Chemistry is the study of matter, which is composed of several elements. An element is a substance that cannot be broken down into other substances by ordinary chemical means. Living things are comprised mainly of the elements carbon, hydrogen, nitrogen, and oxygen, with many other elements (phosphorus, sulfur, calcium, potassium, etc.) also being important.

An atom is the smallest subunit into which an element can be divided while still retaining the properties of the element. However, atoms are themselves comprised of yet smaller particles, termed protons, neutrons, and electrons.

Positively charged protons and uncharged neutrons, the two subatomic particles with significant mass, are packed together to form the nucleus of an atom. A cloud of negatively charged electrons surrounds this nucleus, each electron possessing an insignificant mass as compared to that of the other subatomic particles.

All atoms of a given element possess an identical number of protons. This number defines the element, and is termed the atomic number of the element. The atomic mass of an element is defined as the number of protons plus the number of neutrons.

Although the number of protons present in all atoms of a given element is constant, this is not the case for neutrons. The number of neutrons is generally fairly close to the number of protons, but can vary. Atoms of a given element differing in the number of neutrons are termed isotopes. Isotopes are chemically indistinguishable, but differ in their masses. Certain isotopes, such as $^{14}$C and $^{32}$P, are radioactive.

A molecule is composed of two or more atoms joined by a chemical bond or bonds. Chemical bonds are formed by the exchange or rearrangement of electrons.

An ionic bond is a chemical bond involving the interaction between two charged atoms, termed ions. One of these atoms has gained one or more electrons and is therefore negatively charged, while the other atom has lost one or more electrons and is therefore positively charged.

A covalent bond is a chemical bond involving the sharing of a pair or multiple pairs of electrons. This sharing of electrons between the two atoms may be relatively equal or it may be unequal. When the sharing of electron pairs is unequal, and since electrons are negatively charged, one of the atoms will bear a partial positive charge and the other atom will bear a partial negative charge. Such a bond is termed a polar covalent bond.

Atoms bearing opposite partial charges can participate in bonds similar to, though weaker than, ionic bonds. A hydrogen bond is a chemical bond involving the interaction between a hydrogen atom bearing a partial positive charge and a negatively charged atom.

Water (H₂O), the main component of living cells, consists of a central oxygen atom bonded to two hydrogen atoms. These covalent bonds are polar, thus the oxygen atom possesses a partial negative charge and the hydrogen atoms possess partial positive charges. Water molecules form hydrogen bonds with each other, as well as with ions and other polar molecules. This hydrogen bonding enables sugars and salts to dissolve in water. Collectively, such molecules are termed hydrophilic (water loving).

Molecules that are neither ionic nor polar do not associate favorably with water, and are termed hydrophobic (water hating). Oils, for example, do not appreciably dissolve in water because they are unable to form numerous hydrogen bonds.
Not only are all living organisms comprised of the same chemical elements, but these chemical elements are combined similarly into large molecules (macromolecules). The majority of these macromolecules fit into four main classes: carbohydrates, lipids, proteins, and nucleic acids.

Three of the classes of macromolecules (carbohydrates, proteins, and nucleic acids) are polymers, lengthy chains of repeating similar subunits. These polymers are assembled from their subunits by condensation reactions, and are disassembled into their subunits by hydrolysis reactions. In contrast, lipids are not polymers. However, many lipids are assembled by condensation reactions between different molecules.

**Condensation reactions** are used to build macromolecules from their subunits. A condensation reaction involves the formation of a new covalent bond between two subunits, accomplished by the removal of a single water molecule.

**Hydrolysis reactions** are used to break down macromolecules into their subunits. An hydrolysis reaction involves the breaking of the covalent bond linking two subunits, accomplished by the addition of a single water molecule.

**Carbohydrates**, as a class, include sugars (monosaccharides) and their polymers (polysaccharides). Carbohydrate functions include both short- (glucose, fructose) and longer-term (glycogen, starch) energy storage, structural roles (cellulose, chitin), and roles in cellular communication. Polysaccharides differ from each other in the identity of the individual monosaccharide subunits, by the lengths of the polymeric chains, and by the nature of the covalent linkages formed between these subunits.

**Lipids** are a group of macromolecules comprised almost exclusively of carbon and hydrogen and not readily soluble in water. Lipids function in long-term energy storage (fats, oils), as components of cell membranes (phospholipids, cholesterol), and as chemical messengers (steroid hormones). In contrast to the other three classes of macromolecules, lipids are not polymers. However, many lipids are assembled via condensation reactions between different molecules.

**Proteins** are polymers of subunits termed amino acids. There are twenty different amino acids, which can be assembled in different orders and lengths to form proteins of vastly different structure and function. Protein functions include structural roles (collagen, keratin), energy storage (casein, ovalbumin), transport roles (hemoglobin, lac permease), hormonal roles (insulin, oxytocin), roles in cellular communication (cell surface proteins), movement (actin, myosin), organismal defense (antibodies), and catalysis (enzymes).

**Enzymes** are an important group of proteins capable of greatly increasing the rate of specific chemical reactions within living cells. Each enzyme is specific to a particular reaction or set of closely related reactions.

**Nucleic acids**, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), serve as the hereditary information of all organisms. DNA is the genetic material of all organisms with the exception of some viruses, whose genetic material is the structurally similar RNA. Nucleic acids also play important roles in the production of proteins within cells. A gene is a segment of DNA that serves as the blueprint for a particular protein, and RNA serves as the intermediate in the synthesis of this protein.