CHAPTER **07**

Evolution

1. Evolution

It is the sequence of gradual changes from simple life forms to complex forms, *i.e.* from primitive organisms that lived over million of years ago to new organisms that exist today.

2. Origin of Life

Our earth originated about 4.6 billion years ago, whereas the origin of life on earth occurred 4 billion years after its formation. The **Big-Bang theory** (given by **Abbe Lemaitre** in 1931) explains about the origin of earth as a terrible explosion resulting in the formation of universe or cosmos.

3. Ancient Theories for Origin of Life

- **Special Creation** It states that God has created life.
- **Cosmozoic Theory** It states that life arose from the spores or panspermia which came from outer space.
- **Spontaneous Generation Theory** According to this, life originated from abiotic substances spontaneously.
  Therefore, this theory is also called as theory of **abiogenesis** or **autobiogenesis**.
- **Louis Pasteur** rejected the theory of spontaneous generation. He demonstrated that life evolved from pre-existing life by his swan-neck flask experiment.
- **Theory of Chemical Evolution** It was given by **Oparin** and **Haldane**. According to them, first form of life came from pre-existing, non-living organic molecules (*e.g.* RNA, protein, etc.).

4. Miller and Urey's Experiment

(Evidence of Chemical Evolution)

Stanley Miller (1953) performed a simple experiment under the guidance of **Harold Urey**. They collected water vapour, hydrogen, methane and ammonia (2 : 2 : 1 ratio) in a flask and provided an electric discharge by tungsten electrode.

The amino acids such as glycine, alanine, etc., were formed in their experiment. This experiment, proved that C, H, O and N in various forms can give rise to complex compounds.

5. Evidences for Evolution

A. **Palaeontological evidences** come from the study of fossils. The fossils are the remains of past organisms preserved in sedimentary rocks.

(i) **Fossil Records/Inscriptions** are the remains or impressions of the hard parts of ancient plants and animals on rocks and mountains. The process by which animals or plants become a fossil is called **fossilisation**.
'Study of fossils' is called **palaeontology**.

(ii) **Age Determination of Fossils** Fossils' age can be calculated by methods like uranium lead method and radioactive carbon dating methods, etc.

B. **Comparative anatomy and morphological evidences** These show the similarities and differences among the organisms of today and those that existed many years ago. This can be the achieved by the study of following

(i) **Homologous organs** are those having same structural design and origin but different functions, *e.g.* forelimbs of some animals like whales, bats and cheetah, mouth parts of various insects, etc.

(ii) **Analogous organs** are those which are anatomically different but functionally similar, *e.g.* wings of butterfly and birds. Analogy is based on convergent evolution.

Note

- **Divergent Evolution** It refers to the development of different functional structures from a common ancestral stock (homology) in order to adapt to different environmental conditions.
- **Convergent Evolution** Development of similar morphological characters (analogy) in the organisms of different lineages at same geographical regions is called **convergent evolution**.

C. **Biochemical evidences** (Molecular evidences) suggest that the similarities in proteins and genes performing a common function among diverse organisms indicates a common ancestry.

D. **Embryological evidences** suggest that some organisms that show common descent in embryological patterns, This was first observed by **von Baer** and later reinterpreted by **Haeckel** in the form of recapitulation or biogenetic law stating that ''ontogeny repeats phylogeny''.

E. **Biogeographical evidences** suggest that the species restricted to a region develop unique features. Also, species present in separated regions show similarity of ancestry. This can be explained with the help of adaptive radiation. It is an evolutionary process in which an ancestral stock gives rise to new species adapted to new habitats and new ways of life, *e.g.* Darwin's finches, marsupials of Australia and placental animals in Australia.

6. Biological Evolution

It refers to the origin of first living cell from non-living chemical complexes.

Mechanism of Evolution Various theories were put forward by scientists to explain the evolutionary mechanism.

7. Theories of Evolution

(i) **Lamarckism or Theory of Inheritance of Acquired Characters** Lamarck published a book named '*Philosophie Zoologique*' in 1809 to propose this theory. It states that each organism acquires many characters in his lifetime from the environment he lives in. These acquired characters are inherited by the offspring to form a new species gradually.

Any organ which is used more, slowly enlarges in size and the organ which is not used, degenerates, *e.g.* degeneration of legs of snake, elongation of neck in giraffe. This theory was highly criticised.

(ii) **Modern Lamarckism** August Weismann in 1892 proved using genetics and theories of inheritance that acquired characters, present in genotype of an individual are transmitted to next generation by inheritance. This theory was named as **Theory of Continuity of Germplasm**.

(iii) **Darwinism or Theory of Natural Selection** Darwin concluded that the fitness of individual ultimately refers to its reproductive fitness. Thus, those organisms which are better or adapt well will survive more in nature. This is called **natural selection**. He also explained that different species descending from common ancestor get adapted into different habitats. This is called **branching descent**. Therefore, natural selection and branching descent are two important concepts of Darwinism.

Darwin along with **Alfred Wallace** jointly propounded the 'Theory of natural selection' in 1958. It was based on following factual observations

(a) Limited natural resources, stable population (except for seasonal fluctuations).

(b) Variations (in sexually reproductive animals).

(c) Reproductive isolation, etc.

- **Industrial Melanism** An example of evolution by natural selection was observed in peppered moths (*Biston betularia*) in 1859 in England. Before industrialisation, white-winged moths were more in number compared to dark-winged moths. After industrialisation, dark-winged moths increased in number, as they were able to camouflage themselves from predators on tree trunks turned darker due to air pollution (soot and dust particles). The white-winged moth population declined due to easy detection by predators. Thus, in a mixed population, better adaptable species are selected by nature to grow while others are eliminated.
- **Chemical Resistance** The excessive use of chemicals leads to development of resistance in microbes to such chemicals. These microbes are selected naturally due to favourable variation.

(iv) **Mutation Theory of Hugo de Vries** He studied and carried out experiments on a plant, evening primrose (*Oenothera lamarckiana*). He proposed the mutation theory of evolution on the basis of his observations. de Vries proposed that evolution can also occur due to sudden large changes occurring in a population which caused speciation and called it **saltation** (single step large mutation).

(v) **Modern Synthetic Theory of Evolution**

Modern synthetic theory is actually a form of modern Darwinism. It states that the origin of species is based on the interaction of genetic variation in a population, natural selection and reproductive isolation.

8. Hardy-Weinberg Principle

According to it, the allele frequencies in a population are stable and remain constant from generation to generation. This is called **genetic equilibrium**.

It is expressed as $p^2+q^2+2pq = 1$

[binomial expansion, *i.e.* $(p+q)^2$]

9. Agents of Evolutionary Change

There are following basic mechanisms through which biological evolution takes place

(i) **Genetic drift** (Random drift) is a change that occurs in allelic frequencies by chance.

Sometimes due to changes in allele frequency in new population, some different species are formed. This is called **founder effect** and the original drifted population is called **founder**.

(ii) **Gene Flow** It is the movement of alleles from one population to another.

(iii) **Natural Selection** It occurs due to the inheritance of variations. It leads to the survival of those who best fit in an environment. It can be of three types, *i.e.* stabilisation, directional and disruptive.

(iv) **Genetic Recombination** During gametogenesis, crossing over in meiosis leads to new combination of genes.

10. Account of Evolution

The cellular forms of life first appeared on earth around 2000 million years ago (mya).

A. **Evolution of Plants**

- Plants appeared first on lands before animals.
- **Bryophytes** were the first plants to colonise land followed by vascular plants.
- Vascular plants (pteridophytes and gymno- sperms) first originated in **Silurian period**..
- **Herbaceous lycopods** and **arborescent lycopods** evolved from *Zosterophyllum* of **Palaeozoic era**.
- ***Psilophyton*** is the common ancestor for horsetails, ferns and gymnosperms.

B. **Evolution of Animals**

- Animals evolved around 500 mya and the first animals were invertebrates.
- Jawless fish and amphibious fish with stout and strong fins were found on earth around 350 mya.
- The Jurassic period is called **age of reptiles,** *i.e.* around 200 mya.
- Mammals appeared in Triassic period and the first mammals were like shrews.

11. Human Evolution

The fossil evidences indicate that origin of man occurred in Central Asia, China, Java and India (Shivalik hills).

The human evolution took place as follows

Human Ancestors	Time of Origin	General Feature
Dryopithecus	20-25 mya	Ape-like, hairy, ate soft fruits and leaves. Arms and legs of same length, large brain.
Ramapithecus	14-15 mya	More man-like, walked more erect, teeth like modern man.
Australopithecus (The first ape man)	3-4 mya	Probably lived in East African grasslands and ate fruits, hunted with stones, weapons, brain capacity was 400-600 cc.
Homo habilis (Handy man)	2 mya	Fossils found in East Africa , first hominid, *i.e.* human being- like, brain capacity 650-800 cc, did not eat meat.
Homo erectus (Java man)	1.5 mya	Fossils found in Java in 1891, brain capacity 900 cc, probably ate meat.
Homo sapiens neanderthalensis (Primitive man)	1,00,000-40,000 years ago	Known as Neanderthal man. Fossils found in East and Central Asia, brain size 1400 cc, used hides to protect body, buried their dead. They became extinct 25,000 years ago.
Homo sapiens (Modern man)	75,000-10,000 years ago (ice age)	Arose in Africa, developed cave art around 18,000 years ago, agriculture started around 10,000 years back and thus, human settlement and civilisation started.

Practice Questions

1. According to one of the most widely accepted theories, earth's atmosphere before origin of life consisted of a mixture of

(a) O_3, CH_4, O_2 and H_2O
(b) O_3, NH_3, CH_4 and H_2O
(c) H_2, CO_2, NH_3 and CH_4
(d) CH_4, NH_3, H_2 and H_2O vapours

2. For a long time, it was believed that life came out of decaying and rotting matter like straw, mud, etc. This was the theory of

(a) catastrophism (b) spontaneous generation
(c) panspermia (d) chemogeny

3. Who proposed that the first form of life could have come from pre-existing non-living organic molecules and it precedes chemical evolution?

(a) SL Miller
(b) Oparin and Haldane
(c) Charles Darwin
(d) Alfred Wallace

4. The sequence of origin of life may be

(a) Inorganic materials → Organic materials → Colloidal aggregate → Eobiont → Cell
(b) Organic materials → Inorganic materials → Colloidal aggregate → Eobiont → Cell
(c) Inorganic materials → Organic materials → Eobiont → Cell → Colloidal aggregate
(d) Organic materials → Inorganic materials → Eobiont → Cell → Colloidal aggregate

5. According to Charles Darwin's observations

(a) existing life forms share similarities to the life forms that existed million of years ago
(b) life forms evolve gradually
(c) any population has built in variations which enable them to survive in natural conditions
(d) All of the above

6. Evidence that evolution of life forms has indeed taken place on earth has come from

(a) fossil studies (palaeontological evidences)
(b) morphological and comparative anatomical studies
(c) biochemical studies
(d) All of the above

7. Fossils are useful in

(a) studying extinct organisms
(b) studying history of organisms
(c) Both (a) and (b)
(d) None of the above

8. Embryological support for evolution given by Ernst Haeckel includes the

(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 row of vestigial gill slits in embryo of all vertebrates

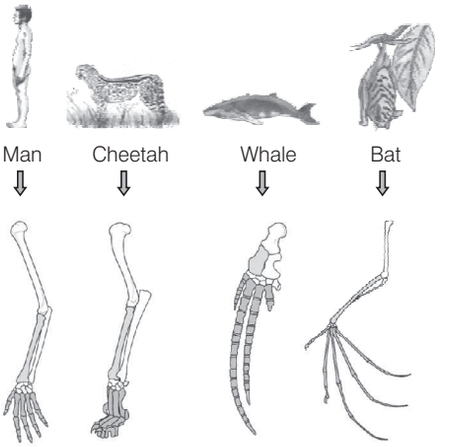
9. What does presence of homologous organs in different animals indicate?

(a) Different ancestry
(b) Common ancestry
(c) Independent development
(d) Dependent development

10. Tendrils of *Cucurbita* and thorns of *Bougainvillea* are examples of

(a) vestigial organs (b) analogous organs
(c) homologous organs (d) homoplasy

11 Diagram given below indicates



(a) analogous organs (b) homologous organs
(c) convergent evolution (d) All of these

12. Change of lighter coloured variety of peppered moths *(Biston betularia)* to darker variety in the industrial era occurred due to

(a) selection of darker variety for survival
(b) deletion of gene
(c) industrial carbon deposited on the wings
(d) translocation of gene

13. Example of anthropogenic evolution is

(a) selection of resistant microbes to pesticides
(b) antibiotic resistant eukaryotic cells
(c) Industrial melanism is *Biston betularia*
(d) All of the above

14. Development of different functional structures from a common ancestral form is called

(a) differential evolution (b) adaptive radiation
(c) non-adaptive radiation (d) regressive evolution

15. The process by which different type of finches were evolved in Galapagos islands is a consequence of

(a) adaptive radiation (b) geographic similarity
(c) geographic dissimilarity (d) adaptive convergence

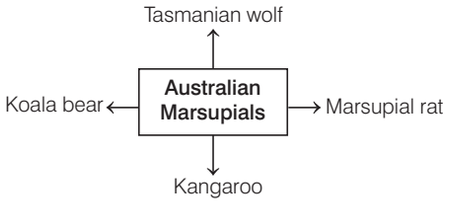
16. The diversity in the type of finches and adaptation to different feeding habits on the Galapagos islands, as observed by Darwin, provides an evidence of

(a) origin of species by natural selection
(b) intraspecific variation
(c) intraspecific competition
(d) interspecific competition

17. Australian marsupials are the example of

(a) homologous radiation
(b) analogous radiation
(c) adaptive radiation
(d) convergent radiation

18. Identify what the given diagram indicates?



(a) Convergent evolution (b) Divergent evolution
(c) Recapitulation (d) Parallel evolution

19. Which of the following is not an examples 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) favourable 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

23. Which of the following situations would most likely result in the highest rate of natural selection?

(a) Reproduction by asexual method
(b) Low mutation is an stable environment
(c) Little competition
(d) Reproduction by sexual method

24. 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

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. Genetic equilibrium refers to the phenomenon in which

(a) the trait remains constant in a population
(b) the total genes remain constant in a population
(c) the total genes keeps on varying in a population
(d) traits keeps on varying in a population

28. Hardy-Weinberg principle can be expressed as

(a) $p^2 - 2pq - q^2 = 1$
(b) $p^2 + 2pq + q^2 \geq 1$
(c) $p^2 + 2pq + q^2 \leq 1$
(d) $p^2 + 2pq + q^2 = 1$

29. Which of the following conditions represents the extent of evolutionary change in Hardy-Weinberg principle?

(a) Value of $(p + q)^2$
(b) Difference between measured value and expected value
(c) Sum of measured value and expected value
(d) This principle cannot predict the extent of evolutionary change

30. 'XX' is a type of selection process in evolution that promotes population changes in one particular direction. 'XX' favours small or large sized individuals mean size of population changes. Identify 'XX'.

(a) Stabilising selection (b) Directional selection
(c) Disruptive selection (d) None of the above

31. Artificial selection to obtain cows yielding high milk output represents

(a) stabilising selection as it stabilises this character in the population
(b) directional as it pushes the mean of the character in one direction
(c) disruptive as it splits the population into two, one yielding higher output and the other lower output
(d) stabilising followed by disruptive as stabilises the population of produce higher yielding cows

32. Choose the incorrect pair.

(a) Invertebrates were formed and active – By 500 mya
(b) Seaweeds existed – Around 320 mya
(c) First organisms that invaded land – Single-celled animals
(d) Fish with stout and strong fins – Around 350 mya

33. Giant dinosaurs and reptiles predominated during the Jurassic period. This period was also marked for the evolution of higher insects and angiosperms, conifers, cycads, etc. Jurassic period belongs to which era?

(a) Cenozoic (b) Palaeozoic
(c) Mesozoic (d) Proterozoic

34. In which era Protozoa, sponge and algae originate?

(a) Cenozoic era (b) Azoic era
(c) Proterozoic era (d) Mesozoic era

35. The correct order of evolutionary scale is

(a) Palaeozoic → Archaeozoic → Cenozoic
(b) Archaeozoic → Palaeozoic → Proterozoic
(c) Palaeozoic → Mesozoic → Cenozoic
(d) Mesozoic → Archaeozoic → Proterozoic

36. First human like hominid is known as

(a) Neanderthal man (b) *Homo habilis*
(c) *Dryopithecus* (d) *Homo erectus*

37. Brain (cranial) capacity of *Homo habilis* was

(a) 750-850 cc (b) 750-800 cc
(c) 650-800 cc (d) 550-700 cc

38. The difference between *Homo sapiens* and *Homo erectus* was

(a) *Homo sapiens* originated in Africa, while *Homo erectus* originated in Asia
(b) *Homo erectus* were much smaller in size than *Homo sapiens*
(c) *Homo erectus* stayed in Africa, while *Homo sapiens* did not
(d) the size of the brain of *Homo erectus* was smaller than that of *Homo sapiens*

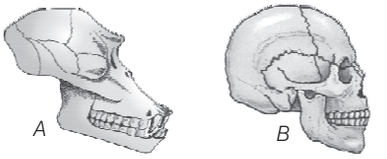
39. *Homo sapiens* arose during

(a) ice age between 75000-10000 years ago
(b) continental drift between 75000-10000 years ago
(c) continental drift between 75000-5000 years ago
(d) ice age between 50000-10000 years ago

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

(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*

41. The diagram given here shows the skull of two different mammals. Choose the most appropriate difference between *A* and *B*.



(a) Skull A has more teeth than skull B
(b) Skull A has more brain capacity than skull B
(c) Skull A is of a human and skull B is of an ape
(d) Skull A is of an ape and skull B is of human

ANSWERS

1.	(d)	**2.**	(b)	**3.**	(b)	**4.**	(a)	**5.**	(d)	**6.**	(d)	**7.**	(c)	**8.**	(d)	**9.**	(b)	**10.**	(c)
11.	(b)	**12.**	(a)	**13.**	(d)	**14.**	(b)	**15.**	(a)	**16.**	(a)	**17.**	(c)	**18.**	(b)	**19.**	(d)	**20.**	(b)
21.	(b)	**22.**	(d)	**23.**	(d)	**24.**	(b)	**25.**	(a)	**26.**	(c)	**27.**	(b)	**28.**	(d)	**29.**	(b)	**30.**	(b)
31.	(b)	**32.**	(c)	**33.**	(c)	**34.**	(c)	**35.**	(c)	**36.**	(b)	**37.**	(c)	**38.**	(d)	**39.**	(a)	**40.**	(a)
41.	(d)																		

Hints & Explanations

2. (***b***) For a long time, it was believed that life came out of decaying and rotting matter like straw mud, etc. This was the theory of spontaneous generation.
Theory of spontaneous generation (abiogenesis or autogenesis) states that, life originated from non-living things in a spontaneous manner.

3. (***b***) Oparin and Haldane proposed that the first form of life could have come from pre-existing non-living organic molecules (e.g. RNA, protein, etc.) and that formation of life was preceded by chemical evolution, i.e. formation of diverse organic molecules from inorganic constituents.

5. (***d***) Based on observations made during a sea voyage in a sail ship called HMS Beagle round the world, Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago. There has been gradual evolution of life forms. A population has been built on variations, in characteristics. Those characteristics which enable some to survive better in natural conditions (climate, food, physical factors, etc.) would outbreed others that are less-endowed to survive under such natural conditions.

8. (***d***) Embryological support for evolution given by Ernst Haeckel includes the presence of row of vestigial gill slits in embryo of all vertebrates. This proposal was disapproved by Karl Ernst von Baer who noted that embryos never pass these gill slits to their the adult stages. He proposed that embryos start from few basic forms similarly in different animals and then develop into branching patterns.

11. (***b***) The given diagram indicates homologous organs. Whales, bats, cheetah and human (all mammals) share similarities in the pattern of bones of forelimbs. In plants, the thorns and tendrils of *Bougainvillea* and *Cucurbita*, respectively represent homology.

12. (***a***) Change of lighter coloured variety of peppered moths (*Biston betularia*) to darker variety in the industrial area occurred due to the selection of darker variety for survival. It is an excellent example which supports the theory of natural selection by Charles Darwin.

14. (***b***) Development of different functional structures from a common ancestral form is called adaptive radiation. The concept of adaptive radiation in evolution was developed by HF Osborn in 1902. Homologous organs show adaptive radiation.

16. (***a***) The diversity in the type of finches and adaptation to different feeding habits on the Galapagos islands was observed by Darwin. He provides an evidence of origin of species by natural selection.

17. (***c***) Darwin explained that adaptive radiation gave rise to the varieties of marsupials (pouched mammals) in Australia by the same process of adaptive radiation as found in the finches of Galapagos Islands.

19. (***d***) Lemur and spotted cuscus are not examples of adaptive radiation. These are examples of convergent evolution.
Rest of the pairs are examples of adaptive radiation.

20. (***b***) The organisms, which acquire or develop favourable variations would survive because they are fittest to face their surrounding, while unfit organisms are eliminated.

21. (***b***) Darwinian fitness can be estimated by the number of offspring produced by different individuals in a population. The organisms which bear favourable variations in accordance to the environment have more offspring than the others which do not have variations in accordance with environment.

23. (***d***) Reproduction by sexual methods brings about changes in genes of progeny. In genes of sexually reproduced organisms, independent assortment of genes and genetic recombination takes place. Due to these events, the progeny have high rate of natural selection than the asexually repoducing organisms.

24. (***b***) Natural selection theory of Darwin did not believe in any role of discontinuous variation. Darwin called these variations as sports, while Hugo de Vries used the term mutation for these variations. These variations are sudden heritable changes, which can occur in any stage of development.

27. (***b***) Hardy-Weinberg principle states that allele frequencies remains constant from generation to generation. This is called as genetic equilibrium.

32. (***c***) The pair in option (c) is incorrect and can be corrected as follows.
First organisms that invaded land were supposed to be plants and not single-celled animals.
Rest of the pairs are correct.

39. (***a***) *Homo sapiens* arose in Africa and moved across continents and developed into distinct races. During the ice age between 75,000-10,000 years ago modern *Homo sapiens* arose.
Pre-historic cave art developed about 18,000 years ago. One such cave paintings by Pre-historic humans can be seen at Bhimbetka rock shelter in Raisen district of Madhya Pradesh. Agriculture came around 10,000 years back and human settlements started.

40. (***a***) The chronological order of human evolution is as follows

Ramapithecus (earliest hominid fossil about 14-15 mya)

↓

Australopithecus (first ape man about 2 mya)

↓

Homo habilis (tool maker handyman about 1.2-1.5 mya)

↓

Homo erectus (Erect man about 1.5 mya)