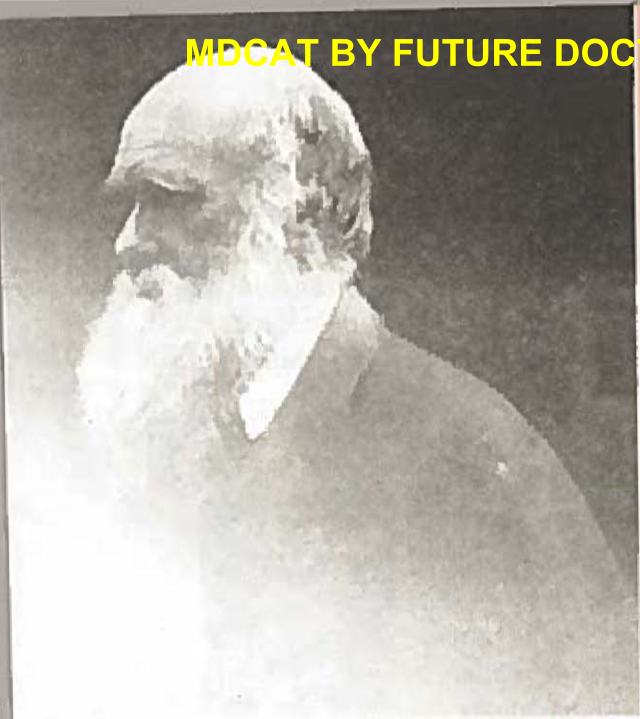
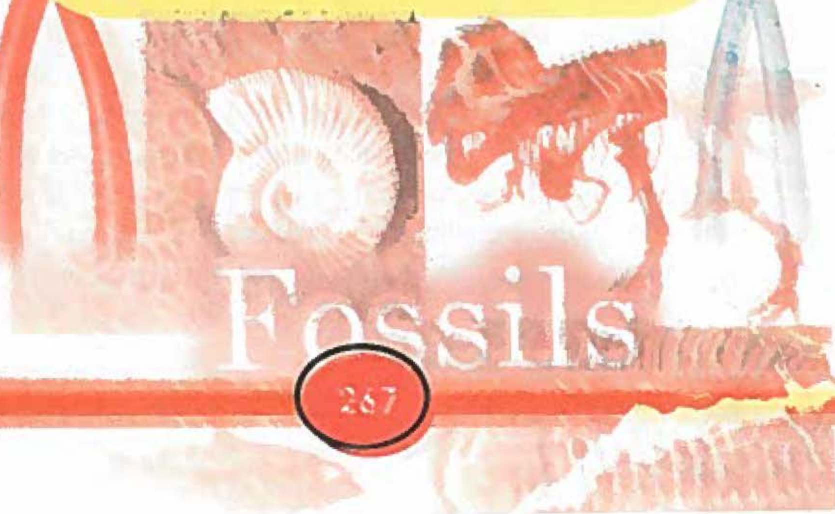


UNIT 24

EVOLUTION

KEY CONCEPTS



Man has always been curious to know how, when and where life originated; and how the diverse forms of animals and plants came into existence. Many scientific and non-scientific theories have been put forth so for regarding the origin of life on earth like special creation, spontaneous generation, cosmozoan, and biochemical evolution. Widely regarded are special creation and biochemical evolution.

24.1 THE EVOLUTION OF THE CONCEPT OF EVOLUTION

Aristotle (384-322 B.C), one of the first great naturalists, categorized all the living things that he encountered. Aristotle thought that all organisms fit into an orderly scheme, later called the *Scala Naturae*, or Ladder of Nature. The ladder stood, so to speak, upon nonliving matter climbed rung by rung from fungi and mosses to higher plants

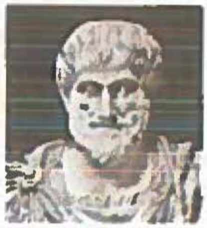


Fig: 24.1 Aristotle

through primitive animals such as mollusks and insects and was finally terminated in human beings. The *Scala Naturae* was considered to be permanent and never changing; each organism has its place on the ladder ordained by God during creation.

Creationism, the idea that each species was created individually by God and never changed thereafter, reigned unchallenged for nearly 2000 years. As European naturalists explored the newly discovered lands of Africa, Asia, and America, they found that the diversity of living things was much greater than anyone had suspected. Some of these exotic species closely resembled one another yet also displayed variations in characteristics. This unpredicted expansion of information led some naturalist to consider that perhaps species could change after all and that some of the similar species might have developed from a common ancestor. Later on, the discoveries of fossils added credibility to this view. The fossil remains also showed a remarkable progression in form. Fossils found in the lowest and oldest rock layers were usually very different from modern forms with a gradual advancement to greater resemblance to modern species in younger rocks, as if there were a *Scala Naturae* stretching back in time.George Cuvier (1769-1832) proposed the theory of catastrophism. Cuvier hypothesized that a vast supply of species was created in the beginning. Successive catastrophes produced the layers of rock and destroyed many species, fossilizing some of their remains in the process. The reduced flora and fauna of the modern world are the species that survived the catastrophes. Louis Agassiz

(1807-1873) proposed that there was a new creation after each catastrophe and that modern species result from the most recent creation.Geologists James Hutton (1726-1797) and Charles Lyell (1797-1875) contemplated the forces of wind, water, earthquake and volcanism as agents for creating layered pattern. These layers of rocks are evidence of ordinary natural processes, occurring repeatedly over a long periods of time. This concept is called uniformitarianism. If slow natural processes alone are enough to produce layers of rock thousands of feet thick then earth must be old indeed, many millions of years old. Hutton and Lyell in fact concluded that earth was a eternal: "No vestige of a beginning, no prospect of an end". Thus, Hutton and Lyell provided the time for evolution but there was still no convincing mechanism.

One of the first to propose a mechanism for evolution was the French Biologist Lamarck (1744 –1829). He hypothesized that organisms evolved through the inheritance of acquired characteristics. Lamarck proposed that all organisms possess an innate drive for perfection, and urge to climb the ladder of nature.

By the mid 1800 some biologists were beginning to realize that the fossil record and the similarities between fossil forms and modern species could be best explained if present day species had evolved from pre-existing forms. The question remains: But how? In 1858 Charles Darwin and Alfred Russell Wallace independently provided convincing evidence that the driving force behind evolutionary change was natural selection.

Fig: 24.2 Lamarck

24.2 EVOLUTION OF EUKARYOTES FROM PROKARYOTES

Fossil records indicate that eukaryotes evolved from prokaryotes somewhere between 1.5 to 2 billion years ago. Two proposed pathways describe the invasion of prokaryote cells by two smaller prokaryote cells. They subsequently became successfully included as part of a now much larger cell with additional structures and capable of additional functions. The process involved in the evolution of eukaryotes are Endosymbiosis and Membrane infolding.

24.2.1 Endosymbiosis:

Research conducted by Lynn Margulis at the University of Massachusetts supports the hypothesis that two separate mutually beneficial invasions of a prokaryote cell produced the modern day mitochondria and chloroplast as eukaryotic organelles. In this model, ancestral mitochondria were small heterotrophs capable of using oxygen to perform cellular respiration and thereby create useful energy.

They became part of a large cell either by direct invasion as an internal parasite or as an indigestible food source. Later, a second invasion brought ancestral chloroplasts, which are thought to be small, photosynthetic cyanobacteria.

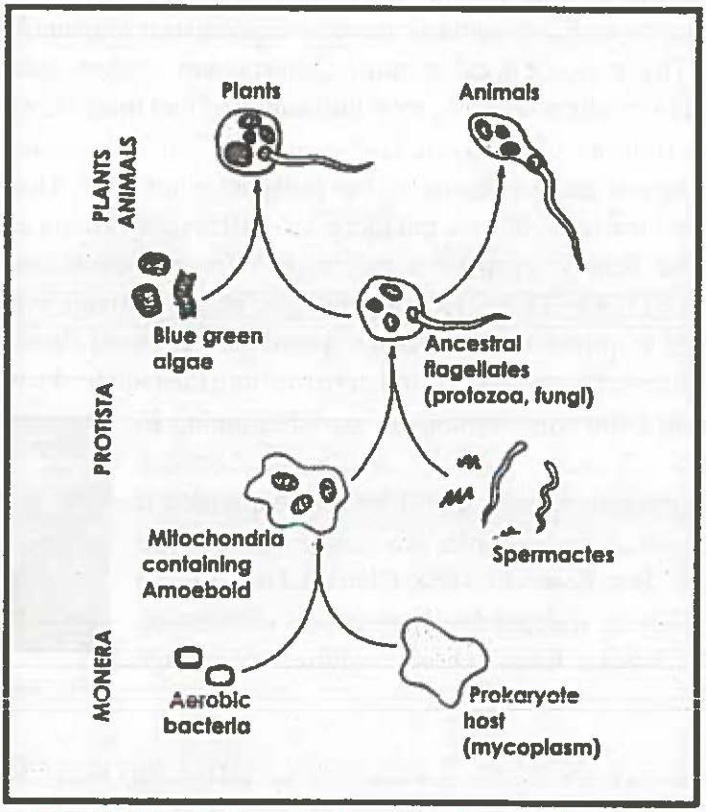


Fig: 24.3 Evolution of eukaryotes from prokaryotes.

Modern day supporting evidence for endosymbiosis shows that both the mitochondria and chloroplasts have their own genes, circular DNA and RNA, and reproduce by binary fission independent of the host's cell cycle. They therefore appear to be more similar to prokaryotes than eukaryotes.

24.2.2 Membrane Infolding:

The invasions of the host prokaryote cell probably were successful because the host cell membrane infolded to surround both invading prokaryote cells and thereby help transport them into the cell. The membrane did not dissolve but remained intact, and thereby created a second membrane around the protomitochondria and protochloroplast.

It is also known that in modern-day eukaryotes the inner membrane of both the mitochondria and chloroplast contain structures more similar to prokaryotes than eukaryotes, whereas the outer membrane retains eukaryote characteristics! It is also suggested that continued membrane infolding created the endomembrane system. It can be said that possibly the first eukaryotic cell type was miraculously born from prokaryotic, symbiotic, multicellular interactions.

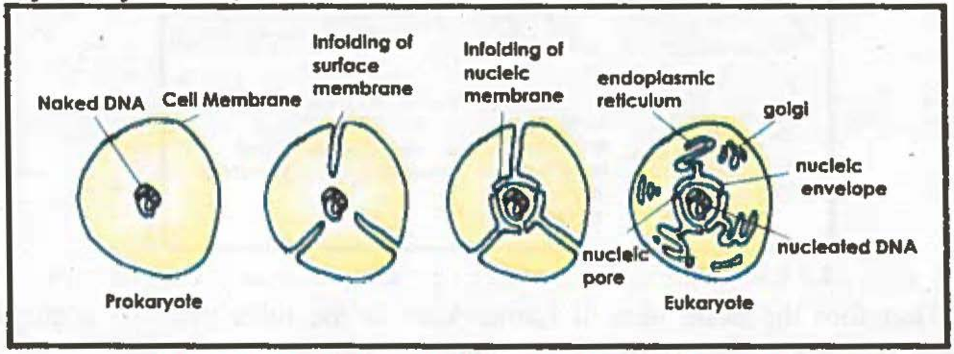


Fig: 24.4 Evolution of eukaryotes from prokaryotes.

24.3 LAMARCKISM

The earliest theory of organic evolution, was that of the French Jean Baptiste de Lamarck (1744-1829), first a soldier, then botanist and finally a professor of zoology in Paris, whose *Philosophic Zoologique* was published in 1809. Lamarck gave an explanation of evolution, based on the inheritance of acquired characters. An acquired character may be defined as a structural change in the body of organism involving a deviation from normal, induced in the life time of an individual due to certain change in the environment or in function i.e. use or disuse of an organ.

Lamarck gave many examples to prove his theory. For example

1. The ancestors of giraffe were forced to live in conditions where there was not enough grass to eat, so they started browsing upon the foliage trees and this effort resulted in elongation of their forelimbs and neck. This increase was passed on from generation to generation.
2. The loss of limbs in snakes is the result of crawling and concealing habit. The snakes e.g. pythons were provided with limbs but when mammals e.g. weasel arose; these snakes began to live in burrows so as to conceal themselves. The result was a gradual reduction and eventually loss of limbs, which were not needed in the new habitat.

Bodily modifications, whether brought through use or disuse or directly by environment cannot lead to the formation of new species unless they are inherited.

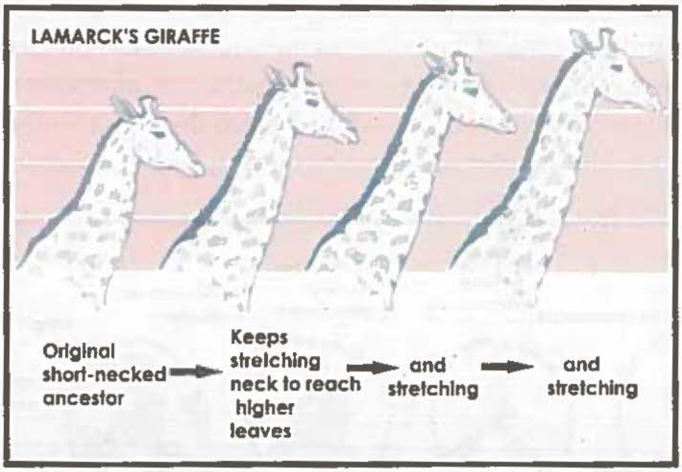


Fig: 24.5 Evolution of long neck of giraffe according to Lamarck.

Therefore the basic idea of Lamarckism is the inheritance of acquired characters, which is wrong in terms of principles of genetics.

24.4 DARWINISM

24.4.1 Darwin's voyage of HMS Beagle and his observations:

Charles Darwin (1809 –1882), was an English naturalist and is regarded as the pioneer of evolutionary idea for his theory of "Origin of species by natural selection" published in the book "Origin of species". After graduation from Cambridge, Darwin was appointed as a naturalist by professor Henslow, on the ship Beagle, which had to make a five year cruise round the world, preparing navigation charts for British navy.

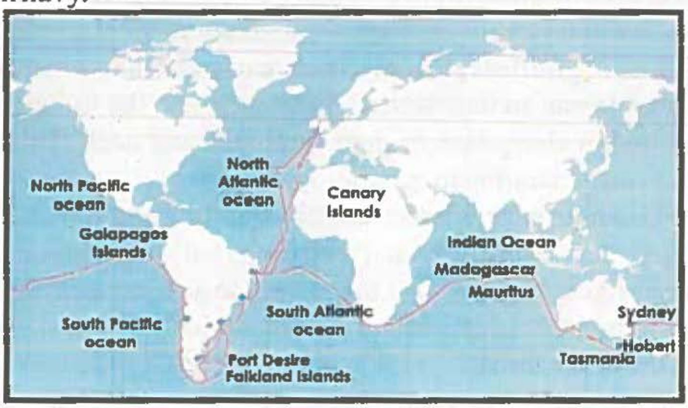


Fig: 24.6 Darwin's voyage (1831-1836) proceeded from England to the coast of South Amer... across the pacific to Australia and back around the South Africa to England.

24.3.2 Darwin's theory of evolution

Darwin started the voyage, believing in the fixity of species or theory of special creation. He spent most of his time in collecting and studying thousands of animals and plants. Strange animals greeted his eye and he was impressed by the unique adaptation of these organisms.

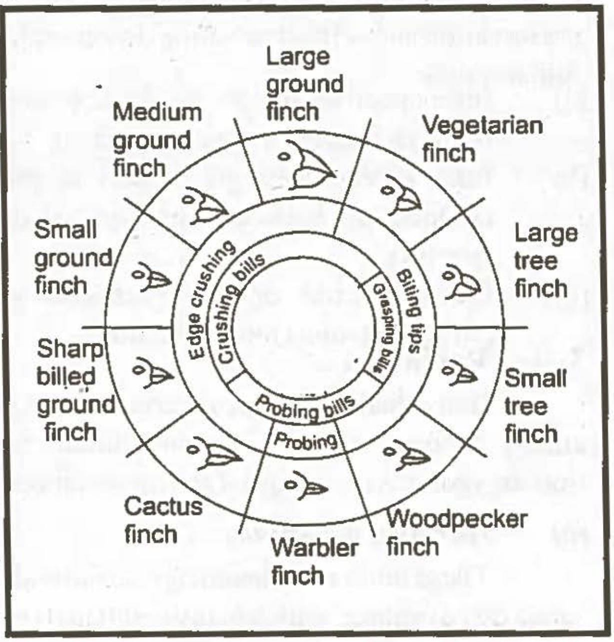


Fig: 24.7 A result of nature selection is adaptation as illustrated by thevarious beaks of Galapagos finch species. The diagram relates the beaks of some finches to their food supply.

He was surprised to see the diversity of giant tortoises and Finches (13 types) in Galapagos Islands, west of Ecuador. He noticed that fauna and flora of South America was distinct from the life forms of Europe. Darwin was impressed by the peculiar geographical distribution and distinctive interrelationship among species

This experience eventually led him to the idea that new species originate from ancestral forms by gradual accumulation of adaptations. The long delayed publication of Darwin's "On the origin of species by means of natural selection" 1859 was catalyzed by Alfred Wallace, who independently arrived at the theory of natural selection.

Salient features of Darwin – Wallace theory are:

1. Over production.
2. Struggle for existence.
3. Variation.
4. Natural selection or survival of the fittest.
5. Speciation or origin of new species.

1. Over Production

Each population of organisms has the potential to reproduce large numbers of off springs. Since environmental resources (food, space, nutrients etc.) are generally limited so limited numbers of offspring survive, due to competition on these resources.

2. Struggle for existence

Since more individuals are born then can survive, there is a severe competition, termed by Darwin as "struggle for existence". Such competition may involve struggle for food, space, mates and other necessities of life or against adverse climatic conditions of environment. The struggle for existence aims at self preservation and self perpetuation. In general, the struggle for existence may be three fold in nature:

(a) Intra specific struggle or rivals (competition between members of same species)

(b) Inter specific struggle or prey or predation (competition between members of different species).

(c) Extra specific or environmental struggle (struggle against forces of nature).

Fig: 24.8 Wolves defending their kill.

3. Variation

Individuals show great variation of form, size, colour, habit and physiology among themselves. No two individuals are alike. Not even identical twins (monozygote). According to Darwin variation is heritable, and is of two kinds:

(a) Harmful variations

These hinder and handicap the individuals in the struggle and place them at a great disadvantage, which many result in its extermination.

(b) Useful variations

These provide an advantage to the possessor over other and therefore increase the chances of survival.

4. Natural selection or survival of the fittest

Darwin argued that in the struggle for existence only those individuals survive, which possess advantageous variation over the unfortunate counterparts, the unfit perish. Darwin called it "natural selection", while Herbert Spencer used the term "survival of the fittest". Thus the fittest are automatically selected and the unfit are eliminated by nature.

5. Speciation or origin of species

The selected or the surviving individuals transmit their useful or successful variation to the succeeding generations. These resulting generations may produce descendants, which are quite different from their ancestors, different enough to be declared as a separate species.

This is the formation of new species or descent with modification or evolution.

24.5 NEO-DARWINISM

Neo - Darwinism and the Modern Synthesis

Since natural selection was proposed, advances in genetics, biochemistry, ecology and paleontology have enable scientists to identify mutation, genetic drift and gene flow as other natural forces of evolutionary change. The pioneering work of Cheverikov, Mayr, Simpson and many other led to what become known as the modern synthesis. Neo Darwinism, which emphasizes the role of genetics in explaining how evolution works. The modern theory accepts five major causes of evolution.

1. Gene and Chromosomal mutation.
2. Genetic recombination.
3. Natural selection.
4. Genetic drift.
5. Reproductive isolation

1. Gene mutation and Chromosomal mutation

As you know, that both gene and chromosomal mutation can bring about variations. These variations can lead to evolution.

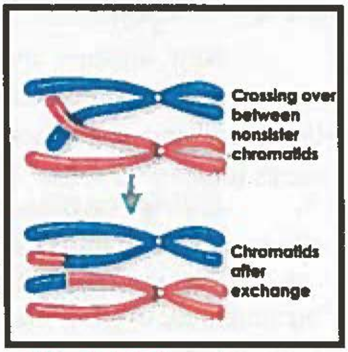


Fig: 24.9 Crossing over

2. Genetic Recombination

Reshuffling of genes occurs during sexual reproduction. Meiosis causes random assortment of genes during synapsis and rearrangement of paternal and maternal chromosomes in both kinds of gametes. Such reassortment of genes is one of the bases for the appearance of new genetic recombinations in the organisms. Crossing over of genes during meiosis also adds to the variations. Thus new combination of characteristics in the organism adds to genetic variability.

3. Natural selection

Natural selection uses the variations and mutations as the raw materials for better survivors. Thus natural selection due to environment always exerts a selective influence and molds the species to fit in its changed environment

4. Genetic drift

Genetic drift is concerned with changes in gene frequencies in small populations by chance. The gene frequencies will continue to fluctuate until a new mutation is either lost or is fixed. When a species moves from its original home into a new area, the individuals are not fully suited to the new environment. They are thus exposed to mutations with their gene pool markedly different from the parent population. Moreover when a species is expanding continuously, the populations invade new areas and become more different genetically after establishing themselves in those areas. This finally results in the modification of these populations into new species. Therefore genetic drift determines evolution.

5. *Reproductive isolation*

Reproductive isolation is regarded as one of the most important factors of evolution. It does not permit the interbreeding among the individuals of different species. It helps in splitting of the species and in the establishment of new species, which is responsible for bringing about evolution.

24.4.1 Evidences of Evolution

New species are evolved by descent with modification from a common ancestor. There are many facts and evidences from almost all subdivisions of biological science, which prove that evolution has occurred. Some of these evidences are as follows.

1. Evidence from comparative anatomy

Studies in comparative anatomy provide many evidences of evolution. In such study we are concerned with homologous structures - structures that have the same general arrangement of parts and similar mode of development but different functions. This condition is homology.

For example, human hand (grasping) a bat's wing (flying), cat's paw and horse front leg (running) and the front flipper of whale (swimming), all consists of the same number of bones, muscles, nerves and blood vessels arranged in the same pattern with similar mode of developments.

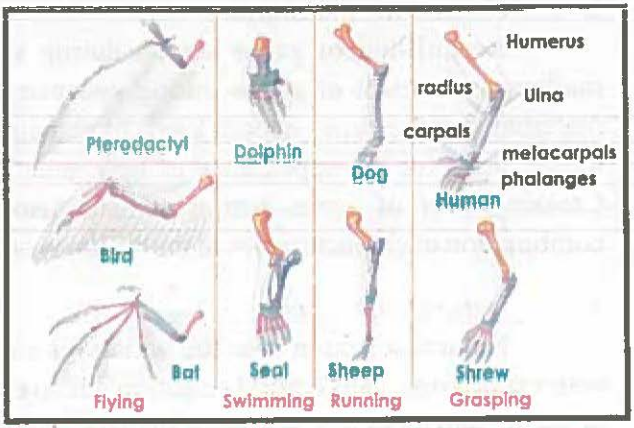


Fig: 24.10 In spite of different uses, the forelimbs of a number of very different vertebrates, all have the same framework of bone structure.

The conclusion drawn from this evidence is that groups of organisms have diverged sufficiently from ancestral type to constitute new species.

Evolution is therefore a conservative process and tends to remodel the existing ones. In the study of comparative anatomy, structures are often found that have the same function and are superficially alike, such as wings of bird, wings of butterfly and that of a flying lizard, yet they are quite different in origin and structural design. Such structures are said to be analogous. In short the analogous organs provide evidence for convergent evolution.

2. Fossil Evidence

Fossils are the remains of members of species that are ancestral to modern species. So a progressive series of fossils leading from an ancient, primitive organism, through several intermediate stages and end in modern form, provide a strong evidence of evolution.Fossil horses represent such a series. Giraffes, elephants and several mollusks show a gradual evolution of body form over time suggesting that species evolved from previous species. Another example is that of *Archeopteryx*, the fossil bird, discovered from rocks in East Germany. This bird possessed both reptilian as well as avian characters.

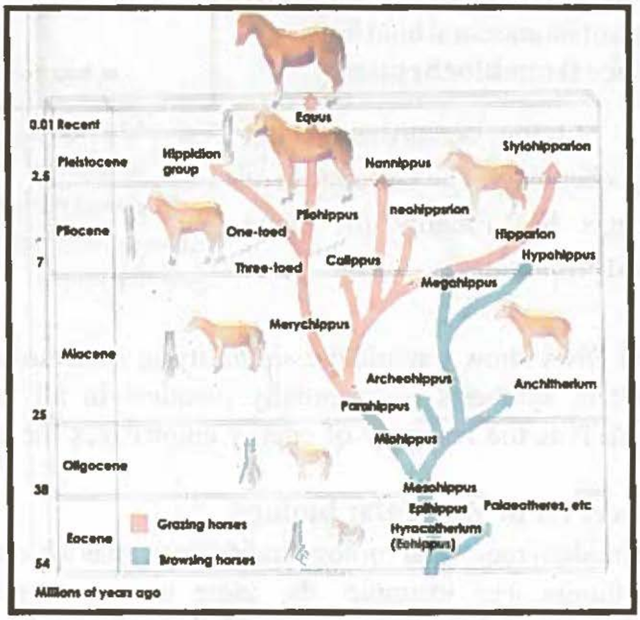


Fig: 24.11 The evolution of modern horse (*Equs*). A progression of fossils can be traced back over 60 million years to the "dawn horse" called *Eohippus*. This small ancestor had four toes in its front feet and three in its hind feet. The evolutionary pattern that lead to the modern horse included a reduction in the number of toes, the development of more complex teeth, and an increase in size. All species become extinct except the ancestral line that ended with *Equus*.

It shows that birds are evolved from reptiles and proves the truth of the statements that birds are glorified reptiles.

3. Evidence from vestigial organs

In evolution, sometimes an organ becomes reduced and may even lose its function. Such organs are vestigial organs. It is believed that once such organs were function able in the ancestors. Presence of vestigial organs is the most convincing evidence of evolution.

Some of the examples of vestigial organs in human beings are nictitating membranes of eye, appendix, coccyx or tail bone and mammary glands of male. Vestigial organs are not confined to man only. Whale has vestiges of hind limbs buried in the flesh, where its tail begins. Python (a snakes) has tiny bony structures beneath the skin, which are the remains of its ancestral hind limb.

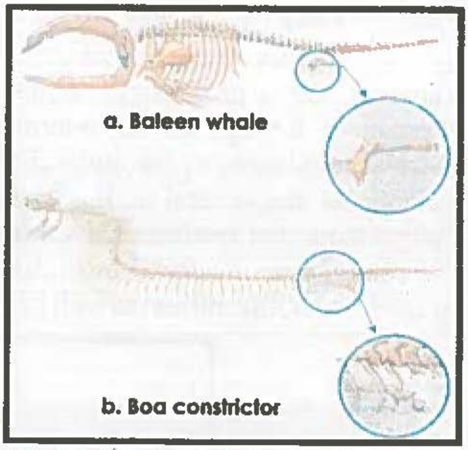


Fig: 24.12 Baleen whales and boa constrictors have no functional legs but still develop the vestigial pelvic bones and even miniature leg bones buried in their sleek sides.

4. Evidence from biochemistry

Living organisms exhibit similarity in biochemistry. The protoplasm of all living beings has roughly the same composition and properties.

The DNA and RNA show remarkable similarity in structure and function. The process of protein synthesis is essentially identical in all living beings. The occurrence of ATP as the reservoir of energy emphasizes the aspect of common origin.

5. Evidences from Molecular biology

The modern molecular biology indicates there is a biochemical similarity in all living things. For example, the same mechanisms for trapping and transforming energy and for building proteins from amino acids are nearly identical in almost all living systems. DNA and RNA are the mechanisms for inheritance and gene activity in all living organisms. The structure of the genetic code is almost identical in all living things. This uniformity in biochemical organization underlies the diversity of living things and points to evolutionary relationships.

6. Evidences from Embryology

The embryologist Karl Von Baer was the first to consider the fact that, no matter how great adult vertebrates may differ from each other in structure and habit, their embryos resemble one another and provides an evidence of evolution. For example, all multicellular animals begin their life as unicellular fertilized egg or zygote, which by the cell division forms hollow blastula, followed by gastrula. The cleavage, blastula and gastrula are almost fundamentally similar in all metazoan groups including man. In the development of frog, there is fish like stage of tadpole.

Haeckle was impressed by the striking similarity that exists between the embryonic development of higher organisms and evolutionary history of the race. This led to the belief that organism during its development repeat its ancestral history. Recapitulation theory of Von Baer or Biogenetic law of Hackle state that ontogeny (embryonic development of individual) recapitulates phylogeny (evolutionary history of the race) or "in development each individual tends to climb to its own family tree". In this way zygote can be supposed to be the unicellular ancestor and the gastrula a diploblastic ancestor in many organisms.

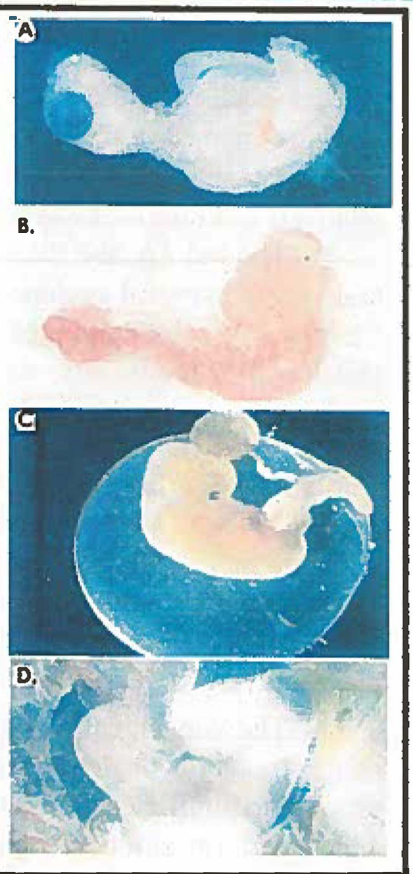


Fig: 24.13 Embryological stages reveal evolutionary relationship early embryonic stages of (A) turtle (B) mouse (C) human (D) chicken showing strikingly similar anatomical features.

24.5.2 Divergent and Convergent Evolution:

Adaptive radiation is one example of divergent evolution. Divergent evolution is the process of two or more related species becoming more and more dissimilar. If species have diverged while adapting to different environmental conditions, they should do so only in certain features, retaining ancestral traits unmodified by this adaptive process. The result should be that species resemble each other in many traits, leaving clues to their history of ancestry in the fine structure of their adaptations.

The term homology means "similarity due to shared developmental pathways." Homology can thus be recognized when structures evolve from the same precursor cells in embryos. Darwin argued that the most logical explanation for this sharing of pathways among different organisms was (1) that organisms had diverged from common ancestors, and (2) that early developmental stages had changed relatively less than later stages during evolution.

The red fox and the kit fox provide an example of two species that have undergone divergent evolution. The red fox lives in mixed farmlands and forests, where its red color helps it blend in with surrounding trees. The kit fox lives on the plains and in the deserts, where its sandy color helps conceal it from prey and predators. The ears of the kit fox are larger than those of the red fox. The kit fox's large ears are an adaptation to its desert environment. The enlarged surface area of its ears helps the fox get rid of excess body heat. Similarities in structure indicate that the red fox and the kit fox had a common ancestor. As they adapted to different environments, the appearance of the two species diverged.

Fig: 24.14 Kit fox and red fox.

The 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. Some animals have organs which perform similar functions and yet they are different in their origin and structure. Such organs are called analogous organs. So in convergent evolution, unrelated species become more and more similar in appearance as they adapt to the same kind of environment. The Cactus, which grows in the American desert resemble to the Euphorbia, which grows in the African deserts. Both have fleshy stems armed with spines. These adaptations help the plants store water and ward off predators. An 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. Some aspects of the lens of eyes also evolved independently in various animals.

24.5.3 Hardy Weinberg theorem:

In 1908, two scientists, Godfrey H. Hardy, an English mathematician, and Wilhelm Weinberg, a German physician, independently worked out a mathematical relationship that related genotypes to allele frequencies. Their mathematical concept, called the Hardy-Weinberg principle, is a crucial concept in population genetics.

It predicts how gene frequencies will be inherited from generation to generation given a specific set of assumptions. The Hardy-Weinberg principle states that in a large randomly breeding population, allelic frequencies will remain the same from generation to generation in the absence of following conditions.

i. mutation
ii. natural selection
iii. infinite large population
iv. all members of the population breed
v. all mating is totally random
vi. everyone produces the same number of offspring
vii. there is no migration in or out of the population

Fig: 24.15

In other words, if no mechanisms of evolution are acting on a population, evolution will not occur--the gene pool frequencies will remain unchanged. However, since it is highly unlikely that any of these seven conditions, let alone all of them, will happen in the real world, evolution is the inevitable result. Godfrey Hardy and Wilhelm Weinberg went on to develop a simple equation that can be used to discover the probable genotype frequencies in a population and to track their changes from one generation to another. This has become known as the Hardy-Weinberg equilibrium equation. In this equation $(p^2 + 2pq + q^2 = 1)$, p is defined as the frequency of the dominant allele and q as the frequency of the recessive allele for a trait controlled by a pair of alleles (A and a). In other words, p equals all of the alleles in individuals who are homozygous dominant (AA) and half of the alleles in people who are heterozygous (Aa) for this trait in a population. In mathematical terms, this is

$$p = AA + \tfrac{1}{2}Aa$$

Likewise, q equals all of the alleles in individuals who are homozygous recessive *(aa)* and the other half of the alleles in people who are heterozygous *(Aa)*.

$$q = aa + \tfrac{1}{2}Aa$$

Because there are only two alleles in this case, the frequency of one plus the frequency of the other must equal 100%, which is to say

$$p + q = 1$$

Since this is logically true, then the following must also be correct:

$$p = 1 - q$$

There were only a few short steps from this knowledge for Hardy and Weinberg to realize that the chances of all possible combinations of alleles occurring randomly is

$$(p+q)^2 = 1$$

or more simply

$$p^2 + 2pq + q^2 = 1$$

In this equation, p^2 is the predicted frequency of homozygous dominant *(AA)* people in a population, *2pq* is the predicted frequency of heterozygous *(Aa)* people, and q^2 is the predicted frequency of homozygous recessive (aa) ones.

From observations of phenotypes, it is usually only possible to know the frequency of homozygous recessive people, or q^2 in the equation, since they will not have the dominant trait. Those who express the trait in their phenotype could be either homozygous dominant (p^2) or heterozygous *(2pq)*. The Hardy-Weinberg equation allows us to predict which ones they are. Since $p = 1 - q$ and q is known, it is possible to calculate p as well. Knowing p and q, it is a simple matter to plug these values into the Hardy-Weinberg equation $(p^2 + 2pq + q^2 = 1)$. This then provides the predicted frequencies of all three genotypes for the selected trait within the population.

24.5.4 Genetic Drift

Allele frequencies in small populations do not generally reflect those of larger populations since too small of a set of individuals cannot represent all of the alleles for the entire population. Genetic drift occurs when the population size is limited and therefore by chance, certain alleles increase or decrease in frequency. This can result in a shift away from Hardy-Weinberg equilibrium (HWE). Unlike natural selection, genetic drift is random and rarely produces adaptations to the environment.

Although population genetics by itself is important, one of the objectives of this field is to assess how changes in allele frequencies affect the evolution of a population. Evolution in its modern form was first explored by Charles Darwin in 1859. In his book *On the Origin of Species*, Darwin outlined what he called "descent with modification" and what we now refer to as evolution. He speculated that all species evolved from a common ancestor. Over time, faced with new environments and habitats, populations of species acquired modifications, which allowed them to better adapt to their environment.

Darwin termed these changes within populations, natural selection, and he proposed the idea of "survival of the fittest." Individual variations which proved beneficial would be preserved within a population, whereas variations that were lethal to the organism would be destroyed. Under natural selection, some individuals in a population have modifications that allow them to more successfully survive and reproduce, making their adaptations more common as a whole due to their increased reproductive success. Over a long period of time, this change in the characteristics of a population can lead to the production of a new species.

24.5.5 Speciation:

Speciation is the evolutionary process by which new biological species arise. Speciation is among the most fundamental events in the history of life. It has occurred millions, if not billions, of times since life originated some 3.5 billion years ago.

How speciation works; starts from an initial step that isolates populations, a second step that results in traits such as mating system or habitat use to diverge, and a final step that produces reproductive isolation. According to this model, the isolation and divergence steps were thought to take place over time and to occur while populations were located in different geographic areas.

Polyploidy, dispersal, and variance only create the conditions for speciation. For the event to continue, genetic drift and natural selection have to act on mutations in a way that creates divergence in the isolated populations.

Sympatric speciation:

Sympatric speciation occurs when populations of a species that share the same habitat become reproductively isolated from each other. This speciation phenomenon most commonly occurs through polyploidy, in which an offspring or group of offspring will be produced with twice the normal number of chromosomes. Where a normal individual has two copies of each chromosome (diploidy), these offspring may have four copies (tetraploidy). A tetraploid individual cannot mate with a diploid individual, creating reproductive isolation.

Sympatric speciation is rare. It occurs more often among plants than animals, since it is so much easier for plants to self-fertilize than it is for animals. A tetraploidy plant can fertilize itself and create offspring. For a tetraploidy animal to reproduce, it must find another animal of the same species but of opposite sex that has also randomly undergone polyploidy.

Allopatric speciation:

Allopatric speciation, the most common form of speciation, occurs when populations of a species become geographically isolated.

When populations become separated, gene flow between them ceases. Over time, the populations may become genetically different in response to the natural selection imposed by their different environments. If the populations are relatively small, they may experience a founder effect: the populations may have contained different allelic frequencies when they were separated. Selection and genetic drift will act differently on these two different genetic backgrounds, creating genetic differences between the two new species.

Parapatric Speciation:

Parapatric speciation is extremely rare. It occurs when populations are separated not by a geographical barrier, such as a body of water, but by an extreme change in habitat. While populations in these areas may interbreed, they often develop distinct characteristics and lifestyles. Reproductive isolation in these cases is not geographic but rather temporal or behavioral. For example, plants that live on boundaries between very distinct climates may flower at different times in response to their different environments, making them unable to interbreed.

Fig: 24.16

Facts about Creation of living organisms

The theory of evolution as proposed by Charles Darwin in the 19th century, is one of the most unbelievable and irrational claims in history. Despite this, over its 150-year history the people who have accepted it have failed to produce any scientific evidence, supporting the theory. The theory puts forth the irrational claim that all living organisms, plants, animals and human beings are the result of blind, unconscious, accidental events. Evolutionists believe that millions of years ago, in the primal soup of the oceans or pools of water, mindless atoms with no knowledge, powers of reason came together in certain proportions and later, by chance, formed the proteins and cells that even today's scientists with most advanced laboratory technology have not been able to duplicate. They go so far as to say that these cells, in their turn- and again by sheer chance- formed starfish, sparrows, hawks, penguins, cats, lambs, loins, apples, apricots, pomegranates, figs and even human beings. If human efforts cannot produce any living thing by using the whole pool of human knowledge, how can life be brought into being with the aid of unconscious atoms and chance events? Any intelligent human being of conscience can certainly understand that all living things including himself cannot be the result of chance vents. Every intelligent, unprejudiced person with a conscious knows that Allah has created all these living things with His incomparable power.

The universe with all its creations both living and non-living has a flawless design, unique systems and an ordered balance that provide all the conditions necessary for living things to survive. Scientific discoveries, especially in the 20th and 21st centuries, have shown that the flawless design of the universe is clearly the work of supreme intelligence, The Allah, with

His supreme intelligence, limitless knowledge and eternal power created the universe. How is it possible to think that the balance in the ecosystem and the universe as a whole came about by mere coincidence when the extraordinary harmony of nature is observable even with the naked eye? It is the most unreasonable claim to say that the universe, each point of which suggests the existence of its Creator, has come into being on its own.The fact about the creation is that there is a mighty force in the universe that has created all different types of living things once by special creation and in them have put the ability to reproduce their next generations. This mighty force is Allah the Almighty Who is the Creator and Who sustains life on earth. The hypothesis that two prokaryotes cells invaded another prokaryote cell resulting in the evolution of a eukaryote cell is as baseless as some ones claim that two rakshas invaded a third one and in this way a motor car was evolved. The above hypothesis suggests that one of the invading prokaryote cell was changed into mitochondria and another invading prokaryote cell was modified into chloroplast. Thousands of questions arise from the above hypothesis.

Some of the questions, the proponents of blind evolution need to answer, are given below:

1. The first and foremost question is how prokaryote cells came into being?
2. How it started division?
3. How proteins, the most complicated organic compounds formed of units called amino acids, were formed?
4. How nucleic acids, which are also complicated organic compounds formed of units called nucleotides, were formed?
5. What is the probability of formation of these two essential organic compounds together? As for the synthesis of one, the other is required. If for example both of the above organic compounds were formed by chance factor, which is practically impossible, at different places then the evolution of a cell and its further division would not have been possible.
6. How autotrophic cyanobacteria developed chlorophyll?
7. The chromosome of prokaryotes is circular in shape while the chromosomes of eukaryotes are of different shapes and size. How these differences developed?
8. How other membranous structures such as Golgi bodies, endoplasmic reticulum, lysosomes, peroxisomes etc were evolved?
9. If billions of prokaryotes are cultured together for a hundred years what will be the probability of evolution of a eukaryotic cell like the one claimed at the beginning?
10. What is the probability of developing a living cell from the material (components) of cell putting together?
11. The most important question is what is life? How is it originated?
12. If evolution is a blind process for example why is it stopped on human being? If not what type of organisms will evolve from humans and when will it start?
13. What about the Universe? Who created it?
14. How the high degree of discipline present in the universe can be explained?
15. What kind of forces are responsible for the movements of earth in its axis and orbit

around the sun?

16. The matter as a whole is inorganic. Organic compounds are produced by the green plants which are producers in the ecosystem. Heterotrophic prokaryote use organic compounds for energy source. Wherefrom the heterotrophic cells obtained these organic compounds?

17. The structure of both mitochondria and chloroplasts are totally different from heterotrophic prokaryote and autotrophic cyanobacteria.

18. How nucleus came into existence because prokaryote cell does not contain a membrane bounded nucleus characteristic of eukaryotic cell?

Therefore there should be a Creator of the universe and an Owner of the balance visibly everywhere from our body to the farthest corners of the vast universe. Who is that Creator? That Almighty Creator is one. He is Allah. He brought into existence everything and Whose existence is without any beginning or end.

KEY POINTS

- Descent with modification is evolution.
- Creationism, the idea that each species was created individually by God and never changed thereafter, reigned unchallenged for nearly 2000 years.
- George Cuvier proposed the theory of catastrophism.
- Geologists James Hutton and Charles Lyell contemplated the forces of wind, water, earthquake and volcanism as agents for creating layered pattern. These layers of rocks are evidence of ordinary natural processes, occurring repeatedly over a long periods of time. This concept is called uniformitarianism.
- The process involved in the evolution of eukaryotes are: endosymbiosis and membrane infolding.
- The earliest theory of organic evolution, was that of the French Jean Baptiste de Lamarck first a soldier, then botanist and finally a professor of zoology in Paris, whose *Philosophic Zoologique* was published in 1809.
- Lamarck gave an explanation of evolution, based on the inheritance of acquired characters.
- Charles Darwin is regarded as the pioneer of evolutionary idea for his theory of "Origin of species by natural selection" published in the book "Origin of species".
- Salient features of Darwin –Wallace theory are: Over production, struggle for existence, variation, natural selection or survival of the fittest and speciation or origin of new species.

EXERCISE

1- Multiple Choice Questions

(i) ***The random loss of alleles in a population is called***
- (a) Mutation (b) Selection
- (c) Gene flow (d) Genetic drift

(ii) ***Human appendix, coccyx and nictitating membrane of the eye are:***
- (a) vestigial organs (b) homologous organs
- (c) analogous organs (d) embryonic organs

(iii) ***The existing species are the modified descendants of pre- existing ones according to:***
- (a) Theory of special creation (b) theory of organic evolution
- (c) uniformitarianism (d) theory of catastrophe

(iv) ***Using the Hardy-Weinberg Principle, which expression represents the frequency of the homozygous recessive genotype?***
- (a) P^2 (b) 2pq
- (c) q^2 (d) q

(v) ***Which one of the following would cause the Hardy-Weinberg principle to be inaccurate?***
- (a) The size of the population is very large.
- (b) Individuals mate with one another at random.
- (c) Natural selection is present.
- (d) There is no source of new copies of alleles from outside the population.

(vi) ***The study of birds is:***
- (a) ornithology (b) ichthyology
- (c) herpetology (d) entomology

(vi) ***Similarity in characteristics resulting from common ancestry is known as:***
- (a) Analogy (b) Homology
- (c) Evolutionary relationship (d) Phylogeny

(vii) ***The parts of the body use extensively to cope with the environment become larger and stronger, while those that are not used deteriorate was argued by:***
- (a) Charls Darwin (b) Alfred Wallace
- (c) Carolus

EXERCISE

(viii) ***Which one of the following pairs represents analogous features?***
- **(a)** Elephant tusks & Human incisors
- **(b)** Insects wings & bat wings
- **(c)** Mammal fore limb & bird wing
- **(d)** Reptilian heart & mammalian heart

(ix) ***In which of the following situations would evolution be slowest for an inter breeding population?***

	Migration	Selection Pressure	Variation due to Mutation
(a)	Absent	Low	Low
(b)	Absent	High	High
(c)	High	Low	High
(d)	High	High	Low

(x) ***Which of the following ideas was not part of Charles Darwin's theory of evolution by natural selection?***
- **(a)** Organisms produce more offspring than the environment can support.
- **(b)** Variation between individuals arises by gene mutation.
- **(c)** Only those individuals that are best adapted to the environment survive and reproduce.
- **(d)** Individuals compete for space and resources.

2- Short Questions

(i) Differentiate between special creation and evolution.

(ii) Why flora and fauna of Australia is different is different from the other world?

(iii) What is the endosymbiosis view of eukaryotic origin

(iv) Define Hardy Weinberg theorm and name conditions necessary to keep population in equilibrium.

(v) Define speciation.

3- Long Questions

(i) Analyze the divergent evolution and convergent evolution in light of evidences from comparative anatomy.

(ii) Describe the mechanism of evolution as proposed by Lamarck.

(iii) Explain Darwin's theory of evolution by natural selection

EXERCISE ?

(iv) Discuss Hardy-Weinberg principle as an evidence of evolution.

(v) Define and explain the mechanism of speciation.

4- **Analyzing and Interpreting**

- Interpret different homologous and analogous structure through observations in plants
- Solve problems related to gene frequencies using Hardy-Weinberg equation.

5- **Initiating and Planning**

- Identify questions that arise from concept of evolution and diversity (e.g. what factors have contributed to the dilemma that pharmaceutical companies face in trying to develop new antibiotics because so many microorganisms are resistant to existing antibiotics?)
- Hypothesize whether Lamarck was criticized in his day for advocating the ideas of evolution or for the mechanism he proposed.

6- **Science, Technology, and Society Connections**

- List the vestigial structure found in man and categorizes them in homologous or analogous organs.
- Describe and analyze examples of technology that have extended or modified the scientific understanding of evolution (e.g. the contribution of radiometric dating to the paleontological analysis of fossils).

7- **Online Learning**

- www.evolution.berkeley.edu
- www.imdb.com
- www.projects.gnome.org/evolution
- www.conservapedia.com/Evolution