BIOMOLECULES
(molecules of life)

By
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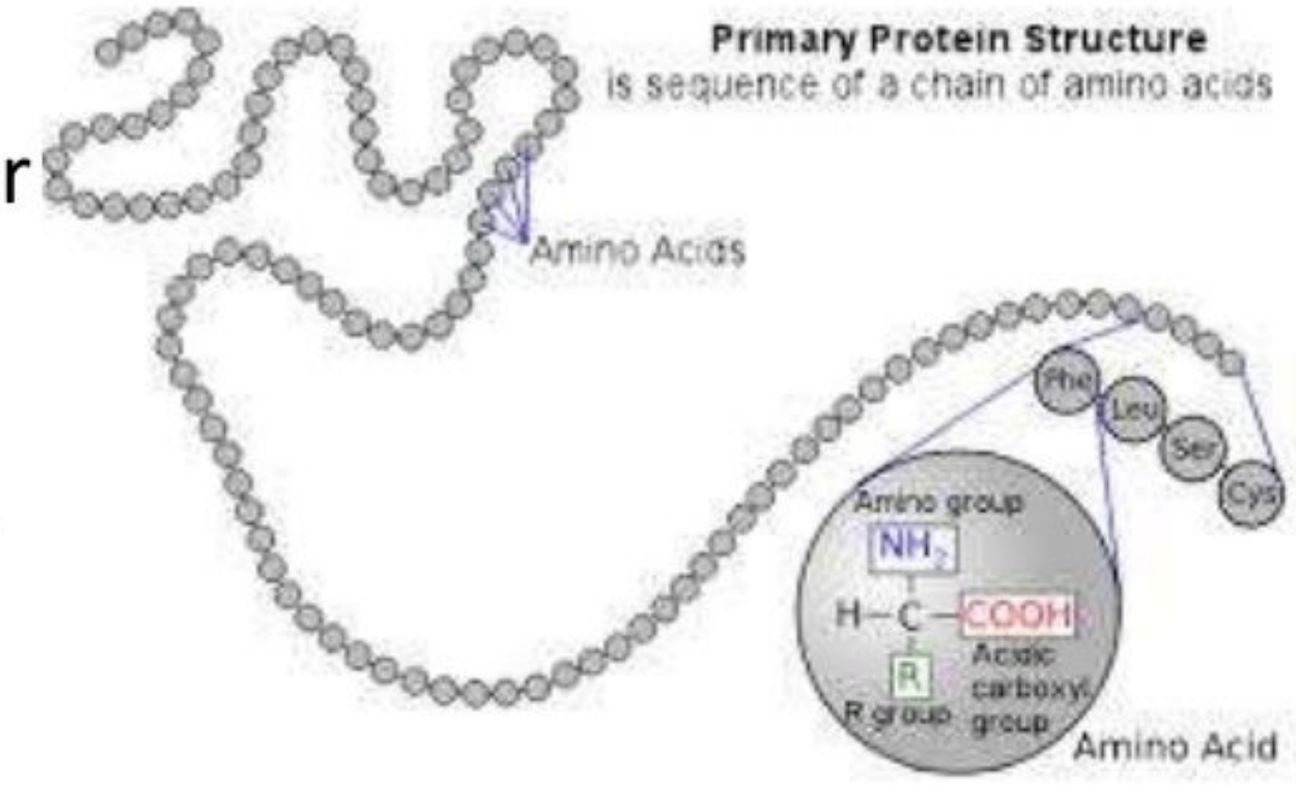
What molecules keep us alive, and how do they do so?

- All living organisms require several compounds to continue to live.
- We call these compounds **biomolecules.** All of these biomolecules are **organic**, which means that they contain carbon.
  - Carbon has four valence electrons, which means this element forms strong covalent bonds with many other elements.

Biomolecules

- Also, our biomolecules are formed by joining many small units together to form a long chain.
- This process is called **synthesis.** Often, a water molecule is removed in the process.
  - When this happens, we call it **dehydration synthesis.**

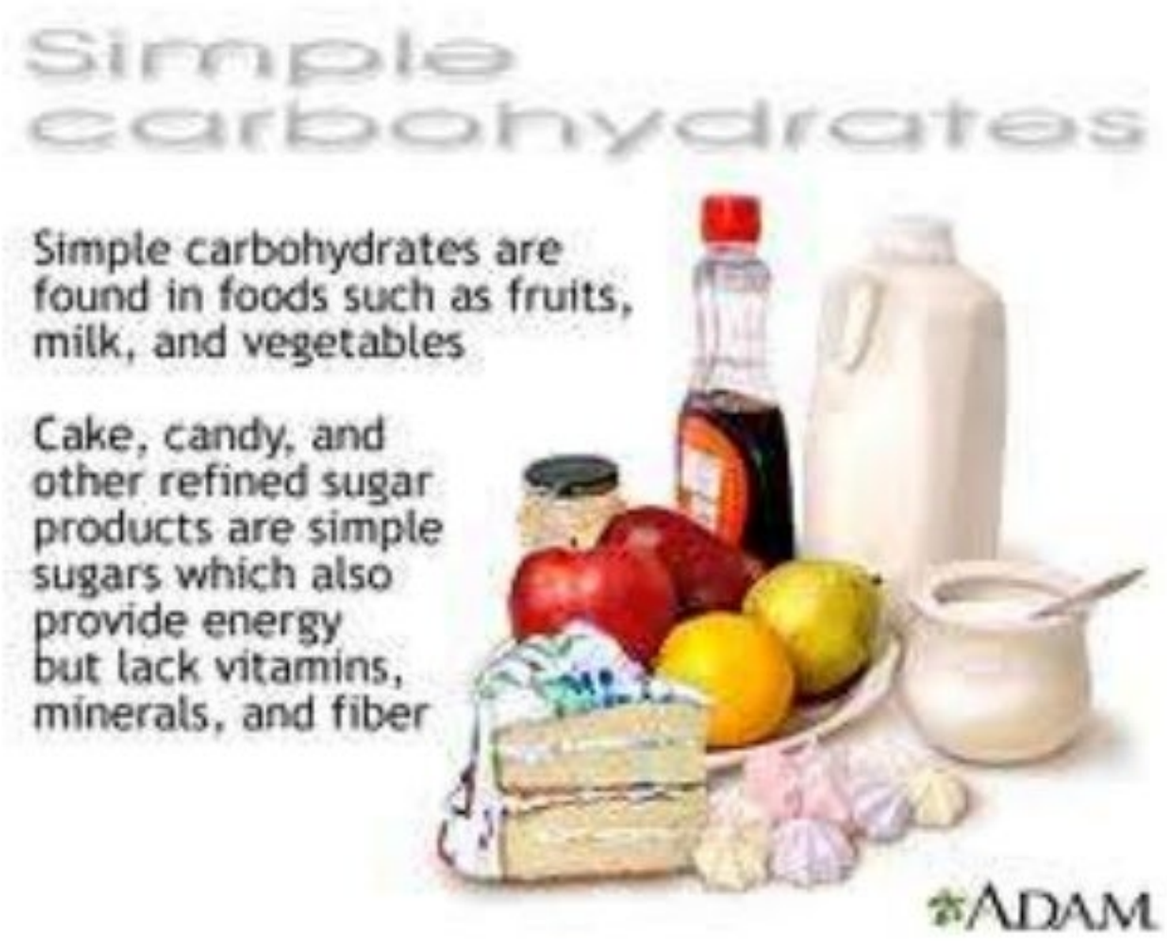


Biomolecules

- All of our biomolecules are classified into four groups:
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic Acids
- Each of these classes have different structures and functions.

Carbohydrates

- **Carbohydrates (carbs)** are biomolecules used for energy and structural support.
- Breaking carbs down provides us with energy.

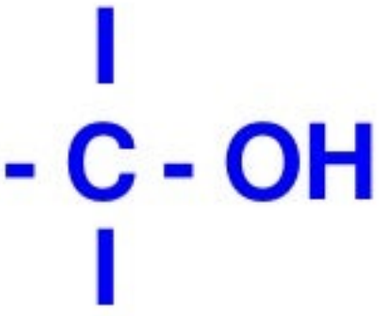


Carbohydrates

- Carbohydrates are made up of **carbon, hydrogen and oxygen.**
- The ratio of these elements is roughly 1carbon: 2 hydrogen :1 oxygen.

- On the basis of hydrolysis
- Monomer: **Monosaccharide**
- Dimer: **Disaccharide**
- Polymer: **Polysaccharide**

Carbohydrates (glycans) have the following basic composition:

$(CH_2O)_n$ or 

- Monosaccharides - simple sugars with multiple OH groups. Based on number of carbons (3, 4, 5, 6), a monosaccharide is a triose, tetrose, pentose or hexose.
- Oligosaccharides – 2 to 10 monosaccharides covalently linked.
- Polysaccharides - polymers consisting of chains of monosaccharide or disaccharide units.

CARBOHYDRATES

Sugars

Monosaccharides

- Aldoses
- Ketoses

Oligosaccharides

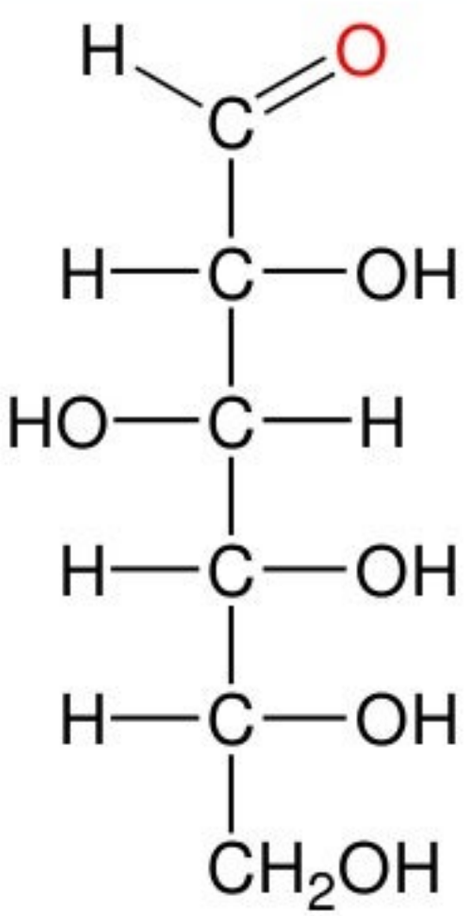
- Disaccharides
- Trisaccharides

Non-sugars (Polysaccharides)

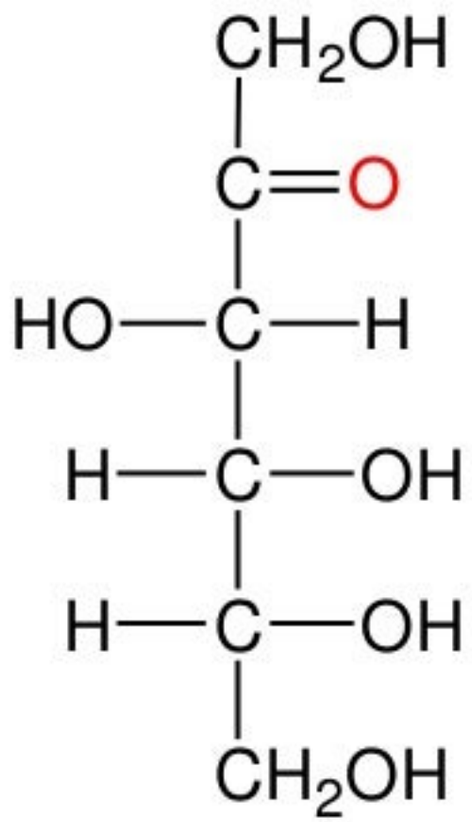
- Homopoly saccharides
- Heteropoly saccharides

Monosaccharides:

They are the simplest carbohydrates that cannot be broken into smaller units on hydrolysis.



D-glucose



D-fructose

- Aldoses (e.g., glucose) have an aldehyde group at one end
- Ketoses (e.g., fructose) have a keto group, usually at C2.

cabohydrates

Oligosaccharides

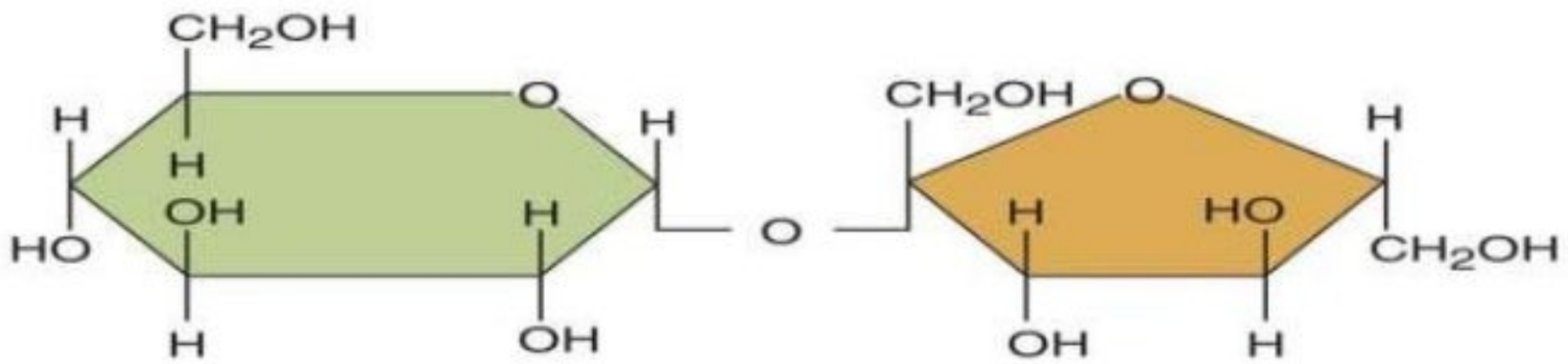
- The carbohydrates which can give two to ten monosaccharides on hydrolysis.so they can be disaccharides like sucrose,maltose,lactose etc

polysaccharides

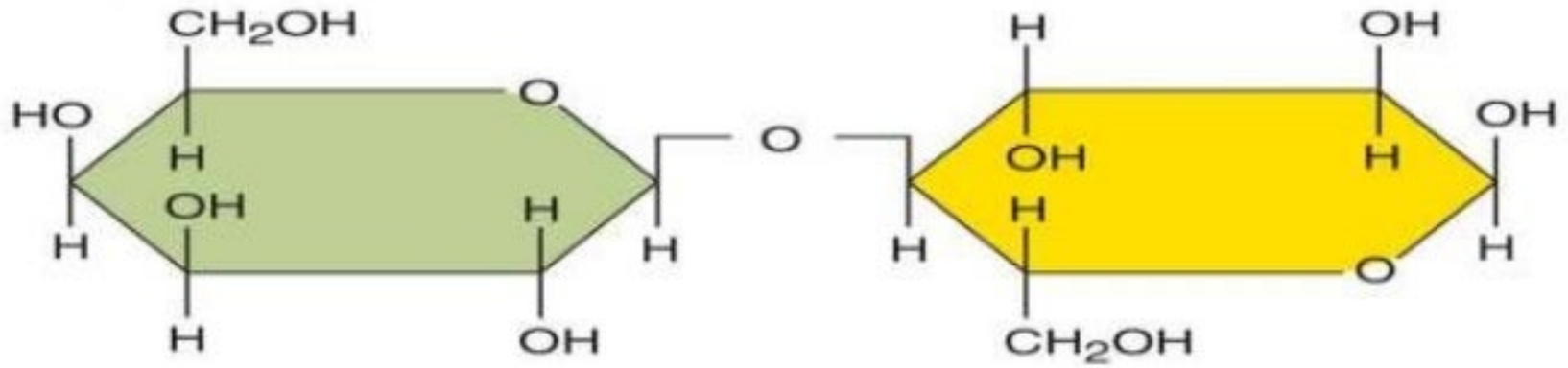
- The carbohydrates which can yeild more than ten monosaccharide units on hydrolysis.eg : starch cellulose,glycogen etc

Oilgosaccharides

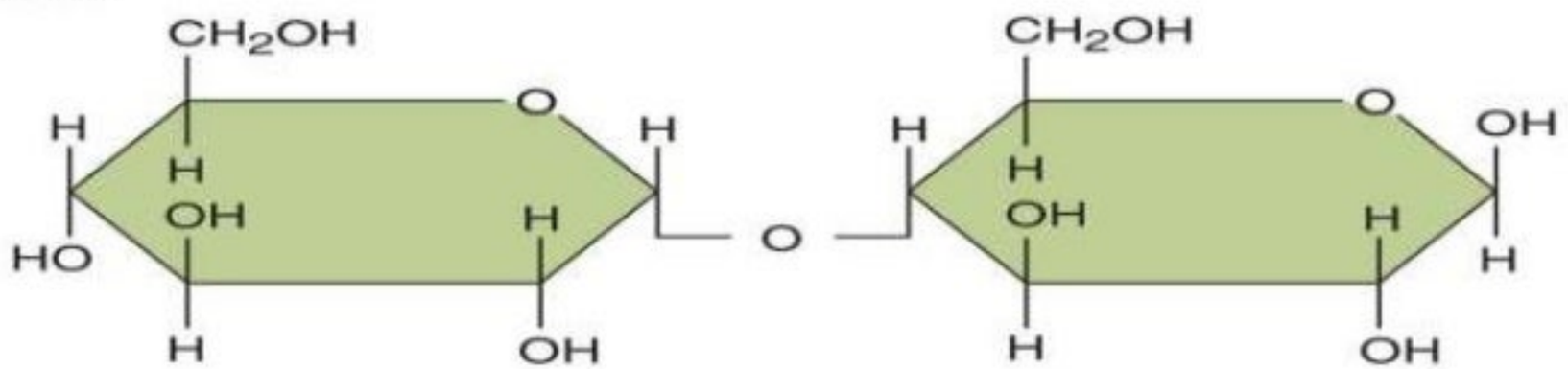
Sucrose



Lactose

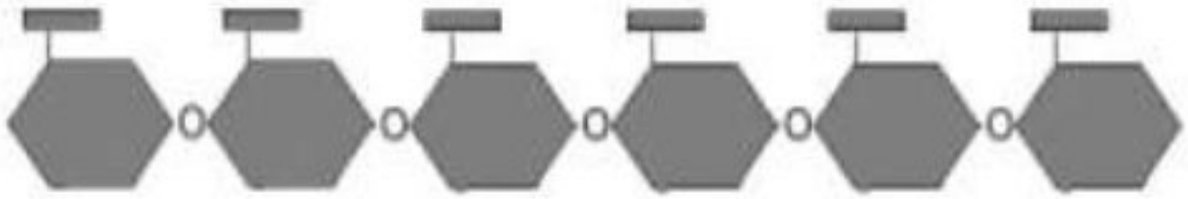


Maltose

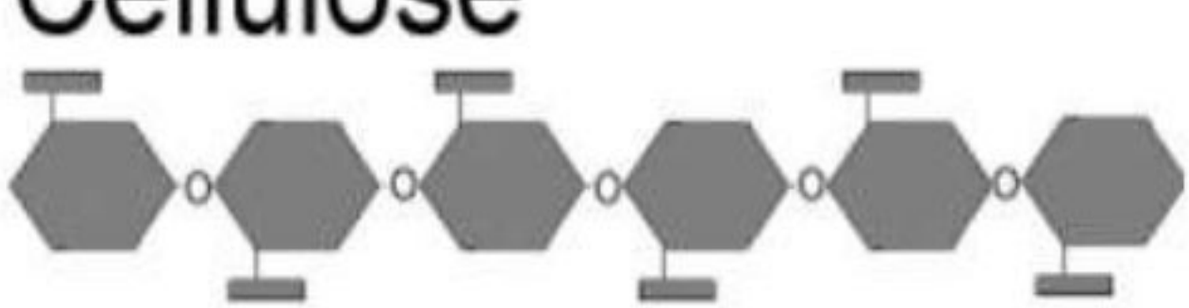


Polysaccharides...

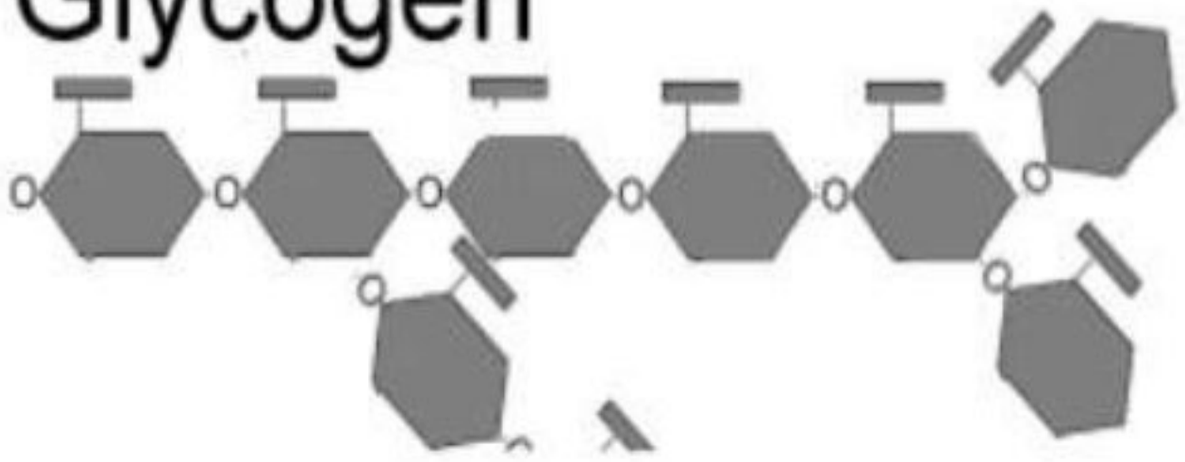
Starch



Cellulose



Glycogen



Structure of glucose(video)

Functions of Carbohydrates:

1. Carbohydrates serve as a major source of energy in animal body.
2. They are essential components of production, temperature control and proper functioning of the different parts of the animal body.
3. They are essential components of milk as lactose.
4. They are stored as glycogen, excess of carbohydrates in the diet is converted into fat and stored in the fat depot. These are reserve energy materials of the body in liver and muscles of animals and starch in plants.
5. Carbohydrates are helpful in absorption of calcium and phosphorus in younger animals.
6. They help the secretion of digestive juices in gastrointestinal tract.

Protein

- **Proteins** serve many vital functions in our body:
  - Structural support
  - Speeding up chemical reactions
  - Transport of molecules
  - …and many more!

Protein(video)

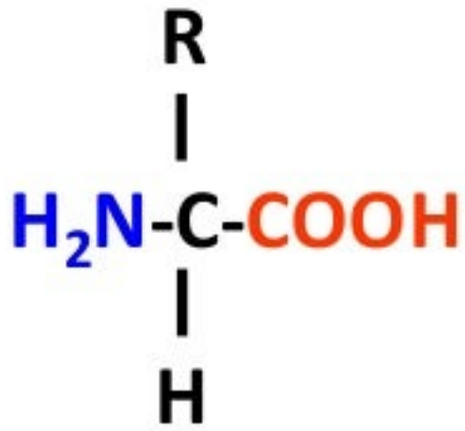
Protein

- All proteins contain carbon, hydrogen, oxygen and nitrogen.
- In addition, sulfur may be present as well.

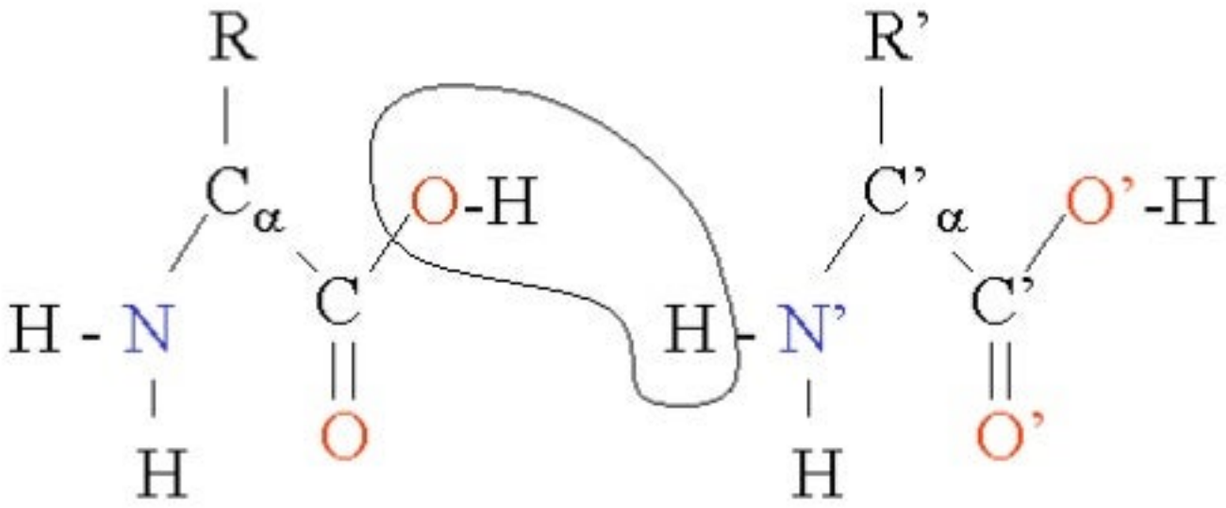
- Monomer: **Amino acid**
- Polymer: **Protein or polypeptide**
  - A peptide is a chain of amino acids, so a polypeptide is several chains put together.

Amino acids

- **amino group**, **carboxyl group**, hydrogen and a **variable** side group (residue) each joined to a central carbon atom



Protein



- Amino acids are bound together through dehydration synthesis.
  - The C-group of one amino acid binds to the N-group of another.
  - We call these bonds **peptide bonds.**

Protein

- Proteins have four phases of production:
  - **Primary**: Amino acids are bound together.
  - **Secondary**: Individual amino acids are bent and molded as needed.
  - **Tertiary**: The entire chain of amino acids is bent and molded as needed, forming a sub-unit.
  - **Quaternary**: Multiple completed sub-units are fitted together to make a complete protein.

Types of protein

- On the basis of molecular structure
- **Fibrous proteins**
- Involved in structure: tendons ligaments blood clots
  (e.g. collagen and spiders silk)
- Contractile proteins in movement: muscle, microtubules
  (cytoskelton, mitotic spindle, cilia, flagella).

- **Globular proteins**
- most proteins which move around
  (e.g. albumen, casein in milk)
- Proteins with binding sites:
  enzymes, hemoglobin, immunoglobulins, membrane receptor sites.

Proteins classified by function

Classification of Some Proteins and their Functions

Class of Protein	Function in the body	Examples
Structural	Provide structural components	Collagen Keratin
Contractile	Move muscles	Myosin Actin
Transport	Carry essential substances throughout the body	Hemoglobin Lipoprotein
Storage	Store nutrients	Casein Ferritin
Hormone	Regulate body metabolism and nervous system	Insulin Growth hormone
Enzyme	Catalyze biochemical reactions in the cells	Sucrase Trypsin
Protection	Recognize and destroy foreign substances	immunoglobulins

THE NUCLEIC ACIDS

Two types of nucleic acid are found

- Deoxyribonucleic acid (DNA)
- Ribonucleic acid (RNA)

The distribution of nucleic acids in the eukaryotic cell

- DNA is found in the nucleus
  with small amounts in mitochondria and chloroplasts
- RNA is found throughout the cell

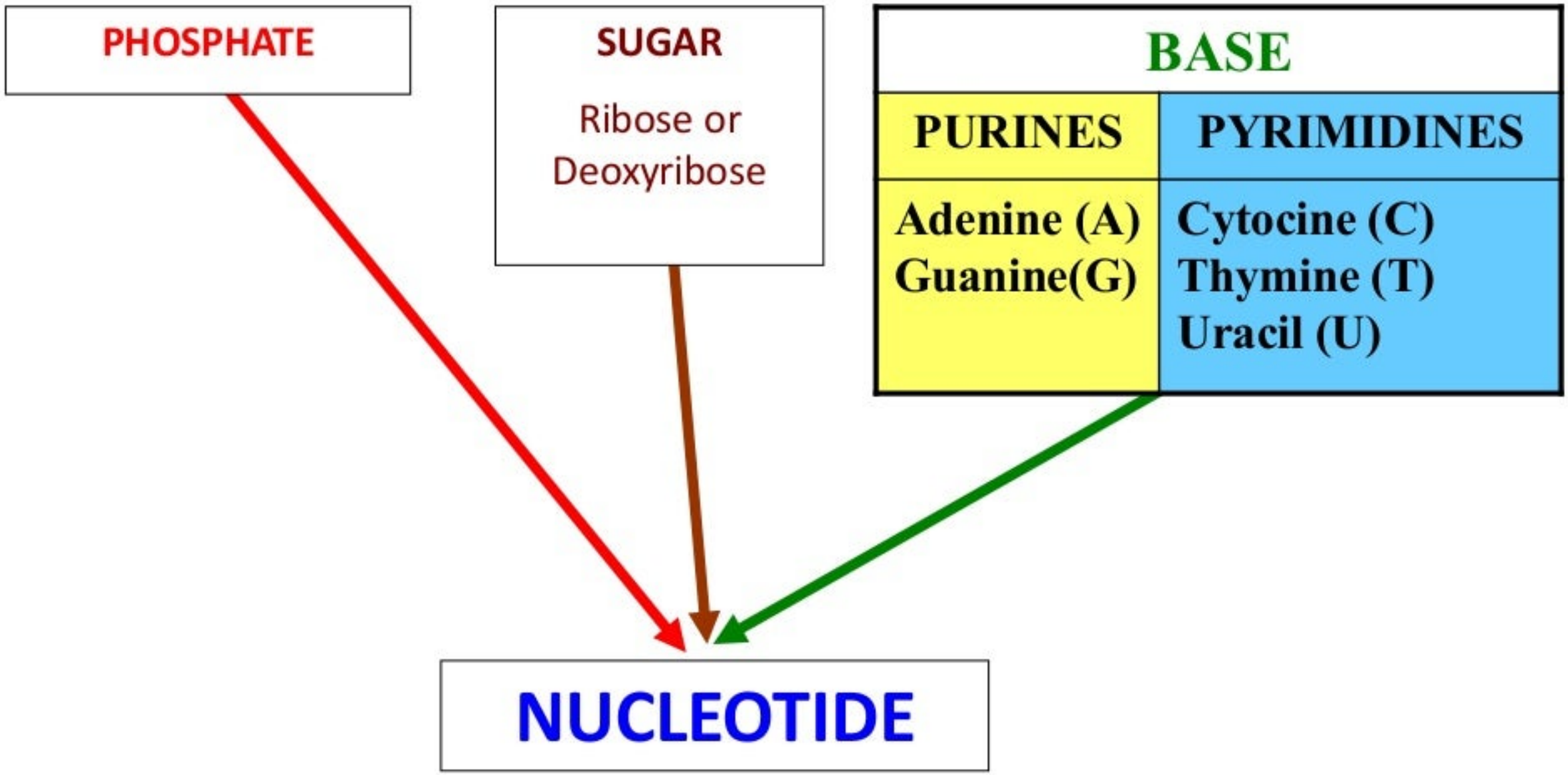
DNA as genetic material: The circumstantial evidence

1. Present in all cells and virtually restricted to the nucleus
2. The amount of DNA in somatic cells (body cells) of any given species is constant (like the number of chromosomes)
3. The DNA content of gametes (sex cells) is half that of somatic cells.
   In cases of polyploidy (multiple sets of chromosomes) the DNA content increases by a proportional factor
4. The mutagenic effect of UV light peaks at 253.7nm. The peak for the absorption of UV light by DNA

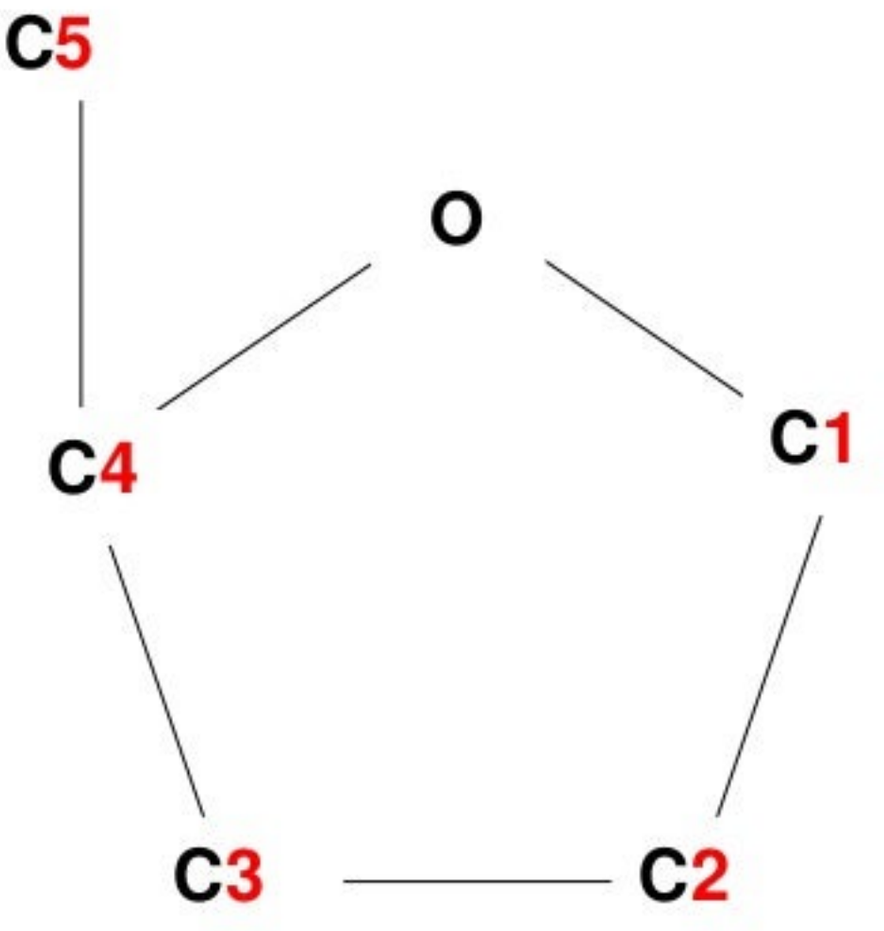
NUCLEIC ACID STRUCTURE

- Nucleic acids are **polynucleotides**
- Their building blocks are **nucleotides**

NUCLEOTIDE STRUCTURE

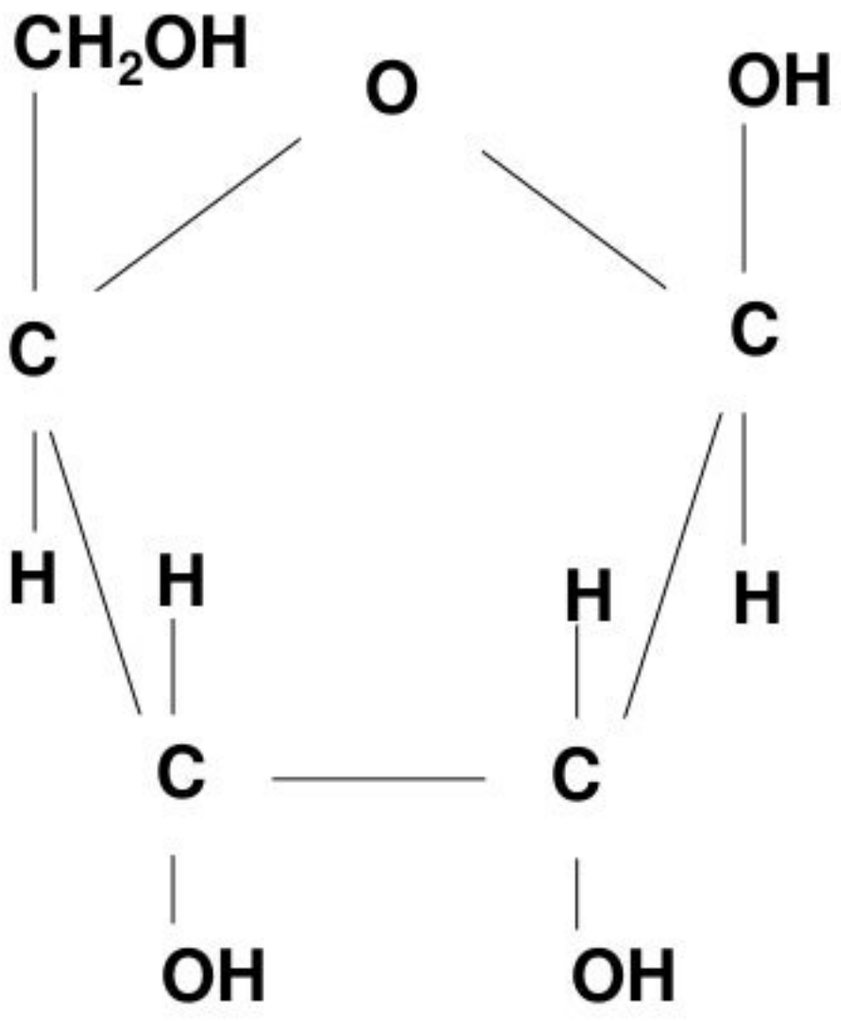


Ribose is a pentose

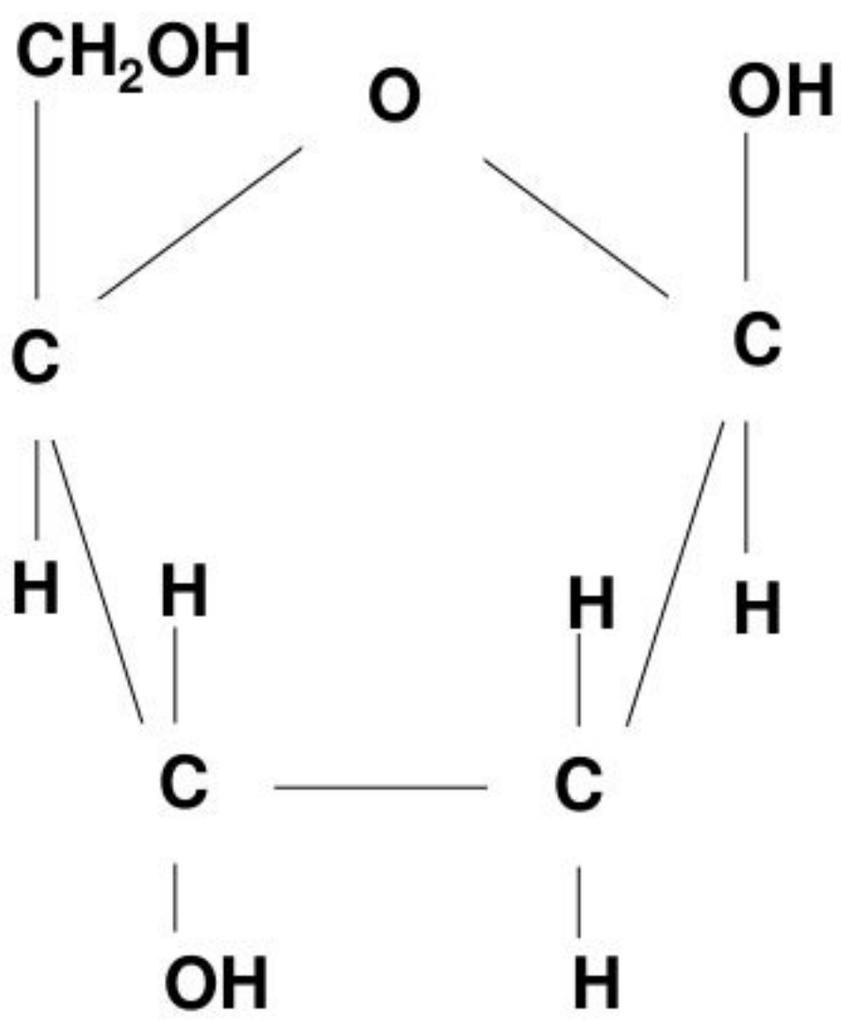


Spot the difference

RIBOSE

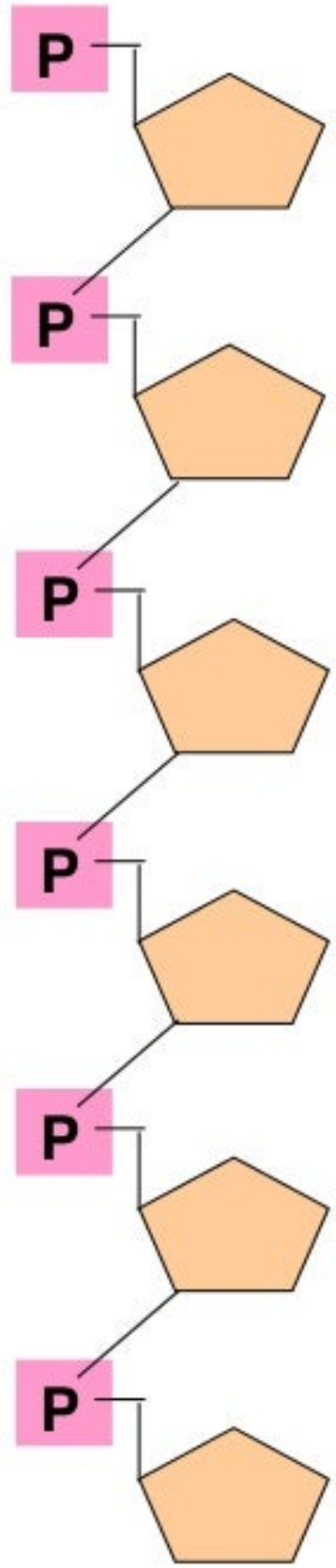


DEOXYRIBOSE



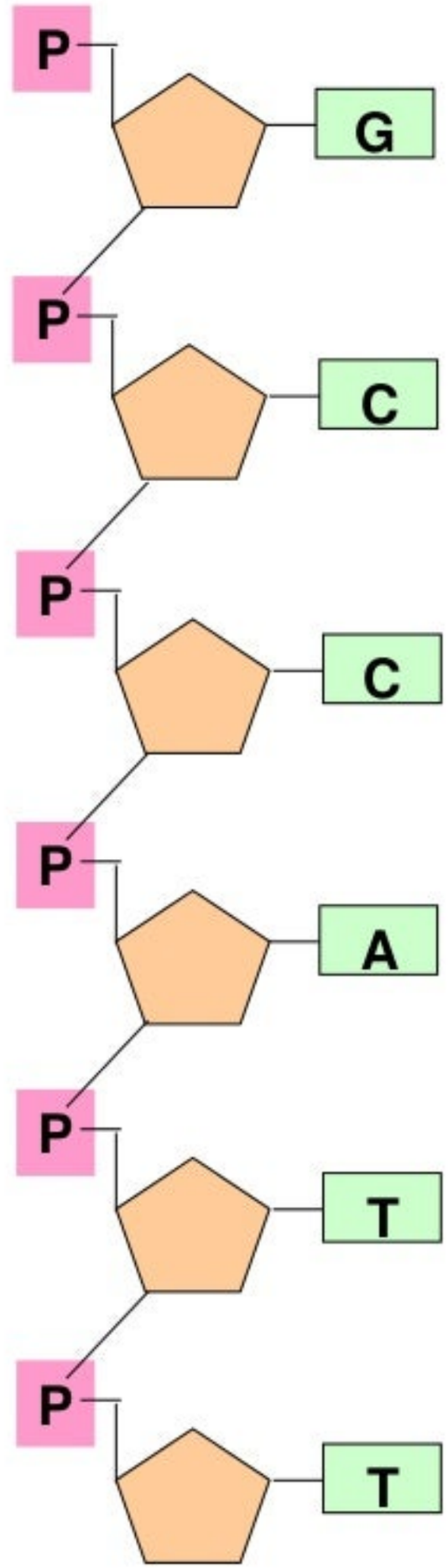
THE SUGAR-PHOSPHATE BACKBONE

- The nucleotides are all orientated in the same direction
- The phosphate group joins the 3rd Carbon of one sugar to the 5th Carbon of the next in line.

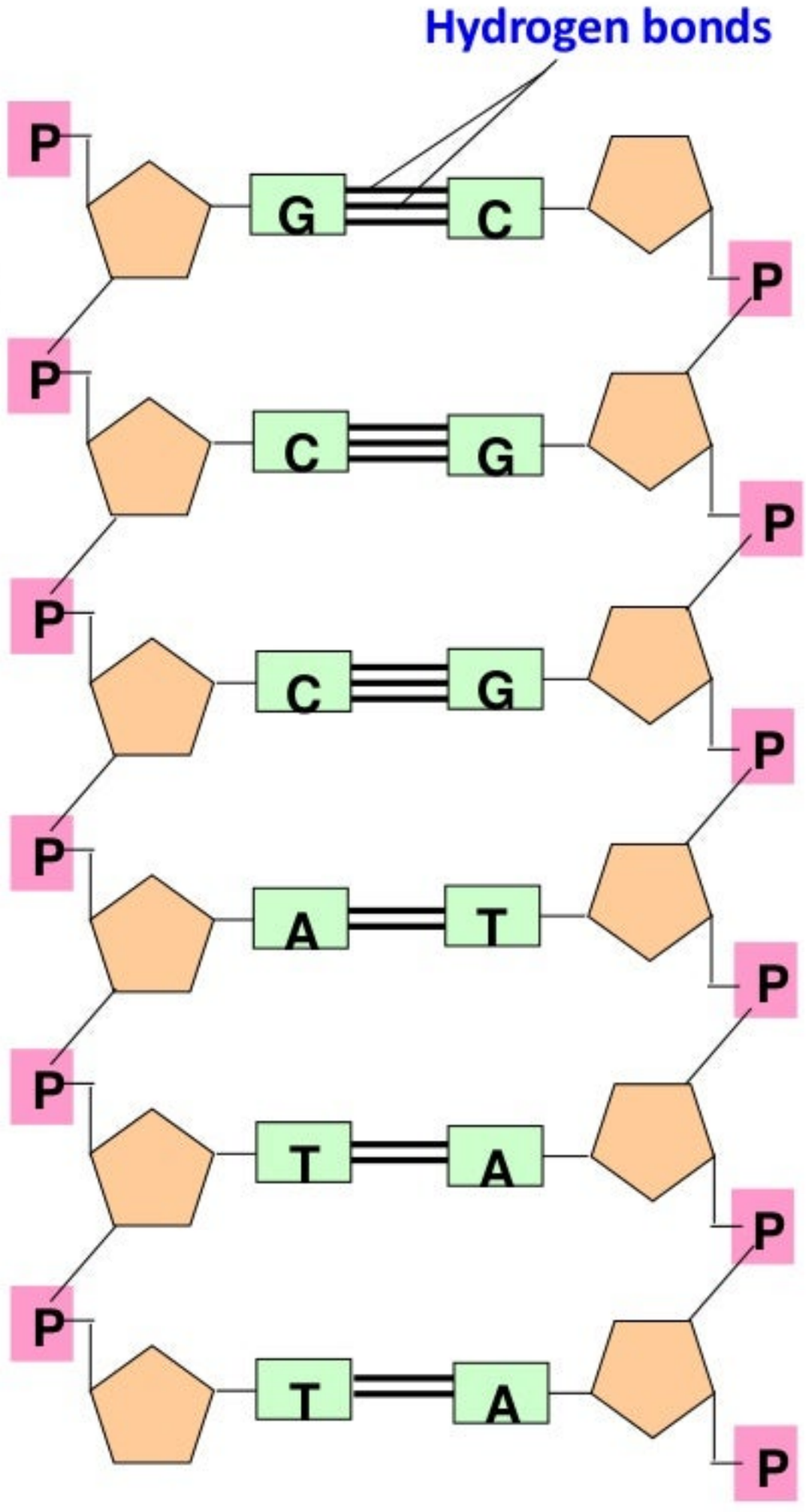


ADDING IN THE BASES

- The bases are attached to the 1st Carbon
- Their order is important
It determines the genetic information of the molecule



DNA IS MADE OF TWO STRANDS OF POLYNUCLEOTIDE



DNA IS MADE OF TWO STRANDS OF POLYNUCLEOTIDE

- The sister strands of the DNA molecule run in opposite directions (**antiparallel**)
- They are joined by the bases
- Each base is paired with a specific partner:

A is always paired with **T**

G is always paired with **C**

Purine with Pyrimidine

- Thus the sister strands are **complementary** but **not** identical
- The bases are joined by **hydrogen bonds**, individually weak but collectively strong.

Function of nucleic acid

Nucleic Acid

Deoxy ribonucleic acid (DNA)

Double stranded,helical,polymers of deoxyribonucleotides found in the nucleus of the cell.

Function :Storage of the genetic material.

Ribonucleic acid (RNA)

Single stranded,non-helical,polymers of ribonucleotides found in the nucleus and cytoplasm of the cell.

Function : To transfer the genetic information from nucleus to cytoplasm for protein synthesis.

Further nsub divided into three types

Messenger RNA / mRNA

Function : It is a complementary copy of selected regions of the DNA. It carries the genetic message from the nucleus to the cytoplasm and acts as the template for protein synthesis.

Ribosomal RNA / rRNA

Function : rRNA along with proteins forms the ribosomes which is the site of protein synthesis. Some of them have catalytic and coenzyme functions as well.

Transfer RNA / tRNA / Soluble RNA

Function : Transfer the amino acids from the cytoplasm to the site of protein synthesis.

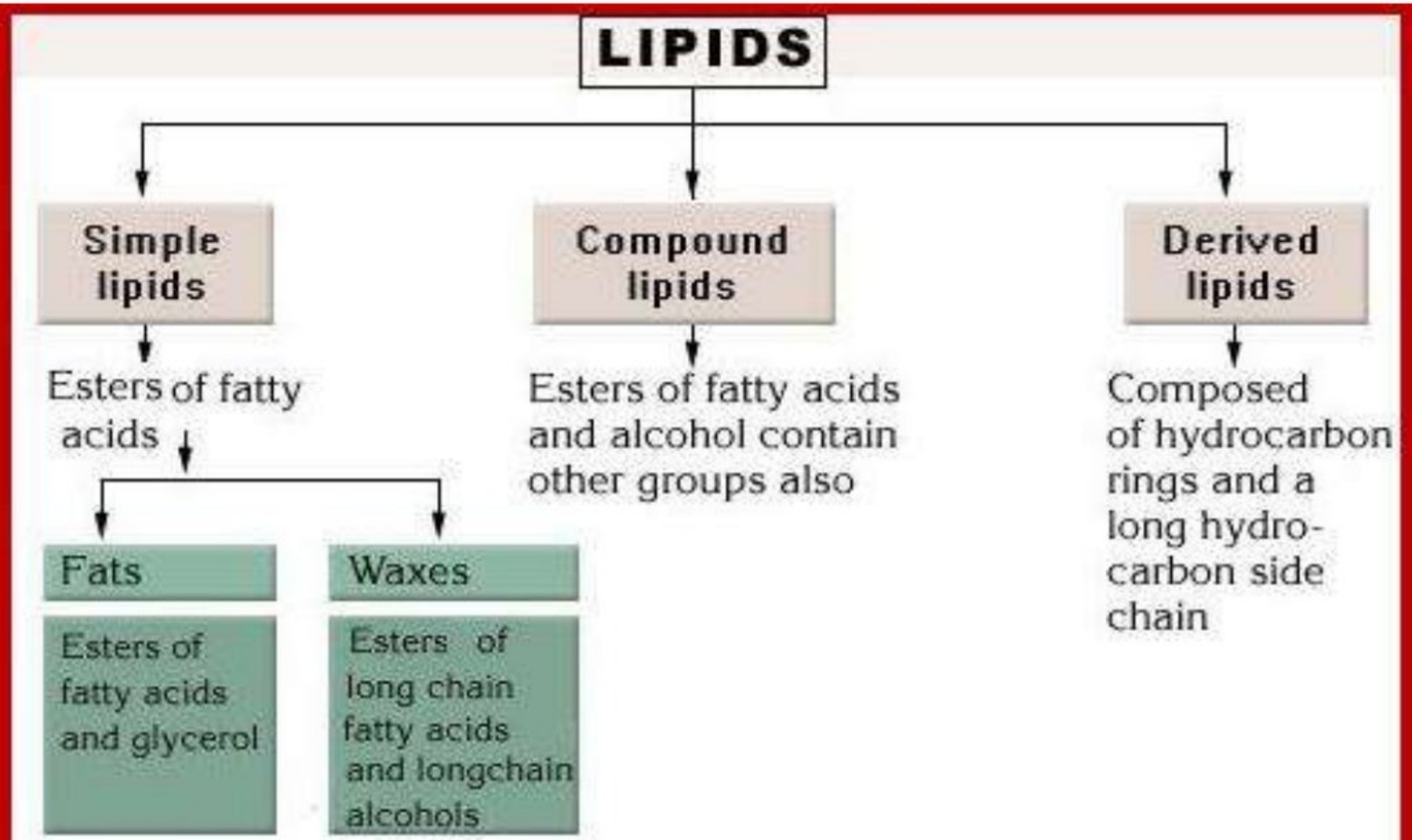
LIPIDS

Lipids

- The lipids are a heterogeneous group of compounds, including fats, oils, steroids, waxes, and related compounds, that are related more by their physical than by their chemical properties.

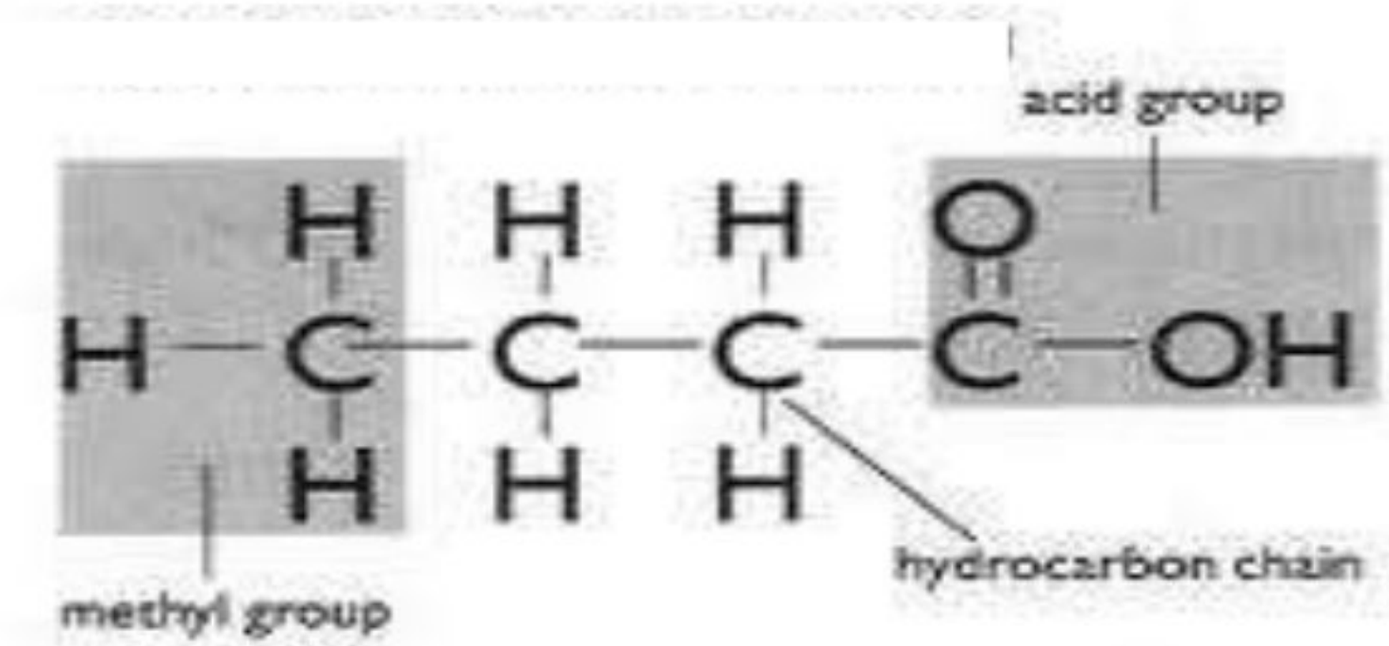
- They have the common property of being
- (1) relatively **insoluble in water** and (2) **soluble in nonpolar solvents** such as ether and chloroform.

Classification of lipids

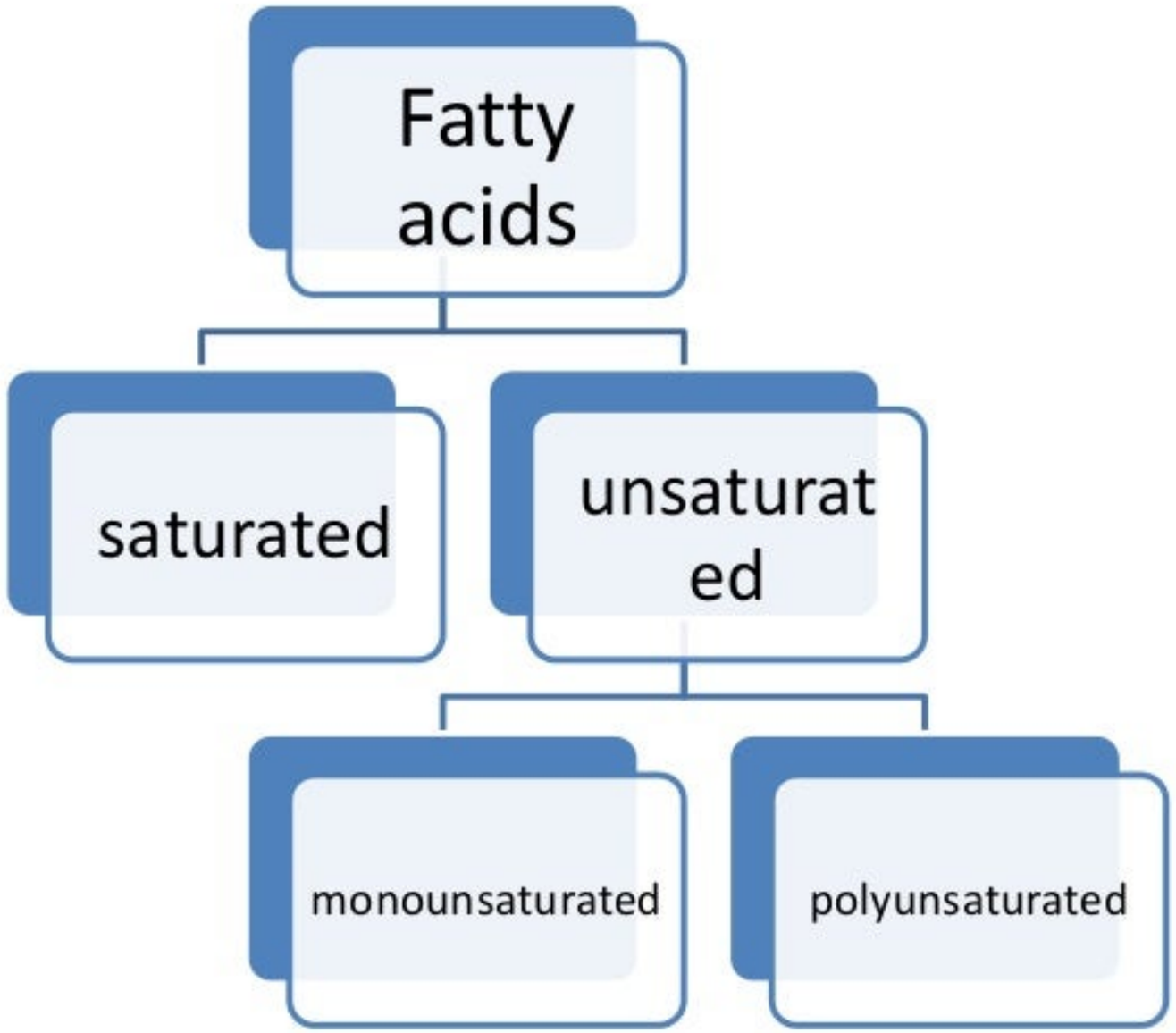


Fatty acids

- They are basic building blocks of lipids(simplest lipids).
- Fatty acids are carboxylic acids.



Classification of fatty acids



FATTY ACIDS

Saturation

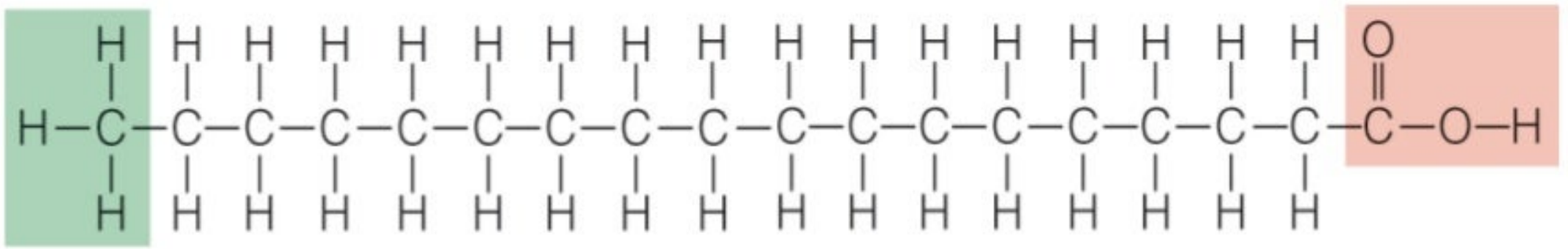
- **Saturated fatty acid** – carbon chains filled with hydrogen atoms (no C=C double bonds)
  1. Saturated fat – triglyceride containing 3 saturated fatty acids, such as animal fats (butter, lard) & tropical oils (palm, coconut)
  2. Appear solid at room temperature

FATTY ACIDS

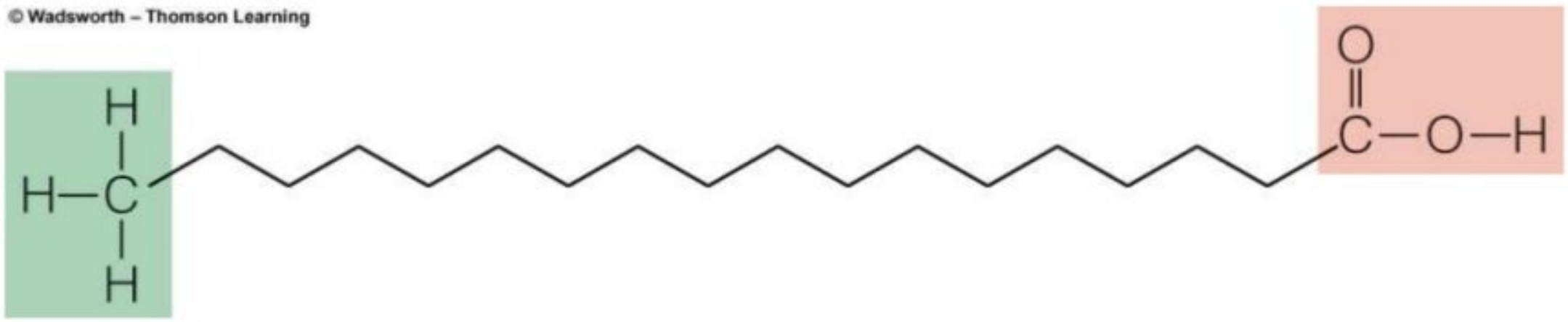
- **Unsaturated fatty acid** – carbon chains lack some hydrogens (>1 C=C double bond)
    1. Monounsaturated fat – triglyceride containing fatty acids with 1 double bond; i.e. canola & olive oil
    2. Polyunsaturated fat- triglycerides containing a high % of fatty acids with >2 double bonds; i.e. corn, safflower, soybean, sunflower oils and fish; 3. Appear liquid at room temperature

Saturated fatty acid

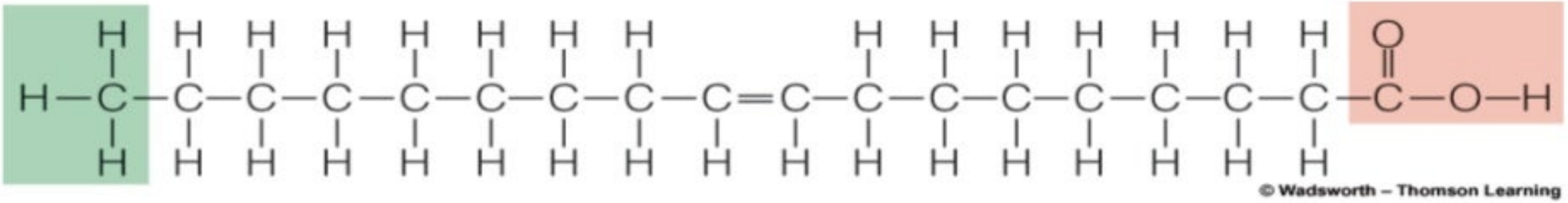
- Length of carbon chain



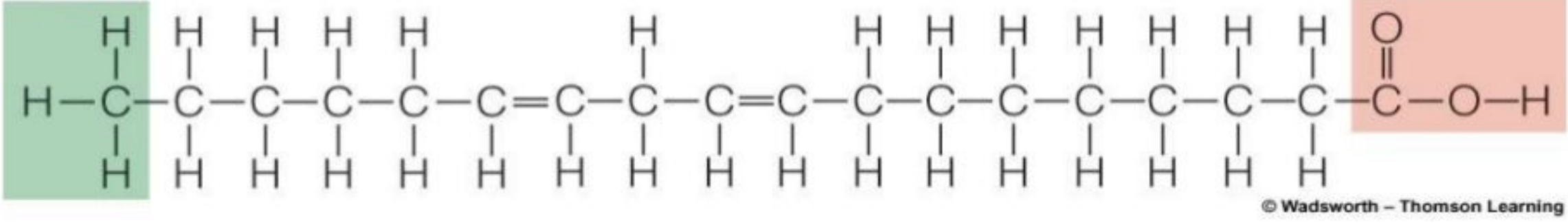
Stearic acid – 18-carbon, saturated



Simplified structure



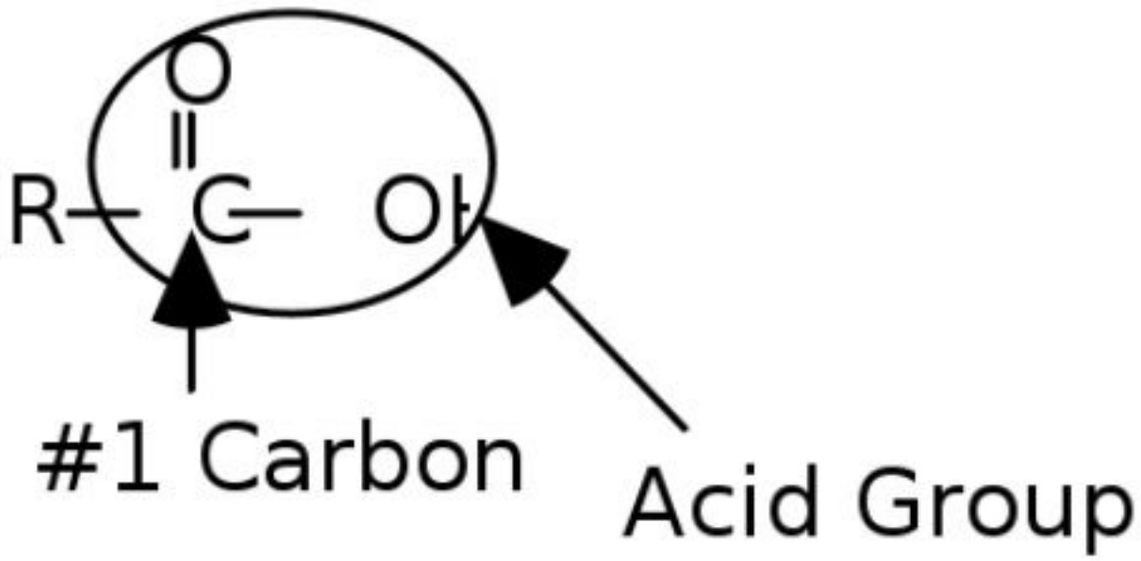
Oleic acid – 18-carbon, monounsaturated

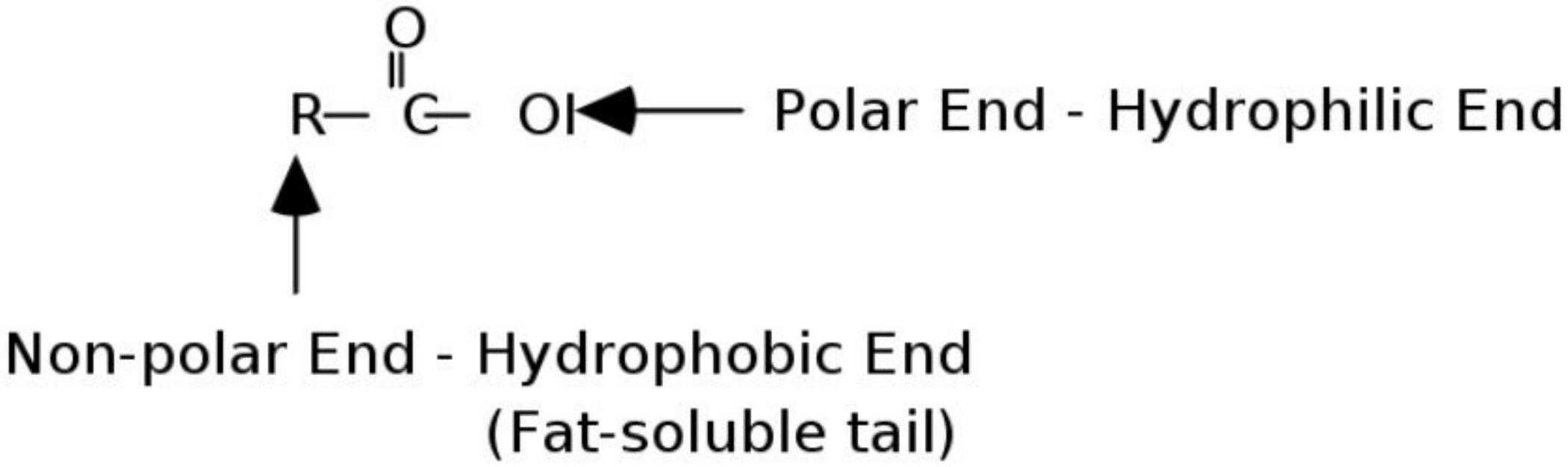


Linoleic acid – 18-carbon, polyunsaturated

Fatty Acids are amphipathic molecules. Why?

Because they have both polar(hydrophilic) and non-polar(hydrophobic) portions in their structure


O
R
C
OH
#1 Carbon
Acid Group


O
R
C
OH
Polar End - Hydrophilic End
Non-polar End - Hydrophobic End
(Fat-soluble tail)

TYPES OF LIPIDS

1. Triglycerides

2. Phospholipids

3. Sterols

TRIGLYCERIDES

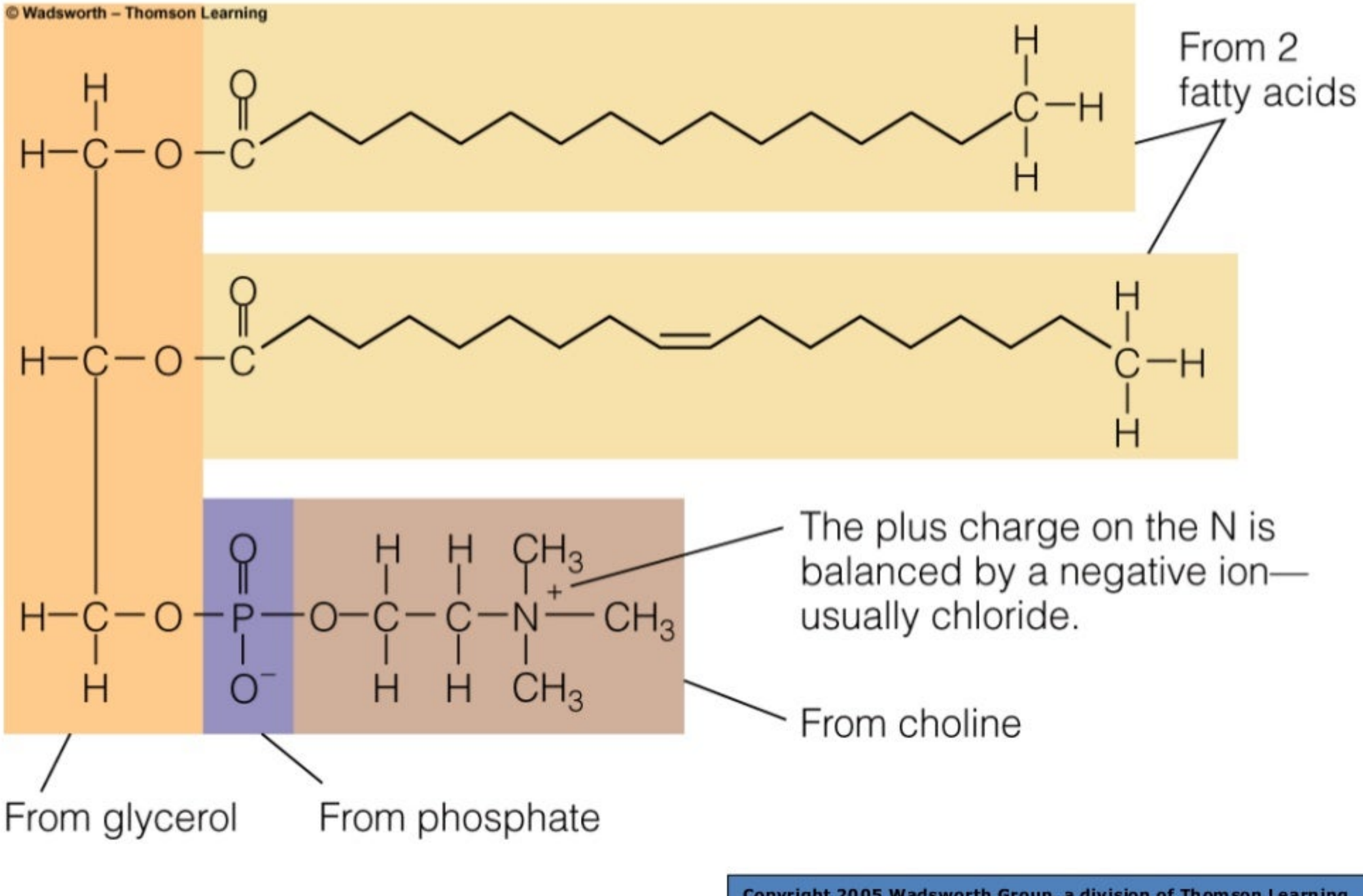
- **Triglycerides** – Fats & Oils
    1. Predominate form of fat in foods and major storage form of fat in the body
    2. Structure – composed of 3 fatty acids + glycerol

PHOSPHOLIPIDS

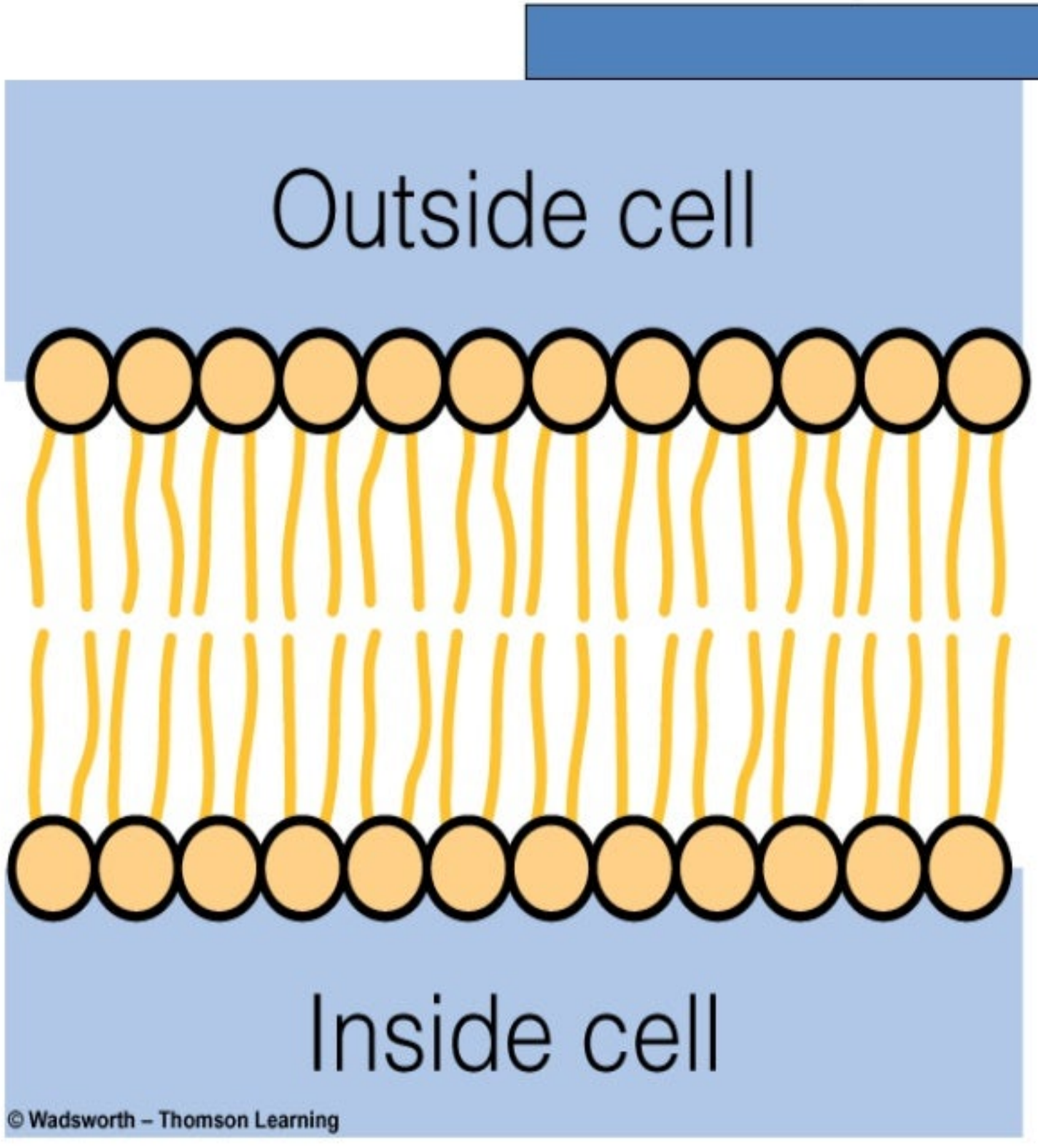
- **Phospholipids** – similar to triglycerides in structure except only 2 fatty acids + choline

  Phospholipids in foods: Lecithin, egg yolks, soybeans, wheat germ, peanuts

Lecithin



Phospholipids



Watery fluid

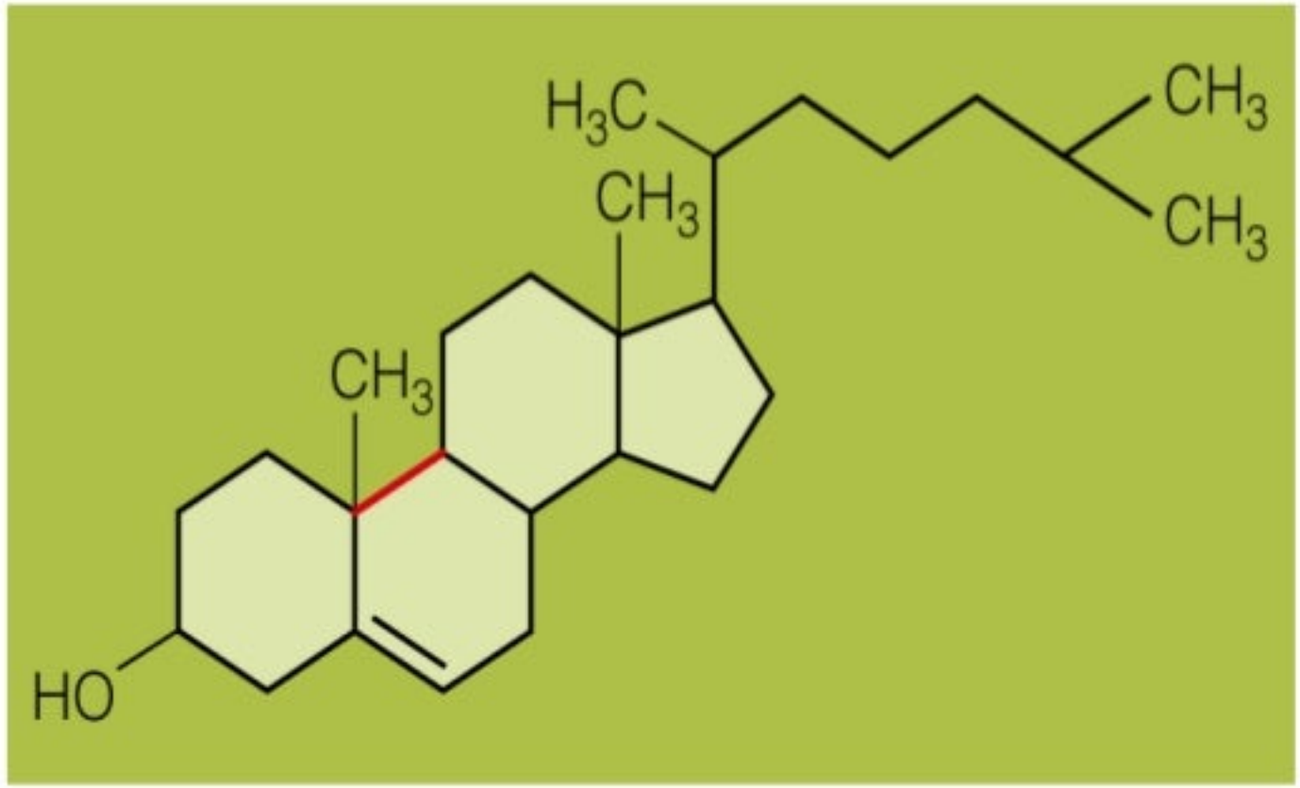
Glycerol heads

Fatty acid tails

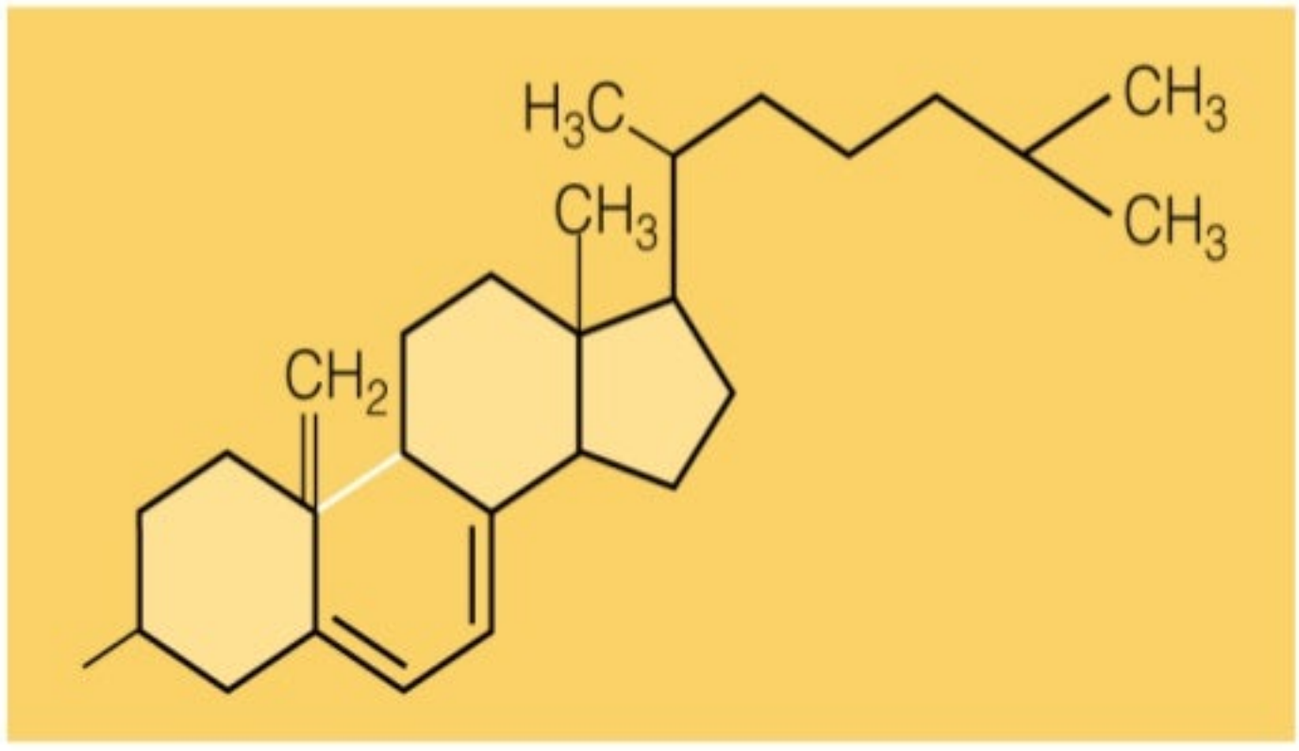
Watery fluid

Sterols

Structure consists of carbon rings



Cholesterol



Vitamin D_3

STEROLS

- Important part of:
    1. Sex hormones – testosterone
    2. Vitamin D
    3. Bile (aids fat digestion)
    4. Adrenal hormones - cortisol
    5. Cholesterol – in foods and made by the liver; dietary sources include egg yolks, liver, meats, dairy products

Functions of Lipids

- Lipids store energy for later use by the body.
- Lipids also serve as padding and protection for the body.
- Lipids do not dissolve in water (hydrophobic), but may contain parts that can dissolve in water.
- The H : O ratio is higher in lipids than it is in carbohydrates.