

## Evidences from Vestigial organs

- 1) Wisdom teeth (The Molar)
- 2) Body hair
- 3) Nipples in Males
- 4) Segmented Muscles of abdomen
- 5) Muscle of pinna (Auricular Muscle).
- 6) Nictitating membrane.

- ⇒ Atavism
- 1) Tail in New born body ( पीलिंग zond's )
  - 2) Combs → long and thick body hair
  - 3) Nipples → Extra in females

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Evidences from connecting links

Virus - B/w living and non living

Euglena - plants & Animals

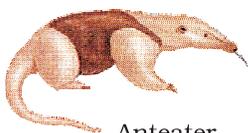
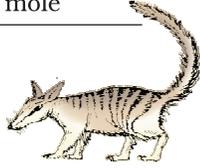
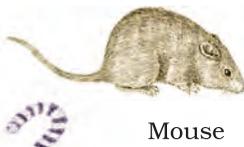
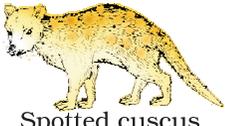
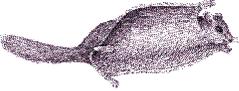
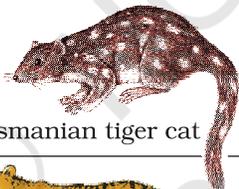
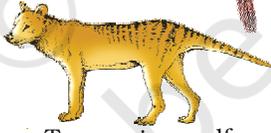
Neopilina - annelida and Mollusca

chimera - cartilage and bony fish

Protopterus (lung fish) - fish and Amphibia

Archaeopteryx - B/w reptiles and birds

platypus  
Echidna → reptile and Mammals.

Placental mammals	Australian marsupials
 Mole	 Marsupial mole
 Anteater	 Numbat (anteater)
 Mouse	 Marsupial mouse
 Lemur	 Spotted cuscus
 Flying squirrel	 Flying phalanger
 Bobcat	 Tasmanian tiger cat
 Wolf	 Tasmanian wolf

**Figure 7.7** Picture showing convergent evolution of Australian Marsupials and placental mammals

different habitats), one can call this convergent evolution. Placental mammals in Australia also exhibit adaptive radiation in evolving into varieties of such placental mammals each of which appears to be 'similar' to a corresponding marsupial (e.g., Placental wolf and Tasmanian wolf-marsupial). (Figure 7.7).

## 7.5 BIOLOGICAL EVOLUTION

Evolution by natural selection, in a true sense would have started when cellular forms of life with differences in metabolic capability originated on earth.

The essence of Darwinian theory about evolution is natural selection. The rate of appearance of new forms is linked to the life cycle or the life span. Microbes that divide fast have the ability to multiply and become millions of individuals within hours. A colony of bacteria (say A) growing on a given medium has built-in variation in terms of ability to utilise a feed component. A change in the medium composition would bring out only that part of the population (say B) that can survive under the new conditions. In due course of time this variant population outgrows the others and appears as new species. This would happen within days. For the same thing to happen in a fish or fowl would take million of years as life spans of these animals are in years. Here we say that fitness of B is better than that of A under the new conditions. Nature selects for fitness. One must remember that the so-called fitness is based on characteristics which are inherited.

Hence, there must be a genetic basis for getting selected and to evolve. Another way of saying the same thing is that some organisms are better adapted to survive in an otherwise hostile environment. Adaptive ability is inherited. It has a genetic basis. Fitness is the end result of the ability to adapt and get selected by nature.

**Branching descent** and **natural selection** are the two key concepts of Darwinian Theory of Evolution (Figures 7.7 and 7.8).

Even before Darwin, a French naturalist Lamarck had said that evolution of life forms had occurred but driven by use and disuse of



organs. He gave the examples of Giraffes who in an attempt to forage leaves on tall trees had to adapt by elongation of their necks. As they passed on this acquired character of elongated neck to succeeding generations, Giraffes, slowly, over the years, came to acquire long necks. Nobody believes this conjecture any more.

Is evolution a process or the result of a process? The world we see, inanimate and animate, is only the success stories of evolution. When we describe the story of this world we describe evolution as a process. On the other hand when we describe the story of life on earth, we treat evolution as a consequence of a process called natural selection. We are still not very clear whether to regard evolution and natural selection as processes or end result of unknown processes.

It is possible that the work of Thomas Malthus on populations influenced Darwin. Natural selection is based on certain observations which are factual. For example, natural resources are limited, populations are stable in size except for seasonal fluctuation, members of a population vary in characteristics (infact no two individuals are alike) even though they look superficially similar, most of variations are inherited etc. The fact that theoretically population size will grow exponentially if everybody reproduced maximally (this fact can be seen in a growing bacterial population) and the fact that population sizes in reality are limited, means that there had been competition for resources. Only some survived and grew at the cost of others that could not flourish. The novelty and brilliant insight of Darwin was this: he asserted that variations, which are heritable and which make resource utilisation better for few (adapted to habitat better) will enable only those to reproduce and leave more progeny. Hence for a period of time, over many generations, survivors will leave more progeny and there would be a change in population characteristic and hence new forms appear to arise.

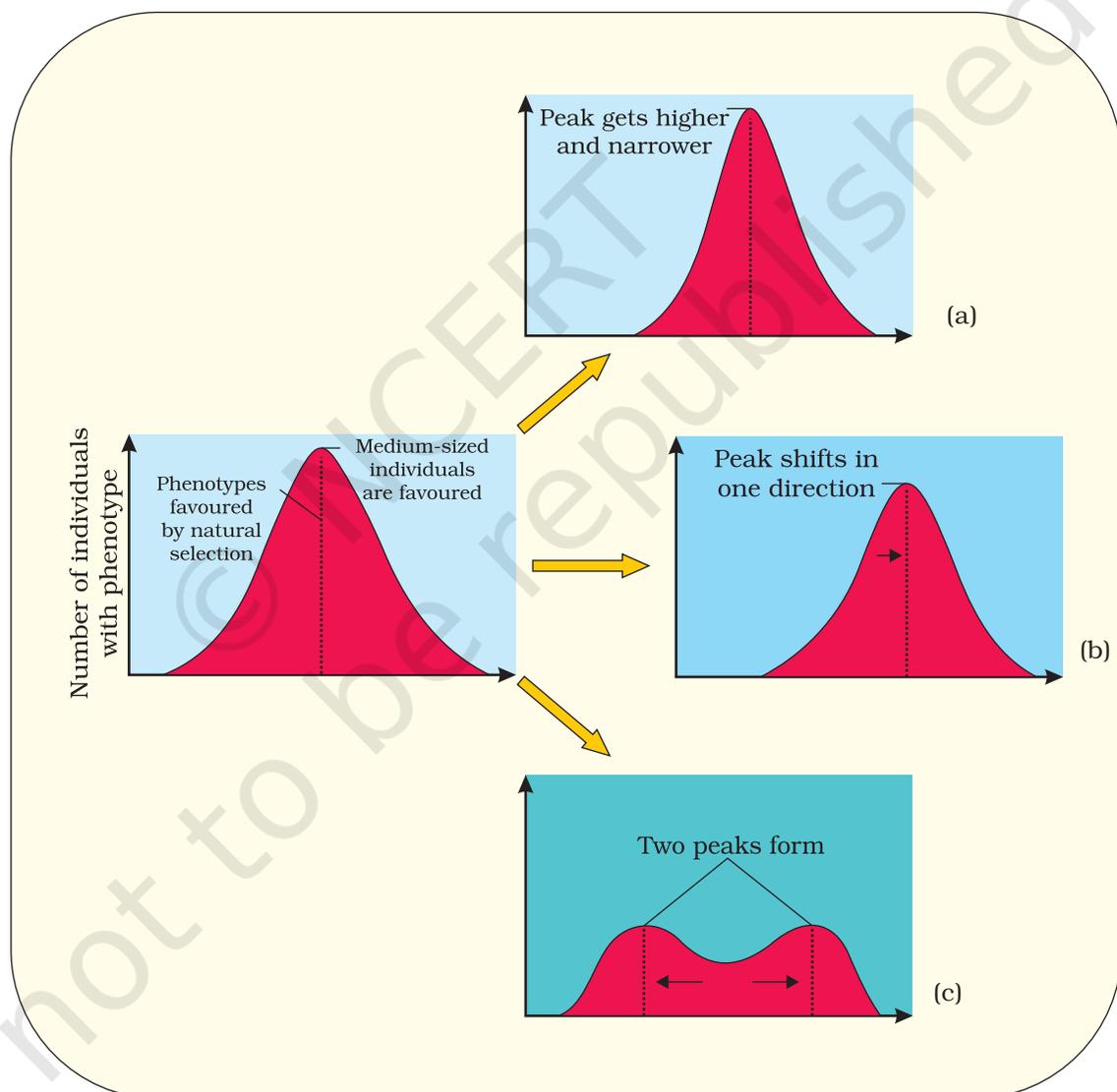
## 7.6 MECHANISM OF EVOLUTION

What is the origin of this variation and how does speciation occur? Even though Mendel had talked of inheritable 'factors' influencing phenotype, Darwin either ignored these observations or kept silence. In the first decade of twentieth century, Hugo deVries based on his work on evening primrose brought forth the idea of mutations – large difference arising suddenly in a population. He believed that it is mutation which causes evolution and not the minor variations (heritable) that Darwin talked about. Mutations are random and directionless while Darwinian variations are small and directional. Evolution for Darwin was gradual while deVries believed mutation caused speciation and hence called it **saltation** (single step large mutation). Studies in population genetics, later, brought out some clarity.

## 7.7 HARDY-WEINBERG PRINCIPLE

In a given population one can find out the frequency of occurrence of alleles of a gene or a locus. This frequency is supposed to remain fixed and even remain the same through generations. Hardy-Weinberg principle stated it using algebraic equations.

This principle says that allele frequencies in a population are stable and is constant from generation to generation. The gene pool (total genes and their alleles in a population) remains a constant. This is called genetic equilibrium. Sum total of all the allelic frequencies is 1. Individual



**Figure 7.8** Diagrammatic representation of the operation of natural selection on different traits : (a) Stabilising (b) Directional and (c) Disruptive



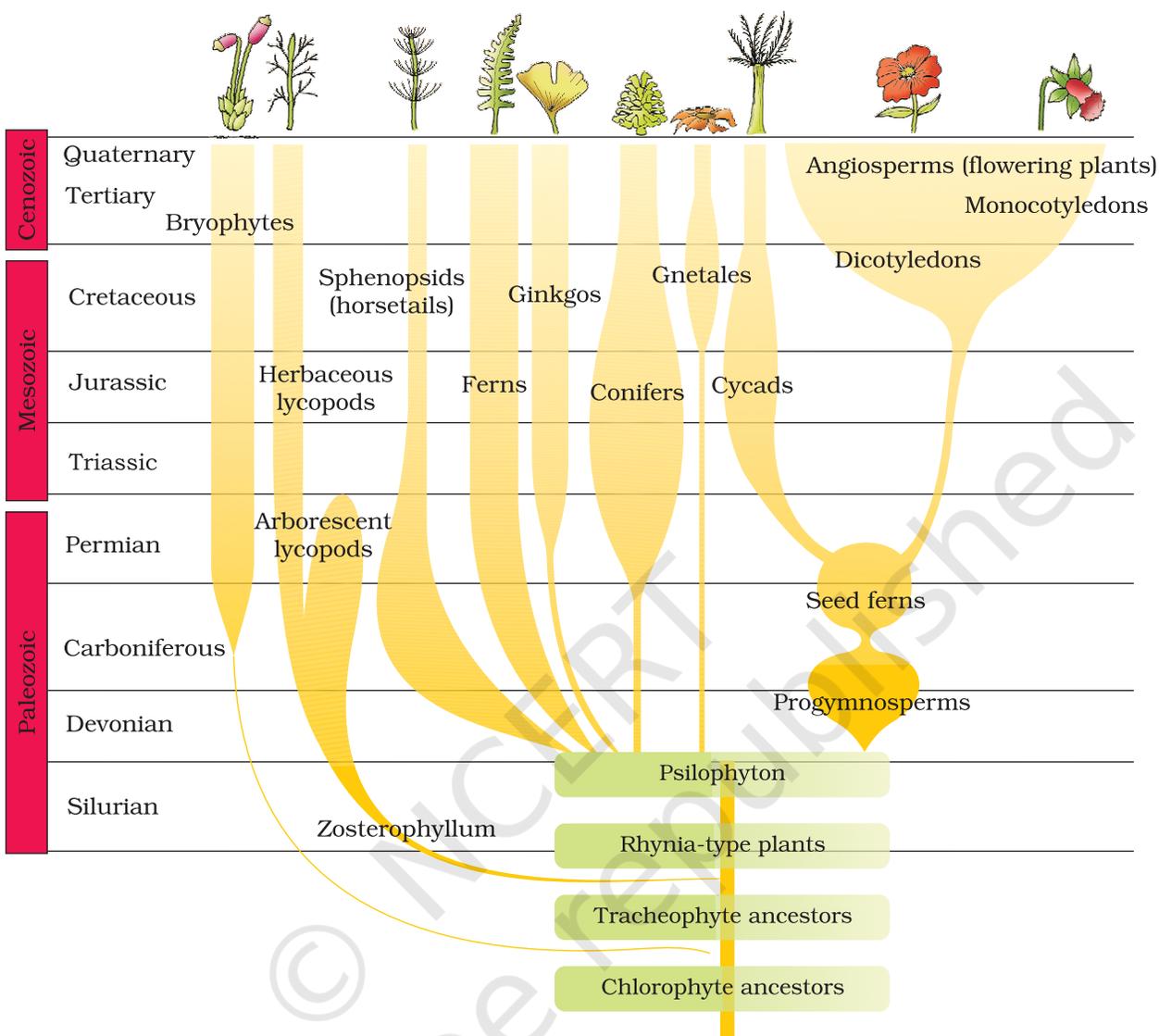
frequencies, for example, can be named  $p$ ,  $q$ , etc. In a diploid,  $p$  and  $q$  represent the frequency of allele  $A$  and allele  $a$ . The frequency of  $AA$  individuals in a population is simply  $p^2$ . This is simply stated in another way, i.e., the probability that an allele  $A$  with a frequency of  $p$  appear on both the chromosomes of a diploid individual is simply the product of the probabilities, i.e.,  $p^2$ . Similarly of  $aa$  is  $q^2$ , of  $Aa$   $2pq$ . Hence,  $p^2+2pq+q^2=1$ . This is a binomial expansion of  $(p+q)^2$ . When frequency measured, differs from expected values, the difference (direction) indicates the extent of evolutionary change. Disturbance in genetic equilibrium, or Hardy-Weinberg equilibrium, i.e., change of frequency of alleles in a population would then be interpreted as resulting in evolution.

Five factors are known to affect Hardy-Weinberg equilibrium. These are gene migration or gene flow, genetic drift, mutation, genetic recombination and natural selection. When migration of a section of population to another place and population occurs, gene frequencies change in the original as well as in the new population. New genes/alleles are added to the new population and these are lost from the old population. There would be a gene flow if this gene migration, happens multiple times. If the same change occurs by chance, it is called genetic drift. Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founders and the effect is called **founder effect**.

Microbial experiments show that pre-existing advantageous mutations when selected will result in observation of new phenotypes. Over few generations, this would result in Speciation. Natural selection is a process in which heritable variations enabling better survival are enabled to reproduce and leave greater number of progeny. A critical analysis makes us believe that variation due to mutation or variation due to recombination during gametogenesis, or due to gene flow or genetic drift results in changed frequency of genes and alleles in future generation. Coupled to enhance reproductive success, natural selection makes it look like different population. Natural selection can lead to stabilisation (in which more individuals acquire mean character value), directional change (more individuals acquire value other than the mean character value) or disruption (more individuals acquire peripheral character value at both ends of the distribution curve) (Figure 7.8).

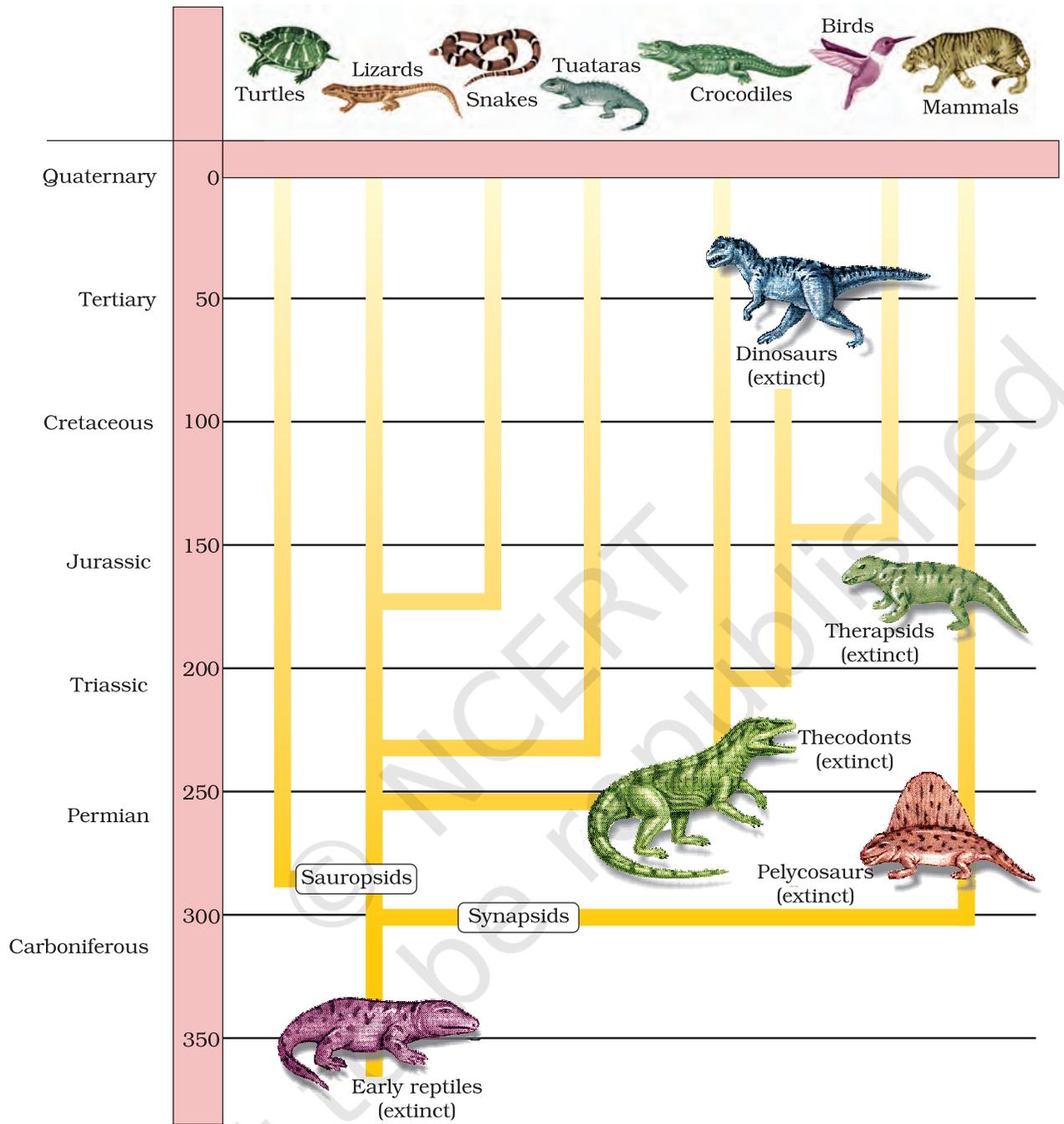
## 7.8 A BRIEF ACCOUNT OF EVOLUTION

About 2000 million years ago (mya) the first cellular forms of life appeared on earth. The mechanism of how non-cellular aggregates of giant macromolecules could evolve into cells with membranous envelop is not known. Some of these cells had the ability to release  $O_2$ . The reaction



**Figure 7.9** A sketch of the evolution of plant forms through geological periods

could have been similar to the light reaction in photosynthesis where water is split with the help of solar energy captured and channelised by appropriate light harvesting pigments. Slowly single-celled organisms became multi-cellular life forms. By the time of 500 mya, invertebrates were formed and active. Jawless fish probably evolved around 350 mya. Sea weeds and few plants existed probably around 320 mya. We are told that the first organisms that invaded land were plants. They were widespread on land when animals invaded land. Fish with stout and strong fins could move on land and go back to water. This was about 350 mya. In 1938, a fish caught in South Africa happened to be a Coelacanth which was thought to be extinct. These animals called lobefins evolved into the



**Figure 7.10** Representative evolutionary history of vertebrates through geological periods

first amphibians that lived on both land and water. There are no specimens of these left with us. However, these were ancestors of modern day frogs and salamanders. The amphibians evolved into reptiles. They lay thick-shelled eggs which do not dry up in sun unlike those of amphibians. Again we only see their modern day descendents, the turtles, tortoises and crocodiles. In the next 200 millions years or so, reptiles of different

shapes and sizes dominated on earth. Giant ferns (pteridophytes) were present but they all fell to form coal deposits slowly. Some of these land reptiles went back into water to evolve into fish like reptiles probably 200 mya (e.g. *Ichthyosaurs*). The land reptiles were, of course, the dinosaurs. The biggest of them, i.e., *Tyrannosaurus rex* was about 20 feet in height and had huge fearsome dagger like teeth. About 65 mya, the dinosaurs suddenly disappeared from the earth. We do not know the true reason. Some say climatic changes killed them. Some say most of them evolved into birds. The truth may lie in between. Small sized reptiles of that era still exist today.

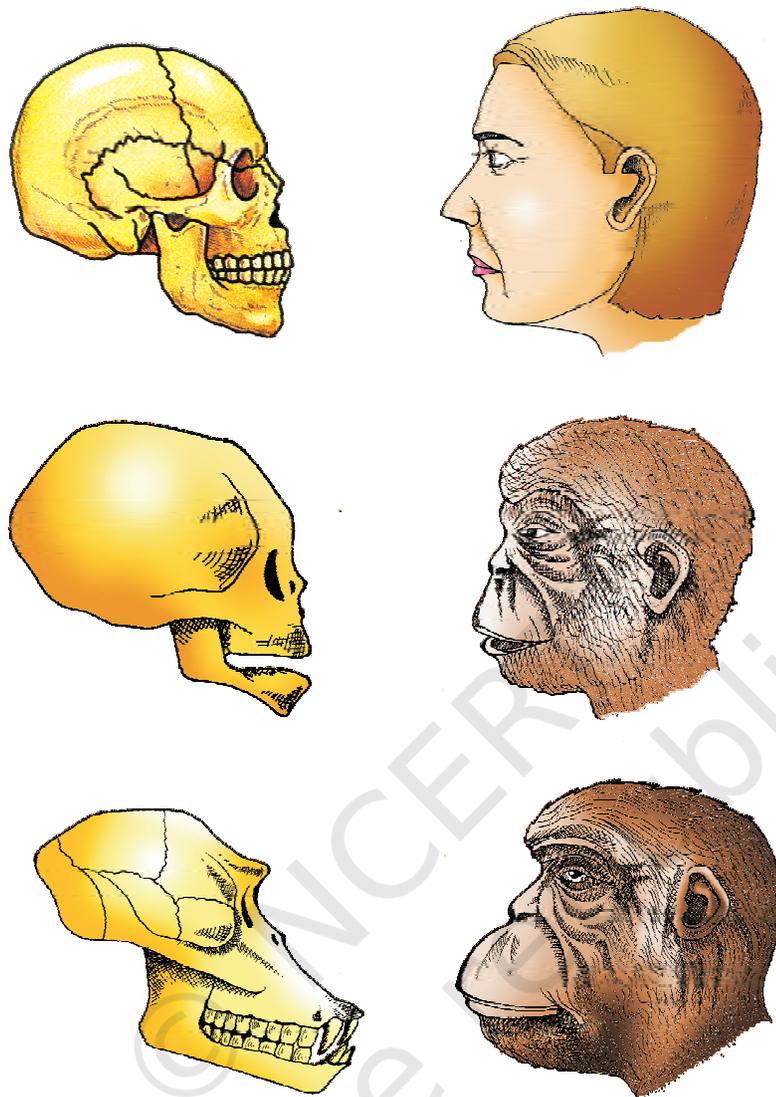
The first mammals were like shrews. Their fossils are small sized. Mammals were viviparous and protected their unborn young inside the mother's body. Mammals were more intelligent in sensing and avoiding danger at least. When reptiles came down mammals took over this earth. There were in South America mammals resembling horse, hippopotamus, bear, rabbit, etc. Due to continental drift, when South America joined North America, these animals were overridden by North American fauna. Due to the same continental drift pouched mammals of Australia survived because of lack of competition from any other mammal.

Lest we forget, some mammals live wholly in water. Whales, dolphins, seals and sea cows are some examples. Evolution of horse, elephant, dog, etc., are special stories of evolution. You will learn about these in higher classes. The most successful story is the evolution of man with language skills and self-consciousness.

A rough sketch of the evolution of life forms, their times on a geological scale are indicated in (Figure 7.9 and 7.10).

## 7.9 ORIGIN AND EVOLUTION OF MAN

About 15 mya, primates called *Dryopithecus* and *Ramapithecus* were existing. They were hairy and walked like gorillas and chimpanzees. *Ramapithecus* was more man-like while *Dryopithecus* was more ape-like. Few fossils of man-like bones have been discovered in Ethiopia and Tanzania (Figure 7.11). These revealed hominid features leading to the belief that about 3-4 mya, man-like primates walked in eastern Africa. They were probably not taller than 4 feet but walked up right. Two mya, *Australopithecines* probably lived in East African grasslands. Evidence shows they hunted with stone weapons but essentially ate fruit. Some of the bones among the bones discovered were different. This creature was called the first human-like being the hominid and was called *Homo habilis*. The brain capacities were between 650-800cc. They probably did not eat meat. Fossils discovered in Java in 1891 revealed the next stage, i.e., *Homo erectus* about 1.5 mya. *Homo erectus* had a large brain around 900cc.



**Figure 7.11** A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee. The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull

*Homo erectus* probably ate meat. The Neanderthal man with a brain size of 1400cc lived in near east and central Asia between 1,00,000-40,000 years back. They used hides to protect their body and buried their dead. *Homo sapiens* arose in Africa and moved across continents and developed into distinct races. During ice age between 75,000-10,000 years ago modern *Homo sapiens* arose. Pre-historic cave art developed about 18,000 years ago. One such cave paintings by Pre-historic humans can be seen at Bhimbetka rock shelter in Raisen district of Madhya Pradesh. Agriculture came around 10,000 years back and human settlements started. The rest of what happened is part of human history of growth and decline of civilisations.