Evolution

INTRODUCTION

- Scientists have been trying to understand for many years how the universe was formed and how life evolved on earth.
- Different theories have been postulated to explain the origin of life.

EVOLUTION

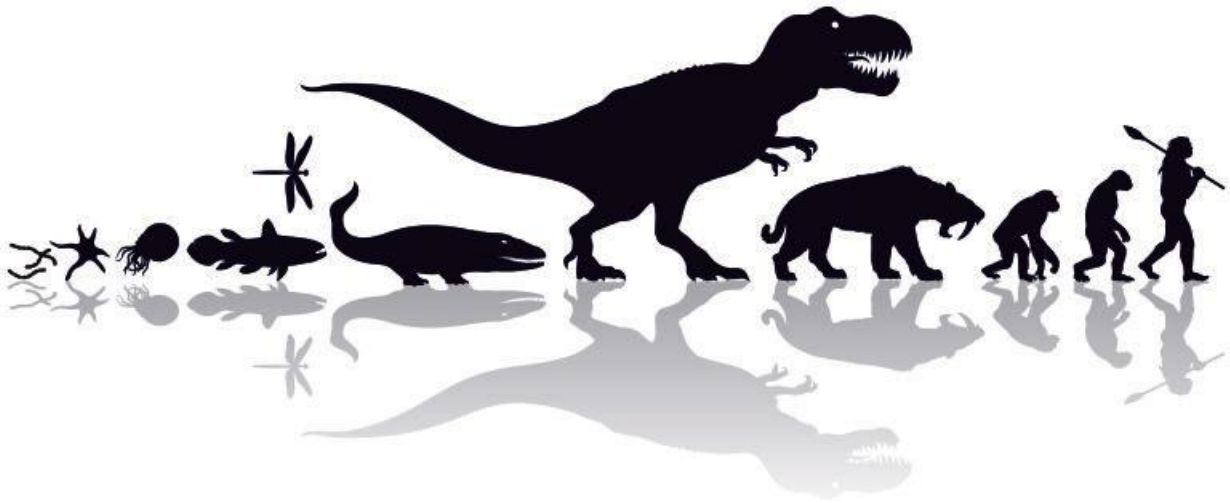
- Evolution is the sequential gradual changes that take place over millions of years in any organism.
- Life originated on the earth after its formation. There were many theories that explained the formation of the universe and then the life on it.

ORIGIN OF UNIVERSE

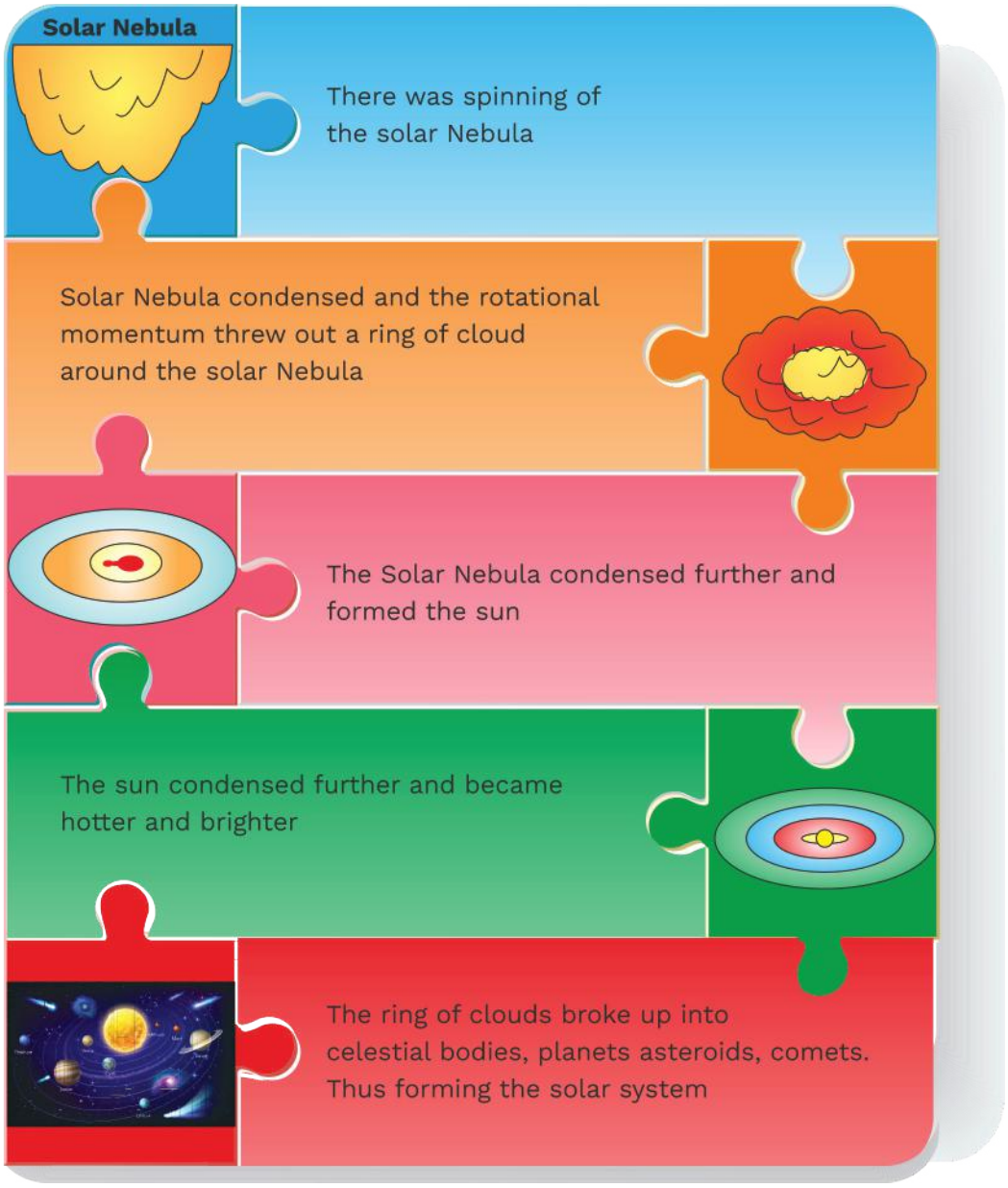
- The most accepted is the Big Bang theory given by Abbe Lemaitre
- It states that about 20 million years ago, there existed a huge cosmic material that exploded and its fragments scattered to far areas.
- The scattering of the fragments was at a great velocity thus making a loud noise and hence the theory named “Big Bang”.

Definition

Evolution is the sequential gradual changes that take place over millions of years in any organism

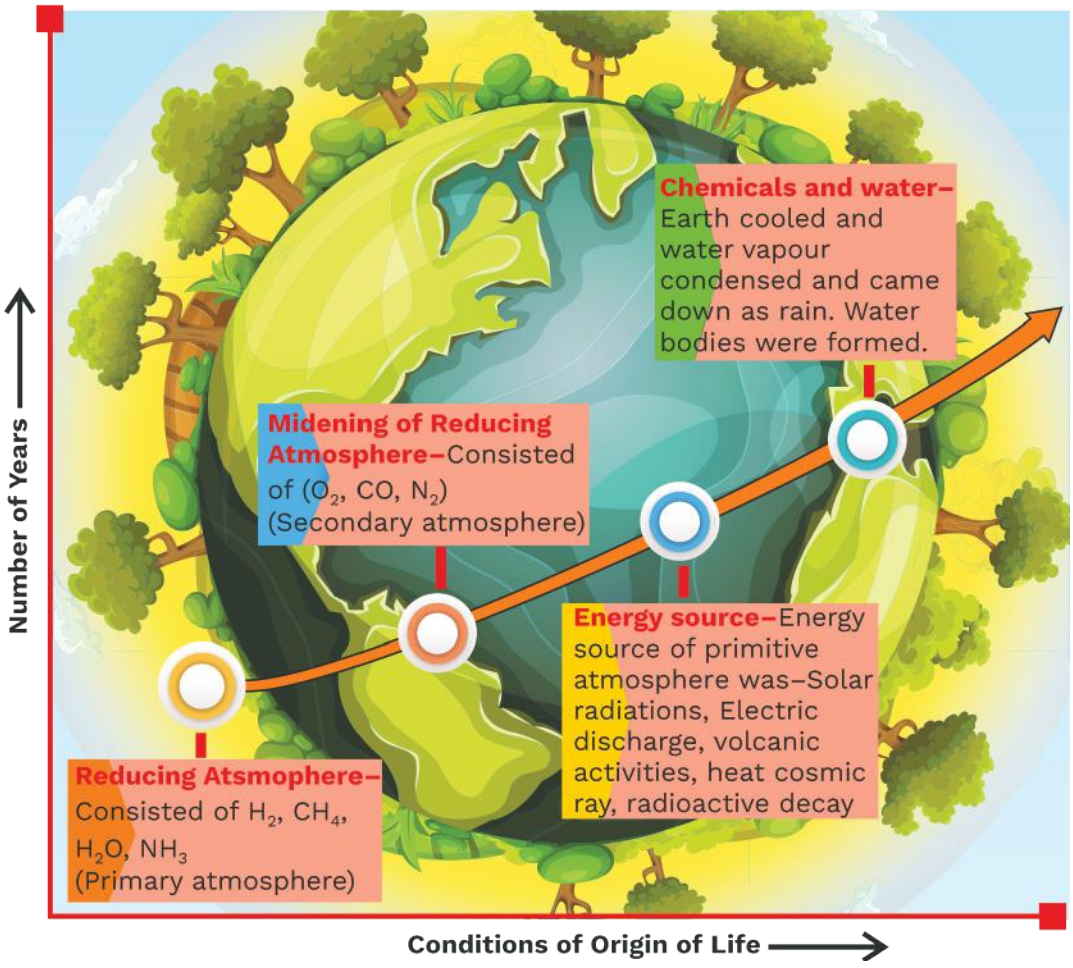


FORMATION OF SOLAR SYSTEM



EARTH'S PRIMITIVE ATMOSPHERE

- Earth's primitive atmosphere was reducing in nature and it slowly changed from reducing to the oxidising. The condition from primitive earth became modified to support life.



THEORIES FOR ORIGIN OF LIFE

- There are many ideas and theories as to the origin of life on Earth. Some of them are –

Theory of Special Creation

- Life was created by a supernatural power or the divine. The main postulates of the theory are:
  - All forms of life were created at a time as such.

- They were created in the same form as they are present today. They have not shown any change or variation since they were formed on this earth.
- The bodies of the organisms were designed in such a way that they could meet all the needs of the organism forever.

- **Objection to the theory-**The postulate that organisms were formed as they are today could not proved scientifically.

Theory of Spontaneous Generation or Abiogenesis

- It stated that life originated spontaneously from non living material.
- **Objection to the theory-**It was proved inaccurate by Francesco Redi, Lazzaro Spallanzani and Louis Pasteur.

Experiment by Francesco Redi

- He placed meat in three jars:
  - One jar was covered with mesh,other with paper and third one was left open.

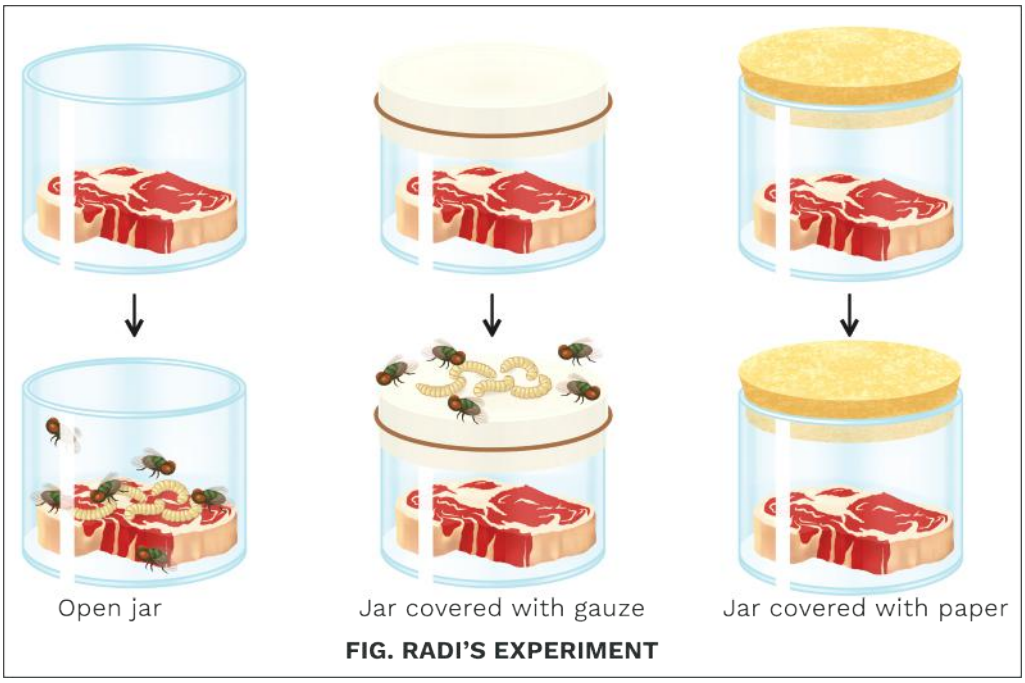


FIG. RADI'S EXPERIMENT

- The meat rotted in the three jars in a few days. The flies were attracted towards the three jars.
- Flies entered into the jar which was open and laid eggs. These eggs hatched and formed new flies.
- Flies could not enter the jars that were covered but eggs were laid on the gauge and paper.
- Thus, it was proved that organisms arise from the eggs and not from the non living materials.

Experiment by Lazzaro Spallanzani

- He took meat and vegetables and boiled them for many hours to make a broth.
- He then sealed the broth and kept it for a few days. No microorganisms appeared in the broth.
- He concluded that heat killed any microorganisms in the broth and thus without them life could not

Pasteur's Experiment

- Louis Pasteur was a French chemist and bacteriologist. He conducted an experiment and

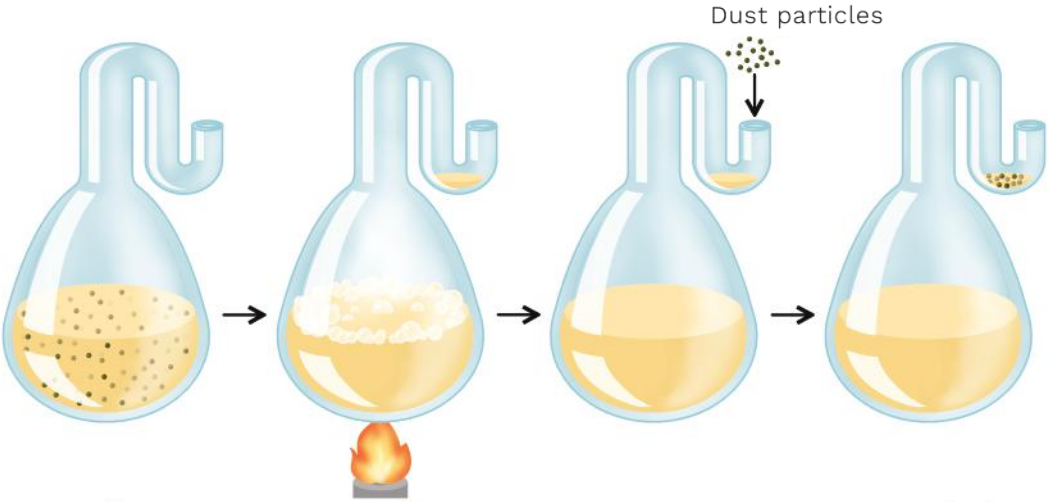


FIG. PASTEUR'S EXPERIMENT

showed that life arises from pre-existing life. He took a long-necked flask and he didn't bend.

- He boiled some meat and vegetables to make a broth. The boiling create the microorganisms present in the broth.
- He kept this flask for a few months, he observed that there was no life that was seen in the flask.
- When the broth cooled the neck had condensation of water molecules which trapped dust particles in the curved neck, but life forms were not seen
- If the neck of the flask was broken and the above procedure repeated after a few months the broad developed colonies of moles and bacteria
- He showed that the microorganisms go form due to the fermentation of the materials used in the broth and not from the nutrient material.
- He disapproved abiogenesis and proved Biogenesis.
- If the flask was tilted, broth passed through the neck of the flask, this caused rapid bacterial growth in the flask.

Theory of Panspermia or Spore theory

- This theory was proposed by Richter.
- According to this theory, small spores or germs reached the earth from some part of the universe with cosmic dust or with the meteorites.
- These spores lead to the emergence of new life on earth.
- **Objection to the theory of Panspermia-**sports cannot living sports cannot survive the extreme cold heat and the ultraviolet radiation is present in the universe. Thus this theory was not accepted.

Modern Theory or Oparin and Haldane Theory of Origin of Life

- Also known as the chemical theory naturalistic theory .
- A.I Oparin was a Russian scientist and J.B.S. Haldane was a biologist or biochemist. They gave their views on the origin of life.

Previous Year's Question

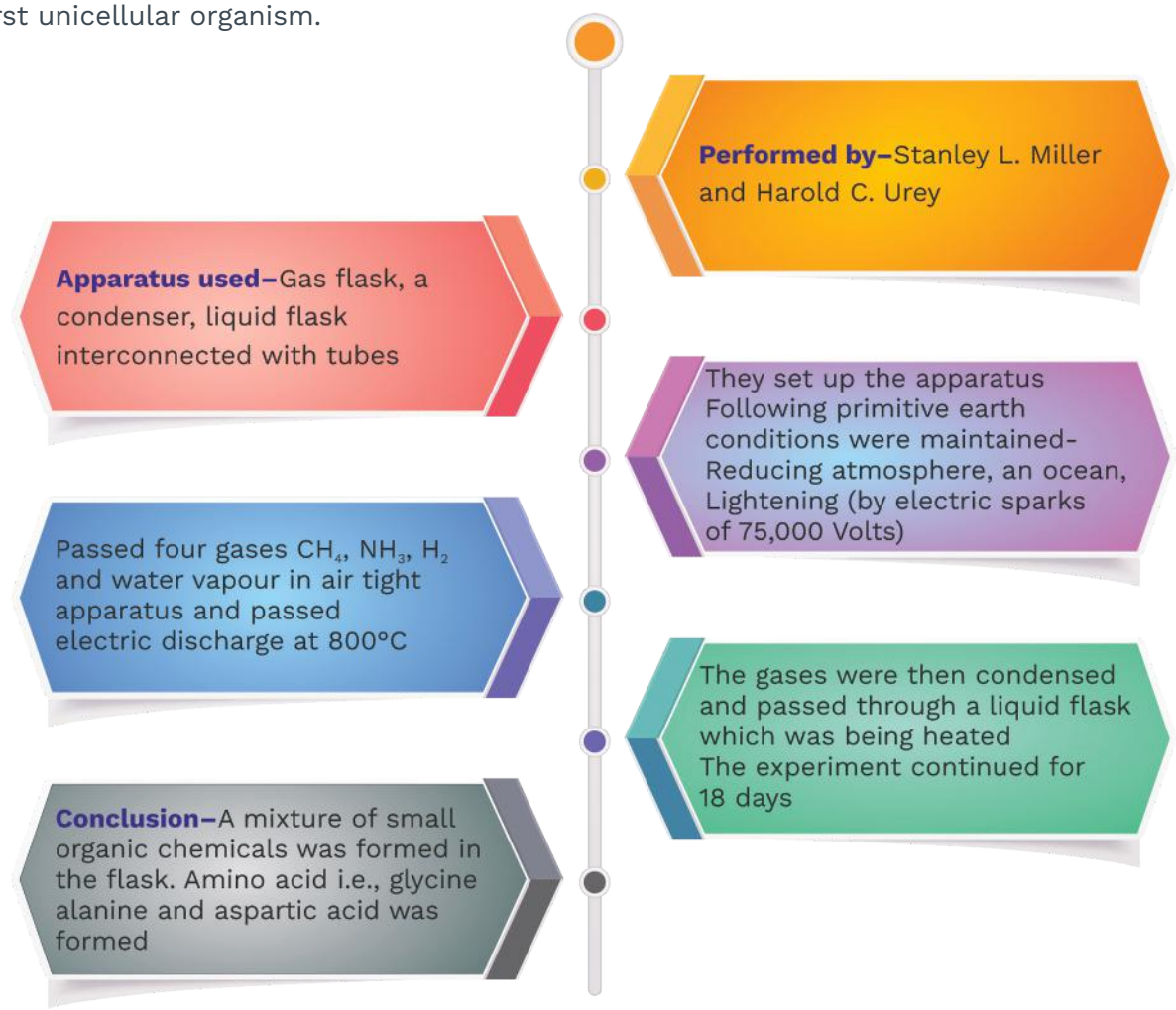
Which one of the following experiments suggests that simplest living organisms could not have originated spontaneously from non-living matter?

(1) Larvae could appear in decaying organic matter.
(2) Microbes did not appear in stored meat.
(3) Microbes appeared from unsterilized organic matter.
(4) Meat was not spoiled.

- They said that spontaneous generation of life in the present environmental conditions is not possible.
- The earth's environmental condition was different from what it is today (it was reducing type).
- Life originated through chemicals through a series of chemical reactions in which simple molecules combine together to form a complex molecules rich finally led to the formation of a new cell and the first unicellular organism, according to them life originated in the water and J.B.S Haldane called the water as 'prebiotic soup' or 'hot boiled soup' in which all the complex chemicals were formed which finally led to the formation of the first unicellular organism.

Rack Your Brain

Which is the most advanced theory of origin of life?



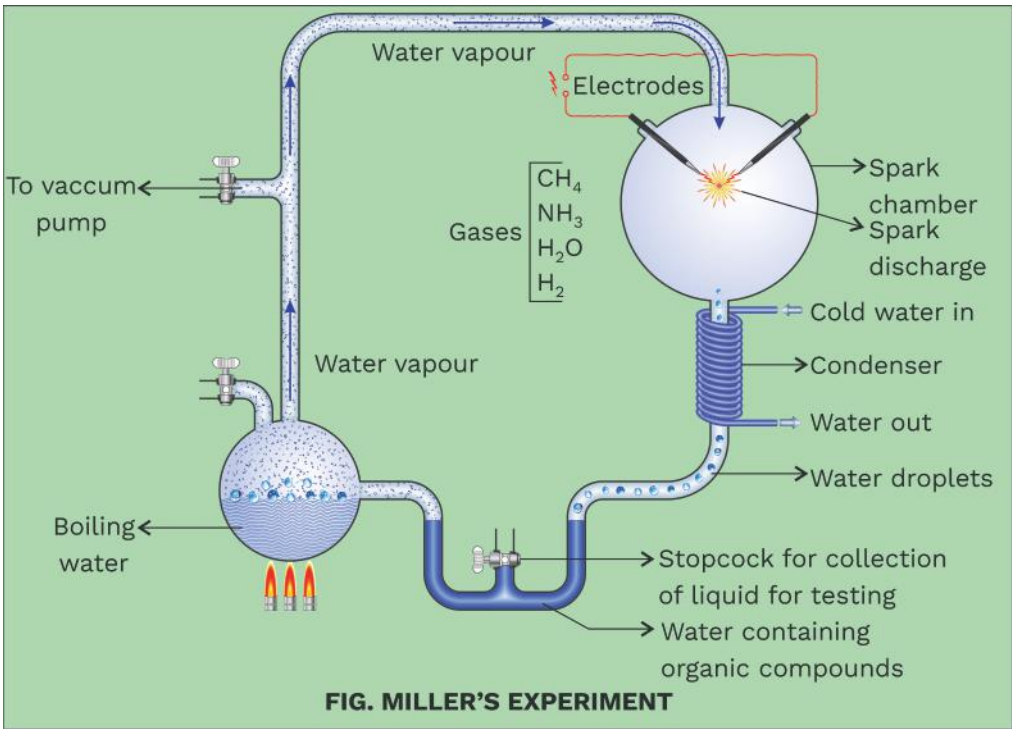


FIG. MILLER'S EXPERIMENT

- Solar radiations provided the energy needed for those chemical reactions there totally was experimentally proved by Stanley L. Miller and Harold C. Urey.

Rack Your Brain

Why new life cannot originate now?

Rack Your Brain

Why new life cannot originate now?

Miller's Experiment

Atomic phase–Initially earth consisted of a large number of atoms like **H, C, O, N, S, P.**

Formation of Simple Inorganic Molecules–Atoms combined to form Simple Molecules

$2H_2 + O_2 \rightarrow 2H_2O$

$2H_2 + C \rightarrow CH_4$

$C + O_2 \rightarrow CO_2$

$N_2 + 3H_2 \rightarrow 2NH_3$

Water and ammonia were first molecules of primitive earth

Formation of Simple Organic Molecules (Monomers)

Energy needed for the formation of the simple organic compounds were from solar radiations and electric discharge.

Inorganic Molecules Combined Together to Form Simple Organic Molecules

$CH_4 + HCN + NH_3 + H_2O \rightarrow$ **Purines Pyrimidines**

$CH_4 + NH_3 + CO_2 + H_2O \rightarrow$ **Amino Acids**

Ocean with the chemicals was termed as prebiotic soup or hot dilute soup

Formation of Complex Organic Molecules (Macromolecules)

Simple Inorganic molecules combined together to form complex organic compounds by polymerisation.

Amino Acid + Amino Acid → Polypeptide + Proteins

Fatty acid + Glyceron → Fats

Sugar + Nitrogenous base + Phosphate → Nucleotide → Polymerised Nucleic Acid.

- The following experiment was conducted to prove the chemical origin of life.
- Modern view regarding the origin of life includes chemical evolution (chemogeny) and biological evolution (biogeny).

CHEMICAL ORIGIN OF LIFE

BIOLOGICAL ORIGIN OF LIFE

- Some scientists also postulated the biological origin of life and stated how the first cell was formed.
- The steps involved in the origin of life were:
  - Aggregation of the organic molecules
  - Origin of prokaryotes
  - Evolution in modes of nutrition
  - Formation of ozone layer
  - Origin of eukaryotes

Aggregation of the Organic Molecules

- There are two hypotheses for the aggregation of the organic molecules.
- According to Oparin, the earliest non-living structures, i.e., the prebionts led to the formation of coacervates. He said that the freeway and consisted of carbohydrates, proteins, lipids nucleic acid that accumulated together to form the coacervates.
- These coacervates were enveloped by water molecules which acted as a barrier between the organic molecules and the surroundings.
- With the increase size, the coacervates divide into smaller units.
- Sidney W fox proposed another theory regarding the formation of first protocells.
- He said that microsphere is a non living structure made up of organic molecules with double-layered membrane.
- These microspheres were found by an aggregation of protein like structures consisting of amino acids he believed that these ...

Definition

Coacervates: They are self-duplicating aggregates of proteins surrounded by lipid molecules.

Definition

Eobionts: Eobionts are hypothetical primordial life-forms or chemical precursor to a living organism.

Origin of Prokaryotes

- The origin of life from the organic molecules have taken place by two ways-Coacervate to eobionts or protocell
- Eobionts to the first living
- The origin of life from the organic molecules have taken place by two ways-
  - Coacervate to Eobionts or Protocells
  - Eobionts to the first living
- Coacervates had all the properties of a living cell. It got integrated with nucleic acid and nucleic acid took control.
- The coacervates lacked a lipid membrane and thus could not be considered to be the one that lead to the formation of the first eobionts.
- Microsphere on the other hand has a lipid layer around itself. Thus it was postulated that microspores may have given rise to the first eobiont.
- Some of the protein molecules that were formed,started functioning as an enzyme. These molecules became better than the other molecules. It also speeded up the formation of the other eobionts molecules.
- RNA and DNA were formed. They started the synthesis of proteins. The DNA underwent mutations.These mutations changed the proteins of the eobionts.
- At last, the lipid layer was developed around the eobionts.This finally lead to the formation of the first cell on the earth.

EVOLUTION IN MODES OF NUTRITION

Heterotrophs

- Initially, when Oxygen was not present there was an anaerobic mode of respiration and the first prokaryotes obtained energy from the fermentation of organic compounds.

Previous Year's Question

First life on earth was
(1) cyanobacteria
(2) chemoheterotrophs
(3) autotrophs
(4) photoautotrophs

Autotrophs

- As the conditions of the earth changed, the synthesis of the organic molecules stopped.The heterotrophs mutated and structurally modified themselves to become autotrophs.

Chemoautotrophs

- These prepared their organic food from inorganic materials and released carbon dioxide into the atmosphere. Even today some nitrifying bacteria are chemoautotrophic.

Photoautotrophs

- With time, the evolution of chlorophyll molecules took place. Some of the cells got embedded within the chlorophyll molecule and thus became photosynthetic.
- Initially, the organisms did not use Oxygen but utilised Hydrogen and were still anaerobic.
- Later, the oxygen releasing photosynthetic organisms were produced.They were similar to the existing blue–green algae. They used water to get Hydrogen and Oxygen.
- Oxygen started oxidising Methane and Ammonia and it started disappearing.

Formation of Ozone layer

- As Oxygen accumulated in the environment, the ultra-violet rays changed some of the oxygen into Ozone.
- This layer blocked the ultra violet rays from leaving the atmosphere.
- Photosynthesis increased the amount of Oxygen in the atmosphere. Slowly and steadily Oxygen started being used for respiration and Carbon dioxide was released.
- Due to the change in the atmospheric conditions, the origin of life is now not possible on the earth.

Previous Year's Question

Which of the following is the correct sequence of events in the origin of life?

I. Formation of protobionts
II. Synthesis of organic monomers
III. Synthesis of organic polymers
IV. Formation of DNA-based genetic systems

(1) I, II, III, IV
(2) I, III, II, IV
(3) II, III, I, IV
(4) II, III, IV, I

Origin of Eukaryotes

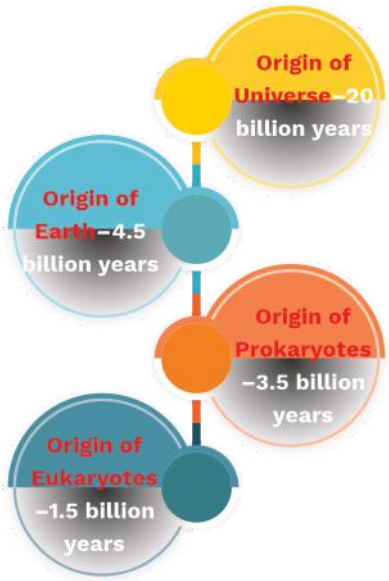
- The eukaryotes developed from the primitive prokaryotic cell about 1.5 billion years ago.
- The prokaryotic cells evolved into eukaryotic cells by the following ways-

Symbiotic Origin

- It was stated by Margulis. According to this theory, some prokaryotic bacteria established themselves into the cells of a host as a symbiont.
- They established themselves and thus became the first eukaryotic cell.
- Mitochondria and Chloroplast have been thought to have established themselves inside the eukaryotic cell. They were the prokaryotic cells that evolved into the eukaryotic cell.
- Cytoplasm further developed specialised organelles.

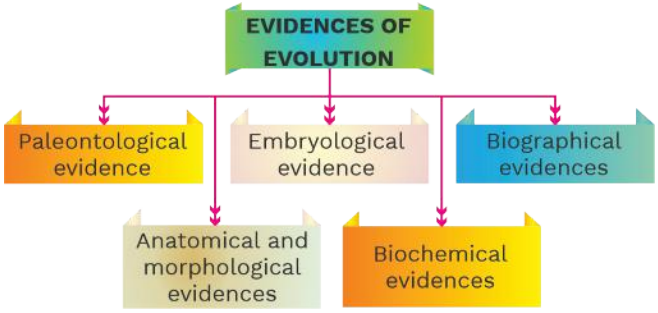
Origin by Invagination

- According to this view, the cell organelles are formed by the invagination of the membranes of primitive prokaryotic cells.



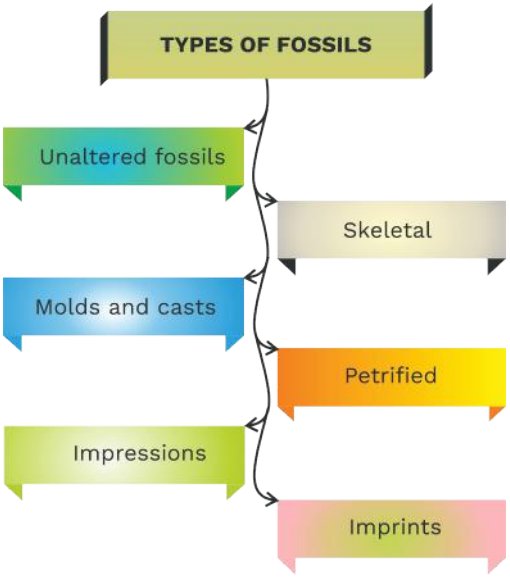
EVIDENCES IN FAVOUR OF EVOLUTION

- There are many types of evidences which support the process of organic evolution:
  - Palaentological
  - Comparative anatomical and morphological
  - Biochemical
  - Embryological
  - Biogeographical



Palaentological

- It is the study of fossils to understand the evolution of different life forms.
- Fossils are important in the study of evolution as-
  - They help in understanding how the structures of organisms have changed in the past years.
  - They take into account the environmental changes occurring through millions of years and their effect on the organism.
  - They help in understanding why certain organisms have become extinct and sometimes the reason for their extinction can also be traced out.
  - They help in tracing the ancestors of the living organisms.
  - They help in finding the missing link between different organisms.

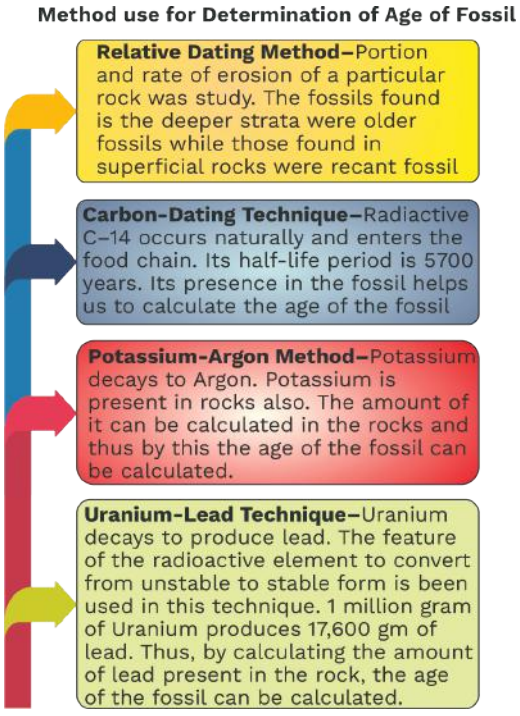


Connecting Links

- The fossil organisms that show characters of two different phyla of animals are called as connecting links.

Examples

- ***Archaeopteryx*-**It was found in the rocks of the Jurassic period in 1861. It was named as *Archaeopteryx lithographica*. It showed the characteristics of both the reptiles and the birds. It possessed feathers and could fly while it also had toothed jaw and clawed fingers.
- Thus *Archaeopteryx* is the connecting link between reptiles and birds.
- ***Ichthyostegia*-**It is a fossil of an amphibian and is a connecting link between the fishes and the amphibians.
- ***Seymouria*-**It is a fossil amphibian which is a connecting link between the amphibians and the reptiles.



- **Pteridosperm-**It is a fossil plant. It is considered to be a connecting link between the ferns and seed-bearing plants.

Evolution of Horse

- Fossil record of the horse is complete and thus it has become easy to study the evolution of horse through fossils.

GEOLOGICAL TIME SCALE

Comparative Anatomy and Morphology of Organisms

- The similarities and differences that existed between the organisms have helped to study their evolution.
- Study of the organs provides us the evidence in favour of evolution.
- Homology found in different animals indicates their evolution from common ancestors. The process in (which species which have diverged after origin from common ancestor giving rise to new species) adapt to new habitats is called

FIG. ARCHAEOPTERYX FOSSIL

Definition

Palaentology: It is the study of fossils to understand the evolution of different life forms.

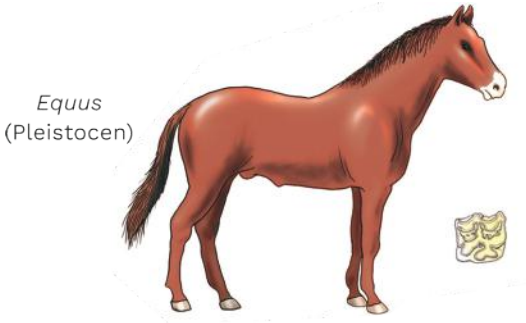
Definition

Connecting link: The fossil organisms that show characters of two different phyla of animals are called as connecting links.

Previous Year's Question

Age of fossils in the past was generally determined by radio-carbon method and other methods involving radioactive elements found in the rocks. More precise methods, which were used recently and led to the revision of the evolutionary periods for different groups of organisms, includes

(1) study of carbohydrates/ proteins in fossils
(2) study of the conditions of fossilization
(3) Electron Spin Resonance (ESR) and fossil DNA
(4) study of carbohydrates/ proteins in rocks



Equus
(Pleistocen)

Equus–Known as horse. It arose in North America and spread to all the would except Australia 150 cm high at shoulder longer head and neck.

Pliohippus
(Pliocen)

Pliohippus–It was the size of modern pony, about 120 cm high at the shoulders. Its each fore and hind not had one complete finger and one complete toe and two splints hidden beneath the skin it was the first one toed horse. The molar teeth were long with well developed. Teeth were adapted for eating grass.

Merychippus
(Miocen)

Merychippus–Known as the ruminating horse. It was of modern pony size. One complete finger, and toe and two splints were present in each fore and hind foot. Splints were absent. Molars were long crowed for eating grass.

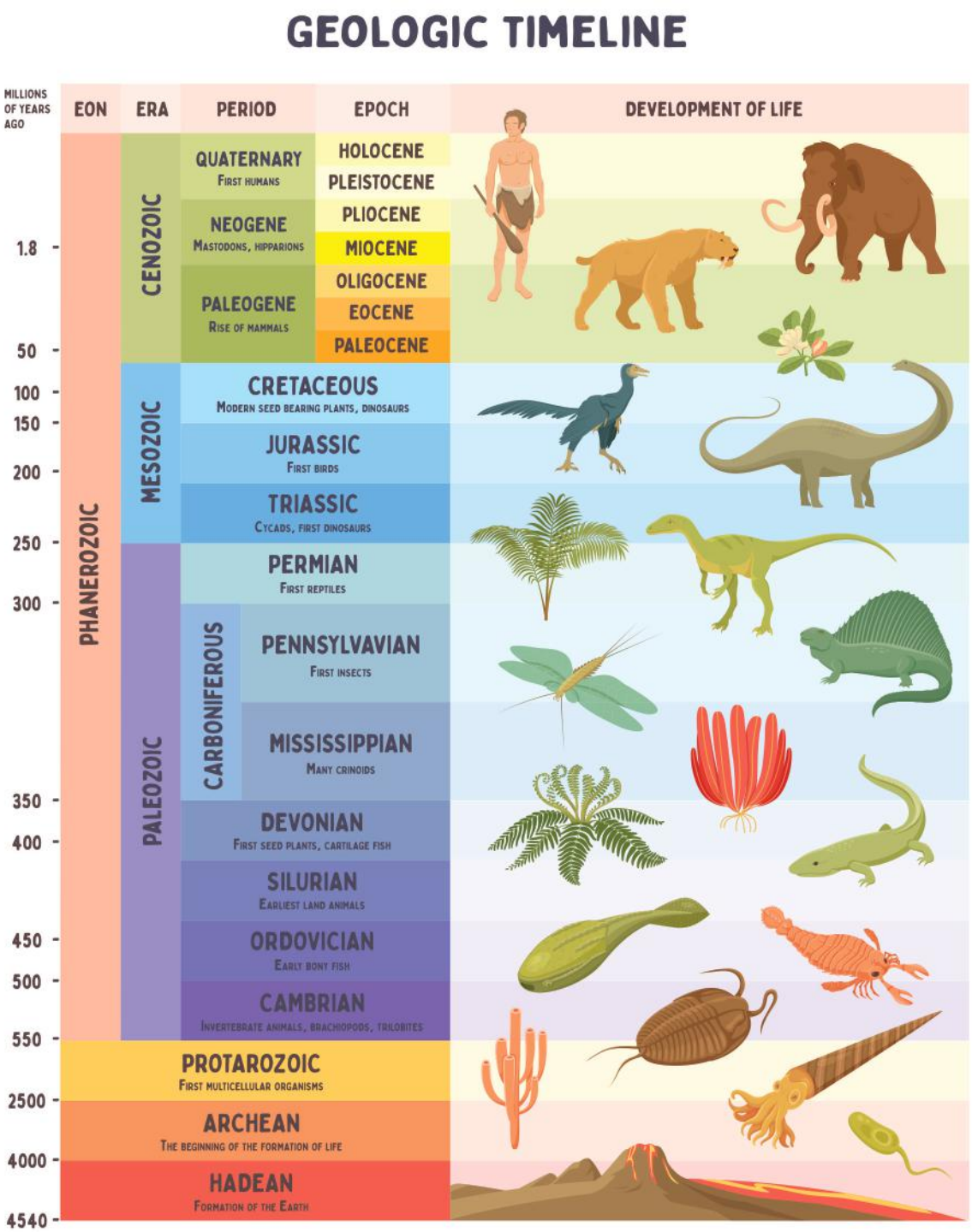
Mesohippus
(Oligocen)

Mesohippus–Kown as intermediate horse. It was of sheep size. The fingers and are splint of fifth finger on the force fat while the hindfoot had three toes. Molar teeth were crowed.

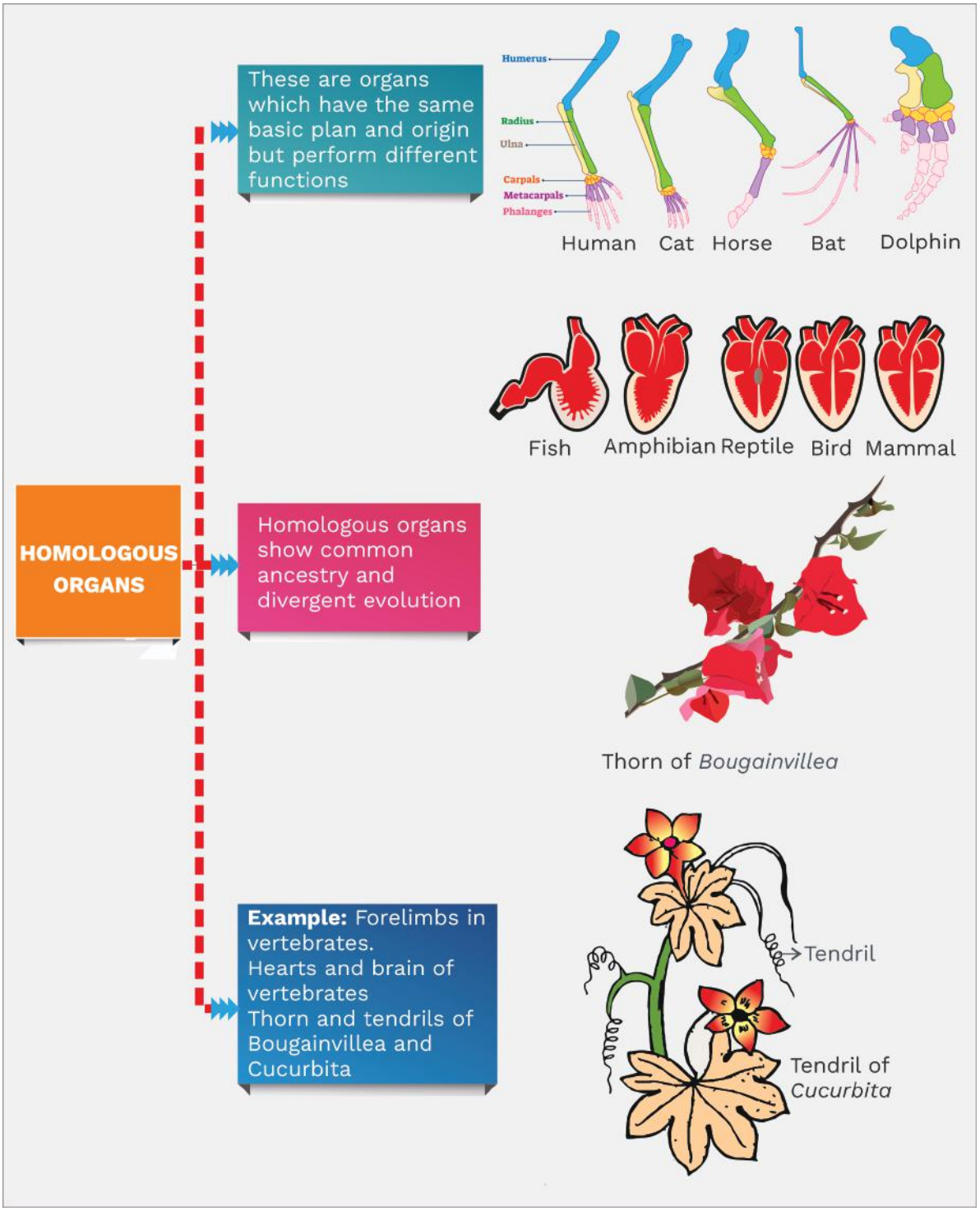
Hyracotherium
(Eocen)

Eohippus (*Hyracotherium*)–Known as dawn horse. It's fossil was found in North America. It has short head and neck. It has four functional toes and a splint on each forefoot of the first. On each hindfoot it has three functional toes and splints of the first and fifth. Molars were crowed for soft vegetation

adaptive radiation.



- Homology shows **divergent evolution.** For e.g.,



Adaptive radiation gave rise to a variety of marsupials in Australia.

- Darwinian finches in the Galapagos island with different types of beaks has evolved from a common ancestor according to different food habits.

Vestigial Organs

- These are the organs which were fully functional in the ancestors, but are not functional in the present organism. These organs appear as reduced form in the organisms. They gradually disappear from the organisms.

Connecting Links

- Living organisms that possess the characteristics of two group of organisms.

Rack Your Brain

Give one example of vertebrate anatomy that evolution of life form has occurred on earth.

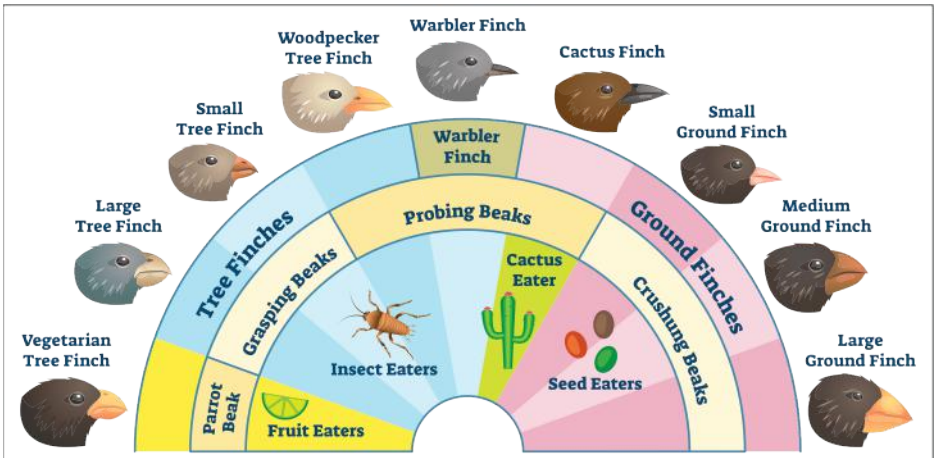
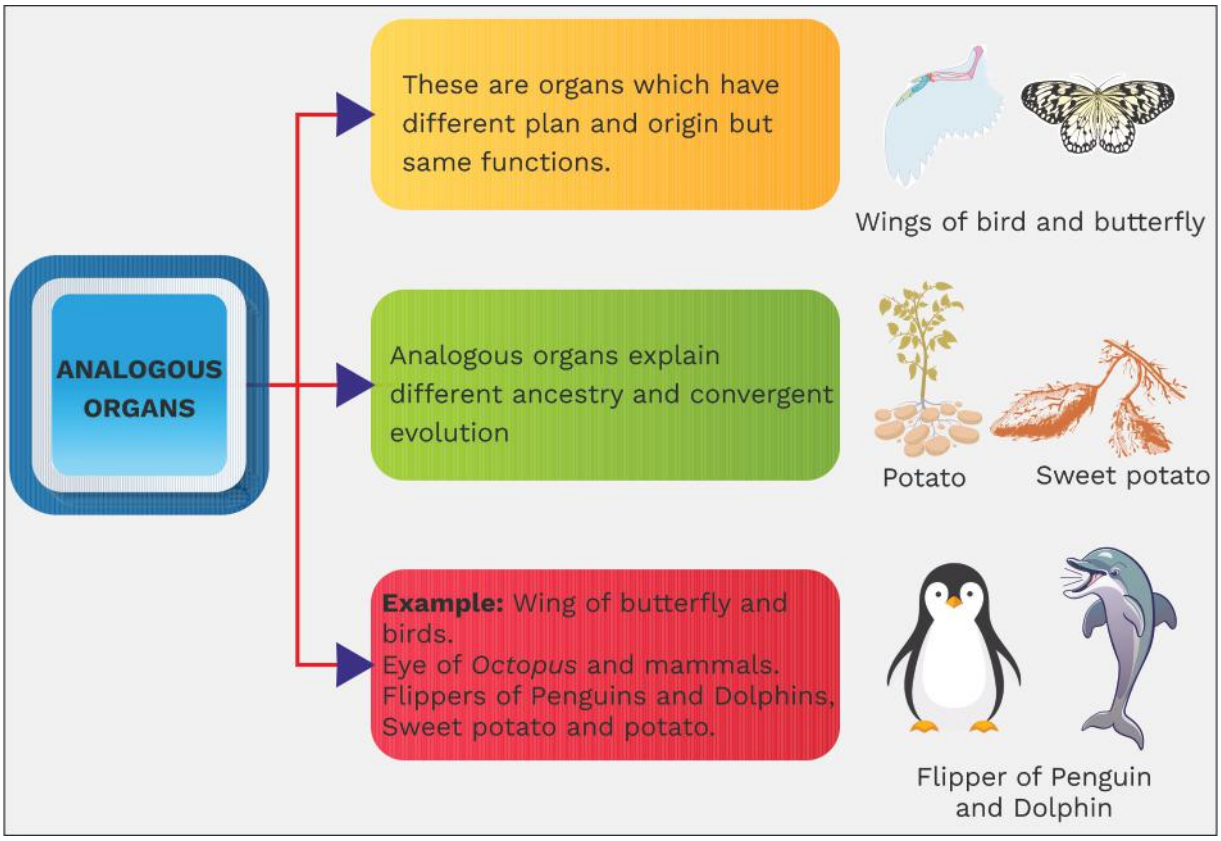


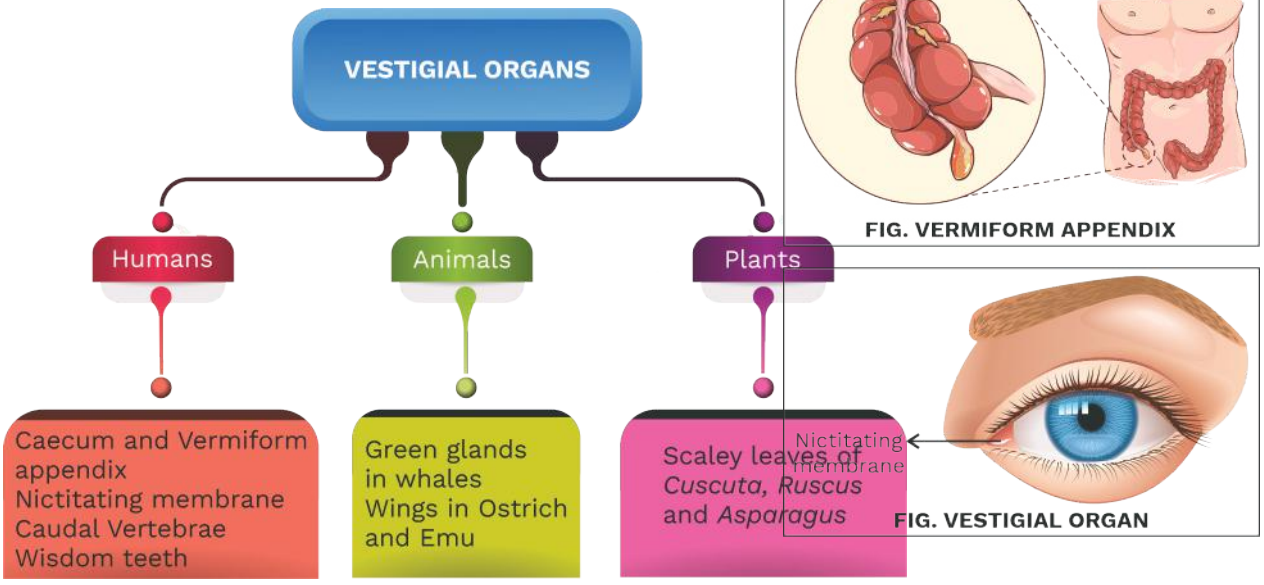
FIG. ADAPTIVE RADIATION

Rack Your Brain

Name any two vertebrate body parts that are homologous to human forelimbs?


ANALOGOUS ORGANS
These are organs which have different plan and origin but same functions.
Wings of bird and butterfly
Analogous organs explain different ancestry and convergent evolution
Potato
Sweet potato
Example: Wing of butterfly and birds.
Eye of Octopus and mammals.
Flippers of Penguins and Dolphins,
Sweet potato and potato.
Flipper of Penguin and Dolphin

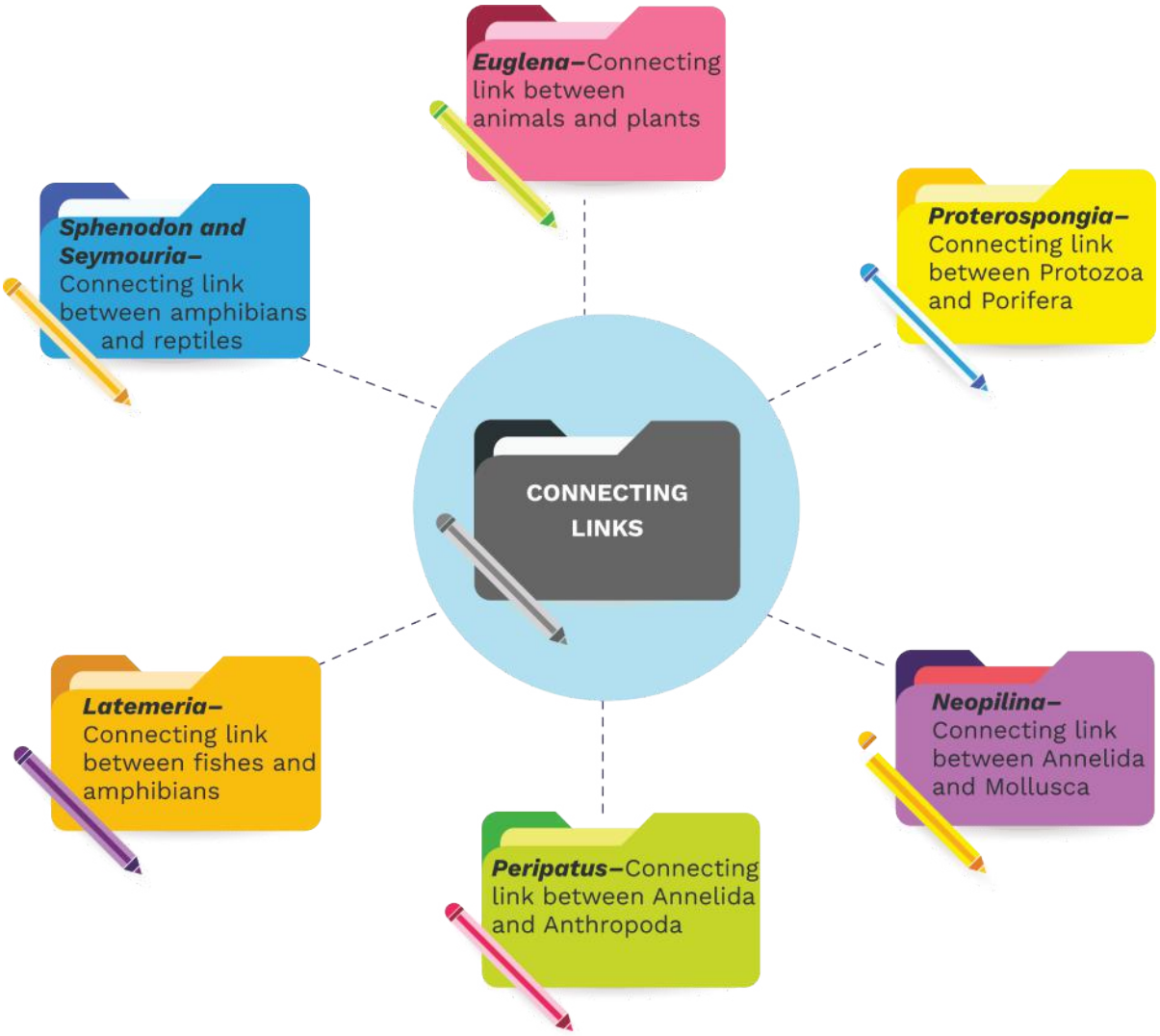
Atavism


VESTIGIAL ORGANS
Humans
Animals
Plants
Caecum and Vermiform appendix
Nictitating membrane
Caudal Vertebrae
Wisdom teeth
Green glands in whales
Wings in Ostrich and Emu
Scaley leaves of Cuscuta, Ruscus and Asparagus
FIG. VERMIFORM APPENDIX
Nictitating membrane
FIG. VESTIGIAL ORGAN

- It is the reappearance of certain ancestral characters which had disappeared or were reduced.
- **Examples:** The occurrence of a short tail in the babies, large canines, power to move the pinna, long hairs.
- In some plants like *Oxalis* and poppy, the stamen and carpel get changed to a leaf-like structure.
- In *Citrus* plants, the petiole is enlarged to produce two lateral leaflets. This makes the leaf trifoliate.

Previous Year's Question

Peripatus is a connecting link between
(1) Mollusca and Echinodermata
(2) Annelida and Arthropoda
(3) Coelenterata and Porifera
(4) Ctenophora and Platyhelminthes



Physiological and Biochemistry/Biochemical Evidences

- Physiology and Biochemistry show that organisms have evolved from common ancestors.
- Some examples are as follows:
  - Protoplasm i.e., cytoplasm and nucleus is present in organisms from Protozoa to Chordata.
  - Enzymes are present in organism and perform the same function in all the organisms in which they are present.
  - The composition of blood is same in organisms in which it is present.
  - The cellular energy is ATP in all organisms and is produced either aerobically or anaerobically.
  - The composition of DNA is the same in all organisms. It is the hereditary material of most organisms. RNA is used to form proteins.

Embryological Evidences

- The embryological development gives a lot of evidences in favour of evolution.

Similar Early Development

- Egg and sperm fuse to form a zygote. All animals start their life with the formation of zygote. Zygote divides and form blastula. Blastula shows gastenelation and forms three layers namely Ectoderm, Mesoderm and Endoderm. The three layers develop into different organs. The similarity in the early development in the animals suggests that these animals have evolved from a common ancestor.

Resemblance among Vertebrate Embryos

- The early embryos of all vertebrates show resemblance in their structure. They show similarity in the structure of head with eye, similar sometimes, similar visceral arches and visceral furrows and embryonic tail. The similarity in the

Definition

Atavism: It is the reappearance of certain ancestral characters which had disappeared or were reduced.

Previous Year's Question

RUBP carboxylase-oxygenase is located in
(1) Mitochondria (2) Chloroplasts
(3) Peroxisomes (4) Golgi bodies

structure of the vertebrates suggests that they have evolved from a common ancestor.

Development of Vertebrate Organs

- The development of organs like heart, brain indicates common ancestry. The fishes have two-chambered heart, frog i.e., amphibians and snake i.e. reptiles have two-chambered heart, while birds and mammals have four-chambered heart. This suggests that these organisms have evolved from a common ancestor.

Previous Year's Question

In the leaves of C_4 plants, malic acid formation during CO_2 fixation occurs in the cells of
(1) bundle sheath
(2) phloem
(3) epidermis
(4) mesophyll

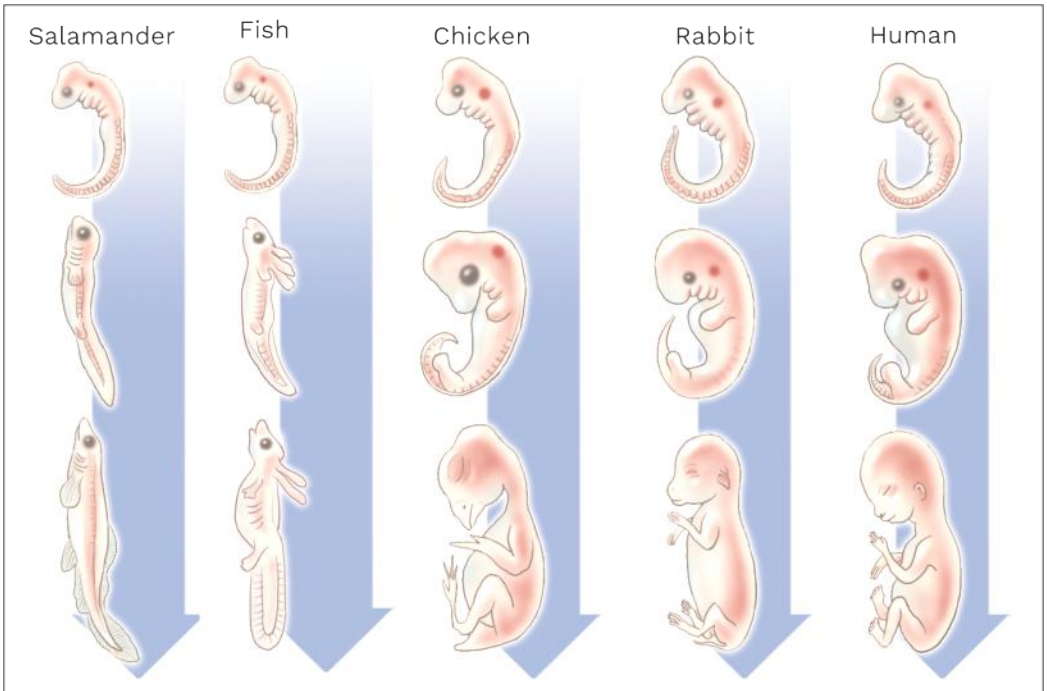


FIG. STAGES OF DEVELOPMENT IN VERTEBRATE EMBRYOS

Biogenetic Law

- Ernst Haeckel called the concept Baer's law put forward by Baer as Biogenetic Law.
- It states that ''Ontogeny repeats Phylogeny"
- This means that an animal during its development from egg to adult repeats the stages through which its ancestors have passed through in its course of development.

Rack Your Brain

Why photorespiration is called a wasteful process?

- Example: Frog during its course of development has a stage that is like a fish-like tadpole larva. The larva also has fins and gills for breathing. This indicates that frog has evolved from Fish like ancestors.
- Tadpole of *Herdmania* has the presence of notochord, dorsally placed nervous system, and tail. The adult does not possess the notochord and tail. Thus, the larva shows ancestral characters.
- Protonema, a development stage in the life cycle of Bryophyte and a pteridophyte resembles a green filamentous alagae. Thus, suggesting the algal ancestory for Bryophytes and Pteridophytes.

Biogeographical Distribution

- The study of the distribution of animals and plants in the world is known as biogeography.
- Initially about 250 million years ago, all the continents were present together and were known as Pangaea. The landmass later split and formed the different continents that were/are separated by different water bodies.
- The continents have different animals and plants and the presence of different plants and animals in different continents explains how the organisms have evolved.

THEORIES TO EXPLAIN EVOLUTION

- Lamarckism
- Darwinism
- Mutation theory
- Modern concept of evolution (Synthetic theory)

Previous Year's Question

The presence of gill slits, in the embryos of all vertebrates, supports the theory of
(1) metamorphosis
(2) biogenesis
(3) organic evolution
(4) recapitulation

Lamarckism

- It was put forward by French naturalist Jean Baptist de Lamarck in his book Philosophie Zoologique in 1809.
- His theory was based on the following factors-
  - Internal vital force
  - New needs
  - Use and disuse of the organs
  - Inheritance of acquired characters
- **Internal vital force-**Components of the organs increases due to internal vital force.
- **New needs-**Environment has an effect on the organisms. A change in the environment brings a change in the organisms. It gives rise to new needs in the organisms.
- **Use and Disuse of Organs-**The organs which are used more get developed. While if any organ is not used it can deteriorate.

- **Inheritance of acquired characters-**Whenever an individual acquires any character during its lifetime due to internal vital force, new needs, use and disuse of organs, they are passed onto the next generation.
- **Examples**
  - Aquatic birds have webbed feet and have evolved from their terrestrial ancestors.
  - Ancestors of Giraffe had small neck and fore limbs. As the grasses were less and giraffes needed to obtain food from the trees so they had to stretch their neck to reach the plants. This acquired character was passed onto the next generation. This continued for many generations and finally, the giraffe developed long neck.
- **Criticism of Lamarckism**
  - The organs that we use more usually degenerates/weakens. Example-Eye sight
  - Weismann cut off the tail of rats for about 22 generations but the tail still appeared. On the basis of this experiment, Weismann proposed the theory of 'Continuity of germplasm'.

According to Weismann

- Somatoplasm and germplasm are present in the organisms. Somatoplasm in somatic cells and germplasm in germinal cells.
- Somatoplasm dies with the death of organism while germplasm transfers to the next generation.
- If any variation develops in germplasm, it is inherited, while if variation develops in somatoplasm, it is not transmitted.

Neo-Lamarckism

- Although Lamarckism remained controversial but some scientists gave the following evidences in favour of Lamarckism. They are known as **Neo-Lamarckians.**

Rack Your Brain

Name any factors that can disturb the genetic equilibrium.

- According to Neo-Lamarckism, environment affected the inheritance of acquired characters. According to it, changing environment gives rise to some physical and chemical changes in organisms, which affect their germplasm, and these acquired characters are definitely inherited. E.g.,
- **Sumner's Experiment:** Sumner kept a white rat in warm temperature resulted in elongation of the body, large pinna and long tail. These features were inherited to the offspring.
- **Mac Dugal's Experiment:** Mac Dugal trained white rats to cross a tank of water following a definite route. These trained rats were mated and their offspring were again trained. It was observed that there was a decrease in the number of errors by offsprings.

Darwinism

- "Darwinism" or "The theory of Natural Selection" was proposed jointly by Charles Darwin and **A.R. Wallace.** This theory was explained by Darwin in his book 'On the origin of Species by means of Natural Selection' (1859).
- Darwin was influenced by two books–
  - "Principles of Population" by Malthus.
  - "Principles of Geology" by Charles Lyell.
- **Alfred Russel Wallace** had travelled to South eastern Asia and South America. The idea of natural selection striked in his mind. Wallace wrote an essay and sent it to Darwin. There was a striking similarity between the views of Darwin and Wallace.

Previous Year's Question

Weismann cut off tails of mice generation after generation but tails neither disappeared nor shortened showing that
(1) Darwin was correct
(2) tail is an essential organ
(3) mutation theory is wrong
(4) Lamarckism was wrong in inheritance of acquired

MAIN FEATURES OF THEORY OF NATURAL SELECTION

Overproduction

- All organisms have the capability to produce an enormous number of offsprings, organisms multiply in geometric ratio.

- E.g., Plants produce thousands of seeds. Insects lay hundreds of eggs. This is done to increase the chances of survival.

Struggle for Existence

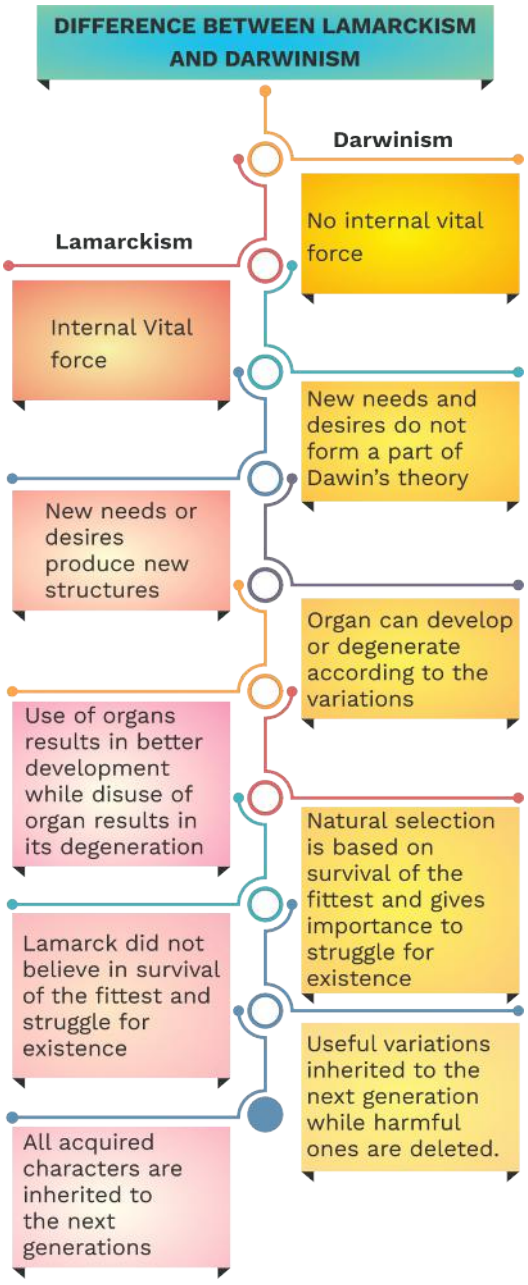
- Every individual competes with others of the same and other species for basic necessities like space, shelter and food, it is called struggle for existence and it continues for the whole life from the zygote stage to natural death.
- The struggle for existence is of three types

Variations and Heredity

- Except the identical twins, no two individuals are similar and their requirements are also not the same. It means there are differences among the individuals. These differences are called variations. Due to variations, some individuals would be better adjusted in the surroundings than the others.
- According to Darwin, the variations are continuous and those which are helpful in the adaptation of an organism towards its surroundings would be passed on to the next generation, while the others will disappear.

Survival of the Fittest or Natural Selection

- The original idea of survival of the fittest was proposed by Herbert Spencer.
- According to Darwin, most suitable and fit individuals are successful in the struggle for existence. The individuals with the most favourable adaptations are able to lead the most successful life and are able to win over their mating partners. Darwin called it sexual selection.
- In the struggle for existence, only those members survive which possess useful variations (means nature selects fit individuals). This was called as natural selection. Fitness is the end result of the ability to adapt and get selected by nature.



Origin of New Species

- Darwin explained that variations appearing due to environmental changes are transmitted to the next generation. So, offsprings become different from ancestors. In next generation, the process of natural selection repeats, so after many generations, a new species is formed.

Criticism Of Darwinism

- Darwin did not explain the development of vestigial organs.
- This theory had no satisfactory explanation for the cause, origin and inheritance of variations.
- Darwin was unable to explain why in a population only a few individuals develop useful variation and others have harmful variations.
- Darwin was unable to differentiate between somatic and germinal variations.
- This theory was unable to explain over-specialisation of some organs like tusk of elephants, antlers of deer.
- The main drawback of Darwinism was lack of the knowledge of heredity.

Neo-Darwinism

- Neo-Darwinism is a modified form of Darwinism along with recent researches of Weismann, Mendel, De Vries, Huxley, Gates, Stebbins etc. They performed many experiments to remove the objections against Darwin's theory.
- The salient features of Neo-Darwinism are as follows:-
  - It is the modification of Darwinism in the light of genetic research.
  - It incorporates causes of variation.
  - It considers only genetically inheritable variations (mutation) as raw material for evolution.
  - Unit of evolution is population.

Rack Your Brain

How does fitness of a population helps in evolution?

Rack Your Brain

Name the scientist who influenced Darwin?

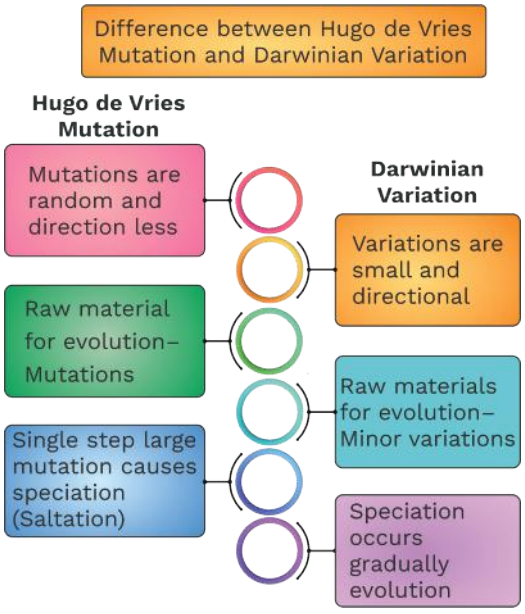
- According to Neo-Darwinism, both mutation and natural selection are responsible for evolution.

Mutation Theory

- The mutation theory was put forward in 1901 by Hugo de Vries.
- The plant on which de Vries had experimented was Oenothera Lamarckiana.
- Role of mutations in evolution is genetic variations.
- Mutations are discontinuous variations called sports by Darwin and saltatory variation by Bateson.
- Features of mutation theory are-
  - It forms the raw material for evaluation.
  - It appears suddenly and produces effect immediately.
  - Mutations can appear in all directions.
  - A single mutation may produce a new species heritable time to time.

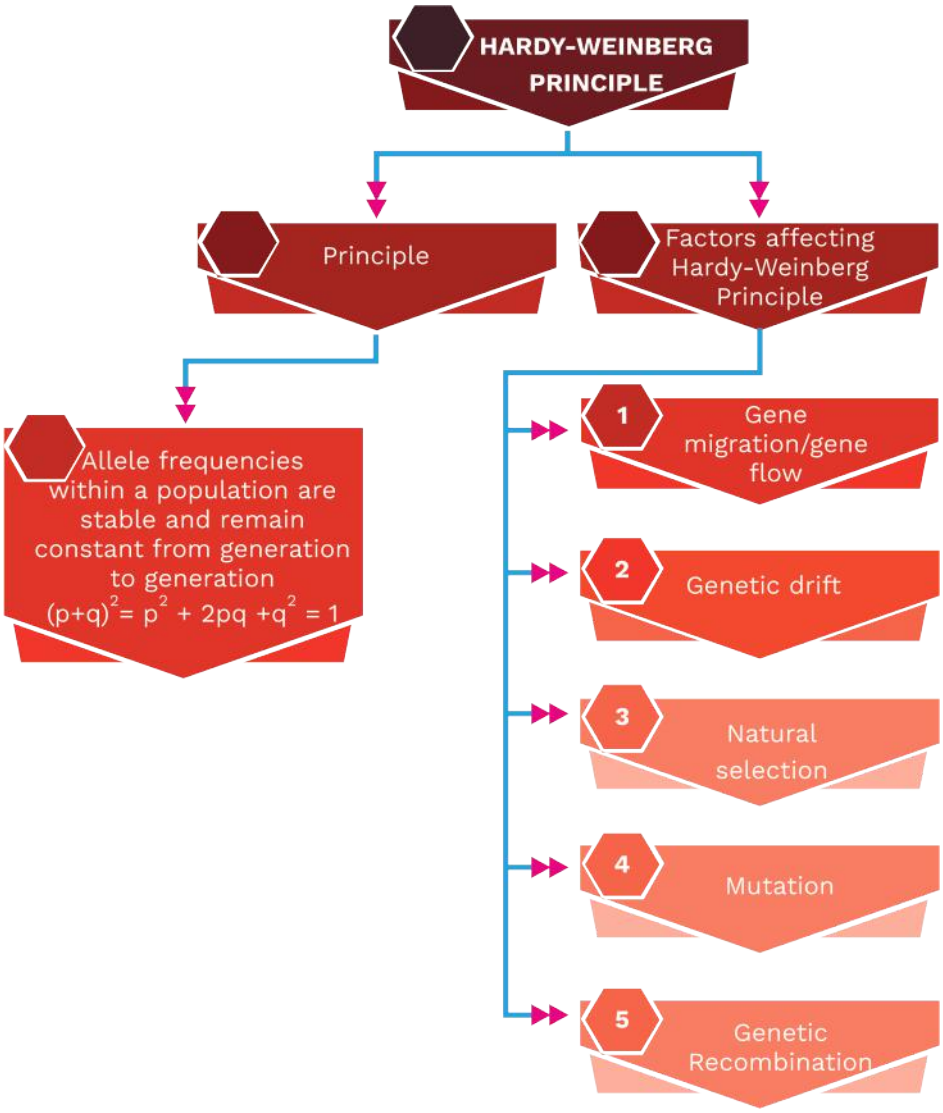
Synthetic Theory

- **Dobzhansky (1937)** in his book 'Genetics and the Origin of Species' provided the initial basis of synthetic theory.
- 'Modern synthetic theory of evolution' was designated by **Huxley in 1942.**
- Some of the important workers who have contributed to the modern synthetic theory are:
- Th. Dobzhansky, R.A. Fisher, J.B.S. Haldane, Sewall Wright, Ernst Mayr and G.L. Stebbins.
- According to synthetic theory, there are **five basic factors involved in the process of organic evolution.** These are:
  - Gene mutations
  - Changes in the chromosome structure and number
  - Genetic recombinations
  - Natural selection
  - Reproductive isolation



Genetic Variation

- Genetic variations are inheritable variations and form the raw material of evolution.
- Causes of genetic variation are environmental factors and genetic factors (migration, non-random mating, genetic drift, mutation, gene recombination and hybridisation).
- The removal of alleles from one population or addition of alleles into another population is called **gene flow** or **gene migration.**



- **Genetic drift:** The theory of genetic drift was developed by **Sewall Wright in 1930.** It is the elimination or addition of the genes of certain characters when some animals in a population migrate or die or emmigrate. It changes the gene frequency of the remaining population. Genetic drift **operates only in a small population.** Change in the frequency of genes in a gene pool is called **genetic drift.**
- Genetic drift in a new colony is called founder effect because only a few founders carrying a small fraction of genetic variability of the parent population begin the colony.
- **Bottle neck effect:** Death of several members of a population due to natural calamities (earthquake, storm, flood) also leads to genetic drift. The original size of population is then restored by mating among the survivors. The new population may lack the genes of certain traits. This may produce a new species after some time. The loss of a section of population by death and after some time a new species is formed. This effect is known as **bottle neck effect.**
- Gene **recombination** is the process of bringing together new combinations of existing genes and alleles.
- Hybridisation is a method of mixing the genes of two populations. It changes the gene frequencies and alters the phenotype of the offsprings.
- **Natural Selection:** If differential reproduction (some individuals produce more, some only a few and others none) is continuous for many generations, genes of the individuals who/that produce more offspring will become predominant in the gene pool of the population. Thus, natural selection occurs through differential reproduction in successive generations.
- Biologists recognise three major categories of natural selection based on its effect on the population over time

Previous Year's Question

In Hardy-Weinberg equation, the frequency of heterozygous individual is represented by
(1) p^2
(2) 2pq
(3) pq
(4) q^2

Previous Year's Question

Genetic drift operates in
(1) small isolated population
(2) large isolated population
(3) non-reproductive population
(4) slow reproductive population

- Stabilizing selection
- Directional selection
- Disruptive selection

- **Stabilising selection** favours individuals possessing an average value for a trait and are selected against individuals with extreme values.
- **Directional selection** tends to favour phenotypes at one extreme of the range of variation.
- **Disruptive selection** favours individuals at both extremes of variation. Selection is against the middle of curve.

Examples of Natural Selection

- **Drug resistance:** The drugs which eliminate pathogens become ineffective in the course of time because pathogenic species which can tolerate them, survive and flourish to produce tolerant population.

Previous Year's Question

In the case of peppered moth (*Biston betularia*) the black-coloured form became dominant over the light-coloured form in England during industrial revolution. This is an example of

(1) appearance of the darker coloured individuals due to very poor sunlight
(2) protective mimicry
(3) inheritance of darker colour character acquired due to the darker environment
(4) natural selection whereby the darker forms were selected

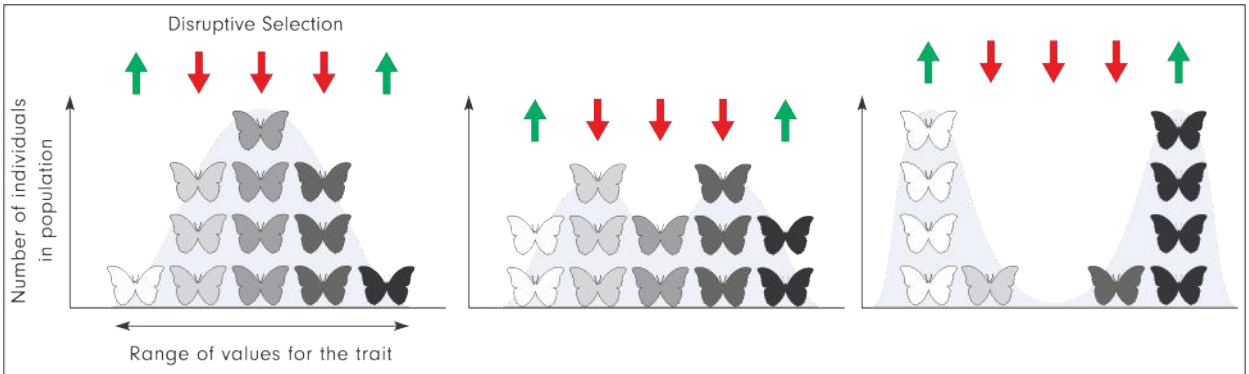


FIG. TYPES OF NATURAL SELECTION

- **Reproductive isolation** is the prevention of

Preindustralisation the bark of the trees were covered with more white winged moth and less than dark coloured or melanised moth. The bark were covered with white lichens which camouflaged the white moth white the dark coloured moth were preyed by birds

Post industrialisation carbon root accumulated on the bark of the trees. This now camouflaged the dark coloured moth and the white coloured moth was expired, this they were preyed upon the black moth increased in number and the white moth decreased in number.

interbreeding between the populations of two different or closely related species. It maintains the characters of the species but can lead to the origin of new species.

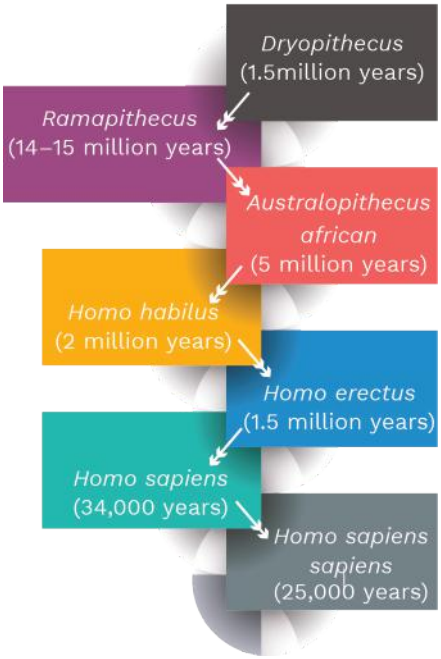
- The mechanism of reproductive isolation is explained by **Stebbins** in his book 'Process of Organic Evolution'.

EVOLUTION OF MAN

- The evolution of human species took place mostly in Africa. It is based on fossil records which clearly indicates that the genera like *Ramapithecus* and *Sivapithecus* which were habitants of Asia and Africa were the forerunners of Hominids. Following steps may be followed in tracing the evolution of modern man (*Homo sapiens*):
  - ***Dryopithecus* (*Proconsul*):** It is the ancient group of apes collectively called *Dryopithecus*. The oldest fossil of this group of *Proconsul* was discovered from South Africa. It inhabited the earth about 25 million years ago and had the characters of both man and apes showing common ancestry.
  - ***Ramapithecus* and *Sivapithecus*:** From Miocene period to early Pliocene period. *Dryopithecus* (*Proconsul*) gave rise to next fossil species *Ramapithecus* and *Sivapithecus*, found at that time in Africa and Asia respectively. They are considered as fore runners of hominids and are on the direct line of human evolution and represent the first man-like primates.
  - ***Australopithecus* (African ape man):** They were descended from *Ramapithecus* and *Sivapithecus*. They lived in Africa about 5 million years ago. This man had a cranial capacity of about 350 cc to 450 cc. It is indicated from fossil records that amongst the apes the Gibbons took the different line

Previous Year's Question

Genetic variation in a population arises due to
(1) recombination only
(2) mutation as well as recombination
(3) reproductive isolation and selection
(4) mutations only



from human evolution about 10 million years ago; the ancestors of Gorilla and Chimpanzee took about 4 million years ago (Gorilla and Chimpanzee separated from each other about 2.3 million years ago).

- ***Homo habilis* (the handy man):** This had been descended from *Australopithecus* about 2 million years ago in Africa. The cranial capacity was about 700 cc (larger than *Australopithecus*). He started to use tools and walked erect.
- ***Homo-erectus* (the Peking man):** *Homo habilis* gave the next man-*Homo erectus* about 1.7 million years ago in Africa and thus migrated to Asia and Europe. Both the fossils of Java man and Peking man belong to *Homo erectus*. Fossils of Java man were discovered at Trimul in Java and fossils of Peking man were discovered in a cave at Choukoutein. The cranial capacity of Java man was 900 cc and that of Peking man was 1050 cc. These men used fire for cooking and made rough tools of stones and bones for killing the animals for their food. Their canine teeth were long.
- **Neanderthal Man (*Homo sapiens neanderthalensis*):** This was descended from *Homo erectus*. He was very much similar to the modern man. Their skull was thick-boned and depressed but the high bone was curved outward. Their lower jaw was deep without chin (almost absent). The cranial capacity was about 1450 cc. They built hut-like structures

Previous Year's Question

The chronological order of human evolution from early to the recent is

(1) *Australopithecus* → *Ramapithecus* → *Homo habilis* → *Homo erectus*

(2) *Ramapithecus* → *Australopithecus* → *Homo habilis* → *Homo erectus*

(3) *Ramapithecus* → *Homo habilis* → *Australopithecus* → *Homo erectus*

(4) *Australopithecus* → *Homo*

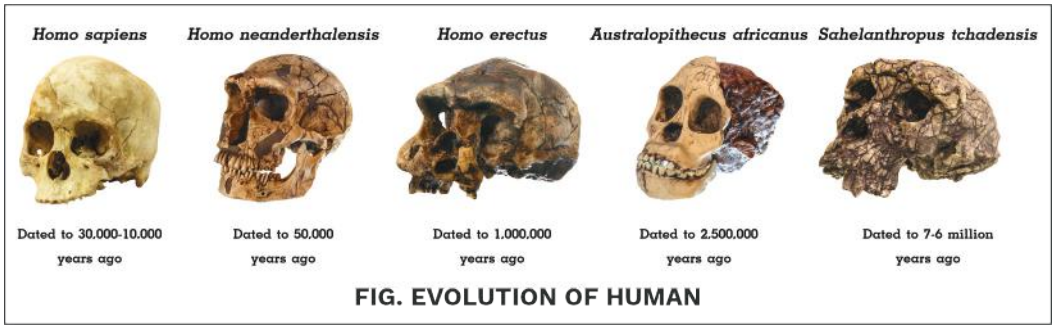


FIG. EVOLUTION OF HUMAN

for dwelling and devised and used various tools made by themselves. This man used animal hides as his clothing and buried their dead. He was an intelligent man.

- **Cro-Magnon man (*Homo sapiens sapiens*):** This man was a sudden transition from Neanderthal man in France about 34000 years ago. They were more advanced than their predecessors.

Rack Your Brain

Which one of the ancestors of mammal showed bipedal movement for the first time?

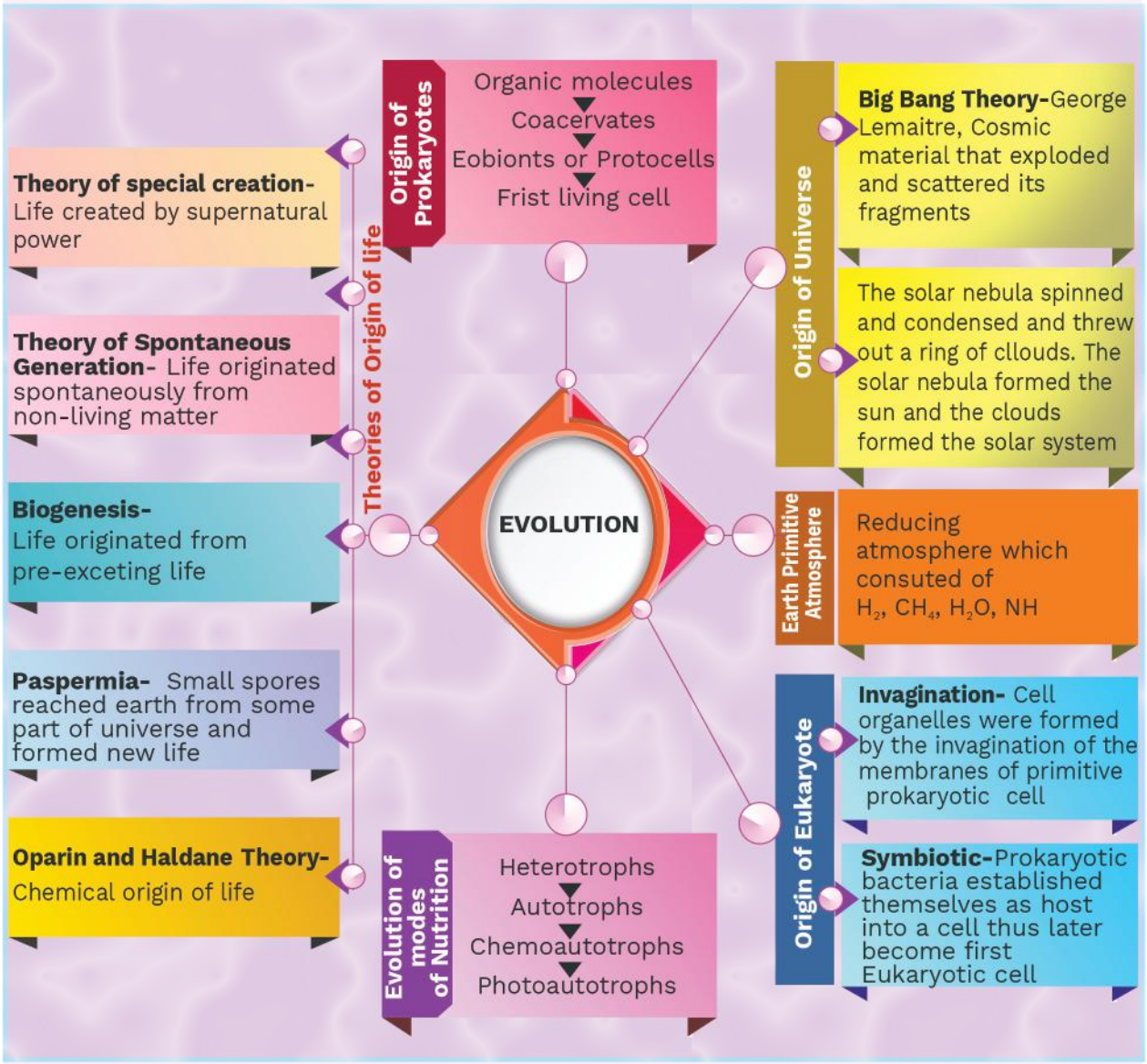
Rack Your Brain

Name any to factors that can disturb the genetic equilibrium.

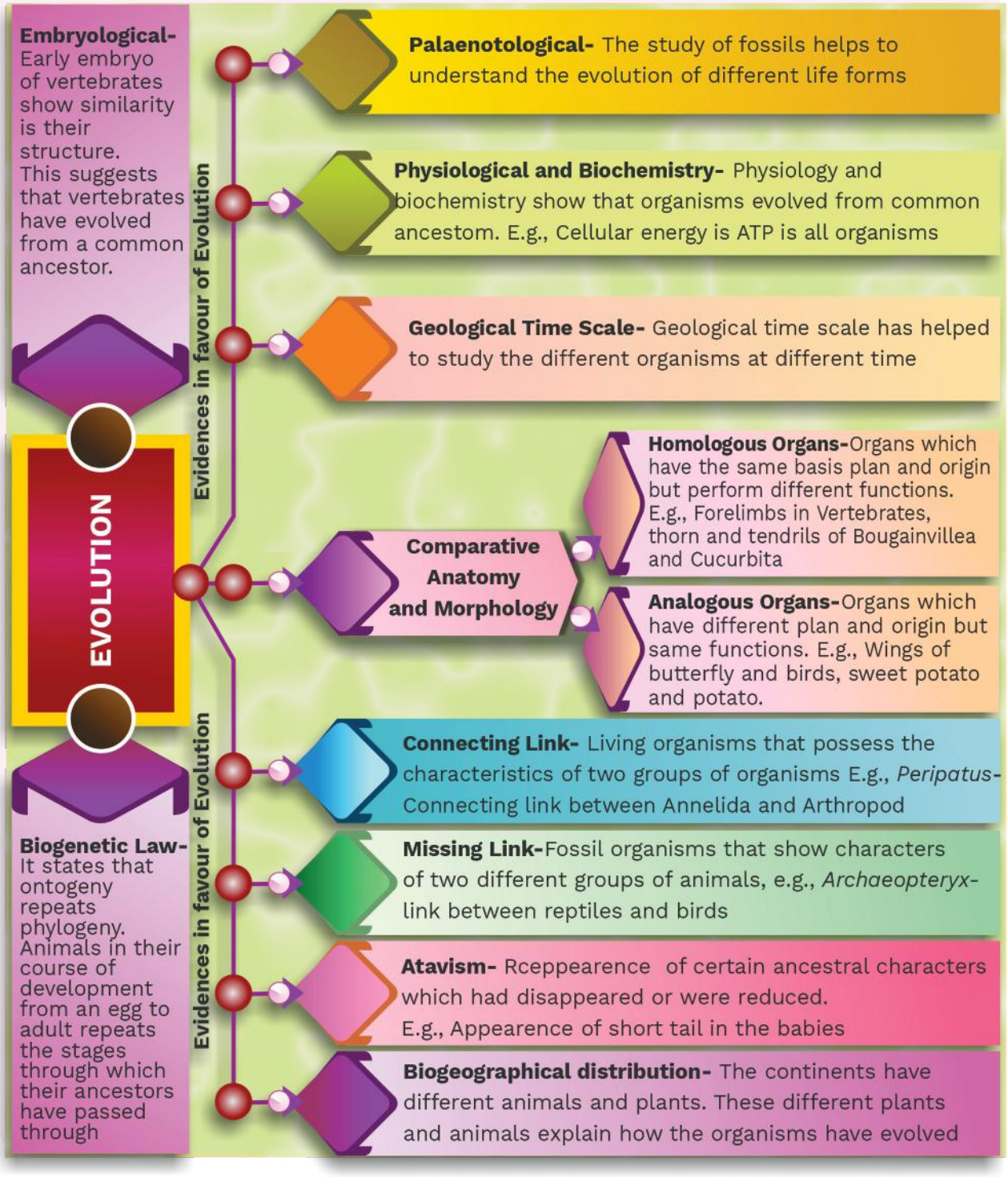
Rack Your Brain

What is the term used for resemblance of varieties of placental mammals to corresponding marsupials in Australia?

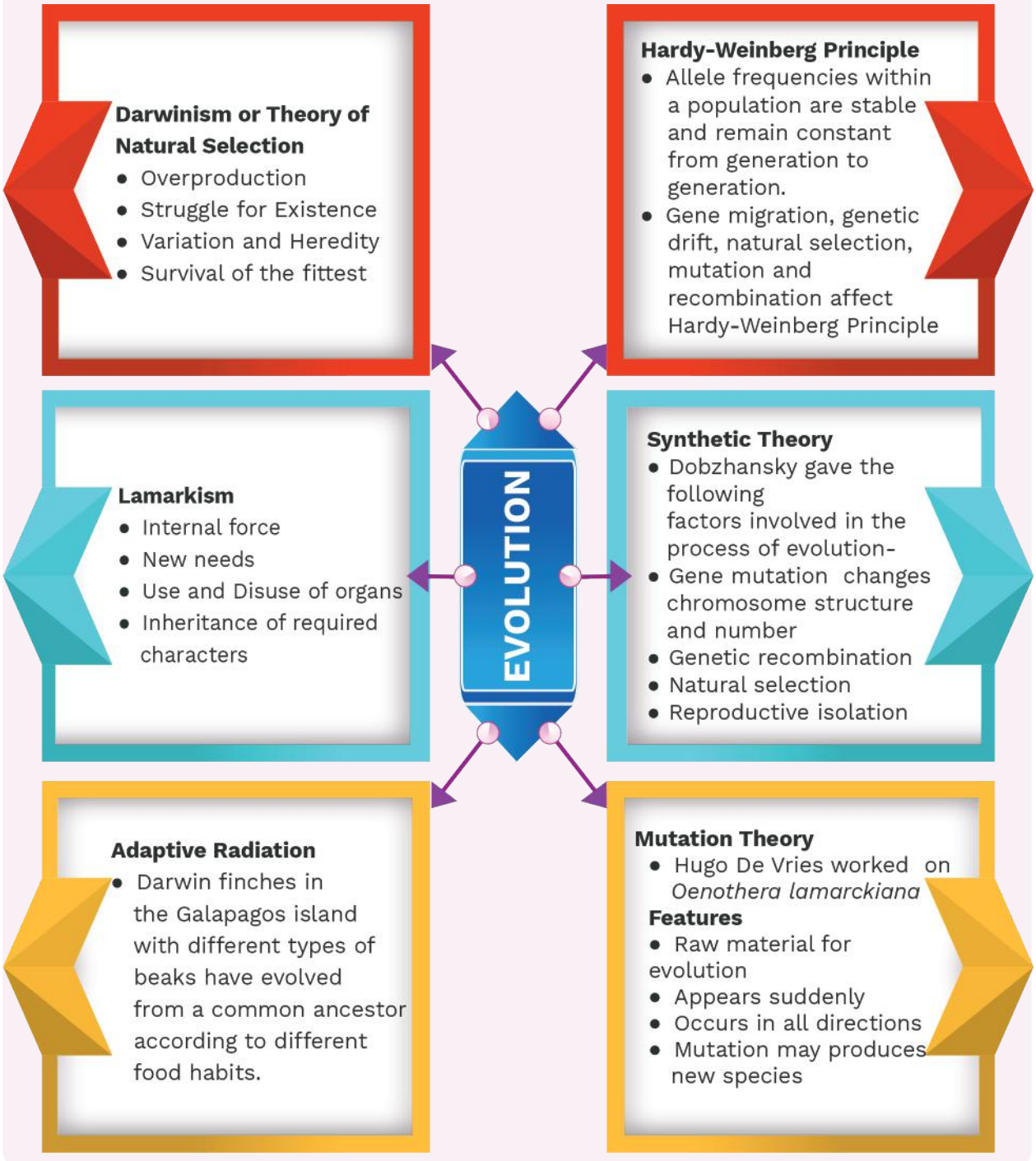
Summary


EVOLUTION
Theories of Origin of life
Theory of special creation- Life created by supernatural power
Theory of Spontaneous Generation- Life originated spontaneously from non-living matter
Biogenesis- Life originated from pre-exceting life
Paspermia- Small spores reached earth from some part of universe and formed new life
Oparin and Haldane Theory- Chemical origin of life
Origin of Prokaryotes
Organic molecules
Coacervates
Eobionts or Protocells
Frist living cell
Evolution of modes of Nutrition
Heterotrophs
Autotrophs
Chemoautotrophs
Photoautotrophs
Origin of Universe
Big Bang Theory-George Lemaitre, Cosmic material that exploded and scattered its fragments
The solar nebula spinned and condensed and threw out a ring of cllouds. The solar nebula formed the sun and the clouds formed the solar system
Earth Primitive Atmosphere
Reducing atmosphere which consuted of H_2, CH_4, H_2O, NH
Origin of Eukaryote
Invagination- Cell organelles were formed by the invagination of the membranes of primitive prokaryotic cell
Symbiotic-Prokaryotic bacteria established themselves as host into a cell thus later become first Eukaryotic cell

Summary


EVOLUTION
Evidences in favour of Evolution
Evidences in favour of Evolution
Embryological- Early embryo of vertebrates show similarity is their structure. This suggests that vertebrates have evolved from a common ancestor.
Biogenetic Law- It states that ontogeny repeats phylogeny. Animals in their course of development from an egg to adult repeats the stages through which their ancestors have passed through
Palaenotological- The study of fossils helps to understand the evolution of different life forms
Physiological and Biochemistry- Physiology and biochemistry show that organisms evolved from common ancestom. E.g., Cellular energy is ATP is all organisms
Geological Time Scale- Geological time scale has helped to study the different organisms at different time
Comparative Anatomy and Morphology
Homologous Organs-Organs which have the same basis plan and origin but perform different functions. E.g., Forelimbs in Vertebrates, thorn and tendrils of Bougainvillea and Cucurbita
Analogous Organs-Organs which have different plan and origin but same functions. E.g., Wings of butterfly and birds, sweet potato and potato.
Connecting Link- Living organisms that possess the characteristics of two groups of organisms E.g., Peripatus- Connecting link between Annelida and Arthropod
Missing Link-Fossil organisms that show characters of two different groups of animals, e.g., Archaeopteryx- link between reptiles and birds
Atavism- Rceppearence of certain ancestral characters which had disappeared or were reduced. E.g., Appearence of short tail in the babies
Biogeographical distribution- The continents have different animals and plants. These different plants and animals explain how the organisms have evolved

Summary


EVOLUTION
Darwinism or Theory of Natural Selection
• Overproduction
• Struggle for Existence
• Variation and Heredity
• Survival of the fittest
Hardy-Weinberg Principle
• Allele frequencies within a population are stable and remain constant from generation to generation.
• Gene migration, genetic drift, natural selection, mutation and recombination affect Hardy-Weinberg Principle
Lamarkism
• Internal force
• New needs
• Use and Disuse of organs
• Inheritance of required characters
Synthetic Theory
• Dobzhansky gave the following factors involved in the process of evolution-
• Gene mutation changes chromosome structure and number
• Genetic recombination
• Natural selection
• Reproductive isolation
Adaptive Radiation
• Darwin finches in the Galapagos island with different types of beaks have evolved from a common ancestor according to different food habits.
Mutation Theory
• Hugo De Vries worked on *Oenothera lamarckiana*
Features
• Raw material for evolution
• Appears suddenly
• Occurs in all directions
• Mutation may produces new species

SOLVED EXERCISE

1. **Industrial melanism is an example of**
(1) drug resistance
(2) darkening of skin due to smoke from industries
(3) protective resemblance with the surroundings
(4) defensive adaptation of skin against ultraviolet radiations

Sol. **(3)**
Industrial melanism is an example of natural selection where an organism.

2. **The concept of chemical evolution is based on**
(1) interaction of water, air and clay under intense heat
(2) effect of solar radiation on chemicals
(3) possible origin of life by combination of chemicals under suitable environmental conditions
(4) crystallization of chemicals

Sol. **(3)**
Chemical origin of life explains the origin of life in water through the interaction of different chemicals.

3. **The Finches of Galapagos islands provide an evidence in favour of**
(1) evolution due to mutation
(2) retrogressive evolution
(3) biogeographical evolution
(4) special creation

Sol. **(3)**
Finches of Galapagos island developed different types of beaks due to the different feeding habits.

4. **Which one of the following describes correctly the homologous structures?**
(1) Organs with anatomical similarities, but performing different functions
(2) Organs with anatomical dissimilarities, but performing same function
(3) Organs that have no function now, but had an important function in ancestor

(4) Organs appearing only in embryonic stage and disappearing later in the adult

Sol. **(1)**
Homologous structures have the same origin but different function.

5. **Which of the following is correct order of the evolutionary history of man?**
(1) Peking man, homo sapiens, Neanderthal man, Cromagnon man
(2) Peking man, Heidelberg man, Cromagnon man,Neanderthal man
(3) Peking man, Heidelberg man, Neanderthal man, Cromagnon man
(4) Peking man, Neanderthal man, Homo sapiens, Heidelberg man

Sol. **(3)**
Evolution of man occurred through different stages.

6. ***Peripatus* is a connecting link between**
(1) Mollusca and Echinodermata
(2) Annelida and Arthropoda
(3) Coelenterata and Porifera
(4) Ctenophora and Platyhelminthes

Sol. **(2)**
Peripatus shows the characters of Annelida and Arthropoda.

7. **In the case of peppered moth (*Biston betularia*) the black-coloured form became dominant over the light-coloured form in England during industrial revolution. This is an example of**
(1) appearance of the darker coloured individuals due to very poor sunlight
(2) protective mimicry
(3) inheritance of darker colour character acquired due to the darker environment
(4) natural selection whereby the darker forms were selected

Sol. **(4)**
It is an example of natural selection.

8. **Which one of the following scientist's name is correctly matched with the theory put forth by him?**
(1) De Vries- Natural selection
(2) Mendel- Theory of Pangenesis

(3) Weismann- Theory of continuity of germplasm
(4) Pasteur -Inheritance of acquired characters

Sol. **(3)**
Weisman gave the theory about germplasm and its effect.

9. **Which was absent in the atmosphere at the time of origin of life?**
(1) NH_3 **(2)** H_2
(3) O_2 **(4)** CH_4

Sol. **(3)**
Oxygen was absent at the time of origin of life. Atmosphere was reducing type.

10. **Evolutionary convergence is development of**
(1) common set of characters in group of different ancestry
(2) dissimilar characters in closely related groups
(3) common set of characters in closely related groups

Sol. **(4)**
Convergence is the development of common characters in a group of animals with different ancestry.