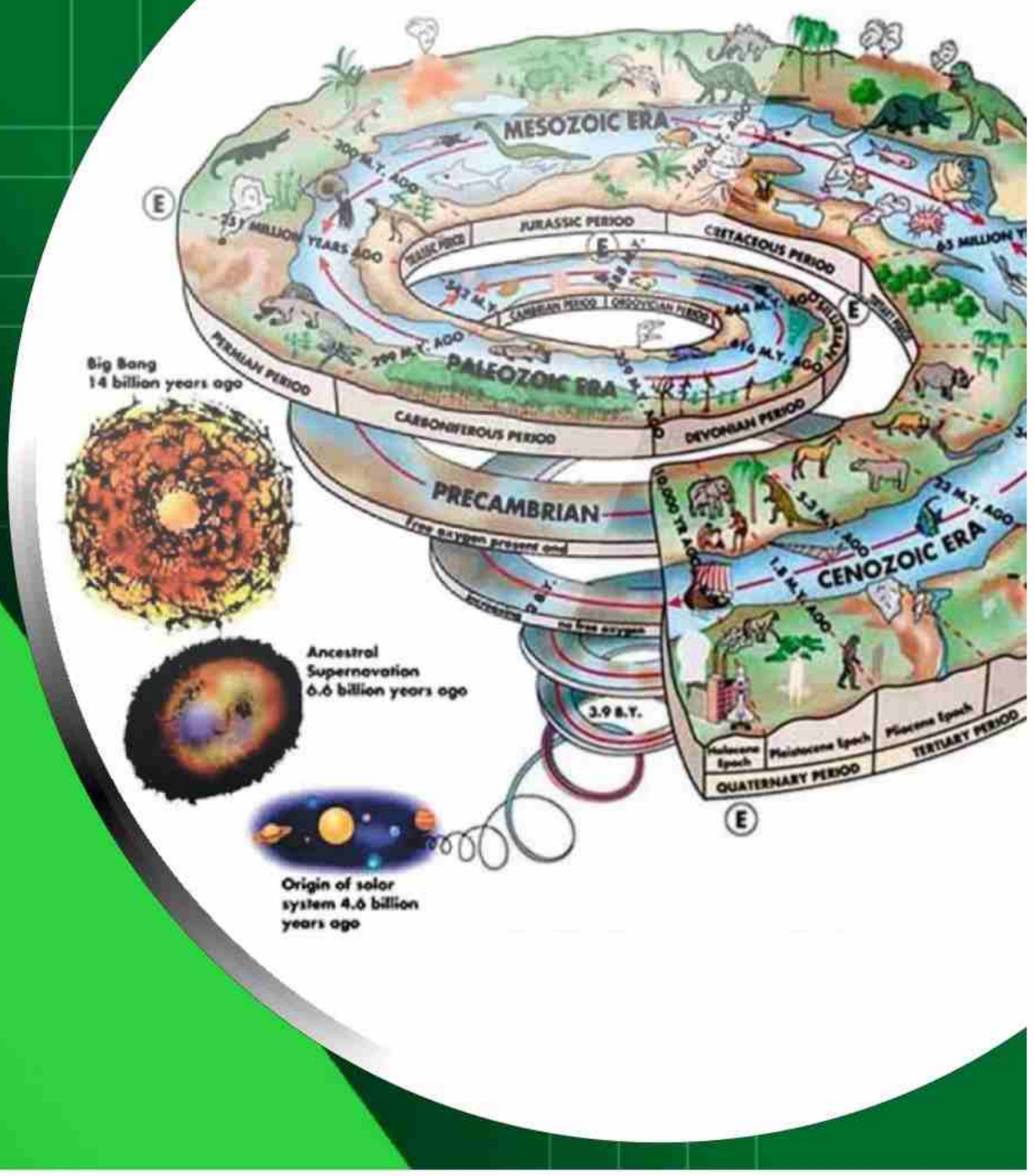
EVOLUTION

Chapter 24

Major Concept

In this Unit you will learn:

- The Evolution and The Concepts of Evolution
- Evidences of Evolution
- Evolution of Eukaryotes from Prokaryotes
- Lamarckism
- Darwinism
- Neo-Darwinism



The process and mechanism of origin of universe and the origin of living forms is of always a matter of enquiry for man. Hence there are always speculations regarding these issues from non-scientific as well as scientific point of views. Though many of us see it as contradictive matter from the religious point of view, the human interest is never ending till the exploration of truth. Without the understanding of physics, chemistry and mathematics, the biology cannot alone explore the reality and truth.

EVOLUTION

(Latin *ēvolūtiōn-*, "unfolding" or "emergence from an enclosing structure, historical development,")

Broadly speaking, evolution is a process of gradual changes and development of something such as earth, solar system, living things and living organisms etc. In Biology, the term evolution refers to a process of development of an entity in the course of time through gradual sequence of changes from simple to complex form. For instance, one might ask which is more primitive, plants or animals? Through the study of living organisms, the answer may be hypothesized.

24.1 THE EVOLUTION OF THE CONCEPTS OF EVOLUTION

The great diversity among living organisms around us made the human to think about their origin. Whether it is through their creation or origin from one another, there are two schools of thoughts. One of the schools of thoughts believes in **Divine Creation** while the other in origin through simple to complex forms.

Theory of special creation

The theory of special creation believes that living entities are created by God. They were created either at the same time or at some intervals. However, the species do not have any inter-relationship with each other from the origin point of view. They were created in the same form as present today so are supposed to be fixed and immutable. Father Suárez (1548-1613) was one of the advocates of Creationism. Carolus Linnaeus (1707-1778), a Swedish Botanist, who wrote number of books describing nature and is best known for

his great scientific work on taxonomy. Initially, he was also believer of the fixity of species.

Theory of Evolution

In contrast to the theory of special creation, the theory of evolution believes that organisms are evolved through gradual process of changes from simple to complex forms during the course of time. Thus plants and animals have developed in continuous, orderly way, under the guidance of natural laws.

George Buffon (1749-1788) was the first to implement the **geological time scale** and developed the idea that living beings evolved constantly. This concept of evolution of living organisms contradicts clearly with the concept of Divine Creation. Gradually, a number of evolutionary biologists contributed to this concept which seemed to be strictly opposing the theory of special creation. The opposition became extremely strong regarding the evolution of man. From the religious point of view, it was never acceptable; as The Holy Book, The Quran says very clearly in many surahs that Allah has created man so how I can evolve. For instance, some of the references can quote as follows:

"And We have certainly created you, [O Mankind], and given you [human] form."

(Surah Al Aaraf-11)

"And [mention, [O Muhammad], when your Lord said to the angels, "I will create a human being out of clay from an altered black mud."

(Surah-tul-Hijr-28)

"And it is He who has created from water a human being and made him [a relative by] lineage and marriage. And ever is your Lord competent [concerning creation]"

(Surah-tul-Furqan-54)

"And of His signs is that He created you from dust; then, suddenly you were human beings dispersing [throughout the earth."

(Surah Alroom-20)

24.2 EVIDENCES OF EVOLUTION

From molecular level to the gross structure of an organism, the process of evolution is supported through evidences from following different disciplines of Biology.

Evidence from Biogeography

The distribution of different species on earth provides evidence of evolution and it correlates the variations of a species and the movement of continents across the globe via plate tectonics. Let's take the example of pouched mammals (marsupials) such as kangaroos and koala found in America, Australia and New Guinea. Currently, the said geographical locations are separated from each other by Pacific Ocean. This makes impossible for said mammals to swim through such large distance. So how could end up in these locations and nowhere in between. It may be answered by the past continental positions and the fossil record of these mammals.

Fig. 24.1 Evidence from biogeography (e.g., Pouched mammals)

The scientists believe that that the existing continents were once a single piece of land termed as **Pangaea**. Slowly and gradually, it broke into different large pieces of land masses which started separating from each other. Thus, marsupials did not need a migration route, rather they rode through the continent to their current positions and diversified themselves.

Evidence from Paleontology

Paleontology deals with the extinct forms of life which are studied through **fossils**. During the course of time, those organisms were preserved somehow, partly or completely. Through such remains, the paleontologists try to reconstruct them. Let's take the example of **Archaeopteryx**, a fossil of a bird being discovered in 1861 in Bavaria, Germany. It is being estimated that Archaeopteryx lived around 150 million years ago. A careful study of this fossil revealed that it showed mixed features of birds as well as reptiles. Just like birds, it has a beak, wings, a tail, and body covered with feathers. However, like reptiles, it showed teeth, fingers and claws in fore limbs, vertebrae in tail and keel-less sternum. The presence of mixed features suggestive of the fact, that some of the ancestral reptiles were turned into early birds which later completely lost the reptilian features and transformed into modern birds.

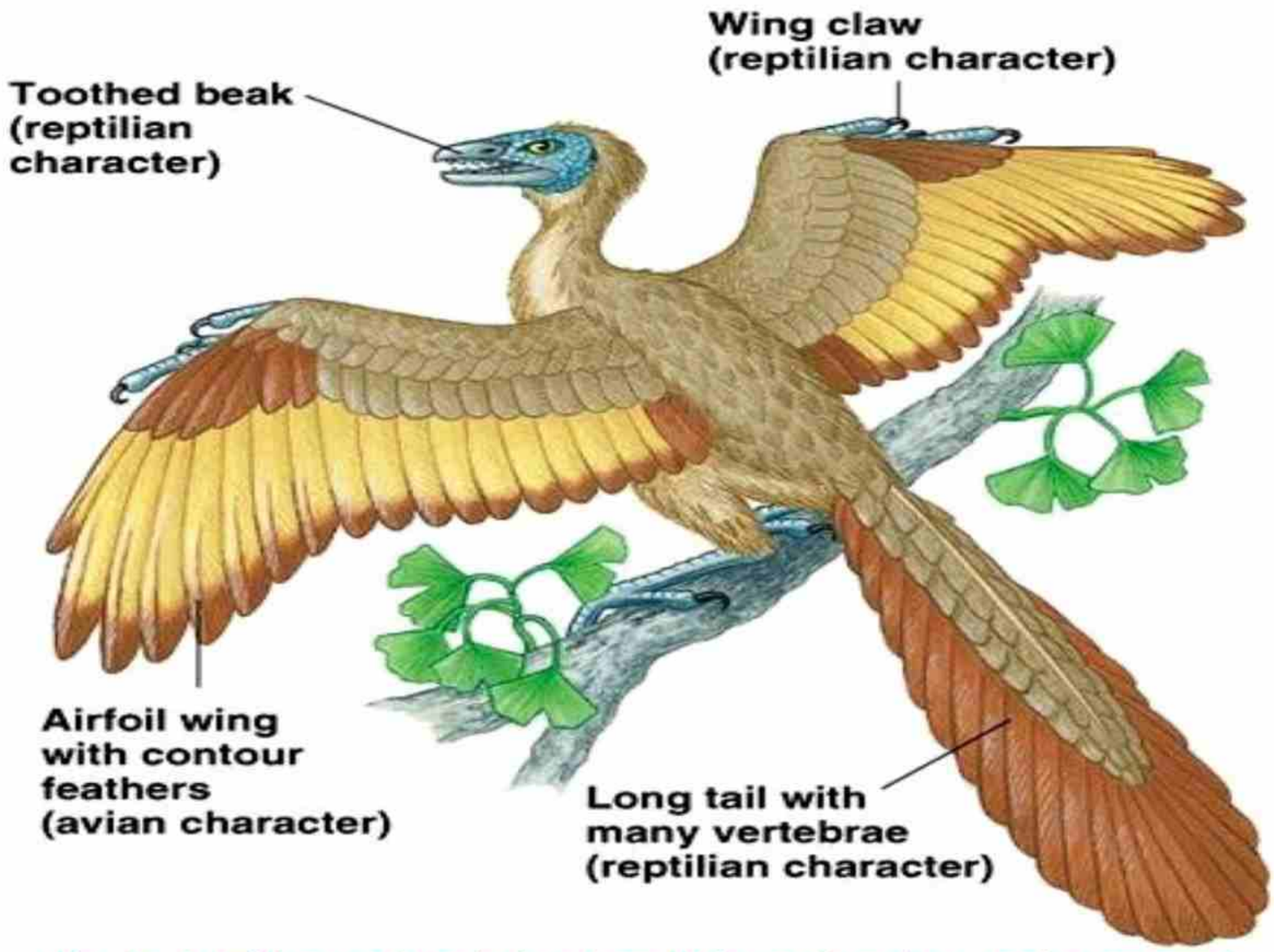


Fig. 24.2 Evidence of evolution from Paleontology (e.g. Archaeopteryx)

Evidence from comparative anatomy (homology)

Different species may show a number of internal or external organs similar to each other or vice versa they may exhibit visibly different structures but involved in the same functions. Organs which are similar in structure but differ in function are termed as **homologous organs**. For example, Arm of man, flippers of dolphin, fore-limb of a horse and wings of bat are homologous to each other. All of these mammalian organs show internally that the skeletal plans are same internally like same number and arrangement of bones, pentadactyl hand, etc. suggesting a common origin. However, they differ in function as per requirement of the habitat and other features. Biologically, this is termed as **divergent evolution** since the two or more species share common ancestry. If species descended from common ancestors, homologies make sense but if all species originated separately, it is difficult to understand why they should share homologous similarities. Without evolution nothing forcing the tetrapods all to have pentadactyl limbs.

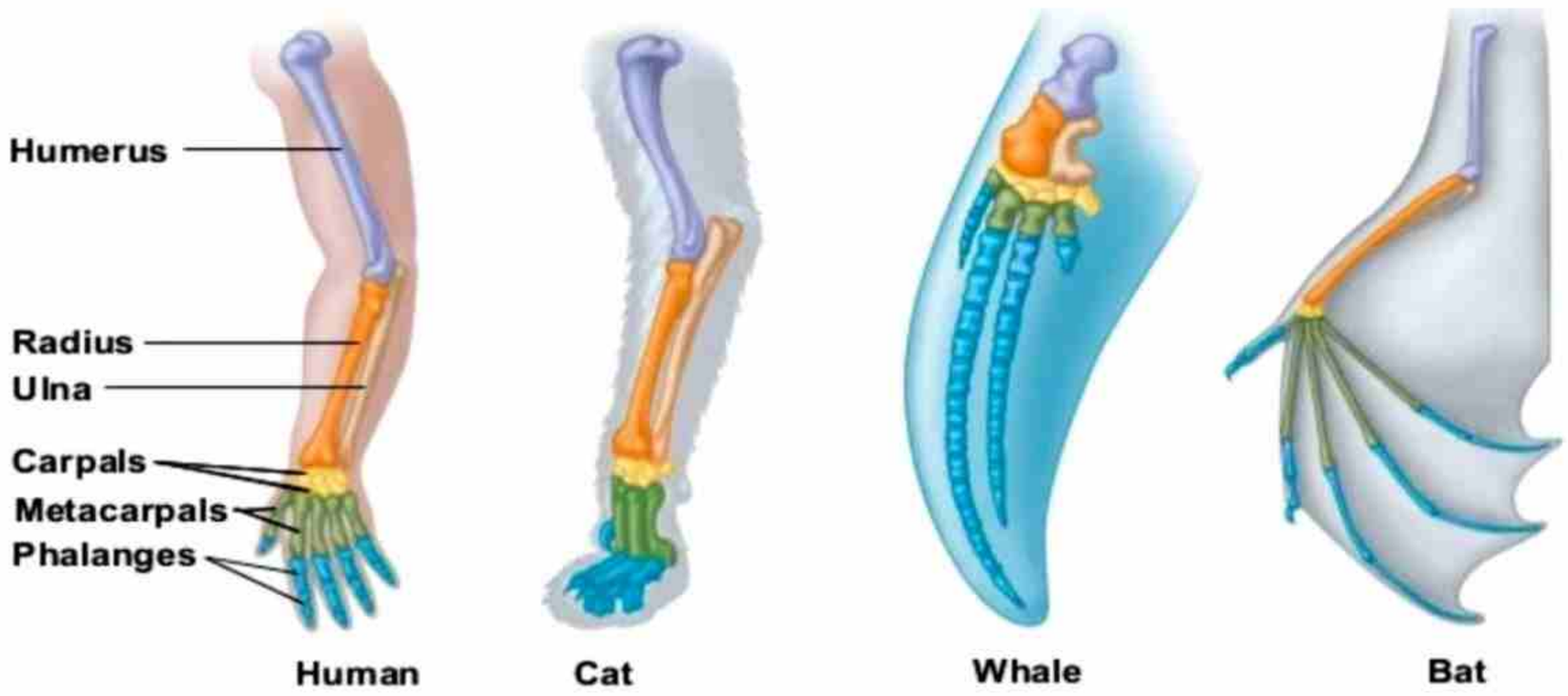


Fig. 24.3 Evidence of evolution from homologous organs

On the other hand some species show organs with similar in function but differ in their anatomical features. Such organs are known as **analogous organs**. For example, wings of an insect, bat and birds both are involved in flying however they have no anatomical resemblances. That shows different ancestry. This is termed as **convergent evolution**.

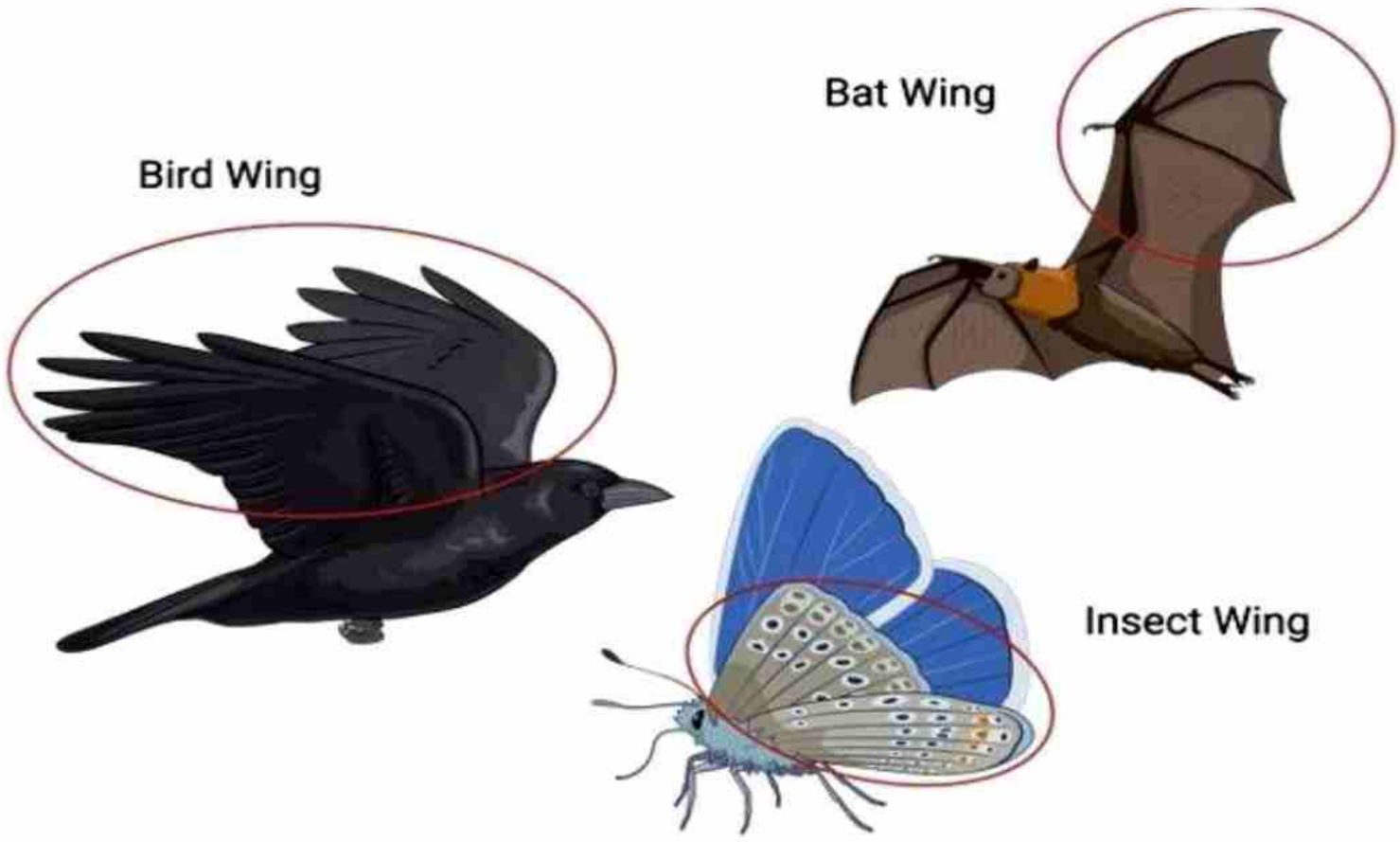


Fig. 24.4 Evidence from analogous organs

Evidence from molecular biology

Molecular biology is concerned with the study of molecules of cell and its organelles. It does provide evidence in favour of evolution. For example, genetic code may be considered in this case as good example. The translation between base triplets in the DNA and amino acids in proteins is universal in all living organisms. It can be confirmed by isolating mRNA for hemoglobin from a mammal and injecting it into bacterium E. coli which normally does not have hemoglobin. But when injected proper mRNA, it starts producing mammalian hemoglobin. Thus, it is evident that the machinery for decoding the message must therefore be common to mammal and E. coli.

A very good example in favour of evolution being observed in antibiotic resistance developed by pathogenic bacteria. If they do not adapt the lethal effect of the antibiotics, they would have been extinct so as a protection, pathogenic bacteria have to develop resistance against them through the process of natural selection. They undergo appropriate mutations in their genes to cope with the effects of antibiotics. This, on the other hand has put the pharmaceutical companies into a constant challenge to develop and improve the new and much effective, wide spectrum as well as specific antibiotics.

24.3. EVOLUTION OF EUKARYOTES FROM PROKARYOTES

Scientists agree on the fact that our planet earth was once covered with water (marine). Gradually, during the course of billions of years, the water receded and the land beneath appeared. So the life forms originated in water, especially in hot springs called hydrothermal vents. It is mentioned in The Holy Quran (sura Al-Anbiya, 21:30):

"And We made every form of life (on earth) appear from water, so do they not believe (even after being aware of these facts mention in the Quran)"

It is assumed that the vents supplied the energy and raw material for the origin and survival of early forms of life. It is now known that a group of bacteria (archaebacteria) can tolerate the extreme temperature of the hydrothermal vents. Such organisms were having a metabolism of catabolic in nature to obtain energy of the complex compound present around them. With the gradual depletion of the complex energy rich compounds in the environment, there became a great need of developing mechanisms for anabolic activities of their own. As a consequence, the evolving bacteria explored new ways of source of energy for their survival. This accounts for the existence of different ways of respiratory mechanisms correlated with existing diversity of nutritive methods among them. Thus some of the heterotrophic bacteria transformed into autotrophic ones. Initially, the autotrophs had to depend upon simple inorganic substances which gave rise sulphur-bacteria and iron-bacteria.

Since the amount of the energy obtained was very small as compared to their requirements so there developed need to evolve much more efficient ways such as photosynthesis. This account for the gradual accumulation of oxygen in the environment to be later consumed by other organisms. It is believed that the prokaryotes may have arisen more than 1.5 billion years ago. Following are two different hypotheses regarding the evolution of eukaryotic cells.

i) Membrane invagination Theory

It suggests that the cell membrane of prokaryotic cells invaginated to enclose the genetic material. This accounts for the

development of true nucleus while the other portions enclosed other necessary materials to transform into different organelles.

ii) Endosymbiotic Theory

It was suggested by Lynn Margulis. According to this hypothesis, the eukaryotic cell might have evolved when a large anaerobic amoeboid prokaryote ingested some aerobic bacteria (mitochondria) and rather than digesting started living with it in endosymbiotic relationship. Likewise, some of such eukaryotic cell, endocytosed autotrophic photosynthetic bacteria and transformed into ancestral autotrophic plant like organism.

The endosymbiotic theory seems more powerful in dealing with the evolution of eukaryotes since both mitochondria and chloroplast have following similar features like prokaryotes;

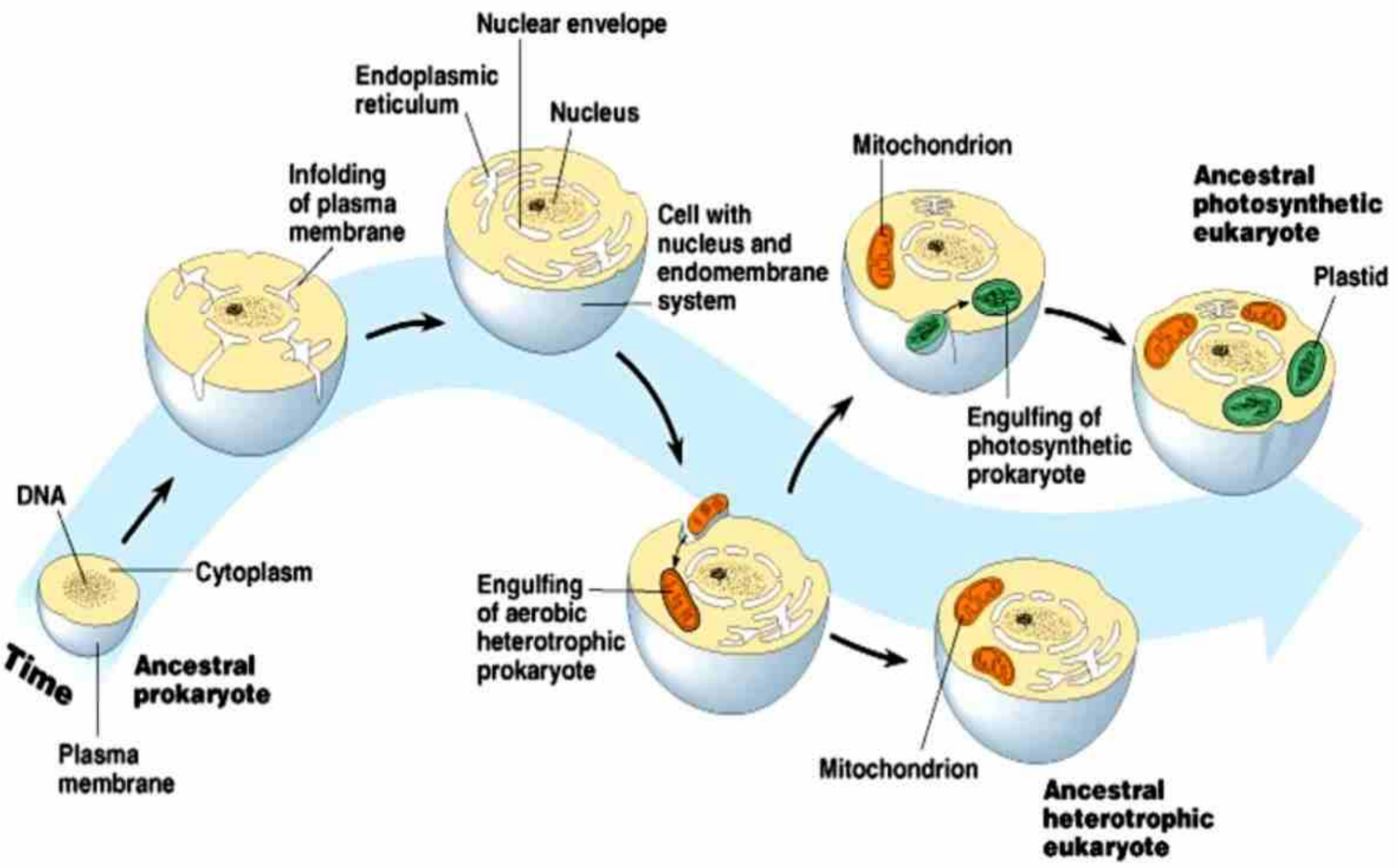


Figure: 24.5 Endosymbiotic Theory

i) Circular DNA molecules
ii) Ribosomes
iii) Metabolism
iv) Binary fission way of reproduction.

Primitive eukaryotes lived singly but later forms arose in the form of colonies also which account for the multicellularity, tissue and higher levels or organization, etc. among the eukaryotes which ultimately led towards the evolution of higher organisms like plants and animals.

24.4 LAMARCKISM

Jean Baptiste de Lamarck or simply known as Lamarck, a French biologist (1744-1829) was one of the proponents to the idea of evolution. He like many others of that era believed that evolution has taken place in accordance with the natural laws. His theory is known as Lamarckism or Inheritance of Acquired Characters. He discussed in detail his theory of evolution in his book *Philosophie Zoologique* in French in 1809. In view of Lamarck, the process of evolution is like a ladder of life proceeding from simple to the complex level of organisms with view of modification of characters of organism during its life time. His proposed theory of acquired characters consists of following postulates: i) Use and disuse of the organs, and ii) Inheritance of acquired characters.

i) Use and disuse of the organs

In view of Lamarck, an organism under the influence of internal or external factors, may either frequently use or disuse its one or more organs. During its persistence efforts of doing so, the organs under discussion are either developed more and become stronger due to more usage, or become weaker due to disuse. Thus as a consequence of constant effects of use or disuse generation after generation, the cumulative effect is seen either as either stronger or degenerating organ. He stated the example of existing giraffe with long neck and longer fore-limbs. According to him, the ancestral giraffe had short neck and fore-limbs. They fed upon the vegetation on ground. Somehow, either due to flooding of the ground or else, the ground vegetation disappeared forcing the ancestral giraffe to feed upon the foliage of trees very high above the ground level. So they had to gradually lift up the neck to pluck the leaves. Thus as a result of continuous efforts of stretching the neck and fore-limbs, the muscles developed stronger and stronger generation after generation, finally transformed into existing giraffe with long and high neck and

longer fore-limbs. He termed such adaptive features as "acquired characters".

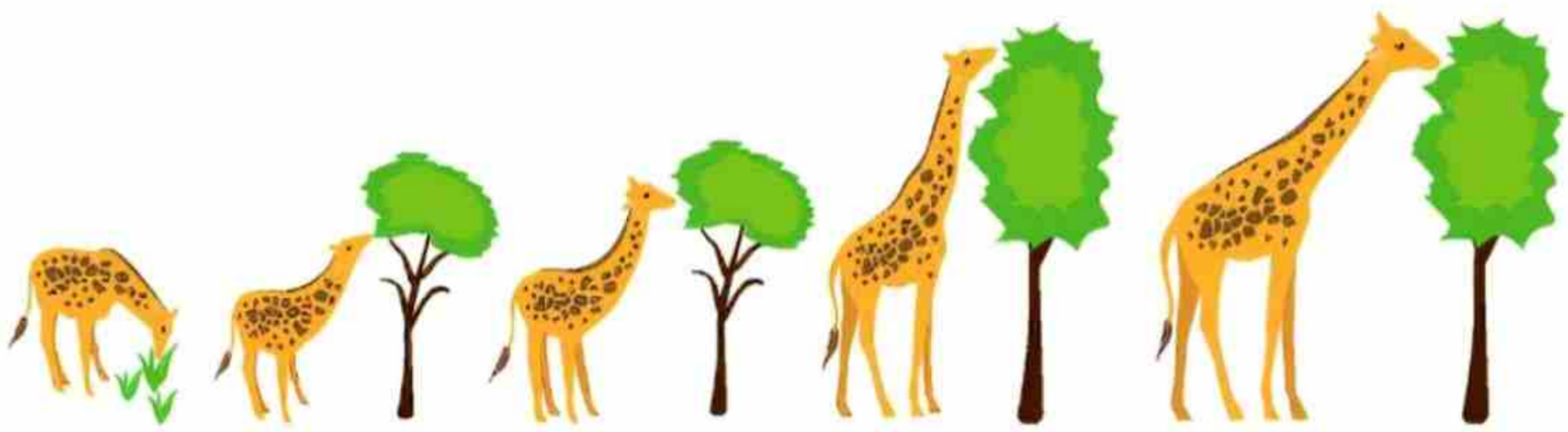


Fig. 24.6 Evolution of giraffe neck

ii) Inheritance of Acquired Characters

Lamarck believed that the characters acquired during the lifetime of individual due to use or disuse of organs was inherited to their offspring. Thus, individuals of the new generations were having stronger muscles of neck and fore-limbs. Finally, as a continuous inheritance, the outcome is the existing giraffe.

Extra Reading Material

Hypothesize whether Lamarck was criticized in his days for advocating the ideas of evolution or for the mechanism he proposed.

Lamarck's theory of inheritance of acquired characters was criticized especially by August Weismann and Cuvier on its genetic basis while on the other hand Charles Lyell and August strongly supported and promoted the ideology of Lamarck. Although Lamarck's ideas were rejected, interest in his ideas has recently resurfaced.

He may not have been correct with his long-necked giraffe example, but on a fundamental level, he was describing "epigenetics" which deals with the study of behaviours, environmental exposures on other external factors may alter how DNA is read and used to express certain proteins

Drawbacks of Lamarckism

Though theoretically seems plausible, yet Lamarck theory has no experimental support. Also the idea of development of acquired characters has no genetic basis and it seems that they influence on the somatic cells rather than the germ cells involved in inheritance. So how could be the acquired characters are inherited to the next generation without affecting the germ cells. As a fact, it is also noted that organs are not modified by the wish of the organism. Also, Lamarckism fails to account for the genetic variability found in the species.

24.5 DARWINISM

Charles Darwin (1809-1882), an English biologist, a geologist and a naturalist is well known for his contribution on evolution. His proposal of origin of species from a common ancestor is generally a widely accepted fact. Though he got education in medicine and surgery, he was never interested in the field of medical. He was much interested in studying nature as got admitted to the Christ College, Cambridge in 1928. In 1831, he decided to go on a five years trip on a ship H.M.S. Beagle heading towards South America.

24.5.1 Darwin's observations during his voyage

His voyage on HMS Beagle started in December 1931 from Plymouth, England. After crossing the Atlantic Ocean, most of his trip was sailing around South America, then proceeding ahead and crossing the Pacific Ocean, they crossed Australia. The journey continued back through the Indian Ocean up to the Cape Town, South Africa and then heading back to South America, finally back to Plymouth, England.

Since most of his trip was sailing around South America, he collected and studied offshore species of both plants and animals. During his studies, Darwin collected a variety of bird specimen, particularly finches in **Galapagos Island**. He observed that the finches of the Galapagos Island were similar to the finches on mainland but each had adaptations in beak in terms of size and shapes to obtain easily and effectively the locally available food.

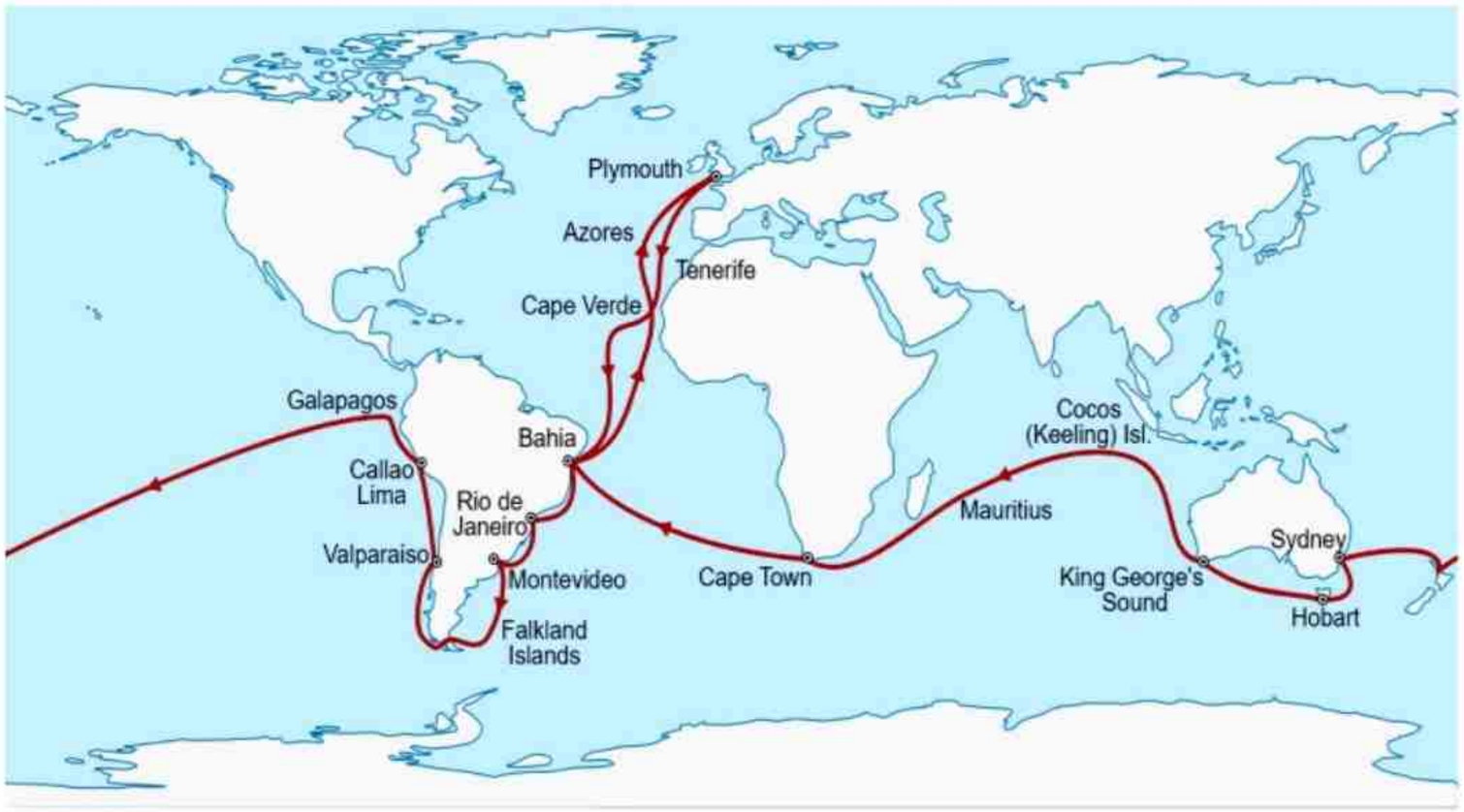


Fig. 24.7 Map showing the journey of the ship HMS Beagle

Through his observation and collection, Darwin was much convinced about the process of natural selection as tool for the process of evolution. He thought that new species could have originated as a consequence of gradual accumulation of such adaptations due to existing geographical or other types of barriers.

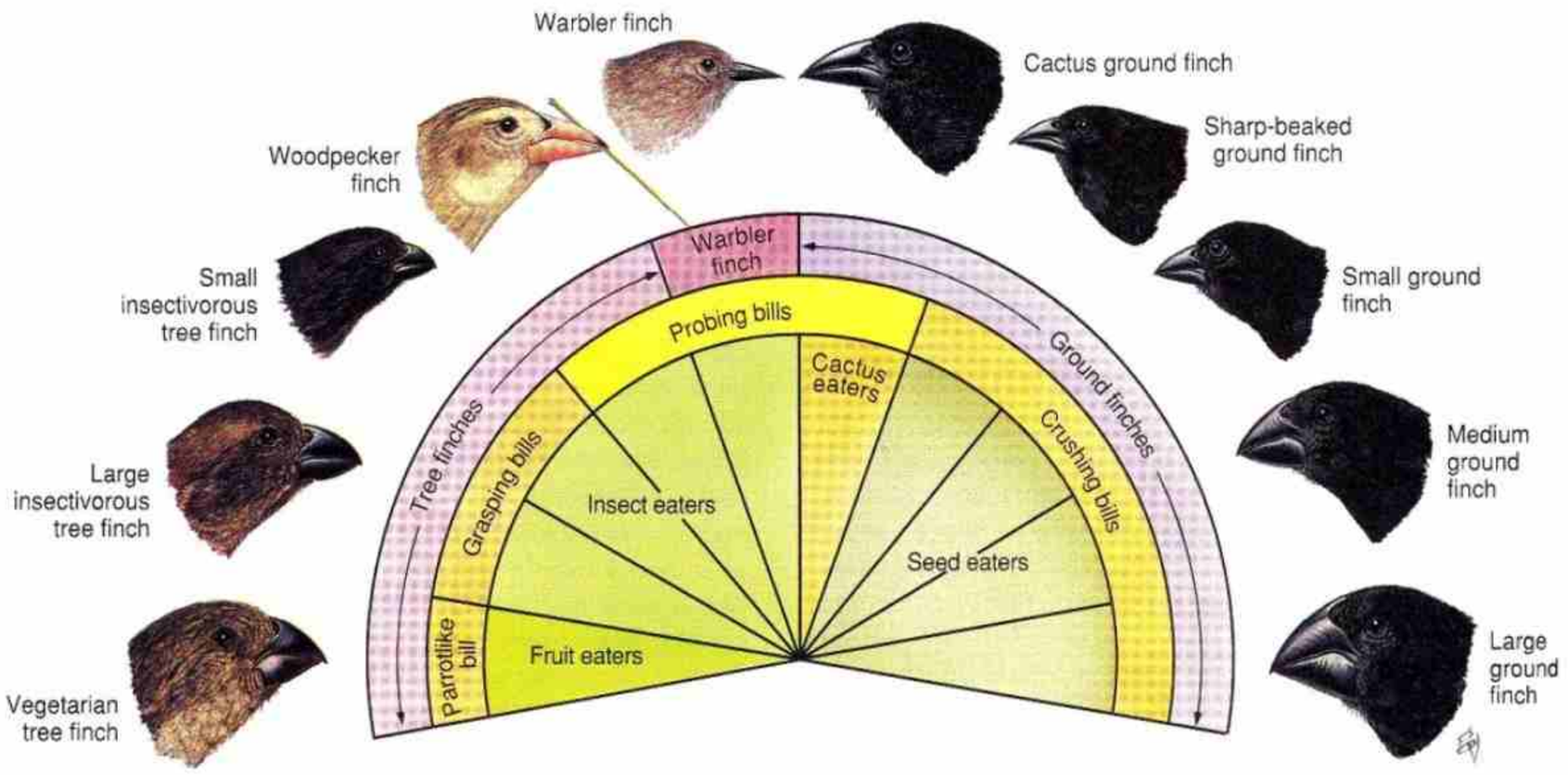


Fig. 24.8 The finches studies by Darwin on Galapagos island

24.5.2 Theory of Natural Selection

Even though the Darwin's journey ended in 1836, he felt himself in uncomfortable position to put forward his theory of evolution until 1842. During this period, he collected ample evidences to support his proposal of natural selection and the origin of species. Initially, he prepared a brief sketch which later turned into a detailed description of the process on evolution. Meanwhile, keeping in view of the sensitivity of the issue, he discussed it with his friends and colleagues before final publication.

According to the Theory of Natural Selection, all living species are descendants of ancestral species and are different from present day ones due to the cumulative change in the **genetic composition** of a population. Darwin considered "Natural Selection" is the mechanism of evolution through which heritable traits that help organisms survive and reproduce become more common in a population over time. Darwin's theory of Evolution is based upon following two key points: i) Descent with modification, ii) Natural Selection and adaptation.

i) Descent with modification

Like other evolutionary biologists, Darwin considered that living organisms are related to each other through common ancestry. The existing diverse forms of living organisms are descent of previous simpler forms and gradually adapted to the changing conditions. Thus the history of life is like a tree, with number of branches coming out of the trunk terminating at existing species. The point of junction of twigs is symbolically representing actually the common ancestors of these branches. Gradually going down towards main trunk representing the common ancestor of all forms of life.

ii) Natural Selection and adaptations

The process of Natural Selection actually operates to select the organisms with better adjustments with their environment. Such organisms have better opportunity for survive and reproduce than the inferior ones. It is comprised of following four stages.

Over production: Each individual species has power to reproduce to increase its number. Due to limited life span, limited available resources, etc. each species tries to over produce its number of

offspring because not all the offspring survive before reaching to the sexual maturity and able to reproduce.

Struggle for existence: During the life time, the individuals of a species have to struggle for the available resources of food, better living conditions, predators, parasites, diseases, etc. Thus not all individuals survive through such struggle, a number of them are vanished. In fact not all of the survivors would be able to reproduce. This causes some other decrease in their number also. They do have to struggle against other closely related species also. The struggle within the individual of the same species is termed as intra-specific struggle while with the other species is termed as inter-specific struggle. Meanwhile, all of them have faced the natural catastrophes also. This is environmental struggle.

Genetic Variations: The individuals of a population differ slightly from each other to ensure their survival and chances of reproduction. Otherwise, for example an epidemic may sweep out the entire group. Thus differences of individuals of a species are termed as variations. It ensures the chances of survival and reproduction and ultimately the longer existence of species as whole. The characters of individuals are genetically termed as traits. The traits making better chances of survival are termed as adaptive traits.

Survival of the fittest: The individuals of a species having the most favourable traits would have greater chances of survival and reproduction than the others. In terms of genetics, it can be said that organisms with better set of genes would have greater chances of survival. Such organisms are considered as fittest. According to Darwin, they would have better chances of survival as they pass their genes through inheritance to their offspring. The whole process is termed as Natural Selection which provides opportunity to the fittest one to survive and reproduce. In a sense, natural selection increases the chances of inheritance of better alleles while decreasing the less favourable alleles. In view of Darwin, the process of natural selection was a way of the origin of new species through a very slow but gradual process of accumulation of changes. Formation of new species is termed as speciation.

24.5.3 Ideas of Charles Lyell, James Hutton, Thomas Malthus in the early development of Darwinism

Darwin was inspired by findings of a number of other researchers regarding the process of fossilization and its correlation with the evolution. Following were important to understand the concept of Darwin regarding evolution.

Contribution of Charles Lyell

He was a great geologist of his time. His theory of uniformitarianism inspired Darwin. According to Lyell, the geologic processes that were around at the beginning of time were the same ones that were happening in the present as well and that they worked the same way. He believed the Earth developed through a series of slow changes that built up over time. Darwin thought this was the way that life on Earth also changed. He theorized that small adaptations accumulated over long periods of time to change a species and give it more favourable adaptations for natural selection to work on. Lyell was a good friend of Captain Robert FitzRoy who piloted the HMS Beagle when Darwin sailed to the Galapagos Islands and South America. FitzRoy introduced Darwin to Lyell's ideas and Darwin studied the geological theories as they sailed.

Contribution of James Hutton

He was a famous geologist by whom Darwin was inspired. Actual idea of fossilization was put forwarded by Hutton before Lyell. He the first to publish the idea that the same processes that formed the Earth at the very beginning of time were the same that were happening in the present day. These "ancient" processes changed the Earth, but the mechanism never changed. Even though Darwin saw these ideas for the first time while reading Lyell's book, it was Hutton's ideas that indirectly influenced Charles Darwin as he came up with the idea of natural selection. Darwin said the mechanism for change over time within species was natural selection and it was this mechanism that had been working on species ever since the first species appeared on Earth.

Contribution of Thomas R. Malthus

Thomas R. Malthus was an economist and one of the persons who fascinated Darwin with his theory on human population.

According to Malthus, the human population was growing faster than the food production could sustain. This would lead to many deaths from starvation and forces the population to eventually level out.

Darwin applied these ideas to populations of all species and came up with the idea of "survival of the fittest". Malthus's ideas seemed to support all of the studying Darwin had done on the Galapagos finches and their beak adaptations. Only individuals that had favourable adaptations would survive long enough to pass down those traits to their offspring. This is the cornerstone of natural selection.

24.5.4 Role of Alfred Russell Wallace in motivating Charles Darwin to publish the Theory of Natural Selection

A. R. Wallace was one of the contemporaries of Charles Darwin. He collaborated with Darwin on the theory of evolution. Wallace supplied Darwin with birds for his studies and helped him a lot in publishing the theory of evolution. In fact, Wallace actually came up with the idea of natural selection independently, but at the same time as Darwin. The two pooled their data to present the idea jointly to the Linnaean Society of London in 1858. It wasn't until after this joint venture that Darwin went ahead and published the ideas in his book "The Origin of Species."

24.5.5 Why the theory of natural selection attributed to Darwin?

Even though both Wallace and Darwin contributed the Theory of Natural Selection equally, Darwin gets most of the credit today. Wallace has been relegated to a footnote in the history of the theory of evolution. Actually, Wallace was the person who motivated Darwin to publish the book “On the origin of species” in 1859. Besides, Darwin later also speculated about evolution of humans on which he published “Descent of Man”. Wallace diverged Darwin at this point.

24.6 NEO DARWINISM

It is interesting to note that Darwin’s Theory of Natural Selection was put forwarded in 1859, the same time when Gregor John Mendel was formulating his Laws of Inheritance during 1856-63 which remained neglected about three decades until rediscovered at the turn of 20th century. So, the Darwin’s study was lacking a

concrete genetic basis. As discussed earlier in view of Darwin, in an individual, accumulation of fittest phylogenetic variations is the major driving force of **speciation**, hence the natural selection is the survival of the fittest in the environment. Neo Darwinism is a modified theory of Darwinism explaining the origin of species on a genetic basis, hence the main driving force of **Neo Darwinism** is genetic variation. Consequently, the main difference lies in the variation type and type of natural selection. The main force driving speciation is the gathering of genotypic variations in a gene pool. Neo Darwinism is also referred to as the Modern synthetic theory of natural selection. In this case, reproductive isolation has a major part in speciation allowing differential amplification of the fittest genes in a gene pool. Thus, natural selection of the most suitable genes is associated with the origination of new species.

POPULATION GENETICS:
It is the branch of biology that deals with the process of origin of variations and their inheritance. It plays a very important role in linking evolution and genetics so as to develop possible account for the origin of life as well as origin of species. It begins at the individual level and then cumulates the data at the population level.

24.6.1 Hardy-Weinberg Theorem

Hardy-Weinberg Theorem is the principle being proposed collectively in 1908 by an English mathematician, Godfrey Hardy and a German Physician, Wilhelm Weinberg to demonstrate mathematically the gene frequencies of different alleles in a given population. According to this theorem, the frequency of dominant allele would not tend to increase. The genetic variation in a population will remain constant from one generation to the next in the absence of disturbing factors. When mating is random in a large population with no disruptive circumstances, the law predicts that both genotype and allele frequencies will remain constant because they are in equilibrium.

Hardy-Weinberg Equation

From their principle, they deduced an equation to calculate the allelic frequencies and genotypes in a population to show the

equilibrium and termed as Hardy-Weinberg equilibrium. For example, in Drosophila the allele for gray body color *(B)* is dominant over the allele for black body *(b)*. In the absence of any other allele for body color, the sum of their frequencies must be equal to one. Now mathematically, if we designate *B* allele with *"p"* and its recessive *b* allele with *"q"* then the equation would be $p + q = 1$. Simply, knowing the frequency of one either *p* or *q* is known, we can determine the value of the other. From this assumption, the following equation can be derived to obtain the offspring genotypes.

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

(Frequency of *BB*) + (Frequency of *Bb*) + (Frequency of *bb*) = (all individuals of population)

Problem:

The frequency of two alleles in a gene pool is 0.19 (*A*) and 0.81 (*a*). Assume that the population is in Hardy-Weinberg equilibrium, then

(a) Calculate the percentage of heterozygous individuals in the population.

Solution:

H-W Equation: $p^2 + 2pq + q^2 = 1$

According to the Hardy-Weinberg Equilibrium equation, heterozygotes are represented by the $2pq$ term. Therefore, the number of heterozygous individuals (*Aa)* is equal to $2pq$ which equals $2 \times 0.19 \times 0.81 = 0.31$ or 31%

(b) Calculate the percentage of homozygous recessives in the population.

Solution:

The homozygous recessive individuals (*aa*) are represented by the q^2 term in the H-W equilibrium equation which equals $0.81 \times 0.81 = 0.66$ or 66%

Factors Affecting Hardy-Weinberg Theorem

i) Mutations:

It introduces new genes into population

ii) Selection:

Either due to natural or artificial selection, some species may be given greater opportunity to reproduce and increase the number of their offspring which can affect the frequencies of alleles.

iii) Non-random mating:

The process of mating should be non-random in a given population and the population size should be large enough.

iv) Gene flow:

It refers to the exchange of genes between different populations of the same species. It may be either due to migration of individuals from one population to another of the same species or to the transfer of gametes. In the absence of natural selection and genetic drift, gene flow leads to genetic homogeneity among demes within a metapopulation, such that, for a given locus, allele frequencies will reach equilibrium values equal to the average frequencies across the metapopulation.

Since all of these disruptive forces commonly occur in nature, the Hardy-Weinberg equilibrium rarely applies in reality. Therefore, the Hardy-Weinberg equilibrium describes an idealized state, and genetic variations in nature can be measured as changes from this equilibrium state.

24.6.2 Genetic Drift (Neutral Selection)

It refers to the changes in allelic frequency in a population from generation to generation. It occurs when allele frequencies grow higher or lower by chance and typically takes place in small populations. Although genetic drift occurs in populations of all sizes, its effects tend to be stronger in small populations. This is also named as neutral selection because most of the variations within and between species are due to random genetic drift of mutant alleles that are selectively neutral.

Example:

In order to make genetic drift clear, let's take an example of a small population of ten rabbits, two of which are white (genotype bb) while eight are brown (genotypes BB or Bb). Both alleles B and b are present in equal frequencies i.e., p=0.5 and q=0.5. Thus if 10 of the individuals reproduce randomly, the probability of having an offspring with alleles B or b is 0.5. Suppose, if (purely by chance) 5 circled rabbit reproduce among themselves (the rest died/caught by hunter, etc.) so the frequency of allele B and would change to 0.7 and o.3 respectively as shown in the Fig.24.10. Now further supposing that only two of the five of the second generation, the b allele will be completely lost.

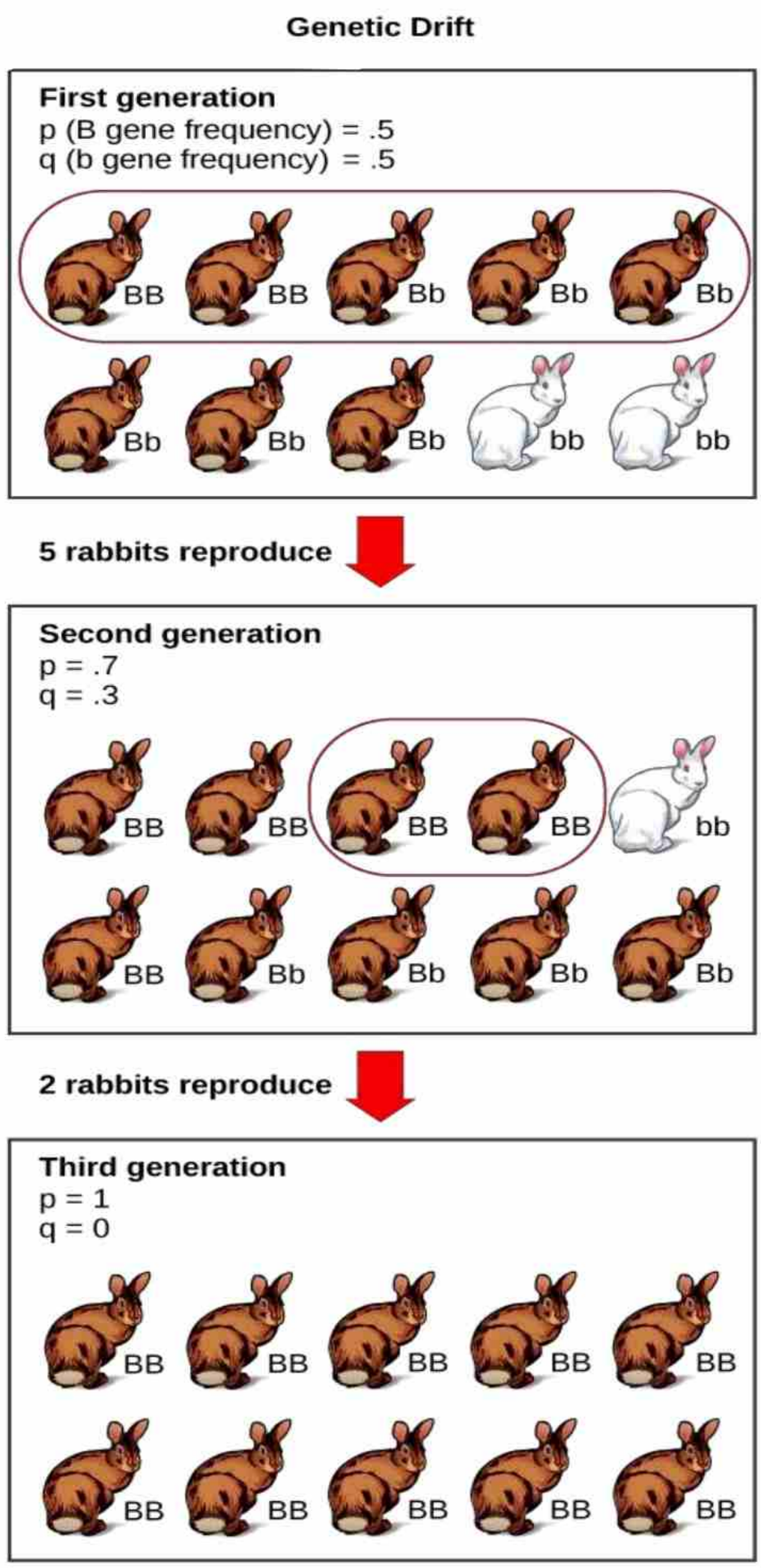


Fig. 24.10 Genetic drift

There are two types of genetic drift

i) Bottleneck effect: In this kind of genetic drift, the size of the population is decreased due to some natural catastrophes like volcano eruption, earthquake, flood, fire, etc. As a consequence, a number of individuals would be eliminated leaving behind few live individuals to reproduce.

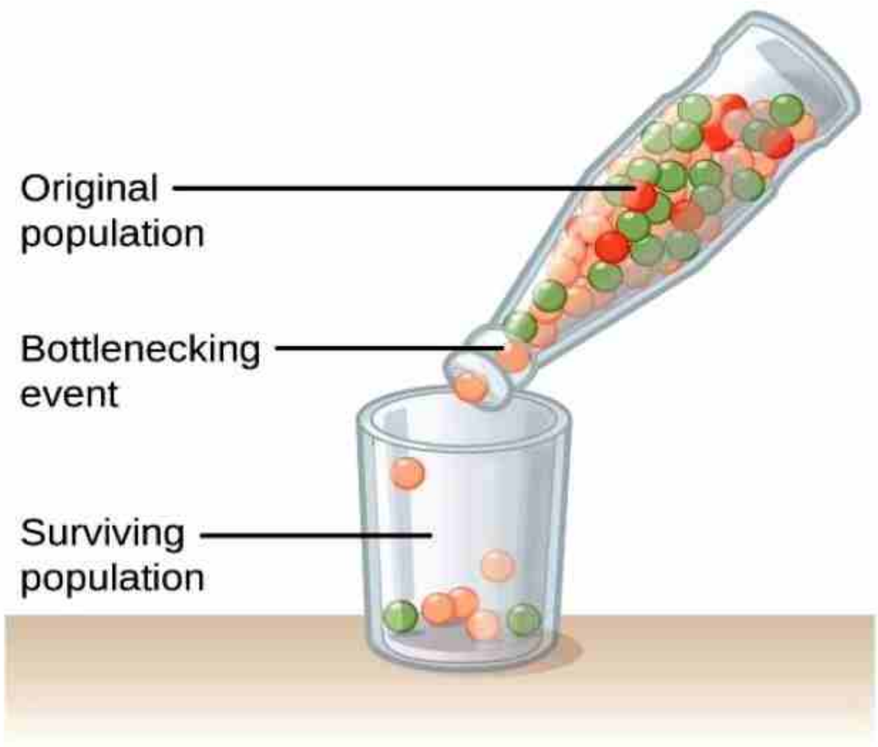


Fig. 24.12 Bottle-neck Effect

ii) Founder effect: In this kind of genetic drift, a new small population separated from the larger one due to some geographical or physical barriers starts reproducing within itself. As a consequence, the allelic frequencies will be different from their original stock.

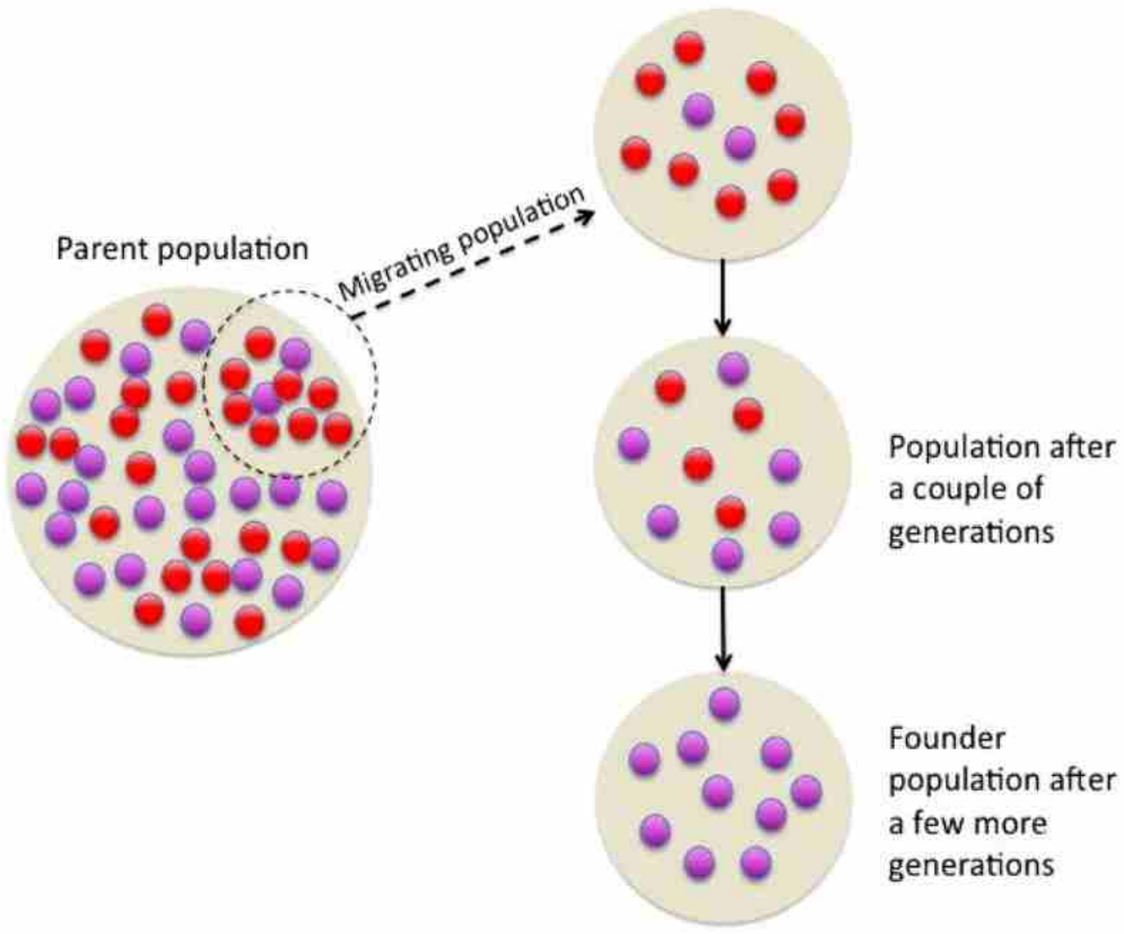


Fig. 24.13 Founder's Effect

24.6.3 Speciation and its mechanism:

It is the biological process of formation of new species of living organisms. It occurs when a group of individuals within a population develop distinct characteristics and becomes reproductively isolated from the rest.

There are different ways for speciation process, viz., allopatric speciation, sympatric speciation, peripatric speciation and parapatric speciation.

Sympatric speciation: In this case, one of the populations of a species occupying the same geographical area becomes distinctly different features so that it is unable to mate with its original stock. There could be different reasons for sympatric speciation such as polyploidy, habitat differentiation and sexual selection. It is more commonly observed among plants than animals.

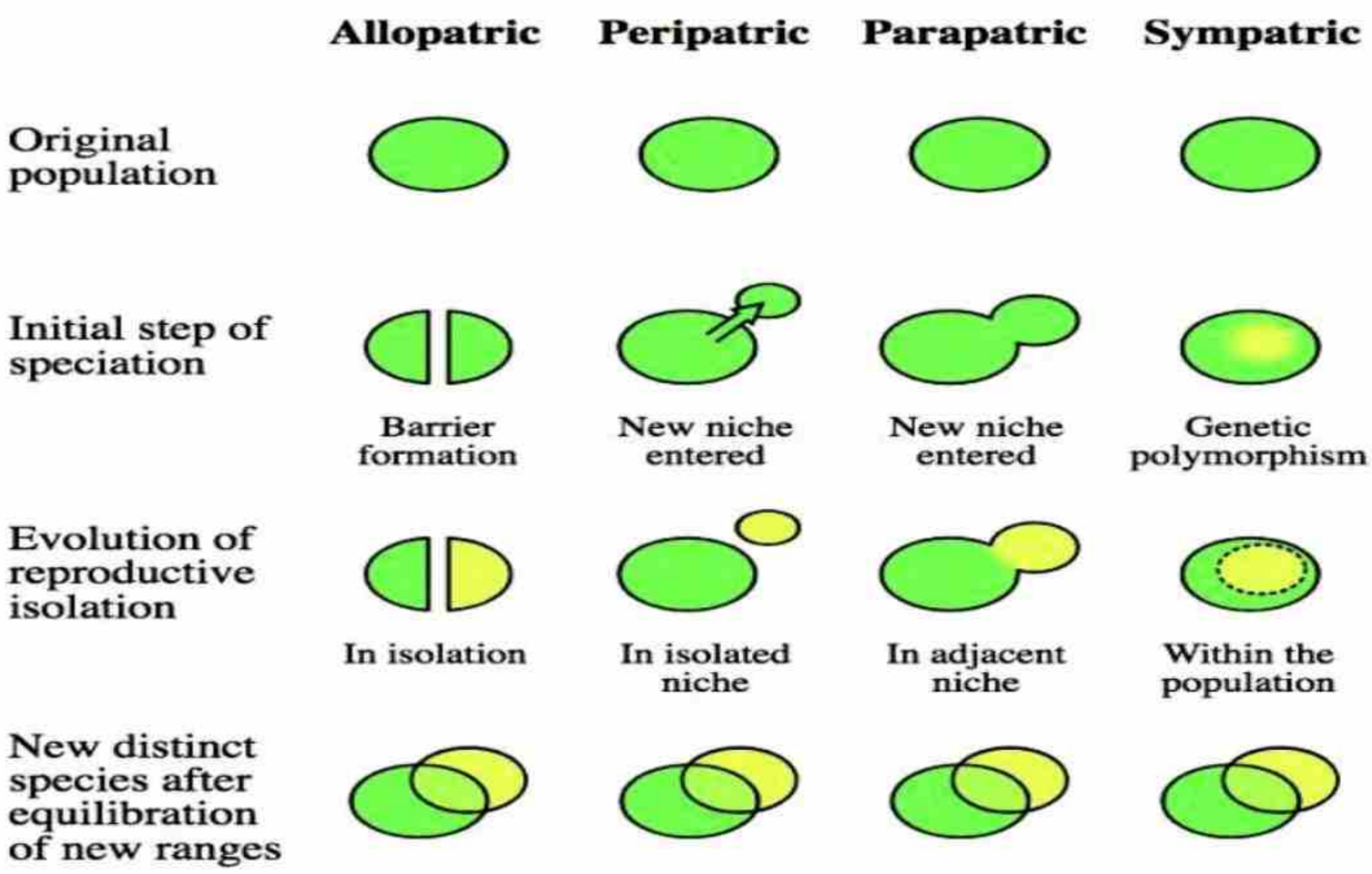


Fig. 24.14 Types of speciation

Allopatric speciation: In this kind of speciation, the populations become geographically separated from each other so that they become reproductively isolated from the rest of their populations. As a consequence, the gene flow stops among them and depending upon

their environmental factors during the course of time, they do genetically differ from them. It is one of the very common ways of speciation.

Peripatric speciation: When small groups of individuals break off from the larger group and form a new species, this is called peripatric speciation. Like allopatric speciation, although there is a geographical isolations exists in this kind of speciation, it differs in way that the separated group is much smaller than the original one.

Parapatric speciation: In this speciation, the populations are not geographically separated from each other, but they enter a quite different habitat within the same area of the parent species. In such case, the populations may interbreed but develop distinct features and habits. The reproductive isolation in this case is behavioral rather than geographical. For instance, it is observed in plants living on boundaries between distinct climates may flower at different times in response to their environments. Thus, they cannot interbreed with the parental types.

ACTIVITY:
Identify the homologous and analogous organs in animas.

SUMMARY

- Evolution refers to a process of development of an entity in the course of time through gradual sequence of changes from simple to complex form.
- The distribution of different species on earth provides evidence of evolution and it correlates the variations of a species and the movement of continents across the globe via plate tectonics.
- In divergent evolution, the two or more species share common ancestry.
- Organs with similar in function but differ in their anatomical features are termed as analogous organs.
- The presence of analogous organs shows different ancestry and this is termed as convergent evolution.
- Life forms originated in water, especially in hot springs called hydrothermal vents.
- Prokaryotes may have arisen more than 1.5 billion years ago.
- Membrane invagination Theory suggests that the cell membrane of prokaryotic cells invaginated to enclose the genetic material.
- Lamarck theory is known as Lamarckism or Inheritance of Acquired Characters.
- In view of Lamarck, the process of evolution is like a ladder of life proceeding from simple to the complex level of organisms with view of modification of characters of organism during its life time.
- Theory of acquired characters consists of use and disuse of the organs, and inheritance of acquired characters.
- Darwin applied these ideas to populations of all species and came up with the idea of "survival of the fittest".
- The main force driving speciation is the gathering of genotypic variations in a gene pool.
- Population genetics deals with the process of origin of variations and their inheritance.
- Genetic Drift (Neutral Selection) refers to the changes in allelic frequency in a population from generation to generation.
- In Bottleneck effect, the size of the population is decreased due to some natural catastrophes like volcano eruption, earthquake, flood, fire, etc.

- In Founder effect, a new small population separated from the larger one due to some geographical or physical barriers starts reproducing within itself.
- Speciation is the biological process of formation of new species of living organisms.

EXERCISE

1. Encircle the most appropriate response.

i) Which of the following was supporting the theory of special creation?
(a) George Buffon (b) Lamarck
(c) Darwin (d) Suárez

ii) Archaeopteryx is a connecting link between
(a) Amphibia and reptiles (b) Reptiles and Aves
(c) Aves and mammals (d) Fish and amphibia

iii) All of the following are homologous organs except
(a) Wings of bat (b) Wings of butterfly
(c) Wings of bird (d) Flippers of dolphin

iv) Which of the following are analogous organs except:
(a) Wings of insect (b) Wings of bird
(c) Wings of bat (d) Arm of man

v) Life originated in
(a) Air (b) Water
(c) Land (d) Space

vi) *Philosophie Zoologique* was written by
(a) Wallace (b) Darwin
(c) Weismann (d) Lamarck

vii) Which of the following is incorrect regarding Lamarck's theory of Inheritance of acquired characters?
(a) Use and disuse of the organs inherited
(b) Continuously using some organ results in its further strengthening in offspring
(c) Continuously disuse of some organ results in its weakening in offspring
(d) Concrete support to the theory through experiments

viii) The theory on human population which inspired Darwin was proposed by
(a) Malthus (b) Lyell
(c) Hutton (d) Wallace

ix) Theory of Natural Selection was lacking any support from
(a) Biogeography (b) Genetics
(c) Comparative anatomy (d) Molecular Biology

x) Which of the following cannot be the disruptive force for Hardy-Weinberg Theorem?
(a) Selection (b) Non-random mating
(c) Mutation (d) Random mating

2. Write short answers of the following questions.

i) Differentiate between the following:
a) Special Creation and Evolution
b) Lamarckism and Darwinism
c) Invagination theory and Endosymbiotic theory
d) Bottle-neck effect and Founder's effect
e) Convergent and Divergent evolution

ii) How the homologous organs support the theory of evolution?
iii) What are analogous organs? Give example.
iv) How Alfred Wallace contributed Charles Darwin regarding the Natural Selection?
v) What do understand by the "descent with modification"?
vi) How Neo-Darwinism differs from Darwinism?
vii) How the sympatric speciation differs from parapatric speciation?
viii) Justify Lamarck as an early proponent of evolution.
ix) What is genetic drift?
x) List out the factors affecting allele frequency

3. Write detailed answers to the following questions.

i) State and explain the contribution of Lamarck in organic evolution.
ii) Discuss the process of origin of single cell Eukaryotes.
iii) How biogeography and paleontology provide evidences in support of evolution?
iv) What is speciation? Explain different ways of speciation.
v) Describe the Theory of Natural Selection.