Evolution

NOTES

For

NEET and AIIMS

Examinations

By PLoS Biology Journal

INDEX

11. A brief account of the evolution
12. Distinguish (i) convergent and divergent evolution (ii) Adaptive radiation and divergent evolution (iii) Darwinism and Lamarckism (iv) Humans and Apes

- Evolution is unrolling or unfolding of nature that brings about an orderly change from one form or condition to another resulting in descendants becoming different from ancestors. Evolution is rather a law of nature
- Evolutionary biology is the study of the history of the development of newer forms of life from the pre-existing ones in various periods of time on earth

1.0 Origin of the universe

- Universe or cosmos is the whole existing space and matter which is differentiated into several galaxies with each galaxy having several stars and cloud of gas and dust
- Most accepted theory to explain the origin of the universe is the Big Bang theory which was proposed by Abbe Lemaitre in 1931. According to this theory, the universe has an explosive beginning. The universe expanded and hence temperature came down

1.1 Origin of the solar system

- According to Nebular Hypothesis of Kent, our solar system was probably created about 4.5 to 5 billion years ago when gaseous cloud called solar nebula was formed

- Our earth was supposed to have been formed about 4.5 billion years back. There was on the atmosphere on the early earth

1.2 Origin of life (biopoiesis)

- As far as we know life occurs only on earth though there is the possibility of its presence elsewhere as well. Methane which has helped develop life on earth occurs on Jupiter, Saturn and interstellar space. Water has been detected on our moon, on mars

1.2.01 Theory of special creation

Life was created by God

(i) The genesis of Bible has proposed that God created the world in six days

Day 1: Heaven and earth

Day 2: Sky and water

Day 3: Land and land plants

Day 4: Sun, moon and stars

Day 5: Birds and fishes

Day 6: Land animals and human

The first man was Adam. He was created from clay. The first woman was Eve who developed from 12^{th} rib of Adam

(ii) Hindu mythology – Hindu believed that the world was created by Brahma. The humans were formed from his head, birds from the chest, goats from mouth and plants from hair. The first man was Manu and the first woman was Shradha

- Theory of eternity

Different living beings, plants, stars etc. existed as such from the beginning and would continue

1.2.02 Theory of catastrophism

This theory was supported by Cuvier (1826), a French paleontologist, who believed that the world has passed through

many ages. A catastrophe occurred at the end of each age, which killed most of the living beings and at the beginning of next new age, a new creation evolved

1.2.03 Theory of the cosmozoic origin

Both living and non-living matters were formed simultaneously. Early living objects were resistant spores call cosmozoa. Cosmozoa gave rise to different types of living beings on earth
This theory was given by Richter in 1865.

1.2.04 Theory of Panspermia

Arrhenius (1908) proposed the theory of directed panspermia. The salient features are
(i) They assumed the presence of advanced civilization on other planets in our galaxy.
(ii) Life on earth and many other planets were infected from these advanced civilized planets
(iii) Directed panspermia theory was supported by genetic code

1.2.05 Theory of spontaneous generation

It originated in Egyptian civilization. Greek philosophers believed in it. Anaximander thought life to arise from much warmed by the sun. Aristotle believed plants to developed from the soil while worms and snails to be products of putrefaction. Frog was believed to arise from moist soil
Van Helmont had claimed the origin of mice of both sexes from human sweat and wheat bran kept in dark for 21 days

1.2.06 Biogenesis

- Theory of spontaneous generation was disapproved through the finding that life comes from pre-existing life

• Francesco Redi (1668) placed thoroughly cooked meat in three jars (i) Uncovered (ii) covered with parchment (iii) covered with muslin.

Maggots developed only in an uncovered jar. No maggot developed in a jar covered with parchment. Flies visited the third jar and laid an egg on muslin. Egg fallen in jar produced maggots.

• Spallanzani (1765) boiled nutrition in glass flasks, sealed the flasks and kept them. The broth remained clear indefinitely with no signs of living beings

• Pasteurs (1862) took broth in flasks straight and swan (bent S-shaped) necks, boiled and allowed the broth to cool. No germ developed in the broth it was connected with the atmosphere through the curved neck of the flask. The dirt particles could not reach the broth because they got trapped in the bend of the neck. When swan neck was broken, broth developed colonies of microorganisms showing that the same have come from the air. The same happened in straight necked flasks

1.2.07 Modern hypothesis of the origin of life

Chemical origin of life (chemogeny)

• Oparin suggested that from the simple compound like nitrides, oxides, ammonia, methane complex organic compounds were formed gradually under the influence of electric charges, ultra-violet rays

• First , were the formation of hydrocarbons, like acetylene, ethylene etc. these then form oxy and hydroxyl derivatives forming aldehydes, ketones and acids, sugar and starch were the main products.

• Miller's experiment – Stanley Miller (1953)a graduate student of Harold C Urey designed an apparatus for stimulating condition

prevalent on earth at the time of abiogenic evolution of organic substances. The apparatus has a spark chamber with two electrodes, a flask for boiling and a condenser. A control apparatus was also prepared but without electrodes in the spark chamber

- Miller used a mixture of methane-ammonia, hydrogen and water. The mixture was exposed to electric discharges, following by condensation and then boiling. It was continued for 18 days.
- Miller was able to identify 15 amino acids, organic acid, ribose sugar and purine, adenine.
- The formation of a protein molecule is considered a landmark in the origin of life

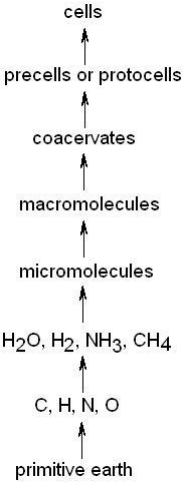
2.0 Biological evolution

- Formation of proteinoids: Proteinoids are molecules which are obtained by synthesizing polypeptides by heating a mixture of amino acids at 160 – 210^{o}C for several hours.
- Formation of coacervates

When macromolecules were formed they undergo aggregation and precipitation in the sea, which led to the formation of organized structures were distinct bodies, which did not mix with the surrounding seawater. They contained proteins, nucleoproteins and other organic and inorganic molecules in various reactions. The surface layer of the coacervates had the ability for selective absorption of substances from the medium. Oparin considered the coacervates as the sole living molecules which gave rise to cells

- Formation of precells or protocells.: The protocells were spherical in shape and a double-layered membrane was present around them. They exhibited reproduction by binary fission. The protocells were heterotrophs; they obtained the energy formed by the fermentation of organic molecules which gave rise to cells

• Formation of precells to cells: When DNA – RNA system developed within protocells, they looked like a bacteria or virus. The DNA acquired the ability for self-duplication and protein synthesis. Thus life originated after a long process of molecular evolution. The protocells in course of time differentiated into cells



3.0 Evidence of evolution

• The convincing evidence for the occurrence of descent with modification come from

(i) Paleontology

(ii) Morphology and comparative anatomy

(iii) Embryology

(iv) Geographical distribution

(v) Taxonomy

(vi) Connecting links

(vii) Cytology

(viii) Biochemistry

(ix) Genetics

3.1 Evidence from paleontology

- Paleontology is the study of past life based on fossil records. Their study reveals the existence of life in past and illustrates the course of evolution of plants and animal
- Leonardo da Vinci is considered the father of paleontology while George Cuvier is called the father of modern paleontology

3.1.01 Types of fossils

(i) Body fossils: These are hard parts of an organism, which provide details of shape and function of an actual organism such as bone, tooth, skull etc.

(ii) Subfossils: These are the remains of plant and animals which were formed during Holocene period after the last ice age and found preserved in rocks formed after 10,000 years.

(iii) Microfossils : Microscopic fossil remains of animals and plants usually less than 0.5 mm in size are known as microfossils.

(iv) Macrofossils: Fossils of larger than one cm size such as corals, skeleton

(v) Pseudofossils: these are inorganic origin objects, which show close resemblance with the forms of organic origin and are found in sedimentary rocks.

(vi) Unusual fossils: Fossils formed as a result of a combination of events and condition which results in all or most of the organism getting preserved in rock.

(vii) Trace fossils: these are fossils of footprints and trail left in mud by past living organisms such as dinosaur's footprint

(viii) Coprolites : These are trace fossils of dropping of animals or faecal matter, either very small like faecal pellets of sea snail or large coprolites of dinosaurs, crocodiles and mammals

3.1.02 Determination of age of fossils

Carbon dating – radioactive C-14 occurs naturally. It enters the food chain and is therefore found in all living beings and their remains. Half-life of C-14 is 5730 years. Carbon dating can measure articles up to 25,000 years old

3.2 Evidence from morphology and comparative anatomy

(a) Homology (Divergent evolution)

Homology is the similarity between organs of different animals based on common ancestry and built on the same fundamental pattern, but perform the varied function

Examples

(1) The flipper of a seal, a wing of bat front leg of horse and arm of man shows homology

(2) Thorns of Bougainvillea and tendrils of Passiflora are modified branched but thorns of Bougainvillea are for protection while tendrils of Passiflora are for climbing

Presence of homologous organ in different group confirms

- Common ancestry and relationship between different groups
- The difference in appearance due to divergent evolution

(b) Analogy (Convergent evolution)

The analogy is the difference in basic structure and origin but is adapted to perform similar functions Examples:

1. Fines of fishes and flippers of a whale. Similar appearance and function but their structural designs are different
2. Wings of butterfly and bat serve the same purpose i.e. flight, but wings of insect are formed of a thin flap of chitin and stiffened by series of veins. Whereas in bat wing is formed of a

fold of integument, supported by the elongated and outspread phalanges.

(c) Adaptive radiation

• The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography is called an adaptive radiation.

Example: Australian marsupials. A number of marsupials, each different from other evolved from an ancestral stock, but all within the Australian island continent

3.3 Embryology

Embryology is the study of formation and early development of an individual from zygote to young ones

(1) Similar early development early embryo development is similar in animals passing through morula (solid ball), blastula (two layered) stages showing their common origin

(2) Resemblance amongst vertebrate embryos. Embryos of all vertebrates pass through fish like state having somites, gill clefts / slits behind neck, tail, notochord

(3) Development of vertebrate organs . Heart of a mammal or bird is initially two chambered (as in fishes), three-chambered (as in amphibians) and then four-chambered

(4) In seventh month of pregnancy human foetus resembles a baby ape

(5) Recapitulation theory / Biogenetic law

Meckel (1810) proposed that developing animal embryo passes through stages resembling adult forms of its ancestors

3.4 Evidences from Geographical distribution

• The degree and period of separation of an area from another correspond to species diversity

• Double coconut occurs only in Seychelles island. Kangaroo and Koala are marsupials found in Australia

• Darwin observed that the finches on mainland of America were all of one type, possessing short straight beaks for seed crushing. These birds from Galapagos island differed in size and shape due to different food types available. Some were vegetarian finches, warbler finches while others were insectivorous finches

Evidences from taxonomy

Depending upon their resemblances and differences, living organisms are divided into groups i.e. monera, protista, fungi, plantal and Animalia. The common characters present in a species, genus, family, class or phylum indicate common ancestry while the difference indicate evolution.

3.5 Evidences from connecting links

While classifying animals one comes across certain animals or small animal groups which exhibit characteristics of more than one group. Such animals or animal group are called connecting links between those two groups

Example: Euglena

A connecting link between animal and plant. Some animal character of Euglena are

(1) Body is covered by a pellicle

(2) Reproduction is an animal like some plants character of Euglena are

(a) It is having chlorophyll and chloroplasts
(b) Nutrition is autotrophic
(c) It synthesis their food through photosynthesis

3.6 Evidence from cytology

(1) The protoplasm of all the organisms have carbon, hydrogen, oxygen and nitrogen

(2) DNA and rarely RNA is the genetic material in all the organisms, which show common ancestry and origin of all organisms.

(3) The same genetic code have triplet codons is found from the viruses to man and all living beings have same amino acids for the same codon.

3.6 Evidence from biochemistry

- Living being possess similar types of biochemicals, biochemical reaction and body functions, Trypsin digest protein from amoeba to man, Amylase digest starch from Porifera to mammalian
- Example, aerobic organisms perform Krebs cycle having similar types of enzymes from Chlamydomonas and amoeba to human being and peepal tree
- A - B blood grouping is present in apes as well as humans but not in monkeys indicating a closer relationship between the former
- The chemical composition of Protoplasm is same in protozoa and mammalia
- Hereditary material is DNA in all organism and its basic structure is same in all animals
- Respiratory protein Cytochrome C are identical in all organism.

3.7 Evidence from genetics

Accumulation of mutation produces new verities and races, e.g. red sunflower, dwarf wheat etc. Hybridisation and induction of polyploidy has given rise to new plants

4.0 Modern theories for the evolution

Four modern theories have been put forward to explain the mode of evolution. These are

(i) Lamarck's theory of inheritance of acquired characters or Lamarckism

(ii) Darwin's theory of natural selection or Darwinism

(iii) De Vries mutation theory

(iv) The modern concept of evolution

4.1 Lamarckism or Inheritance of acquired characters

• Jean Baptiste de Lamarck was a French naturalist, well known for his theory of evolution

• The central idea of Lamarckism is that the characteristics acquired by an organism during a lifetime in response to environmental conditions are passed on to their offspring. The main points include

(i) Organisms and their organs have a natural tendency to continuously increase in size, generation after generation

(ii) Continuous changes in the environmental conditions directly influence the natural habits, a way of living or organism and their structural organism and their structural organization

(iii) The growth of less used parts decline, while that of better-used parts progresses

(iv) The growth of organs either better or poor acquired during the lifetime of an organism is heredity

• Examples of Lamarckism

(1) Giraffe – the ancestors of giraffe were bearing a small neck and forelimbs and were like horses, but as they were living in places with no surface vegetation, they have to stretch their necks and forelimbs in order to eat leaves from trees

(2) Flightless birds : The development of flightless birds like an ostrich from flying ancestors is considered due to continued disuse of wings as they were found in well-protected areas with plenty of food

(3) Snakes: The present-day limbless snakes with long slender neck were developed from the limbed ancestors. It is due to continued disuse of limbs and stretching of their body to suit their creeping mode of locomotion and fossorial mode of living

• Evidence in favour of the law of inheritance of acquired characters are-

(1) During vegetative propagation of plants and regeneration in animals somatic cells can produce the germ cells

(2) Sudden heritable variations or mutations were obtained by Auerbach et. Al on exposure of Drosophila to high energy radiations like UV – rays, X-ray, γ-ray and mustard gas etc.

• Lamarckism or theory of inheritance of acquired characters was discarded due to following reasons

(1) Blind, deaf and lame parents do not produce abnormal offspring

(2) Despite use of iron shoes to keep their feet short by Chinese women, their young ones at birth have normal feet size

4.1.01 Neo-Lamarckism

• These criticism lead to the foundation of Neo-Lamarckism

The postulates of Neo-Lamarckism are

(1) According to Neo-Lamarckism, there is a causal relationship between the structure, function and environment

(2) Some of the variations acquired by an individual can be transmitted to its offspring

(3) The role of internal vital forces in evolution has been discarded

(4) Only those variations are inherited, which are associated with the germ cells or where the somatic cells give rise to germ cells
(5) It has been realized now that the body character of organisms are related to result of the interaction of genes and the environmental conditions

4.2 Darwin's theory of natural selection or Darwinism

• Charles Darwin was born in 1809. In 1831, he accepted an unpaid post of naturalist on the survey ship, i.e. HMS Beagle, in which he spent five years in sea charting the East coast of South America
• Features of the theory of natural selection are
(1) Overproduction: Organisms have a very high reproductive potential and capacity , multiply in geometric ratio.
(2) Limitations of food and space: The resources of the earth are limited. Therefore, populations of different species cannot increase beyond a certain limit.
(3) Struggle for existence: A struggle or competition occurs amongst organisms to obtain the available resources. It is of three types-

(a) Intra-specific struggle: This is the acutest type of struggle, which occurs amongst individuals of the same species for similar basic necessities like food, shelter, breeding place, light, water etc
(b) Inter-specific struggle: the struggle occurs amongst individuals of different species for similar requirements like food, shelter
(c) Environmental struggle: The struggle is between organism and restricting environmental factors like carrying capacity,

drought, heavy rains, floods, famine, earthquake, volcano, lightning, meteorite, etc.

4.2.01 Variations

• They are small morphological and behaviouristic differences amongst the individuals. Variation can be continuous discontinuous, harmful.

• Darwin believed that continuous and useful variation constitute the raw material of evolution. Neutral and occasionally harmful variations may also prove helpful with the change of environment.

Natural selection and survival of the fittest:

In the struggle of existence, only those individuals survive which possess the most useful variations. This has been called natural selection by Darwin and survival of the fittest by Spencer

• This theory was criticized because

(1) Darwin did not explain the mechanism of origin of variations

(2) He did not know the mode of transmission of variations to the next generation.

(3) Continuous variation cannot go beyond the limit of species. Mutation is actually the source of evolution

(4) Darwinism does not explain the origin of variation, new characters

(5) It is unable to explain the persistence of degenerate organ and over-specialization (e.g. tusk of an elephant)

(6) There are certain organisms which have remained unchanged for the past several million years

4.2.02 Evidence in support of Darwinism

(1) Evident facts: High rate of reproduction, limitation of resources, an abundance of variation are quite evident

(2) Entomophily: Many pollinating insects have proboscis length exactly matching the position of nectary in flower. This may develop due to natural selection.

(3) Mimicry: It is the resemblance of an organism to another or a natural object so as to conceal itself for protection or some other advantage like catching of prey. E.g. praying mantis, stick insect

(4) Extinct forms: Extinction of past plants and animals can be explained only by the development of better organisms through natural selection

(5) Adaptations: Variations present in the population help the individuals in adapting themselves to changed environmental conditions. Adaptations produce new ecotypes from which new forms can develop

(6) Artificial selection : It is a selective breeding of plants and animals so as to obtain varieties with desired traits.

(a) Agriculture perhaps originated with a selection of nonbrittle ear in Triticum monococcum (Einkorn wheat) This was later replaced by naked and high yielding wheat

(b) Through artificial selection, wild cabbage has given rise to several vegetables like Kale, kohlrabi, cabbage, Cauliflower, Broccoli etc

(c) High milk yielding varieties of Buffalo have developed by monitoring of animals producing more milk and breeding them with bulls of high milk yielding lineage

4.2.03 Neo-Darwinism

- The theory of evolution as proposed by Darwin and Wallace has been modified in the light of modern evidence from genetics,

molecular biology, paleontology, ecology and is known as neo-Darwinism

- Neo-Darwinism distinguishes the germplasm and somatoplasm
- It explained that adaptations result from the multiple forces and natural selection is one of them
- As per Darwinism, characters are not inherited as such, instead there are character determiners which control the development.
- The characters are the result of genes of organisms and the environment during its development

4.3 De Vries mutation theory

- The term mutation was introduced by Hugo de Vries, a Dutch botanist who independently rediscovered Mendel's law of heredity
- Mutation theory was put forward by him in 1908
- Salient features of mutation theory are as follows

(a) Mutation acts as a raw material for evolution.

(b) Mutation is large heritable and subjected to natural selection

(c) Mutation is large heritable changes in contrast to small, a directional fluctuating variation of Darwin

(d) The mutation may occur in any direction and may be useful or harm

(e) Sometimes, new species are produced by a single mutation

4.3.01 De Vries mutation theory criticism

1) D.M. Davis claimed that the Oenothera lamarckiana (evening primrose) was a hybrid plant, which could be obtained by the hybridization of two wild species and is not a normal plant

2) Natural mutation are not the common phenomenon

3) Most of the mutation is recessive

4) Development of mimicry cannot be explained satisfactorily

5) Theory failed to explain the role of nature

5.0 Modern concept of evolution

- The present concept of evolution is a modified form of Darwin's and Hugo de Vries theories. This is also called the synthetic theory of evolution
- The main postulates of this theory are

(1) This theory recognizes four basic types of process. These are

(a) Migration of individuals from one population to another, hybridization between races or closely related species both increase the genetic variability

(b) Mutation, genetic recombination and natural selection are equally important

(c) The effect of the change, acting on the small population may alter the way in which natural selection guides the course of evolution.

(2) All sexually reproducing organisms contain a large gene pool of genetic variability, which maintain a dynamic equilibrium between inflow and outflow of genes

(3) Genes may be added to the gene pool by immigration from other gene pool and mutation.

(4) Genes are removed from the gene pool by natural selection and chance elimination of alleles, which take place in small population or during reduction of population size

(5) Genetic recombination following the principles of Mendelian heredity is constantly reshuffling the genes in the gene pool.

(6) Natural selection, which results from the interaction between populations and their environment, may either stabilize gene composition by eliminating most immigrants and mutants or change in a various way

(7) Evolution takes place through alternations of the frequency of genes and gene combination in the population brought about by natural selection

(8) Reproductive isolation, includes all the barriers to gene exchange between the populations has a canalizing effect

(9) The populations that are reproductively isolated from each other are almost certain to evolve in different directions while those that are not so isolated because of gene exchange will evolve in the same direction

6.0 Mechanism of evolution

6.1 Hardy – Weinberg Law

• Hardy-Weinberg Law was proposed in 1908 by the independent contributions of two scientists, Hardy (England) and Weinberg (Germany)

• Gene Pool

Gene pool is defined as "the sum total of genes present in a population "or "A gene pool comprises a diverse form of a gene combination and recombination by the process of sexual reproduction."

• Gene frequency

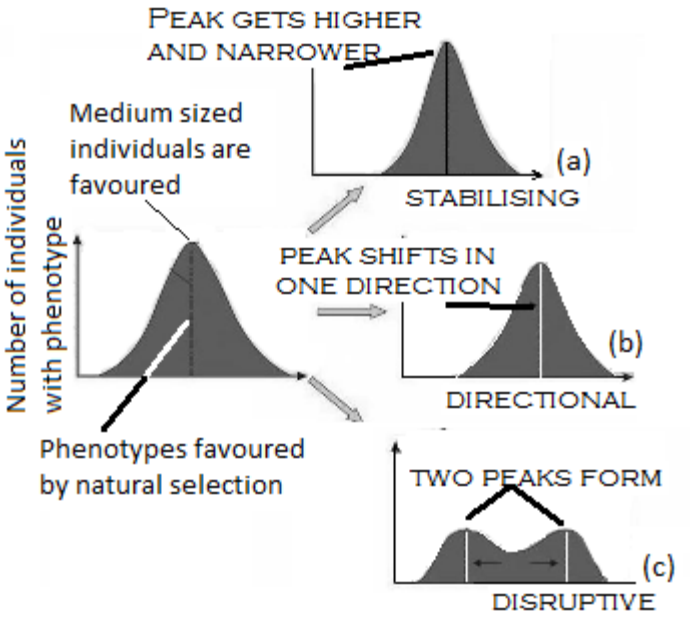
The ratio of the gene in a gene pool or in a population is called gene frequency

When the gene frequency of another allele in the population can be calculated by applying a simple formula. If the gene frequency of A – allele is p and a-allele is q, the p+q =1

The frequency of AA individual in the population is p^2, of aa is q^2 , of Aa is 2pq. Hence p^2+q^2 +2pq = 1

6.2 Significance

- This law states that the gene frequencies in the large population remain constant generation after generation where there is no selection and mutation. In a small population, this equilibrium cannot be maintained
- When the population is large and in equilibrium rate of evolution is zero as there is no possibility of evolutionary change



• Gene flow

Animals are not static. They have a tendency to migrate and mate with an inmate of the population. Thus the genes of one population are transferred to another population. This is called gene flow and are an important source of genetic variation

• Genetic drift

Genetic drift is an evolutionary force operating in a small population The change in the frequency of gene purely by chance is called genetic drift

7 Human evolutionary trends

The gradual evolution of man from ape is fully supported by available fossils

1. Propliopithecus: It was an ape-like a primate, but in the possession of short arms, it resembled a man. It lived, about 30 million years ago
2. Aegyptopithecus: It is similar to propliopithecus. It is believed that it was ancestral of Dryopithecus
3. Dryopithecus: It is a group of apes that lived about 20 million years ago. Their forelimbs were shorter than hindlimbs. It is also an ancestor of modern apes like Chimpanzee and Gorilla
4. Oreopithecus : In the structure of teeth and erect walking, it resembles a man, but having long forelimbs, it resembles apes. Straus and Simpson suggest that man and oreopithecus have parallel evolution and hence are not ancestral to man.
5. Ramapithecus: It lived 12 to 12 million years ago. The dentition is more identical to the dentition of man and their fossil was collected from Africa and India
6. Kenyapithecus: It is closely related to Ramapithecus. Its fossil is collected from East Africa.
7. Australopithecus: It is connecting link ape and man. It lived 2 to 5 million years ago. The characters of Australopithecus like man and ape are as below

- A man like characters: Erect posture, bipedal locomotion and dentition is like that of man

- Ape-like characters: Teeth were larger than modern man, the absence of chin, eyebrow ridges projected over the eyes

8. Homo habilis : It is first human being like, It is an erect ape-man,chin absent, dental formula same as human,jaw 'U' shaped, cranial capacity -650-800cc. the first man who made tools of stone for protection

9. Homo erectus: It is an erect ape man. They are commonly called Java man because their fossils were collected from Java. They lived about 5,00,000 years ago. The main characters of Homo erectus are

- They have upright bipedal locomotion
- They were slightly taller than Australopithecus.
- The face is chinless
- They used fire and variety of tools
- cranial capacity -800-1000cc

10. Peking man: Complete erect posture, Lived in caves, cranial capacity -850-1300cc, jaws prognathous, used fire for protection and cooking, Omnivorous, use sharp tools of stones and bones for cutting and killing animals

11. Homo sapiens

(1) Neanderthal man: They existed about 75,000 years ago. The main character is

- Their eyebrow ridges were heavy and protruding
- Their teeth were large
- They had no chin
- Their cranial capacity was about 1400 cc

(2) Rhodesian man: The fossils were collected from Rhodesia. The cranial capacity was about 1300 cc

(3) Cro-magnon man: These were the men who lived in Europe during the last 30,000 years. They possessed all characteristics of modern man

(4) Modern man: They were originated 8000 years ago. The cranial capacity of modern man is 1450cc

The main human races are:

(a) Caucasoid race
(b) Negroid race
(c) Mongoloid race
(d) American race
(e) Australian race
(f) Indian race

8 Different types of evolution

a) Parallel evolution

An evolutionary process by which two or more separate species in the same environment develop similar adaptation or characteristic for survival.

Parallel evolution is similar to convergent evolution in a way that two unrelated species evolved similar traits. However, in parallel evolution, the two species evolved same traits while living in the same type of environment whereas in convergent evolution the two species evolved same traits in different types of environment.

Examples

1. North American cactus and the African euphorbia that developed similar adaptation, which is their thick stems and sharp quills to survive the hot, arid climates.

2. Internal fertilization has evolved independently in sharks, some amphibians and amniotes.

3. two groups of organisms living in similar habitats such as a marsupial mammals distinctive characteristic of these species are that most of the young are carried in a pouch in Australia and placental mammals on another continent.
4. Colouration that serves as a warning to predators and for mating displays has evolved in many different species.
5.The eye of the octopus has the same complicated structure as the human eye.

b) Divergent evolution (Homologous organs)

Also called as Adaptive Radiation

The process by which an interbreeding population or species diverges into two or more descendant species, resulting in different species developing new characteristics to enable them to survive to their new habitats.

Homologous organs are examples of divergent evolution similar structures but dissimilar function is in the state of homology and such structures are referred to as homologous structures. Examples The arm of a human, the wing of a bird. The leg of a dog and the flipper of a dolphin or whale are homologous structures.

c) Convergent evolution (Analogous organs)

A kind of evolution wherein organisms evolve structures that have similar (analogous) structures or functions in spite of their evolutionary ancestors being very dissimilar or unrelated.

convergent evolution is the process whereby organisms not closely related (not monophyletic), independently evolve similar traits as a result of having to adapt to similar environments or ecological niches

example of convergent evolution is the similar nature of the flight/wings of insects, birds, pterosaurs, and bats. All four serve

the same function and are similar in structure, but each evolved independently.

d) Retrogressive evolution

This is the process in which complex forms of organisms develop towards the simpler structural and physiological organizations.

For eg - Monocot plants are considered as more advanced groups of plants with a simple structure and herbaceous habit.

Several species of cave-dwelling animals, including fish, crabs, and salamanders, have evolved blindness and deteriorated eye structure.

e) Progressive Evolution : This is the type of evolution in which simple forms of organisms develops towards the complex forms and physiological organizations. For eg - evolution of multicellular organisms from unicellular organisms.

9. Speciation

Speciation is a process of evolution that leads to the formation of new, distinct species that are reproductively isolated from one another.

a) Allopatric speciation

When a species split into two group or more geographically isolated population, natural selection to cause genetic drift as mutations arise within populations. Over time, the separate populations may develop morphologically distinct features due to adaption to their new environment. It is a divergent speciation

Examples are Finches of Darwin

b) Sympatric Speciation

Sympatric speciation is the evolutionary process whereby species are formed from a single ancestral species while inhabiting the same geographic area or without geographical isolation. sympatry occurs when members of one population make use of a new niche. Mainly present in plants due to polyploidy. It is a divergent speciation

c) Phyletic evolution

a type of evolution characterized by the gradual change, without divergence, of an entire group of organisms. Phyletic evolution is usually characterized by moderate or low evolution rates and is detected when one studies the evolution of The evolution of the horse over 50 million years of its evolution

Eohippus → Orohippus→ Mesohippus → Miohippus→ Merychippus→ Hipparion→ Pliohippus→ Dinohippus→ Equus

d) Quantum evolution

the comparatively rapid transition from one stable type of biological adaptation to another distinctly different type under the influence of some strong selection pressure. It is caused by a major mutation

10. Isolations

The field of biology describes "isolation" as a process by which two species that could otherwise produce hybrid offspring are prevented from doing so. There are five isolation processes that prevent two species from interbreeding: ecological, temporal, behavioral, mechanical/chemical and geographical.

a) Ecological Isolation

Ecological isolation occurs when two species live in different habitats and will not encounter one another, each is isolated from the other species. For example line and tiger

b) Temporal Isolation

Temporal isolation is when species that could interbreed do not because the different species breed at different times.. For example, the field crickets Gryllus pennsylvanicus and Gveleti becomes sexually mature at different seasons, one in the spring and the other in the autumn.

c) Behavioral Isolation

Behavioral isolation refers to the fact that many species perform different mating rituals. This is a common barrier between animals. For example, certain species of crickets will only mate with males that produce a particular mating song. Other species of rituals may include a mating dance or emitting a scent. These clues are ignored by species not accustomed to the ritual.

d) Mechanical or Chemical Isolation

Mechanical isolation is caused by structures or chemical barriers that keep species isolated from one another. These chemical barriers will only allow sperm from the correct species to fertilize the egg.

e) Geographical Isolation

Geographical isolation refers to the physical barriers that exist that keep two species from mating. For example, a species of monkey that is located on an island cannot breed with another species of monkey on the mainland. The water and distance between the two species keep them isolated from one another and make it impossible for them to breed.

11. A brief account of the evolution

It is believed that first life form came into existence on earth around 2000 million years ago (mya). The vast expanse of geological time has been separated into eras

The vast expanse of geological time has been separated into eras,

Era	Plant and Animal Development
Cenozoic 66 million years ago	Extinction of dinosaurs and many other species. → "Age of mammals" → Humans develop
Mesozoic 252 to 66 million years ago	"Age of Reptiles" First flowering plants , First birds, Dinosaurs dominant
Paleozoic 541 to 251.902 million years ago	"Age of Amphibians", Extinction of trilobites and many other marine animals, First reptiles, Large coal swamps Large Amphibians abundant
	"Age of Fishes" First insect fossils , Fishes dominant ,First land plants
	"Age of Invertebrates" First fishes, Trilobites dominant, First organisms with shells
Precambrian 4,600 million years ago	Origin of Earth , First one-celled organisms , First multicelled organisms

12. Distinguish

i) Difference between convergent and divergent evolution

Convergent evolution	divergent evolution
Different ancestor species are genetically different	Common ancestor, shares genetic homology
Convergent evolution is a process by which distantly related species develop similar structures as adaptations to the environment	Divergent evolution is a process by which an interbreeding species diverges into two or more descendant species.
Both species live in the same environment.	The divergence of two different species results in two species becoming less like the common ancestor.
developing analogous structures.	developing homologous structures.
Ostriches, rheas, and emus are examples of convergent evolution. Wings of insects birds and bats	Dinosaurs, Darwin's finches, and forelimb structures of vertebrates are examples of divergent evolution.

ii) Difference between Adaptive radiation and divergent evolution

Adaptive radiation	divergent evolution
adaptive radiation is a process in which organisms diversify rapidly from an	The process by which an interbreeding population or species diverges into two or

ancestral species into a multitude of new forms,	more descendant species, resulting in once similar or related species to become more and more dissimilar
Adaptive radiation is a type of microevolution.	Divergent evolution is a type of macroevolution.
The outcome of the adaptive radiation is different morphological, physiological and ecological changes in a particular population.	A new generation of species is formed which are unable to interbreed with the original species.
Examples of adaptive radiation include Darwin's finches and Australian marsupials.	Penta-dactyl limb structure of mammals is an example of divergent evolution.

iii) Difference between Darwinism and Lamarckism

Darwinism	Lamarckism
It does not believe in the internal vital force	This theory states that there is an internal vital force in all organisms.
They do not form part of Darwin's natural selection theory.	It considers new needs or desire produce new structures and change habits of the organism

An organ can develop further or degenerate only due to continuous variations.	According to this theory if an organ is constantly used it would be better developed whereas disuse of organ results in its degeneration.
Struggle for existence is very important in this theory	It does not consider struggle for existence.
Only useful variations are transferred to the next generation	All the acquired characters are inherited to the next generation.
Darwin's natural selection theory is based on survival of the fittest.	Lamarckism does not believe in survival of the fittest.

iv) Difference between Humans and Apes

Humans	Apes
Walks fully erect after infancy on the soles of the feet.	Walks semi-erect on outer edges of feet and knuckles of hands.
Head erect and balanced on the neck	Head balanced on heavy shoulders and is buried
Cranium rounded with a cranial capacity of about 1450cm3	Cranium flattened with a cranial capacity under 650cm3
Jaw small with a prominent chin	Jaw strong without well-marked chin.
Anterior premolar in the	Anterior premolar in the

lower jaw is small and bicuspid.	lower jaw is strong and pointed.
Canines are not projecting	Canines are projecting.
Body covered with short and sparse hair.	Body covered with long and coarse hair.

That's all folks

सर्वे भवन्तु सुखिनः सर्वे सन्तु निरामयाः । सर्वे भद्राणि पश्यन्तु मा कश्चिदद्दुःखभाग्भवेत् ॥

All should/must be happy, be healthy, see good; may no one have a share of sorrow.