CHAPTER

07

Evolution

Evolution

Evolution refers to the slow and steady process of transformation from basic life forms to more complex ones. This process has been ongoing for millions of years and has led to the creation of new species that exist today.

Origin of Life

Approximately 4.6 billion years ago, our planet Earth was formed, and it took another 4 billion years for life to emerge on its surface. According to the ***Big-Bang theory,*** proposed by Abbe Lemaitre in 1931, the universe was created through a massive explosion, which ultimately led to the formation of our planet.

Ancient Theories of Origin of life

There are various ancient theories about the origin of life, including:

Special Creation: This theory states that life was created by God.

Cosmozoic Theory: This theory suggests that life originated from spores or panspermia that came from outer space.

Spontaneous Generation Theory: This theory proposes that life originated spontaneously from abiotic substances. It is also known as the theory of abiogenesis or autobiogenesis.

However, Louis Pasteur disproved the theory of spontaneous generation by conducting the ***swan-neck flask experiment***. He showed that life **arises** only from **pre-existing life.**

Theory of Chemical Evolution: This theory was proposed by Oparin and Haldane. They believed that the first form of life came from non-living organic molecules such as **RNA** and **protein**, which existed before the emergence of life.

Miller's Experiment

The Miller-Urey experiment, regarded as evidence of chemical evolution, was conducted by Stanley Miller under the supervision of Harold Urey in 1953. The experiment involved collecting a mixture of water vapour, hydrogen, methane, and ammonia (in a 2:2:1 ratio) in a flask, and then introducing an electric discharge through a tungsten electrode.

The results of the experiment demonstrated the formation of amino acids such as **glycine and alanine.** This simple experiment established that various forms of carbon, hydrogen, oxygen, and nitrogen could give rise to complex compounds.

Evidences for Evolution

Evolution is the process by which living organisms change over time. This idea is supported by a wealth of scientific evidence from various fields of study. Here are some of the most compelling evidences for evolution:

A. Paleontological evidences:

Palaeontology is the study of ***fossils***, which are the remains or impressions of past organisms that are preserved in *sedimentary rocks*. Fossil records provide valuable information about the organisms that lived on Earth millions of years ago. By examining these fossils, scientists can learn about the ***anatomy***, ***behaviour***, and ***evolution of ancient species***.

(i) ***Fossil records/inscriptions***: Fossilization is the process by which the hard parts of ancient plants and animals are preserved in rocks and mountains. Fossil records are the remains or impressions of these organisms that are found in sedimentary rocks. These records provide evidence of the existence and evolution of various species over millions of years.

(ii) **Age determination of fossils**: Fossils can be dated using various methods such as uranium-lead dating and radioactive carbon dating. By determining the age of a fossil, scientists can learn about the time period during which the organism lived and how it evolved over time.

B. Comparative anatomy and morphological evidences:

Comparative anatomy is the study of ***similarities*** and ***differences*** among the organisms of today and those that existed many years ago. This can be achieved by studying the following:

(i) ***Homologous organs***: Homologous organs are those that have the ***same structural design*** and ***origin but different functions***. For example, the *forelimbs of whales, bats, and cheetahs* have the same basic structure despite being used for different purposes. Similarly, the mouth parts of various insects have the same basic structure despite being used for different functions.

(ii) ***Analogous organs***: Analogous organs are those that are ***anatomically different but functionally similar.*** For example, *the wings of birds and butterflies have different structures* but serve the same purpose of flying. This is because they evolved through ***convergent evolution***, where unrelated organisms evolve similar traits to adapt to similar environments.

• **Divergent Evolution** is a process in which different functional structures develop from a ***common ancestral stock (known as homology)*** to adapt to varying environmental conditions.

• **Convergent Evolution**, on the other hand, is the development of ***similar morphological characters (known as analogy***) in organisms of different lineages at the same geographical region.

C**. According to molecular evidence**: similarities in the proteins and genes that perform the same function in different organisms suggest a common ancestry.

D. Embryological evidence shows that some organisms share common descent in their embryonic patterns. This was first observed by **von Baer** and later reinterpreted by **Haeckel** as the **biogenetic law or recapitulation**, which states that "**ontogeny repeats phylogeny.**"

E. Biogeographical evidence suggests that species restricted to a particular region develop unique features. Additionally, species present in separate regions exhibit similarities in their ancestry. This can be explained by the process of adaptive radiation, in which an ancestral species gives rise to new species adapted to different habitats and ways of life. Examples include **Darwin's finches, Australian marsupials, and placental animals in Australia.**

Biological Evolution

Biological evolution is the process by which the first living cell emerged from non-living chemical compounds. Scientists have proposed various theories to explain the mechanisms of evolution.

One such theory is **Lamarckism**, also known as the theory of inheritance of acquired characteristics, which was introduced by Lamarck in his book "Philosophie Zoologique" in 1809. This theory suggests that an organism acquires traits during its lifetime from its environment, and these acquired traits are gradually inherited by its offspring, leading to the formation of a new species. For instance, an organ that is used more will increase in size, while an organ that is not used will degenerate. However, this theory was heavily criticized.

Another theory related to Lamarckism is **modern Lamarckism**, which was proposed by August Weismann in 1892. Weismann used genetics and theories of inheritance to demonstrate that acquired traits present in an individual's genotype can be transmitted to the next generation through inheritance. This theory is known as the theory of continuity of germplasm.

Darwinism, or the **theory of natural selection**, is another important theory of evolution. Darwin proposed that an individual's fitness is determined by its ability to reproduce, and those organisms that are better adapted to their environment will have a greater chance of survival. This process is called **natural selectio**n. Darwin also suggested that different species descended from a common ancestor and became adapted to different environments. This process is known as **branching descent**. ***Natural selection*** and ***branching descent*** are two fundamental concepts of Darwinism.

Darwin and **Alfred Wallace** jointly proposed the **'Theory of Natural Selection'** in 1858, which was based on several factual observations. These observations included limited natural resources, stable population (except for seasonal fluctuations), variations in sexually reproductive animals, and reproductive isolation.

An example of evolution through natural selection **(industrial melanism)**was observed in peppered moths in **England** in 1859. Before industrialization, white-winged moths were more abundant than dark-winged moths. However, after industrialization, the dark-winged moths increased in number because they were better adapted to camouflage themselves from predators on the darker tree trunks caused by air pollution (soot and dust particles). The white-winged moth population declined due to easy detection by predators. Therefore, better adaptable species are selected by nature to grow while others are eliminated in a mixed population.

The excessive use of chemicals can lead to the development of resistance in microbes to such chemicals, which is another example of natural selection. These microbes are selected naturally due to favourable variation.

Hugo de Vries studied and carried out experiments on the evening primrose plant **(Oenothera lamarckiana)** and proposed the mutation theory of evolution based on his observations. He suggested that evolution can also occur due to sudden, large changes in a population, which he called **saltation** (single-step large mutation).

The **modern synthetic theory of evolution** is a form of modern Darwinism that suggests the origin of species is based on the interaction of genetic variation in a population, natural selection, and reproductive isolation.

Hardy-Weinberg principle

The Hardy-Weinberg principle is a fundamental concept in population genetics, which states that the frequency of alleles in a population remains constant over time, assuming certain conditions are met. This concept is also known as **genetic equilibrium**. In other words, if a population is not subject to any external forces such as natural selection, mutation, migration, or genetic drift, the proportions of alleles in the **gene pool will remain stable and predictable**.

The Hardy-Weinberg principle can be expressed mathematically as $\mathbf{p^2 + 2pq + q^2 = 1}$, where p and q represent the frequencies of two alleles in a population. The square of p represents the frequency of homozygous dominant individuals, q^2 represents the frequency of homozygous recessive individuals, and 2pq represents the frequency of heterozygous individuals.

This principle assumes that the population is l**arge, random mating occurs, there is no migration or emigration, no mutation takes place, and there is no natural selection**. While these conditions are rarely met in real-world populations, the Hardy-Weinberg principle provides a useful baseline for understanding how genetic traits are passed down from generation to generation. It also serves as a valuable tool for population geneticists to detect deviations from genetic equilibrium and investigate the underlying causes.

Agents of evolutionary change

Evolutionary change refers to the gradual process by which species or populations of organisms change over time in response to their environment. The agents of evolutionary change are the factors or mechanisms that cause changes in the genetic makeup of populations. Some of the most important agents of evolutionary change include:

Mutation: Mutation is a random change in the genetic material of an organism. Mutations can occur spontaneously or as a result of exposure to environmental factors such as radiation or chemicals. Mutations are the ultimate source of genetic variation within populations.

Gene flow: Gene flow is the movement of genes between different populations of the same species. This can occur through migration of individuals from one population to another or through the exchange of gametes (sex cells) between populations.

Genetic drift: Genetic drift is the random fluctuations in gene frequencies that occur in small populations due to chance events. Genetic drift can have a significant impact on the genetic makeup of small populations and can lead to the loss of genetic diversity over time.

Natural selection: Natural selection is the process by which certain traits become more or less common in a population over time due to differential survival and reproduction. Traits that enhance an organism's ability to survive and reproduce in a particular environment are more likely to be passed on to future generations.

Sexual selection: Sexual selection is a type of natural selection that operates on traits that affect an organism's ability to attract mates. Traits that are favored by sexual selection may not necessarily enhance survival but can still have a significant impact on the genetic makeup of populations over time.

Account of evolution

These agents of evolutionary change can act individually or in combination to shape the genetic makeup of populations over time, leading to the emergence of new species and the extinction of others.

The story of life on Earth has been shaped by millions of years of evolution. Here's a brief account of how plants and animals evolved over time.

A. Evolution of Plants:

Plants were the first living organisms to colonize land, appearing around 2000 million years ago. The evolution of plants can be traced through different stages:

Bryophytes were the first plants to grow on land, followed by vascular plants.

Vascular plants, including pteridophytes and gymnosperms, originated during the **Silurian period.** ***Herbaceous*** and ***arborescent lycopods*** evolved from Zosterophyllum during the **Palaeozoic era.**

Psilophyton is the common ancestor for horsetails, ferns, and gymnosperms.

B. Evolution of Animals:

Animals first appeared around 500 million years ago, and the first animals were invertebrates. Over time, animals evolved into various forms:

Jawless fish and ***amphibious fish*** with ***stout and strong fins*** were found on Earth around 350 million years ago.

The ***Jurassic period***, around 200 million years ago, is known as the age of ***reptiles***.

Mammals appeared during the ***Triassic period***, and the first mammals were similar to shrews.

The evolution of life on Earth is an ongoing process, and these milestones are just a small part of the story.

Human evolution

Fossil evidence suggests that the origins of humans can be traced back to Central Asia, China, Java, and India, specifically the Shivalik hills.

The evolution of humans took place through several stages, with each stage characterized by different physical and behavioral traits.

Here is a brief summary of some of the major human ancestors, along with their time of origin and general features:

Dryopithecus: Lived 20-25 million years ago. This ape-like creature was hairy, ate soft fruits and leaves, and had arms and legs of the same length. They also had a large brain.

Ramapithecus: Lived 14-15 million years ago. More man-like than Dryopithecus, Ramapithecus walked more upright and had teeth similar to those of modern humans.

Australopithecus: Lived 3-4 million years ago. They probably lived in East African grasslands, ate fruits, and hunted with stones and weapons. Their brain capacity was 400-600cc.

Homo habilis: Lived 2 million years ago. This was the first hominid, or human-like creature. They had a brain capacity of 650-800cc and did not eat meat. Fossils of Homo habilis were found in East Africa.

Homo erectus: Lived 1.5 million years ago. Fossils of Homo erectus were found in Java in 1891. They had a brain capacity of 900cc and probably ate meat.

Homo sapiens neanderthalensis (Neanderthal man): Lived 100,000-40,000 years ago. Fossils of this species have been found in East and Central Asia. They had a brain size of 1400cc and used hides to protect their bodies. They also buried their dead, and became extinct around 25,000 years ago.

Evolution

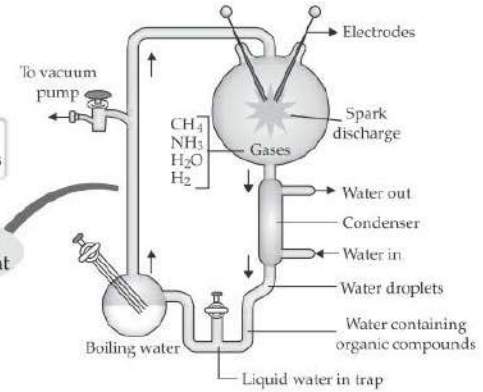
Origin of Life

- The universe originated about 20 billion years ago.
- The earth was formed about 4.5 billion years ago.

Theories

- Modern synthetic theory
  - Changes occurring in the allele frequencies within the population
- Cosmic theory/Panspermia
  - The units of life (spores) were transferred to earth.
- Biogenesis
  - Life originates from pre-existing life.
- Special creation theory
  - Living and non–living things were created by God.
- Spontaneous generation (Abiogenesis)
  - Life came out of decaying and rotting matter
- Chemical evolution theory
  - Life originated from non-living inorganic & organic molecules

Origin of Life-Urey and Miller's Experiment



Human Evolution

Human ancestors	Origin period
Dryopithecus	20-25 mya
Ramapithecus	14-15 mya
Australopithecus	3-4 mya
Homo habilis	2 mya
Homo erectus (Java man)	1.5 mya
Homo sapiens neanderthalensis (primitive man)	1,00,000-40,000 years ago
Homo sapiens sapiens (modern man)	75,000-10,000 years ago

Evidences

Palaeontological Evidence

- By study of fossils
- Fossils help to study phylogeny, connecting link and about extinct animals.

Morphological & Anatomical

Homologous Organs

- Human hand, Whale's flippers, Bat's wing, and Cheetah's foot.
- Thorns of *Bougainvillea* and tendrils of *Cucurbita*.

Analogous Organs

- Wings of insects and wings of birds.
- Eyes of Octopus and mammals
- Flipper of Penguins and Dolphins.
- Sweet potato (modified root) and Potato (modified stem).

Bio-Geographical

Adaptive Radiation

Darwin Finches

Marsupial Radiation

Placental Mammals

e.g., Placental wolf and Tasmanian wolf-marsupial.

Bio-Chemical

Similarities in proteins and genes.

Embryological

Similarities in embryo development.

Natural Selection

- Dark-coloured peppered moth *Biston betularia*, (var. *carbonaria*) preferred over the white moth.
- By anthropogenic action

Theory of Biological Evidences

Darwinism

- Natural Selection
- Heritable minor variations.
- Over production by organisms.
- Limited natural resources.
- Struggle for existence.
- Survival of the fittest.

Theory of Mutation

- Proposed by Hugo de Vries
- Single step large mutation.
- Mutation caused speciation

Hardy Weinberg

Factors affecting

- Gene Migration
- Genetic drift
- Mutation
- Genetic recombination
- Natural Selection

Trace the Mind Map

First Level · Second Level · Third Level

Practice Questions

1.Which of the following provide evidence for evolution of life forms on earth?

(a) Fossil studies (paleontological evidences)

(b) Morphological and comparative anatomical studies

c) Biochemical studies

(d) All of the above

2.Fossils are useful in studying which of the following?

(a) Extinct organisms

(b) History of organisms

(c) Both (a) and (b)

(d) None of the above

3.Which embryological evidence supports evolution, as given by Ernst Haeckel?

(a) Presence of hair all over the body in adult human

(b) Absence of tail bone and presence of wisdom tooth

c) Absence of vestigial gill slits in human's embryo

(d) Presence of a row of vestigial gill slits in the embryo of all vertebrates

4.What does the presence of homologous organs in different animals indicate?

(a) Different ancestry

(b) Common ancestry

(c) Independent development

(d) Dependent development

5.Which of the following is an example of analogous organs?

(a) Tendrils of Cucurbita

(b) Thorns of Bougainvillea

c) Wings of birds and insects

(d) None of the above

6.What is the term used to describe the development of different functional structures from a common ancestral form?

(a) Differential evolution
(b) Adaptive radiation
(c) Non-adaptive radiation
(d) Regressive evolution

7.The evolution of different types of finches in the Galapagos Islands is a result of which process?

(a) Adaptive radiation
(b) Geographic similarity
(c) Geographic dissimilarity
(d) Adaptive convergence

8.What evidence does the diversity of finches and their adaptation to different feeding habits in the Galapagos Islands provide according to Darwin?

(a) Origin of species by natural selection
(b) Intraspecific variation
(c) Intraspecific competition
(d) Interspecific competition

9.What type of radiation is exemplified by Australian marsupials?

(a) Homologous radiation
(b) Analogous radiation
(c) Adaptive radiation
(d) Convergent radiation

10.Which of the following is not an example of adaptive radiation?

(a) Wombat, numbat, flying phalanger
(b) Darwin's finches
(c) Different mammals in other parts of the world
(d) Lemur and spotted cuscus

11.The concept of survival of the fittest is made possible by which of the following factors?

(a) Overproduction
(b) Favorable variations
© Environmental changes
(d) Inheritance of acquired characters

12.How can Darwinian fitness be estimated?

(a) By the length of time individuals survive in a population

(b) By the number of offspring produced by different individuals in a population

c) By the size of an individual in a population

(d) By the species' ability to recover after mass extinction

13.What are the two key concepts of Darwin's theory of evolution?

(a) Genetic drift and mutation (b) Adaptive radiation and homology

(c) Mutation and natural selection (d) Branching descent and natural selection

14.Which of the following situations is most likely to result in the highest rate of natural selection?

(a) Reproduction by asexual method (b) Low mutation rate in a stable environment

(c) Little competition (d) Reproduction by sexual method

15.Which of the following factors was not taken into account by Darwin in his theory of natural selection?

(a) Struggle for existence (b) Discontinuous variations

(c) Parasites and predators as natural enemies (d) Survival of the fittest

16.What was Lamarck's explanation for long-necked giraffes?

(a) Stretching of necks over many generations

(b) A short neck suddenly changed into a long one

(c) Natural selection

(d) Mutation

17.Hugo de Vries proposed his idea of mutation based on his work with which of the following plants?

(a) Pea plant (b) Drosophila (c) Evening primrose (d) Maize plant

18.Genetic equilibrium refers to which of the following phenomena?

(a) The trait remains constant in a population

(b) The total genes remain constant in a population

(c) The total genes keep varying in a population

(d) Traits keep varying in a population

19. Which of the following is not an example of adaptive Radiation?

(a) Wombat, numbat, flying phalanger

(b) Darwin's finches

(c) Different mammals in other parts of world

(d) Lemur and spotted cuscus

20. Survival of the fittest is possible due to the

(a) overproduction

(b) favorable variations

(c) environmental changes

(d) inheritance of acquired characters

21. Darwinian fitness can be estimated by

(a) how long different individual in a population survive

(b) number of offspring produced by different individuals in population

(c) individual have a large size in population

(d) species recover after mass extinction

22. Which of the following are the two key concepts of Darwinian theory of evolution?

(a) Genetic drift and mutation

(b) Adaptive radiation and homology

(c) Mutation and natural selection

(d) Branching descent and natural selection

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By Darwin in his theory of natural selection?

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25. What was the Lamarck's explanation for long necked

Giraffes?

(a) Stretching of necks over many generations

(b) Short neck suddenly changed into long one

(c) Natural selection

(d) Mutation

26. Hugo de Vries put forth his idea of mutation by his work on

(a) pea plant (b) Drosophila (c) evening primrose (d) maize plant

27.When comparing Homo sapiens to Homo erectus, what is the main difference between the two?

(a) The origin of Homo sapiens and Homo erectus

(b) The size difference between Homo sapiens and Homo erectus

c) The location where Homo erectus settled compared to Homo sapiens

(d) The difference in brain size between Homo sapiens and Homo erectus

28.What is the chronological order of human evolution from the earliest to the most recent stages?

(a) Ramapithecus Australopithecus ® Homo habilis ® Homo erectus

(b) Australopithecus ® Ramapithecus ® Homo habilis ® Homo erectus

c) Pithecanthropus pekinensis ® Homo habilis ® Homo erectus

(d) Australopithecus ® Ramapithecus ® Pithecanthropus pekinensis ® Homo erectus

29.Which of the following statements best describes the difference between natural selection and sexual selection?

a) Sexual selection occurs during sexual intercourse.

b) Natural selection is a type of sexual selection.

c) Sexual selection is a type of natural selection.

d) Sexual selection occurs within demes.

30.What is indicated by homologous organs?

a) Different ancestry.

b) Common ancestry.

c) Independent development.

d) Dependent development.

31.Which of the following best describes the similarity in proteins found in the blood of man and ape?

a) Cellular homology.

b) Molecular homology.

c) Cellular analogy.

d) Molecular analogy.

32.According to the Neo-Darwinian theory, what is responsible for the origin of new species?

a) Mutations.

b) Useful variations.

c) Mutation together with natural selection.

d) Hybridization.

33.Who proposed the theory of "Continuity of germplasm"?

a) Hugo de Vries. b) Weismann. c) Darwin. d) Lamarck.

34.Which of the following pairs is incorrect?

a) Oparin – Probiont.
b) Spallanzani – Approve abiogenesis.
c) Haldane – Hot dilute soup.
d) Fox – Coacervates.

35.Which of the following best describes what divergent evolution gives rise to?

a) Homologous organs.
b) Analogous organs.
c) Both homologous and analogous organs.
d) None of these.

36.What is the most significant evolutionary change that enabled land vertebrates to be completely free from the water?

a) Four legs.
b) Four-chambered heart.
c) Lungs.
d) Shelled eggs and internal fertilization.

37.Which of the following is not an example of adaptive radiation?

a) Wombat, marsupial rat, flying phalanges.
b) Darwin's finches.
c) Different placental mammals in Australia.
d) Placental wolf and Tasmanian wolf.

38.What are Pasteur and Koch known for?

a) Discovery of nucleic acids (DNA and RNA).
b) Discovery of ultracentrifuge.
c) Germ theory of disease.
d) Gene splicing.

39. Maximum cranial capacity is of

a) Neanderthal man b) Cro –magnon man c) Modern man d) Java man

40. In pleistocene epoch, the ancestor of horse is

a) Eohippus b) Mesohippus c) Merychippus d) Equus

41. Which group is evolutionary modern?

a)Gymnosperms b)Grasses c) Pteridophytes d) Algae

42. The Mesozoic era is also called as the golden age of the

a) Amphibians b) Reptiles c) Mammals d) birds

43. In human beings, vestigial organs are

a) Wisdom teeth, coccyx, vermiform appendix, nail eyelid

b) Wisdom teeth, coccyx, vermiform appendix, pancreas, elbow joint

c) Wisdom teeth, coccyx, vermiform appendix, nictitating membrane, auricular muscles

d) Coccyx, wisdom teeth, nail, auricular muscles

44. Which one of the following is the most primitive ancestor of man?

a) Homo habilis b) Australopithecus

c) Ramapithecus punjabicus d) Homo neanderthalensis

45. First land plants (pinophyte) were originated in

a) Ordovician period b) Cambrian period c) Silurian period d) Cretaceous period

46. Earliest fossil ape prior to the ape man was

a) Ramapithecus b) Dryopithecus c) Australopithecus d) Homo erectus

47. Arrange the following events of modern concept of evolution sequentially

I. Genetic variations in population

II. Natural selection

III. Heredity

IV. Isolation

V. Speciation

The correct option is

a) I, II, III, IV, V b) I, III, II, IV, V

c) I, IV, III, II, V d) I, IV, II, III, V

48. Organic evolution is also called

a) Chemical evolution
b) Stellar evolution
c) Biological evolution
d) All of these

49. In equation, $p^2+2pq+q^2=1$

Where,

I. P^2= Homozygous dominant genotype
II. Q^2= Heterozygous dominant genotype
III. 2pq= Heterozygous genotype

Identify which entity (p^2,q^2 and 2pq) is not described correctly?

a) Only I
b) I and III
c) I and II
d) Only II

50. The present concept of evolution is known as

a) Neo-Darwinism theory of evolution
b) Synthetic theory of evolution
c) Modern concept theory of evolution
d) All of the above

Answers

1.(d) All of the above: Fossil studies provide physical evidence of the existence of life forms that lived millions of years ago and their gradual changes over time. Morphological and comparative anatomical studies reveal similarities and differences in the structure and function of organisms, indicating evolutionary relationships. Biochemical studies, such as DNA sequencing, provide molecular evidence of the relatedness of different species.

2.(c) Both (a) and (b): Fossils provide a record of the history of life on Earth, including the evolution of different groups of organisms, and the appearance and disappearance of species. Fossils also provide evidence for the distribution of organisms in different regions and their interactions with the environment.

3.(d) Presence of a row of vestigial gill slits in the embryo of all vertebrates: Ernst Haeckel proposed that the presence of gill slits in the embryos of all vertebrates suggests a common ancestry, as these structures are not functional in mammals, but are functional in fish and amphibians.

4.(b) Common ancestry: The presence of homologous organs in different animals, such as the forelimbs of vertebrates, indicates that these structures evolved from a common ancestor, but have been modified over time to serve different functions in different species.

5.(c) Wings of birds and insects: Analogous organs are those that have similar functions but different origins, such as the wings of birds and insects, which have different anatomical structures but serve a similar purpose.

6.(b) Adaptive radiation: Adaptive radiation is the process by which a single ancestral species evolves into a diverse array of descendant species, each with a distinct set of adaptive traits.

7.(a) Adaptive radiation: The evolution of different types of finches in the Galapagos Islands is an example of adaptive radiation, as a single ancestral species of finch colonized the islands and evolved into different forms, each adapted to a different ecological niche.

8.(a) Origin of species by natural selection: The diversity of finches and their adaptation to different feeding habits in the Galapagos Islands provides evidence for Darwin's theory of natural selection, which states that individuals with advantageous traits are more likely to survive and reproduce, leading to the evolution of new species.

9.(c) Adaptive radiation: Australian marsupials are an example of adaptive radiation, as they evolved to fill the ecological niches that were previously occupied by placental mammals in other parts of the world.

10.(d) Lemur and spotted cuscus: Lemurs and spotted cuscus are not an example of adaptive radiation, as they do not exhibit a diversification of species into different ecological niches.

11.Answer: (b) Favorable variations

Explanation: Survival of the fittest refers to the idea that individuals with favorable traits for a particular environment are more likely to survive and reproduce than those without such traits. These favorable traits are the result of variations that occur due to mutations or genetic recombination during reproduction. Therefore, favorable variations are necessary for the concept of survival of the fittest.

12.Answer: (b) By the number of offspring produced by different individuals in a population

Explanation: Darwinian fitness is a measure of an individual's ability to survive and reproduce in a particular environment. It is estimated by measuring the number of offspring produced by different individuals in a population over several generations. Individuals with higher fitness produce more offspring that survive and reproduce in the next generation.

13.Answer: (d) Branching descent and natural selection

Explanation: Darwin's theory of evolution is based on two key concepts: branching descent and natural selection. Branching descent refers to the idea that all living organisms are descended from a common ancestor through a process of divergence and speciation. Natural selection is the process by which organisms with favorable variations for a particular environment survive and reproduce more successfully than those without such variations.

14 Answer: (d) Reproduction by sexual method

Explanation: Reproduction by sexual method increases genetic variation in a population, which provides more opportunities for natural selection to act. Sexual reproduction results in offspring with different combinations of genetic traits from their parents, which increases the chances of some individuals having favorable variations for a particular environment. This, in turn, increases the rate of natural selection.

15.Answer: (b) Discontinuous variations

Explanation: Darwin's theory of natural selection is based on the idea that individuals with favorable variations for a particular environment are more likely to survive and reproduce than those without such variations. However, Darwin did not take into account the concept of discontinuous variations, which are distinct and non-overlapping variations that occur in some traits, such as blood types or eye color. Discontinuous variations do not have a gradual range of variation, and hence, they are not subject to natural selection.

16.Answer: (a) Stretching of necks over many generations

Explanation: Lamarck proposed that long-necked giraffes evolved as a result of stretching their necks to reach higher leaves over many generations. According to Lamarck, this stretching of the neck resulted in the development of longer necks, which were then passed on to their offspring. However, this idea has been disproven by modern scientific evidence, which supports the theory of natural selection.

17.(c) Evening primrose. Hugo de Vries proposed his idea of mutation based on his work with the evening primrose (Oenothera Lamarckiana). He observed sudden changes in the characteristics of the plant, which he called "mutations," and suggested that these mutations could be the source of new species.

18.(a) The trait remains constant in a population. Genetic equilibrium refers to a state in which the frequency of alleles in a population remains constant from generation to generation. This means that the trait associated with a particular allele will also remain constant, as long as the environmental conditions do not change.

19.(c) Different mammals in other parts of the world. Adaptive radiation is the process by which a single species evolves into multiple species that occupy different ecological niches. This process is typically associated with island or geographically isolated populations. Examples of adaptive radiation include Darwin's finches, Hawaiian honeycreepers, and Australian marsupials.

20.(b) Favourable variations. Survival of the fittest is a key concept in Darwinian theory, but it is made possible by the existence of favourable variations in the population. These variations arise through genetic mutations, which create new combinations of genes that may provide a survival advantage in a particular environment.

21.(b) Number of offspring produced by different individuals in a population. Darwinian fitness is a measure of an individual's reproductive success in a population. It is determined by the number of offspring an individual produces and the degree to which those offspring survive to reproduce themselves.

22.(d) Branching descent and natural selection. The two key concepts of Darwinian theory are branching descent (the idea that all living organisms are descended from a common ancestor) and natural selection (the process by which advantageous traits are selected for in a population).

23.(d) Reproduction by sexual method. Natural selection operates most efficiently in populations that reproduce sexually, as this creates more genetic variation and allows for the production of new combinations of genes. Asexual reproduction and low mutation rates may limit the amount of genetic diversity in a population and reduce the rate of natural selection.

24.(b) Discontinuous variations. Darwin was aware of the existence of discontinuous variations (i.e., variations that do not occur along a continuous spectrum) but did not fully understand their genetic basis. He also did not know about the role of DNA in heredity, as this was not discovered until many years later.

25.(a) Stretching of necks over many generations. Lamarck's theory of evolution proposed that traits acquired during an organism's lifetime could be passed on to its offspring. He used the example of giraffes to explain his theory, suggesting that giraffes stretched their necks to reach leaves on high branches and that this stretching resulted in longer necks in their offspring. However, this idea has been disproven by modern genetics.

26.(c) Evening primrose. Hugo de Vries proposed his idea of mutation based on his work with the evening primrose (Oenothera Lamarckiana). He observed sudden changes in the characteristics of the plant, which he called "mutations," and suggested that these mutations could be the source of new species.

27.(d) The difference in brain size between Homo sapiens and Homo erectus. Homo erectus is an extinct species of human that lived between 2 million and 200,000 years ago. One of the key differences between Homo erectus and Homo sapiens is the size of their brains. Homo sapiens have larger brains, which may have contributed to their ability to develop complex social structures and technologies.

28.(b) Australopithecus → Ramapithecus → Homo habilis → Homo erectus: This is the correct chronological order of human evolution from the earliest to the most recent stages, based on the fossil record and other evidence.

29.(c) Sexual selection is a type of natural selection: Natural selection is the process by which certain traits become more or less common in a population over time due to their effects on survival and reproduction. Sexual selection is a specific type of natural selection that operates through the competition for mates, where certain traits are favored because they increase an individual's ability to attract and mate with a partner.

30.(b) Common ancestry: Homologous organs are structures in different species that have a similar basic form and function, suggesting a common ancestry. For example, the forelimbs of birds, bats, and humans all have the same basic bone structure, even though they are adapted for different functions in each species.

31.(b) Molecular homology: Proteins found in the blood of humans and apes are similar at the molecular level, indicating a common ancestry and evolutionary history. This is an example of molecular homology, which is one of the types of evidence used to support the theory of evolution.

32.(c) Mutation together with natural selection: According to the Neo-Darwinian theory, the origin of new species is primarily driven by mutations that produce genetic variation, which is then acted upon by natural selection. Useful variations are those that increase an individual's fitness, or ability to survive and reproduce, and are more likely to be passed on to future generations.

33.(b) Weismann: August Weismann proposed the theory of continuity of germplasm, which states that hereditary information is transmitted only through the germ cells (sperm and eggs) and not through the somatic cells of an organism.

34.(b) Spallanzani – Approve abiogenesis: Spallanzani was a scientist who conducted experiments on spontaneous generation, which was the idea that living organisms could arise spontaneously from non-living matter. He disproved this idea through his experiments on the spontaneous generation of microorganisms.

35.(a) Homologous organs: Divergent evolution occurs when two or more species diverge from a common ancestor and develop different traits over time. This gives rise to homologous organs, which are structures in different species that have a similar basic form and function due to common ancestry.

36.(c) Lungs: Lungs are the most significant evolutionary change that enabled land vertebrates to be completely free from the water. They allowed these animals to breathe air and live on land, which opened up new ecological niches and opportunities for evolution.

37.(d) Placental wolf and Tasmanian wolf: Adaptive radiation is the process by which a single ancestral species diversifies into many different species, each adapted to a different ecological niche. Placental wolf and Tasmanian wolf are not examples of adaptive radiation, as they are two different species from different lineages that evolved similar adaptations due to convergent evolution.

38.(c) Germ theory of disease: Pasteur and Koch are known for their work on the germ theory of disease, which states that many diseases are caused by microorganisms such as bacteria and viruses.

39.(c) Modern man: Modern humans (Homo sapiens) have the largest cranial capacity of any hominid, averaging around 1400 cubic centimeters.

40.(a) Eohippus: Eohippus, also known as Hyracotherium, is considered the ancestor of modern horses. It lived during the early Eocene epoch, around 55 million years ago.

41.(b) Grasses are considered evolutionary modern because they have undergone significant adaptations to become one of the most successful plant groups on Earth, with a wide distribution and diverse ecological roles.

42.(b) The Mesozoic era is often called the "golden age of the reptiles" because this was the time when dinosaurs, pterosaurs, and other reptilian groups dominated the land, sea, and air.

43.(a) Vestigial organs are those that have lost most or all of their original function in the course of evolution. In humans, examples of vestigial organs include wisdom teeth, the coccyx (tailbone), the vermiform appendix, and the nictitating membrane (third eyelid).

44.(c) Ramapithecus punjabicus is considered by some scientists to be the most primitive ancestor of humans because it has some skeletal features that are similar to those of later hominids. However, its exact relationship to modern humans is still debated.

45.(c) The first land plants, or psilophytes, originated in the Silurian period, around 420 million years ago. These plants were simple, nonvascular forms that paved the way for more complex plant groups to evolve later.

46.(b) Dryopithecus is the earliest fossil ape that has been discovered so far, dating back to the Miocene epoch (approximately 23-5 million years ago). It was a small, tree-dwelling primate that is thought to be closely related to the ancestor of modern orangutans.

47.(b) The correct sequence of events in the modern concept of evolution is: I. Genetic variations in population, III. Heredity, II. Natural selection, IV. Isolation, V. Speciation.

48.(c) Organic evolution refers to the process of biological evolution, which involves the gradual change of species over time through mechanisms such as natural selection, genetic drift, and mutation.

49.(b) The correct descriptions of the entities in the equation are: P^2 = homozygous dominant genotype, 2pq = heterozygous genotype, Q^2 = homozygous recessive genotype. Therefore, options (b) I and III are not described correctly.

50.(b) The present concept of evolution is known as the synthetic theory of evolution or the modern synthesis, which combines the principles of Darwinian natural selection with genetics, molecular biology, and other disciplines to provide a comprehensive understanding of evolutionary processes.