Molecules of life

- Inorganic molecules do not contain carbon atoms

- Organic molecules contain carbon atoms arranged in rings or chains. The ends of these chains may join together to form ring structures. This is unique property of carbon atom.

- Carbon can form four covalent single bonds. Ex. Methane CH_4. It can also form double and triple bonds.

- All key components of every living cell are made of **macromolecules**.

They can be classified into four main classes:

Carbohydrates
Nucleic acids
Proteins
Lipids

- Macromolecules are made the same way in all living things, and they are present in all organisms in roughly the same proportions; they make up what we visually recognize as life

- Macromolecules are large organic **polymers** (many segments) constructed of many organic molecules called **monomers**.

Macromolecule	**Monomers**
Carbohydrates	monosaccharides
Lipids	glycerol, fatty acids
Proteins	amino acids
Nucleic acid	nucleotides

Carbohydrates

- Composed of carbon, hydrogen, and oxygen to form monomers.

- Carbohydrates:

1. are the immediate source of energy (sugars)
2. provide shape to certain cells (cellulose in plant cell walls)
3. components of antibiotics and coenzymes essential part in nucleic acids (DNA, RNA) and in ATP (has the simple sugar ribose)

Monosaccharides

- Empirical formula: $C_nH_{2n}O_n$; Ex: $C_3H_6O_3$
- Triose: 3C; Pentose: 5C; Hexose:6C
- Simple sugars: Glucose, fructose, galactose
- Glucose: $C_6H_{12}O_6$

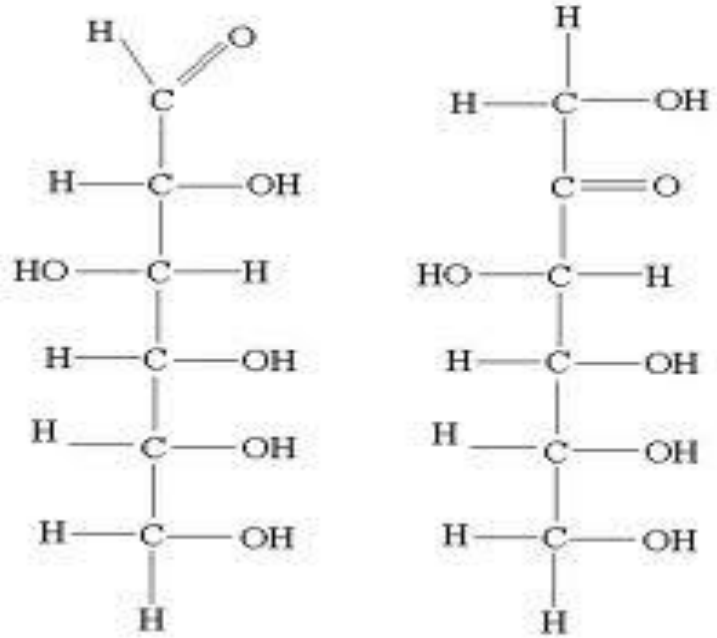
  the most abundant carbohydrate

  basic building block for other carbohydrates

  also called dextrose

  found in sap of plants and in human bloodstream as blood sugar

- Fructose: from its name; it is the sugar in fruits.
- Glucose and fructose are isomers (same empirical formula, but different structural formula).



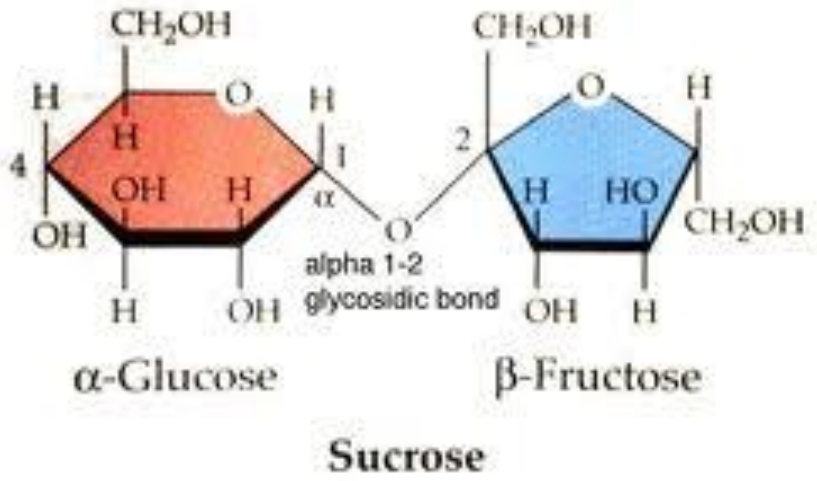
Disaccharides

- **Sucrose**: ordinary table sugar: glucose +fructose
- **Lactose:** milk sugar: glucose + galactose
- **Maltose:** from starch digestion: glucose + glucose
- Disaccharide is converted to glucose and transported by bloodstream
- Most common disaccharide is **sucrose**

Disaccharide synthesis reaction (dehydration)

- Glucose + Fructose $\longrightarrow$ Sucrose + H_2O

Sucrose has the molecular formula $C_{12}H_{22}O_{11}$



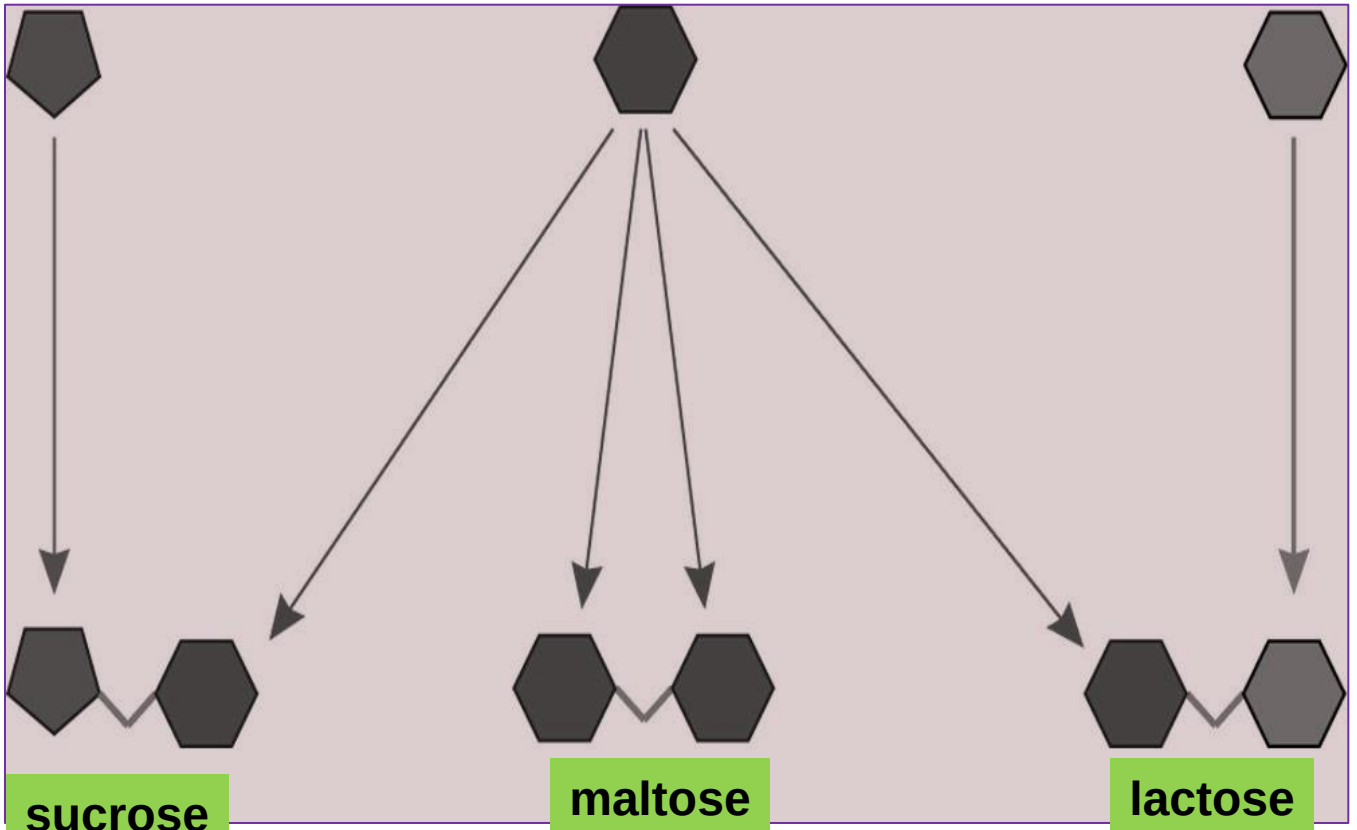
Sucrose

Three types of monosaccharides

fructose

glucose

galactose



Three types of disaccharides

sucrose

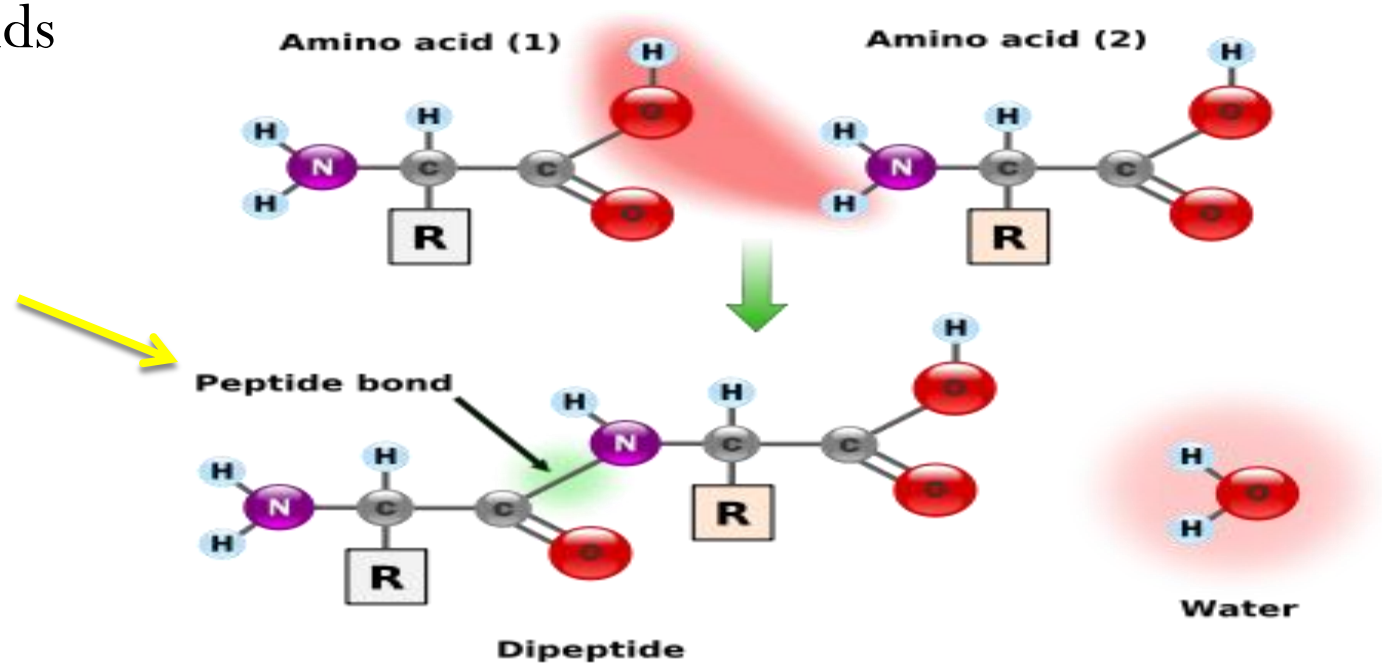
maltose

lactose

- Complex sugar is polysaccharide
- **Starch**: plants convert excess glucose into starch for storage
- **Glycogen**: animals store excess glucose by polymerizing it to form glycogen.
- **Cellulose**: the major structural material of which plants are made. Wood is largely cellulose while cotton and paper are almost pure cellulose. Like starch cellulose is a polysaccharide with glucose as its monomer.

Proteins

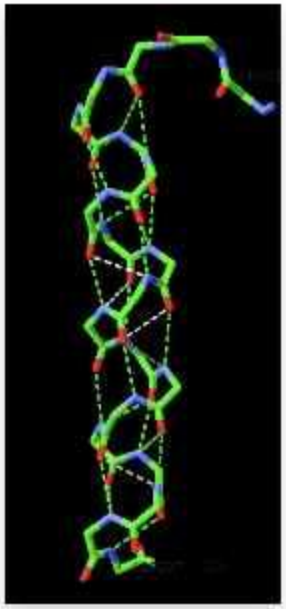
- Polymers made up from monomers called amino acids. There are about 20 naturally occurring amino acids. Amino acid contains amino functional group attached on one end and a carboxylic acid group at the other end.
- Peptide bond is formed by dehydration reaction between amino acids



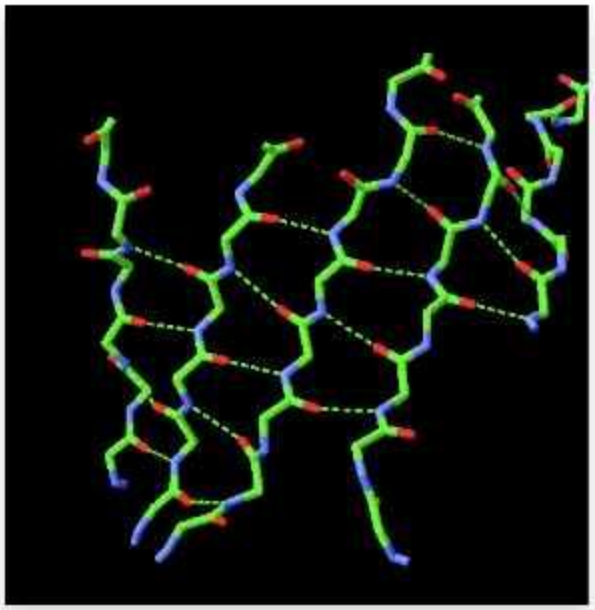
- **Primary protein structure**: listing of amino acids in their proper order. The specific amino acid sequence is controlled by genetic information of an organism

- **Secondary structure**: some amino acid sequences tend to twist forming a secondary structure of polypeptide, whereas other sequences remain straight. The secondary structure could be

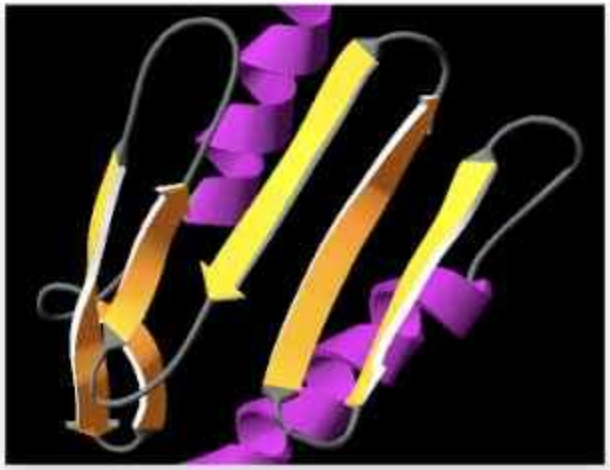
1. **alpha helix**: coiled spring shape. This shape is maintained by hydrogen bonds. Hydrogen bonds do not form molecules but result in orientation of one part of a molecule to another part within the same molecule.
2. Another form is the **beta pleated sheet**: hydrogen bonds that cause polypeptides to make several flat folds.



Alpha helix



Beta pleated sheet



- **Tertiary protein structure**: single polypeptide can have one or more coils and pleated sheets along its path.

- These different molecule portions can interact to form more complex globular structure. This occurs when the coils and pleated sheets twist and combine with each other.

- Myoglobin: oxygen holding protein displays tertiary structure (153 amino acids). It is composed of 1 helical molecule folded back and bonded to itself in several places.

- **Quaternary structure**: several polypeptides each with its own tertiary structure twist around each other and chemically combine

- Interactions of side chains can be by disulfide covalent bonds. Ex: in antibodies (immunoglobulins) that are involved in fighting infectious diseases (ex flu).

Form and function of proteins

- Protein should have specific tertiary structure to function effectively
- Ex: antibody with key and lock property
- Ex: Sickle cell anemia: Normally there are two chains: alpha and beta polypeptide chains. Beta chain has 146 a.a. if only one a.a. is replaced by another, hemoglobin molecule will not function properly resulting in sickle cell anemia. Red blood cell will have sickle structure, body is deprived from adequate oxygen supply.

- Some diseases are caused by proteins having the same chains but the difference in the three dimensional structure ex. Rouge proteins called ***prions***

- These prions cause mad cow disease, where a.a. sequence is identical to normal brain protein but folded differently. When these malformed proteins enter the body, they cause normal proteins to fold differently resulting in the death of brain cells which causes loss of brain function and death

- Certain proteins under heat or light undergo denaturation resulting in loss of protein function.

Function of protein

- **Structural proteins**: to maintain the shape of cells and organisms. Ex: collagen is protein found throughout body that gives tissues shape, support, and strength.

- **Regulator proteins**: help determine what activities will occur in organism. Ex: enzymes (in the GI tract for food digestion), hormones (insulin, glucagon, and oxytocin), and chaperones (help other proteins to fold properly, ex. Help repair heat damaged proteins)

- Diabetes mellitus is the increase in blood sugar level with symptoms of thirst and loss of consciousness

- If the glucose level is low, **glucagon** is released from the pancreas to stimulate the breakdown of glycogen

- If glucose level is high, **insulin** is released form pancreas to cause glucose change to glycogen

- **Oxytocin** stimulates the contraction of uterus during childbirth. Pitocin is artificial oxytocin used by physicians to induce labor

- **Carrier proteins**: deliver molecules from one place to another in blood stream. Ex: Lipoproteins, HDL, LDL. These carry lipids throughout the body.