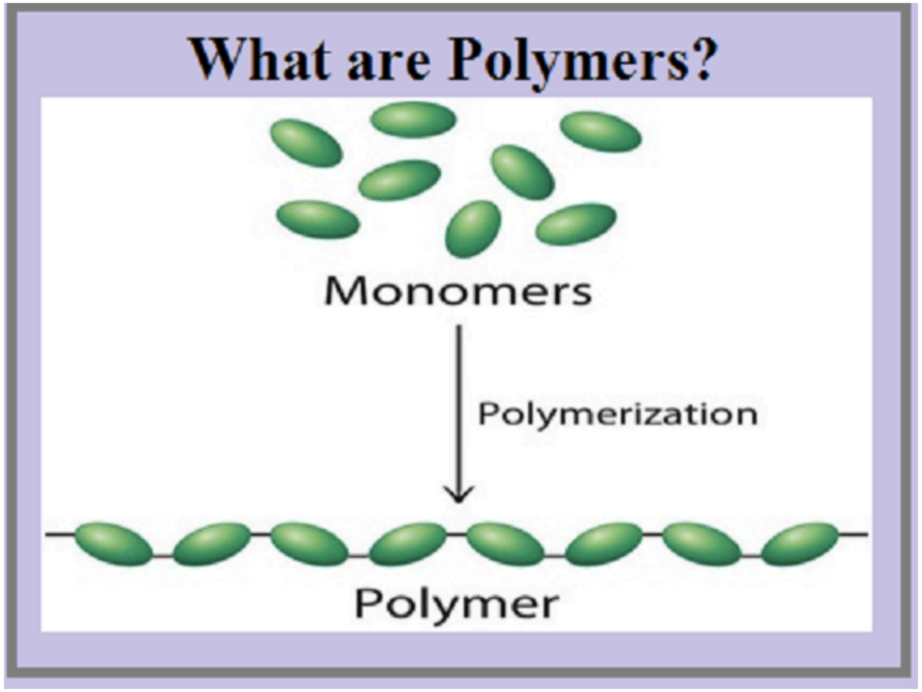
Polymers! [Ted Ed Polymers]

I. Synthesis and Hydrolysis of Polymers

- The most important biological compounds are polymers
- Poly means "many"



Polymers

1. **Many piece chain of subunits (monomers)**
2. **Subunits are**
   a. **MONOSACCHARIDES (SIMPLE SUGARS)**

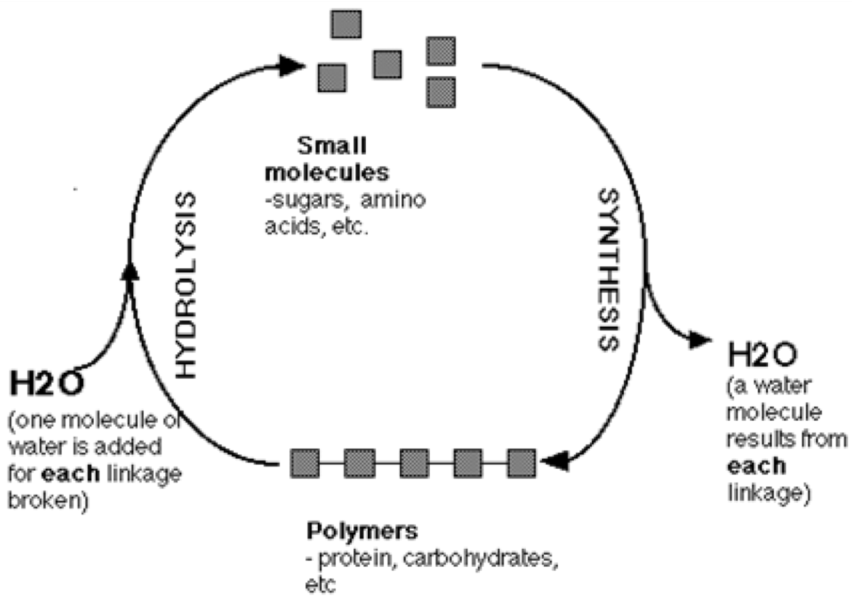
   b. **AMINO ACIDS**

   c. **NUCLEOTIDES**

   d. **FATTY ACIDS**

Polymers are:

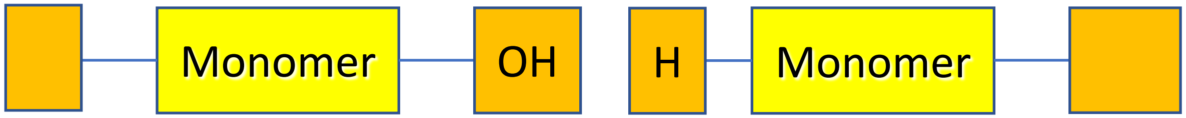
- **made (DEHYDRATION SYNTHESIS) or broken down (HYDROLYSIS) over and over in living cells**



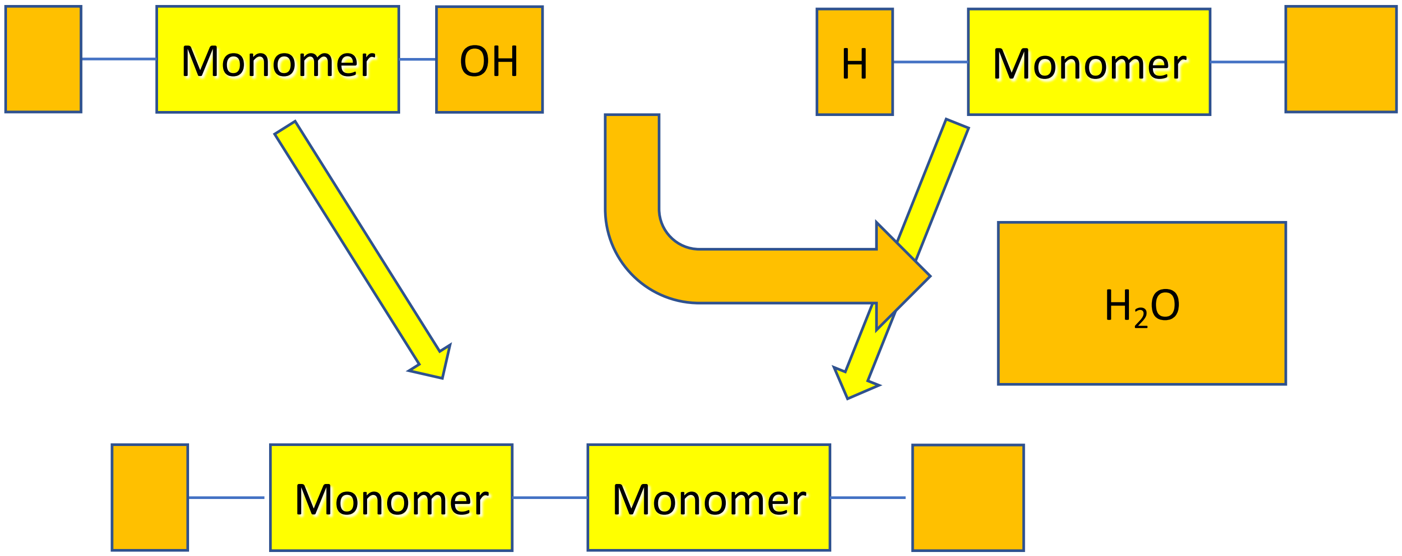
Cells have a common method of joining monomers together to make polymers

Background:

- Organic molecules contain Carbon (C) and hydrogen (H)
- Often organic molecule contain functional groups containing carboxyl (COOH) or hydroxyl groups (OH) or both.
- This is important because H and OH can be found hanging off monomers

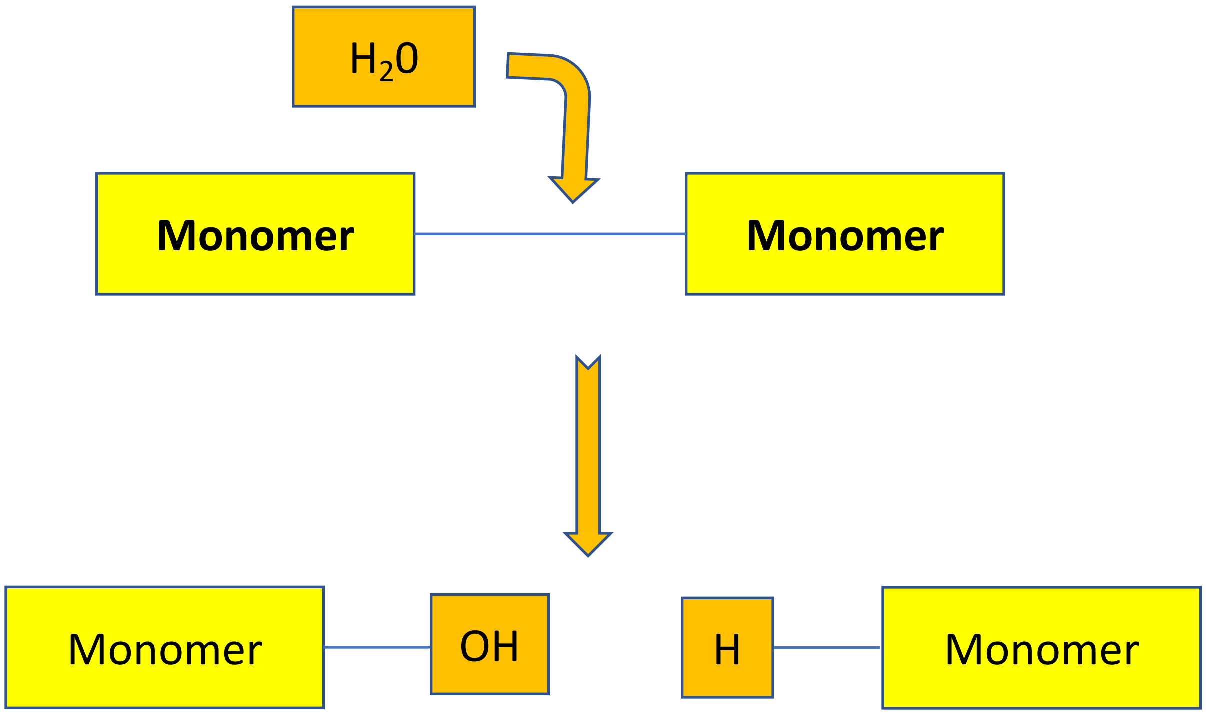


Dehydration Reaction



Synthesis occurs when subunits bond
Following the removal of H_20

Hydrolysis Reaction



Degradation or hydrolysis occurs when subunits in a Macromolecule separate after the addition of H_20

II. Types of Polymers

A. PROTEINS: Polymers of AMINO ACIDS

B. NUCLEIC ACIDS (DNA, RNA): Polymers of NUCLEOTIDES

C. CARBOHYDRATES: Polymers of MONOSACCHARIDES

D. LIPIDS: Polymers of FATTY ACIDS and GLYCEROL

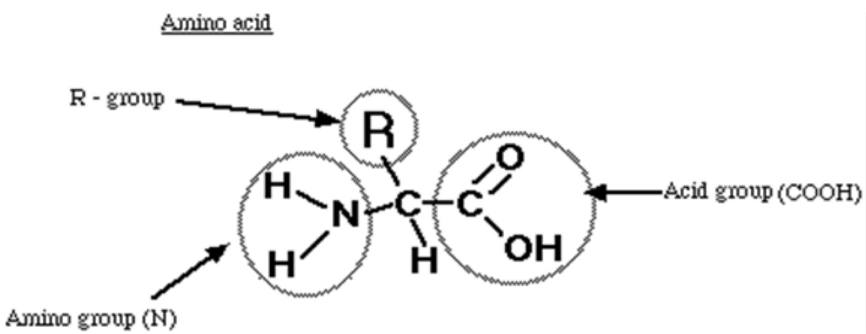
Amino Acids

I. <u>Amino Acids</u>

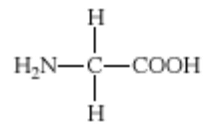
- Proteins are chains of amino acids

Amino acid basic structure consists of:

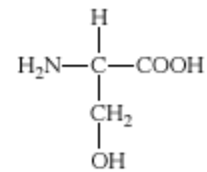
- Amino group (N)
- Acid Group (COOH)
- R- group (Remainder which individualizes the amino acid)



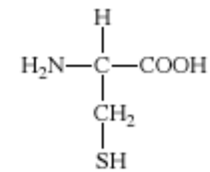
- The R group can vary from a single hydrogen atom (H) to a complicated ring structure



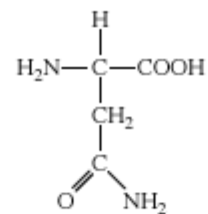
glycine
(Gly, G)



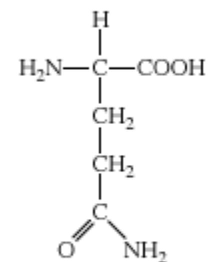
serine
(Ser, S)



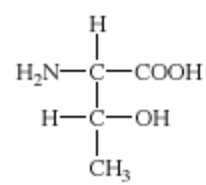
cysteine
(CysH, C)



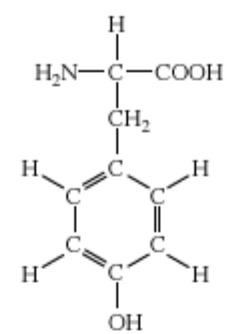
asparagine
($AspNH_2$ or Asn, N; Asx or B)



glutamine
($GluNH_2$, GluN, or Gln, Q; Glx or Z)



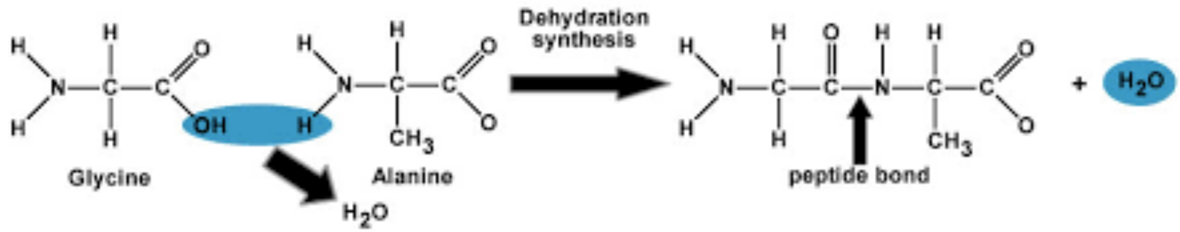
threonine
(Thr, T)



tyrosine
(Tyr, Y)

- **Peptide Bond:**
  - The bond linking two amino acids forms a dipeptide
  - One water molecule is given off in dehydration synthesis to form this bond.

- H_2O is removed - bond between NITROGEN and CARBON forms a peptide bond



- **TWO amino acids linked together – DIPEPTIDE**

- **THREE amino acids linked together –TRIPEPTIDE**

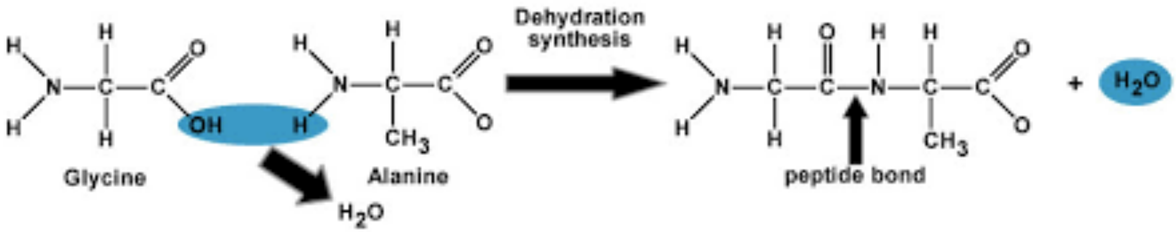
- **Many amino acids linked together – POLYPEPTIDE (30 to 30,000 amino acids)**

II. Levels of Protein Organization:

Primary, Secondary, Tertiary and Quaternary Structure

A.PRIMARY structure

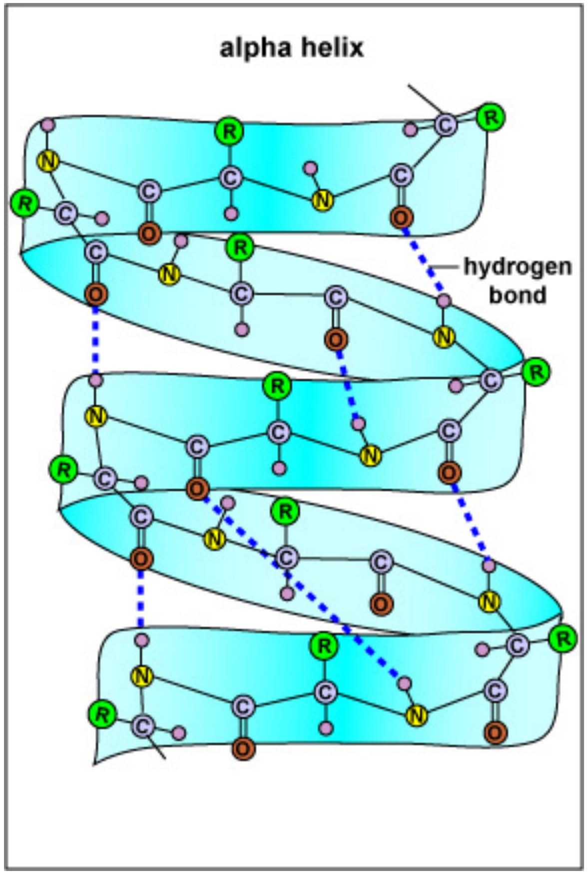
1. POLYPEPTIDE chain
2. AMINO ACIDS linked together



B. Secondary Structure

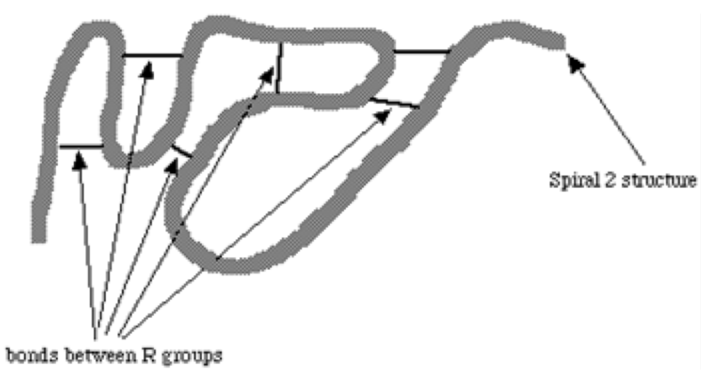
1. HYDROGEN BONDS form between the HYDROGEN on the amino group and the OXYGEN in the acid group of close amino acids to twist the first structure into an ALPHA HELIX

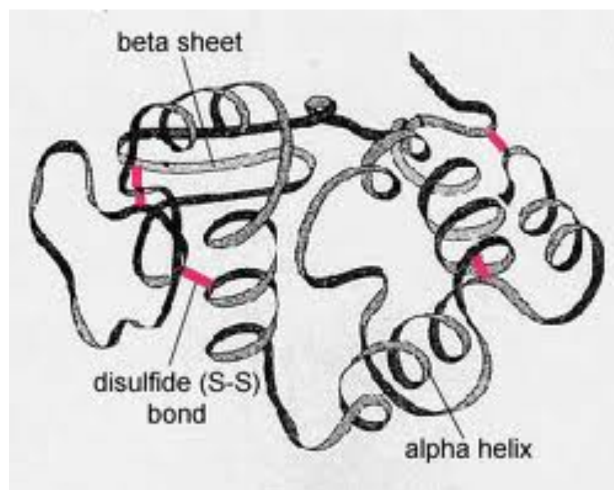
2. Coiling is due to hydrogen bonds



C. Tertiary Structure

- The spiral strand folds into a specific shape, due to the various kinds of bonds between R-groups
- This gives the protein its three dimensional shape (conformation)





Quaternary Structure

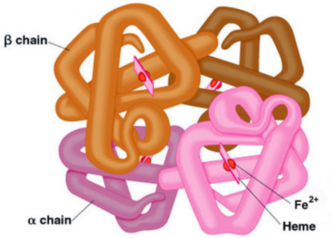
1. Some proteins (fairly often) are actually MACROMOLECULES of tertiary polypeptides joined to form a functional protein

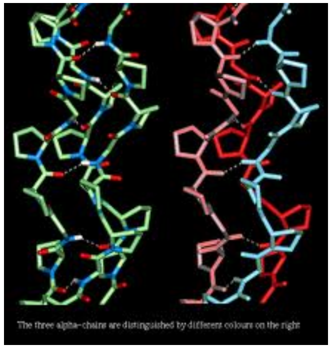
2. Examples:

HEMOGLOBIN – 4 subunits (2 alpha chains, 2 beta chains)

COLLAGEN - 3 helical subunits coiled together

Animation





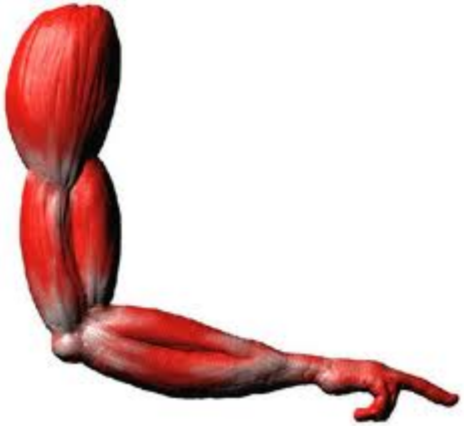
E. DENATURATION

1. **Loss of protein's tertiary structure by breaking 'R' group bonds**
2. **Protein LOSES shape and function, becoming DENATURED**
3. **Caused by:**
   a. **TEMPERATURE ANIMATION addendum: TED-Ed: Unboil**
   b. **pH CHANGE**
   c. **HEAVY METALS (ie. Lead, Mercury)**
4. **Example:**

   HEATING an egg white

   Adding VINEGAR to milk

III. Functions of Proteins



A. Polymers of AMINO ACIDS

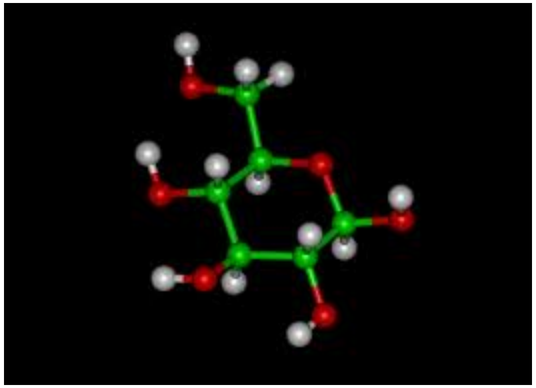
B. Have 3 major functions

1. STRUCTURE & MOVEMENT
   a. KERATIN -- hair, nails
   b. COLLAGEN-- cartilage, tendons
   c. Actin, myosin -- muscle tissue

2. METABOLISM
   a. ENZYMES
   b. Are CATALYSTS:
   c. SPEED UP CHEMICAL REACTIONS and allow to happen at a lower temperature
   d. Therefore CRITICAL to all cell activity

3. ANTIBODIES and HORMONES

Carbohydrates



- Empirical Formula: $(CH_2O)_n$
- A repeating chain of sugars (saccharides)
- Polysaccharides – Many saccharides linked together
- To break the bond between two sugars, an H_20 is added back (hydrolysis)

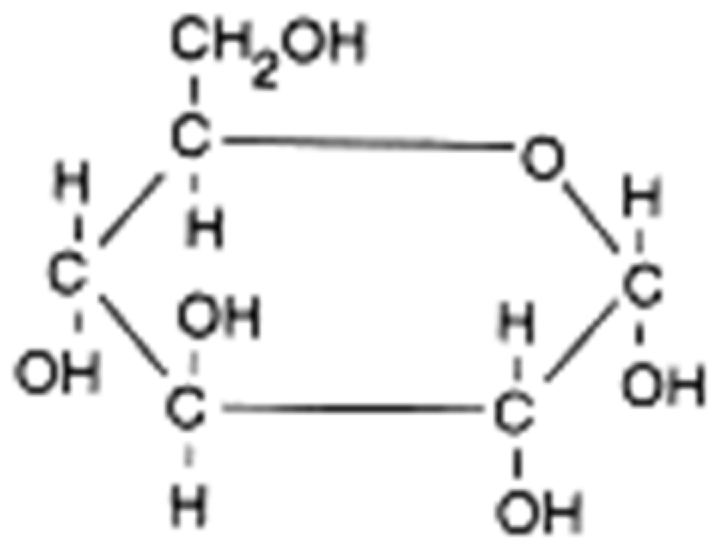
Carbs/Health Ted-Ed

Carbohydrates
I. Carbohydrates

- Main functions of carbohydrates are:
  - Energy
    - Bonds between atoms can be broken, the hydrogen atoms are stripped off and energy released can be used by the cells
  - Structural
    - Cellulose is the major structural compound in plants
    - Used in the cell wall

II. Glucose

- A basic sugar
- $C_6H_{12}O_6$
- Has a ring structure
- This is a mono (one) saccharide
- Others include fructose, ribose, deoxyribose etc…



Animation Ted Ed Sugar

How Sugar affects Brain Ted-Ed

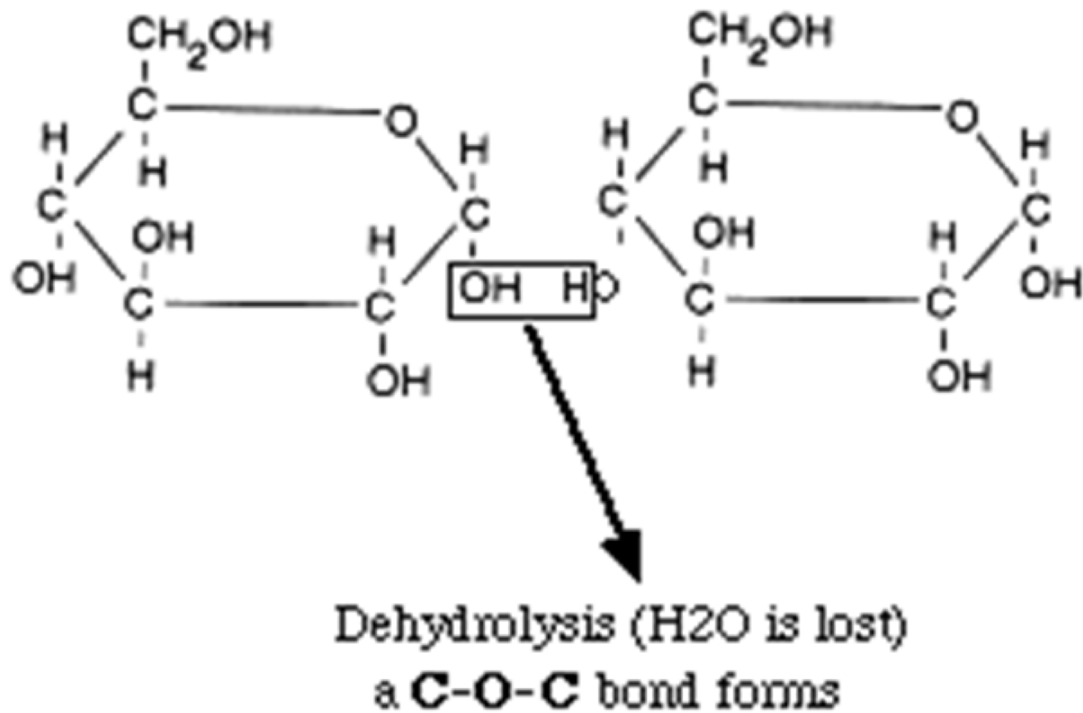
II. Dissacharide

- Two sugars joined together
- Examples of disaccharides :

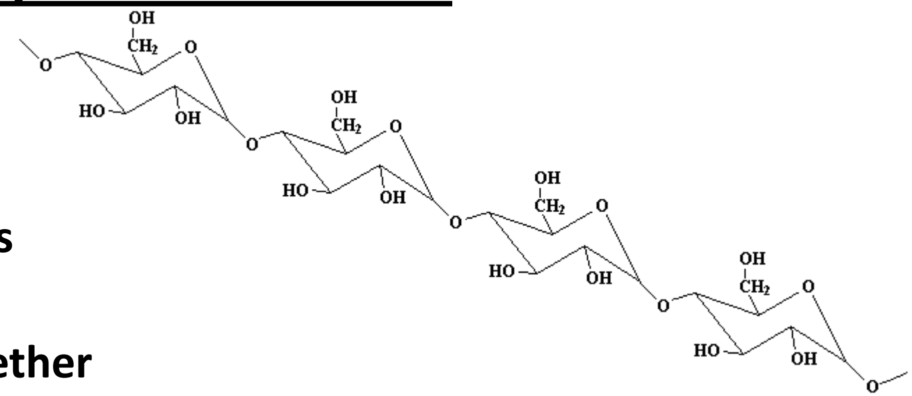
Maltose (two glucoses)

Sucrose (a glucose and fructose)

Lactose (galactose and glucose)

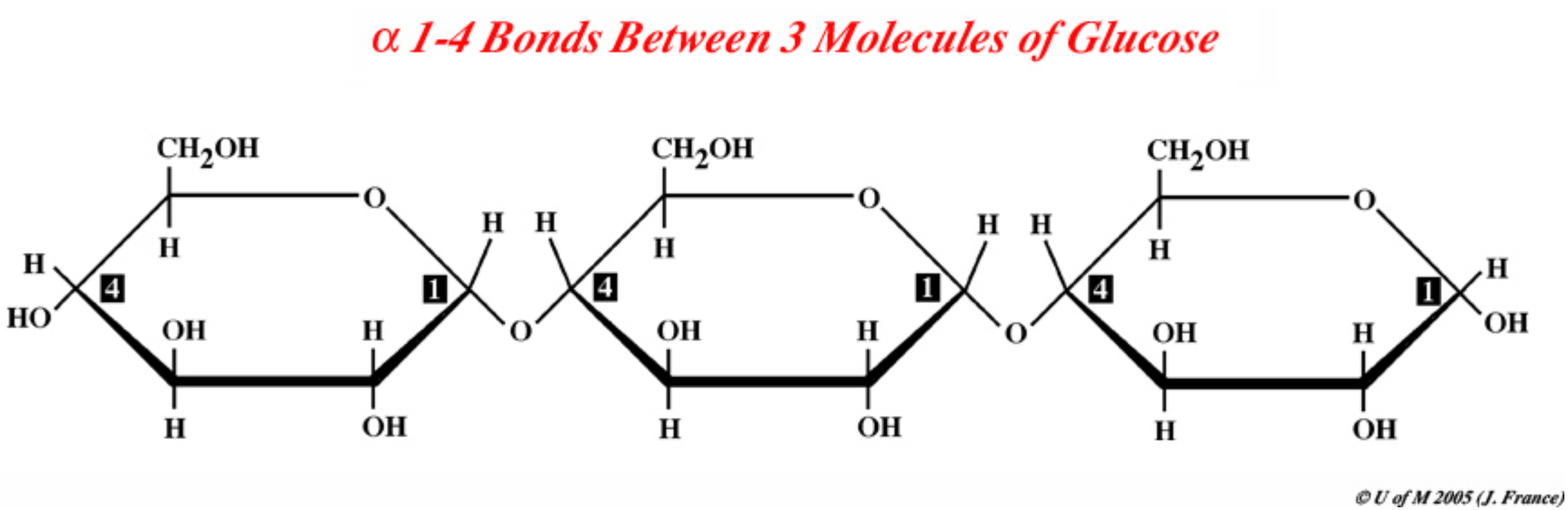


IV. Three Important Polysaccharides



A. Starch

1. Main storage form of sugar in plants
2. Few side chains
3. Many glucose molecules linked together



B. Glycogen

1. Main sugar storage in animals
2. Many side chains
3. Linked as for starch

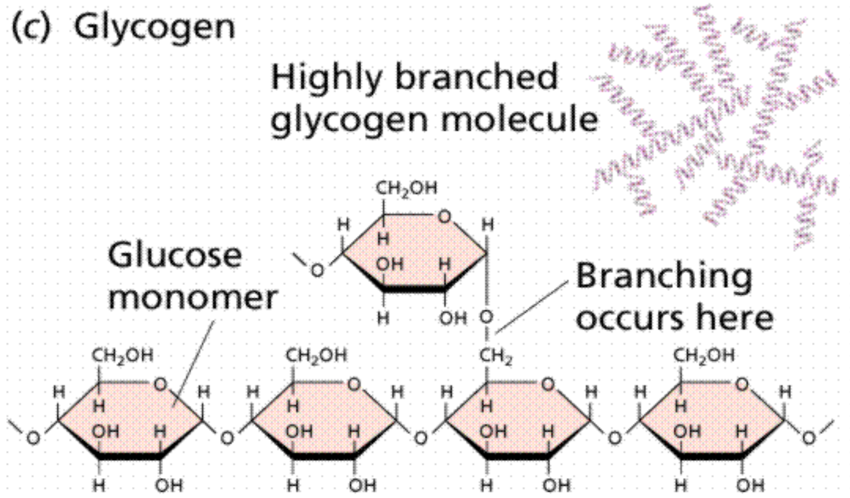
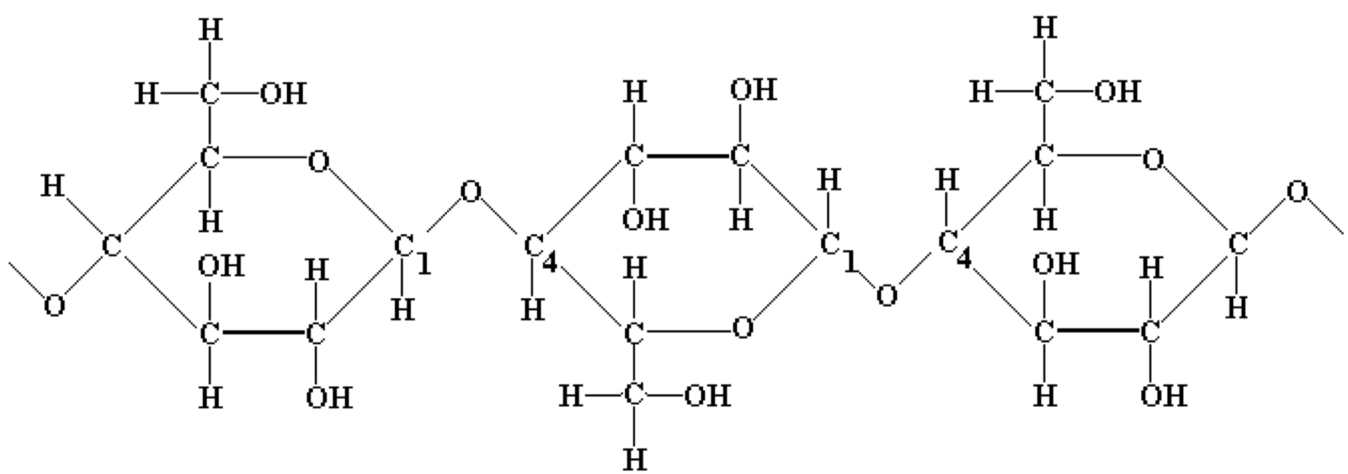


Figure 3.12 (3)

C. Cellulose

1. Structural (cell walls)
2. Long chains
3. Linkage between Carbon atoms of adjacent chains sugars is different than starch and glycogen
4. No mammals can break this bond

16.3.1.7a Cellulose



Neutral Fats, Steroids and Phospholipids

I. General Info

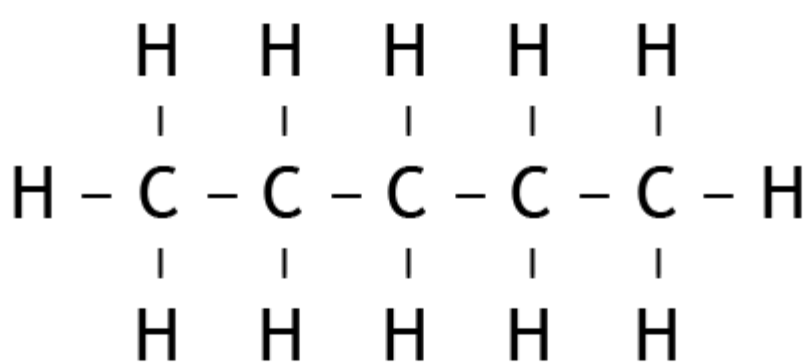
TED-Ed: Fats Animation

A. Large molecules, insoluble in water (non-polar)

B. Used for long-term storage for energy (more efficient [more E stored per cm^3] than glycogen or starch)

C. Examples: Vegetable oils, animal fats

Fig. 1 Saturated Fat

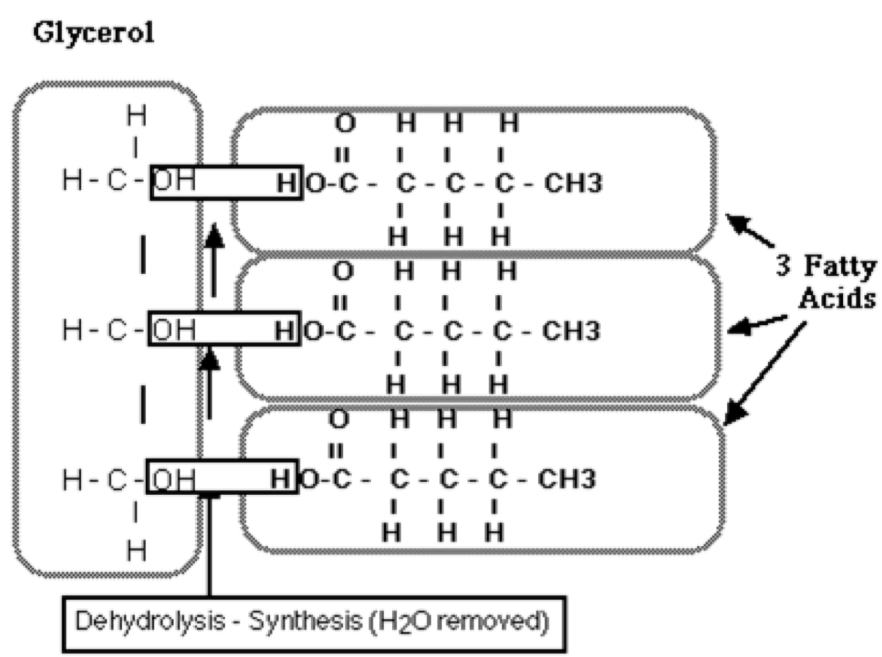


II. Structure

A. Neutral Fat

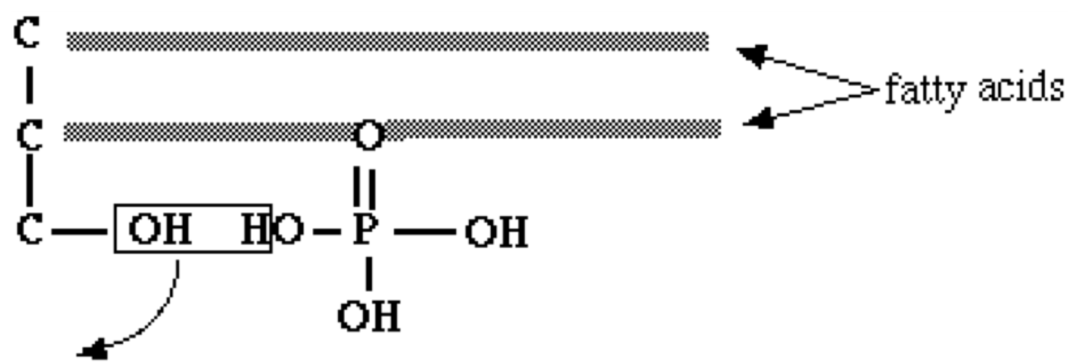
1. **A glycerol (1,2,3-propantriol, for you IUPAC fans!) (3-Carbon) backbone with 3 fatty acids.**

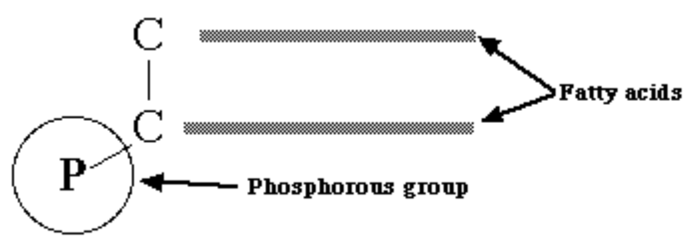
A fatty acid = hydro- carbon chains with a carboxylic acid at one end) attached:



B. Phospholipids

- Same as fat, but with the third fatty acid group replaced by a phosphate group! (simplified)

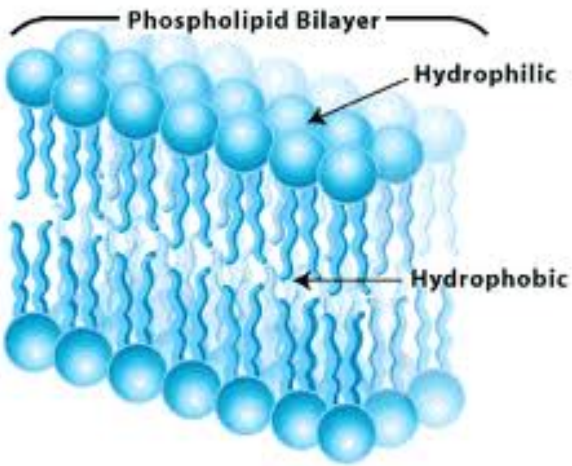




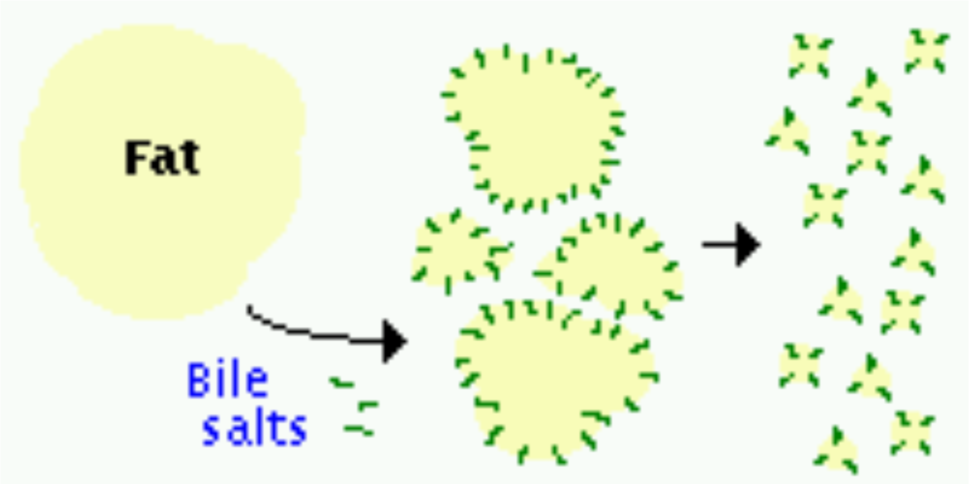
Phospholipids (cont'd)

- The phosphate head is polar
- The hydrocarbon chains are non-polar
- The major component of cell membrane

  a) membrane structure: a double layer of these, positioned w/heads "out", tails "in":



- **When added to dishwater, soap will disperse through it, and form droplets with any non-polar greasy guck in the dishwater (called EMULSIFICATION)**
- **Same principle used in mammal digestive system: BILE is the emulsifier that breaks up fatty foods** **TED-Ed: Soap Animation**

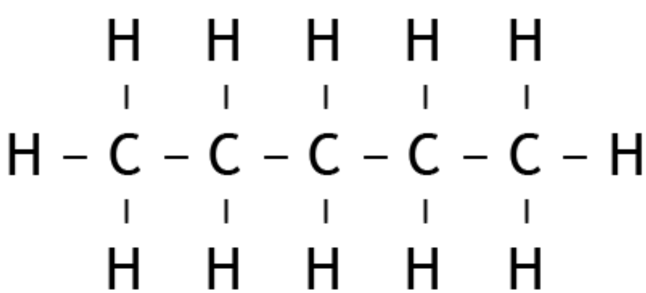


III. Saturated and Unsaturated Fats

A. Saturated

1. All C-C bonds are SINGLE
2. Tend to be solids at room temperature
3. Examples: lard, butter, animal fats
4.

Fig. 1 Saturated Fat



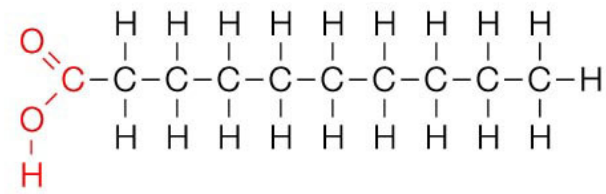
B. Unsaturated

1. **Some C-C bonds are DOUBLE**

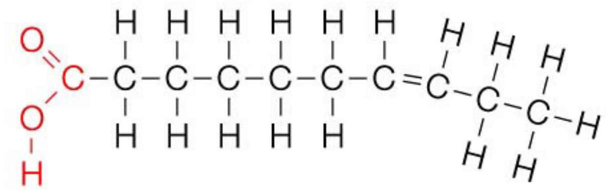
2. **Tend to be liquid at room temperature ("kinks" in the chain formed by dbl bonds prevent close packing)**

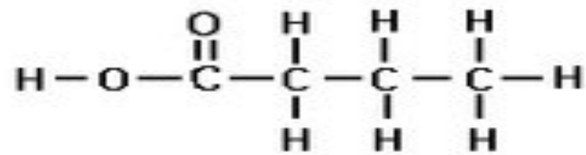
3. **Examples: olive oil, corn oil, peanut oil**

Saturated



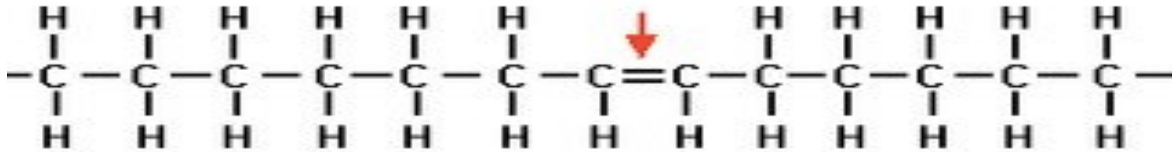
Unsaturated



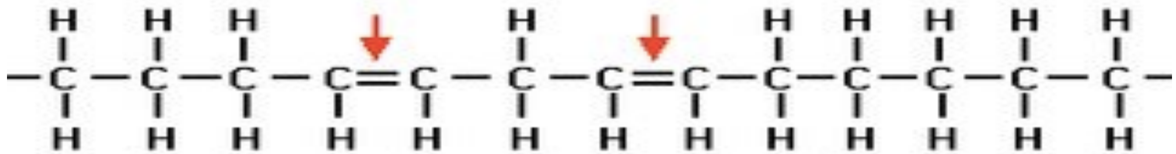


Butyric Acid-Saturated Fatty Acid

4.



Oleic Acid- Monounsaturated Fatty Acid



Linoleic Acid- Polyunsaturated Fatty Ac

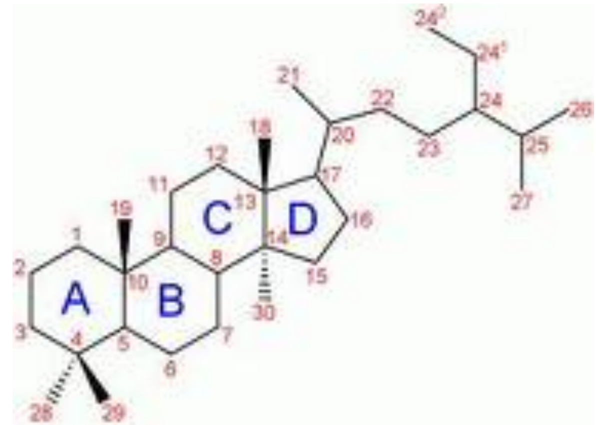
5. Monounsaturated

a) One carbon atom not saturated

6. Polyunsaturated

a) Many double bonds (therefore fewer Hs)

IV. Steroids

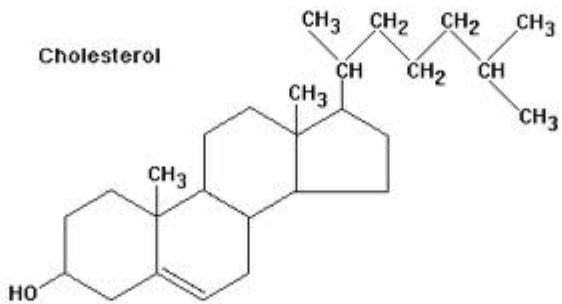


A. 4 carbon rings

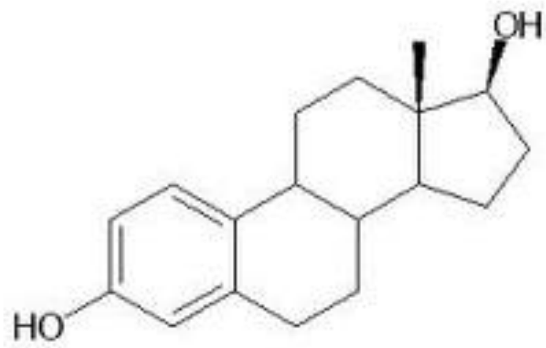
(5 or 6 carbons per ring)

B. Example: Cholesterol
   1. A vital component of eukaryotic cell membranes
   2. Is modified to synthesis hormones like estrogens, testosterone, aldosterone

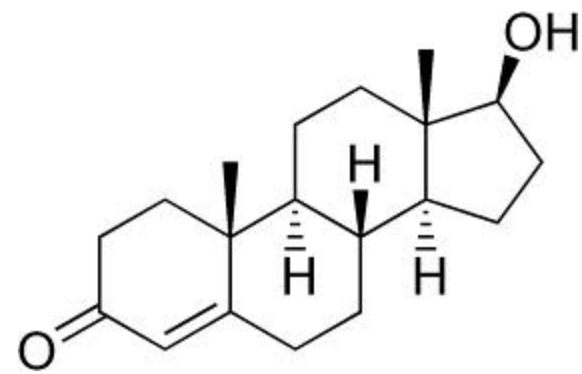
C. Synthesized by body and eaten in animal flesh/fat



Cholesterol



Estradiol



Testosterone