PALEONTOLOGY

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1. ORIGIN & EVOLUTION OF LIFE

1.1Theories of origin of life

1.1.1 Oparin-Haldane Hypothesis

According to Oparin and Haldane, the early Earth had a reducing atmosphere, which is an oxygen-deficient atmosphere where molecules tend to give up electrons. In these circumstances, they recommended that:

Basic inorganic molecules might have reacted (with energy from the sun or lightning) to create the building blocks amino acids and nucleotides, which might have gathered in the oceans to create a "primordial soup" of matter.

In subsequent reactions, the constituent parts might have merged to form bigger, more complex molecules (polymers), such as proteins and nucleic acids, potentially in pools by the water's edge.

The polymers might have come together to form entities or constructions that could support and reproduce themselves. Haldane proposed that macromolecules formed cell-like structures by enclosing themselves in membranes, while Oparin hypothesised that these may have been "colonies" of proteins grouped together to carry out metabolism.

This model's specifics are probably not entirely accurate. For instance, it's currently unknown if pools near the edge of the ocean are a viable location for the origin of life, and geologists no longer believe that the early atmosphere was decreasing. But the basic idea – a stepwise, spontaneous formation of simple, then more complex, then self-sustaining biological molecules or assemblies – is still at the core of most origins-of-life hypotheses today.

1.1.2 Miller- Urey experiment

To put Oparin and Haldane's theories to the test, Stanley Miller and Harold Urey conducted an experiment in 1953. They discovered that under reducing conditions supposed to match those of early Earth, organic compounds might be generated spontaneously.

Miller and Urey created a closed system with a heated water pool and a concoction of gases that were supposed to be common in the early earth's atmosphere (H_2O, NH_3, CH_4, and H_2). Miller and Urey fired electrical sparks through their experimental apparatus to mimic the lightning that could have provided power for chemical processes in Earth's early atmosphere.

Miller and Urey discovered that different kinds of amino acids, carbohydrates, lipids, and other organic compounds had produced after letting the experiment run for a week. However, the Miller-Urey experiment demonstrated that at least some of the building blocks for large, complex structures like DNA and protein may develop spontaneously from simple chemicals.

1.1.3 Gene first hypothesis

One hypothesis is that self-replicating nucleic acids, like RNA or DNA, were the original forms of life, and that other components (like metabolic networks) were subsequent additions to this fundamental system. The "genes-first hypothesis" refers to this.

According to many scientists who support this theory, RNA, not DNA, was probably the earliest genetic substance. The RNA world hypothesis refers to this. For a number of reasons, scientists prefer RNA to

DNA as the initial genetic molecule. The fact that RNA can act as a catalyst in addition to delivering information is arguably the most significant. On the other hand, there are no known naturally occurring catalytic DNA molecules.

Ribozymes are RNA catalysts that may have had a significant impact on the RNA world. Perhaps, a catalytic RNA may catalyse a chemical reaction to duplicate itself. Such a self-replicating RNA may transmit genetic information from one generation to the next, meeting the prerequisites for life and possibly evolving. In reality, scientists have developed synthetically tiny ribozymes that can replicate themselves.

1.1.4 Metabolism first hypothesis

The metabolism-first hypothesis, an alternative to the genes-first theory, postulates that the first basic life may have originated from self-sustaining networks of metabolic reactions (predating nucleic acids)

These networks may have developed, for example, close to undersea hydrothermal vents that offered a steady supply of chemical precursors, and they may have been persistent and self-sustaining (meeting the basic criteria for life).

In this case, chemicals created via initially straightforward pathways might have served as catalysts for the synthesis of more complicated compounds. The metabolic networks may have eventually been able to construct big molecules like proteins and nucleic acids. It would have been a late step to form "individuals" surrounded by membranes and isolated from the social network.

1.1.5 Origin from outer space

While sounding like science fiction, the possibility that organic molecules may have arrived on Earth via meteorites is backed up by solid data. For instance, researchers have shown that under space-like circumstances, organic compounds can be created from simple chemical components found in space (high UV irradiation and low temperature). We also know that some organic substances can be found in other star systems and space.

Most critically, it has been discovered that a number of meteorites contain chemical molecules (derived from space, not from Earth). ALH84001, a meteorite that originated on Mars and contained organic compounds with various ring configurations, was found there. Another meteorite, the Murchison meteorite, included a range of amino acids as well as nitrogenous bases (such as those present in DNA and RNA).

1.1.6 Theories of Organic Evolution:

Basic Concept of organic evolution

I. It assumes present day organism have descended with modification from some pre-existing forms. This principle is called descent with modification.

II. Evolution is irreversible.

III. The process is still operating today and will continue to operate for million years.

1.1.6.1 Lamarckism

This principle deals about the use and disuse of an organ as well as the inheriting of acquired traits. When the environment changes, an animal uses some of its organs more frequently while using others less frequently to satisfy these needs. Throughout time, some organs get stronger and more efficient than others due to abuse.

Take the giraffe neck as an illustration. At the period, trees tended to grow excessively tall, thus the giraffe adopted a lengthened neck in response to demand.

1.1.6.2 Darwin's theory of natural selection

He claimed that in the struggle for survival among organisms, those who had favourable mutations would endure in greater numbers at the expense of others. Natural selection is the term used to describe this retention of advantageous variation. Natural selection is more of an active competing process where collaboration among organisms has frequently been necessary for survival. As a result, the phrase "survival of the fittest" refers to organisms that are best adapted to their environment. The other unfortunates are eliminated by nature.

1.1.6.3 Genes and Heredity- Mendelism

Genes dictate every trait an organism possesses, making them separate, stand-alone components. Genes can be either dominant or recessive. In the initial hybrid generation, only the traits of the dominant gene are externally displayed by the individuals. The gametes in his experiment are always pure and carry either the tall gene or the dwarf gene. Recessive gene traits are only ever present in pure organisms.

1.1.6.4 Weisman's theory of germplasm

Somatoplasm and germplasm, two different forms of protoplasm, make up an organism's body. Whereas the germplasm, which serves as a link between generations and is subject to environmental changes, is immortal and includes hereditary units that determine an organism's characteristics, the soma is susceptible to environmental changes but also mortal. As a result, the trait that germplasm introduces can only be inherited.

1.1.6.5 Sexual Dimorphism

The majority of the higher animal groupings are dimorphic, having both male and female versions. Males have different chromosomes (XY), while females have identical chromosomes (xx). Following a sexual union, the resulting zygote may have either the XX or XY pair, depending on the sex.

1.1.7 Life through the Geological Timescale

1.1.7.1 Precambrian life

Before 3.5 billion years ago, there was no evidence of life. Earth's formation occurred 4.6 billion years ago. As the earth formed, it was covered in hazardous gases like CH4, NH3, CO2, and SO2, as well as meteorite bombardment. Because there was no ozone layer creation, the presence of dangerous ultraviolet rays (UV) was the primary barrier to the emergence of life. Around 700 ppm of carbon dioxide (CO2) were present. Simple prokaryotic cell structures known as Cyanophytes, or blue-green algae, started to develop in the water. They are the forerunners of all significant tribes. They engaged in the photosynthetic process, also known as CO2 and H2O absorption, when there was sunlight present since the carbon dioxide concentration at that time was so high. By releasing oxygen into the atmosphere, this mechanism reduced atmospheric CO2 and prepared the stage for the explosion of life. At first, dissolved oxygen existed in the ocean but not in the atmosphere. As the ocean's surface becomes saturated with dissolved oxygen, oxygen continues to build up in the atmosphere. The development of oxygen is not the sole element influencing the emergence of life on Earth. Since the ocean's water is impermeable to harmful UV radiation, the ocean's surface provided an ideal environment for the emergence of life. As atmospheric oxygen levels rise, a reaction occurs that produces ozone layers when UV rays are present. This serves as a kind of protective blanket that opened the door for the explosion of life on Earth. So, life first evolved in the ocean before spreading to land a few billion years later.

1.1.7.2 Phanerozoic life

Although life began in the Precambrian, primitive organisms underwent diversification during this period. For instance, as time progressed, everything from cells to fully grown organisms became more sophisticated. Eukaryotic cells developed from prokaryotic ones. At this time, the entire vertebrate fauna evolved, starting with fish and progressing through amphibians, reptiles, birds, and mammals to the modern human. Invertebrates like trilobites, Echinodermata, coral, and Mollusca also developed at this time. The Phanerozoic aeon is known for its numerous mass extinctions. Some species of these vertebrates and invertebrates went extinct as a result of this catastrophic event, while others underwent morphological changes to maintain the existing environmental adaptation conditions. Yet other species evolved into more complex, advanced organisms like humans. The beginning of the massive diversification of life to a greater extent was indicated by the border between the Cambrian and Precambrian. Edicara fauna is one of the compelling arguments for it. Because there was more life during the Phanerozoic aeon, fossil records and age determination are extremely dependable.

The Phanerozoic has generally been divided into the Palaeozoic, Mesozoic, and Cenozoic eras. Invertebrates are known to have existed during the Palaeozoic, reptiles during the Mesozoic, and aves, mammals, and flowering plants during the Cenozoic. Similar to how animals evolved, plants too underwent similar process. For instance, the trachaeophyta group of terrestrial plants most likely formed from some green algae by building vascular systems in the stem and roots to collect water and nutrients. The ordo-silurian beds are those. Ferns were created as a result of the first land plant evolution. Gymnosperms are the first plant groups to evolve, followed by more advanced plant clades like the angiosperms. Throughout the Cenozoic, earlier flowering plants began to develop into flowering plants. Invertebrates also developed their morphology and habitat in accordance with what has been extensively covered in their respective area.

2. FOSSIL AND FOSSILIZATION

2.1 FOSSIL

Latin's definition of the term "fossil" is "Anything dug up" or obtained from the earth. The naturally preserved remnants or traces of plants or animals that existed in the geologic past are called fossils.

Prehistoric life that first arose 40,000 years ago is referred to as a fossil by geologists. Because they are prehistoric remains, the relics of the Indus and Nile civilisations are not considered fossils, but the remains of the Neanderthals and the stone tools they used are.

Natural processes are required to maintain the fossil. An artificially preserved organic substance that is not a fossil. For instance, the Egyptian "MUMMY" is by no means a fossil.

Most fossils are retained in sedimentary rock, though occasionally they are well preserved in volcanic rocks.

2.2 Condition of preservation

Most fossils are retained in sedimentary rock, though occasionally they are well preserved in volcanic rocks. The favourable conditions for the preservation of fossils are as follows:

2.2.1 Presence of hard skeletal matter.

Its body has some kind of hard substance, either in the form of an exoskeleton or an endoskeleton. As an organism dies, the soft organic tissues are typically observed decomposing and being destroyed by bacterial activity in the presence of oxygen in the atmosphere, making it unlikely that they would be maintained. For such a damaging process, hard particles or tissues may escape and be maintained.

2.2.2 Detachment from atmosphere

One powerful disintegrating agent is oxygen. So, as soon as an organism dies, the dead body must be removed from atmospheric contact by some natural processes; otherwise, oxygen-containing bacteria will quickly breakdown it. Because they are less likely to come into contact with the atmosphere, the sea, river, and lake are better for preservation. They therefore have a higher possibility of fossilisation than terrestrial organisms.

2.2.3 Sedimentation and permanent covering.

By using some materials, such as the sediments that accumulate in rivers, lakes, and the ocean, the odds of preserving deceased organisms will grow from temporary covering to permanent covering.

A localised, highly fossiliferous rock may have outstanding preservations as a result of catastrophic conditions that caused one-time rapid sedimentation.

2.2.4 Chemical environment.

A solution's acidity or alkalinity can be determined based on the concentration of hydrogen ions in the solution, or pH. Typically, the pH scale runs from 0 to 14. Acidic aqueous solutions at 25 °C have a pH under 7, while basic or alkaline aqueous solutions have a pH above 7.

$pH = -\log[H+]$

Keep the water's CO2 content between 7.8 and 8.3 ppm in the photic zone (the area where sunlight falls), where more photosynthetic plants exist than animals. More CaCO3 can be supplied in such an alkaline environment than can be dissolved.

Due to the absence of photosynthetic plants below the photic zone due to low oxygen levels, seawater's CO2 content rises, lowering the pH level and making the environment more acidic. Even at shallow water depths in higher latitudes, such an ecosystem persists.

The rate at which CaCO3 dissolves increases as sea water temperature drops with increasing latitude.

"CCCD" stands for "Calcium Carbonate Compensation Depth" The level of seawater at which the rate of evaporation equals the supply is known as CCCD (Calcium Carbonate Compensation Depth).

Geographic location affects CCCD differently

Higher latitude of 400–500 m

Lower latitude 4000–5000 m (Pacific Ocean)

2.2.5 Effect of diagenetic processes

Diagenetic is generally a process of hardening. Organic material is partially or completely replaced by inorganic minerals due to leaching from acidic groundwater, which results in exceptionally well-preserved fossils.

CaCO3 is typically replaced by silica in solutions.

Organic matter can occasionally become harder due to recrystallization, although excellent recrystallization completely removes the organic shell.

2.2.6 Less deformation and metamorphism of rocks

Destructive factors include excessive deformation, orogenic movement-related metamorphism, igneous intrusion, and other natural occurrences.

2.3 Derived fossils

A fossil redeposited in a sediment which is younger than the one in which it first occurred

2.3.1 Petrification

Replacement of organic material by silica in such a sophisticated way as volume to volume and molecule to molecule replacement takes place causing no change in initial structure.

2.3.2 Carbonization

Except carbon all other organic material is removed. The extreme of carbonization is shown by coal.

2.3.3 Isochemical alteration

Since calcite is more stable than aragonite recrystallize to calcite structure. Such process does not cause any change in chemical structure. This explains absence of aragonite in rocks older than Cenozoic.

2.4 Indirect fossils

2.4.1 Mould fossils

When the organic tissues within an organism are totally removed by solution or leaching and only the outer expression/ morphology is preserved by the sediment, cover, enclosing a void inside, it is known as External Mould.

2.4.2 Cast fossils

In case an organism possesses a hollow cavity, it may be filled by fine sediments and the internal morphology of the organism is preserved known as Cast fossil.

2.4.3 Trace fossil/ Ichno fossil

When the physical traces of life activities such as tracks, trails, and foot-print are indicated on the upper surfaces of fine-grained sedimentary rocks; these are known as trace fossils.

Coprolite (Excretory materials of higher vertebrates like dinosaurs)

Faecal pallets- (excreta of invertebrate)

Trace fossils on the basis of behavioural patterns:

Repichinia – crawling impressions

Cubichinia – resting impression

Pascichinia – feeder at surface

Fodichinia – feeding traces

Fugichinia – escape structures

2.5 INDEX FOSSIL

Those fossil forms which have short time ranges of their existence and wide geographical distribution, are called “Index fossil”.

3. BIOSTRATIGRAPHY

3.1 BIOZONES

3.1.1 Concurrent-range zone

A concurrent-range zone makes advantage of the overlapped ranges of two taxa, with the appearance of one taxon defining the lowest boundary and the disappearance of the other taxon defining the highest limit. The names of the zones' two taxa correspond to their concurrent ranges.

3.1.2 Assemblage zone

A biostratigraphy unit that is not defined by a single index fossil but rather by a group of related fossils.

3.1.3 Taxon-range zone

A taxon-range zone is simply the biozone defined by the first (first appearance datum or FAD) and last (last appearance datum or LAD) appearances of a single taxon. The boundaries are set by where that particular taxon is found in the lowest and highest layers.

3.1.4 Lineage zone

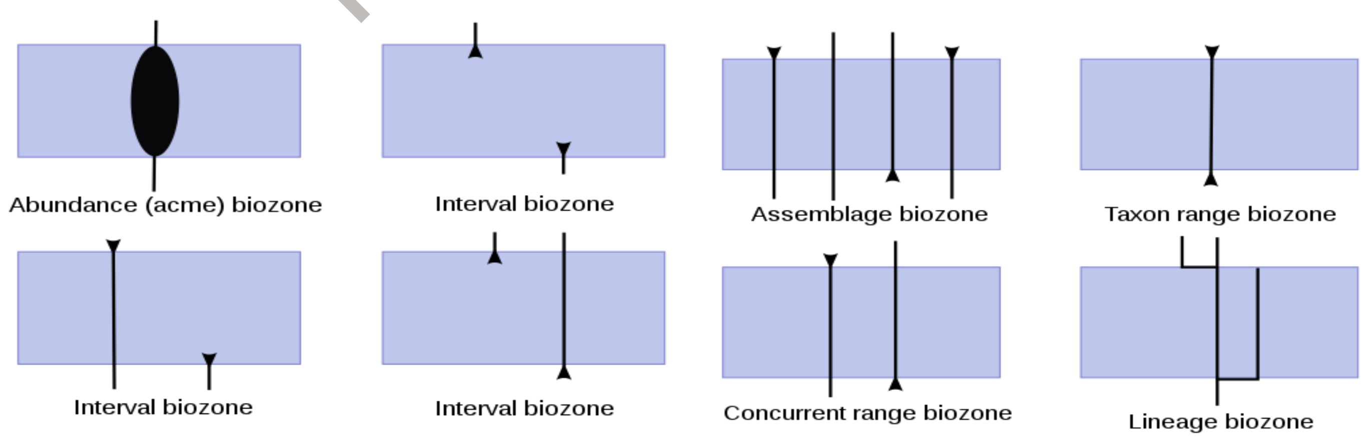
A biozone is called a lineage zone or a consecutive range zone if it is a specific part of an evolutionary lineage.

3.1.5 Abundance zone

An abundance zone, also called an acme zone, is a biozone that is defined by the range in which a certain taxon is most common. Because an abundance zone needs a statistically high number of a certain taxon, the only way to figure out what it is is to look at how many of that taxon there have been over time.

3.1.6 Interval zone

An interval zone is the group of layers between two bio-horizons that are chosen at random. For instance, a highest-occurrence zone is a biozone with the appearance of one taxon as the upper boundary and the appearance of another taxon as the lower boundary.



3.2 TYPE SPECIMENS

3.2.1 Syntype or co-type:

Any specimen mentioned in the protologue when there is no holotype, or any one of two or more specimens that are both called types at the same time.

3.2.2 Holotype

The single specimen that was chosen as the type of a species by the person who first named and wrote about the species.

3.2.3 Paratype

What the scientific name of a species or other taxon actually refers to, but it is not the holotype.

3.2.4 Lectotype

A lectotype is a specimen that was originally a syntype but was later chosen by the author to be a holotype.

3.2.5 Neotype

If the original type material is lost or destroyed, the original author can choose new types from the material collected from the same location and horizon. The word for this is "neotype."

3.2.6 Topotype

All of the species' other specimens that were collected from the type locality are called topotypes.

3.2.7 Pleistotypes

Pleistotypes are the type specimens of a species that were found in another place by a later worker.

3.2.8 Plastotype

A plastotype is a copy of a type specimen.