Origin of Life and Human Evolution

Introduction

Life is the inherent capacity of organisms to utilise the outside materials (light, water, gases or food) for energy, growth and reproduction through chemical reactions (metabolism) in a controlled manner.

Philosophers and scientists have long attempted to learn how, when and where life originated, and the way in which the original simple life gave rise to the different kinds of organisms (bacteria, fungi, protists, algae, animals and plants) found in the world today.

17.1 Theories of origin of life

Origin of life is a unique event in the history of universe. Various theories have been put forward to explain the phenomenon of origin of life. A few of them were only speculations while others were based on scientific grounds. These theories are

(i) Theory of special creation

(ii) Theory of spontaneous generation

(iii) Theory of biogenesis

(iv) Theory cosmozoic

(v) Theory of sudden creation from inorganic material

(i) **Theory of special creation :** According to a Spanish Priest Father **Suarez** (1548 – 1617 B.C.), the whole universe was created in six days by the god.

(ii) **Theory of spontaneous generation or Abiogenesis :** This theory postulates that life originated from non-living matter spontaneously from time to time. This theory was supported by Plato, Aristotle, Anaximander, John Ray, Needham, Von Helmont, *etc.,* upto the end of seventeen century. Huxley (1870) criticised this theory and propounded the theory life originated from preexisting life only. Abiogenesis means origin of life from non living organism.

(iii) **Biogenesis :** Scientists like **Redi** (1668) **Spallanzani** (1767), **Louis Pasteur (**1866) provided experimental support for the Biogenesis concept of **Huxley.**

Francisco Redi (1668) showed that maggots could not be created from meat. Actually, the smell of meat attracts flies which lay eggs on the flesh. These eggs hatched into flies.

Spallanzani (1767) showed that even primitive, unicellular organisms cannot arise from non-living matter.

Louis Pasteur (1860-62) obtained air samples in the flasks of broth (yeast and sugar solution) whose drawn-out necks were sealed cooling these contained a partial vacuum. Where a sample was required, the flask was opened. Air was drawn in and the flask was resealed. Flasks were incubated. These flasks which were opened in the streets became turbid while those exposed to dust-free air rarely contained bacteria.

Louis Pasteur also, used swan-necked flasks whose long, curved necks permitted exchange of air between outside and inside of the flask, but dust and bacteria were trapped along the wall of the neck. On tilting the flask, the bacteria got washed down into the broth, so that the latter became cloudy due to bacterial growth.

(iv) **Cosmozoic Theory :** Richter (1865), Preyer (1880), Arrhenius (1908), Hoyle (1950) and Bondi (1952) Watson (1982) believed in eternity of life. According to Arrhenius life was transferred from "cosmozoa" (life of outer space) to different planets small units called 'spores'.

(v) **Theory of sudden creation :** Cuvier (1769-1832) believed in catastrophism from inorganic material.

17.2 Haldane and oparin's theory

Haldane, a British scientist, stated that in the early atmosphere of gas mixture probably carbon dioxide, ammonia and water vapours were predominantly present. When ultraviolet rays reacted on them, organic molecules were formed. Gradually, quantity of these oceans which later gave rise to amino acids, proteins, carbohydrates, nucleic acids, *etc.*

Oparin (1924) proposed that life could have originated from non-living organic molecules. He believed in **Biochemical origin of life. Haldane** (1929) also stated similar views. Oparin greatly expended his ideas and presented them as a book "***The origin of life***" in 1936.

According to this theory, the Earth originated about 4,500 million years ago. When the earth was cooling down, it had a reduced atmosphere. In this primitive atmosphere nitrogen, hydrogen, ammonia, methane, carbon mono-oxide and water were present. Energy was available in the form of electric discharges by lightening and ultraviolet rays. As soon as the earth crust was formed, it was very much folded. Torrential rains poured over the earth for centuries and were deposited in deep places.

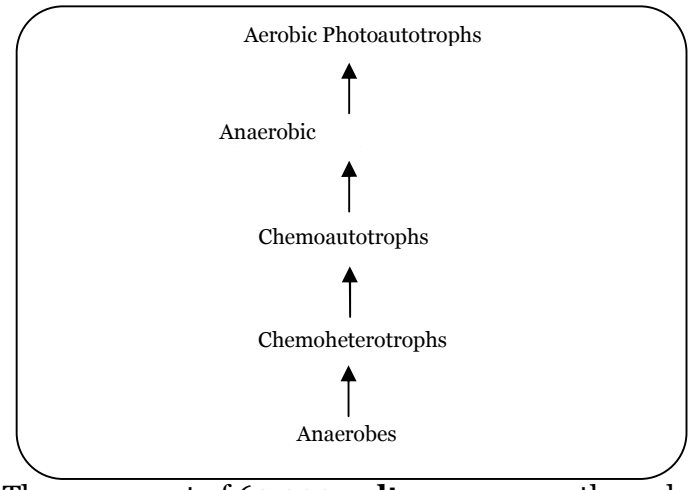
The atmospheric compounds, inorganic salts and minerals also came in deep places oceans, these molecules gave rise to a variety of compounds and finally to the self-duplicating molecules. Ultimately these molecules were enclosed in membranes derived from lipids and proteins, along with water and chemical compounds, giving rise to cell like units. So the first organisms were chemohetrotrophs. Again random combinations may have led to the formation of **chlorophyll** containing organisms which could produce their own food **(autotrophs)** by a process called photosynthesis. These organisms had a better chance to live because they synthesise starch from carbon dioxide and water in presence of sunlight. During photosynthesis, oxygen was produced. The oxygen was used by other organisms for respiration. Also oxygen, when acted upon by ultraviolet rays, formed **ozone layer** through which ultraviolet rays cannot pass. This layer is formed about 25 km. from earth's surface. After the formation of ozone layer, organisms could come to the surface of the ocean and could survive even on land, if thrown out of oceans. The Oparins's and Haldane's theory of origin of life is most accepted these days as it is supported by Miller's experiment duly supported by David Buhal, Melvin Kelvin's experiment etc. O_2 is absent in the primordial atmospheres at the time of origin of life

17.3 Miller's Experiment

An American scientist (Biologist) **Stanley Miller** (1953) performed an experiment under support Oparin's theory of origin of life. He believed that basic compounds which are essential for life can be synthesised in the

laboratory by creation in the laboratory, on a small scale, the conditions which must have existed at the time of origin of life on earth.

Miller took a flask and filled it with methane, ammonia and hydrogen at 0°C. This proportion of gases probably existed in the environment at time of origin of life. This flask was connected with a smaller flask, that was filled with water, with the help of glass tubes. In the bigger flask, two electrodes of tungsten were fitted.



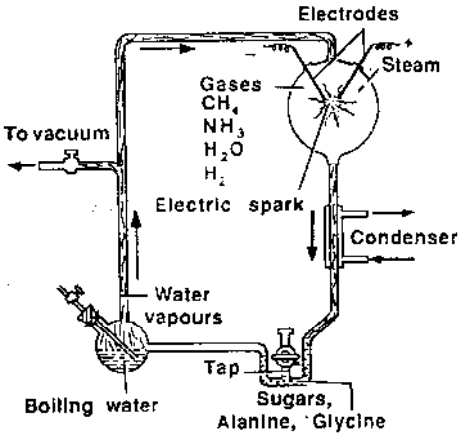


Fig: Experiment conducted by Stanley Miller

Then a current of 60,000 **volts** was passes, through gases containing bigger flask for seven days. At the end of seven days, when the vapours condensed, a red substance was found in the U-tube. When this red substance was analyzed, it was found to contain **amino acids, Glycine** and nitrogenous bases which are found in the nucleus of a cell. An experiment to prove that organic compounds were the basis of life, was performed by miller. From the above theory we conclude that **life first originated in water.**

17.4 Organic evolution

The word evolution originated from the Latin work '*evolver*' which means to unroll or to unfold. Evolution can be defined as an extremely slow process of continuous changes by means of which new types of organs or organisms developed and some older types become totally extinct.

(i) **Chemical or molecular evolution :** Referred to as formation of complex compounds from simpler ones and formation of more complex molecules.

(ii) **Organic or biological evolution :** Gradual change occurs in living world producing more organised and diversified varieties of life forms is referred as organic evolution.

(iii) **Directions of evolution :** Evolution may take place along four main direction

(a) **Progressive :** Where there is an over increasing complexity in the structure and differentiation of parts

(b) **Retrogressive :** Where there is gradual decline or degeneration of complexities and retrogression or suppression of parts.

(c) **Parallel :** Where structurally similar types show identical changes in identical conditions of environment.

(d) **Convergent :** Where a change occur in same direction in types which were dissimilar to start with.

17.5 Evidences of evolution

Evidences to support the theory of evolution come from different fields of science. Some evidence are given below.

(i) **Taxonomy :** Phylogenetic tree in scheme of classification provides a proof of descent from a common ancestor.

(ii) **Comparative anatomy :** Study of functional anatomy is called tectology.

(iii) **Homology and homologous organs**

(a) Homologous organs are similar in origin but similar or dissimilar in function.

(b) Forelimbs of tetrapoda like flippers (paddles) of whale or seal, wings of bat, cat's pad, fore limbs of horse, human hand and wings of birds are all homologous organs.

(c) Fore-limbs are modified for swimming, flying, running and grasping.

(iv) **Analogy and analogous organs**

(a) Analogous organs are similar in function but dissimilar in origin.

(b) Examples : Wings of bird and wings of butter flies. Gills of palaeomon and gills of fishes.

(v) **Vestigeal organs**

(a) Vestigeal organs are non-functional and rudimentary organs correspond to fully developed and functional organs of related organisms.

(b) Examples : (1) Plica semilunare's (2) Muscles of ear pinna (3) Body hairs (4) Mammary glands in male (5) Vermiform appendix (6) Cannine teeth and third molar (7) Coccyx (fused caudal vertebral) (8) Panniculus carnosis (subcutaneous muscles for moving skin).

(c) Hind limbs in python and Boas, pelvic girdle and pinna of whale, wings of flightless birds.

(d) MSH (Melanocyte stimulating hormone) secreted by pars intermedia of pituitary in man is vestigeal hormone.

(vi) **Connecting links :** Shows characteristics of two groups.

Organisms	Connection between
(1) Viruses	Living and non-living
(2) Euglena (Protozoa)	Plants and animals
(3) Proterospongia (Protozoa)	Protozoa & porifera
(4) Peripatus (Arthropoda)	Annelida and arthropoda
(5) Neopilina (Mollusca)	Annelida & mollusca
(6) Balanoglossus (Hemichordata)	Non-chordata & chordata
(7) Dipnoi (lung fish)	Pisces and amphibia
(8) Archeopteryx (Aves)	Reptiles & birds
(10) Prototheria (Mammalia)	Reptiles & mammals

(vii) **Living fossils :** Representative of its own groups.

(1) Peripatus (Arthropoda)	(4) Limulus (Arthropoda)
(2) Nautilus (Mollusca)	(5) Neopilina (Mollusca)
(3) Sphenodon (Reptilia)	(6) Latimaria (Fish)

(viii) **Embryology :** Embryological stages of different groups of organisms show striking similarities.

(a) In all vertebrates pharyngeal cleft, pharyngeal arch, embryonic tail are found.

(b) Development of kidney (Pronephric, Mesonephric, Metanephric).

(c) Heackel (1866) – Propounded "**The theory of recapitulation**" or Biogenic law which states that an individual organism in its development (ontogeny) tends to repeat the stages passed through by its ancestors (phylogeny) e.g. **ontogeny repeat phylogeny.**

(ix) **Atavism :** Atavism or reversion is the sudden reappearance of some ancestral features. *e.g*. large cannines, thick body hairs (e.g. Lion's boy of Russia) short temporary tails additional pairs of nipples, gill slits.

17.6 Geological times scale

It has been estimated that the age of our earth is near about 4600 million years, possibly even more. Life first appeared in water about 3700 million years ago. The duration of the earth's history has been divided into five principal geological time-spans called the eras. Of these, the three more recent eras are further divided into smaller spans known as the periods, which are in turn split up into epochs. The geological time-scale indicating the sequence and duration of the eras and periods with their dominant forms of life.

Geological times scale

Era	Period	Epoch	Million of year	Fauna
Coenozoic	Quaternary	Recent (Holocene)	0 – 0.01	Age of man
		Pleistocene	0.01 – 2	Evolution of man Society and culture
	Tertiary	Pliocene	2 – 6	Evolution of primitive man like forms (Hominids)
		Miocene	6 – 24	Evolution of man like ape modern dogs, elephants, cattle etc.
		Oligocene	24 – 37	Decline of monotreme and marsupials Rapid evolution of – Apes from monkey turtles, gavials and crocodiles. Arthropods very successful
		Eocene	37 – 58	Divergent evolution of birds and mammals. Origin of horse.
		Palaeocene	58 – 66	Origin of primitive primates (Ancient eutherian mammals)
Mesozoic	Cretaceous		66 – 144	Origin of first eutherian mammals. Origin of true birds. Extinction of dinosaurs
	Jurassic		144 – 208	Marsupials from mono tremes. First bird Archaeopteryx Dinosaurs dominant, origin of birds
	Triassic		208 – 286	First dinosours and primitive mammals. Decline of primitive amphibians. Advance insects and sea urchins diversification of snails, bivalve molluscs
Palaeozoic	Permian		245 – 286	Extinction of trilobites. Diversification of reptiles and small insect.
	Carboniferous		286 – 360	Origin of reptiles. Diversification of amphibia
	Devonian		360 – 408	Age of fishes. Origin of amphibia
	Silurian		408 – 438	First Jawed fish. Origin of scorpions, spiders.
	Ordovician		438 – 505	Origin of fishes, age of giant mollusca Decline of trilobites.

	Cambrian		505 – 570	Primitive echinoderms, origin of trilobites. Non-chordate of all phyla flourished.
Proterozoic	Precambrian		700	Protozoans flourished Origin of marine metazoans (sponges, cnidarians, annelids, molluscs and arthropods).
Archaeozoic			1500 – 3100	Era of invisible life Prokaryotes and eukaryotes originated.
Azoic			3100 – 4,600	Origin of earth No life.

17.7 Lamarckism

Jean Baptiste Pierre antoine De mo-net Lamarckism (1744-1829). Theory proposed by Lamarck is known as Lamarckism or Theory of inheritance of acquired characters in his famous book *"Philosphic Zoologique"* (1809). It states that modifications which an organism acquires in adaptation to the environment in it's life time are automatically inherited to the next generation.

(i) **Propositions of Lamarckism**

(a) The effect of environment causes change in the organisms.

(b) Production of new organ results from the new need.

(c) Development of organs takes place by constant use and degenerations by disuse. or Modifications produced by above reasons are carried to the off springs.

(ii) **Explanations**

(a) **Reaction to the environment :** The plants grown in different environment exhibit mark differences. He noted smaller & weaker plant in poor soil but healthy plant in rich soil.

(b) **Use & Disuse :** Giraffe which had a short neck in the remote past when food (grasses) were available on the ground level. Gradually, as the trees became higher in the need of food initiated to reach the food, neck automatically became elongated after generations.

(c) **Effect of needs :** Changes in environment initiate development of new organs.

(d) **Inheritance of acquired characters :** Changes acquired by organisms in life time due to environmental effects are inherited to the off springs.

(iii) **Evidences advanced by Lamarck**

(a) The webbed toes of aquatic birds.

(b) Different sizes of pinna in various animals.

(c) Better development of right hand in human.

(d) Loss of limbs in the snake (vestiges of hind limb in python).

(e) Reduction of eyes in moles due to nocturnal and fossorial life.

(iv) **Criticism of Lamarckism :** Cuvier and Weismann, Treatest critic of Lamarckism considered 'Ghost story'.

(a) Tendency of reduction : Retrogressive metamorphosis in Herdmania.

(b) Men desired to fly but could not developed wings → Objection to new need.

(c) A man constantly busy in reading develops impaired eye instead of better developed eye → objection to use & disuse.

(d) Objections to inheritance of acquired characters →

(1) Wound or sears obtained by brave father in a war is not inherited.

(2) Blind and deaf parent can produce a normal off spring.

(3) Holed ear lobes of Indian woman – produces off springs without hole.

(4) Weismann remove the tail of mice continuously for about 22 generations and even the off springs of 22nd generation were with normal tail.

According to Weismann changes taking place in germplasm are inherited to next generation only, gave Germplasm theory or theory of continuity of germplasm.

(v) **Neo-Lamarckism**

(a) Neo-Lamarckism – Spencer, Kammerer, Gadow Mc Dougell.

(b) They suggested that in some cases the acquired characters are inherited which affect germplasm.

(c) William Beebe showed that many instincts are inherited.

(d) Training of rat experiment of Mc Dougell also support them.

17.8 Darwinism

Charles Darwin (1809-1882) **:** Greatest naturalist and philospher. Defined evolution as "Descent with modification". Process of gradual change in successive generations cause evolution of complex organisms from simpler forms through continuous variations. Darwin travelled for 5 years a British Govt. Ship. HMS. Beagle and studied fauna & flora.

Alfred Russel Wallace (1823-1913) **:** Also of the view similar to Darwin. Both propounded – "Theory of natural selection". Studied theory of Thomas Malthus – "Population increase in geometrical while food in arithmetical ratio". Put his ideas in – *"Origin of species by natural selection"* (1859).

(i) **Facts and Deduction of Darwinism.**

	Facts	Deduction
(a)	(1) Organisms multiply in geometrical ratio. (2) Number of survivor remains roughly constant	Struggle for existence.
(b)	(1) Struggle for existence (2) Variation & heridity	Survival of the fittest and natural selection.
(c)	(1) Survival of the fittest (2) Continued changes	Origin of new species (speciation)

(ii) **Explanations :** Darwinism based on

(a) Over production.

(b) Struggle for existence. (Intraspecific & interspecific environmental struggle).

(c) Variations & their inheritance.

(d) Survival of the fittest.

(e) Natural selection and species formation.

(iii) **Effect of natural selection :** If the conditions change under new conditions.

(a) Harmful characters will be eliminated by selection.

(b) Beneficial characters are intensified and modified.

(c) Many characters neither beneficial nor harmful will persist unchanged.

(d) All these conditions & adaptations are preserved and accumulated in the individuals of species and ultimately lead to origin of new species from the older ones.

(iv) **Criticism of Darwinism :** Although accepted by most biologists, also attacked due to short comings.

(a) Does not explains use & disuse as well as vestigial organs.

(b) Stressed upon small fluctuating variations which are intact and play no part in evolution.

(c) Unable to differentiate between somatic and gametic variations.

(d) Explains survival of the fittest but not the arrival of the fittest.

(e) Over specialization of certain organ were not explained.

(f) Natural selection was unable to explain the evolution of terrestrial animals from the aquatic animals.

(g) Theory of sexual selection given by Darwin never found acceptance.

(v) **Neo-Darwinism**

(a) Genetics contributed the modifications in the classical concept of Darwinism and placed 'Neo-Darwinism" or Modern synthetic theory of evolution.

(b) Main contributors – Dobzhansky (1937) and G.L. Stebbins etc.

(c) Modern synthetic theory of evolution was designated by Huxley in 1942.

(d) Dobzhansky wrote the book *"Genetics and the origin of species"*

(e) According to synthetic theory five basic factors involved in the process of organic evolution. Gene mutation, Changes in chromosome structure and number, Genetic recombinations, Natural selection, Reproductive isolation.

(f) After criticism of darwinism, Darwin gave a new concept "Theory of Pengenesis" and thenafter "Theory of sexual selection" (1882).

17.9 Hardy-Weinberg equilibrium

According to Hardy-Weinberg concept the gene frequencies will remain constant its all the above five conditions are met. The distribution of genotypes could be described by the relationship $A^2 + 2Aa + a^2 = 1$. where A^2 = frequency of homozygous dominant gene, $2Aa$ = frequency of hetrozygous genotype, a^2 = frequency of homozygous recessive genotype. Mutation introduce new genes into a species resulting a change in gene frequencies. G.H. Hardy and Wilhelrm Weinberg in 1908 established a simple mathematical relationship to the study of gene frequencies. If certain conditions existed, gene frequencies would remain constant. The condition necessary for gene frequencies to remain constant are following.

(i) Mating must be completely random.

(ii) Mutations must not occur.

(iii) Migration of individual organism into and out the population must not occur.

(iv) Population must be very large.

(v) All genes must have an equal chance of being passed to the next generation.

17.10 Human evolution

Huxley (1863) in his book 'Man's place in nature' established the close similarities among monkey, ape and man. According to Huxley man evolved from apes. Charles Darwin (1871 A.D.) supported Huxley's view in his book 'Descent of man'. Carolus Linnaeus (1707-1778 A.D.) – Father of taxonomy gave man the scientific

name – *Homo sapiens*. Study of human evolution – Anthropology. According to anthropologists like Eugene Dubois, W.C. Pie, Raymond Dart, Simon, S.R.K Chopra etc. place of human origin is central Asia, about 24-36 million years ago.

(i) **Origin of mammals :** Mammals evolved from cynodont reptiles (from cotylosauers) in early Jurassic period about 210 million years ago. Early mammals were Quadrupedal, insectivorous arboreal, nocturnal. Originated about 65 million years ago (in palaeocene epoch).

(ii) **Character :** Arboreal habit

(a) Opposable great toe and thumb for grasping.

(b) Eyes in front of head for stereoscopic vision.

(c) Expanded forebrain.

(d) Lengthy gestation.

(e) Primates contains two sub-order

Order-Primates

Sub-order 1

Prosimians

Tarsiers	**Lemurs**	**Lorises**
Found in forest of Philippines & East Indies.	Confined largely to Islands of Madagascar	Occur in Africa & Asia including South India.
Insectivorous mouse sized.	Squirrel like animals.	
Large eyes Nocturnal.	Feed upon plant material including fruits.	

Sub-order 2

Anthropoids (Anthrop = man; oid = like)

Super family + Ceboidea (New world monkeys)

Found in South America e.g. Ateles (Spider monkey)

Flat nose widely separated nostrils.

Prehenside tail.

Non-opposable thumb.

clawed digits.

Super family 2- Cereopithecoidea (old world monkey)

Found in Africa and Asia e.g. Papio (Baboon) Maccaca (Rhesus monkey), Langur etc.

Narrow nose

Short and non-prehensile tail

Opposable thumbs.

Nailed digits.

Super family 3- Hominidae. (Hominoids) include all the apes and Human.

Apes include

Gibbon, Orangutan — Found in Asia

Gorilla, Chimpanzee — Found in Africa

(iii) **Place of human origin :** One of the oldest fossils reported from South Africa of Procunsal. Ramapithecus considered to be earliest man like primates. Fossil of Ramapithecus discovered by G.E. Lewis in Sivalika hills of India (14-15 million years ago). Indicates that man originated in central Asia.

(iv) **Time of human origin :** Estimated as late miocene or early Pliocene epoch of coenozoic era about 15-20 million years ago.

17.11 Sequence of human evolution

Ape or Prior to Ape man → Ape man or Pre human → Primitive man or sub-human.

(i) **Ape or Prior to ape man**

(a) **Propliopithecus and Ageyptopithecus**

(1) Fossils found 30 million years ago from Oligocene rock of Fayum deposits of Egypt.

(2) Resembled both apes and man.

(b) **Dryopithecus or proconsul**

(1) Fossils discovered by L.S.B Leakey in 1930 from early miocene rock of about 20 million year ago around the victoria in East Africa.

(2) Belived to be ancester of today's hominids (Apes and human), more near to ape man.

(3) About 25 million year ago become abundant.

(c) **Oreopithecus**

(1) Fossil recovered from coal mine rocks of Pliocene in Italy.

(d) **Ramapithecus**

(1) G.E. Lewis discovered from Shivalik Hills of India in Pliocene period.

(2) More man like than ape like.

(3) Considered as direct ancestor of man.

(ii) **Ape man or Pre human**

(a) **Zinjanthropus :** Used wooden clubs and hammer of stone.

(b) **Kenyapithecus** : Closely related to Ramapithecus.

(c) **Australiopithecus**

(1) Commonly called Southern ape.

(2) Cranial capacity – 300-500 c.c.

(3) Lived 2 to 5 million years ago.

(4) Considered as connecting link between man & ape.

(5) Tuang baby (A. africans) discovered in 1924 from Africa.

(6) Lucy (A. afarensis) – Ancestor of man who first stored erect.

(iii) **Primitive man or subhuman**

(a) **Homo habilis :** Tool maker, cranial capacity 700 *c.c.*

(b) **Pithecanthropus or Homoerectus**

(1) Popularly called Javaman.

(2) Fossils discovered from Java, China and Africa.

(3) Cranial capacity – 900 *c.c.*

(4) Large protruding jaws.

(5) Fire first used for protection and cooking.

e.g. Pithecathropus erectus (Dubois) Homo erectus eructus.

(c) **Sinanthropus**

(1) Popularly called Peking man.

(2) In middle pliestocene.

(3) Cranial capacity – about 1075 *c.c.*

(4) Slightly shorter, lighter and weaker than Javaman

(d) **Neanderthal man**

(1) In late pleistocene.

(2) Named as homo sapiens neanderthalensis.

(3) Cranial capacity 1400 *c.c.*

(4) Belived in immortality of soul.

(5) Ceremonial burial of the dead.

(6) Became extinct 35,000 years ago.

(e) **Cro-magnon man**

(1) Recent (holocene)

(2) Most recent ancestor of today's man.

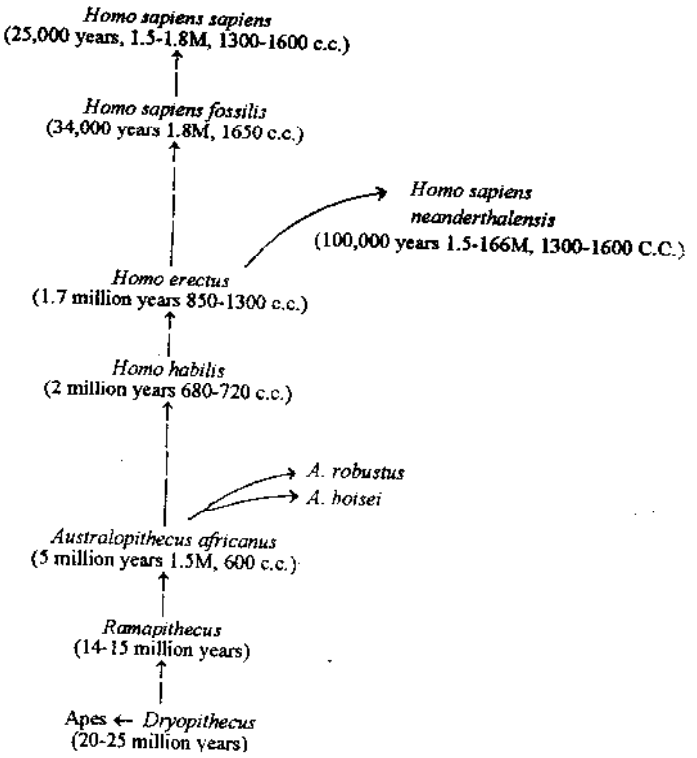
(3) Named homo sapiens fossilis.

(4) Cranial capacity – 1360 *c.c.*

(5) Omnivorous

(6) Artiste made coloured cave painting (Bhimbetka in M.P.)

(7) Became extinct about 10,000-11,000 year ago.



Schematic Representation of Evolution of Man. Age, height and cranial capacity are also given

(f) **Modern man**

(1) Recent (holocene)

(2) First appeared about 10,000 years ago. (homo sapiens sapiens)

(3) Average cranial capacity 1360 *c.c.* 1450 *c.c.*

(4) Developed sound into words.

(g) **Man of future**

(1) Homo sapiens futuris.

(2) A prediction by American anthropologist Dr. Saprio.