EVOLUTION

EVIDENCES OF EVOLUTION

Evidences of Evolution

- Evidences of evolution fall under 2 categories:
- Direct and indirect evidences.
- Fossil records are the direct evidences for organic evolution.
- Indirect evidences of evolution are from:
    a) comparative anatomy and morphology.
    b) embryology
    c) physiology and biochemistry
    d) Molecular biology

Paleontological evidences

- Study of fossils- Paleontology.
- Fossils- remnants of life forms or the parts found preserved in rocks (earth crust).
- Fossils are written documents of evolution.
- Leonardo da Vinci- father of Paleontology.
- Fossil may be body part or imprints of organisms.

Evidences from fossils

- Primitive fossils have simple structures.
- Recently formed fossils have complex structure.
- Certain fossils are connecting links between different species.

Conclusion:

complex structured organisms originated from simple structured organisms.

Significance of fossils

- To study evolutionary history eh: horse evolution).
- To study connecting links between 2 groups of animals (eg: Archaeopteryx).
- To study about extinct animals (eg: dinosaurs).
- To study about geological period by analyzing fossils in different sedimentary rock layers.

Archaeopteryx

- It is a fossil bird discovered by Wagner in 1861 from Jurassic limestones of Bavaria in Germany.
- It is a connecting link between reptiles and birds.
- Size of a crow and lived in forest.
- Confirms theory of descent with modification.

Archaeopteryx

Avian features	Reptilian features

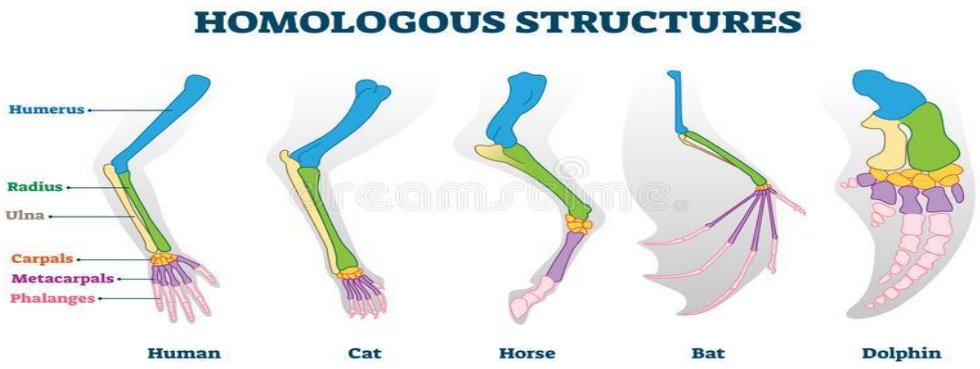
• Forelimbs modified into wings. • Presence of feathers • Fused bones • Sternum with keel • Clavicle fused into furcula	• Non pneumatic bones • Free carpals & metacarpals • Abdominal ribs • Jaws with thecodont dentition • Clawed digits • Body scales

Comparative morphology & Anatomy

- ❖ Study of external structures-morphology.
- ❖ Study of internal structures- anatomy.
- ❖ Examples:
  - ▪ Homologous organs
  - ▪ Analogous organs.
  - ▪ Vestigial organs

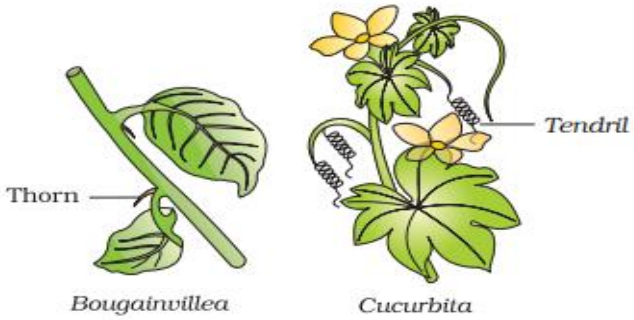
HOMOLOGOUS ORGAN	ANALOGOUS ORGAN
Organs having same basic structure and embryonic origin but performing different functions	Organs having different basic structure and embryonic origin but performing similar functions
Result of divergent evolution	Result of convergent evolution
• Eg: forelimb of whales, bats, cheetah • Thorns of bougainvillea, tendrils of cucurbita	• Eg: wings of butterfly and birds • Sweet potato and potato

- Forelimbs of human, cat, horse, bat, dolphins show same internal structures, such as blood vessels, nerves, muscles, bones but show different function.



Homologous organs

- Thorns, tendrils are modified stems which show different functions.

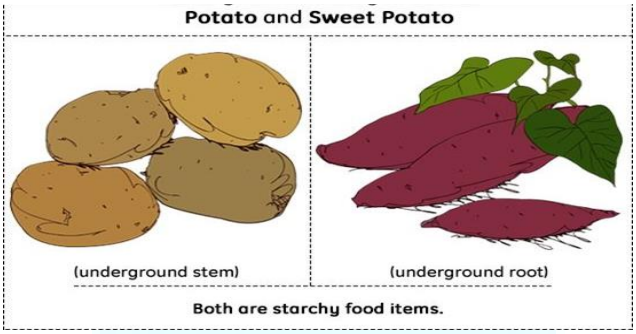


Analogous structure

- Organs which perform same function but show difference in structure.

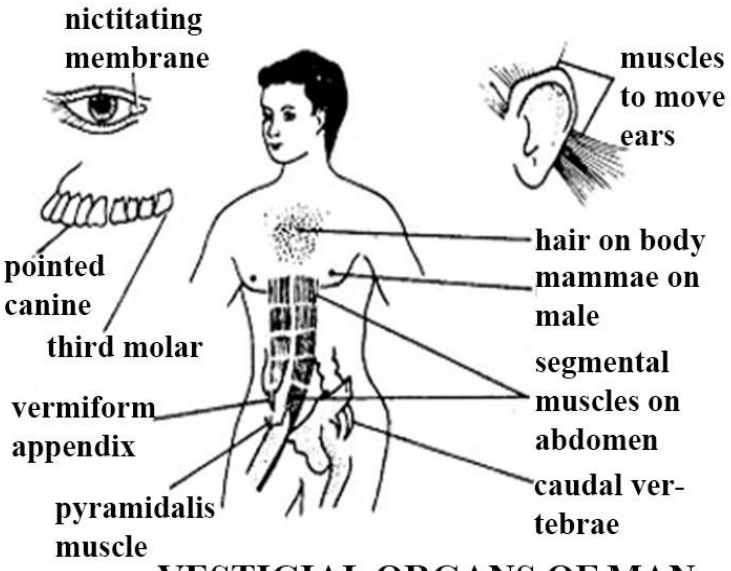
Analogous organs

- Potato and sweet potato have same function (storage of food) but are different in structure and origin (underground stem, underground root).



Vestigial organs

- Remnants of organs which were found in the ancestral forms.
- but changes in the environment rendered them no more necessary for the survival.
- They were gradually reduced to vestiges and and became useless.
- Examples:
  - Vermiform appendix
  - Nictitating membrane
  - Ear muscles
  - Third molar (wisdom teeth)



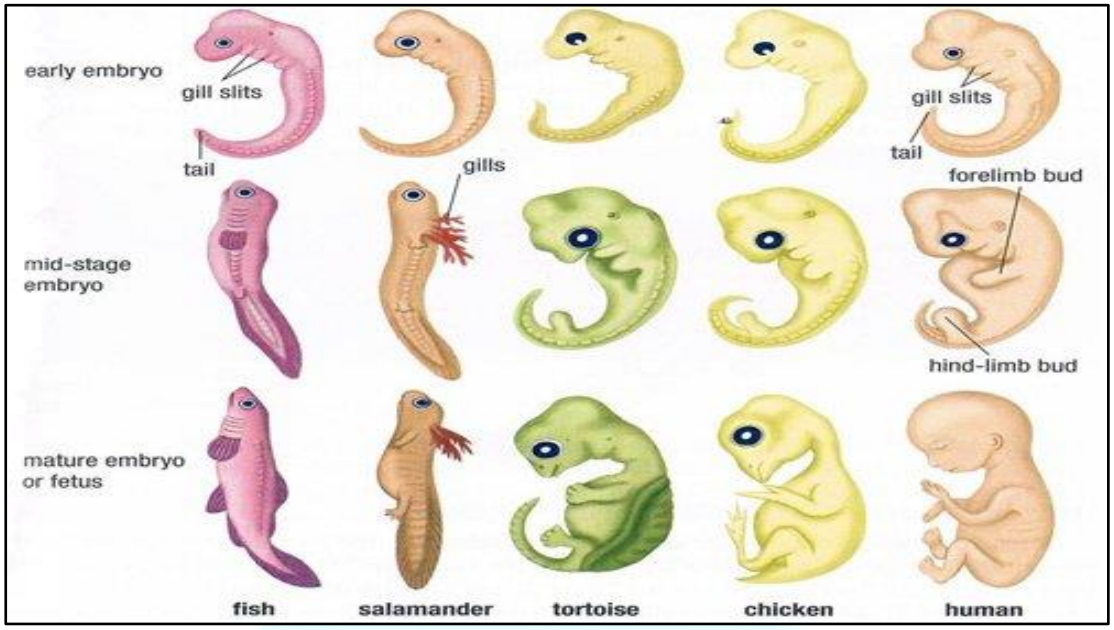
VESTIGIAL ORGANS OF MAN

Embryological evidences

- Embryology refers to the development of organism from egg to adult.
- It is also called ontogeny.
- Remarkable similarity in the embryos from fish to man.
- During embryonic stages an organism repeats its evolutionary history
- 2 theories:

1. Von Baer's principle
2. Ernest Heckel's Biogenetic law (recapitulation theory)

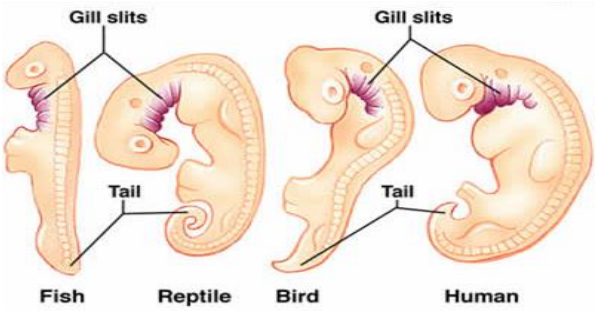
Embryological evidences



Embryological evidences

Von Baer's principle,

1. Young stages of animals are like young embryonic stages of lower animals, but not like adults of other animals.
2. General characters appear before special characters in development.
3. From the more general, the less general and finally the special characters appear.
4. An animal, during development departs progressively from forms of other animals.
5. Ontogeny recapitulates phylogeny.
    - Ontogeny- embryonic developmental history.
    - Phylogeny- evolutionary or racial history.



Evidences from Biochemistry

- Similarities in proteins, genes and other macromolecules.
- Similarities in metabolism.
- Cells of all living things contain protoplasm.
- Chromosomes are made up of DNA and RNA.
- Enzymes have similar structure and physiological actions.
- In all organisms energy is stored as ATP molecules.

Evidences from Biochemistry

- Hormones have similar structure and function.
- Carbohydrates, proteins, fats are the basic substances.
- Genes determine the hereditary traits.
    - A, B, O Blood groups can be seen other primates.

Evidences from Molecular Biology

- From Comparative study of proteins in different species the evolutionary relationship among organisms can be identified.
- Comparing differences in amino acids in the beta chain of haemoglobin in man.
    - Chimpanzee- no change
    - Gorilla - difference in one amino acid

- Rat - difference in 31 amino acids.

CLASSICAL THEORIES OF EVOLUTION

ORIGIN OF UNIVERSE

- Big bang theory.
- Universe is 2000 crore (20 billion) years old.
- The mass which had high temperature and density underwent a massive explosion, and later temperature and density reduced to form the present universe.
- Universe started expanding ever since that big bang explosion which occurred 13.8 billion years ago.
- Thermonuclear explosion

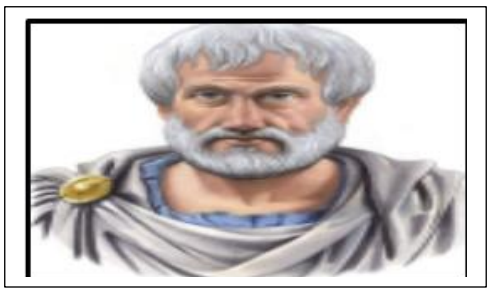
THEORIES ON ORIGIN OF LIFE

1. Theory of spontaneous generation/Abiogenesis
2. Theory of special creation
3. Theory of panspermia/cosmozoic theory
4. Theory of biochemical origin of life

THEORY OF SPONTANEOUS GENERATION

- Theory of abiogenesis.
- Organisms arose *de novo* from abiotic factors.
- *de novo* means from nowhere.
- The oldest theory about origin of life.
- Philosophers believed that frogs, toads, snakes etc. originated spontaneously from river mud.

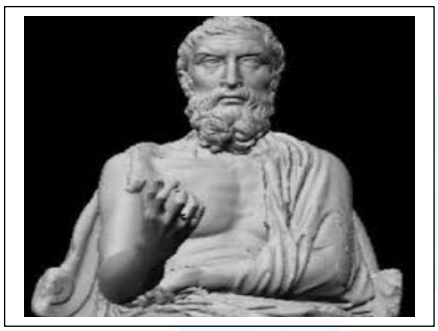
ARISTOTLE'S THEORY OF ABIOGENESIS



- Aristotle believed that insects (maggots) originated from decaying meat and fishes arose from mud.

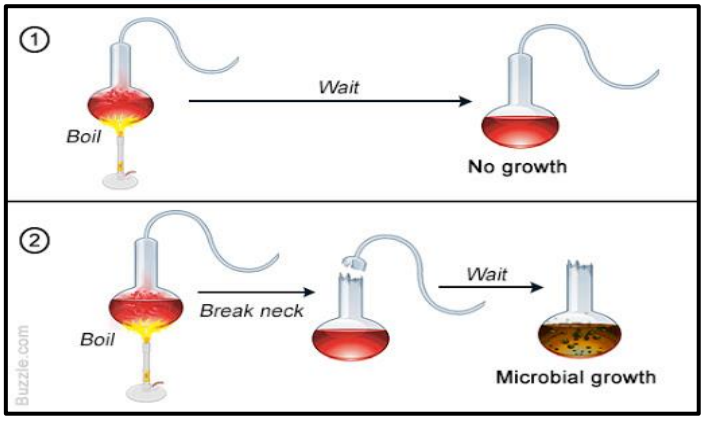
EPICURUS'S THEORY OF ABIOGENESIS

- Epicurus (341-271 BC) believed that Worms and other creatures arose spontaneously from soil or manure by the action of sun and rain.
- Other philosophers such as Thales, Anaximander, Plato, Paraceleus and Anaxagoras also believed in abiogenesis.



LOUIS PASTEUR

- Experimentally disproved theory of abiogenesis.
- Swan neck shaped flask- prevents entry of microorganisms.
- Prepared hay infusion and boiled for several minutes.
- He used 2 sterilised flasks. He filled two flasks with inactivated yeast infusion.
- He sealed the opening of the first flask and left the second flask open.
- Living organisms were found in open flask, but absent in closed flask.



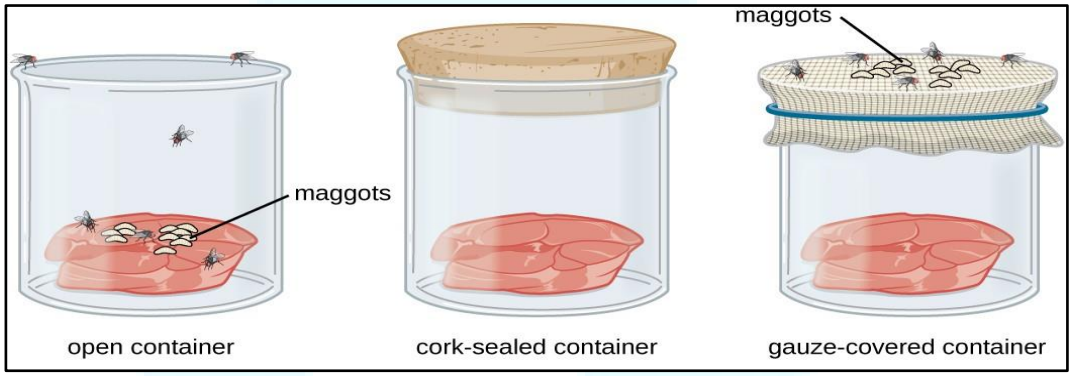
Conclusion:

- Live originated from pre-existing life.

- Living organism originated only from eggs or spores produced by their parents.
- This is called biogenesis.
- Biogenesis refers to the origin of life from pre-existing life by reproduction.

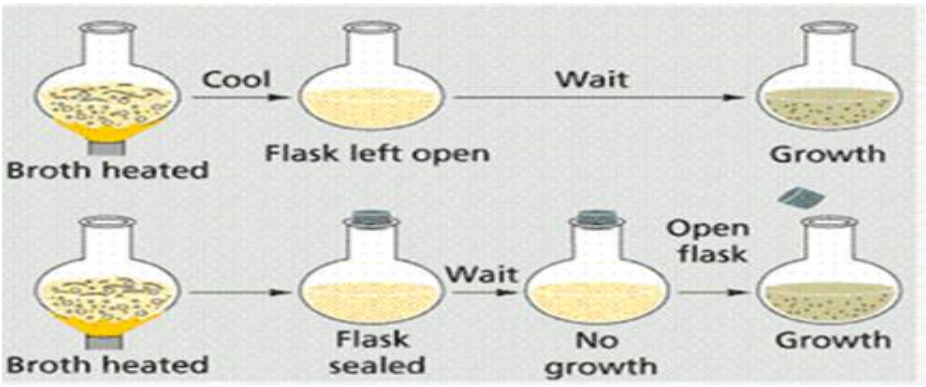
REDI'S THREE JAR EXPERIMENT

- Took meat/ fish in 3 jars
  - Jar 1 : left open- flies entered- laid eggs- larvae.
  - Jar 2 : covered with cork- flies couldn't enter or lay Eggs.
  - Jar 3 : covered with gauze -flies didn't enter jar- laid eggs on gauze- larvae on gauze



SPALLANZANI'S BROTH EXPERIMENT

- Prepared broth.
- Boiled for several hours.
- Boiling killed microbes.
  - Jar 1 - left open- showed growth of microorganisms.
  - Jar 2- sealed immediately- free from microorganisms.
- Life couldn't appear in the absence of microbes in jar 2



ENTRI

THEORY OF SPECIAL CREATION

- Life was created by a supernatural power.
- Religious viewpoint of Judaism, Christianity, Islam.
- Life was created by God.
- God created all plants and animals of the world.
- "Humans were created from dust of the ground and breathed into his nostrils the breath of life, and the man became a living sole"
- In Bible, According to Book of Genesis, whole world was created in 6 days.
- All living organisms were created on same day.
- They were created in the present form.
- Organisms never changed after their creation (no evolution).
- Their body and organs are fully developed to meet the requirements to run the life (no adaptations).

- Father Suarez (Sadrez), Spanish Monk- the greatest supporter of the theory.


R. P. FRANCISCI
SUAREZ
GRANATENSIS e Societate JESU,
Doctoris Eximii.
DE
INCARNATIONE
PARS SECUNDA.
OPERUM TOMUS DECIMUS SEPTIMUS.
VENETIIS,
Ex Typographia Balleoniana.
MDCCXLVI.

- Life was created by a supernatural power or God either once or at successive intervals.

- He attempted to calculate the year in which man was created and concluded that it was in 4074 BC.
- According to Hindu mythology, Brahma, the God of creation created the world.
- God incarnates on earth in ten different forms or Avathars.
- According to Deshavathara stories God incarnated on earth in ten different forms such as fish, turtle, mammals etc.

OBJECTIONS:

1. It is a Religious belief
2. No experimental evidences
3. Fossil evidences disproved this

THEORY OF PANSPERMIA

- Also called Cosmozoic Theory.
- Proposed by Ritcher (1865), Arrhenius (1908).
- Life was distributed throughout cosmos in the form of resistant spores called cosmozoa.
- Life which originated in some other part of the universe was distributed to different planets in the form of spores or cosmozoa, and hence reached earth.
- These resistant spores floated through space or was attached to meteorites and thus reached earth.
- Under favourable conditions on earth these spores developed into living forms.

- Crick & Orgel(1973), suggested that microbes cannot reach earth by natural means.
- Microbes were purposefully send to earth from another planet using spaceships.
- Picnic hypothesis by Gold (1960), speculates that modern earthly life has evolved from microorganisms which were left behind as pollution by untidy visitors.

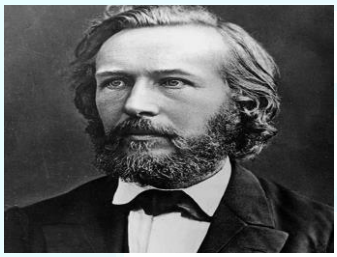
OBJECTIONS:

1. Even the most resistant spore would be killed in outer space due to extreme conditions such as intense cold, extreme dryness, severe radiations.
2. Panspermia or cosmozoa would be killed long before completing such an interstellar voyage.
3. Theory of panspermia whether accidental or directed, does not explain the origin of life.
4. It simply transfers the place of origin of life from earth to some other part of the universe.

MODERN THEORY OF EVOLUTION

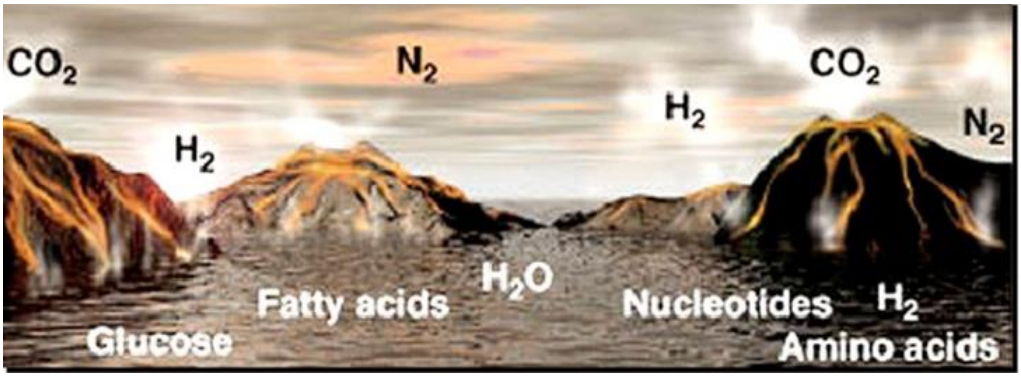
ERNST HAECKEL

- German Zoologist.
- Life originate from simple inorganic substances.



THEORY OF BIOCHEMICAL ORIGIN

- Also called Theory of Molecular Evolution.
- Theory states that the most primitive organisms would have been generated in the remote past from some inorganic matter as a result of the action of electrical discharges, ultraviolet rays and radiations of radioactive elements.
- Complex organic molecules were formed from simple inorganic molecules.
- The energy for these processes were supplied by electricity of lightening, UV rays from Sun, volcanic eruption.



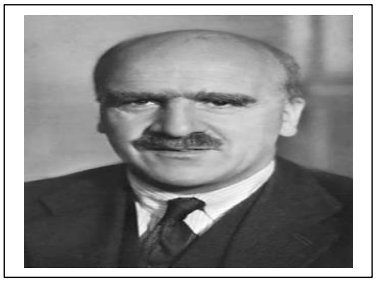
Proponents:

- Ernest Haeckel
- Oparin & Haldane
- Miller & Urey

A.I. OPARIN

- Soviet Biochemist.
- In his book "The origin of life", (1924) gave an account of the modern version of the biochemical or molecular origin of life.
- The entire process of the biochemical origin of life can be categorised into two subsequent events, viz. chemical evolution and biological evolution.
- It occurred after the origin of universe and origin of earth.
- Theory of Primary Abiogenesis.
- "Abiogenesis first, biogenesis ever since"

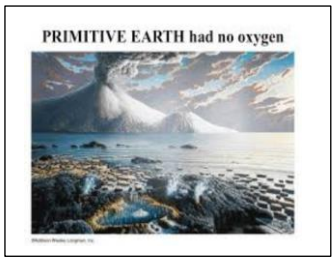
J.B.S. HALDANE



- British-Indian Scientist.
- Introduced the concept of Hot dilute soup.
- organic macromolecules were first formed in sea.
- Molecules collided and underwent chemical changes and polymerization to form complex organic molecules.
- Polysaccharides, lipids, proteins, nucleic acids, nucleoproteins

CHEMICAL EVOLUTION

- Elements like hydrogen, nitrogen, oxygen and carbon were most abundant in the primitive earth.
- They combined with one another to form simple compounds.
- Hydrogen, nitrogen, oxygen, carbon combined to form methane, ammonia, water.
- Since the temperature of the earth was high, ammonia and methane remained as gases and water as superheated steam.
- The earth's primitive atmosphere therefore consisted of four simple gases, viz. ammonia, methane, hydrogen and water vapour.
- Reducing atmosphere –free oxygen was absent.
- As time elapsed, temperature of earth reduced.
- Liquefaction of some of the gases, and solidification of liquids occurred.
- Water vapour cooled and due to condensation poured down as rain.
- Earth was very hot and rain droplets evaporated immediately and returned to atmosphere.
- This process continued for millions of years and resulted in cooling of earth.
- Gradual accumulation of water led to the formation of rivers, streams and oceans.
- Simple molecules reached sea through rain water.
- Some of the atmospheric ammonia and methane were brought down by the rain and got dissolved in the ocean.
- Dissolved minerals led to the accumulation of minerals and salts in seawater.
- This was a major event in the origin of life.



FORMATION OF ORGANIC COMPOUNDS

- The next step was the synthesis of simple organic molecules from simple four gases: methane, hydrogen, ammonia, water vapour.
- Out of which methane played a vital role.
- Methane combined with other elements to form propane, ethane, ethyl alcohol, acetic acid, glycerol, fatty acid and monosaccharide sugar.
- Ammonia played an important role in the formation of nitrogenous compounds such as amino acids and nitrogen bases.
- Active molecules such as AMP, ADP, ATP were also formed.
- These macromolecules came down to the earth with the heavy rain and accumulated in the oceans and seas.
- The formation of macromolecules was the next step in molecular evolution.
- J.B.S. Haldane British-Indian Scientist introduced the concept Hot dilute soup- organic molecules in the sea organic macromolecules were first formed in sea.

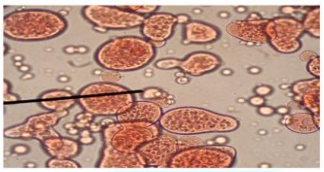
- Molecules collided and underwent chemical changes and polymerization to form complex organic molecules such as Polysaccharides, lipids, proteins, nucleic acids, nucleoproteins.
- According to Moody (1970), Fox and Dose (1972), proteins were the first molecules to originate during molecular evolution.
- The first formed protein were termed protenoids.

FORMATION OF NUCLEIC ACID

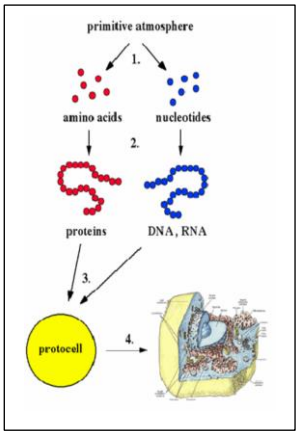
- Nucleic acids were formed as chains of nucleotides.
- Each nucleotide is composed of a purine or a pyrimidine, a phosphate and a sugar.

COACERVATES

- Complex organic molecules present in sea combined in different proportions.
- Coacervates- colloidal particles of organic materials (Oparin).
- Sidney Fox called it "Proteinoid/ microsphere".
- First formed proteins –proteinoids (S. Fox, 1965).



PROTOCELL / PROTOBIONT

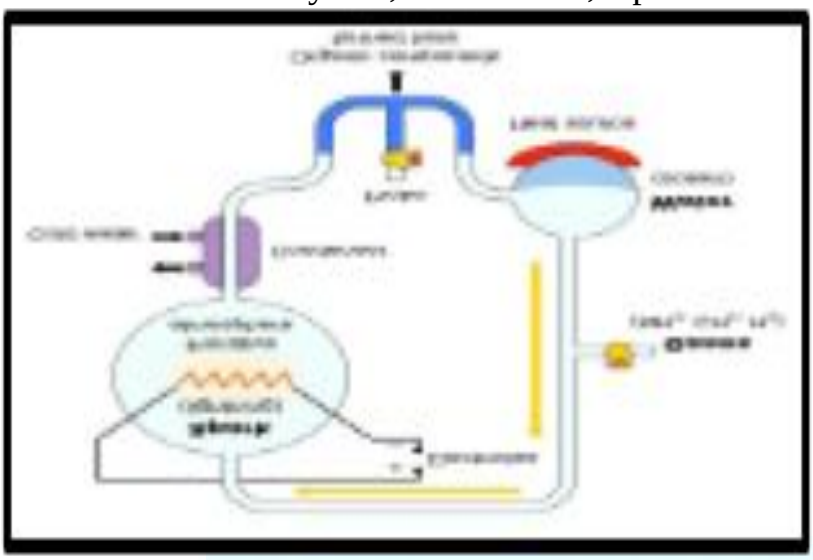


- Protocell = First living form.
- It is the First Molecules that Originated in the sea spontaneously.
- It showed the property of self division.
- It Attained spherical shape, double membrane structure.
- It was Without nucleus.
- Showed Asexual reproduction- budding.
- RNA, protein, polysaccharide together formed single celled organisms which later modified as cell.

MILLER AND UREY EXPERIMENT

- Recreated the primitive earth's atmosphere in laboratory.
- A mixture of gases such as CH_4, NH_3, H_2 water vapour at 800^0 C was taken in a sealed flask and was subjected to electricity.

- Gas mixture used for the experiment - methane, ammonia, hydrogen, water vapour.
- Energy source- high voltage electricity.
- Amino acids precipitated.
- Products formed -Glycine, beta alanine, alpha alanine.



SCIENTISTS	FINDINGS
Ernst Haeckel's	Life originate from simple inorganic substances
A.I. Oparin	Theory of Primary Abiogenesis
J.B.S. Haldane	Introduced the concept of Hot dilute soup.
Moody, Fox and Dose	proteins were the first molecules to originate during molecular evolution
Urey &Miller	Recreated the primitive earth's atmosphere in laboratory

SPECIATION

- Species is the basic unit in the classification of animals.
- It is a group of naturally interbreeding organism, which are reproductively isolated from such other group.
- Speciation refers to the formation of new species.
- According to Mayr(1959),speciation is the method by which evolution progresses and each new species or subspecies is the keystone in evolutionary advance.

Species concept

- Mayr's definition of species ,widely accepted today is known as "the biological species concept".
- Species is a dynamic unit capable of change and modification.
- Reproductive isolation ,which prevents interbreeding and gene exchange,is the main barrier isolating one species from the other.
- Intermediate or transitional forms between species are usually absent.

Species have characteristics such as

1. Distinctive morphological features.
2. Reproductive isolation.

3. Absence of intermediate forms.
4. Common gene pool.
5. Capacity to interbreed producing fertile off -spring.
6. Hybrid produced will be sterile.
7. New species arise.
8. From preexisting species by gradual change.

- Species has been differentiated into subspecies, clines and demes.
- A subspecies is defined as "geographically isolated population of a species which are capable of interbreeding and producing fertile offspring.
- Only slight morphological differences are present between the subspecies of a species.
- They accumulate more and more genetic differences in course of time ,and finally they attain the status of separate species,when they are no longer capable of interbreeding.
- Thus subspecies is the stage that leads to the evolution of a new species.

Differences between species and subspecies.

- The members of a subspecies of a species are capable of interbreeding giving raise to fertile offspring.
- The members of a two different species are reproductively isolated and even if they interbreed only sterile hybrids are produced.
- Different subspecies are found to occupy separate territories, and the territories may not overlap.
- While different species occupy different territories (allopatric)or may occur in the same area (sympatric)or territories may overlap.
- Morphological differences are greater between different species and intermediate forms do not occur.
- Slight morphological differences only exist between the subspecies of a species and intermediate forms are present.

Borderline situation between species and subspecies

- Semispecies :Mayr)(1970) defined semispecies as showing some of the characteristics of species and some of subspecies.
- *Drosophila paulistorum* is a complex of six semispecies.
- There is no morphological characteristics to distinguish them,they show strong preference for mating within their own semispecies.

Sibling species

- Sympatric species (living in the same area) that are morphologically similar , but reproductively isolated are called sibling species(Mayr).
- Anopheles mosquitoes ,siblings species can be diagnosed by their egg floats.
- Among drosophila ,six sibling species related to D.willistoni have been reported.

The cline

- It is a group of logical population, of a widely distributed species, which exhibit continuous variation in their morphological features(Julian Huxley).
- The common zebra inhabiting the southern half of Africa,shows the steady decrease in the black striping of the leg,form northern region to South Africa.

The deme

- According to Dobzhansky (1950)deme is a “mendelian population” which is a group of potentially interbreeding individuals of a local population which share a common gene pool.
- E.g Carp in a pond or paramecium in a ditch.