THE STORY OF CREATION

Chapter-17
THE LIVING WORLD

It is better to adhere to a theory that may subsequently prove to be wrong than to have no theory at all. (D.I.Mendeleyev)

17.01. INTRODUCTION

The Creation is not limited within non-living physical world. The Creation of the living world upon this planet is also important. Most possibly it created living Nature in a very small space of this World upon our planet.

How our Great Nature exists beyond non-living physical world and evolved into the living world? Is this living Nature a continuation of the Grand Nature? Yes, it is.

Is it confined to one planet? So far known, yes it is confined to one planet. But life or pre-life or biomolecular environment may occur in other comic body though we are yet to gather information.

Grossly we observe that, among innumerable matter around us, some are carbon-based organic compounds that evolved into complex bio-organic compounds (proteins, fats, nucleic acids etc). From this inert bio-organic matter, more specific organisation of biological matter emerged. We call them living things. Once created within a non-living surrounding, it compounded in varieties and increased in complexity.

From hereon we shall deal with the complexity and diversity of living matter, its creation and evolution that finally produced us the *Homo sapiens*.

17.02. LIFE

First of all, what is life? How it differs from non-life?

If we say that life expresses a set of qualities may be called livingness, it would be sheer tautologies. We are to define life from its functional aspect and how it differs from its opposite, non-life.

The inert matter of Nature at a specific organisation level, turns out to become living matter. The biochemical evolution that occurred first along with general chemical and geological evolution, led to organic and bio-organic evolution. Living features germinated therefrom in the long past under suitable environment.

micro-particles → atoms & molecules → compound → inorganic & organic compound → bio-organic matter → living things.

Life can be described as a state capable of doing some distinguished functions. It is attached to a physical body possessing a set of molecular-biomolecular system capable of reproductive capacity when fed appropriately from surrounding environment. The grand inert matter at some specific organisation and at some specific conditions, produced life made up of inorganic and organic substances, organised at molecular to biological level to acquire such specific functions, called living functions. Non-living things lack them. Living things when get disorganised or decease or die, do not show such functions.

Plants, animals, algae, fungi, protozoa and bacteria – all belong to this new world of Nature. They are all formed from same bio-organic molecules of protein, nucleic acid, carbohydrate, lipid etc which are large molecules built from simpler organic molecules like amino acids, hydrocarbons and others. Simple organic molecules are derived from the same inert physical matter.

All living things are essentially made from same material. They acquire new properties of livingness because of specific organisation**,** much in the same way, inert physical matter acquire physical properties like colour, flavour, crystalline structure.

Can we define life as a machine? No. Can we call it living machine? Broadly speaking, yes.

A machine embodies a group of a system made from assemblage of several parts into some specific order. This results into the machine's acquiring some new functions unknown before that assemblage. The machine further requires some inputs in terms of materials and power, and some control mechanism within or outside. It gives some desired or planned output and some waste products. A living thing works much in similar way.

Still a machine is not a living thing though a living thing works like a machine. The difference is due to another factor, livingness. A

machine cannot work on its own. A living body can do that. A machine lack some other living functions.

A living thing's capacity to live through generations, is known as **self-perpetuation**. We may call it the essence of life. Self-perpetuation is possible for two most primary living functions –

(1) producing offspring and

(2) assimilating food and energy for existence and reproduction.

In other words, *metabolism and reproduction, are two essential functions of life*.

This differentiates life from non-life. Through metabolism, the living thing continues to live for a life-span and through reproduction it continues to live beyond the individual life-span.

When a star is formed, it accretes matter from its surrounding space. We may say that the star is born which thereafter continue to provide its own power to exist. All these together is a kind of function remotely similar to metabolism. When it bursts into stellar fragments, it does not reproduce another star. It is true that another star may be born from this fragmented stellar matter. But this does not resemble reproduction of living being that multiply in number to make a population of the specie.

Life assimilates, collects and grows on surrounding materials and reproduces its likes. A non-life can assimilate, collect, can even grow but cannot reproduce its likes with its own genetic information. Assimilation of matter by non-life is based upon naive physical laws but assimilation by life works, over and above that, on bio-chemical and biological laws. Herein exclusive physical laws are not in total control.

Once created in some form from non-living matter, living things are born from living things only (life begets life). It does not create from the same non-living matter in the same way. But It remains absolutely dependent on the non-living Nature for its existence and perpetuation. Also it is dependent upon other living things.

Remaining dependent upon the Nature as a whole, it induces changes in the ecology resulting into dynamic interactions between the living world and the nonliving world. This is the major condition for emergence, perpetuation and continuation of life.

An individual life ends in death but life continues through progeny. Death is the end of all living functions of the individual when the component inorganic and organic matter go back to the Grand Physical Nature ('panchabhuta' or five physicalities of Nature).

A death cannot be explained easily in binary fission of living cell. When a cell divides into two, the same cell continues to remain alive by half so there occurred no death in the same sense. Here again the same cell is no longer alive due to its division into two halves, hence in some way we may say that death has occurred.

Human being finds it difficult to accept death as the end of livingness. A person who was alive little while ago, talked and ate and moved, is now no more though the same body is lying down without much change in person. What is missing? Something non-corporeal that was inside sometime ago which is no more there. We termed it spirit, or soul or atma. Popular belief is that death cannot be a simple end of living functions but escape of that soul from physical body. They tried to get some solace in imaginary life-after-death.

Simple living things when evolved into higher life-forms, exhibit other living functions. For example, since life needs food and energy from its surroundings, they have to have movement and locomotion.

Our Grand Nature is greatly varied in different regions and changes continuously. The changes are dynamic in ecological niches. Living organisms have to take note of them and accordingly re-orient itself. So they need to respond and adapt itself to external stimuli. This imparts a dynamism to the living body, higher than fixed mechanical response. Irritability and adaptability evolved as additional living functions necessary for survival of those specie.

We may now say that life becomes a complex, unique organisation of inert matter of Nature, with a set of biochemical-biological reactions that results in living functions of growth, development, reproduction, response, adaptation and evolution.

In *Principles of Biochemistry*, the American biochemist, **Albert Lester Lehninger** (1917-1986) wrote '*Living things are composed of lifeless molecules. When these molecules are isolated and examined individually, they conform to all physical and chemical laws that describe the behaviour of inanimate matter'*.

When these lifeless molecules are organised in a specific way, it becomes a living thing. It exists as an individual entity in a population of similar entities, that too within an environment of other living entities and physical Nature.

Physical things, left on its own, tend to equilibrium with its immediate surrounding. Life maintains its entity persistently and denies or tends to deny the equilibrium till its death. This is another way of looking into life. The basic distinction between the living and non-living system is this persistent absence of equilibrium in living

ones. Living things constantly work at the expense of free energy, to prevent the equilibrium required by the laws of physics under the existing external conditions. This is called the '*principle of persistent non-equilibrium'* of living systems.

There occurs a continual interaction of opposite processes: synthesis and destruction of molecules, birth and death of individuals, appearance and extinction of species. Life can only exist where synthesis and destruction occur together. But that may not be the feature of living world alone. In fact, it is a general feature of this Great Nature by and large.

17.03. LIVING FUNCTIONS

There is really no unequivocal definition of life. Our understanding is essentially descriptive.

Two essentials functions, metabolism and reproduction, are preconditions of life.

With the evolution of complex living forms, some other functions such as circulation, excretion or transpiration, movement and locomotion, control etc. appeared. In general, the following functions are widely recognised.

1. **Homeostasis –** It is the regulation of the internal environment to maintain a constant state. (For example, electrolyte concentration or sweating to reduce temperature.)
2. **Organization –** It is structurally composed of one or more cells, when cells are the basic units of life.
3. **Metabolism – It can t**ransform energy by converting chemicals and energy into cellular components (called anabolism) and decompose organic matter through the process called catabolism. Living things require energy to maintain internal organization and to produce other living phenomena.
4. **Growth – It m**aintains higher rate of anabolism than catabolism so that a growing organism can increase in size in all of its parts, rather than simply accumulating matter.
5. **Adaptation – It has t**he ability to change over time in response to the environment. This is fundamental to the process of evolution and is determined by the organism's heredity as well as composition of metabolized substances along with some external factors.
6. **Response to stimuli – It has the capacity to** respond in many forms, from the contraction of a unicellular organism to external chemicals, to complex reactions involving all the senses of multicellular organisms.
7. **Reproduction – It must possess t**he ability to produce new individual organisms, asexually or sexually.

Let us be acquainted with some biological terms in some details.

Metabolism is a vital function by which a living body process food material required for growth and maintenance of the body. It can be reduced to three sub-functions, *nutrition*, *respiration* and *synthesis*.

Primary physical components required for the job, are energy and nutrient. Energy is required to power the functions while nutrients for making physical bodies, growth and replacement of worn-down parts. Nutrients provide the organic and inorganic material source while respiration provides the gaseous source and generates energy. The process by which nutrients are formed into new structural parts, can be called the *synthetic activity*. Synthesis occurs in living units to produce bio-organic things. Power for this activity is provided by respiration. Complex nutrients are reduced into simpler biomolecules before synthetic activities.

Metabolism may occur in two ways – (1) anabolic and (2) catabolic. The former constitute the synthetic process by which nutrients are processed biochemically by the living thing for its growth and energy. It happens in photosynthesis and nutrition. In the catabolic process, organic body consumed as food, is broken down to release required energy as it happens in respiration.

Nutrition can be reduced into five smaller processes – ingestion (intake of nutrients), digestion (processing the nutrients with digestive chemicals), absorption (processing of nutrients for absorption), assimilation (processing the absorbed nutrients towards growth and repair) and egestion (throwing out of undigested nutrients). Nutrients come from food.

Plants get its food from surrounding Nature. They are *autotrophs* and can build their own food from inert matter. Animals get their food from plants and animals. Animals are *heterotrophs* and cannot build organic compounds from inorganic source. They need already prepared organic things which they decompose into simpler organic matter.

Plants convert inorganic matter into organic food by photosynthesis. Photosynthesis is the synthetic (anabolic metabolism) process where glucose is produced from carbon dioxide and water in presence of solar energy. Solar energy is absorbed by chlorophyll of plants and transforms its ADP molecules into ATP molecule, storing energy by photolysis and photo-phosphorylation. Then synthesis of carbohydrate takes place by Kelvin cycle using carbon dioxide of the atmosphere and converting them into PGA (phosphoglyceric acid), PGAld (Phosphoglyceraldihyde) lastly into] glucose.

Respiration provides energy on using materials supplied by nutrients. Respiration is a bio-chemical process occurring inside a cell where some respiratory matter (oxygen in case of aerobic respiration) is taken in. Breathing is an external affair of the respiratory process. Plants have no respiratory organ. They work on through stomata, lenticles and Pneumatophores. Animals respire through wet body surface (amoeba, sponge, hydra), cuticle or skin (worms), spiracles and trachea (arthropods), gills (fish)), and lungs(human). Respiration may occur anaerobic or aerobic way.

Fermentation is the third way to supply energy. Where oxygen is required for respiration, the process is called aerobic one. Here organic molecule glucose first transforms into an acid by *glycolysis*. It works within the cytoplasm of the cell. In the second phase (Kreb's cycle and electron transport system), that acid is oxidised to produce carbon dioxide, water and energy. It works inside mitochondria housed within cell-body. Where no oxygen is required, the respiratory process would be anaerobic. Here glucose is broken down into the same acid by the same process of glycolysis. It transforms into acetaldehyde or into other compounds by enzymes to produce energy. In the fermentation process, glucose ferments to produce organic compounds like lactic acid or ethyl alcohol and produce energy.

Reproduction is another essential feature of self-perpetuation. By this, life continues to exist as species. Reproduction appears like the biological goal of each and every existence. Earlier at primary cell level, reproduction was carried out by binary fission. Later complex life learnt to reproduce in so many ways. Primarily, there are four ways of reproduction – *vegetative* (as in cuttings), *parthenogenesis*, *asexual* (as in spores) and *sexual* (where two different cellular things merge to reproduce a fertilised egg-cell).

Vegetative reproduction are seen in plants as in cuttings. It may further occur by numerous methods. Some plants reproduce simply by fission, some by budding or by fragmentation or by underground stem or adventitious buds or fleshy roots or bulbils. It is also found in animal - hydra.

Asexual reproductions occur by amitosis or mitosis process in cells or germ-cells, in plants and animals. It may occur in many ways – fission, budding, Gemmule-formation, regeneration, and sporulation. Animal amoeba, paramecium reproduce by binary fission. Amoeba may also replicate by multiple fission.

Sexual reproduction is an advanced feature and occurs in both plants and animals by meiosis cell division of germ-cells. Here male and female which reproduce two types of special cells, called germ-cells, maturing into gamets. Male-female gamets join in to fertilise itself into zygote. This may happen by syngamy or conjugation, found in lower plants. It may be of several types - autogamy, exogamy, hologamy, isogamy (where two gametes are identical), anisogamy (where two gametes are not identical), oogamy or fertilisation (where small motile male gametes fertilise bigger non-motile female gamets).

Fertilisation may occur internally (as in insects, birds, mammals) or externally (as in fish, toad etc). Further fertilisation may be oviparous (as in fish, birds), ovoviviparous (as in snails, sharks) and viviparous (cow, goat, human). In conjugation (ex. spyrogyra, mucor, paramecium), two gametes are nearly identical. They conjugate, form zygospore (2n) that divide into haploid (n) and then into zygote.

In Parthenogenesis, reproduction occur through unfertilised eggs as in spyrogyra, mucor, bees, ants, etc.

Replication transfers very specific information to the next generation. Mass of information are of all sorts, as may be required for growth, metabolism, reproduction etc. They are all of specific kind for the entire life span of the organism. Such passing of information to the progeny, is heredity.

Living things, once born, has to pass through a *life cycle*. Average life-span of specie is determined statistically.

Circulation is a living function, distinctly observable in higher forms of multi-cellular life by which nutrients, oxygen, hormones, etc are transported onto different organs and into different cells by a liquid medium. It also removes waste products. In plants, water is the carrying medium, while blood and lymph are the medium in animals. Circulation may be open or closed. Hearts pump the liquid medium into the body of the animal system. Plants have no such pumping organ. They conduct by root pressure, atmospheric pressure or capillary pressure, cohesion and transpiration pull etc. Lower plants and water plants conduct through osmosis.

Excretion is a living function by which waste products after metabolism are excreted from the body. Animals have excretory organs for the purpose. Unicellular organism excretes through vacuole and cell membrane. Plants often store wastes as crystals/colloids. Some excrete shedding leaves, bark, fruits, gum,

resin or by transpiration. Animal's excretory organs may be flame cells, nephridia, malpighian tubules, green gland or kidney.

Movement means motion of parts of an organism. *Locomotion* means motion of the whole organism itself. Movement and locomotion are required for life to get necessary raw materials for metabolism, to control and to save the organic system from untimely death. Energy of movements are obtained from metabolism of the system.

Plants make movement by protoplasmic circulation or rotation, ciliary or amoeboid movement induced by light, heat, chemicals, water or electricity. Plants also make movement or curvature by its motion of growth and trophism. We observe several types of trophic movement like hydro-tropism, geo-tropism, photo-tropism. Animals move by pseudopodial organ (amoeba), flagella (euglina) or cilia (paramecium), by looping, swimming, slipping and creeping (earthworm), by crawling, leaping and walking on limbs, or by flying on wings.

Most living things contain some systems in order to respond to external environments. Such response to stimuli is called *irritability* by which it knows the changes in the environment so as to modify itself accordingly. Sense-organs exhibit higher forms of irritability. Higher the organisation and complexity of life-forms, higher is the function of irritability and consequent *adaptability*. When environmental changes are permanent, irritability becomes permanent that result in gradual modifications in successive individuals.

In Nature, all events are causal and a system is only a perpetuation of events for some period of time. The perpetuity is effected by some control mechanism. More the simple elementary system are packed into a complex system, more its control gets complicated, requiring a set of information for sequence of elementary or functional systems. Most living things have some kind of *control mechanism* and information processing system. Living functions like growth, reproduction, circulation excretion etc. are governed by a set of regulations in this controlling mechanism. For example, the control is carried out in the brain and nervous system in human being. In a cell-body, DNA in the nucleus provide the basic necessary information and control. In some organism, RNA may do that job. Self-perpetuation is maintained by this control.

A living organism needs to have steady access to energy and nutrients outside. For this a steady state control comprising of

nutrient supply, internal control of the organism, protective activity, self-repair, self-replacement etc. is to be provided.

Self-perpetuation is controlled by development, growth and reproduction provided by heredity and evolution. Simpler or lower type of organisms show the basic living functions (i.e. metabolism and replication) while higher organism exhibit more complex functions.

Biophysicists comment that living things function on negative entropy. In other words, living process can be viewed as a delay of spontaneous diffusion or dispersion of internal energy of biological molecules towards more potential microstates.

According to physicists such as John Bernal, Erwin Schrödinger, Eugene Wigner, and John Avery, life is a member of the class of phenomena that are open or continuous systems capable to decrease their internal entropy at the expense of substances or free energy taken in from the environment and subsequently rejected in a degraded form.

Again living beings are thermodynamic systems that have an organized molecular structure.

Hence, life is a self-sustained chemical system capable of undergoing evolution. In another language, living things are self-organizing and autopoietic (i.e. self-producing).

Variations of this definition include Stuart Kauffman's definition as an autonomous agent or a multi-agent system capable of reproducing itself or themselves, and of completing at least one thermodynamic work cycle. Life can be modeled as a network of inferior negative feedbacks of regulatory mechanisms subordinated to a superior positive feedback formed by the potential of expansion and reproduction.

Again we like to repeat that life consist of things with the capacity for metabolism and motion; some describe that life is self-reproduction "with variations" or "with an error rate below the sustainability threshold."

17.04. TAXONOMY

The cell is the basic and the smallest structural unit of living things.

The term 'cell' has got several meaning. Here we mean it a biological cell. Since the component nucleic acid molecules of

cellbody, can reproduce with the help of protein bodies, they should be called the smallest living form or ultimate life molecule.

Generally, we recognise the cell as the smallest structural unit of life. All cells are made of nearly same organic molecules and organs and work with some essential living functions. The cell may occur in various types.

The lowest organisms are made up of improperly-organised cells and are called *sub-cellular*. The sub-cellular class probably evolved earliest, as it appears from its poor cell organisation.

When living things are made up of well-organised cell structure, we call them *cellular*.

A cellular living organism may be made up of single cell or many cells. Single-cell organisms are called *unicellular* while many-cell organisms *multi-cellular*. Most living things occur as multi-cellular.

Living cells are often classified as *prokaryotes* and *eukaryotes*. The former includes those cells where constituents of cells are not fully organised. In later types, cells exhibit well-organised constituent structures. Life arose first in the form of prokaryotic cells and later evolved into unicellular eukaryotes and then into multi-cellular eukaryotes

[prokaryotes → unicellular eukaryotes → multi-cellular eukaryotes].

In multi-cellular organism, cells are organised together to form *tissue* in order to perform a specific function. When several tissues organise themselves to do some specific functions of higher level, it is called an *organ*. When some organs combine to act some characteristic function, it is said to be an *organic system*. Higher living things exhibit several distinct organic systems. Simple to complex functions are undertaken by such simple to higher level of organisation of cells

cell → tissue → organ → organ system → living body

Life emerged from unicellular into multi-cellular. Higher the living things, more complex are their functions.

Living world in its short span of evolution diversified enormously. Some life forms were now extinct. We have discovered some of them as fossils. Lots disappeared without leaving any evidence. Some are still living around yet to be identified.

This great living world requires some grouping or classification of living forms for our convenience to study them. Earlier in chapter-3, we have seen how Aristotle and Linnaeus classified them. With more knowledge of this world we are to classify them more scientifically.

The subject, *taxonomy* takes care of classifying the living world into an order - in hierarchy.

A kind of grouping is first made on sharing certain common features. Next subgroups are made based on additional common features in a group. The process goes on in the subgroup again. In this way we get down to species level.

Another principle of grouping could have been followed for better understanding of the living world. As life forms evolved from simple to complex in some way, with sufficient knowledge of this evolutionary scheme of complexification, we can classify them on the lineal basis. With our present level of knowledge, we have large gaps such lineal scheme.

The classification of living world began as early as Aristotle and his pupil Theophrastus. In modern ages, Carolous Linnaeus divided the living things into two kingdoms – (1) plants and (2) animals.

After the discovery by Leewenhoek, Haeckel proposed three kingdom as (1) Protista, (2) Plantae and (3) Animalia.

After development of electron microscopy, a group of cells were found as prokaryotes (that do not fully develop with distinct nucleus).

In 1938 the American biologist **Herbert Faulkner Copeland** (1902-1968) proposed four kingdom. The fourth one Protista included bacteria and blue-green algae.

Based on the French biologist **Edouard Chatton** (1883-1947)'s idea of importance of prokaryote-eukaryote, soon a superkingdom was found necessary.

With the discovery of varieties of the living world such as virus, bacteria, euglena type algae, we could not convincingly group them into two kingdoms. For this reason, the living Nature was then divided into four kingdoms by the ecologist, **Robert Harding Whittaker** (1920-1980) of USA, in 1959. They were

(1) Protista,
(2) Fungi,
(3) Plantae and
(4) Animalia (within Empire Eukaryote).

The kingdom Protista consisted of two sun-kingdoms, monera & eunucleata (single celled eukaryotes). Sub-cellular life forms, virus, were not included.

In 1982, the biologist **Lynn Margulis** (b1938) classified five kingdoms as (1) Monera, (2) Protoctista, (3) Fungi, (4) Plantae and (5) Animalia.

The American microbiologist, **Carl Richard Woesse** (b1928) in 1990, introduced three-domain classification as archaea, bacteria and eukaryote. It is based upon genetic relationship rather than obvious morphological similarities. Archaea are neither bacteria nor eukaryotes – they are prokaryotes. Under the domain Eukarya, we have kingdom Protista, Plantae, Fungi, and Animalia.

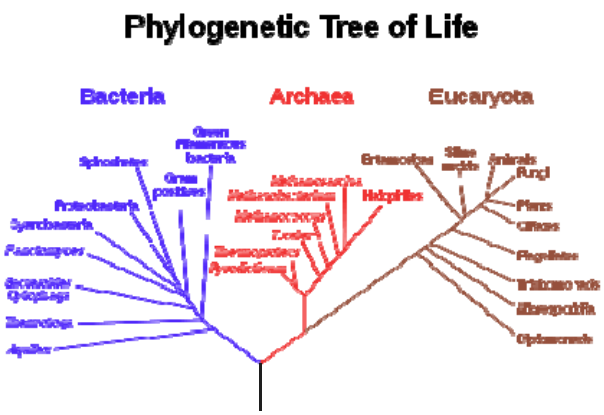

Fig:17.01. Phylogenetic tree based on Woese et al. rRNA analysis in 1990.

In 1993, the British biologist, **Thomas Cavalier-Smith** (b1942), divided the living world into eight kingdoms – (1) Plantae, (2) Animalia, (3) Protozoa, (4) Fungi, (5) Eubacteria, (6) Archaebacteria, (7) Chromista, and (8) Archezoa.

By 1998, Cavalier-Smith had reduced the total number of kingdoms from eight to six - Animalia, Protozoa, Fungi, Plantae (including red and green algae), Chromista and Bacteria. Five of Cavalier-Smith's kingdoms are classified as eukaryotes

(1) Bacteria (with arcaebacteria as subkingdom), (2) Chromista (including Alveolata, cryptophytes, Heterokonta, Haptophyta, Rhizaria etc), (3) Fungi, (4) Protozoa, (5) Plantae (including red and green algae) and (6) Animalia.

Six kingdoms are grouped into two broad kingdoms – Prokaryote and Eukaryote. The former includes only the kingdom Bacteria.

In 2004, **Simpson** and **Roger**, noted that Protista are eukaruotes baring animals, plants or fungi. Accordingly next year, eukaryotes are divided into six supergroups (Excavata, Amoebozoa, Opisthokonta, Rhizaria, Chromalveolata and Archaeplastida). Animals and fungi and choanoflagellates etc are grouped into Opstokonta.

Fig:17.2. Eukaryotic relationships, modified from Simpson and Roger (2004).

In this system, the traditional kingdoms have vanished. For example, research shows that the multicellular animals (Metazoa) are descended from the same ancestor as the unicellular choanoflagellates and fungi. A classification system which places these three groups into different kingdoms (with multicellular animals forming Animalia, choanoflagellates part of Protista and Fungi a separate kingdom) is not monophyletic. The monophyletic group is the Opisthokonta, made up of all those organisms believed to have descended from a common ancestor, some of which are unicellular (choanoflagellates), some of which are multicellular but not closely related to animals (some fungi), and others of which are traditional multicellular animals.

However, doubts were being expressed as to whether some of these supergroups were monophyletic, particularly the Chromalveolata, and a review in 2006 noted the lack of evidence for several of the supposed six supergroups.

As of 2010, there is widespread agreement that the Rhizaria belong with the Stramenopiles and the Alveolata, in a clade dubbed the SAR supergroup, so that Rhizara is not one of the main eukaryote groups. Beyond this, there does not appear to be a consensus. Rogozin *et al.* in 2009 noted that 'he deep phylogeny of eukaryotes is an extremely difficult and controversial problem.' As of December 2010, there appears to be a consensus that the 2005 six

supergroup model does not reflect the true phylogeny of the eukaryotes and hence how they should be classified, although there is no agreement as to the model which should replace it. (source: Wikipedia)

Usually, each kingdom is divided into Phylum (Divisions in case of plants and microbes), Class, Order, Family, Genera and Species. Sometimes further sub-division is made as sub-kingdom, sub-phylum, sub-class or super class. The grouping from individual to kingdom level is done in the following manner:

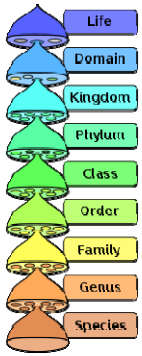

Fig:17.3. The hierarchy of biological classification's eight major taxonomic ranks, which is an example of definition by genus and differentia. A domain contains one or more kingdoms. Intermediate minor rankings are not shown.

The subject of classification, in taxonomy, is a very controversial one and seldom we find a clearly acceptable classification. Further with more and more knowledge and discoveries, revision becomes unavoidable. But someone must begin from somewhere.

No individual is exactly similar with another one in all respects, though they belong to same specie. There will always be some differences among the individual member of a specie. Typical individual differences characterise the group, called variety or sub-specie. *Species* is the basic unit of taxonomy. It comprises of the distinct group of self-perpetuating individuals, more or less isolated genetically and geographically distributed in its environment.

Linnaeus defined species (1738) as - *those diverse forms that the Infinite Being produced initially*.

Earnst Mayr defined in 1942 - *species are groups of actually or potentially interbreeding natural populations which are reproductively separated from each other such groups*. In the light of recent knowledge, *a species is the set of organisms whose genomes are sufficiently similar one another and exchange of genes can take place among them without changing the aspect of species significantly*. In other words, members of a specie look same in outer

appearances, have similar reproductive organs or systems and come of a common ancestor. Since modern forms evolved from some ancestral forms, classification is likely to be in the order of descent from earlier ancestors. It would also reflect extent of divergence from ancestors.

The German entomologist **Emil Hans Willi Hennig** (1913-1976) derived a cladistic principles in 1950. It stresses branching sequences on genealogy. *Cladograms* are made on the basis of observed or presumed number of characters shared by groups. Classification may also be based upon both genealogy and extent of divergence. Results are summed up in *phylogenetic trees.*

Let us summarise different classifications in the following Ttable: 17.01.

Table:17.1. Different classification of kingdoms in history (source : Wikipedia)

Linnaeus 1735[6] 2 kingdoms	Haeckel 1866[1] 3 kingdoms	Chatton 1925[7][8] 2 empires	Copeland 1938[9][10] 4 kingdoms	Whittaker 1969[4] 5 kingdoms	Woese et al. 1977[11][12] 6 kingdoms	Woese et al. 1990[13] 3 domains	Cavalier-Smith 2004[5] 6 kingdoms
(not treated)	Protista	Prokaryota	Mychota	**Monera**	Eubacteria	Bacteria	Bacteria
					Archaebacteria	Archaea	
		Eukaryota	Protoctista	Protista	Protista	Eukarya	Protozoa
							Chromista
Vegetabilia	Plantae		Plantae	Plantae	Plantae		Plantae
			Protoctista	Fungi	Fungi		Fungi
Animalia	Animalia		Animalia	Animalia	Animalia		Animalia

The Kingdom Virus includes sub-cellular viruses and viroids that exist on the threshold of life and non-life. At times it stays on like any inanimate matter. It quickly springs into life under suitable conditions and reproduces.

The Kingdom Monera contains prokaryotic unicellular bodies. It means imperfect cell organisation compared to eukaryotic bodies. The cell structure is poorly compiled into a diffused state. The kingdom included bacteria, archaebacteria and blue-green algae.

Under the three-domain system of taxonomy of 1991, monera has been included in two domains of Archaea and Bacteria (Eukaryote being the third domain)

The Kingdom Fungi (or Protocista) includes Fungi or Eumycophyta . There occurs 50,000 species in this kingdom. They resemble like plants but without any presence of chlorophyll. They

are saprophitic or parasitic on other plants or on animals. They also resemble animals but cannot ingest like animals. They excrete digestives to digest the food outside their bodies and absorb them.

The Kingdom Protoctista includes predominantly single-celled organism of eukaryotic type. They include algae (except blue-green and grass-green algae), protozoa and slime moulds. Algae is a group of very simple plants without true stems or leaves. They are generally aquatic. Some 20,000 species of algae can be found. It has four classes now : Brown Algae (Phaeophyceae), Red Algae (Rhodophyceae), Green Algae (Chlorophyceae) and Diatoms.

Protozoa is an animal in which no division of the body into cells occur. They range from lowest animals (very much like bacteria but for the fact that they have at least one clearly marked nucleus) to more complex forms with special parts for special purposes. Most of them are very small and live in water. Some of them are parasites. Amoeba, malaria parasites, sea plankton etc are examples of 28,000 varieties of the group. Protozoa has one phylum Protozoa divided into 4 classes: Flagellata (example - Euglena), Sarcodina (example - Amoeba), Ciliophera (example- Permecium, Stentor) and Sporozoa (example- Plasmodium, Monocystis).]

The Kingdom Plant comprises of chlorophyll-containing plants, which have little or no power of digestion of solids. They get all or most of their food in the form of gas or of solutions of chemical substances in water. They are autotrophs as they can make their food from nutrients drawn from outside Nature and convert into organic forms with the help of solar energy by photosynthesis. Plants have no power of moving from place to place like animals. Plants cells are different from animal cells. The pattern of cytokinesis of plant cells after mitotic division is unlike animals. Animal cells grow inwards towards the centre while plant cells form an interior cell plate growing outwards between two daughter cells.

Fig:17.03 Plant kingdom.

The kingdom was broadly divided earlier into two sub-kingdoms - Archegoniatae and Spermatophyta. The sub-kingdom Archeginiatae have Archegonium (female sex-organ) bottle like in form and undergoing the process of reproduction by Sphorophyte and Gametophyte in turn. It was subdivided into two divisions: Bryophyta and Pteridophyta. The subkingdom Spermatophyta was

divided into two super-divisions: (1) Gymnospermae and (2) Angiospermae.

Table:17.2. Diversity of Living Plants

Diversity of living plant divisions			
Informal group	**Division name**	**Common name**	**No. of living species**
Green algae	**Chlorophyta**	green algae (chlorophytes)	3,800
	Charophyta	green algae (desmids & charophytes)	4,000 - 6,000
Bryophytes	**Marchantiophyta**	liverworts	6,000 - 8,000
	Anthocerotophyta	hornworts	100 - 200
	Bryophyta	mosses	12,000
Pteridophytes	**Lycopodiophyta**	club mosses	1,200
	Pteridophyta	ferns, whisk ferns & horsetails	11,000
Seed plants	**Cycadophyta**	cycads	160
	Ginkgophyta	ginkgo	1
	Pinophyta	conifers	630
	Gnetophyta	gnetophytes	70
	Magnoliophyta	flowering plants	258,650

Plant kingdom was thus divided into ten divisions with common names as follows : (1) Bryophyta (moss type plants), (2) Psilophyta (whisk ferns), (3) Filicophyta (ferns), (4) Sphermophyta (horsetails, scouring rushes), (5) Lycophyta (club mosses, spike mosses, quill worts), (6) Cycadophyta (Cycads - palm like trees), (7) Coniferophyta(conifers such as Pine, Larch, fir, spruce etc), (8) Ginkgophyta (Gingko biloba), (9) Gnetophyta (Gnetophytes) & (10) Magnoliophyta (Angiospermae, flowering plants).

The classification is recently reorganized. We now have about 350,000 species of plants, as seed plants, bryophytes, ferns and fern allies, existing currently. As of 2004,

some 287,655 species had been identified, of which 258,650 are flowering plants, 16,000 bryophytes, 11,000 ferns and 8,000 green algae.

The Kingdom Animalia are the group of living things that take in oxygen and give off carbon dioxide all the time. It has a system for the digestion of food in the form of plant or animal substance, being without the power of building up its food from the simpler chemicals. Generally it has some power of free motion.

Animal kingdom with 10,71,000 type of living species, is broadly grouped into three sub-kingdoms: Parazoa, Mesozoa and Metazoa. It is further divided into several phylum.

The sub-kingdom Parazoas are animals lacking tissues or organs and occurring in indeterminate shape.

The sub-kingdom Metazoa of the earlier classification, comprises the largest group of animals where animal bodies are made of more than one cell and cells are united into tissues. Animals further have system of parts, generally with nerves and a body hollow where digestion takes place.

Metazoa has 25 phylum. We present below (Table:17.3) one list of extant animal kingdom with common name, period of origin and available number of species.

Among 25 phylum of Metazoa, the Phylum Chordata was divided earlier into two sub-phylum – Protochordata or Acraniata and Vertebrata.

It is now divided into three sub-phylum – Tunicata (Urochordata, 3000 species, Silurian?), Cephalochordata (Acrania, 23 species, Cambrian), and Vertebrata (Craniata, 47000 species, Ordovician).

We, the *Homo sapiens*, belong to the vertebrata-group.

The sub-phylum Vertebrata is divided further into seven classes – Agnatha or jawless fish, Chondrichthyes (jawed fish), Osteichthyes, Amphibia (frogs, crocodiles etc.), Reptalia (snakes, lizards etc.), Aves (birds) and Mammalia.

We, the *Homo sapiens*, belong to mammalia class which is subdivided into Prototheria, Metatheria and Eutheria.

We, the homo sapiens, belong to Eutheria that includes twelve orders – Edentata, Sirenia, Cetacea, Proboscidea, Hyracoidea, Artyoductila, Perissoductyla, Rodentia, Carnivora, Insectivora, Chiroptera and Primates.

We, as *Homo sapiens*, belong to the order of primates.

Table:17.3. Divesity of Animal kingdom.

A.Sub-kingdom - **Parazoa**.			
Phylum Placozoa			1
Phylum Porifera	= sponge	Cambrian	9,000
B.Sub-kingdom- **Mesozoa**.			
Phylum Mesozoa			100
C.Sub-kingdom- **Metazoa**.			
Radiata			
Phylum Cnidaria	= Coelenterata	Vendian	9,000
Phylum Ctenophora	= combjelly	Devonian	101
Phylum Platyhelminthes	= flatworm		20,000
Phylum Nemertea			
(Rhynchocoela) = ribbonworm		Carboniferous	900
Phylum Gastrotricha			450
Phylum Rotifera	= wheel worm	Eocene	1,800
Phylum Introverta		Cambrian	900
Phylum Onychophora	= velvet worm	Cambrian	80
Phylum Tardigrada	= water bears	Cretaceous	400
Phylum Pogonophora	= beard worm	Vendian;	150
Phylum Chaetognatha	= arrow worm	Cretaceous;	100
Phylum Nematoda	= round worm	Carboniferous;	12,000
Phylum Annelida	= segmented worm	Cambrian;	15,000
Phylum Arthropoda		Cambrian;	1,000,000
Phylum Mollusca		Cambrian;	100,000
Phylum Apometamera		Devonian;	400.
Phylum Phoronida		Devonian ?	15.
Phylum Brachiopoda	= Lampshell	Cambrian;	340.
Phylum Bryozoa	= moss animals	Ordovician;	4,600.
Phylum Echinodermata		Cambrian;	7,000.
Phylum Hemichordata		Cambrian;	85.
Phylum Chordata			50,000.

Notes (for Table:17.3):
Phylum Introverta includes Kinohyancha, Lorcifera, Priapulida, & Acanthocephala. Phylum Nematoda includes Ademophorea, Secernenta and Nematomorphs. The following are often referred in separate phylums : Phylum Entopracta, Phylum Gnathostomulida (Jaw-worms), Phylum Aschhelminthes (Spiny-headed worms), Phylum Sipuncula (Peanut worms), Phylum Eciurida (Spoon worms), Phylum Pentastomida (Tongue worms), *Phylum Lophophoarata (?) and Phylum Trochelminthes (?).

Though unfamiliar to us, the animal kingdom is now revised into four subkingdoms: Parazoa, Eumetazoa, Radiata and Bilateria.

Parazoa includes two phylum, Ctenophora and Cnidaria.

The Bilateria includes Orthonectida, Rhombozoa, Acoelomorpha, superphylum Deuterostomia and Protostomia.

Superphylum Deuterostomia includes Chordata, Hemichordata, Echinodermata Xenoturbellida and Vetuliocolia.

Protostomia includes three superphylum – Ecdvsozoa, Platyzoa, Lophotrochozo

17.05. REMARKS

We belong to this living world of this planet in the whole Universe. We are created by this Nature. How this Nature created us, within its millions of creations, one that can understand the process itself? Are we the Ultimate aim of its creation? How one creation of this Grand Nature, possess the mechanism of understanding?

Before that, we have to have some knowledge about the nature of the living world in general, the varieties of its creations and the sequence in which creations occurred.

Modern science stepped up its pace from 15th century, as we have seen it in chapter-3. Biological science came up rather sluggishly. It is in the 18th century that a theory of evolution of life was proposed that pulled down the age-old idea of Divine Creation of everything, the stars, the sky, plants and animals, and particularly human being.

Let us turn our attention to that theory.
