Organic Compounds

Carbohydrates, Lipids, and Proteins

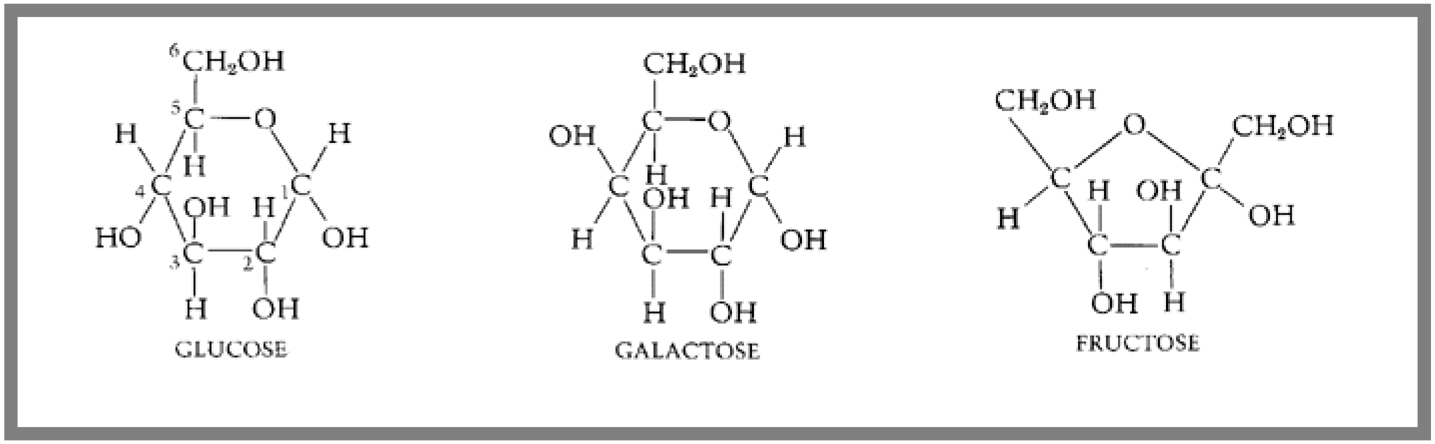
Simple Sugars

Simple carbohydrates are found in foods such as fruits, milk, and vegetables

Cake, candy, and other refined sugar products are simple sugars which also provide energy but lack vitamins, minerals, and fiber

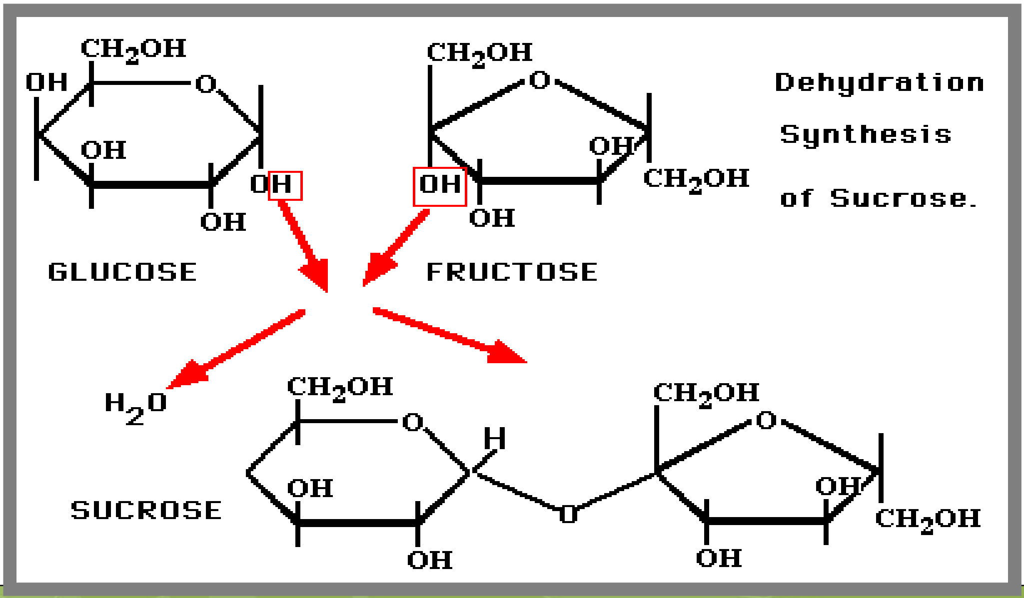
Monosaccharides

- Building blocks of carbohydrates
- Many end in ose
- Molecular formula $C_6H_{12}O_6$
- Carbon ring main structure
- Immediate energy source

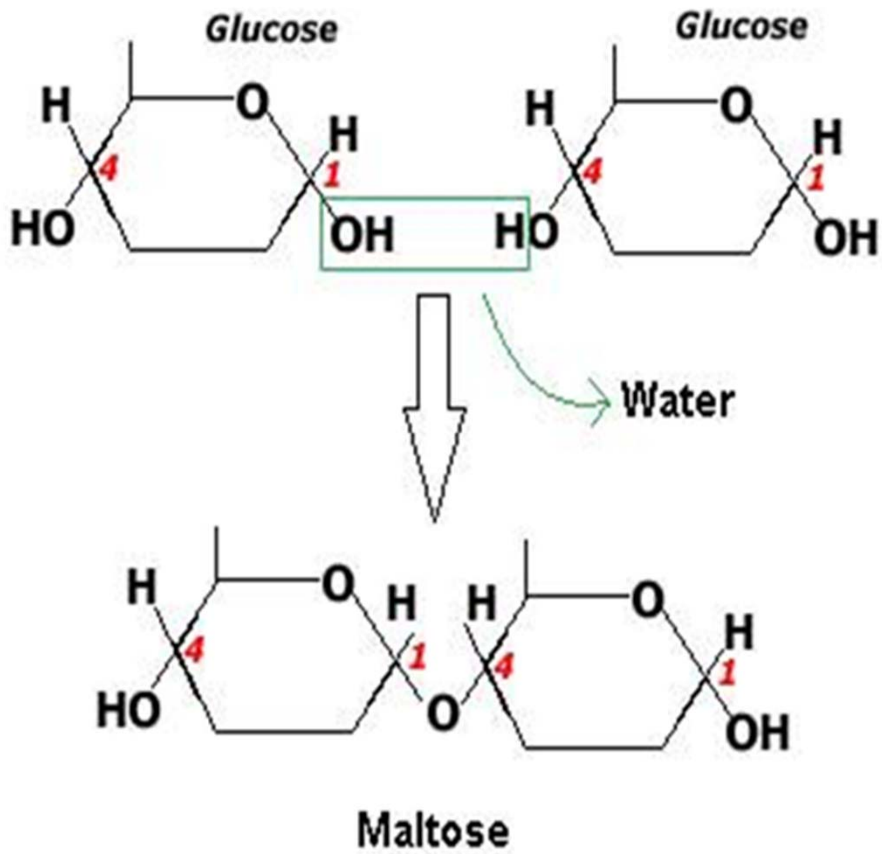


Dehydration Synthesis

- To make a disaccharide, 2 simple sugars must be linked together by removing a water molecule.
- Examples of disaccharides include: maltose, sucrose (common table sugar) and lactose
- Molecular formula: $C_{12}H_{11}O_{22}$

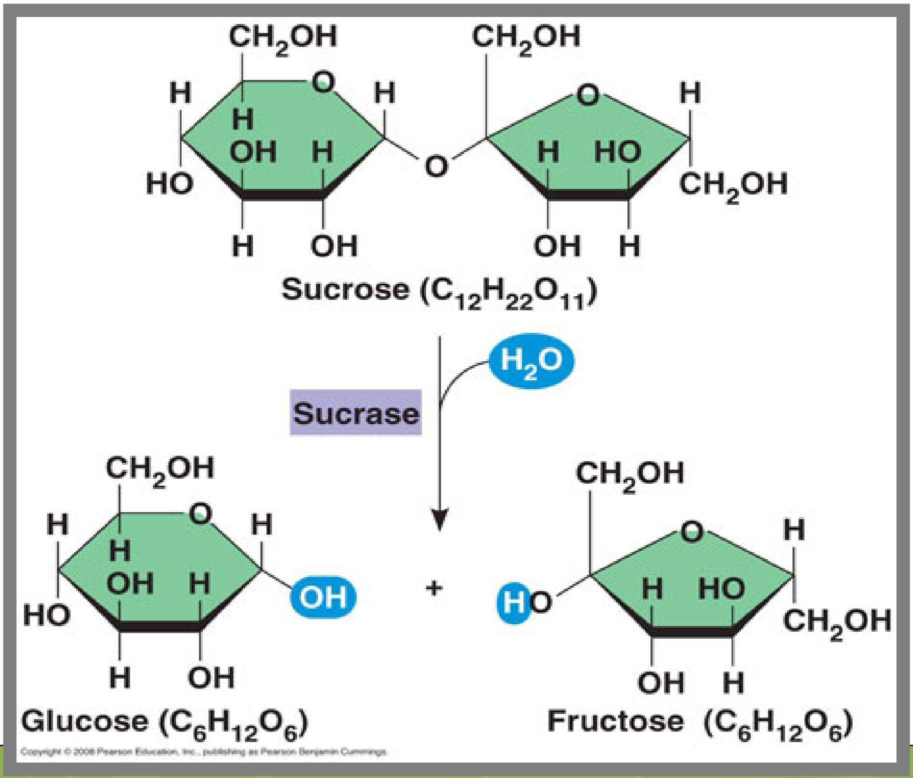


Disaccharide: Maltose



Enzymatic Hydrolysis

- Breaking down a complex substance into smaller, simpler units by adding a water and using enzymes (organic catalysts – get the reaction going but are not part of the overall chemical activity)



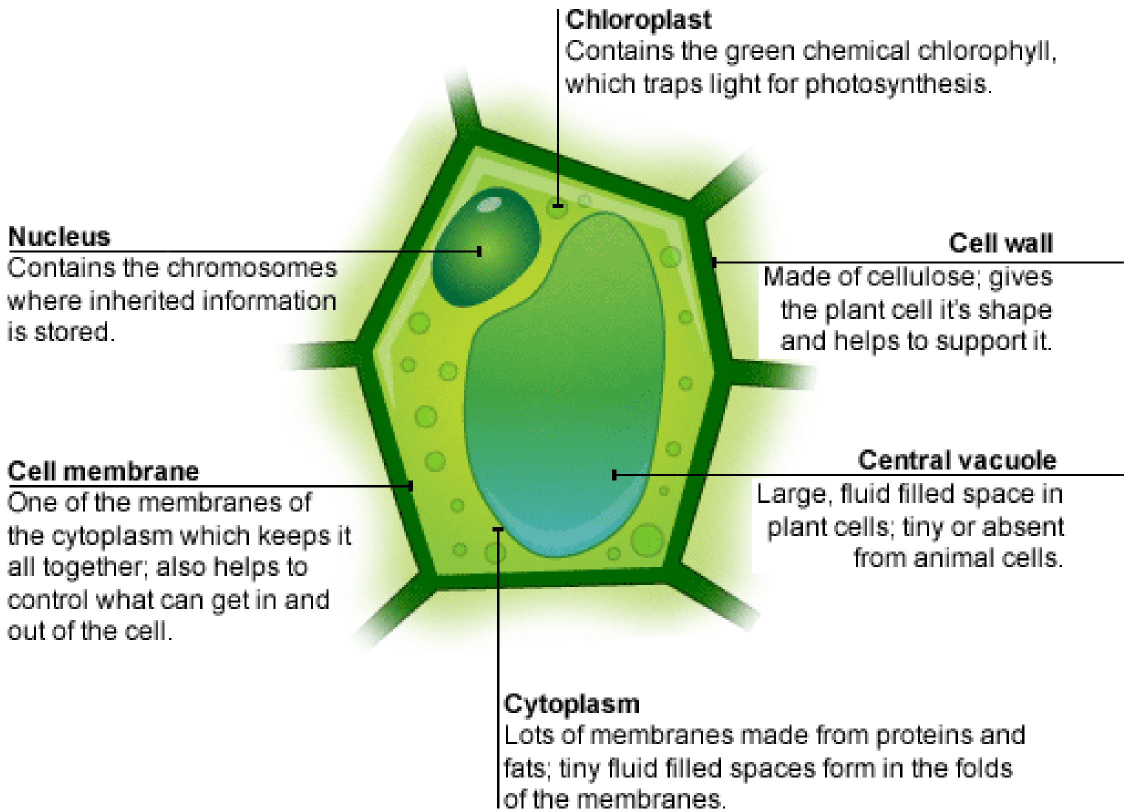
Polysaccharides (starches)

- Three or more monosaccharides linked together by dehydration synthesis (in a chain formation)
- **Polymer:** three or more of any basic repeating unit linked together in a chain-like structure
- **Examples include:**

  chitin (exoskeletons of insects & crustaceans

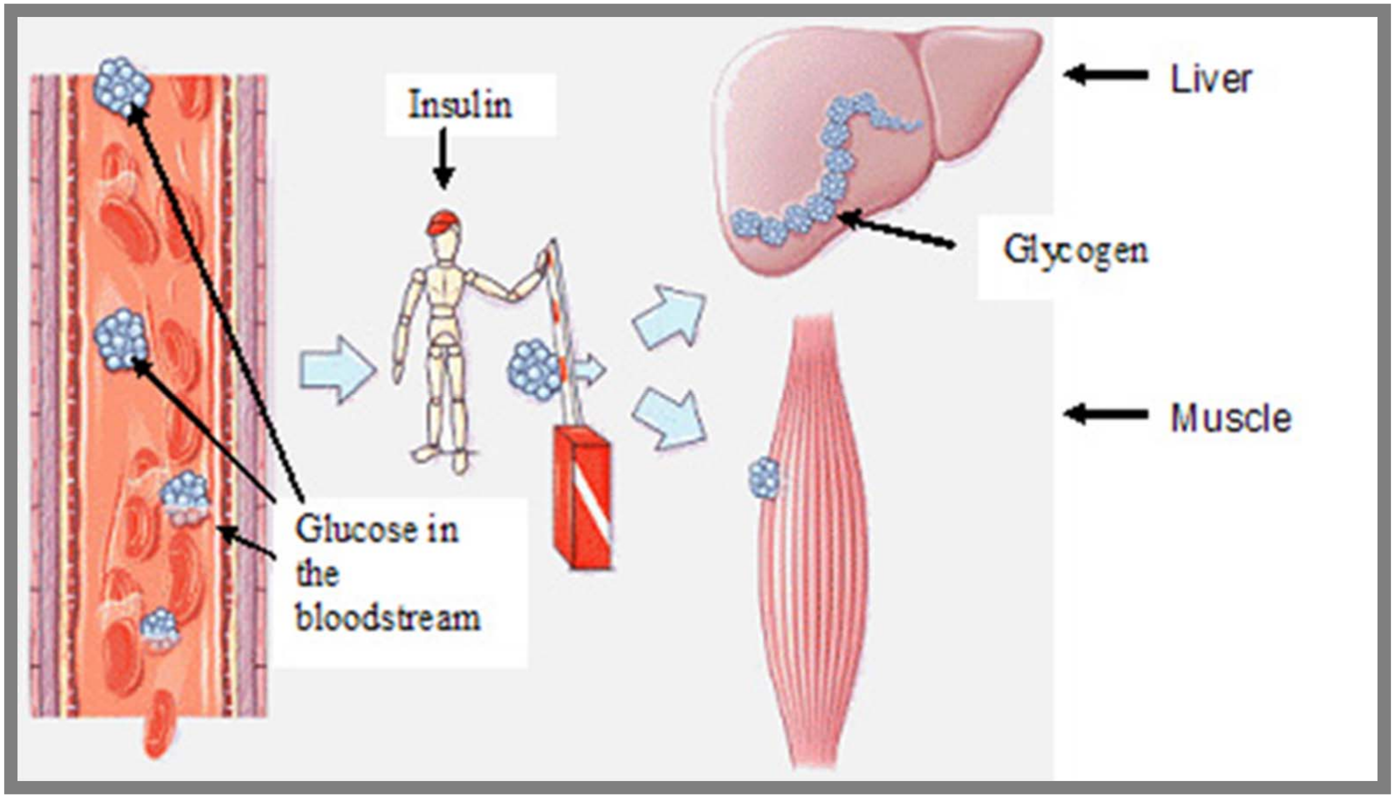
Polysaccharides (starches)

- **Cellulose** – makes up cell walls surrounding plant cells

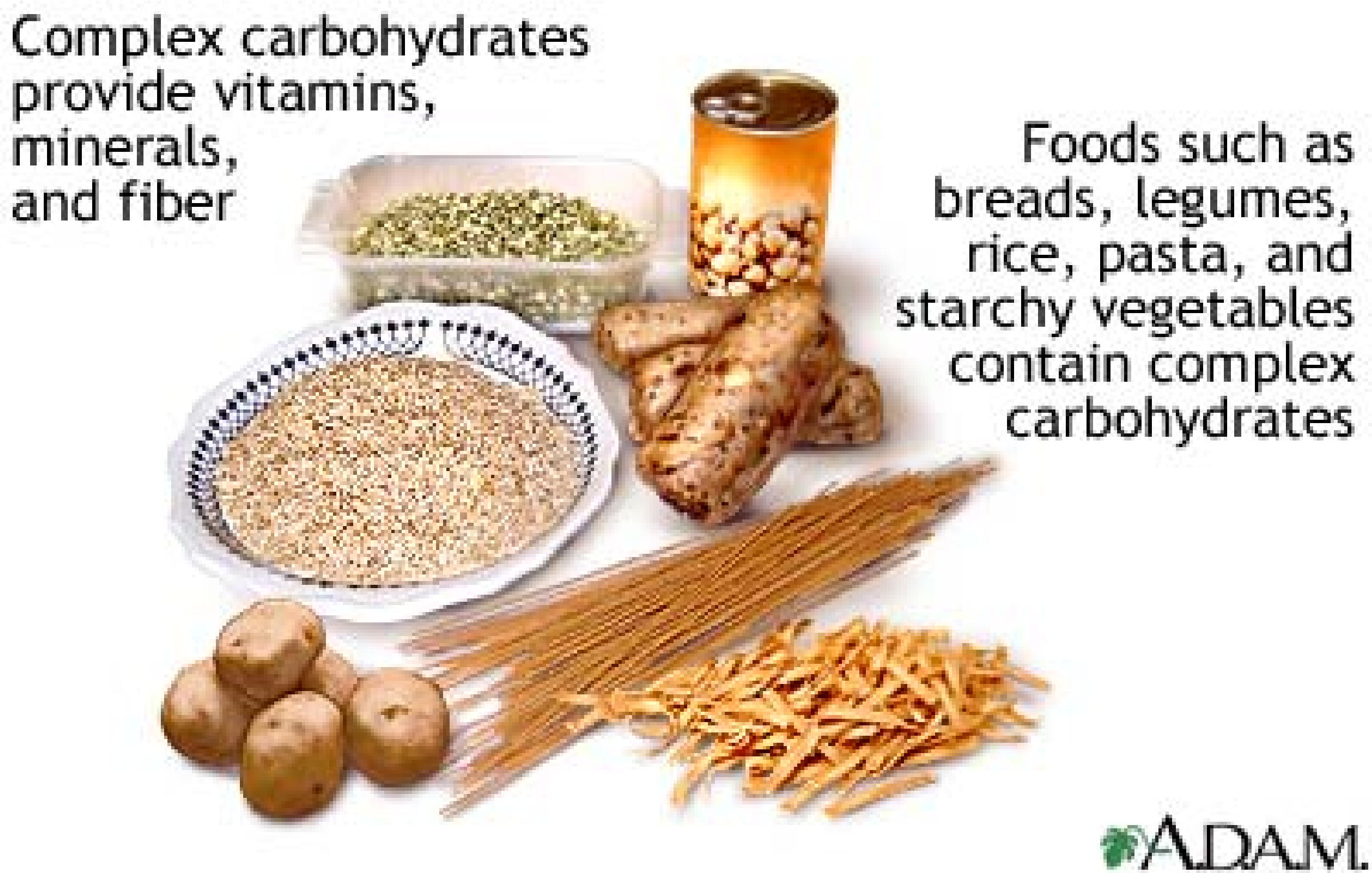


Polysaccharides (starches)

- **Glycogen** (animal starch) stored in liver and skeletal muscles.



Complex Carbohydrates

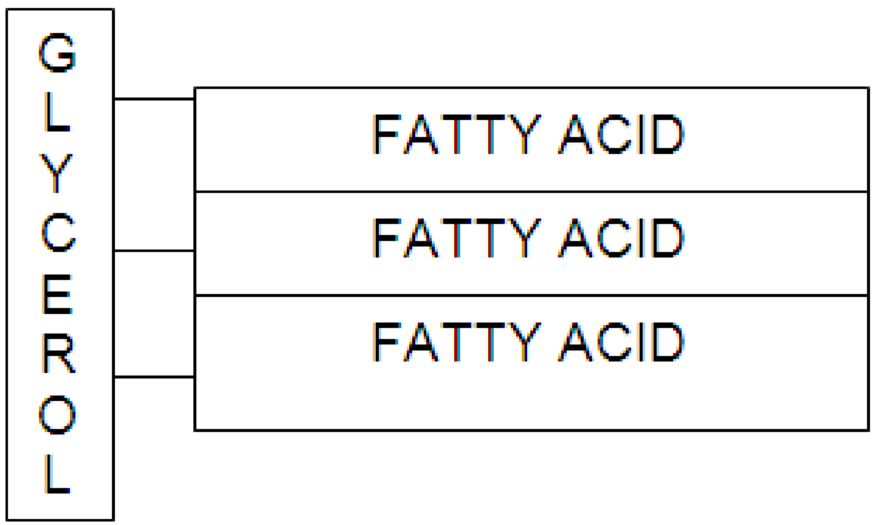


Lipids: Fats, Oils, & Waxes

- Contain the elements C, O, & H
- **RESERVE ENERGY SOURCE:** a ***gram of fat can provide up to 6 times*** the amount of energy as one gram of carbohydrates.
- **Lipids make up cell structures** such as cell membranes.
- In animal cells, **lipids are used for insulation and cushioning.**
- Building blocks: **3 fatty acids and 1 glycerol**
- Ratio of hydrogen to carbon always **GREATER** than **2:1**but varies from molecule to molecule.

Lipids: Fats, Oils, & Waxes

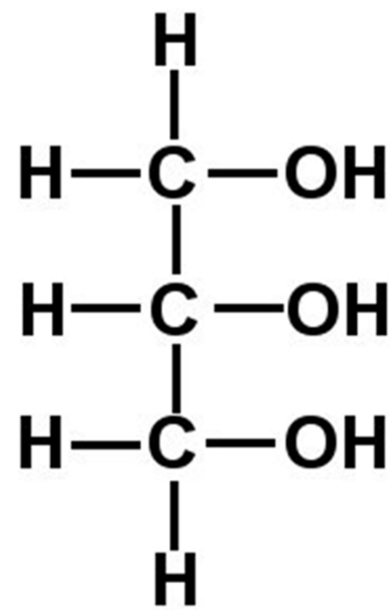
- Structurally shaped like the letter E where the glycerol is the spine and the 3 fatty acids are the horizontal lines of the E.
- A lipid is **NOT** a polymer!



Glycerol

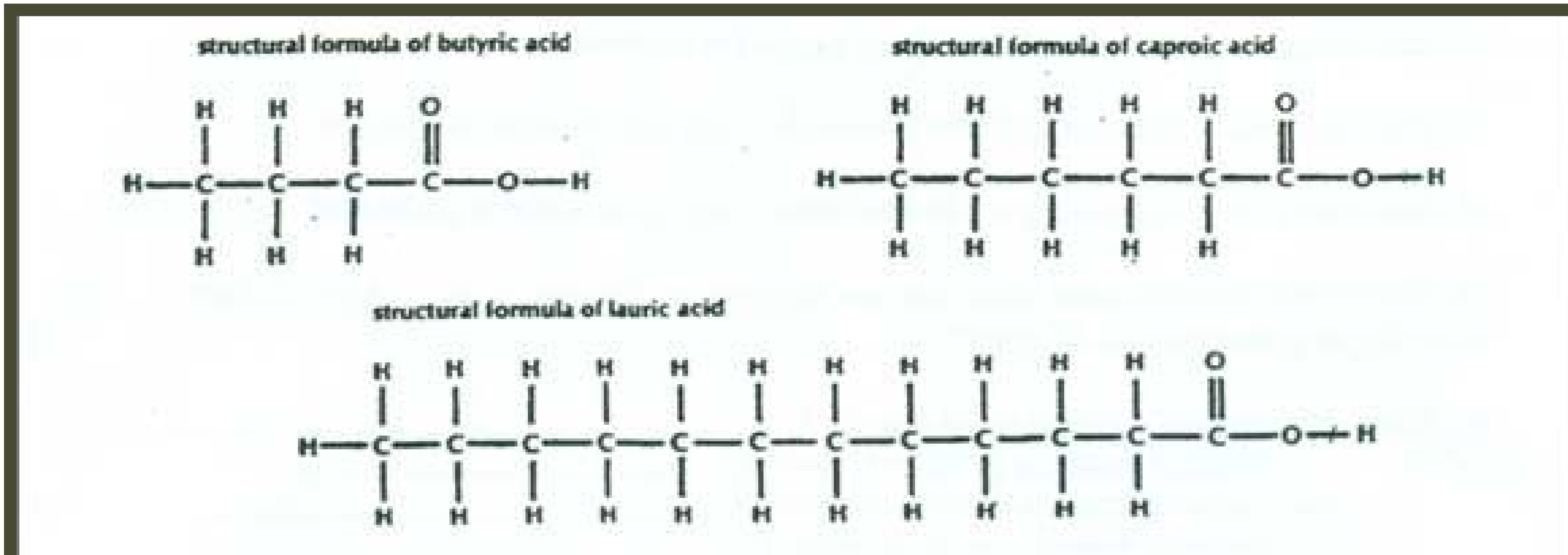
- **Glycerol** (vertical molecule) is made up of 3 carbons to which 3 hydroxyl groups (-OH) are attached. These hydroxyl groups make the molecule water soluble
- Sweet-tasting & considered non-toxic

Type of sugar alcohol



Fatty Acids

- **Fatty acids** are a hydrocarbon chain with a hydroxyl group at one end.
- There are many different types of fatty acids; they differ in the length of the hydrocarbon chains

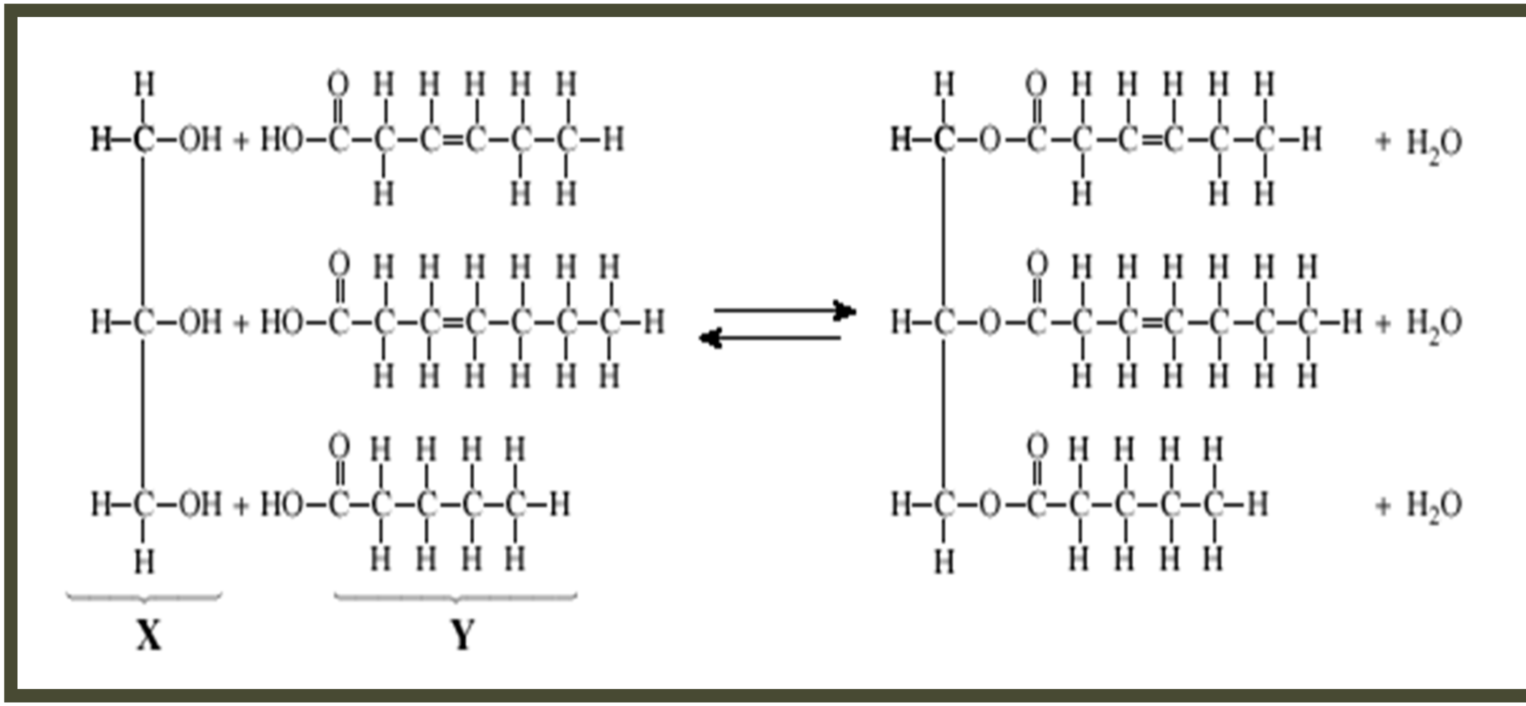


Formation/Digestion of a Lipid

- Lipids are formed from through **dehydration synthesis** of 1 glycerol & 3 fatty acid molecules
- To digest a lipid, water is added and the lipid is broken down into its building blocks through **enzymatic hydrolysis**

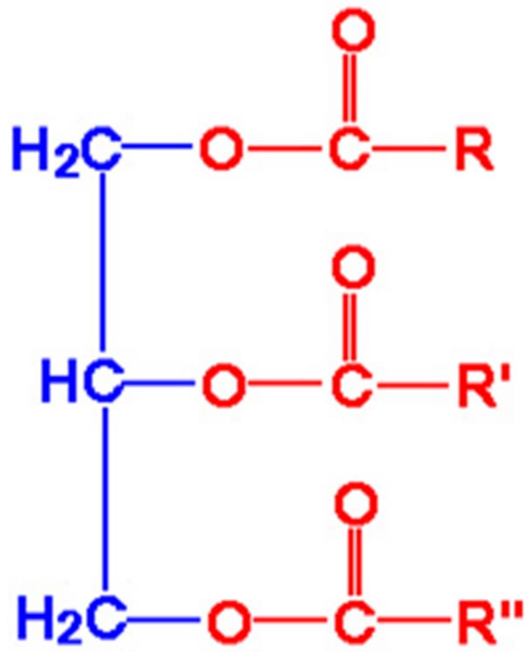
$$\textbf{1 glycerol + 3 fatty acids} \underset{\text{hydrolysis}}{\overset{\text{dehydration synthesis}}{\rightleftarrows}} \textbf{1 lipid + 3 waters}$$

Formation/Digestion of a Lipid



Triglycerides

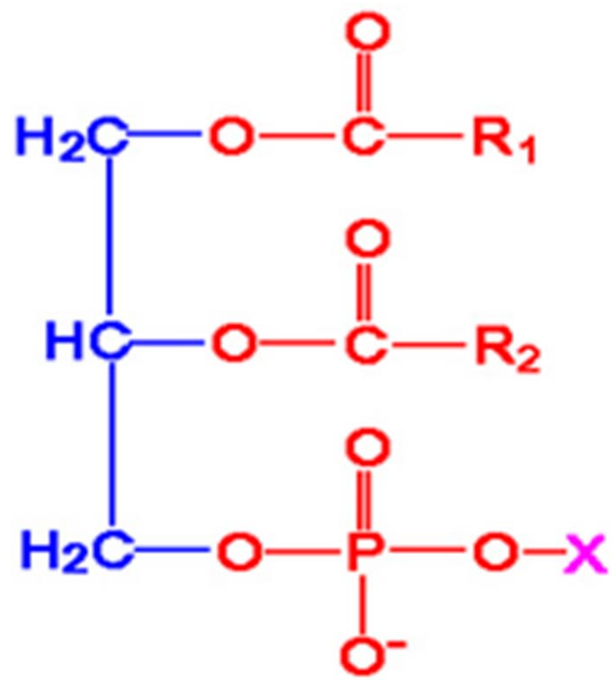
- Consist of three fatty acids bonded to a glycerol molecule
- Have the characteristic "E" lipid shape
- Exist as fats and oils **(fats are solid at room temperature; oils are liquid at room temperature)**
- Most fats we eat are in the form of triglycerides
- Our bodies store fats as triglycerides



R represents the fatty acid hydrocarbon chain

Phospholipids

- Similar in structure to triglycerides except that **one fatty acid chain is replaced with a phosphate group**
- **Phosphate group** is **hydrophilic** (polar) and can interact with water. *(water loving)*
- **Fatty acids groups** are **hydrophobic** (nonpolar) and does not interact with water *(water phobic)*
- **Found in the structure of cell membranes (lipid bi-layer)**



R represents the fatty acid hydrocarbon chain
X represents a variable subgroup

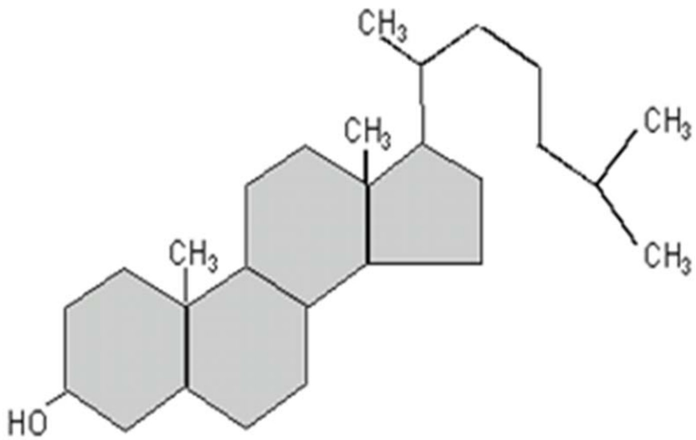
Cholesterol

- Waxy, fat like steroid found in the bloodstream
- Comes from two sources – the body and food
- Cholesterol is an essential part of the human body and must be present for the body to function properly.
- Cholesterol is synthesized by the liver to be used in the manufacture of bile salts or in the synthesis and repair of cell membranes.
- Used by the adrenal glands, testes, and ovaries in the synthesis of certain steroidal hormones.
- Cholesterol is also the **precursor** (substance from which another substance is formed) for the body uses to make Vitamin D.
- **Although cholesterol is important to your body, the average high-fat/high-cholesterol diet tends to add too much cholesterol to the blood.**

Cholesterol (cont'd)

- Excess cholesterol accumulates, along with other substances, on the walls of blood vessels. Over time, the arteries narrow, decreasing blood flow to the heart, which could lead to a **"heart attack".**
- If the narrowing of the arteries occurs in brain tissue, this could result in a **stroke.**
- Blood cholesterol is measured in milligrams per deciliter (mg/dl). Current guidelines suggest that a **total blood cholesterol less than 200 mg/dl is an acceptable level for adults.**
- Cholesterol is found in ***meat, poultry, seafood, eggs and dairy products. It is especially high in egg yolks and organ meats such as liver, brains and kidneys.***

Cholesterol (cont'd)



Structure of cholesterol

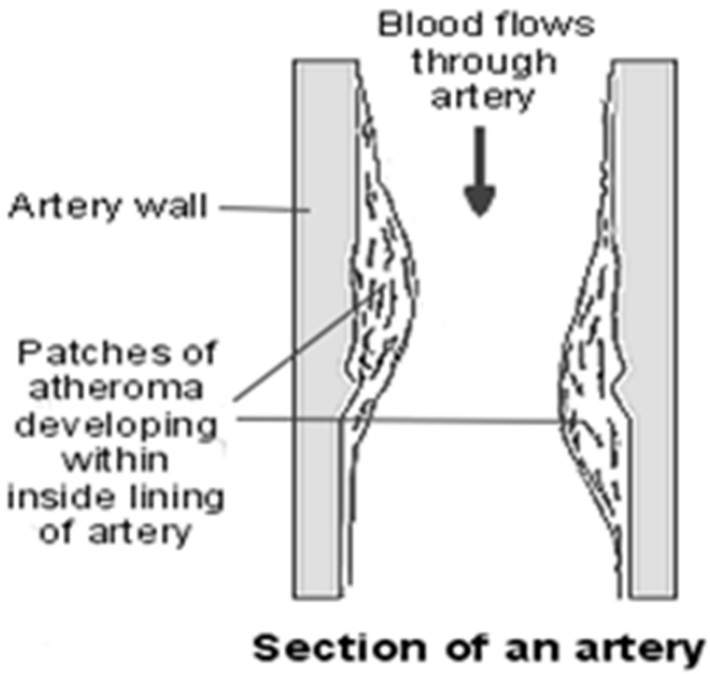


Diagram of arterial plaque (atheroma)

Lipoproteins

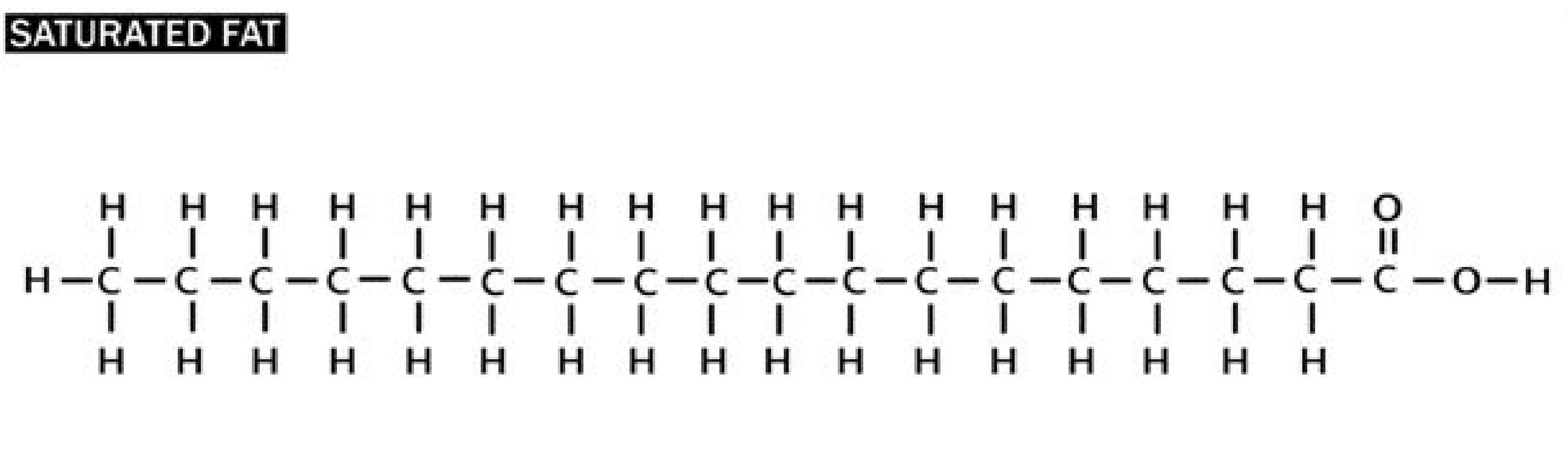
- Special types of proteins that attach to cholesterol and carry it thorough the blood.
- The amounts and types of lipoproteins are an important indicator of a person's risk of heart disease.
- **Low-density lipoprotein, LDL**, is commonly termed "bad" cholesterol, because an excess of cholesterol carried by these proteins can lead to the build up of plaque in the arteries.
  - ***High LDL levels*** (above 160mg/dl) increase the risk of heart disease because they keep cholesterol in blood circulation and carry it to the arteries where it can be deposited. Excess body fat and a diet high in saturated fat tend to increase LDL levels.
- **High-density cholesterol, HDL,** is considered "good" or protective cholesterol, because they carry cholesterol away from the arteries to the liver to be excreted from the body.
  - Individuals with ***high HDL levels*** (above 35mg/dl) have a lower risk of heart disease. Regular exercise helps to increase HDL levels.

Saturated Fats

- These fats are generally solids as room temperature.
- Saturated fats are unhealthy fats and are related to an increased risk of cardiovascular disease.
- Of all the fats taken into the body, saturated fats are the most important determinants of blood cholesterol levels.
- Saturated fats stimulate the production of LDL cholesterol ("bad" cholesterol). **These fats raise the blood cholesterol and LDL-cholesterol levels more than intake of dietary cholesterol.**
- **All animal fats**, such as those found in dairy, meat, and poultry, are saturated fats.
- Processed foods and fast foods also contain saturated fats.
- Some vegetable oils, such as palm, palm kernel, and coconut, are also saturated fats.

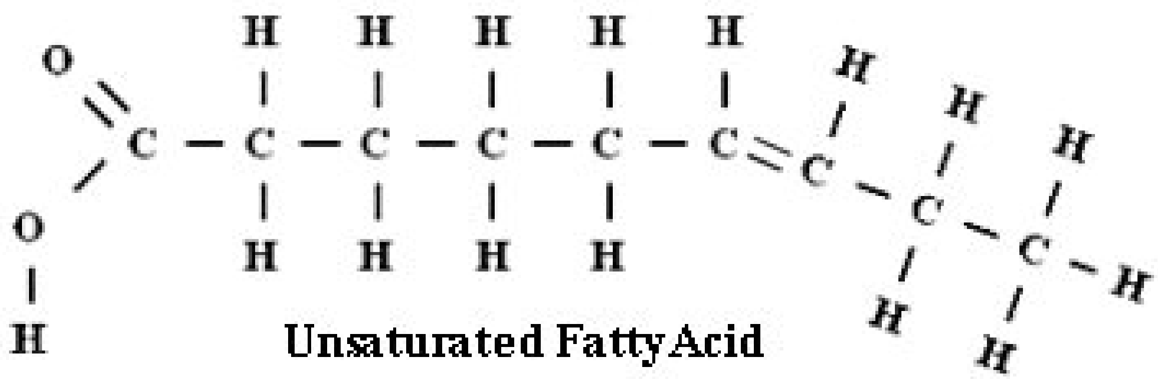
Saturated Fats (cont'd)

- These fats have **all single bonds between the carbons of the fatty acid hydrocarbon tails.**
- As a result, **the hydrocarbon tails are symmetrical and can pack closely together, making them difficult to break down.**



Monounsaturated Fats

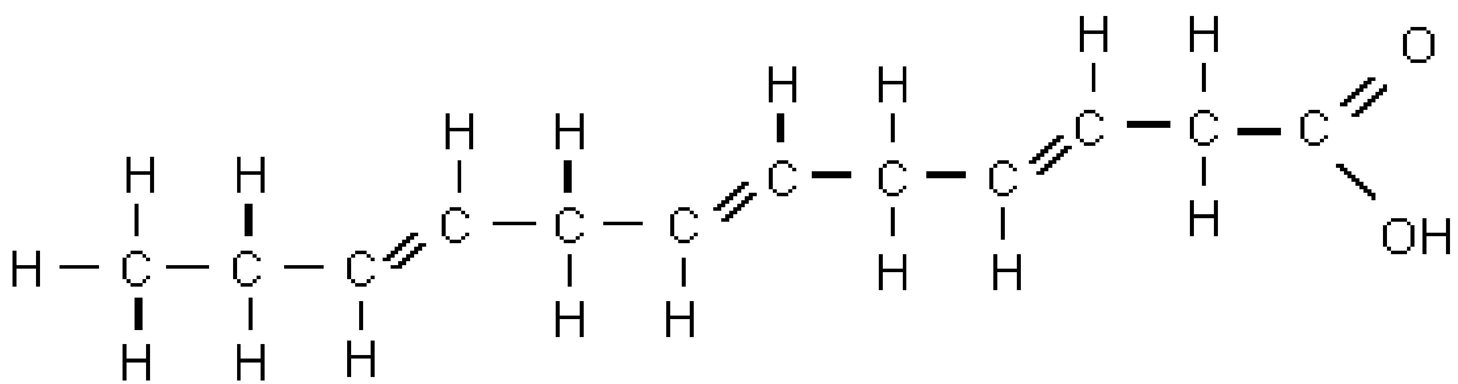
- Usually are liquid at room temperature.
- Found in olive oil, peanut oil, and canola oil.
- One carbon in the fatty acid hydrocarbon tail has a double bond, making the fatty acid bendable, less stable, and easier to digest.
- Monounsaturated fats lower the LDL cholesterol without lowering the HDL blood cholesterol (good cholesterol).



Unsaturated Fatty Acid

Polyunsaturated Fats

- Usually liquid at room temperature.
- More than one carbon double bond in the fatty acid hydrocarbon tail, making the compound easier to break down.
- Found in corn oil, safflower oil, soybean oil, and sunflower oil.
- Also found in fish and fish oils which help to decrease triglyceride levels.

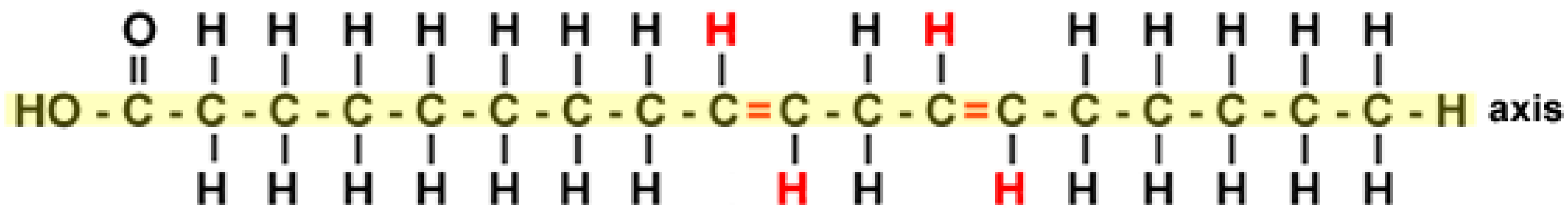


Unsaturated Fatty Acid

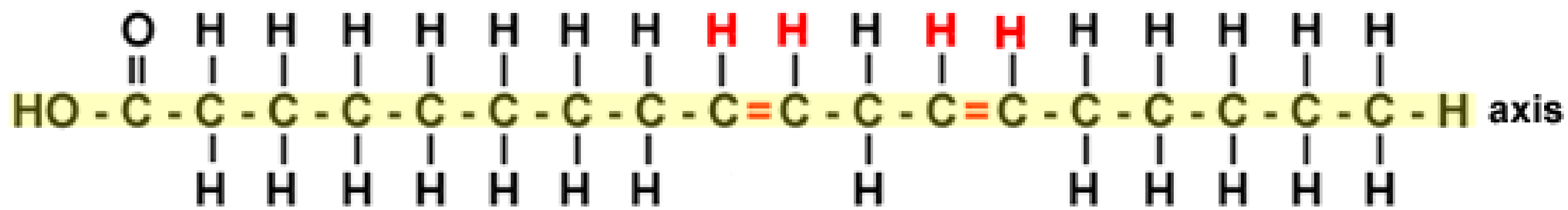
Hydrogenation

- In nature, fatty acid double bonds (carbon to carbon) are generally structured with the single hydrogens on the same side of the molecule. **This is called a *cis* configuration**.
- Food manufacturers use a special process called ***hydrogenation*** to take liquid cis configuration oils and turn them into margarine or shortening (solids at room temperature). **This process also increases stability of the product as well as shelf life.**
- During hydrogenation, the chemical structure of unsaturated fats is altered by adding more hydrogen atoms to make these fats more saturated.
- As a result of the process, some of the double bonds of the fatty acids get twisted so that the hydrogen atoms around the double bonds now are on opposite sides of the bond. This is known as a ***trans*** configuration or a ***trans fat.***
- ***Trans fats are more stable than cis fats and harder to break down. They can contribute to elevated cholesterol levels and an increased chance of heart disease***

Linoleic Acid

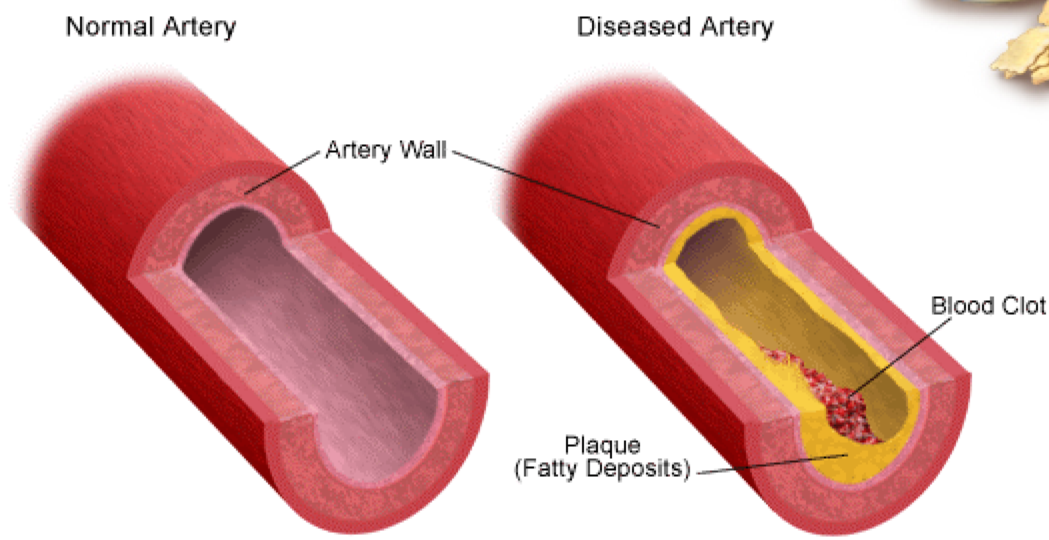


linoleic acid: *trans* configuration (*trans* isomer)



linoleic acid: *cis* configuration (*cis* isomer)

Trans Fatty Acids



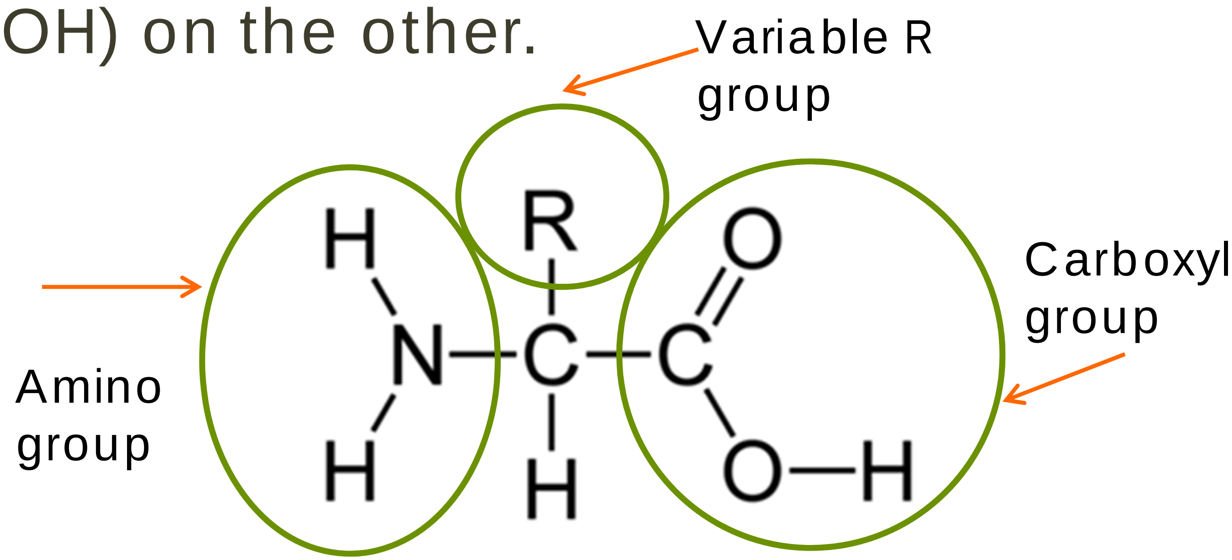
What are Proteins?

Four Main Classes of Proteins

- **Structural body parts:** hair, nails, connective tissue, parts of cell membranes
- **Pigments:** hemoglobin (on RBC, carries oxygen to your cells), chlorophyll (involved in capturing sunlight for photosynthesis)
- **Hormones:** chemical messengers that stimulate specific cells or tissues (adrenalin, estrogen, testosterone)
- **Enzymes:** ***organic catalysts*** that regulate the rate of chemical reactions inside living organisms (catalysts change the rates of chemical reactions ***WITHOUT*** becoming part of the reaction).

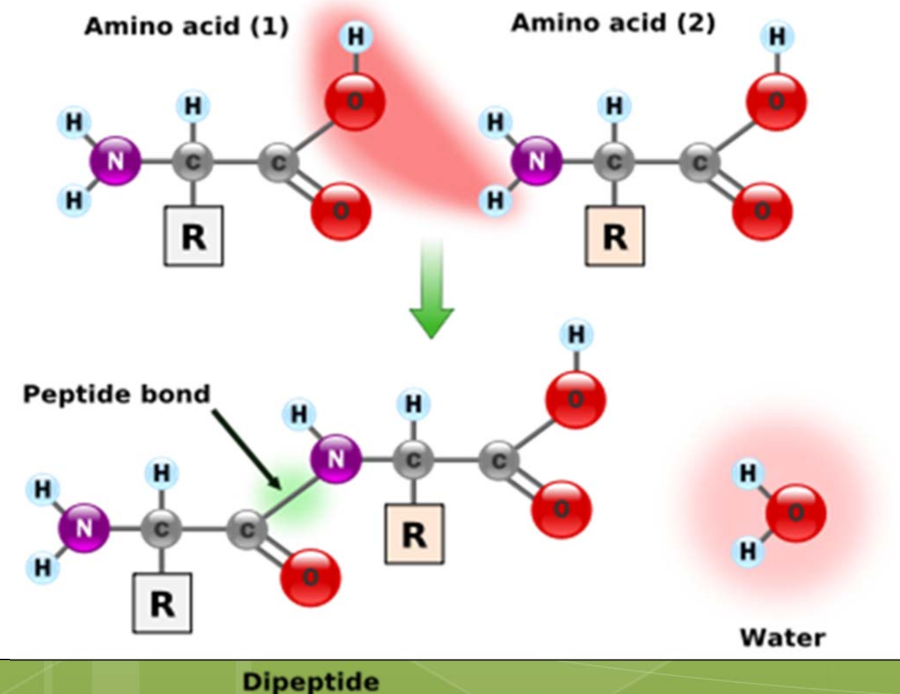
Amino Acids

- Amino acids are the basic building blocks of proteins.
- There are 20 amino acids; the differ only in one part of the molecule – the R or variable group.
- Made up of a central Carbon atom with an amino group ($-NH_2$) on the one side and a carboxyl group ($-COOH$) on the other.



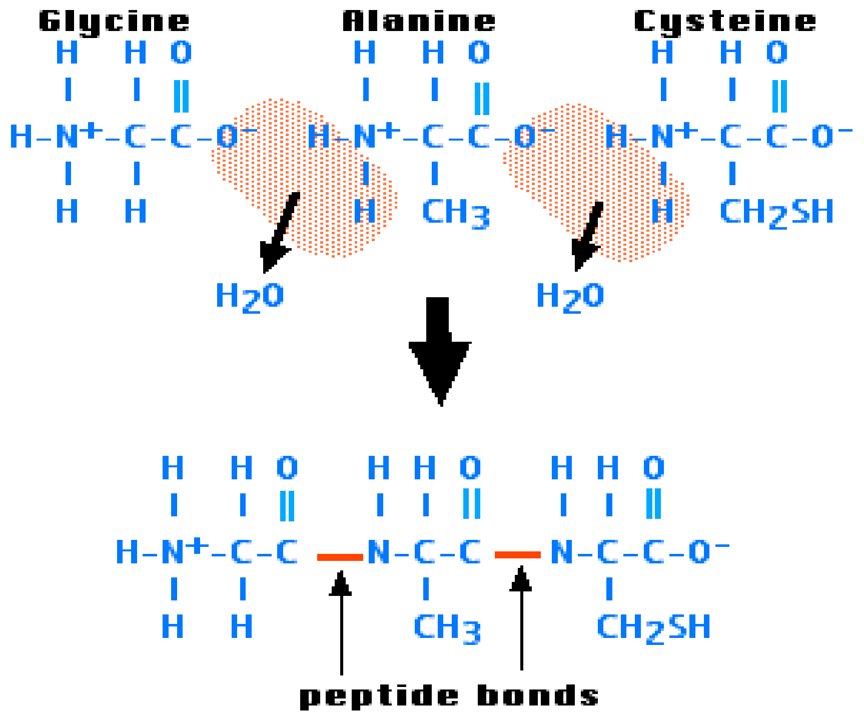
Formation of a Dipeptide

- 2 amino acids are bonded together by the process of dehydration synthesis.
- **Peptide Bond**: the bond that forms between the nitrogen of one amino acid and the carbon from the carboxyl group of the other amino acid.



Polypeptide

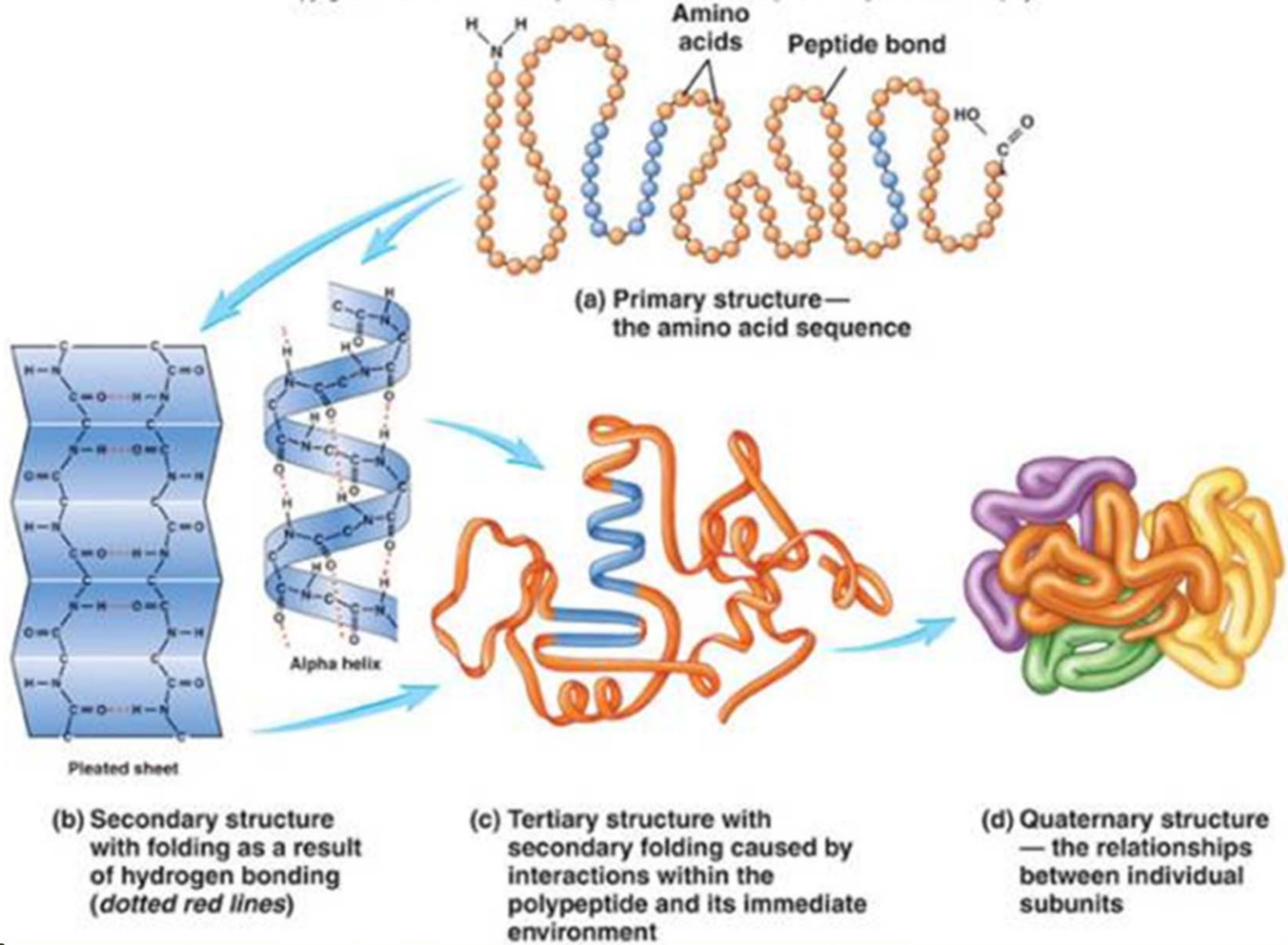
- **Polypeptide**: three or more amino acids linked together by ***peptide bonds***
- Polypeptides are examples of ***polymers***



How Proteins are Formed

- **The sequence of amino acids in a polypeptide chain determines the protein's shape; the shape of the protein determines the protein's function.**
- ***Primary structure*** (polypeptide chain) is linked together by **hydrogen bonds** and folds to form ***secondary structures.***
- When the ***secondary structures*** fold on themselves, **tertiary structures** are formed.
- **Other polypeptide chains** sometimes combine ***tertiary structures*** to form a ***quaternary structure***.
- **The final shape of the protein is specific and will determine the exact function of the protein.**

Protein Formation



Proteins in our Diets

- Of the 20 amino acids we need to synthesize proteins in our bodies, only 12 of these can be synthesized by our bodies. The other 8, called **ESSENTIAL AMINO ACIDS** must be **ingested through food.**
- In order for protein synthesis to occur, **all 20 amino acids must be present at the time of synthesis.**
- **complete protein foods**: red meat, poultry fish, cheese, eggs, milk, and yogurt.

Proteins in our Diets (cont'd)

- **Incomplete protein foods:** grains, nuts, beans, seeds, peas, and corn.
- These foods must be ***eaten together*** to obtain all 8 essential amino acids at one time.

Deamination

- If all 20 amino acids are ***NOT*** present for protein synthesis, the amino acids will be sent to the liver where **DEAMINATION** of the amino acids will occur (removal of the amino groups).
- The amino groups will then be converted to ammonia (which is toxic to our bodies) and then through a series of reactions, into **UREA.**
- **UREA** is sent via the bloodstream to the ***kidneys*** to be **EXCRETED** from the body as ***urine***.
- **The rest of the amino acid can be used in the process of cellular respiration to obtain energy for cellular activities.**