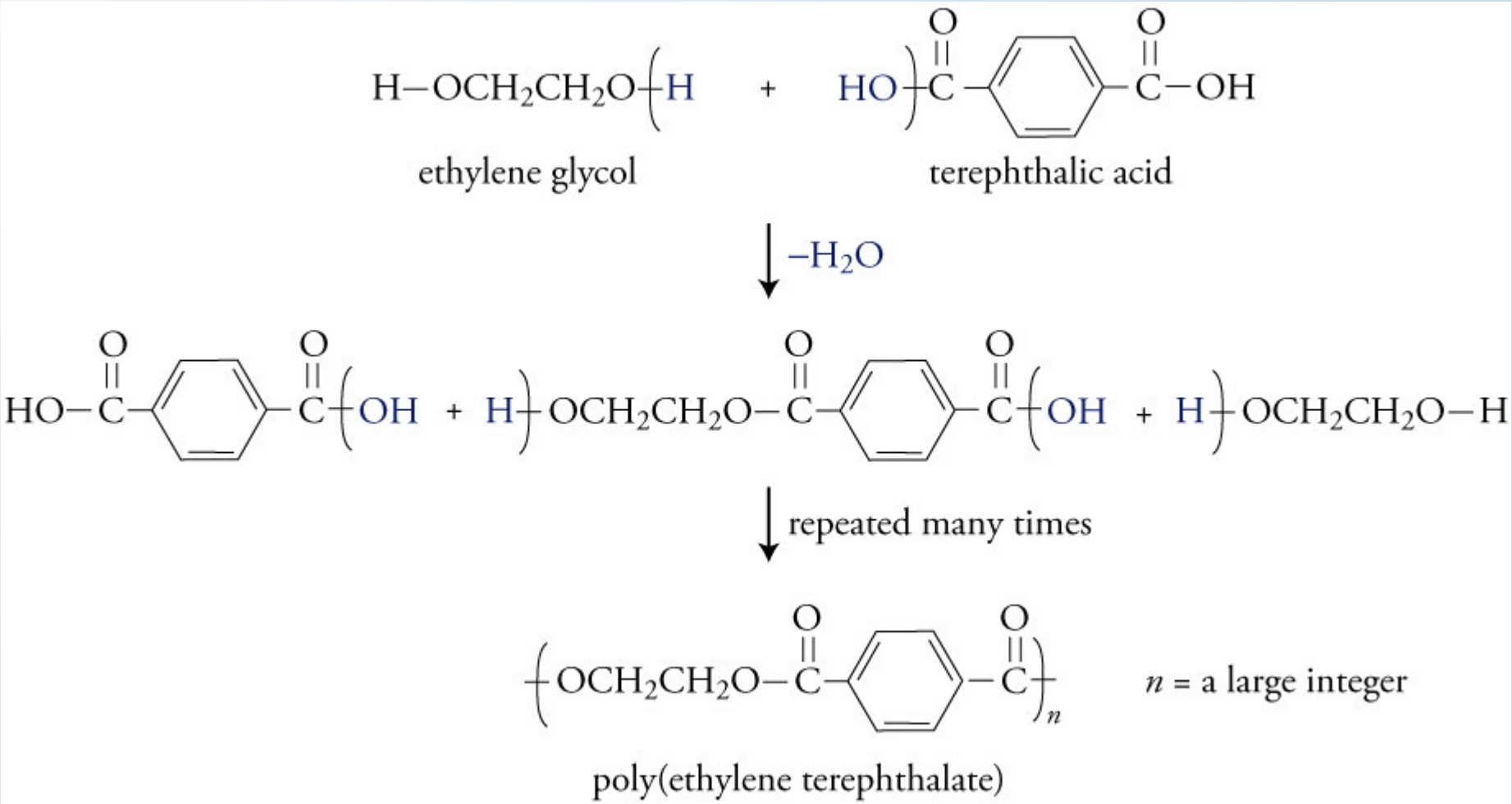


general polymer formula

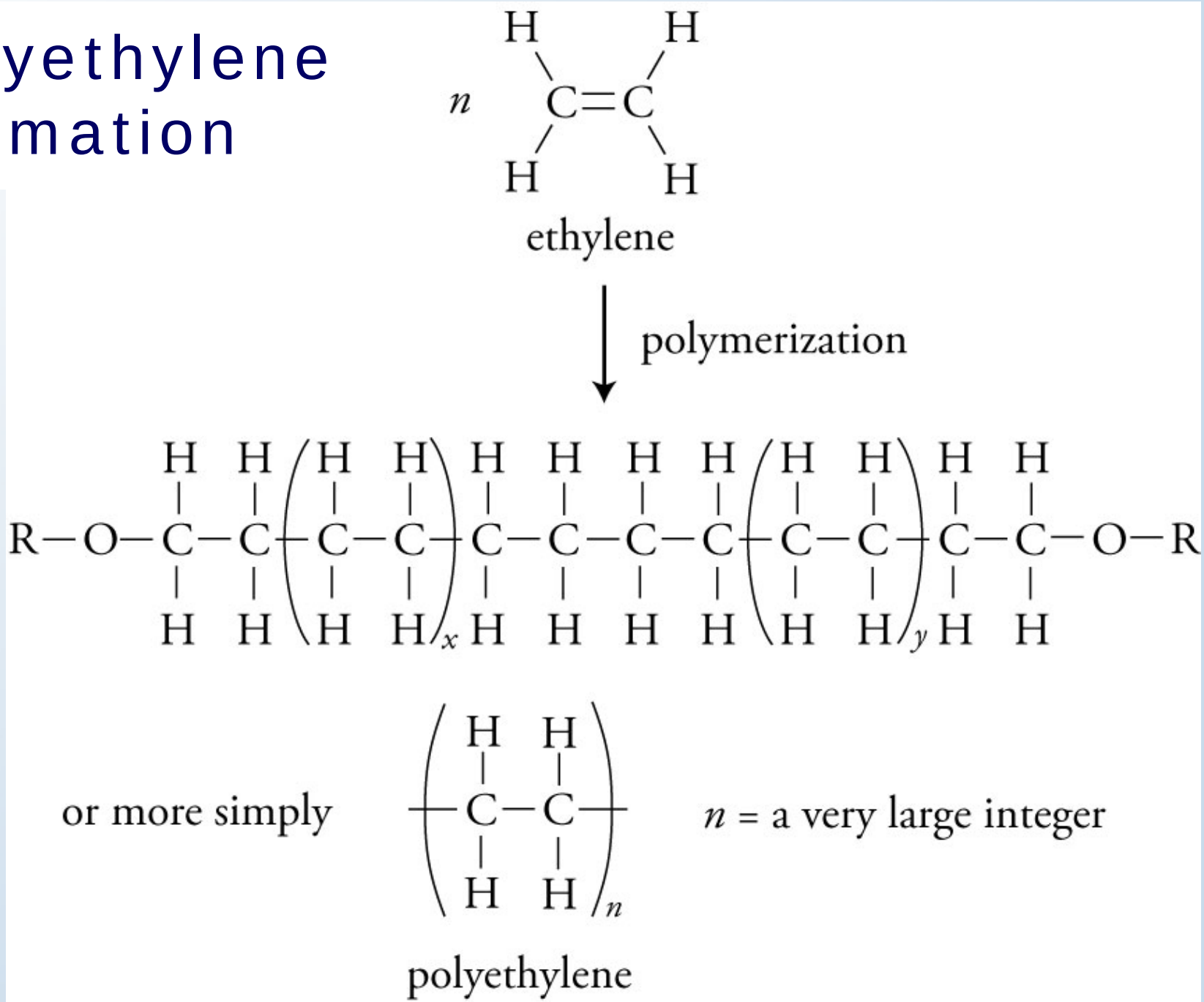


nylon 66

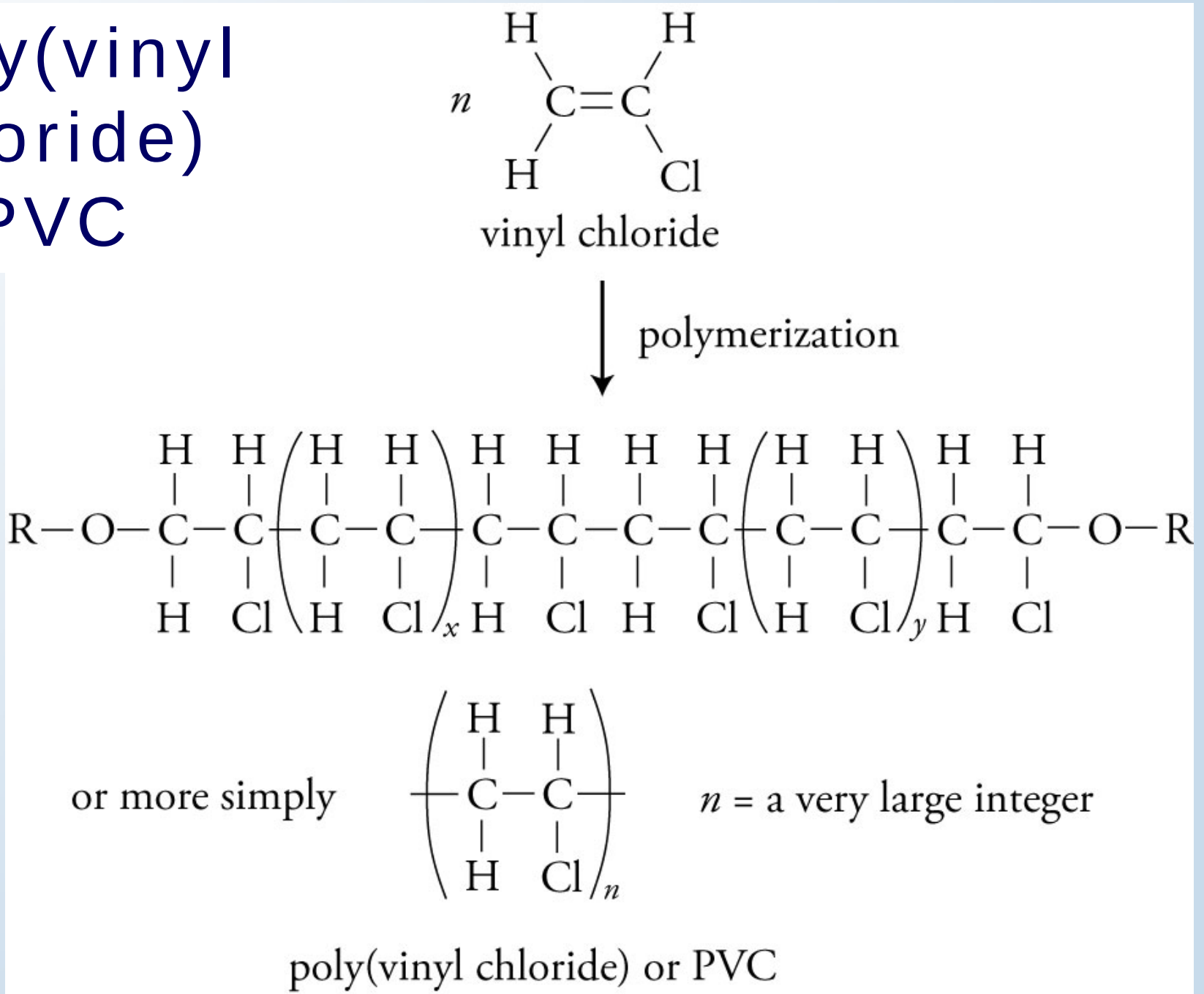
Polyester Formation



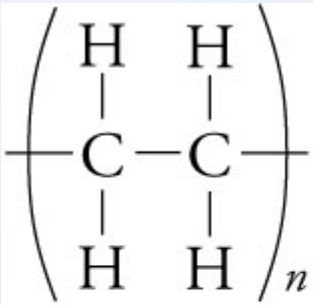
Polyethylene Formation



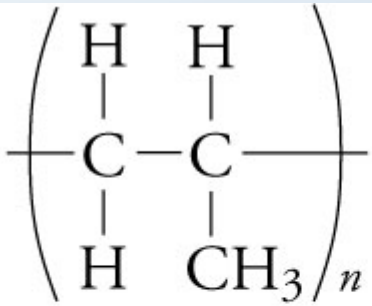
Poly(vinyl chloride) or PVC



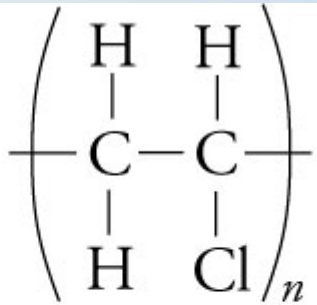
Addition Polymers



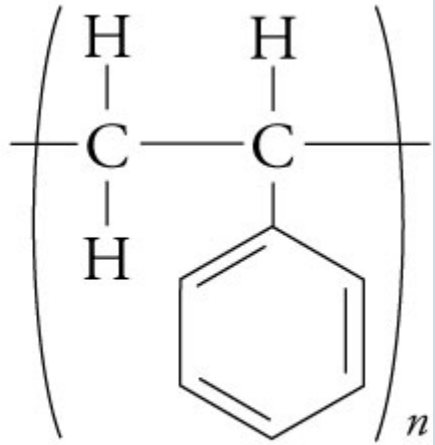
Polyethylene



Polypropylene

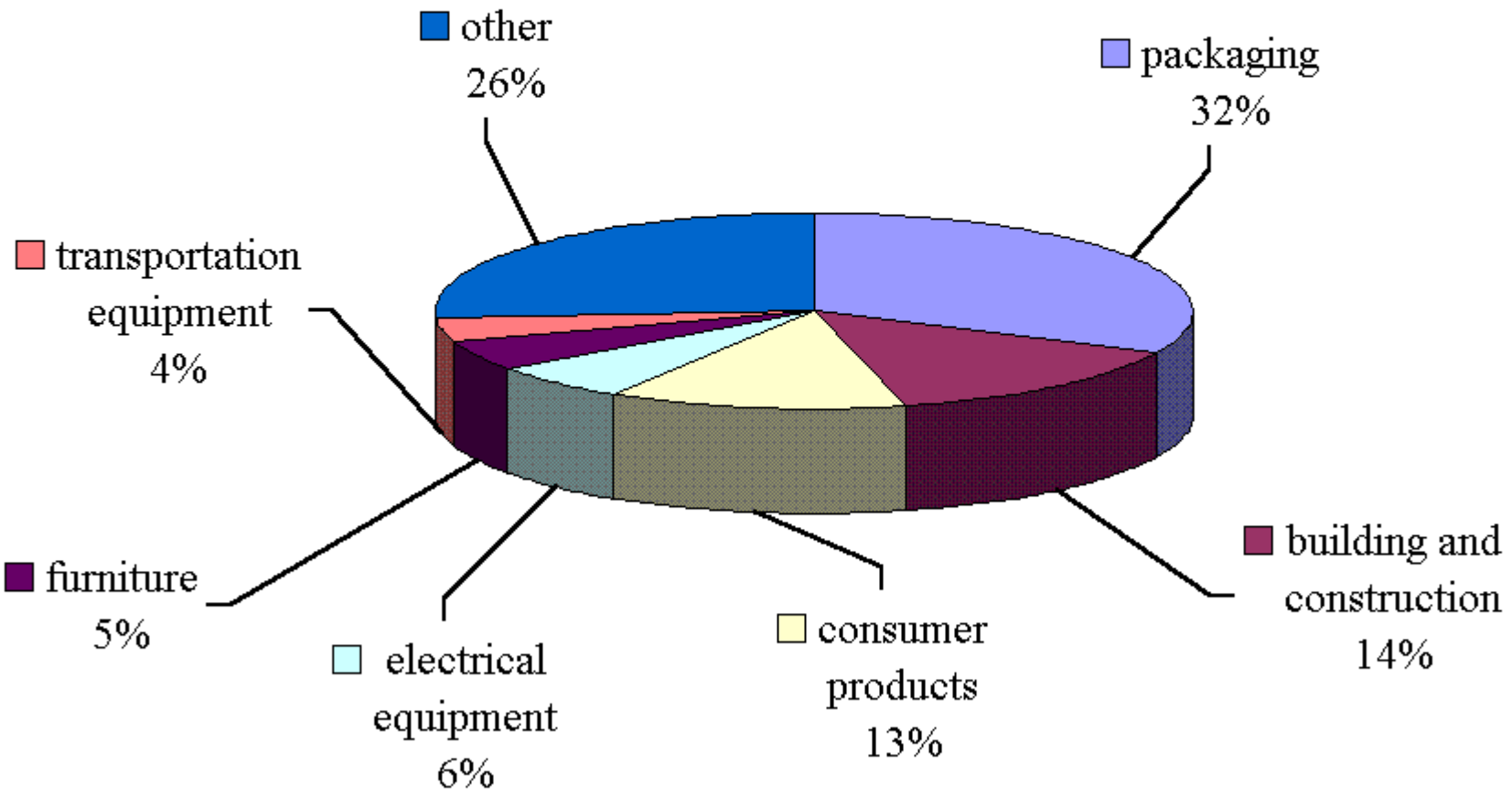


Poly(vinyl chloride)
or PVC

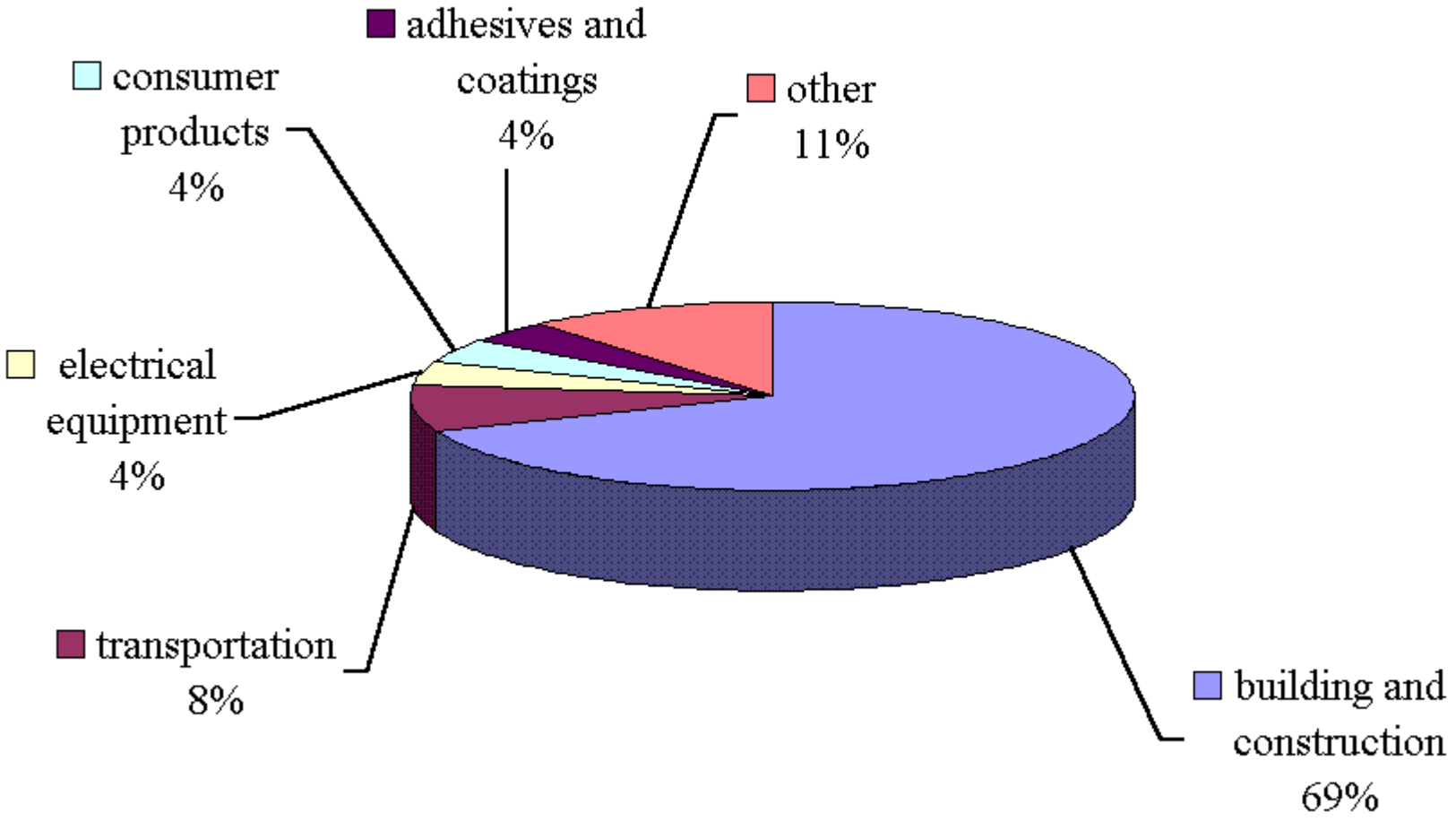


Polystyrene

Thermoplastics' Uses



Thermosets' Uses



Recycling Codes