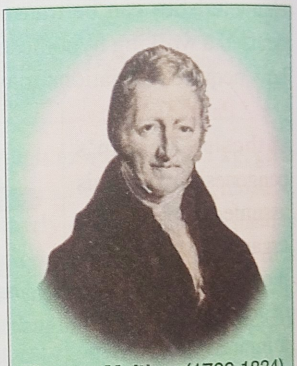
tal changes would produce modified organs, which in turn would produce modified pangenes that would transmit the change to the next generation.

In year 1875, Galton made pangenesis hypothesis untenable by presenting several experimental proofs. He and others at later time made a series of experiments involving blood transfusions and later, transplants of ovaries between black and white varieties of rabbits and chickens. Gametes produced by the transplanted ovaries were consistent with the phenotype of the individual in which the ovary originated and not with the animal currently carrying the ovary. Blood transfusions had no effect on the gametes produced. These experiments readily demonstrated that the pangenesis hypothesis was incorrect.

3. Having explained the origin of variation (although incorrectly), Darwin wondered how artificial selection (a term familiar then only to animal breeders) could be carried in nature. There was no breeder in nature to pick and choose. In 1838, Darwin found the solution in Thomas Robert Malthus book *'An Essay on the Principle of Population'* in which Malthus asserted that the reproductive capacity of mankind far exceeds the food supply available to nourish an expanding human population. Humans compete among themselves for the necessities of life.


Thomas Malthus (1766-1834).

It, thus, occurred to Darwin that **competition** existed among all living things. Darwin then envisioned that the **"struggle for existence"** might be the means by which the well-adapted individuals survive and ill-adjusted are eliminated. Darwin was the first to realize that perpetual selection existed in nature in the form of **natural selection**. In natural selection, as contrasted to artificial selection, the animal breeder or horticulturist is replaced by the conditions of the environment that prevent the survival and reproduction of certain individuals. Thus, natural selection is a term serving to inform us that *some individuals leave more offspring than others.* It is not purposeful or guided by a specific aim; it does not seek to attain a specific end.

Darwin-Wallace Theory of Natural Selection

Darwin-Wallace explanation of the way in which evolution occurs may be generalized as follows–*"The change in species by the survival of an organismal type exhibiting a natural variation that gives it an adaptive advantage in an environment, thus, leading to a new environmental equilibrium, is evolution by natural selection."* Thus, natural selection is a continuous process of trial and error on a gigantic scale, for all of living matter is involved. It includes the following elements :

1. The universal occurrence of variation. Variation is the characteristic of every group of animals and plants and there are many ways in which organisms may differ. (Darwin and Wallace did not understand the cause of variation, and assumed it was one of the innate properties of living things. We now know that inherited variations are caused by mutations.)

2. An excessive natural rate of multiplication. Every species, in the absence of environmental checks, tends to increase in a geometrical manner. If a population of a given species doubles in one year and if there are no checks on its increase, it will quadruple the next year, and so on. Such a great reproductive potential of different species may be easily observed in nature. It has been estimated that a common Atlantic coast oyster may shed as many as 80 million eggs in one season. A salmon produces 28,000,000 eggs in a season. A single pair of English sparrows would be the ancestors of over 275 billion individuals in 10 years if they and their descendants could reproduce at their natural rate without any check. Darwin calculated that even a pair of elephants which are about the slowest breeding animals known, could, in the absence of any checks, have 29 million descendants at the end of 800 years.

2. In the late 1830s, Darwin attended the meetings of animal breeders and intently read their publication. Animal breeders were conversant with the variability in their pet animals, and dwelled on the technique of **artificial selection**. Thus, the breeders selected and perpetuated those variant types that interested them or seemed useful to them. The breeders, however, had only vague notions as to the origin, or inheritance, of the variable traits.

Dog diversity illustrates artificial selection.

Darwin acknowledged the unlimited variability in organisms, but was never able to explain satisfactorily how a variant trait was inherited. Although Darwin criticized many aspects of Lamarck's theory, he did not deny that acquired characteristics can be transmitted. He realized that the nature of inheritance was unknown, but he devised a working hypothesis, called **hypothesis of pangenesis** (= origin from all) in 1868 to explain how acquired variations may be transmitted.

Pangenesis hypothesis. Darwin's pangenesis hypothesis assumed that all the organs, and perhaps all the cells, in the body of an animal produced miniatures of themselves. These miniatures, called **gemmules** or **pangenes**, were shed into the blood stream and carried to the sex glands (*viz.*, reproductive organs, the testes and ovaries), where they were assembled to form sex cells— the eggs or sperms. Later, when a fertilized egg undergoes development, according to the concept, the pangenes present are responsible for the particular features of the new individuals. In this manner, environmen-

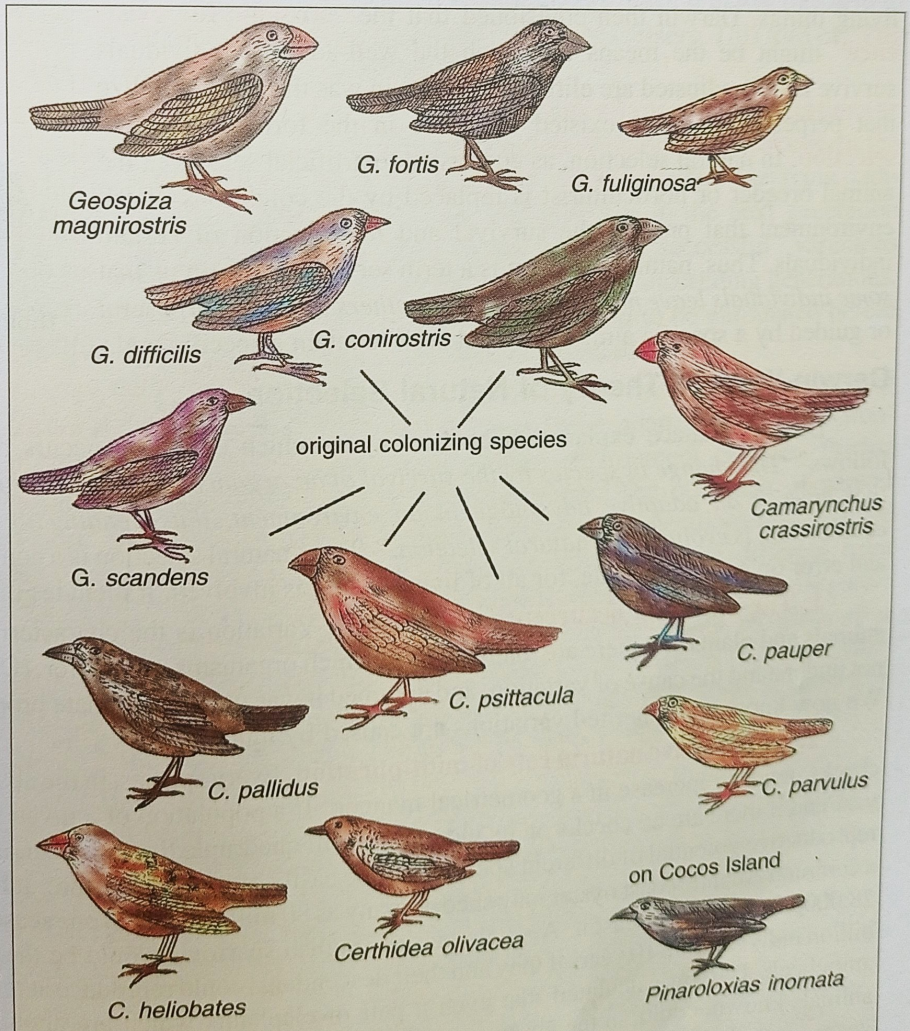


Fig. 5.4. Darwin's finches.

darwini. It appeared to Darwin that *species change not only in time but also with geographical distance.*

In the Galapagos Islands Darwin's scientific curiosity was greatly motivated by the many distinctive forms of life. The Galapagos consists of an isolated cluster of rugged volcanic islands in the eastern Pacific on the equator about 600 miles west of Ecuador. One of the most unusual animals is the giant land-dwelling tortoise, which may weigh as much as 275 kg, grow to 183 cm in length, and attain an age of 200 to 250 years. The Spanish word for tortoise, *galapago* gives the islands their name. Darwin noticed that the tortoises were clearly different from island to island, although the islands were only a few miles apart. In isolation, Darwin reasoned, each population had evolved its own distinctive features. Yet, all the island tortoises showed basic resemblances not only to each other but also to relatively large tortoises on the adjacent mainland of South America. All this communicated to Darwin that island tortoises shared a common ancestor with the mainland forms. The same was true of a group of small black birds known today as Darwin's finches. Darwin observed that the finches were different on the various islands, yet they were obviously closely related to each other. Darwin concluded that finches were derived from an ancestral stock that had emigrated from the mainland to the volcanic islands and had undergone profound changes under the different conditions of the individual islands. Apparently, *a single ancestral group can give rise to several different varieties of species.*

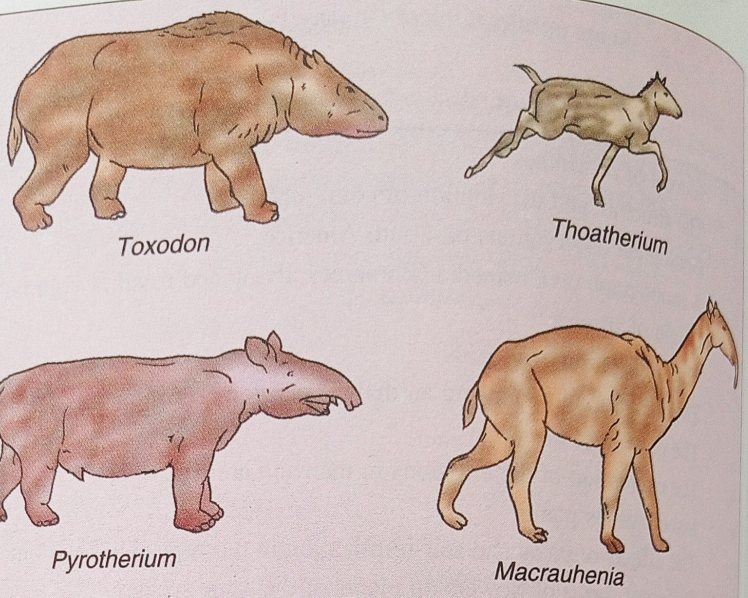
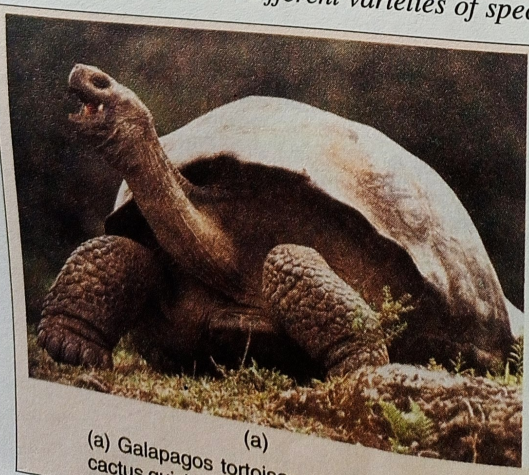
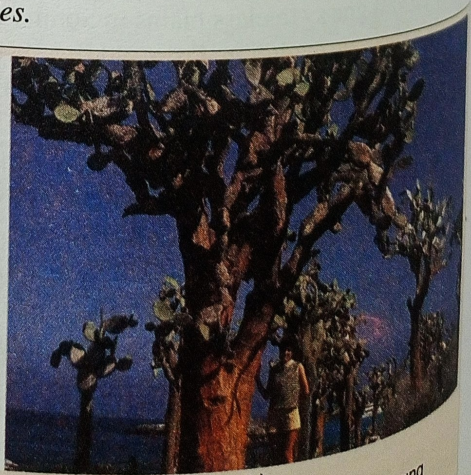


Fig. 5.3. Curious extinct hoofed mammals (ungulates) of South America. Bones of these great mammals were found by Darwin on the flat treeless plains of Argentina (after Volpe, 1985).



(a)



(b)

(a) Galapagos tortoises feed on prickly pear cactuses. (b) On islands with tortoises, a young cactus quickly grows a tall trunk, which lifts the succulent pads beyond the reach of the tortoises.

Table 5-1. Some publications of Charles Darwin.

	Title of book	Year of Publication
1.	Journal of researches	1839
2.	The structure and distribution of coral reefs	1844
3.	Geological observations on South America	1846
4.	A monograph on Cirripedia (Barancles, living and fossil, 4 volumes)	1851, 1854
5.	Origin of species	1859
6.	The fertilization of orchids	1862
7.	The variation of plants and animals under domestication	1868
8.	The descent of man	1871
9.	The expression of the emotions in men and animals	1872
10.	Insectivorous plants	1875
11.	The effects of cross and self-fertilization in the vegetable kingdom	1876
12.	Different forms of flowers on plants of the same species	1877
13.	The power of movement in plants	1880
14.	The formation of vegetable mould through the action of worms	1881

Facts that influenced Darwin's Thoughts

During the period in which Darwin massed his evidence and developed his natural selection theory, many things affected his thinking, of which three, in particular, deserve mention here :

1. During his voyage, Darwin took only a few books on board. One of them was the newly published first volume of **Charles Lyell's** *Principles of Geology*, a parting gift from his Cambridge mentor, **John Henslow**. In this book, **Lyell** challenged the prevailing belief that the earth has been created by a divine plan merely 6,000 years ago. On the contrary, the earth's age could be measured in hundreds of millions of years. Lyell asserted that the earth's mountains, valleys, rivers, and coastlines were shaped not by Noah's Flood but by the ordinary action of the rains, the winds, earthquakes, volcanoes, and other natural forces. Darwin was impressed by Lyell's emphasis on the great antiquity of the earth's rocks, and gradually came to conclusion that the characteristics of organisms as well as the face of the earth could change over a vast span of time.

The living and extinct organisms that Darwin observed in the flat plains of the Argentine pampas (Pampas are vast grassy treeless plains in South America) and the Galapagos Islands sowed the seeds of Darwin's views on evolution. From old river beds in the Argentine pampas, he dug up bony remains (fossils) of extinct mammals such as *Toxodon, Macrauchenia, Pyrotherium* and *Thoatherium* (Fig. 5.3). The presence of *Thoatherium* testified that a horse had been among the ancient inhabitants of the continent. It was the Spanish settlers who reintroduced the modern horse, *Equus*, to the continent of South America in the sixteenth century. Darwin wondered that a native horse should have lived and disappeared in South America. This was one of the first indications that *species gradually became modified with time, and that not all species survived through the ages.*

Further, when Darwin collected the remains of giant armadillos and sloths on an Argentine pampa, he revealed the fact that, although they clearly belonged to extinct forms, they were constructed on the same basic plan as the small living armadillos and sloths of the same region. This observation initiated him to think of the fossil sequence of a given animal species through the ages and causes of extinction. Moreover, what Darwin had appreciated was that *living species have ancestors.* On travelling from the north to the south of South America, Darwin observed that one species was replaced by similar, but slightly different, species. In the southern part of Argentina, Darwin caught a rare species of ostrich that was smaller and differently coloured from the more northern common American ostrich, *Rhea americanus.* This rare species of bird was later named *Rhea*

Darwin acted as the secretary of Geological society, where he came in contact with an emine geologist, **Charles Lyell**. It was not until 1844 that Darwin developed his idea of natural selection an essay, but not for publication. He showed the manuscript to **Lyell** who encouraged him to prepa a book. Darwin still took no steps toward publishing his views. Perhaps he was well aware of ho Lamarck's earlier theory had been received and wanted all possible supporting evidence befo publishing his own new theory. It appears that Darwin might not have prepared his famous volum had not a fellow naturalist in the Dutch East Indies, **Alfred Russel Wallace** (1823 – 1913

Fig.5.2. Five-years (from 1831 to 1836) world voyage of *H.M.S. Beagle*. Darwin's observations on this voyage convinced him of the reality of evolution (after Volpe, 1985).

independently conceived of the idea of natural selection. **Wallace** had travelled widely in tropical South America and Southeastern Asia, for studying the flora and fauna of these regions. **Wallace** also inspired by reading Malthus's essay, and the idea of natural selection came to him in a flash of insight during a sudden fit of malarial fever (This happened in February, 1858, when he was working in the island of Ternate in Indonesia). In June of 1858, Wallace sent Darwin a short essay *"On the tendency of varieties to depart indefinitely from the original type,"* and asked him if he thought of sufficient interest to present it to the Linnaean Society. We can easily imagine Darwin's amazement upon receiving Wallace's essay. Upon the insistence of the geologist **Charles Lyell** and the botanist **Joseph Hooker**, Darwin prepared an abstract of his conclusions for joint publication with Wallace's essay. Wallace's essay and a portion of Darwin's manuscript, each containing remarkably similar views, were read simultaneously before the Linnaean Society in London on July 1, 1858. The joint reading of the papers stirred little interest.

Darwin then laboured for eight months to compress his voluminous notes into a single book, which he modestly called " only an Abstract". Wallace shares with Darwin the honour of establishing the mechanism by which evolution is brought about, but it was the monumental *The Origin of Species* with its impressive weight of evidence and argument that left its mark on mankind. The fact that this book, written by Darwin alone, exposed the public at large to the theory of natural selection, and that Wallace was still in Indonesia at the time of the controversy and could not champion Darwin's defence by adding his own views, brought the public to associate only Darwin with this theory. Thus the theory is called the **Darwinian**, rather than the **Darwin-Wallace theory of evolution**.

Darwin died on April 19, 1882, when he was 73 years old. During his life, he wrote numerous books, journals, etc. Some of them can be listed in Table (5 . 1)

7. Kammerer worked on the tailed amphibian *Proteus anguinus* which lives in complete darkness in the water of underground cave. It was blind and colourless. He brought *Proteus* in daylight due to which it became coloured (brown and black), which passed on to its progeny. Eyes of *Proteus* also developed normally in daylight. This showed that any change in environmental conditions induced changes in the animals and the acquired characters were inherited.

Further, **Winterbert** (1962) has tried, with some success, to give Lamarckism a chemical basis by involving the capacity of every living being to react to environmental changes and aggressions. According to **Winterbert**, nothing is acquired by the living organism that is not the response of internal factors to an outside influence or ethological change. Living means reacting, never undergoing. Above all, it means not waiting around for a fortunate chance occurrence to save the situation (**Grasse**, 1977).

2. THEORY OF NATURAL SELECTION (DARWINISM)

More than a century ago, in 1859, **Charles Robert Darwin** (1809–1822) gave the biological world the master key that unlocked all previous perplexities regarding the mechanism of organic evolution. His natural selection theory can be compared only with such revolutionary ideas as Newton's law of gravitation and Einstein's theory of relativity (**Volpe**, 1985). The concept of natural selection was explained clearly and convincingly by Darwin in his masterpiece – *The Origin of Species* (The full title of the book was *On the Origin of Species by Means of Natural Selection, or The Preservation of Favoured Races in the Struggle for Life*). This epoch-making book was the fruition of more than twenty years of meticulous accumulation and analysis of facts. The first edition of the book, some 1,250 copies, was sold out on the very day it appeared, November 24, 1859. This book had opened a Pandora's box; it was immediately both acidly attacked and effusively praised.

Charles Robert Darwin was born on February 12, 1809 in Shrewsbury, England. His personality was not the type that one associates with a successful man, let alone a great one. While his family held a distinguished reputation (his grandfather **Erasmus Darwin** was a noted poet scientist, his father **Robert**, was an eminent physician, and his mother was a Wedgwood, the family of pottery fame), Charles was a singularly undistinguished individual whose contemporaries viewed him as just a normal, gentle, cautious, morally upright English lad. After completing his early education at Shrewsbury, Charles Darwin was sent at the age of fifteen to study medicine at the University of Edinburg. His medical interests soon dissipated, and he became something of an academic rover, studying a little science, but finding it too formal for his tastes.

His father then suggested him to become a clergyman, which appealed him. So, he got transferred, after two years, to Christ's college, Cambridge University, to study theology. There too he spent his energy in card-playing and drinking. He was obviously not ready for clerical commitments.

He did manage, however, to find some constructive interest in natural history and in collection of natural objects of all kinds. His friendship with Professor **John Stevens Henslow**, botanist at Cambridge, stimulated an interest in botany, while his exposure to the geologist **Sedgwick** stimulated an interest in geological explorations. Through the recommendation of **Dr. Henslow**, Darwin accepted a most inauspicious position as a naturalist without pay aboard the H.M.S. *Beagle*. The ship was to spend five years in exploration, mostly of South America. Darwin was to provide a collection of material representing the natural composition of the areas visited.

The ship *Beagle* left Plymouth on December 27, 1831 and visited many islands of the Atlantic ocean, some coasts of South America and some islands of south Pacific, of which Galapagos Islands are the most important. During his five years (from 1831 to 1836) on the *Beagle*, Darwin recorded almost everything he observed and sent an enormous amount of material back to England.

Upon his return home in 1836, he spent two years writing a book of his experiences, The *Voyage of the Beagle*. In 1838, he got married and later had two daughters and five sons. From 1838 to 1841,