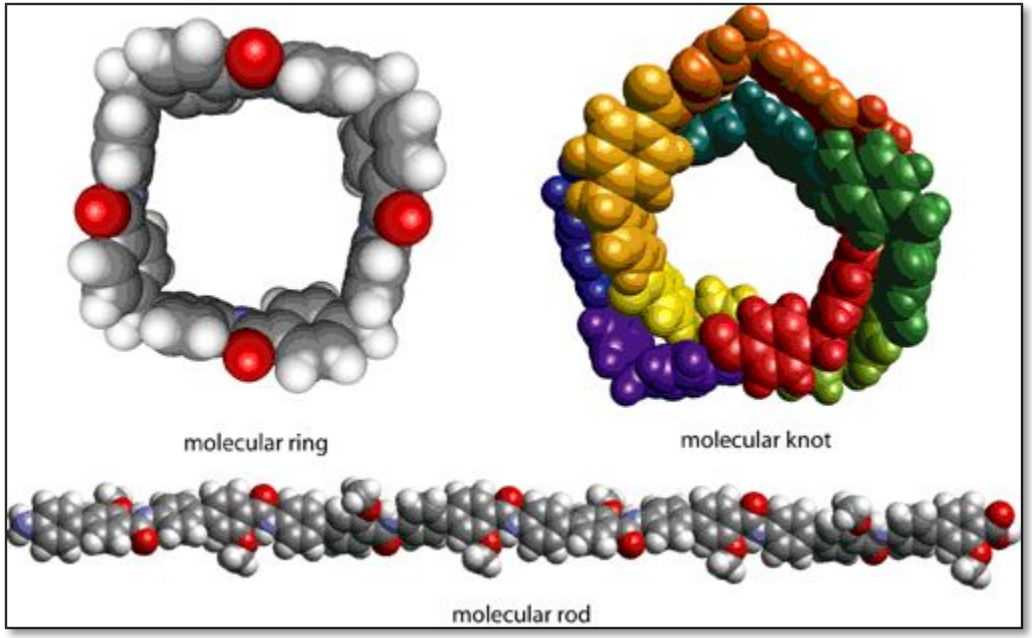
BIO-103:
Biological Macromolecules

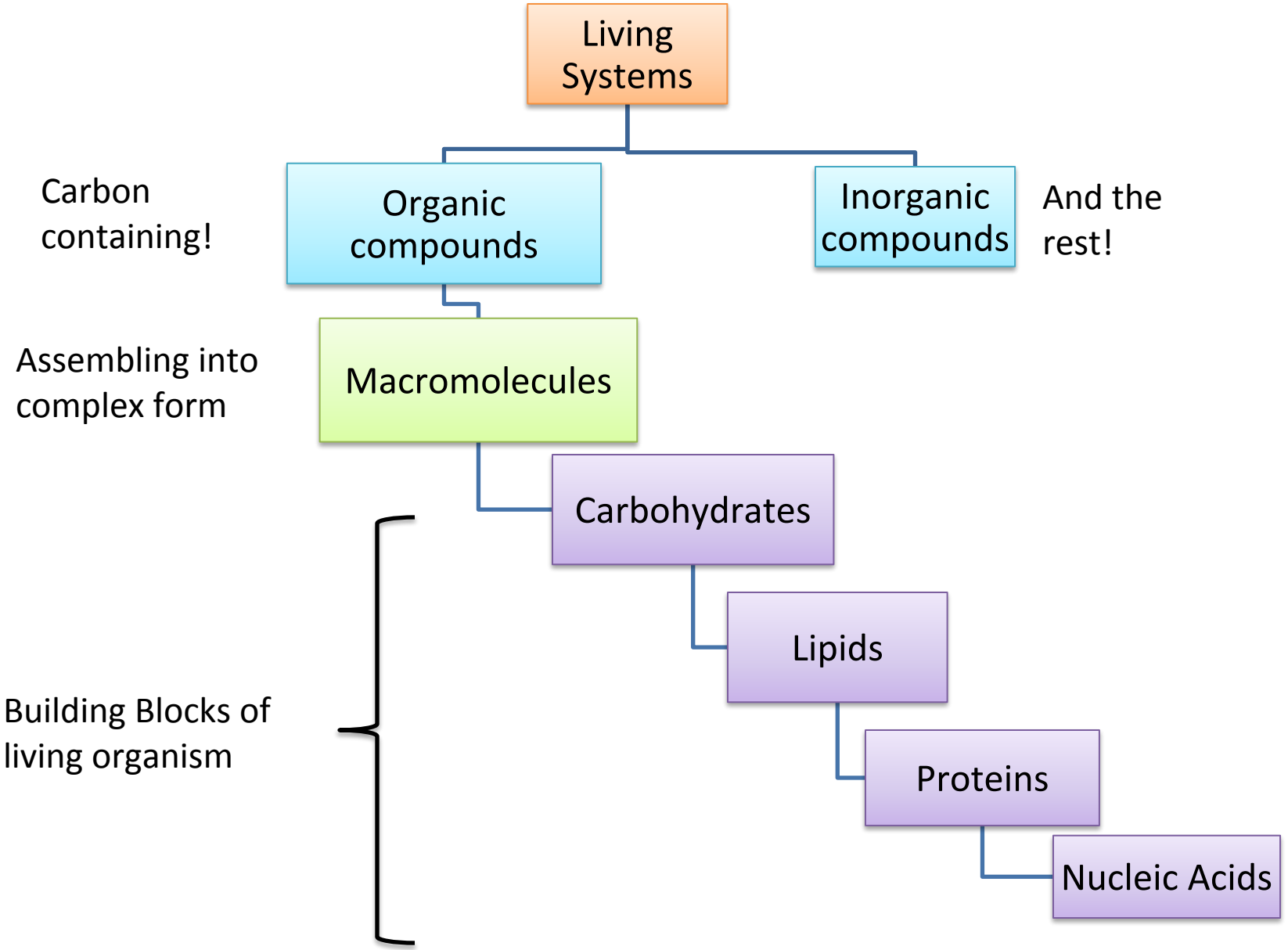


LECTURE: 06-07

Lecture Outline

- Introduction & basic terminologies
- Carbohydrate
- Protein
- Lipid
- Nucleic Acid

Introduction/ at a glance

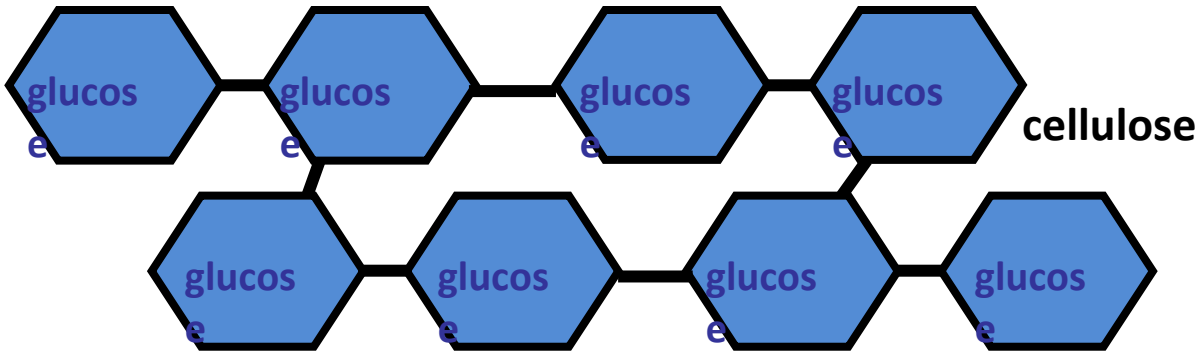


Terminologies/Definitions

- **Macromolecule:**

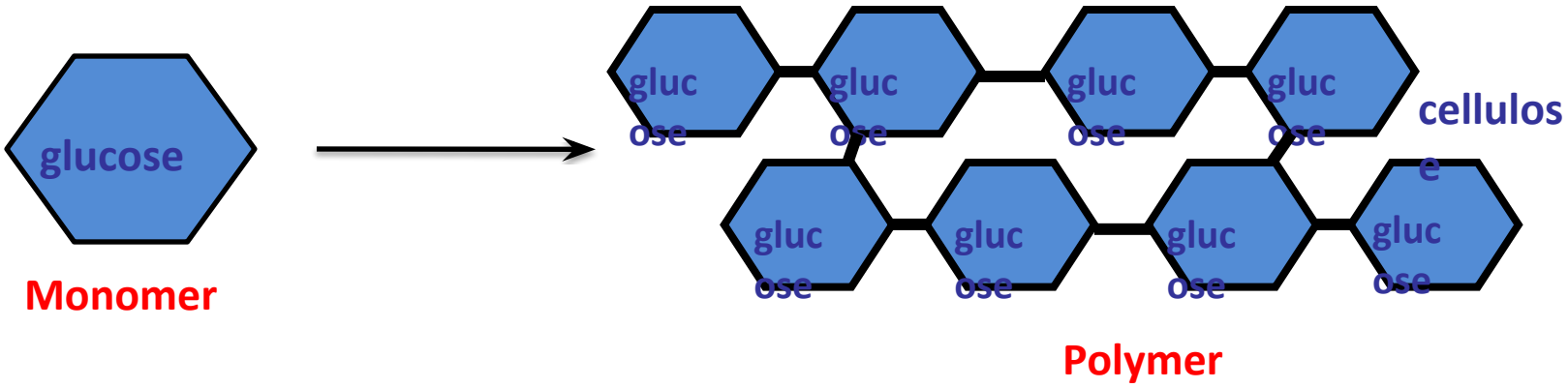
 Small molecules assemble in different orientation to make large molecule or Macromolecules.

❖ **Example:** Glucose molecules assemble to make cellulose (a carbohydrate) .



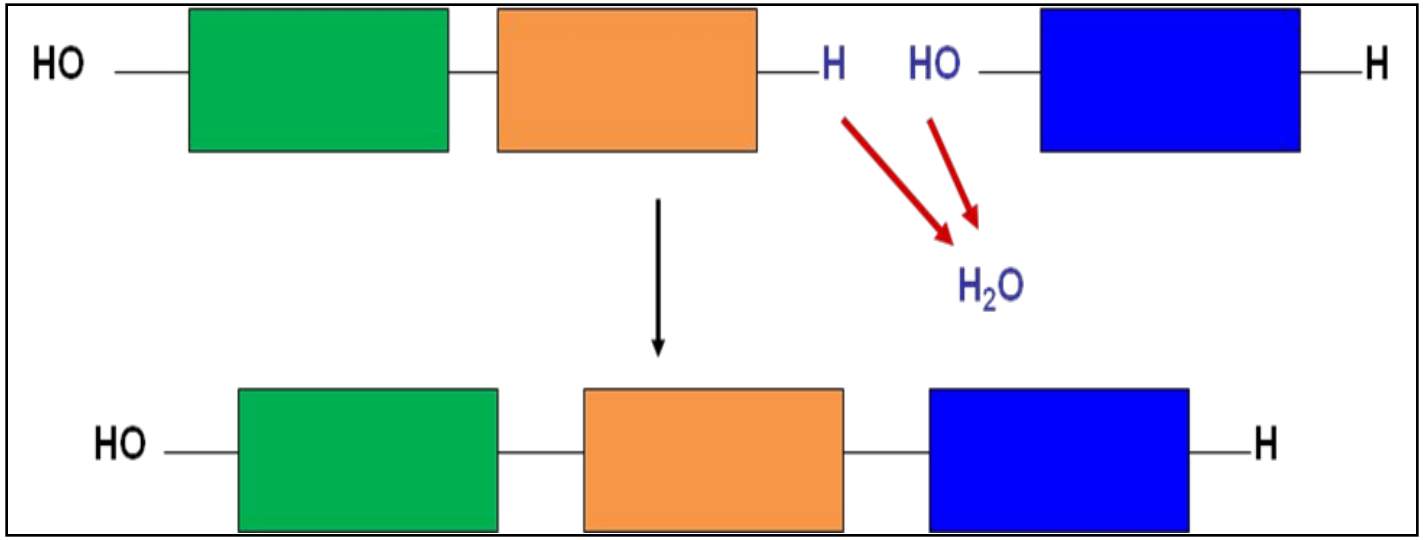
Terminologies/Definitions

- **Monomers** are small molecules or building blocks which may be joined together in a repeating fashion to form more complex molecules called polymers.
- A **polymer** may be a natural or synthetic macromolecule comprised of repeating units of a smaller molecule (monomers).



Terminologies/Definitions

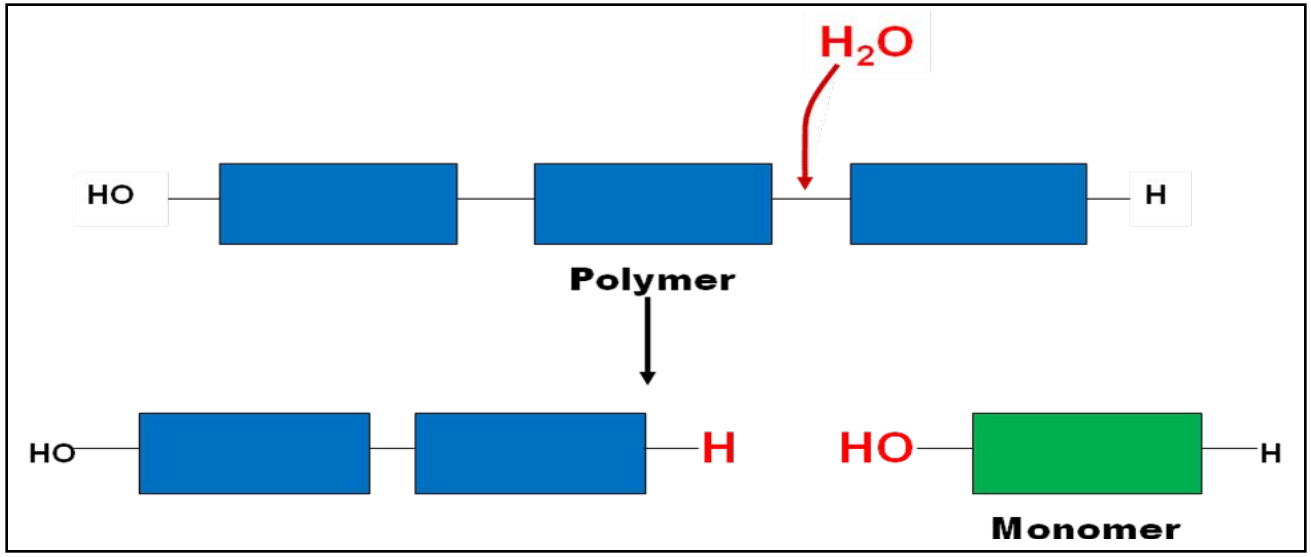
- **Polymerization** is the linking together of monomers to form polymers.
- A **condensation** reaction occurs via the loss of a small molecule, usually from two different substances, resulting in the formation of a covalent bond.



Need the Input of energy

Terminologies/Definitions

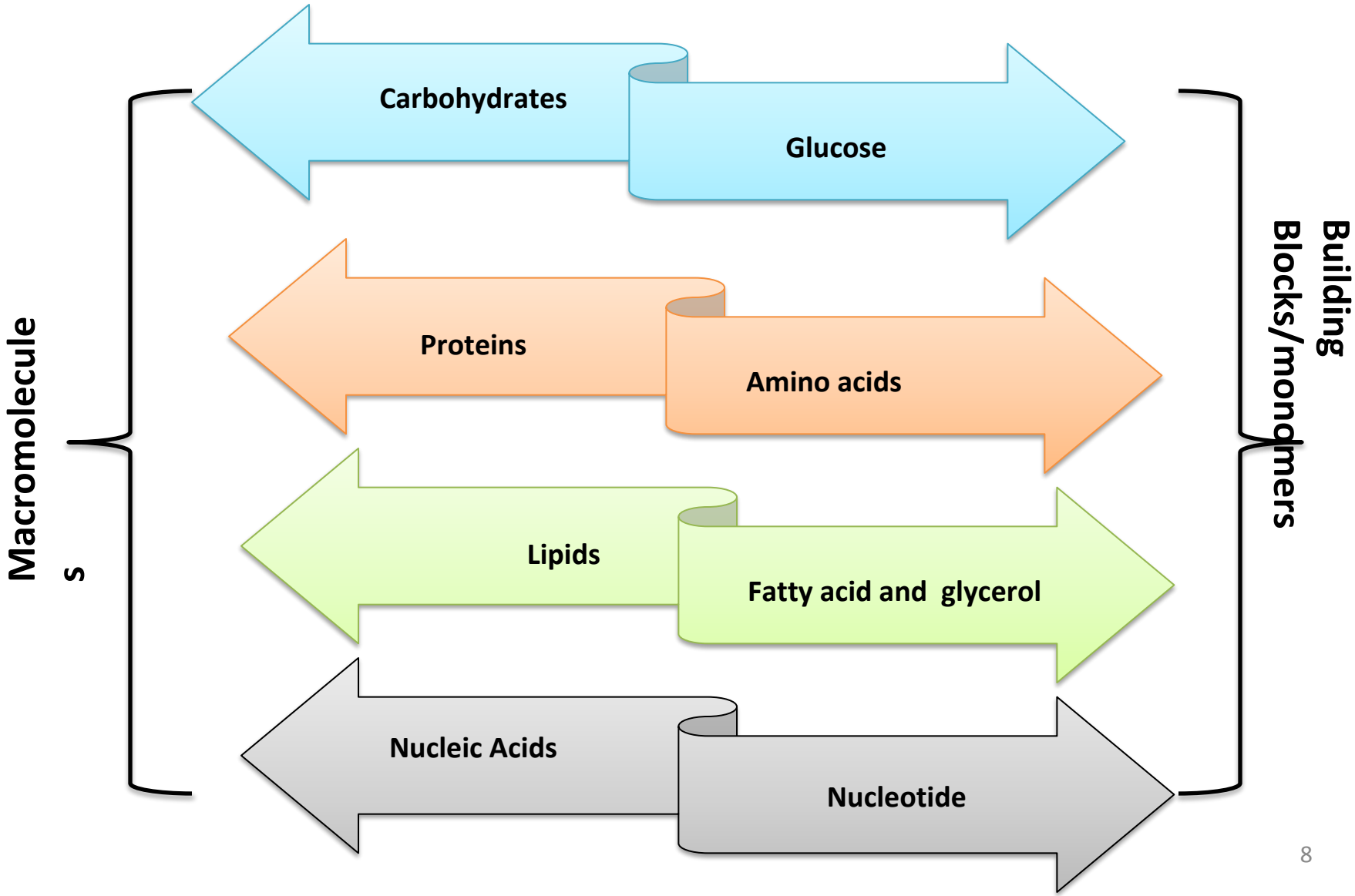
- **Hydrolysis,** which is the reverse of condensation, breaks apart large organic molecules into smaller ones.
- By breaking the bonds between monomers, Hydrolysis **liberates the energy** that polymers contained during condensation; thus, some of the energy required to polymerize is returned upon hydrolysis.



Liberation of energy

Try to link up with the context of Metabolism that we've learned earlier…!!!

Terminologies/Definitions

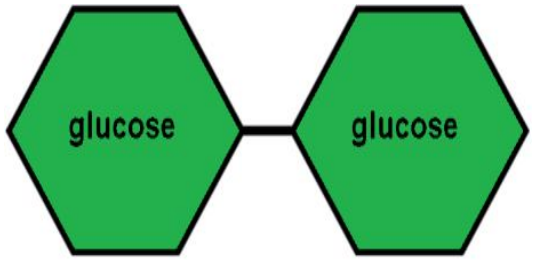


CARBOHYDRATE

- Common symbol: $(CH_2O)_n$
- Most common is Glucose.
- In glucose, Carbon, Hydrogen and Oxygen makes a molecule of glucose in 1:2:1 ratio.
- Chemical formula: $C_6H_{12}O_6$. or $(CH_2O)_6$
- Structural materials, storing and transporting energy
- Three types: monosaccharides, oligosaccharides, and polysaccharides.

CARBOHYDRATE

- Two monosaccharide's will make disaccharide.



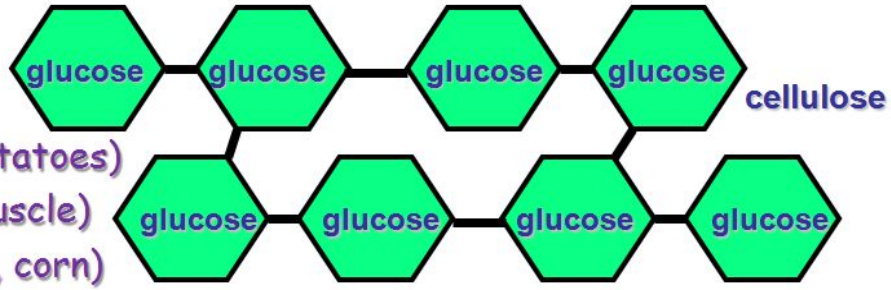
Examples:

Sucrose (glucose+fructose) (Table Sugar)
Lactose (glucose+galactose) (Milk Sugar)
Maltose (glucose+glucose) (Barley/germinating seeds)

- **Polysaccharides:** Long chains of monosaccharide units bound together

Examples:

- starch (bread, potatoes)
- glycogen (beef muscle)
- cellulose (lettuce, corn)



Sugar


Starch

Cellulose


Glycogen

Starch and Glycogen

- Starch is energy storage molecule in plants
- Glycogen is energy storage molecule in animals.
- Starch and glycogen can be digested by animals.

Cellulose

- Different bond formed than starch
- Structural component in plants
- Cannot be digested by animals

Chitin

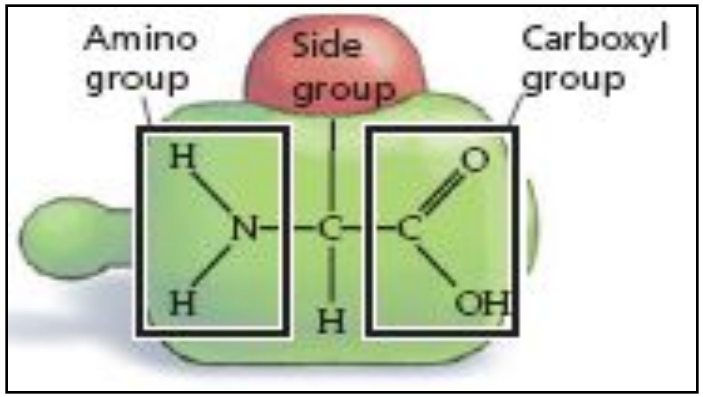
- Partly derived from non-sugars (nitrogen)
- Composes exoskeletons of insects

Functions of Carbohydrates

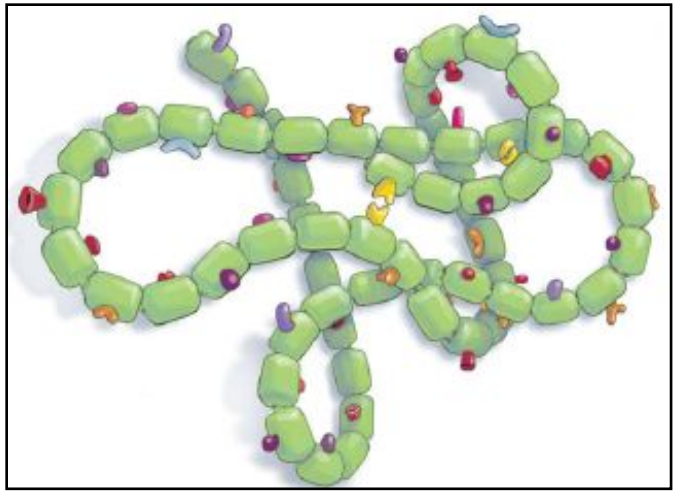
- Providing energy and regulation
- Sparing the use of proteins for energy
- Preventing ketosis and breakdown of fatty acids and
- Biological recognition processes
- Flavor and Sweeteners
- Dietary fiber, which is also a form of carbohydrate, is essential for the elimination of waste materials and toxins from the body

PROTEINS

- Most diverse in both structure and function
- Proteins are the polymers of amino acids
- Thousands of different kinds of proteins are made from only **twenty** monomers, called **amino acids**.



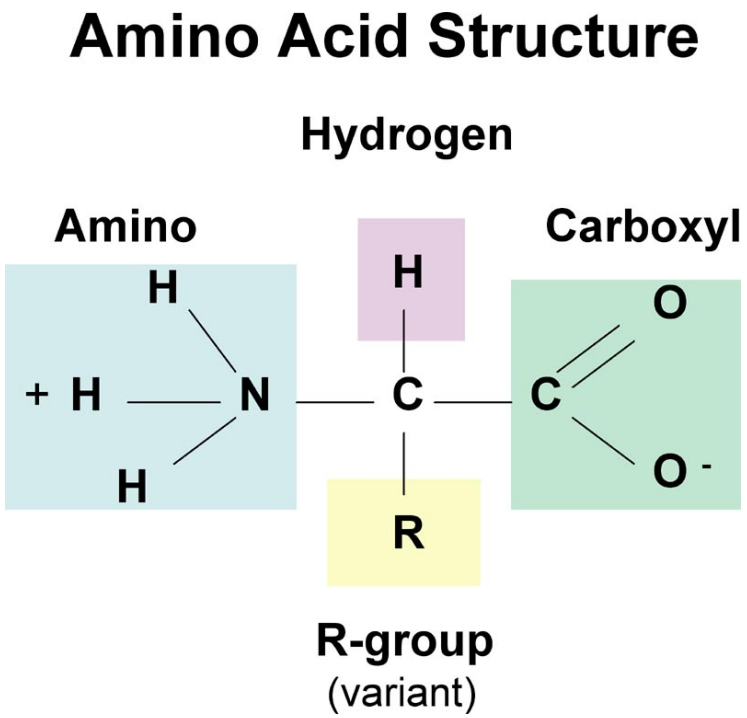
Monomer



Polymer

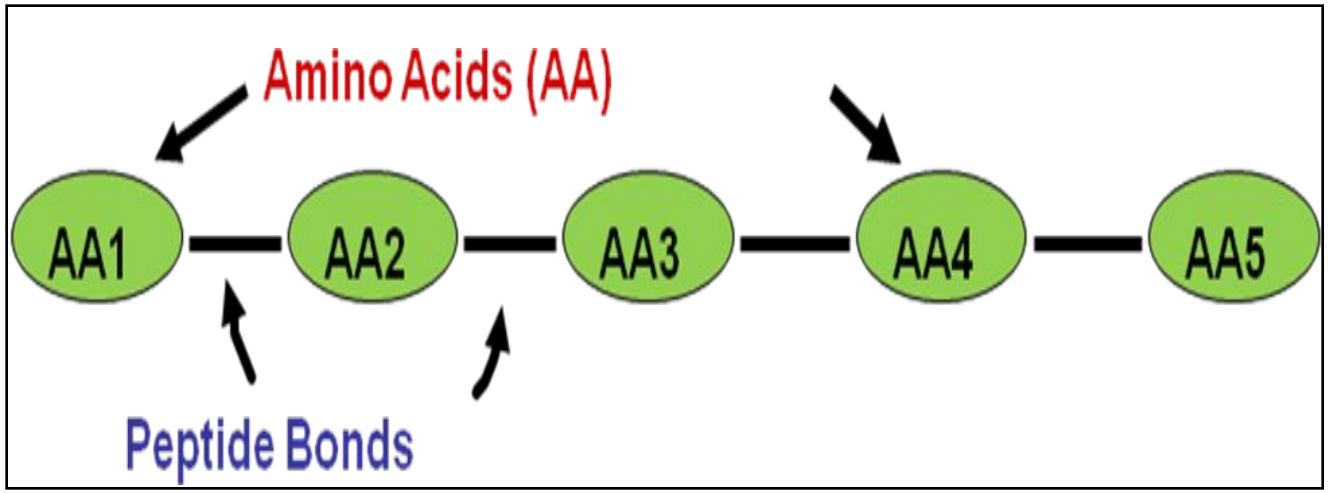
Amino Acids: Building Block of Proteins

- Contains an amine group (NH_3) (basic/positive)
- A carboxyl group (COOH) (acidic/negative)
- One or more atoms called an "R group"
- All three groups are attached to the same carbon atom



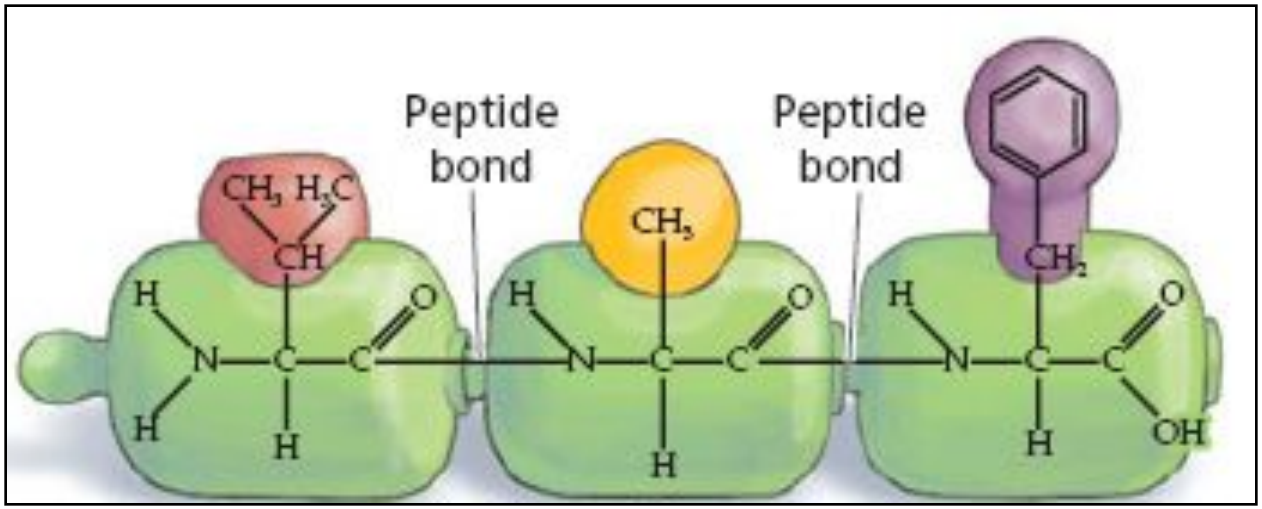
Amino Acids: Building Block of Proteins

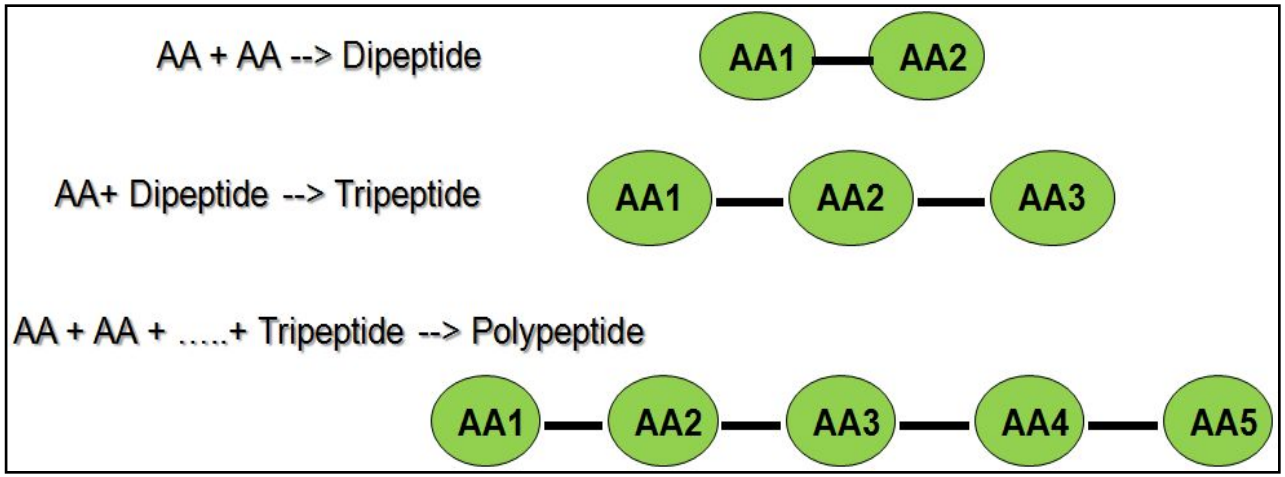
- Amino acids are divided into two groups-
  - **Essential:** must be supplied in the diet.
  - **Non-essential:** not supplied in the diet.
- Amino acids are bonded together by **peptide bonds** to form protein.



Peptide Bonds

- The bond that forms between two amino acids is called a **peptide bond**.





Levels of protein structure

Primary structure: The linear arrangement of amino acids in a protein

Secondary structure: Areas of folding or coiling within a protein. e.g. α-helices and β-pleated sheets

Tertiary structure: Final three-dimensional structure of a protein, which results from a large number of non-covalent interactions between amino acids.

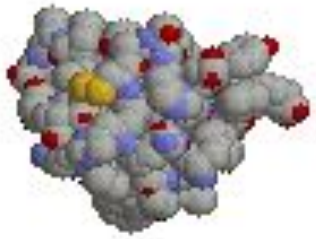
Quaternary structure: Non-covalent interactions that bind multiple polypeptides into a single, larger protein. e.g. Hemoglobin

Levels of protein structure

Primary structure

Secondary structure

Tertiary structure



Main functions of proteins

- Protein's main function is to build, maintain and repair all our body tissues
- Protein can also be used as energy source by body

Biological functions of proteins

- Protein acts as storage material of food and energy.
- Many proteins are enzymes that catalyze biochemical reactions
- Proteins are molecular instrument through which genetic information is expressed.
- They act as antibodies to prevent disease.
- The milk proteins help the growth of infant mammals.

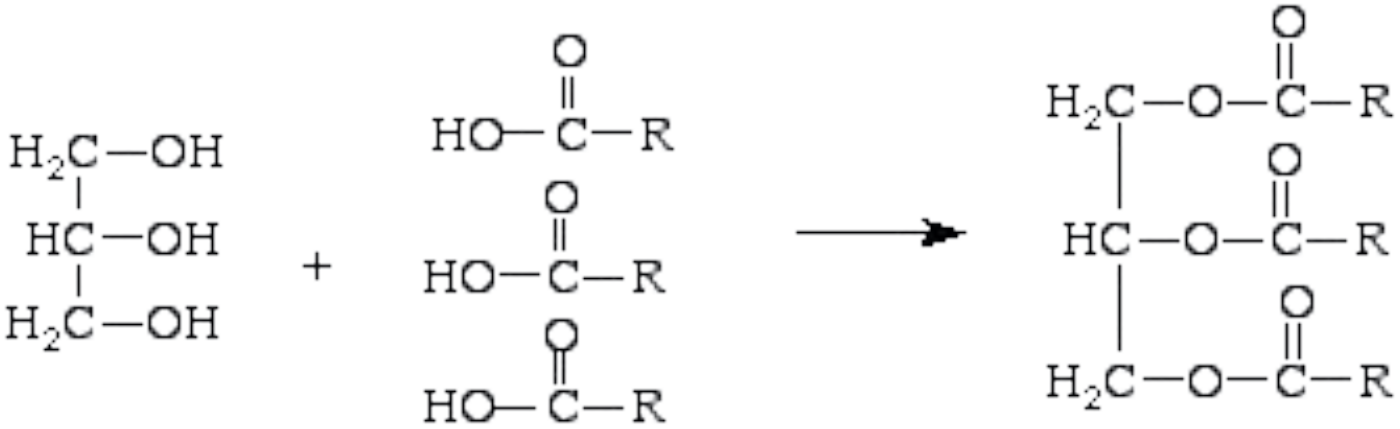
For detail functions see the notes underneath…

Lipids

- **Composed of Carbon, Hydrogen, and Oxygen**
- Differ from carbohydrates: no specific ratio (C:H:O)
- **Building blocks are fatty acids and glycerol.**
- **Energy storage molecules "stores the most energy" 2X of Carbohydrates**
- **Structurally heterogeneous, Not soluble in water**
- **Are soluble in hydrophobic solvents.**
- **Examples: 1. Fats 2. Oils 3. Phospholipids**

  4. Waxes 5. Steroid hormones 6. Triglycerides

Synthesis of triglycerides



Glycerol

Fatty acids
Can be saturated/unsaturated

Relate with the melting points and physical states……..
Higher the un-saturation-lower the melting point……..

Fats

Fats are solid at ordinary temperatures. Generally, fats are produced by animals. In animals, fats are stored in adipose cells. Fats are also important as cushions for body organs and as an insulating layer beneath skin.

Oils

Oils are liquid at ordinary temperatures. Generally, oils are produced by plants. Some common vegetable oils are peanut, soybean, and corn oil.

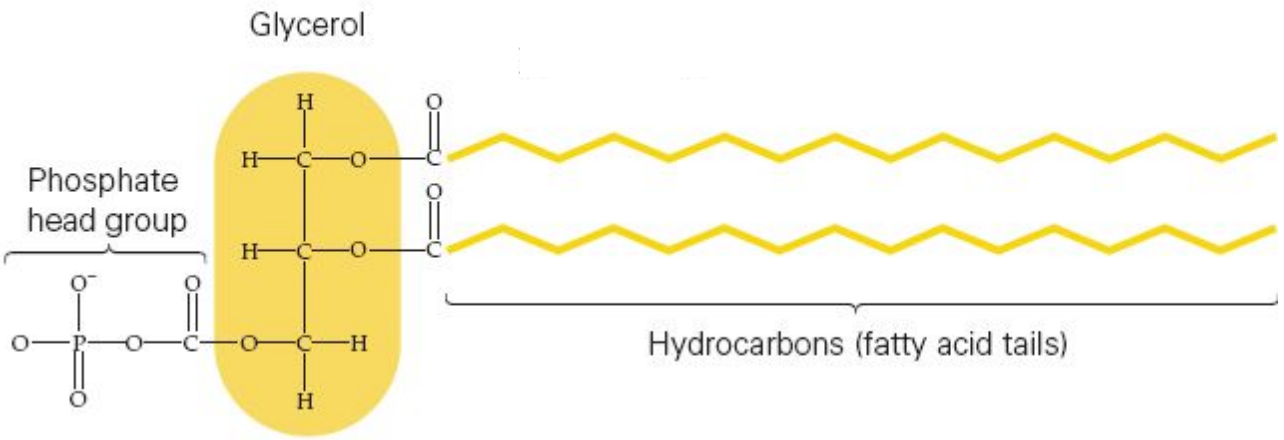
Waxes

Both plants and animals produce waxes. The waxy coating on some plants leaves is an example of plant waxes. Beeswax is an example of a wax produced by an animal.

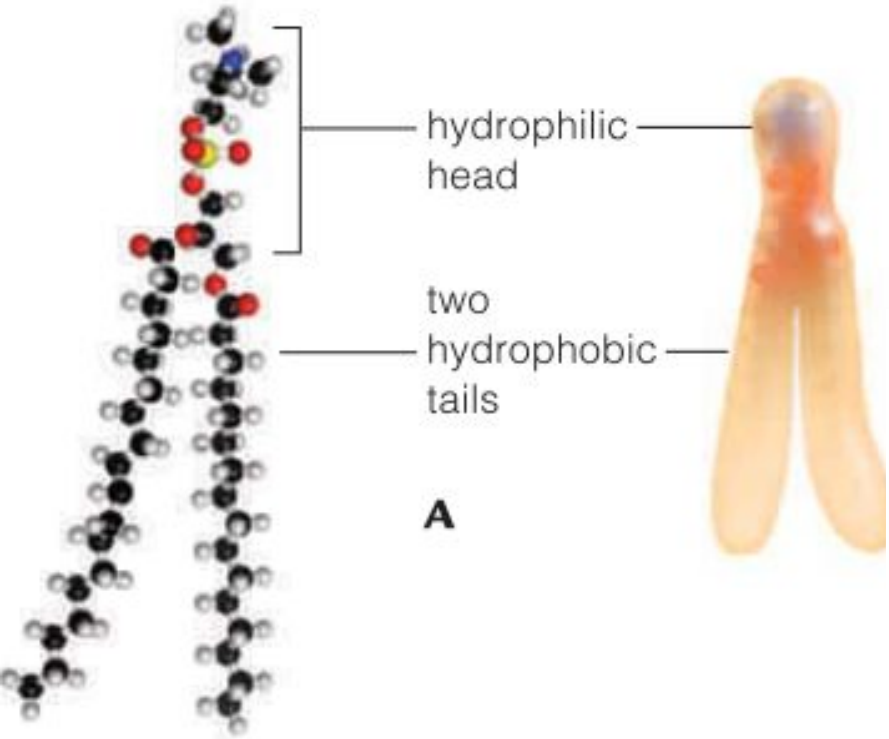
Recall the saturated and unsaturated FA in this context….

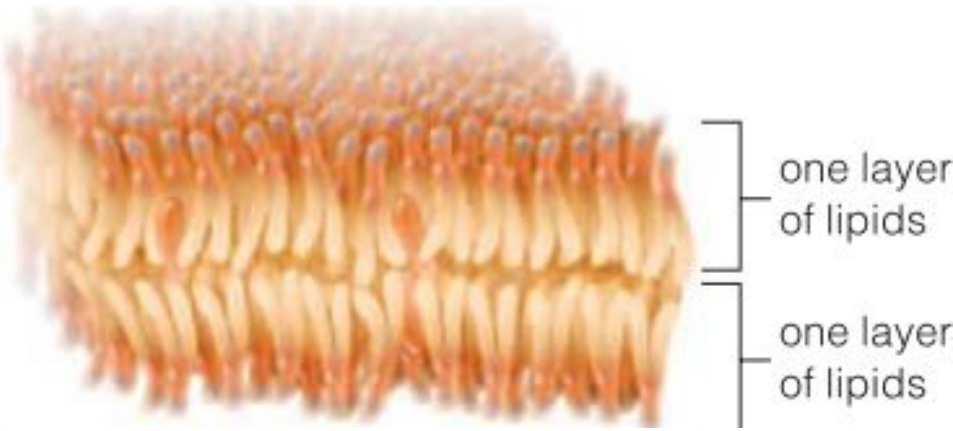
Phospholipids

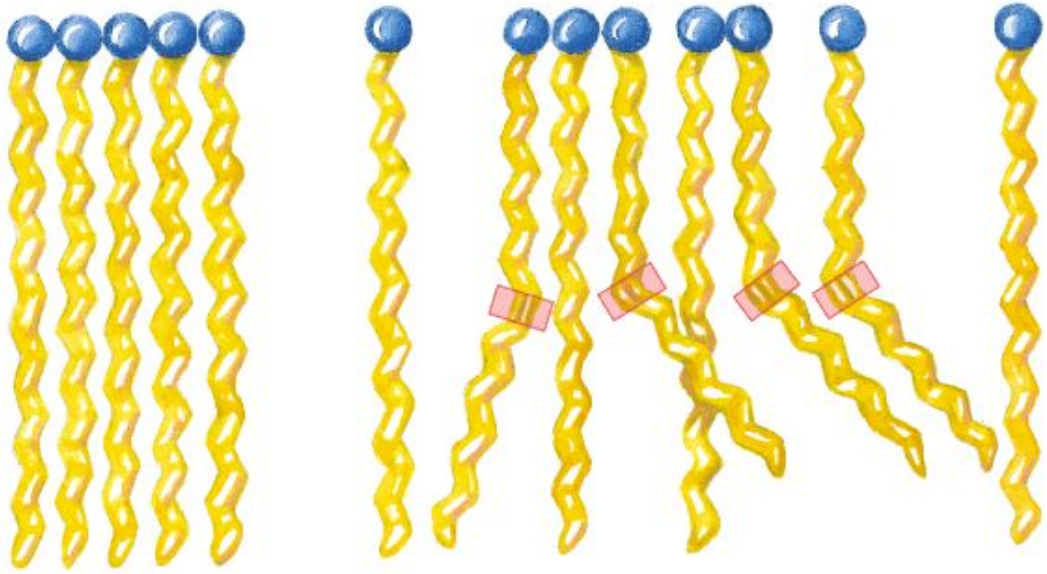
- Phospholipids are a variation on the triacylglycerol theme in which
  - One fatty acid is replaced with a phosphate group, which in turn is bound to additional functional groups.
- Structurally and functionally, the important thing about phospholipids is that
  - These molecules are simultaneously hydrophobic (at one end, the fatty acid end) and hydrophilic
    (at the other end, the phosphate end). **Amphiphile**



Recall the cell membrane in this context…







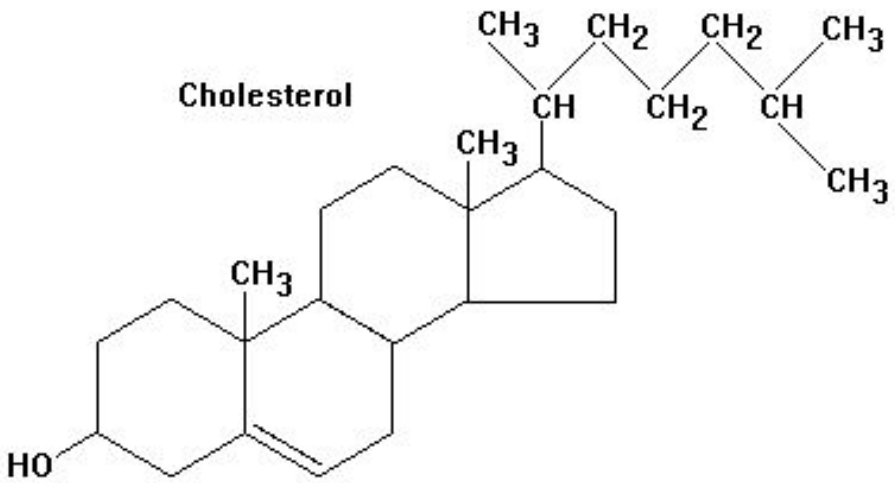
Saturated fatty acids

Mixture of saturated and unsaturated fatty acids

Here it goes…let's think laterally..!

Steroids

- All steroids possess a common ring structure.
- These ring structures vary by attached functional groups.
- Cholesterol is example of a steroid; cholesterol is a membrane component
- The common steroid structure is the basis of sterol hormones including the human sex hormones (the estrogens and the androgens, including testosterone).



Nutrition and Health

- Most of the lipid found in food is in the form of triacylglycerols, cholesterol and phospholipids
- A minimum amount of dietary fat is necessary to facilitate absorption of fat-soluble vitamins (A, D, E and K) and carotenoids
- Essential Fatty Acids
- Trans Fat

The fat guidelines

- Limit total fat intake to less than 25–35% of your total calories each day;
- Limit saturated fat intake to less than 7% of total daily calories;
- Limit trans fat intake to less than 1% of total daily calories;
- The remaining fat should come from sources of monounsaturated and polyunsaturated fats such as nuts, seeds, fish and vegetable oils; and
- Limit cholesterol intake to less than 300 mg per day, for most people

Nucleic Acids

- **The chemical link between generations**
- **The source of genetic information in chromosomes**
- **Dictate amino-acid sequence in proteins**
- **Simple units called nucleotides, connected in long chains**
- **Nucleic acids** are composed of long chains of **nucleotides** linked by **dehydration synthesis**

Nucleic Acids

Two types:

a. Deoxyribonucleic acid (DNA-double helix)

b. Ribonucleic acid (RNA-single strand)

Nucleotides have 3 parts:

1- phosphate group (P)

2- pentose sugar (5-carbon)

3- nitrogenous bases:

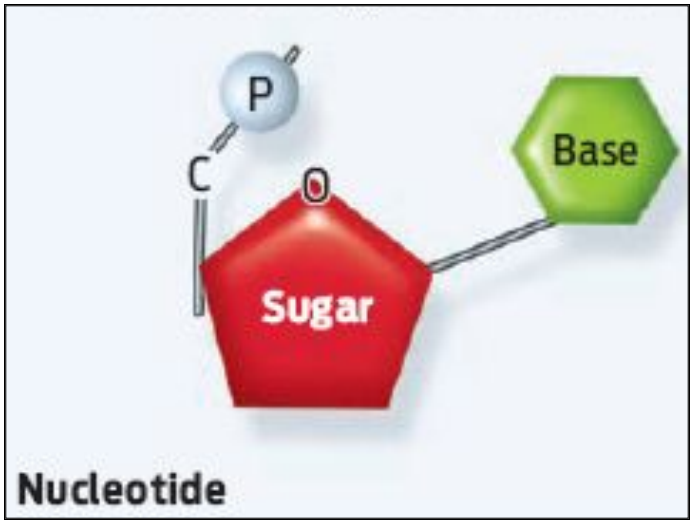
adenine (A)

thymine (T) DNA only

uracil (U) RNA only

cytosine (C)

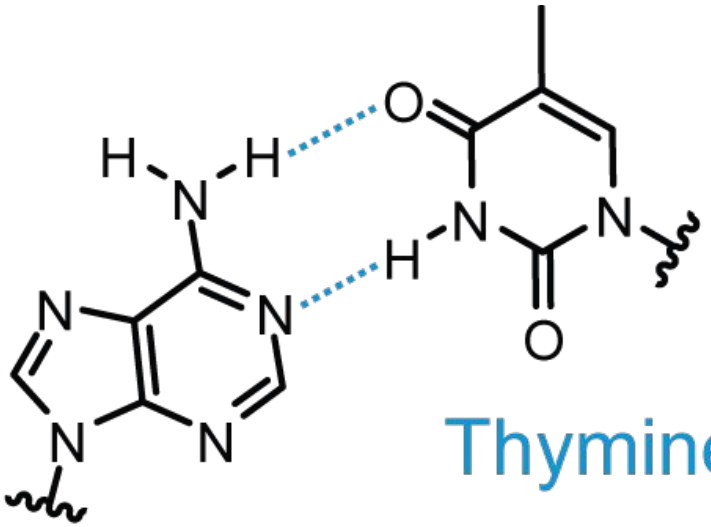
guanine (G)

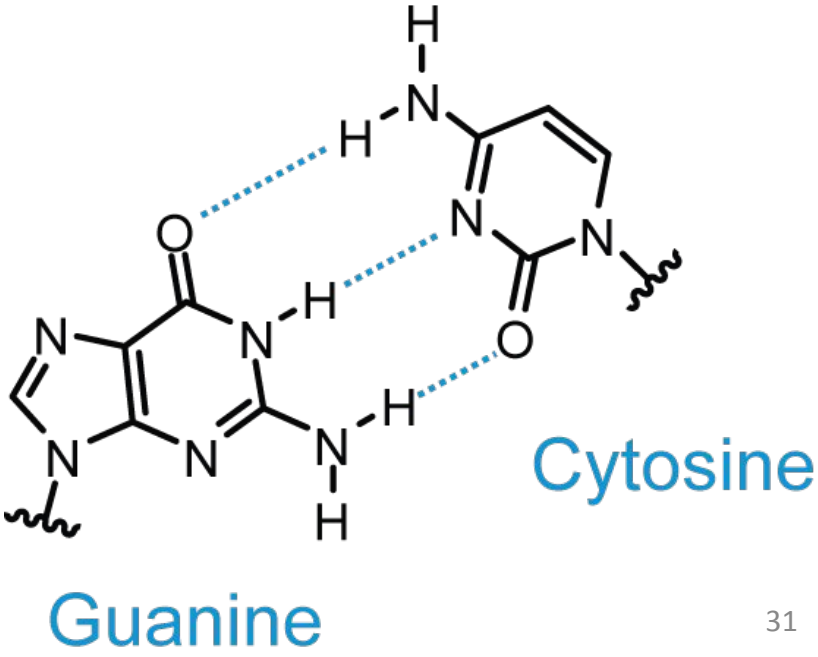


Nucleic Acids

- The secondary structure is similar to the proteins
- The concentration of adenine equals that of thymine
- The concentration of guanine equals that of cytosine

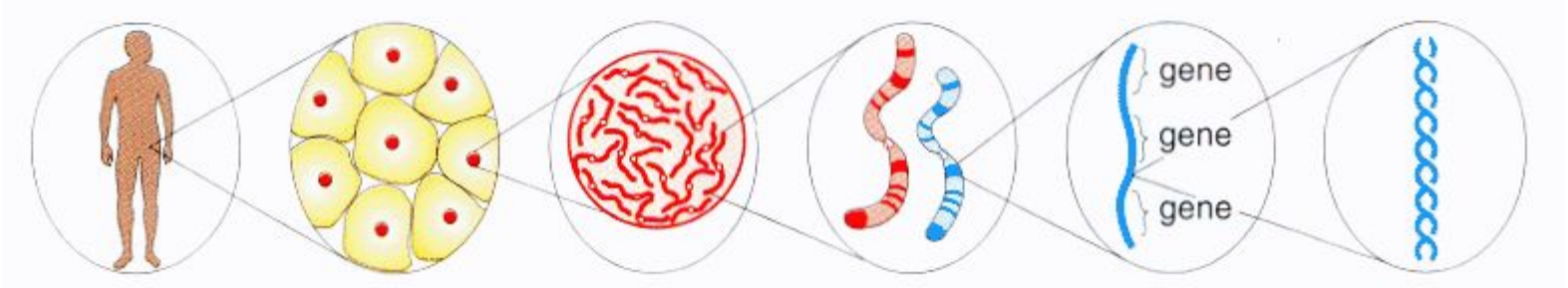
Why?





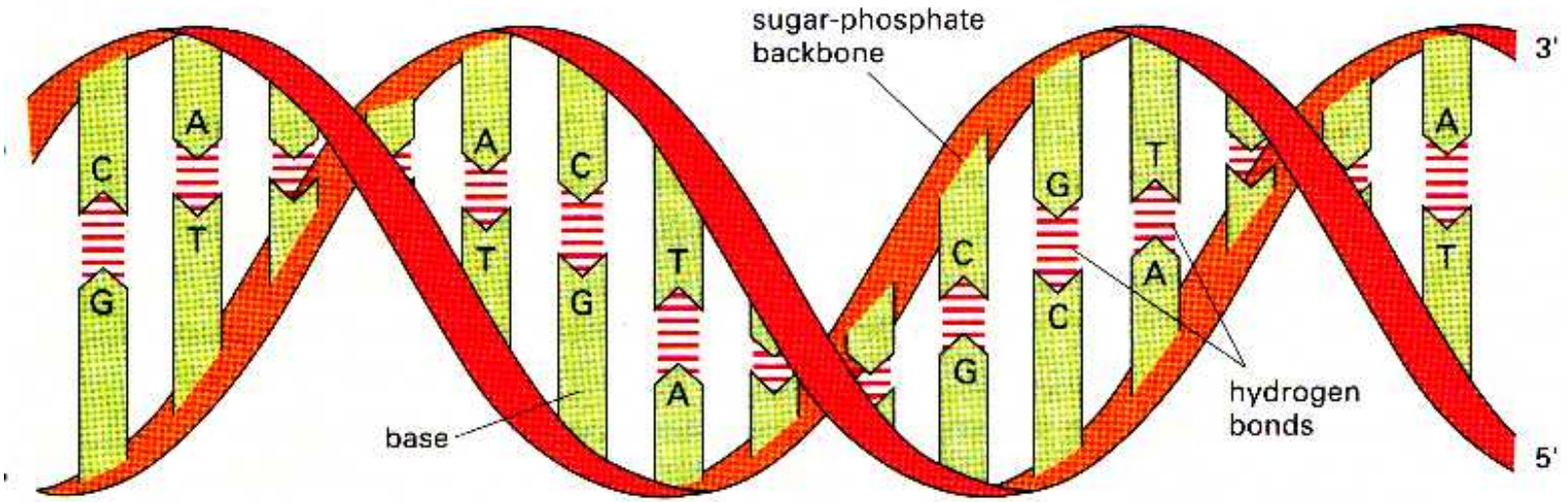
Cells

Genes



Chromosomes

DNA



	DNA	RNA
Structural Name:	Deoxyribonucleic Acid	Ribonucleic Acid
Function:	Medium of long-term storage and transmission of genetic information	Transfer the genetic code needed for the creation of proteins from the nucleus to the ribosome. Without RNA, proteins could never be made.
Structure:	Typically a double- stranded molecule with a long chain of nucleotides.	A single-stranded molecule in most of its biological roles and has a shorter chain of nucleotides.
Bases/Sugars:	Long polymer with a deoxyribose and phosphate backbone and four different bases: adenine, guanine, cytosine and thymine.	Shorter polymer with a ribose and phosphate backbone and four different bases: adenine, guanine, cytosine, and uracil.
Base Pairing:	A-T (Adenine-Thymine), G-C (Guanine-Cytosine)	A-U (Adenine-Uracil), G-C (Guanine-Cytosine)

Thank you.
Any Questions?