Biochemistry

Biological molecules are often polymers made from monomers.

Many biological molecules have molar masses of 1,000,000 or more.

Four classes of biological molecules

Protein – polymer composed of amino acids
20 amino acids occur naturally
Amino acids have an amine end, $–NH_2$, and a carboxylic acid end, CO_2H
Amino acids bond to one another through the amine and carboxylic acids forming peptide linkage, which is an amide bond or amide linkage. Forming the bond releases a water molecule.
A molecule with two peptide linkages is a dipeptide, one with three is a tripeptide, while molecules with up to 50 are called polypeptides. For example, human insulin has 48 peptide linkages.
Proteins are polypeptides often containing thousands of amino acids.
The carbon attached to the amine in an amino acid is called the alpha carbon (α), to which attaches one of 20 side chains (-R).
The twenty naturally occurring amino acids are glycine, alanine, leucine, isoleucine, praline, serine, threonine, cysteine, asparagine, glutamine, tryptophan, aspartic acid, glutamic acid, lysine, argentine, and histidine.
Side chains that contain $-CO_2H$ have an acidic pH in water. Side chains that contain $-NH_2$ have a basic pH in water, while other side chains give neutral pH solutions in water.
Proteins have a primary structure that is given by the linkage of amino acids.
Loops, bends, and twists in protein structure are secondary structure. Two examples of secondary structure are alpha helixes (a spring-like coil) and beta sheets (paper folded back and forth).
Protein chains are antiparallel in a beta sheet.
Hydrogen bonding gives rise to secondary structure.
Tertiary structure is the three-dimensional structure of a protein, which can be long, spherical, or in between.
Hydrogen bonds and other intermolecular forces (not bonds) keep the tertiary structure of the protein together.
The term 'enzyme' means a protein that is a biological catalyst. A catalyst makes a chemical reaction go faster without being used up in the reaction. Not all catalysts are enzymes because not all catalysts are proteins (for example platinum metal is used as a catalyst in your automobile). The chemical reactions to sustain life would not be possible without enzymes because the reactions would not be fast enough.
Enzymes have an active site that has a specific 3-dimensional shape (tertiary structure) Enzymes are selective for specific biological molecules, called substrates, that fit into the active site.
The chemical reaction for an enzyme and a substrate is given in two steps by:

substrate + enzyme → substrate-enzyme → product1 + product2 + enzyme
For example, ptyalin is an enzyme in saliva that breaks down sugar. The reaction would take years without the enzyme:
sucrose + ptyalin → sucrose-ptyalin → glucose + fructose + ptyalin

Lipid – fat, oil, wax or steroid that is usually composed of an alcohol and one or more carboxylic acids.
Lipids are not soluble in water
Fats and oils are made up of glycerol and 3 fatty acid molecules (a triacylglyceride or triglyceride)
A fatty acid is a long hydrocarbon chain with a carboxylic acid group at the end, where the hydrocarbon chain can be saturated or unsaturated.
Triglycerides are held together (glycerol to fatty acid) with ester linkages.
Forming the ester linkage releases a water molecule.
Fats are semisolid lipids usually obtained from animals. The fatty acids in fats tend to be more saturated fatty acids.
Oils are liquid lipids usually obtained from plants. The fatty acids in oils generally have more unsaturation than the fatty acids in fats.
Vitamins A, D, E, and K are lipids.

Carbohydrate – simple sugar or polymer composed of simple sugars
Sugars often contain aldehyde or ketone as well as hydroxyl functional groups.
Starch and cellulose are polymers of simple sugars that differ in the type of glycoside linkage
A glycoside linkage is a C – O – C bond, an ether bond, that holds two sugar molecules together.
Carbohydrates means water (hydrate) + carbon
Names of carbohydrates end in the suffix –ose.
Carbohydrates (made of simple sugars) contain an aldehyde or ketone group and hydroxyl functional groups.
A single sugar is called a monosaccharide.
A monosaccharide with an aldehyde group is called an aldose.
A monosaccharide with an ketone group is called an ketose.
Simple sugars often have a ring form in solution.
For glucose, the ring structure has 5 carbon atoms and 1 oxygen atom. The ring forms from a hydroxyl group bonding to the carbonyl carbon.
A disaccharide is two simple sugars (monosaccharides) joined together.
The linkage (bond) is called a glucoside linkage, which is an ether bond (C-O-C).
Polysaccharides contain many monosaccharides joined with glucoside linkages.
Starch and cellulose are very similar chemically. They differ because of the 3-dimensional structure (the location of the bonds).

Nucleic Acid – a biochemical polymer composed of a sugar, organic base, and a phosphate group that contains the genetic material.
Individual nucleic acids (called nucleotides) are held together through the phosphate groups by phosphate linkages that attach through the sugar molecule.
DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) are two types of nucleic acids.
DNA has a 5-carbon sugar, called deoxyribose, while RNA has a 5-carbon sugar called ribose. Ribose has an –OH group where deoxyribose has an –H group.
The nitrogen bases in DNA are adenine (A), guanine (G), cytosine (C), and thymine (T). In DNA
The nitrogen bases in RNA are adenine, guanine, cytosine, and uracil.
Every living cell contains nucleic acids.
The DNA molecular structure is a double helix where the bases across the double helix always pair A to T and G to C. Hydrogen bonding, an intermolecular force (not an actual chemical bond), causes the bases to pair, thus giving DNA its characteristic double-helix shape.