CHAPTER

24

Evolution

Animation 24: Evolution
Source & Credit: Wikispaces

Questions of origins of earth and life on it have been on the minds of humans since prehistoric times. Many of us are also concerned with questions of origin: How old is the planet earth? How long has life been on earth? How did life arise on earth? How did a certain animal species come into existence? Answers for these questions come from scientific inquiry. In this chapter we will study some aspects of organic evolution.
Evolution refers to the processes that have transformed life on earth from its earliest forms to the vast diversity that we observe today. Evolutionary change is based mainly on the interactions between populations of organisms and their environments. Whenever we say or hear the word evolution, name of Darwin comes in our mind immediately. In fact, he was the first person who argued from evidence that species were not specially created in their present forms, rather they had evolved from ancestral species. He also proposed a mechanism for evolution, which he termed Natural Selection.

CONCEPT OF EVOLUTION VS SPECIAL CREATION

In a bid to explain the cause of diversity of life and interrelationship among living organisms, two schools of thought emerged in the earlier 19th century. Creationists believed in the Theory of Special Creation, whereas evolutionists believed in the Theory of Natural Selection. According to the theory of special creation, all living things came into existence in their present forms especially and specifically created by Nature. Among the scientists who believed in divine creation was Carolus Linnaeus (1707-1778).

Animation 24.1: Evolution
Source & Credit: wifflegif

Scientist's Name	Life Span	Achievements
Linnaeus Lamarck	1707-1778 1744-1829	Sought and found order in the diversity of life. He introduced binomial nomenclature for naming species. Published his theory of evolution.
Malthus	1766-1834	Published Essay on the "Principle of Population".
Cuvier	1769-1832	Contributed much to the science of Palaeontology and explained Earth's history by catastrophism.
Lyell	1797-1875	Published Principles of Geology.
Darwin	1809-1882	1. Voyage of the Beagle 2. Began his notebooks on the origin of species. 3. Wrote his essay on the origin of species.
Mendel	1822-1884	Published papers on inheritance.
Wallace	1823-1913	Sent his theory to Darwin.

The idea that organisms might evolve through time, with one type of organism giving rise to another type of organism, is an ancient one, existing from the days of Aristotle. Aristotle recognized that organisms ranged from relatively simple to very complex structures. However, the present day concept of evolution is based on a known history (Table 24.1).

Let us now discuss some details of the work done by these scientists. As you know, Carolus Linnaeus in the eighteenth century classified organisms. He grouped similar species in the same genus and similar genera in one family. But as a natural theologian, he believed that species were permanent creations. A century later, the taxonomic system of Linnaeus became a focal point in Darwin's arguments for evolution.

EVOLUTION FROM PROKARYOTES TO EUKARYOTES

One of the speculations trying to explain the origin of life is that it may have begun deep in the oceans, in underwater hot springs called hydrothermal vents. These vents could have supplied the energy and raw materials (for the origin and survival of early life forms. A group of bacteria, called archaeobactiria-that tolerate temperatures up to 120°C and seem to have undergone less evolutionary ihange than any other living species supports this vent hypothesis.

The nutrients produced in the primitive environment would have limited early life., If life were to continue, another source of nutrients was needed. Photosynthesis, probably freed living organisms from a dwindling supply of nutrients. The first photosynthetic organisms probably used hydrogen sulfide as a source of hydrogen for reducing carbon dioxide to sugars. Later, water served this same purpose, and oxygen liberated by photosynthetic reactions began to accumulate in the atmosphere. Earth and its atmosphere slowly began to change.

Ozone in the upper atmosphere began to filter ultraviolet radiation from the sun, the reducing atmosphere slowly became an oxidizing atmosphere, and at least some living organisms began to utilize oxygen. About 420 million years ago, enough protective ozone had built up to make life on land possible. Ironically, the change from a reducing atmosphere to an oxidizing atmosphere also meant that life could no longer arise abiotically .The first cells were most likely very simple prokaryotic forms. The prokaryotes may have arisen more than 3.5 billion years ago. Eukaryotes are thought to have first appeared about 1.5 billion years ago. The eukaryotic cell might have evolved when a large anaerobic (living without oxygen) amoeboid prokaryote ingested small aerobic (living with oxygen) bacteria and stabilized them instead of digesting them. This idea is known as the endosymbiont hypothesis (Fig.24.la) and was first proposed by Lynn Margulis. According to this hypothesis, the aerobic bacteria developed into mitochondria, which are the sites of aerobic respiration and most energy conversion in eukaryotic cells. The possession of these mitochondria like endosymbionts brought the advantage of aerobic respiration to the host.

Flagella (whiplike structures) may have arisen through the ingestion of prokaryotes similar to spiral-shaped bacteria called spirochetes. Ingestion of prokaryotes that resembled present-day cyanobacteria could have led to the endosymbiotic development of chloroplasts in plants.

Another hypothesis for the evolution of eukaryotic cells proposes that the prokaryotic cell membrane invaginated (folded inward) to enclose copies of its genetic material (Fig. 24.1b). This invagination resulted in the formation of several double membrane-bound entities (organelles) in a single cell. These entities could then have evolved into the eukaryotic mitochondrion, nucleus, chloroplast etc.

Whatever the exact mechanism for the evolution of the eukaryotic cell might be, the formation of the eukaryotic cell led to a dramatic increase in the complexity and diversity of life-forms on the earth. At first, these newly formed eukaryotic cells existed only by themselves. Later, however, some probably evolved into multicellular organisms in which various cells became specialized into tissues, which, in turn, formed organs for many different functions. These multicellular forms then adapted themselves to life in a great variety of environments.

Animation 24.2: Evolution from Prokaryots to Euokaryot
Source & Credit: Ameoba Sisters

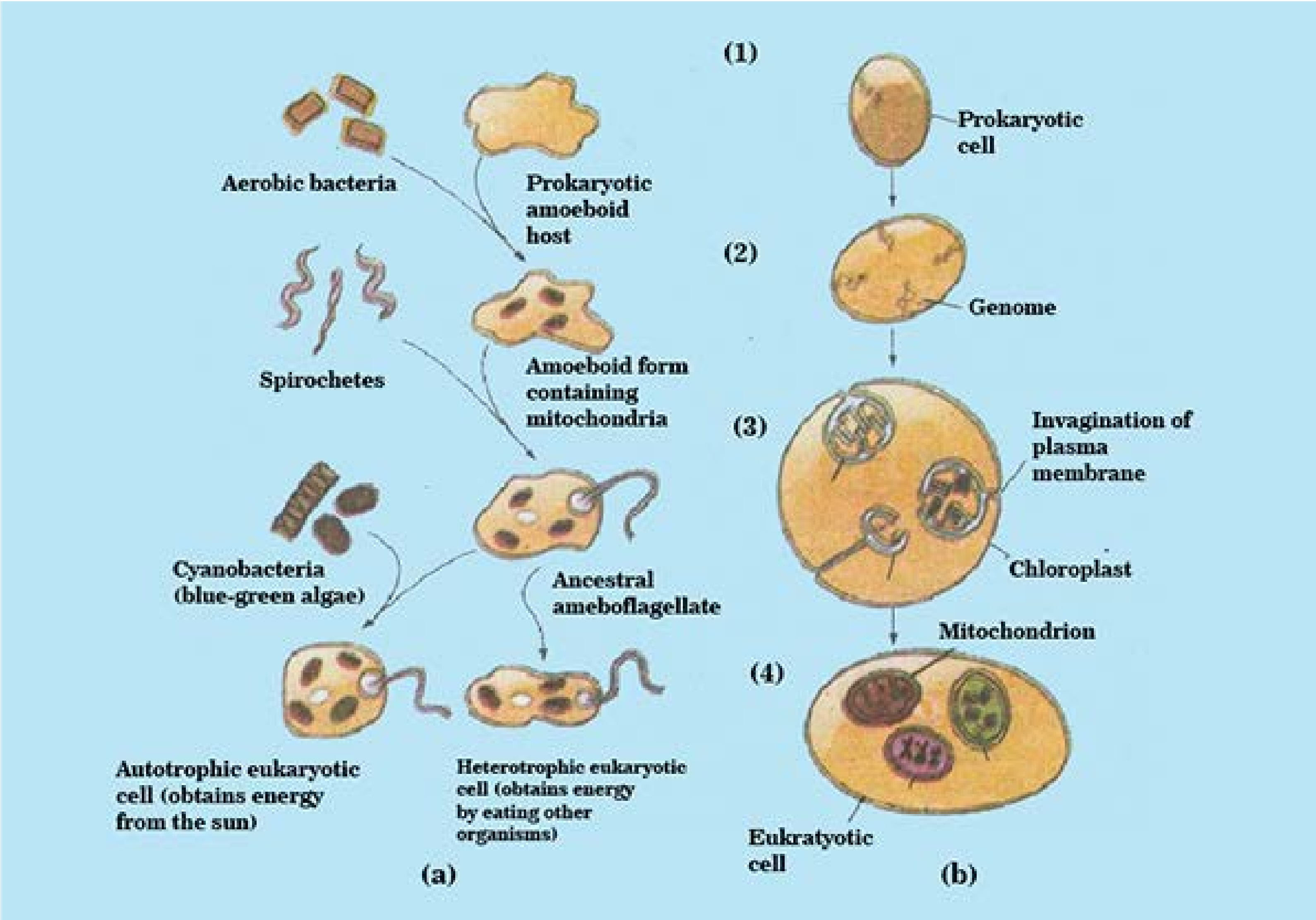


Figure 24.1: Two hypotheses on the evolution of the eukaryotic cell. (a) Endosymbiont hypothesis, (b) Membrane invagination hypothesis. (1) A prokaryotic cell (2) Duplicates its genetic material (genome) (3) The plasma membrane then invaginates to form double membrane-bound organelles, and the individual genomes separate from each other (4) The nuclear genome eventually enlarges, while the other organelle genomes lose many of their genes, resulting in a eukaryotic cell.

INHERITANCE OF ACQUIRED CHARACTERISTICS

Toward the end of the eighteenth century, several naturalists suggested that life had evolved along with the evolution of earth. But only one of Darwin's predecessors developed a comprehensive model that attempted to explain how life evolves. Jean Baptiste Lamarck (1744-1829) published his theory of evolution in 1809, the year Darwin was bom. Lamarck was in-charge of invertebrate collection at the Natural History Museum in Paris. He presented a mechanism to explain how specific adaptations evolve. Lamarck argued that those parts of the body used extensively to cope with the environment become larger and stronger, while those that are not used deteriorate.

Among the examples Lamarck cited were the blacksmith developing a bigger bicep in the arm that works the hammer and giraffe stretching its neck to new lengths in pursuit of leaves to eat. The second idea Lamarck adopted, was called the inheritance of acquired characteristics. In this concept of heredity, the modifications an organism acquires during its lifetime can be passed along to its offspring'e.g. the long neck of the giraffe, Lamarck reasoned, evolved gradually as the cumulative product of a great many generations of ancestors stretching higher and higher. However, now we know that acquired characteristics cannot be inherited.

Charles Darwin

Charles Darwin was born in Shrewsbury, in Western England, in 1809. He joined ' the expedition on Beagle to South American coastline. He observed and collected thousands of specimens of diverse fauna and flora of South America. He noticed that the fauna and flora of the different regions of the continent had a definite South American stamp, very distinct from the life forms of Europe. Furthermore, the South American fossils that Darwin found, though clearly different from modem species, were distinctly South American in their resemblance to the living plants and animals of that continent.

A particularly puzzling case of geographical distribution was the fauna of the Galapagos islands. Most of the animal species on the Galapagos live nowhere else in the world, although they resemble species living on the South American mainland. It was as though the islands were colonized by plants and animals that strayed from the South American mainland and then diversified on the different islands. Among the birds Darwin collected on the Galapagos were 13 types of finches that, although quite similar, seemed to be different species. Some were unique to individual islands, while other species were distributed on two or more islands that were close together.

After returning to Great Britain in 1836, Darwin perceived the origin of new species and adaptations as closely related processes. A new species would arise from an ancestral form by the gradual accumulation of adaptations to different environments, separated from original habitat by geographical barriers. Over many generations, the two populations could become dissimilar enough to be designated as separate species. This is apparently what happened to the ***Galapagos*** finches.

By the early 1840s, Darwin had worked out the major features of his theory of natural selection as the mechanism of evolution. In 1844, Darwin wrote a long essay on the origin of species and natural selection.

But before it could be published Alfred Wallace, a young naturalist working in the East Indies developed a theory of natural selection essentially identical to Darwin's. Wallace's paper, along with extracts from Darwin's unpublished 1844 essay, were presented to the Linnaean Society of London on July 1, 1858. Darwin quickly finished **The Origin of Species** and published it the next year. In this book Darwin developed two main points:

1. Descent with Modification :

Darwin believed in perceived unity in life, with all organisms related through descent from some common ancestor that lived in the remote past. In the Darwinian view, the history of life is like a tree, with multiple branching and rebranching from a common trunk all the way to the tips of the living twigs, symbolic of the current diversity of organisms. At each fork of the evolutionary tree is an ancestor common to all lines of evolution branching from that fork.

2. Natural Selection and Adaptation :

Darwin suggested that populations of individual species become better adapted to their local environments through natural selection. Darwin's theory of natural selection was based on the following observations.

1. Production of more individuals than the environment can support, leads to a struggle for existence among individuals of a population, with only a fraction of offspring surviving each generation.
2. Survival in the struggle for existence is not random,, but depends in part on the hereditary constitution of the surviving individuals. Those individuals whose inherited characteristics fit them best to their environment are likely to leave more offspring than the less fit individuals.
3. This unequal ability of individuals to survive and reproduce will lead to a gradual change in a population, with favourable characteristics accumulating over the generations thus leading to the evolution of a new species.

Neo-Darwinism - The modern evolutionary synthesis

The **Origin of Species** convinced most biologists that species are **products of** evolution. An important turning point for evolutionary theory was the birth of population genetics, which emphasizes the extensive genetic variation within populations and recognizes the importance of quantitative characters. With progress in population genetics in the 1930s, Mendelism and Darwinism were reconciled, and the genetic basis of variation and natural selection was worked out. Thus, a comprehensive theory of evolution that became known as the **modern synthesis or Neo-Darwinism** was developed in the early 1940s. It is called a synthesis because it integrated discoveries and idea« from many different fields, including paleontology, taxonomy, biogeography, of course, population genetics.

Evidences of Evolution

Evolution leaves observable signs. Darwin's theory of evolution was mainly based on the evidence from the geographical distribution of species and from the fossil record. However, there have been many evidences as biology progressed. New discoveries, continue to validate the evolutionary view of life. Let us discuss now some of the evidences.

Biogeography : It was the geographical distribution of species— biogeography— that first suggested the idea of evolution to Darwin. Islands have many species of plants and animals that are endemic but closely related to species of the nearest mainland or neighboring island. Consider armadillos, the armored mammals that live only in America. The evolutionary view of biogeography predicts that contemporary armadillos are modified descendants of earlier species that occupied these continents, and the fossil record confirms that such ancestors existed.

The Fossil Record : The succession of fossil forms is a strong evidence in favour of evolution. It provides a visual record in a complete series showing the evolution of an organism. For instance, evidence from biochemistry, molecular biology, and cell biology places prokaryotes as the ancestors of all life, and predicts that bacteria should precede all eukaryotic life in the fossil record. Indeed, the oldest known fossils are prokaryotes.

Another example is the chronological appearance of the different classes of vertebrate animals in the fossil record. Fossil fishes, the earliest vertebrates, with amphibians next, followed by reptiles, then mammals and birds. This sequence is consistent with the history of vertebrate descent. The evolution of horse provides an example of such a history.

Fossils are either the actual remains or - traces of organisms that lived in ancient geological times. The organism may be embedded in sand, resin or ice, or an impression or cast is made of the body parts, the tissue being replaced or petrified by silica or calcium carbonate minerals. Most fossils are found in sedimentary rocks.

Comparative Anatomy : Anatomical similarities between species grouped in the same taxonomic category bring another support to the theory of the Descent with modification. For example, the same skeletal elements make up the forelimbs of human, cats, whales, bats, and all other mammals, although these appendages have very different functions.

The basic similarity of these forelimbs is the consequence of mammals from a common ancestor. The amis, wings, flippers, and forelegs of different mammals are variations on a common anatomical theme that has been modified for divergent functions. Similarity in characteristics resulting from common ancestry is known as homology, and such anatomical signs of evolution are called homologous structures. Comparative anatomy supports that evolution is a remodeling process in which ancestral structures that functioned in one capacity become modified as they tale on new functions. The flower parts of a flowering plant are homologous. They are considered to have evolved from leaves, to form sepals, petals, stamens and carpels

Homologous organs are functionally different but structurally alike e.g. Fore limbs of man, bat, horse, whale etc. are example of divergent evolution. Analogous organs are functionally alike but structurally different e.g. wings of bat, birds and insects etc. are examples of convergent evolution.

The oldest homologous structures are vestigial organs, rudimentary structures of marginal, if any, use to the organism. Vestigial organs are historical remnants of structures that had important functions in ancestors but are no longer essential presently. For instance, the skeletons of whales and some snakes retain vestiges of the pelvis and leg bones of walking ancestors, (Fig. 24.2) vermiform appendix in carnivores, ear muscles in man etc.

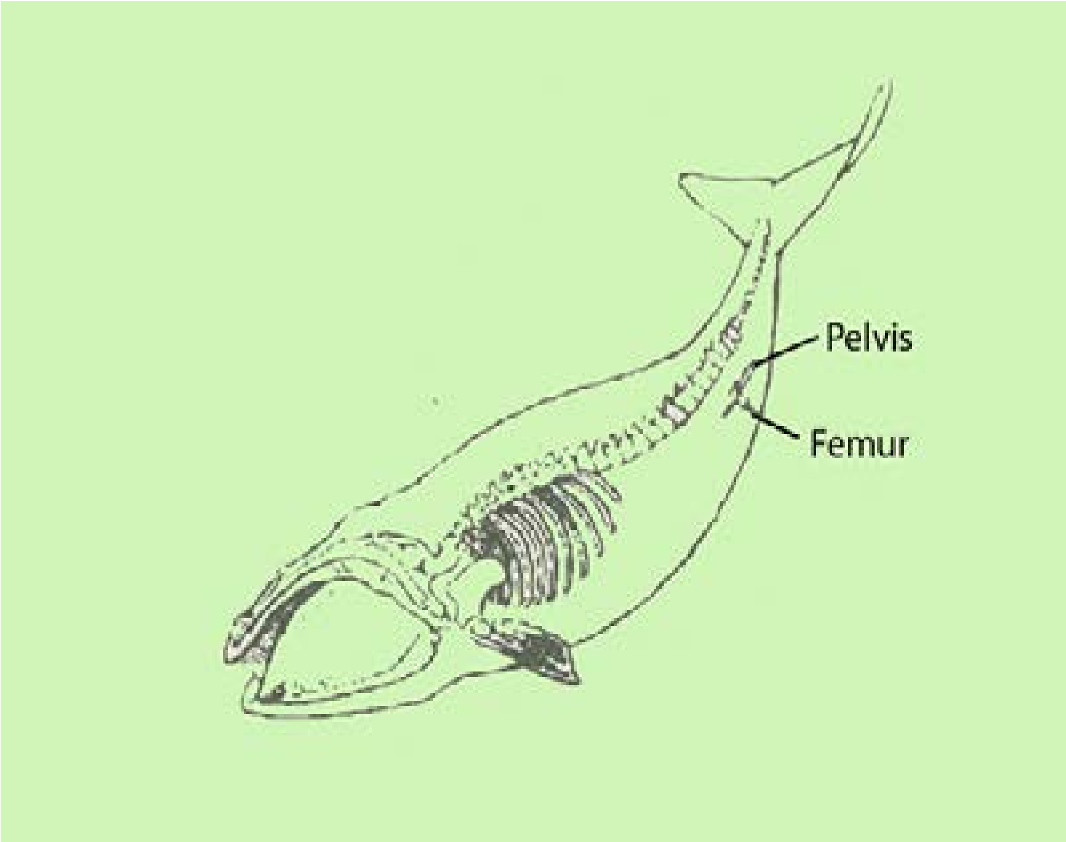
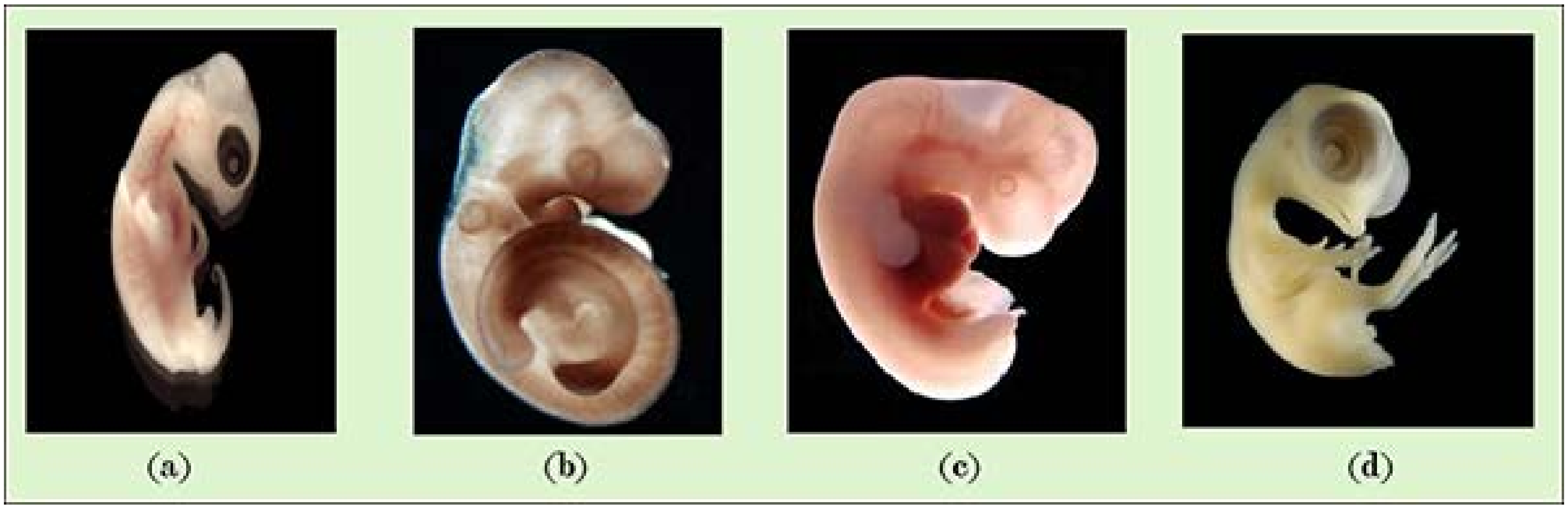


Fig. 24.2: The whale retains pelvic and leg bones as useless vestiges



ig. 24.3 Homologies among vertebrates are clearly evident early in development, as the photos reveal. Embryo (a) turtle, (b) mouse, (c) human, (d) chick.

Comparative Embryology : Closely related organisms go through similar stages in their embryonic development. For example, all vertebrate embryos go through a stage in which they have gill pouches on the sides of their throats. At embryonic stage of development, similarities between fishes, frogs, snakes, birds, humans, and all other vertebrates are much more apparent than differences (Fig.24.3). As development progresses, the various vertebrates diverge more and more, taking on the distinctive characteristics of their classes. In fish, for example, the gill pouches develop into gills; in terrestrial vertebrates, these-embryonic structures become modified for other functions, such as the eustachian tubes that connect the middle ear with the throat in humans.

Comparative embryology can often establish homology among structures, such as gill pouches, that become so altered in later development that their common origin would not be apparent by comparing their fully developed forms.

Molecular Biology: Evolutionary relationships among species are reflected in their DNA and proteins—in their genes and gene products. If two species have genes and proteins with sequences of monomers that match closely, the sequences must have been copied from a common ancestor. For example, a common genetic code brings evidence that all life is related. Molecular biology has thus provided strong evidence in support of evolution as the basis for the unity and diversity of life. Similarly, taxonomically remote organisms, such as humans and bacteria, have some proteins in common. For instance, cytochrome c, a respiratory protein is found in all aerobic species.

NATURAL SELECTION AND ARTIFICIAL SELECTION

Natural selection occurs through an interaction between the environment and the variability inherent in any population. Darwin found evidence in artificial selection, the breeding of domesticated plants and animals. Humans have modified other species over many generation by selecting individuals with the desired traits as breeding stock. The plants and animals we grow for food bear little resemblance to their wild ancestors. From the changes achieved by artificial selection within a relativ ely short period of time, Darvviq postulated that natural selection operating over vast spans of time could account for the entire diversity of life. Population is a group of inter-breeding individuals belonging to a particular species and sharing a common geographic area.

Natural selection can amplify or diminish only those variations that are heritable. It is noteworthy to say that adaptations that an organism acquires by its own actions are not heritable. The specifics of natural selection are regional and timely; environmental factors vary from place to place and from time to time. An adaptation in one situation may be useless or even detrimental in other circumstances. An example of natural selection in action is the evolution of antibiotic resistance in bacteria.

POPULATION, GENE POOL, ALLELE AND GENOTYPE FREQUENCIES

A population is a localized group of individuals belonging to the same species. For now, we will define a species as a group of populations that have the potential to interbreed in nature. Each species has a geographical range within which individuals are not spread out evenly, but are usually concentrated in several localized populations. A population may be isolated from others of the same species, exchanging genetic material only rarely. Such an isolation is particularly common for populations confined to widely separated islands, unconnected lakes, or mountain ranges separated by lowlands. Within a population individuals are concentrated in centers and are more likely to interbreed with members of the same population than with members of other populations. Therefore, individuals near a population center are, on average, more closely related to one another than to members of other populations.

The total aggregate of genes in a population at any one time is called the population's gene pool. It consists of all alleles at all gene loci in all individuals of the population. For a diploid species, each locus is represented twice in the genome of an individual, who may be either homozygous or heterozygous.

Animation 24.3: Gene Pool
Source & Credit: S-Cool

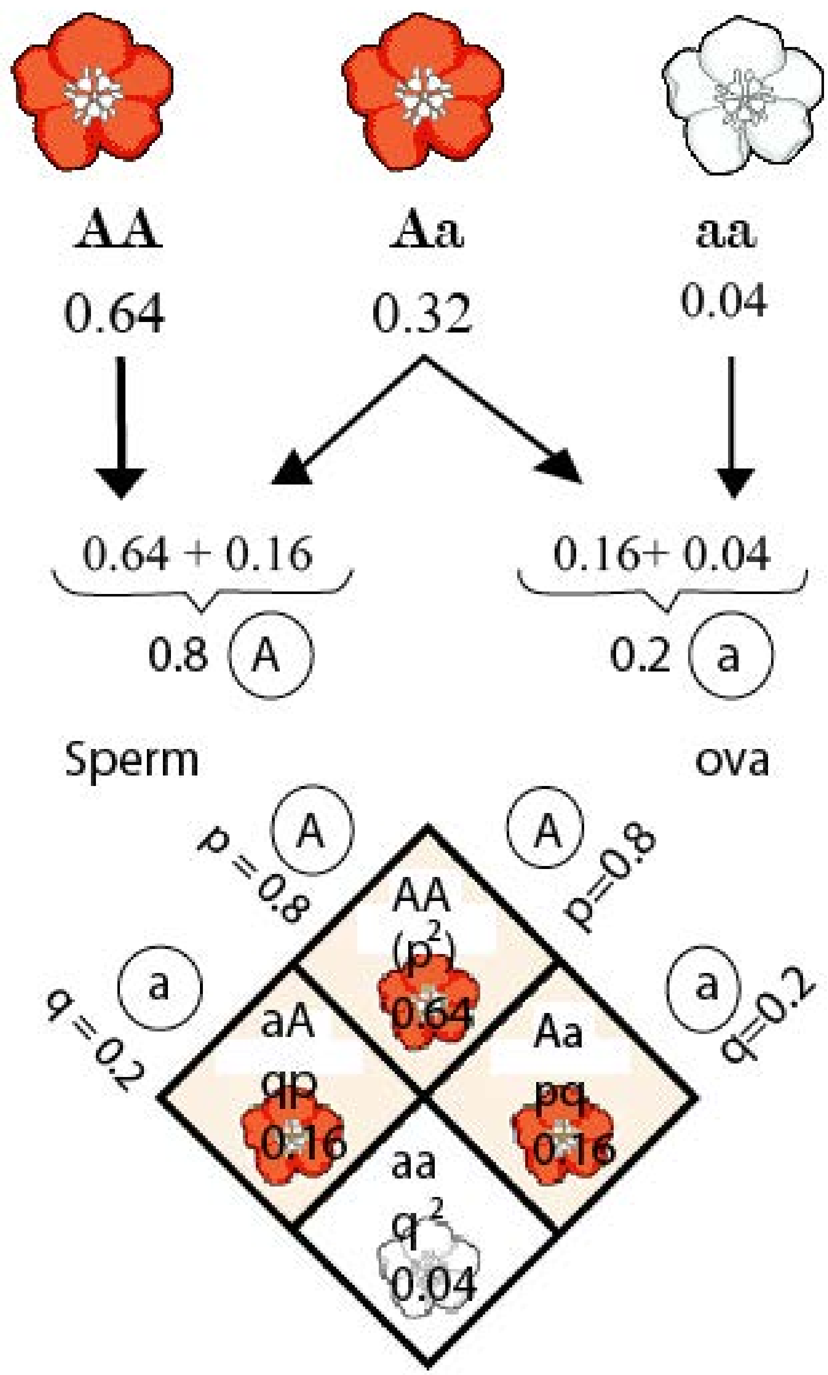


Figure 24.4: The Hardy-Weinberg theorem. The genetic structure of a non evolving population remains constant over the generations. Sexual recombination alone will not alter the relative frequencies of alleles or genotypes, (p = frequency of A; q = frequency of a)

If all members of a population are homozygous for the same allele, that allele is said to be **fixed** in the gene pool. More often, there are two or more alleles for a gene, each having relative frequency (proportion) in the gene pool. Let us consider an example. Imagine a wildflower population with two varieties contrasting in flower color. An allele for pink flowers, which we will symbolize by A, is completely dominant over an allele for white flowers, symbolized by a. Suppose these are the only two alleles for this locus in the population. Our imaginary population has 500 plants. Twenty have white flowers because they are homozygous for the recessive allele; their genotype is aa. Of the 480 plants with pink flowers, 320 are homozygous (AA) and 160 are heterozygous (Aa). Since these are diploid organisms, there are a total of lOOOcopies of genes for flower color in the population. The dominant allele accounts for 800 of these genes (320x2 = 640 for AA plants, plus 160x1 = 160 for An individuals). Thus, the frequency of the A allele in the gene pool of this population is 80%, or 0.8. And since there are only two allelic forms of the gene, the a allele must have a frequency of 20%, or 0.2. Related to these allele frequencies are the frequencies of genotypes. In our model wildflower population, these frequencies are: AA=0.64 (64%) (320 out of 500 plants), Aa=0.32 (160/500), and aa = 0.04 (20/500).

Hardy-Weinberg Theorem

The frequencies of genotypes of non evolving populations are described by Hardy-Weinberg theorem. Hardy-Weinberg theorem is named for the two scientists who derived the principle independently in 1908. It states that the frequencies of alleles and genotypes in a population's gene pool remain constant over the generations unless acted upon by agents other than sexual recombination. So shuffling of alleles due to meiosis and random fertilization has no effect on the overall genetic structure of a population. A general formula, called the Hardy- Weinberg equation is used for calculating the frequencies of alleles and genotypes in populations at equilibrium.

For a gene locus where only two alleles occur in a population, population geneticists use the letter p to represent the frequency of one allele and the letter q to represent the frequency of the other allele. In the imaginary wildflower population, p=0.8 and <7=0.2. Note that p+q= 1; the combined frequencies of all possible alleles must account for 100% of the genes for that locus in the population. If there are only two alleles and we know the frequency of one, the frequency of other can be calculated:

Ifp + q-1, then 1-p = q, or l-q - p

When gametes combine their alleles to form zygotes, the probability of generating an AA genotype is p^2. In the wildflower population, p-0.8, and p^2=0.64, the probability of an A sperm fertilizing an A ovum to produce an AA zygote. The frequency of individuals homozygous for the other allele (aa) is q^2, or 0.2x0.2=0.04 for the wildflower population. There are two ways in which an Aa genotype can arise, depending on which parent contributes the dominant allele. Therefore, the frequency of heterozygous individuals in the population is 2pq (2x0.8x0.2=0.32, in our example). If we have calculated the frequencies of all possible genotypes correctly, they should add up to 1:

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

P +	2pq +	q^2 = 1
Frequency of AA	Frequency of Aa plus aA	Frequency ofaa

For our wildflowers,this is 0.64 + 0.32 + 0.04=1*

* In fact the Hardy-Weinberg equation is a binomial expansion: $(p+q)^2$ or $p^2+2pq+q^2$

Factors affecting gene frequency

Many factors can alter gene frequency. Out of these five affect the proportion of homozygotes and heterozygotes enough to produce significant deviations form the proportion claimed by Hardy Weinberg principle. They are reflected in the table below.

Table 24.2 Factors for evolutionary change

Factor	Description
Mutation	The ultimate source of all changes; individual mutations occur so rarely that mutation alone does not change allele frequency much.
Migration	A very potent agent of change, migration locally acts to prevent evolutionary changes by preventing populations that exchange members from diverging from one another. Emigration and immigration of members of a population, cause disturbance in the gene pool.
Genetic drift	It is the change in frequency of alleles at a locus that occurs by chance. In small populations, such fluctuations may lead to the loss of particular alleles. This may occur in a small population when a few individual fail to reproduce and then genes are lost from the population.
Non-random mating	Inbreeding is the most common form; it does not alter allele frequency, but lessens the proportion of heterozyote individuals. Individuals with certain genotypes sometimes mate with one another more commonly than would be expected on a random basis. This is called non-random mating, causing the frequencies of particular genotypes to differ greatly from those predicted by the 1 lardy-Weinberg principle.
Selection	Some individuals leave behind more progeny than others, and the rate at which they do so is affected by their inherited characteristics. This is called selection. Selection can be artificial selection or natural selection. In artificial selection, the breeders select for the desired characters. In natural selection, the environment plays this role, thus affecting the proportions of gene in a population.

ENDANGERED SPECIES

Extinction has been the fate of most plant and animal species. It is a natural process that will continue. In recent years, however, the threat to the welfare of wild plants and animals has increased dramatically—mostly as a result of habitat destruction. Tropical rain forests, the most threatened areas on the earth, have been reduced to 44% of their original extent. In certain areas, such as Ecuador, forest coverage has been reduced by 95%. This decrease in habitat has resulted in- tens of thousands of extinctions. Accurately estimating the number of extinctions is impossible in areas like rain forests, where taxonomists have not even described most species. We are losing species -that we do not know exist and we are losing resources that could lead to new medicines, foods, and textiles, Other causes of extinction include climate change, pollution, and invasions from foreign species. Habitats other than rain forest—grasslands,'marshes, deserts, and coral reefs—are also being seriously threatened.

Animation 24.4: Endangeres Species
Source & Credit: TES

An endangered species is in imminent danger of extinction throughout its range (where it lives). A threatened species is likely to become endangered in the near future. Saving species requires more than preserving a few remnant individuals. It requires a large diversity of genes within species groups to promote species survival in changing environments. This genetic diversity requires large populations of plants and animals. Preservation of endangered species depends on a multifaceted conservation plan that includes the following components:

1. A global system of national parks to protect large tracts of land and wildlife corridors that allow movement between natural areas.
2. Protected landscapes and multiple-use areas that allow controlled private activity but also retain value as a wildlife habitat.
3. Zoos and botanical gardens to save species whose extinction is imminent.

In Pakistan. Cheetah. Tiger. Asian lion. Indian rhino. Cheer pheasant. Crocodile and Gaviul have been declared extinct. While. Indus dolphin. Blackbuck, Common leopard. Great Indian bustard. Houbara bustard. White-headed duck and Marbled teal are among the animal near to extinction.

Deserts, Sub-mountianous tract and Wetlands are habitats in peril. We must protect them rapidly. Endangered species of plants have been recorded to more than 500.

Animation 24.5: Endangeres Species
Source & Credit: Education World

EXERCISE

Q1 Fill in the blanks.

1. Archaebacteria can tolerate high temperature sup to____________
2. The first eukaryote appeared about________ years ago.
3. _________ presented the theory of the origin of species by means of Natural Selection.
4. ________developed a theory of natural selection essentially identical to Darwin's.
5. ________are considered to be the ancestors of all life.
6. A respiratory protein called__________is found in all aerobic organisms.
7. Total aggregate of genes in a population at any time is called its____________
8. Hardy Weinberg theorem describes a__________population.
9. __________ is a series of changes in the genetic composition of a population over time.
10. Level of classification between species and family is called________.
11. Hardy Weinbeig equation is binomial expansion of________.
12. An_______species is in imminent danger of extinction throughout its range.
13. A _______ is a localized group of individuals belonging to the same species.
14. The first photosynthetic organisms used_________as source of hydrogen for reducing carbon dioxide to sugars.
15. ______________ published an essay on The Principle of Population'.

Q.2 Short questions.

1. What are hydrothermal vents?
2. State Endosymbiont hypothesis.
3. Define population genetics.
4. How does fossil record provide evidence of evolution?
5. Explain the term homology with a suitable example.
6. What are vestigial organs? Give two examples.
7. How are evolutionary relationships reflected in DNA and proteins?
8. State Hardy Weinberg theorem.
9. What is the difference between endangered species and threatened species?
10. Name any five species, declared extinct in Pakistan.

Q.4 Extensive Questions

1. What are the endangered species? What measures could be adapted for their preservation?
2. State and explain Hardy-Weinberg theorem.
3. Describe evidences of evolution from any five branches of biology.
4. How did evolution proceed from prokaryotes to eukaryotes? Analyze the Darwin's theory of natural selection as mechanism of evolution.