Section B and C

Volume-01

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1. MOLECULES AND THEIR INTERACTION RELEVANT TO BIOLOGY

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Biochemistry:
Biochemistry is the study of various chemical reactions taking place in cell or organism. Biochemistry seeks to describe the structure, organiztion and function of living matter in molecular terms. The major title*metabolism*- in which degradation (catabolism) of food substances to provide energy for cellular functions and anabolism is the biosynthesis in this reactions the formation of compounds required for the cell.
Due to major researches and discoveries,biochemistry has made gigantic strides. In recent years molecular biology attracted many students, the very roots of molecular biology are deeply seated in biochemistry. In every domain of life sciences, the biochemistry is un-separable segment.
Biochemistry draws its major themes from various disciplines-like organic chemistry-which describes structural properties of biomolecules, biophysics-applies the techniques, microbiology-provide single cell system to study it at individual level, physiology-which integrates life processes at tissue level, cell biology, genetics, and so on...

A. STRUCTURE OF AN ATOM, MOLECULE AND CHEMICAL BONDS

Each matter is composed of very small and ultimate particles called atoms, same element have similar atom to one another and equal in weight. Atoms of different elements have different properties and weight. Although, at one time, the atoms were conceived to be the smallest particles, subatomic particles were later recognized in due course of time. The three fundamental subatomic particles are: ***proton*** (positively charged), ***neutron*** (neutral), and ***electron*** (negatively charged). Besides of these fundamental particles, about more than thirty five other atomic particles are also known to exist. Many of them are, however, extremely unstable and they merely represent a bundle of energy. Some of the stable particles other than fundamental particles are positron, photon, neutrino, graviton and antiproton. These particles are, however, of little importance in the study of Biochemistry because their existence is rarely encountered in biological systems.

Ernest Rutherford in 1911 proposed the most satisfactory *Planetary model*, for the arrangement of fundamental particles inside an atom, which is accepted even today with some modifications. Accordingly, an atom is made up of a central nucleus containing positively-charged protons and neutral neutrons, surrounded by negatively-charged electrons which move around it (the nucleus) in discrete, successive, concentric volumes in space known as orbits or shells. The model is similar to the sun's planetary system but differs from it in having the subatomic particles, protons and electrons as charged.

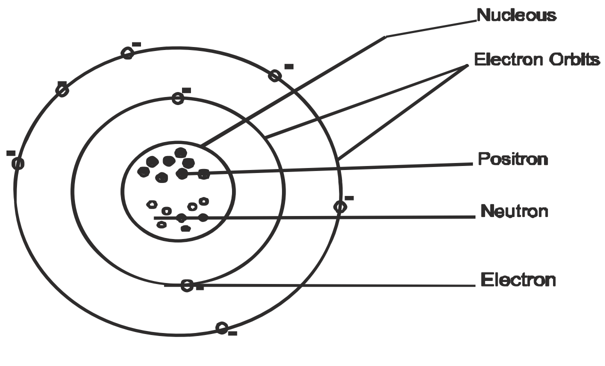

Fig 1 : Structure of an Atom

The electron shells or orbits are numbered (from within) as 1, 2, 3, 4, 5, 6 and 7 and are indicated by the letters K, L, M, N, O, P, Q respectively. Each shell has a specific number of electrons. The maximum number is given by $2n^2$, where n is the serial number of the shell. Thus, the maximum number of electrons in K, L, M, N, O, P, Q shells will be 2, 8, 18, 32, 50, 72, 98 respectively. The maximum number of electrons in the outermost shell is 8 and in the penultimate shell are 18.

The shells are subdivided into sub-shells; the number of subshells in a shell is equal to the number of the shell from within. K shell has one subshell called ***s***; second L shell has two subshells ***s*** and ***p***; the third M shell has three subshells ***s***, ***b*** and ***d*** and fourth N subshell has four subshells ***s***, ***p***, ***d*** and ***f***. The sub-shells ***s***, ***p***, ***d*** and ***f*** can have a maximum of 2, 6, 10 and 14 electrons, respectively.

The position of electrons in the various shells and subshells are represented as follows. Major shells in which the electrons exists are indicated by the numbers 1, 2, 3 etc. and the subshells designated by *s, p, d, f* etc. The superscript on *s, p, d* and *f* gives the number of electrons in the subshell. Thus, *s* specifies the presence of two electrons in the *s* subshell of the first major shell (K). Similarly, $4/^8$ indicates the presence of 8 electrons in the subshell of fourth major shell (*f*).

Hydrogen (H) atom is the simplest atom which consists of one proton, one neutron and one electron. In this atom, the single electron is situated in the one orbit around the nucleus. In (He) helium atom also, two electrons are situated in the single shell. In other elements the electrons are arranged in several shells. Thus, a (Ne) neon atom has two shells of 2 and 8 electrons (total 10 electrons) and (Ar) argon atom has three shells of 2, 8 and 8 electrons (a total of 18 electrons). These orbits or shells may never have more electrons than a certain maximum. When this maximum number of electrons is reached, the shell is said to be saturated. The elements whose outermost shells are saturated with electrons are relatively inert and do not participate in the chemical reactions under normal conditions. The elements in this category (He, Ne, Ar, Kr, Xe, Rd) are gases at normal temperature and they are called *noble gases* because of their inertness. These elements are placed in Group O of periodic table. The elements, whose atoms have electrons one more or one less (or even higher values) in their outermost shell, are chemically active. This chemical activity may be represented as a tendency of those atoms to acquire noble (Group O) configuration by accepting or losing electron(s), acquiring the stable configuration results in lowering of energy.

The mass of an atom depends entirely upon its nucleus. A neutron has nearly the same mass as a proton. Thus, each proton or neutron weighs $1.66043 \times 10^{\sim 24}$g. The mass of an electron is negligible, about $1/1823^{th}$ of the mass of a proton or neutron. The mass of a proton or neutron is known as atomic mass unit (*amu*). For instance, if a carbon atom contains 6 protons, 6 neutrons and 6 electrons, its *amu* will be equivalent to the proton + neutron, i.e., 6 + 6 = 12. The *amu* is also the atomic weight of that element. Thus, atomic weight of an element may be defined as the combined weight of protons and neutrons, in a unit weight. The number of protons on an atom is called the atomic number of the atom. Thus, the atomic number of the carbon is 6. Although the number of neutrons for a particular atom is fixed, it may vary, sometime giving rise to different species of the same atom.

If a neutron is removed from the nucleus or added to it, it will change atomic weight by one unit. But the position charge on the nucleus does not alter, hence, the atomic number remain the same. The different atomic species, having same atomic number (as they have same proton number) but different atomic weight (as they have different neutron numbers) is called *Isotopes*. Thus, a hydrogen atom with two neutrons (named as deuterium) is an isotope of normal hydrogen atom. The isotopes are designed by writing its proton number to the left side as superscript on atomic symbol letter. Carbon has several isotopic forms; the most abundant of these are ^{12}C, ^{13}C, ^{14}C. Isotopes are also written with the mass number following the symbol; C-14 for example.

IONIZATION POTENTIAL

The amount of energy required to remove to most loosely held electron from a normal (uncharged) gaseous atom is called ionization potential. It may be expressed as:

$$A_{(g)} \xrightarrow{Ep} A^{+}_{(g)} + e^{-}$$

Where, g is gaseous form of the atom A, and *Ep* denotes the amount of energy required to remove one electron. The removal of electron generates a positive charge on the atom. The magnitude of ionization potential depends upon various factors. If the radius of the atom is large, the orbiting electrons are farther from the positively charged nucleus and it is easier to remove them. Therefore, the ionization potential of the atoms with larger radii is smaller. The magnitude of the positive charge on the nucleus also affects the ionization potential. If the charge (positive) on the nucleus is increased, it becomes more difficult to remove electrons and therefore the ionization potential increases.

The Ionization potential also depends upon the number of electron orbits. The inner shells or orbits of the electrons act as a shield or screen between the nucleus and the outer shells. Therefore, each inner shell existing between the nucleus and the outermost shell produces a shielding effect, which decreases the force of attraction between the nucleus and the electrons of outer shells. Hence, higher the number of inner shells, lesser the value of ionization potential.

During ionization an atom can lose more than one electron. To remove one electron from an uncharged atom the amount of energy required is commonly called *first* ionization potential. The energy required for the removal of one electron from a charged ion, i.e., a second electron of the original atom is called *second* ionization potential.

$$A^{+}_{(g)} \xrightarrow{II\,`Ep} A^{3+}_{(g)} + e^{-}$$

Similarly, *third* ionization potential represents the energy required to remove one electron from a 2^{+} ion, i.e., third electron from the original atom.

$$A^{2+}_{(g)} \xrightarrow{III\,`Ep} A^{3+}_{(g)} + e^{-}$$

NATURE OF CHEMICAL BONDING

When an atom combines with other atoms they are held together by chemical bond. A chemical bond is not a physical structure like a pair of handcuffs linking two people together. Instead it is an energy relationship between the electrons of the reacting atoms and it is made or broken in less than a trillionth of a second.

A perusal of the periodic table shows that besides the inert gases (He, Ne, Ar, Kr, Xe, Rd- all of them have 8 electrons in their outermost shells except He where outermost shell is also the first shell (K) and cannot have more than 2 electrons).

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