Organic Chemistry Notes—

Organic compounds refer to a group of compounds that always contain C and H, and usually O and/or N. These are usually large compounds produced by plants and animals.

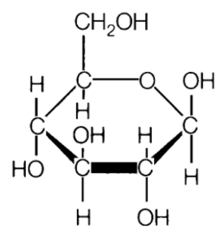
Carbon has 4 valence electrons that allow it to make 4 bonds with other elements. The joining elements make covalent bonds. This chemical property of C allows it to be versatile and make long chains or rings. This is why organic compounds can be large and complicated.

H
H —C—H
H methane

Ways to show molecule content and structure:

Structural formula--This is a diagram that shows all of the elements present and how they connect to one another. Lines show where pairs of electrons are being shared between atoms. The lines represent covalent bonds. (also Methane molecule above.)

water's structural formula



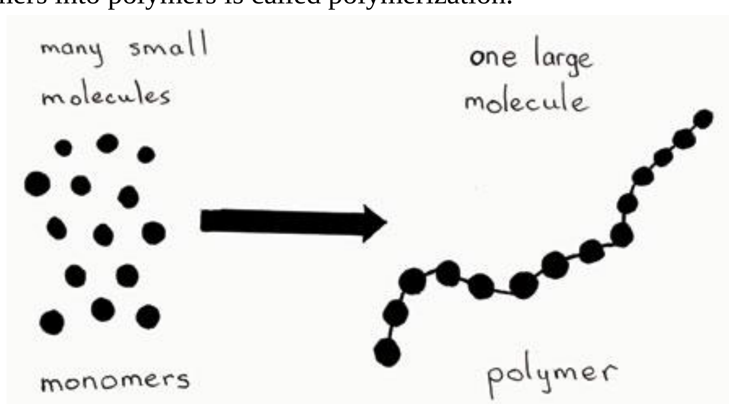
Glucose's structural formula

Molecular formula-- This type of formula just lists the elements present and the number of each. This formula does not tell about the bonds between atoms of elements.

Water: $\mathbf{H_2O}$ Carbon dioxide: $\mathbf{CO_2}$ Glucose: $\mathbf{C_6H_{12}O_6}$

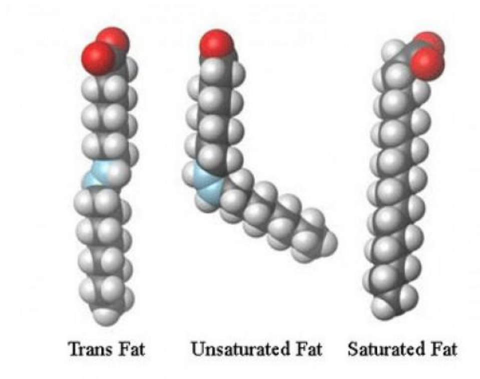
4 major organic compounds--

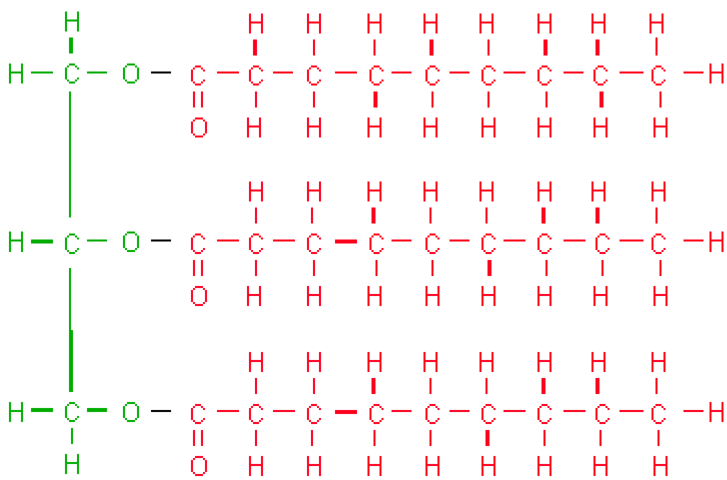
These are carbohydrates, proteins, lipids, and nucleic acids. These are called macromolecules due to their size. These large molecules are polymers (many parts) made up of smaller units called monomers (one part).The process of joining monomers into polymers is called polymerization.



Lipids:

These molecules contain elements C, H, O. These elements have a ratio of 1:2 for carbons to hydrogen, but very few oxygen. This group includes fats, oils, and waxes. Most lipids are made from a glycerol and 3 fatty acids. Lipids serve as form of long term storage of energy for cells. They can store more energy per gram than the same mass of carbohydrates. Since they are long term storage it is hard to obtain quick energy from them. Carbohydrates are better for quick energy release than lipids. i.e. oranges during a soccer or football game rather than a bacon sandwich. Lipids are also important parts of biological membranes and waterproof coverings. Steroids are also lipids. When a lipid has as many H's bonded to it as possible then it is called a saturated fat. Unsaturated fats are healthier. Saturated fats are straight structures in a solid form, while unsaturated fats are liquid because they are bent and unable to line up to make a solid shape. A trans fat is when an unsaturated fat has hydrogen added to it and so its shape is changed.



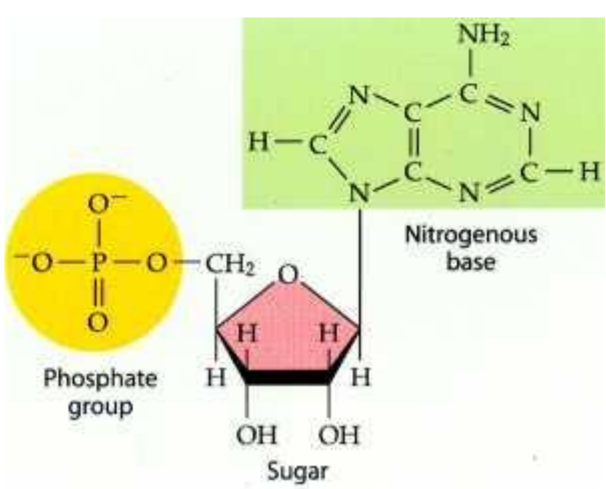
1 TRIGLYCERIDE  3 FATTY ACIDS

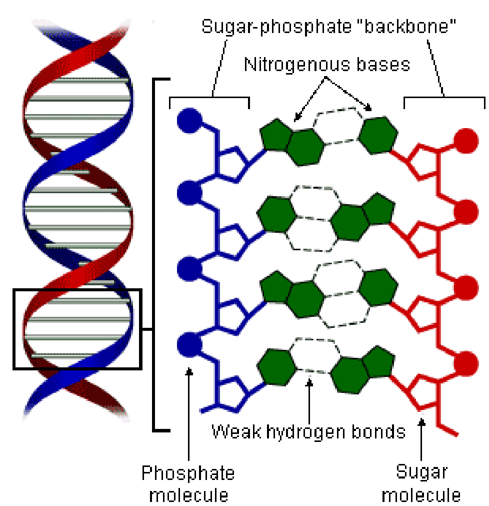
2

The fatty acids join to the triglyceride by a dehydration reaction so that water is removed.

Nucleic acids:

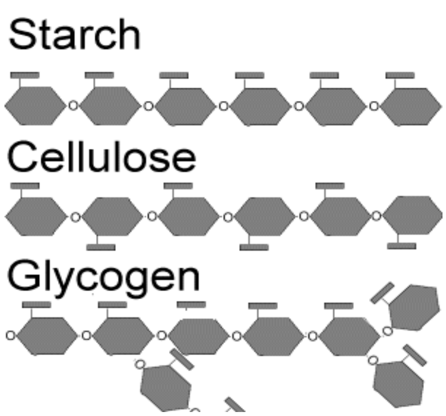
Nucleic acids store and transmit genetic information. They contain elements C, H, N, O, P but have no ratio. Nucleic acid is the polymer created from joining the nucleotide monomers together. Nucleotides are made up of three parts: a 5 C sugar(either ribose or deoxyribose), a phosphate group, and one of 4 nitrogen bases (Adenine, Guanine, Cytosine, and Thymine/Uracil). The type of sugar determines if it is DNA (deoxyribose nucleic acid) or RNA (ribose nucleic acid). These bases join up in predictable pairs: In DNA-- A always with T and G always with C. In RNA--T is replaced with Uracil. These predictable pairings helped determine the structure of the Double-helix model of DNA.

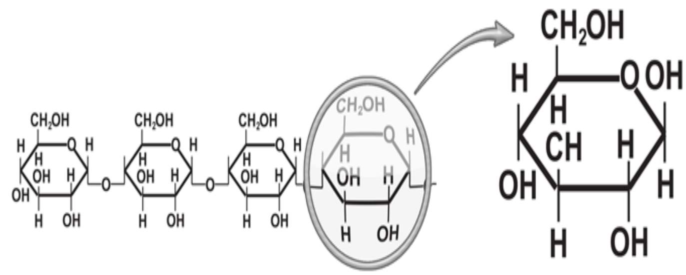




Carbohydrate:

These are compounds that always contain the elements C, H, O in a 1:2:1 ratio. Counting the number of C and H of an unknown compound will tell you if it is a carbohydrate or not if you are given the structural or molecular formula. Carbohydrates are better known as sugars. Their names usually end in –ose. The sugars Fructose and Galactose have the same molecular formula but different structural formulas. This difference makes them isomers of each other. Glucose, Fructose, and Galactose are monosaccharides (one sugar), also called simple sugars. If you chemically combine two of the same one or two different simple sugars this makes a disaccharide (two sugars). More than two sugars together makes a complex sugar or polysaccharide (many sugars). Polysaccharides are examples of polymers (many parts). Polymer is a compound made by joining many smaller identical compounds together in a chain i.e. starch is a complex sugar made from chains of glucose. Cellulose is also made from glucose but has different angles (alpha and beta) in the bonds. Glycogen is a complex storage molecule.





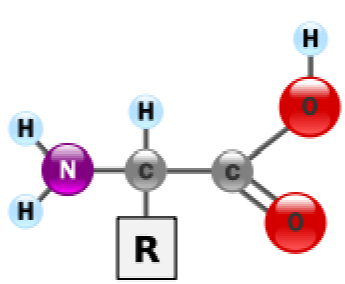
Starch Glucose

Carbohydrates are a source of fuel and building materials. Plants use starch to store energy (made from glucose) Animals use glycogen to store energy (made from glucose). Plants use cellulose to support cell walls (made from glucose).

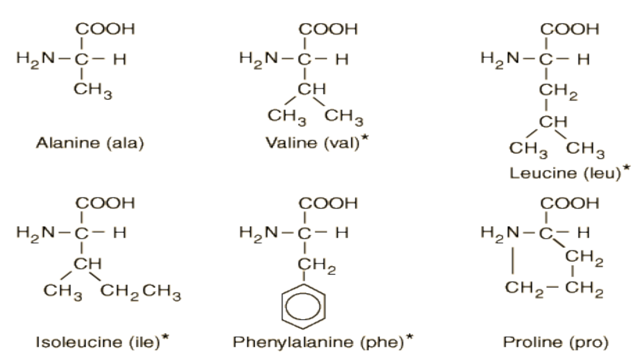
Protein:

These are compounds that contain the elements C, H, O, N sometimes S but in no ratio. These compounds make up substances such as fingernails, spider webs, hormones, hemoglobin, enzymes. These are large complex polymers made from monomers called amino acids. There are 20 different amino acids which can be arranged into different combinations to make different proteins. Just as letters in the alphabet spell out different words, amino acids spell/produce different proteins. The 26 letters have different shapes which we can recognize and hundreds of thousands of words which come from those letters have different sequences which give them meaning. The 20 amino acids have different chemical properties. All have 3 parts—two that are the same (amino group and carboxyl group) in all 20 and 1 that differs which makes each amino acid different from the others. This special portion is called the R group.

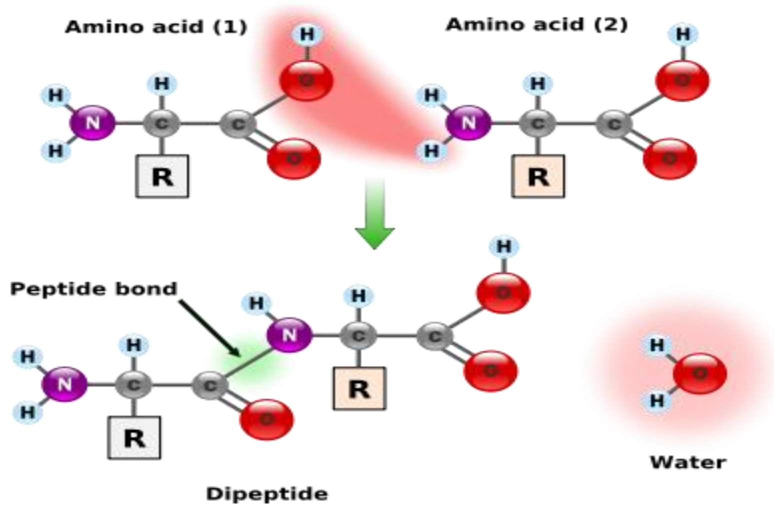
General amino acid structure:



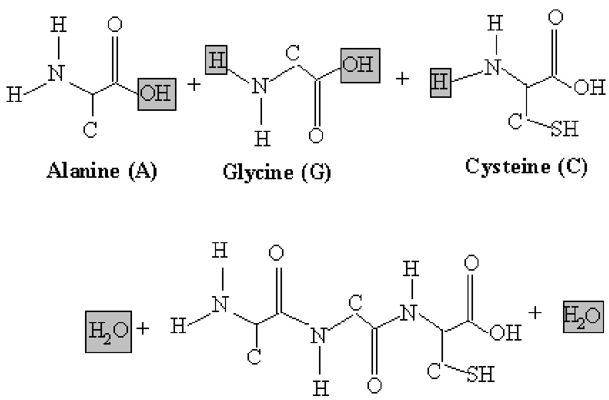
Examples of amino acids:



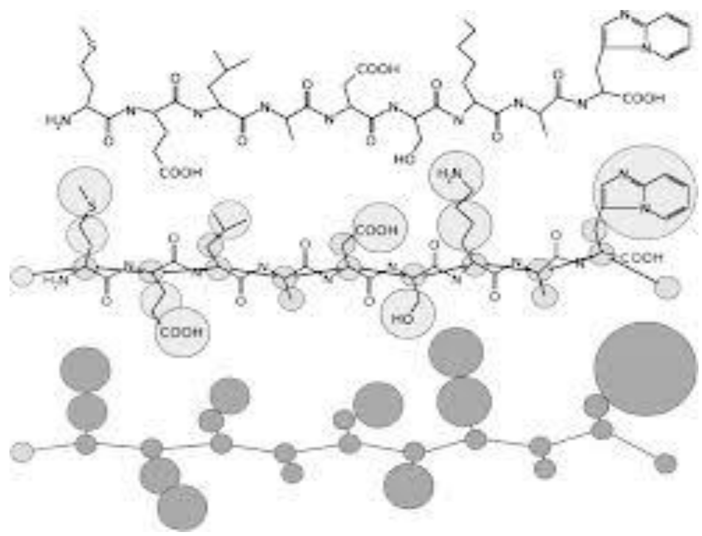
The bond between 2 amino acids is a covalent peptide bond. A chain of amino acids form a protein molecule. This chain is also called a polypeptide. This protein chain has no function yet. This initial sequence of amino acids is established/made during translation. The translation sequence is made directly from the cell's DNA (genes). This initial sequence is called the primary structure of the protein.



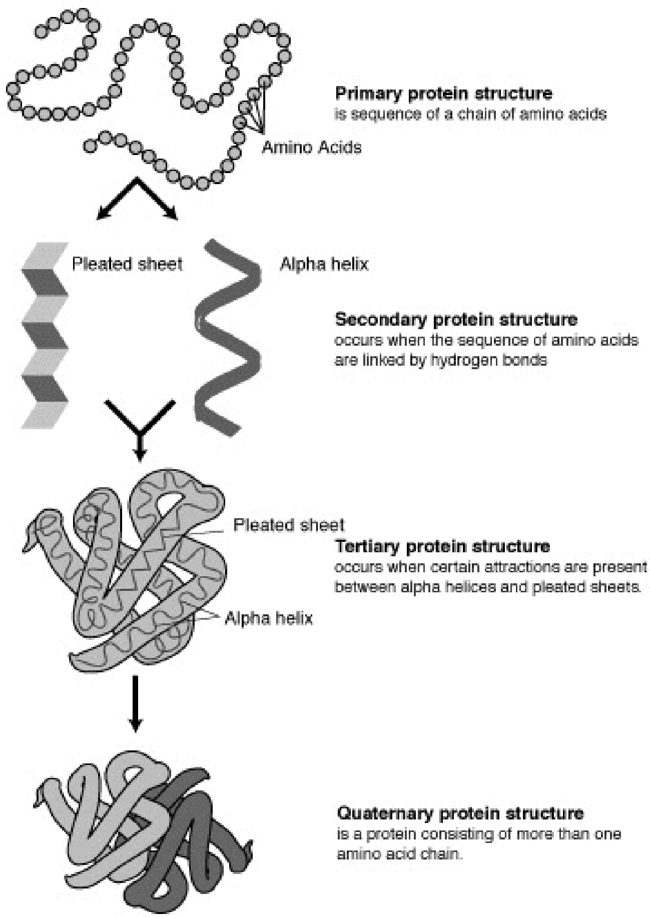
Polypeptide chain:



Polypeptide Chain AGC plus 2 molecules of water



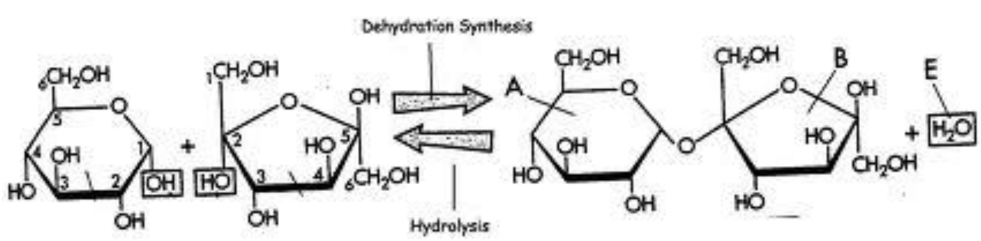
The R groups line up along the sides of the polypeptide chain. As the chain continues to grow in the number of amino acids added to it, it has to bend and twist into a secondary structure. These secondary structures are alpha (α) helices and beta (β) pleated sheets which are held together by H+ bonding. Secondary structures continue to bend until R groups begin to interact and form noncovalent/covalent bonds. These R group-R group bonds create a tertiary structure. Most proteins exist in this level of structure. But some proteins need a 4th or quaternary form to achieve their functional state. This fourth level is formed when third level proteins join together. Quaternary proteins always consist of 2 or more polypeptides held together by noncovalent bonds between R groups. A protein function is mostly determined by its shape, much like a hammer or wrench has a shape that is suited to its function. Some proteins make up large portions of cell membranes, are used to form bone and muscle, transport materials in and out of the cell, fight disease.



Making and breaking macromolecules:

Dehydration Synthesis:

Carbohydrates, proteins, and lipids are made from smaller subunits into the larger complex macromolecules. These larger structures are joined together during a dehydration synthesis. This is a chemical reaction where two smaller molecules are joined together chemically by removing elements from each molecule. These removed elements create water. Loss of water is the dehydration and synthesis makes the new larger molecule.



Hydrolysis:

When the complex structures of carbohydrates, protein, and lipids need to be broken down into the simpler substances for energy or for structural parts within the organism, a chemical reaction of hydrolysis does this. This process is the reverse of dehydration synthesis. Hydrolysis splits larger molecules by adding a water molecule.