

## EVOLUTION

- Evolution is unrolling or unfolding of nature that brings about an orderly change from one form or condition to another resulting in descendents becoming different from ancestors. Evolution is rather a law of nature
- Evolutionary biology is the study of history of development of newer forms of life from the pre-existing ones in various periods of time on earth

### ORIGIN OF UNIVERSE

- Universe or cosmos is the whole existing space and matter which is differentiated into several galaxies with each galaxy having several stars and cloud of gas and dust
- Most accepted theory to explain the origin of universe is the Big Bang theory which was proposed by Abbe Lemaitre in 1931. According to this theory, universe has an explosive beginning. The universe expanded and hence temperature came down

### ORIGIN OF SOLAR SYSTEM

- According to Nebular Hypothesis of Kent, our solar system was probably created about 4.5 to 5 billion years ago when gaseous cloud called solar nebula was formed
- Our earth was supposed to have been formed about 4.5 billion years back. There was on atmosphere on early earth

### ORIGIN OF LIFE ( Biopoiesis)

- As far as we know life occurs only on earth though there is possibility of its presence elsewhere as well. Methane which has helped develop life on earth occurs on Jupiter, Saturn and interstellar space. Water has been detected on our moon, on mars

### Theory of special creation

Life was created by god

- (i) Genesis of Bible has proposed that god created the world in six days
  - Day 1: Heaven and earth
  - Day 2: Sky and water
  - Day 3: Land and land plants

Day 4: Sun, moon and stars

Day 5: Birds and fishes

Day 6: Land animals and human

The first man was Adam. He was created from clay. The first woman was Eve who developed from 12<sup>th</sup> rib of Adam

- (ii) Hindu mythology – Hindu believed that the world was created by Brahma. The humans were formed from his head, birds from chest, goats from mouth and plants from hair. The first man was Manu and the first woman was Shradha
- Theory of eternity  
Different living beings, plants, stars etc. existed as such from the beginning and would continue
- Theory of catastrophism  
This theory was supported by Cuvier (1826), a French palaeontologist, who believed that the world has passed through many ages. A catastrophe occurred at the end of each age, which killed most of the living beings and at the beginning of next new age, a new creation evolved
- Theory of cosmozoic origin  
Both living and non-living matters were formed simultaneously. Early living objects were resistant spores called cosmozoa. Cosmozoa gave rise to different types of living beings on earth  
This theory was given by Richter in 1865.
- Theory of Panspermia  
Arrhenius (1908) proposed the theory of directed panspermia. The salient features are
  - (i) They assumed the presence of advanced civilization on other planets in our galaxy.
  - (ii) Life on earth and many other planets were infected from these advanced civilized planets
  - (iii) Directed panspermia theory was supported by genetic code
- Theory of spontaneous generation  
It originated in Egyptian civilization. Greek philosophers believed in it. Anaximander thought life to arise from mud warmed by sun. Aristotle believed plants to develop from soil while worms and snails to be products of putrefaction. Frogs were believed to arise from moist soil  
Van Helmont had claimed origin of mice both sexes from human sweat and wheat bran kept in dark for 21 days

## Biogenesis

- Theory of spontaneous generation was disapproved through the finding that life comes from pre-existing life
- Francesco Redi ( 1668) placed thoroughly cooked meat in three jars (i) Uncovered (ii) covered with parchment (iii) covered with muslin. Maggots developed only in uncovered jar. No maggot developed in jar covered with parchment. Flies visited third jar and laid egg on muslin. Egg fallen in jar produced maggots.
- Spallanzani ( 1765) boiled nutrition in glass flasks, sealed the flasks and kept them. The broth remained clear indefinitely with no signs of living beings
- Pasteurs (1862) took broth in flasks straight and swan ( bent S –shaped) necks, boiled and allowed the broth to cool. No germ developed in the broth it was connected with atmosphere through curved neck of the flask. The dirt particles could not reach the broth because they got trapped in bend of neck. When swan neck were broken, broth developed colonies of microorganisms showing that the same have come from air. The same happened in straight necked flasks

### MODERN HYPOTHESIS OF ORIGIN OF LIFE

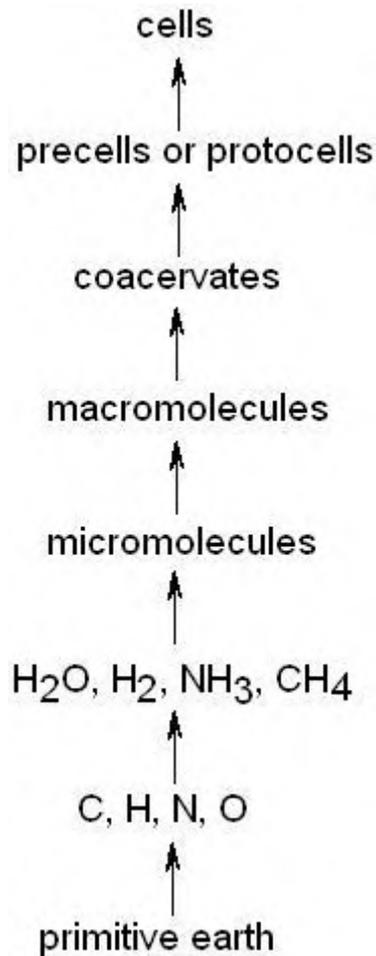
#### Chemical origin of life ( chemogeny)

- Oparin suggested that from the simple compound like nitrides, oxides, ammonia, methane complex organic compounds were formed gradually under the influence of electric charges, ultra-violet rays
- First , were the formation of hydrocarbons, like acetylene, ethylene etc. these then form oxy and hydroxyl derivatives forming aldehydes, ketones and acids, sugar and starch were the main products.
- Miller’s experiment – Stanley Miller (1953) a graduate student of Harold C Urey designed an apparatus for stimulating condition prevalent on earth at the time of abiogenic evolution of organic substances. The apparatus has a spark chamber with two electrodes, a flask for boiling and a condenser. A control apparatus was also prepared but without electrodes in spark chamber
- Milller used a mixture of methane ammonia, hydrogen and water. The mixture was exposed to electric discharges, following by condensation and then boiling. It was continued for 18 days.
- Miller was able to identify 15 amino acids, organic acid, ribose sugar and purine, adenine.

- The formation of protein molecule is considered a land mark in the origin of life

## Biological evolution

- Formation of proteinoids: Proteinoids are molecules which are obtained by synthesizing polypeptides by heating a mixture of amino acids at 160 – 210°C for several hours.
- Formation of coacervates  
When macromolecules were formed they undergo aggregation and precipitation in the sea, which led to the formation of organized structures were distinct bodies, which did not mix with the surrounding sea – water. They contained proteins, nucleoproteins and other organic and inorganic molecules in various reactions. The surface layer of the coacervates had ability for selective absorption of substances from the medium. Oparin considered the coacervates as the sole living molecules which gave rise to cells
- Formation of precells or protocells.: The protocells were spherical in shape and a double layered membrane was present around them. They exhibited reproduction by binary fission. The proto cells were heterotrophs; they obtained the energy formed by the fermentation of organic molecules which gave rise to cells
- Formation of precells to cells: When DNA – RNA system developed within protocells, they looked like a bacteria or virus. The DNA acquired the ability for self duplication and protein synthesis. Thus life originated after a long process of molecular evolution. The proto cells in course of time differentiated into cells



### EVIDENCE OF EVOLUTION

- The convincing evidences for the occurrence of descent with modification come from
  - (i) Paleontology
  - (ii) Morphology and comparative anatomy
  - (iii) Embryology
  - (iv) Geographical distribution
  - (v) Taxonomy
  - (vi) Connecting links
  - (vii) Cytology
  - (viii) Biochemistry
  - (ix) Genetics

#### Evidences from paleontology

- Paleontology is the study of past life based on fossil records. Their study reveals the existence of life in past and illustrates the course of evolution of plants and animal

- Leonardo da Vinci is considered father of paleontology while George Cuvier is called father of modern paleontology

## Types of fossils

- (i) **Body fossils:** These are hard parts of an organism, which provide details of shape and function of actual organism such as bone, tooth, skull etc.
- (ii) **Subfossils:** These are the remains of plant and animals which were formed during Holocene period after the last ice age and found preserved in rocks formed after 10,000 years.
- (iii) **Microfossils :** Microscopic fossil remains of animals and plants usually less than 0.5 mm size are known as microfossils.
- (iv) **Macrofossils:** Fossils of larger than one cm size such as corals, skeleton
- (v) **Pseudofossils:** these are inorganic origin objects, which show close resemblance with the forms of organic origin and are found in sedimentary rocks.
- (vi) **Unusual fossils:** Fossils formed as a result of combination of events and condition which results in all or most of the organism getting preserved in rock.
- (vii) **Trace fossils:** these are fossils of foot prints and trail left in mud by past living organisms such as dinosaur's foot print
- (viii) **Coprolites :** These are trace fossils of dropping of animals or faecal matter, either very small like faecal pellets of sea snail or large coprolites of dinosaurs, crocodiles and mammals

## Determination of age of fossils

Carbon dating – radio active C-14 occurs naturally. It enters food chain and is therefore found in all living beings and their remains. Half life of C-14 is 5730 years.

Carbon dating can measure articles upto 25,000 years old

## Evidences from morphology and comparative anatomy

### (a) Homology ( Divergent evolution)

- Homology is the similarity between organs of different animals based on common ancestry and built on same fundamental pattern, but perform varied function

### Examples

- (1) The flipper of seal, wing of bat front leg of horse and arm of man shows homology

- (2) Thorns of Bougainvillea and tendrils of Passiflora are modified branched but thorns of Bougainvillea are for protection while tendrils of Passiflora are for climbing

Presence of homologous organ in different group confirms

- Common ancestry and relationship between different groups
- Difference in appearance due to divergent evolution

(b) Analogy ( Convergent evolution)

- Analogy is the difference in basic structure and origin but are adapted to perform similar functions Examples:
  1. Fines of fishes and flippers of whale. Similar appearance and function but their structural designs are different
  2. Wings of butterfly and bat serve the same purpose i.e. flight, but wings of insect is formed of a thin flap of chitin and stiffened by series of veins. Where as in bat wing is formed of a fold of integument, supported by the elongated and outspread phalanges.

(c) Adaptive radiation

- The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography is called adaptive radiation.  
Example: Australian marsupials. A number of marsupials, each different from other evolved from an ancestral stock, but all within the Australian island continent

## Embryology

Embryology is the study of formation and early development of an individual from zygote to young ones

- (1) Similar early development early embryo development is similar in animals passing through morula ( solid ball), blastula ( two layered) stages showing their common origin
- (2) Resemblance amongst vertebrate embryos. Embryos of all vertebrates pass through fish like state having somites, gill clefts / slits behind neck, tail, notochord
- (3) Development of vertebrate organs . Heart of a mammal or bird is initially two chambered ( as in fishes), three chambered ( as in amphibians) and then four chambered
- (4) In seventh month of pregnancy human foetus resembles a baby ape

## (5) Recapitulation theory / Biogenetic law

Meckel ( 1810) proposed that developing animal embryo passes through stages resembling adult forms of its ancestors

### Evidences from Geographical distribution

- The degree and period of separation of an area from another correspond to species diversity
- Double coconut occurs only in seychelles island. Kangaroo and Koala are marsupials found in Australia
- Darwin observed that the finches on mainland of America were all of one type, possessing short straight beaks for seed crushing. These birds from Galapagos island differed in size and shape due to different food types available. Some were vegetarian finches, warbler finches while others were insectivorous finches

### Evidences from taxonomy

Depending upon their resemblances and differences, living organisms are divided into groups i.e. monera, protista, fungi, plantal and Animalia. The common characters present in a species, genus, family, class or phylum indicate common ancestry while the difference indicate evolution.

### Evidences from connecting links

While classifying animals one comes across certain animals or small animal groups which exhibit characteristics of more than one group. Such animals or animal group are called connecting links between those two groups

Example: Euglena

A connecting link between animal and plant. Some animal character of euglena are

- (1) Body is covered by pellicle
- (2) Reproduction is animal like some plants character of euglena are
  - (a) It is having chlorophyll and chloroplasts
  - (b) Nutrition is autotrophic
  - (c) It synthesis their food through photosynthesis

### Evidences from cytology

- (1) Protoplasm of all the organisms have carbon, hydrogen, oxygen and nitrogen

(2) DNA and rarely RNA is the genetic material in all the organisms, which show common ancestry and origin of all organisms.

(3) The same genetic code have triplet codons is found from the viruses to man and all living beings have same amino acids for same codon.

## Evidences from biochemistry

- Living being posses similar types of biochemicals, biochemical reaction and body functions
- Example, aerobic organisms perform Krebs cycle having similar types of enzymes from chlamydomonas and amoeba to human being and peepal tree
- A - B blood grouping is present in apes as well as humans but not in monkeys indicating a closer relationship between the former

## Evidences from genetics

Accumulation of mutation produce new varieties and races, e.g. red sunflower, dwarf wheat etc. Hybridisation and induction of polyploidy has given rise to new plants

Four modern theories have been put forward to explain the mode of evolution.

These are

- (i) Lamarck's theory of inheritance of acquired characters or Lamarckism
- (ii) Darwin's theory of natural selection or Darwinism
- (iii) De Vries mutation theory
- (iv) Modern concept of evolution

## Lamarckism or Inheritance of acquired characters

- Jean Baptiste de Lamarck was a French naturalist, well known for his theory of evolution
- The central idea of Lamarckism is that the characteristics acquired by an organism during lifetime in response to environmental conditions are passed on to their offspring. The main points include
  - (i) Organisms and their organs have a natural tendency to continuously increase in size, generation after generation
  - (ii) Continuous changes in the environmental conditions directly influence the nature habits, way of living or organism and their structural organization
  - (iii) The growth of less used parts decline, while that of better used parts progresses

- (iv) The growth of organs either better or poor acquired during lifetime of an organism is heredity
- Examples of Lamarckism
    - (1) Giraffe – the ancestors of giraffe were bearing a small neck and fore –limbs and were like horses, but as they were living in places with no surface vegetation, they has to stretch their necks and forelimbs in order to eat leaves from trees
    - (2) Flightless birds : The development of flightless birds like ostrich from flying ancestors is considered due to continued disuse of wings as they were found in well protected areas with plenty of food
    - (3) Snakes: The present day limbless snakes with long slender neck were developed from the limbed ancestors. It is due to continued disuse of limbs and stretching of their body to suit their creeping mode of locomotion and fossorial mode of living
  - Evidences in favour of law of inheritance of acquired characters are-
    - (1) During vegetative propagation of plants and regeneration in animals somatic cells can produce the germ cells
    - (2) Sudden heritable variations or mutations were obtained by Auerbach et. Al on exposure of Drosophila to high energy radiations like UV – rays, X-ray,  $\gamma$ -ray and mustard gas etc.
  - Lamarckism or theory of inheritance of acquired characters was discarded due to following reasons
    - (1) Blind, deaf and lame parents do not produce abnormal offspring
    - (2) Despite of use of iron shoes to keep their feet short by Chinese women, their young ones at birth have normal feet size
  - These criticism lead to the foundation of Neo-Lamarckism  
The postulates of Neo-Lamarckism are
    - (1) According to Neo-Lamarckism, there is causal relationship between the structure, function and environment
    - (2) Some of the variations acquired by an individual can be transmitted to its offspring
    - (3) The role of internal vital forces in evolution has been discarded
    - (4) Only those variations are inherited, which are associated with the germ cells or where the somatic cells give rise to germ cells
    - (5) It has been realized now that the body character of organisms are related to result of interaction of genes and the environmental conditions

Darwin's theory of natural selection or Darwinism

- Charles Darwin was born in 1809. In 1831, he accepted an unpaid post of naturalist on the survey ship, i.e. HMS Beagle, in which he spent five years in sea charting the East coast of South America
- Features of theory of natural selection are
  - (1) Overproduction : Organisms have a very high reproductive potential and capacity , multiply in geometric ratio.
  - (2) Limitations of food and space: The resources of earth are limited. Therefore, populations of different species cannot increase beyond a certain limit.
  - (3) Struggle for existence: A struggle or competition occurs amongst organisms to obtain the available resources. It is of three types-
    - (a) Intra-specific struggle: This is the most acute type of struggle, which occurs amongst individuals of the same species for similar basic necessities like food, shelter, breeding place, light, water etc
    - (b) Inter-specific struggle: the struggle occurs amongst individuals of different species for similar requirements like food, shelter
    - (c) Environmental struggle: The struggle is between organism and restricting environmental factors like carrying capacity, drought, heavy rains, floods, famine, earthquake, volcano, lightning, meteorite, etc.

Variations

- They are small morphological and behavioural differences amongst the individuals. Variation can be continuous discontinuous, harmful.
- Darwin believed that continuous and useful variation constitute the raw material of evolution. Neutral and occasionally harmful variations may also prove helpful with the change of environment.

Natural selection and survival of the fittest:

In the struggle of existence, only those individuals survive which possess the most useful variations. This has been called natural selection by Darwin and survival of the fittest by Spencer

- This theory was criticized because
  - (1) Darwin did not explain the mechanism of origin of variations
  - (2) He did not know the mode of transmission of variations to the next generation.

- (3) Continuous variation cannot go beyond limit of species. Mutation are actually the source of evolution
  - (4) Darwinism does not explain origin of variation, new characters
  - (5) It is unable to explain the persistence of degenerate organ and over-specialisation ( e.g. tusk of elephant)
  - (6) There are certain organisms which have remained unchanged for the past several million years
- Evidences in support of Darwinism are
    - (1) Evident facts: High rate of reproduction, limitation of resources, abundance of variation are quite evident
    - (2) Entomophily: Many pollinating insects have proboscis length exactly matching the position of nectary in flower. This may develop due to natural selection.
    - (3) Mimicry: It is the resemblance of an organism with another or a natural object so as to conceal itself for protection or some other advantage like catching of prey. E.g. praying mantis, stick insect
    - (4) Extinct forms: Extinction of past plants and animals can be explained only by development of better organisms through natural selection
    - (5) Adaptations: Variations present in the population help the individuals in adapting themselves to changed environmental conditions. Adaptations produce new ecotypes from which new forms can develop
    - (6) Artificial selection : It is a selective breeding of plants and animals so as to obtain varieties with desired traits.
      - (a) Agriculture perhaps originated with selection of nonbrittle ear in *Triticum monococcum* ( Einkorn wheat) This was later replaced by naked and high yielding wheat
      - (b) Through artificial selection, wild cabbage has given rise to several vegetables like Kale, kohlrabi, cabbage, Cauliflower, Broccoli etc
      - (c) High milk yielding varieties of Buffalo have developed by monitoring of animals producing more milk and breeding them with bulls of high milk yielding lineage

#### Neo-Darwinism

- The theory of evolution as proposed by Darwin and Wallace has been modified in the light of modern evidence from genetics, molecular biology, palaeontology, ecology and is known as neo-Darwinism
- Neo-Darwinism distinguishes the germplasm and somatoplasm

- It explained that adaptations result from the multiple forces and natural selection is one of them
- As per Darwinism, characters are not inherited as such, instead there are character determiners which control the development.
- The characters are the result of genes of organisms and the environment during its development

## De Vries mutation theory

- The term mutation was introduced by Hugo de Vries, a Dutch botanist who independently rediscovered Mendel's law of heredity
- Mutation theory was put forward by him in 1908
- Salient features of mutation theory are as follows
  - (1) Mutation acts as a raw material for evolution.
  - (2) Mutation are large heritable and subjected to natural selection
  - (3) Mutation are large heritable changes in contrast to small, directional fluctuating variation of Darwin
  - (4) Mutation may occur in any direction and may be useful or harm
  - (5) Sometimes, new species are produced by a single mutation
  - (6) This theory has following criticism
    - 1) D.M. Davis claimed that the *Oenothera lamarckiana* ( evening primrose) was a hybrid plant, which could be obtained by the hybridization of two wild species and is not normal plant
    - 2) Natural mutation are not the common phenomenon
    - 3) Most of the mutation are recessive
    - 4) Development of mimicry cannot be explained satisfactorily
    - 5) Theory failed to explain the role of nature

## MODERN CONCEPT OF EVOLUTION

- The present concept of evolution is a modified form of Darwin's and Hugo de Vries theories. This is also called synthetic theory of evolution
- The main postulates of this theory are
  - (1) This theory recognizes four basic types of process. These are
    - (a) Gene mutation are changes in chromosome structure and number and genetic recombination provide the genetic variation without which changes cannot takes place and natural selection guides populations of organism for adaptations.

- (b) Migration of individuals from one population to another, hybridization between races or closely related species both increase the genetic variability
- (c) Mutation, genetic recombination and natural selection are equally important
- (d) The effect of change, acting on small population may alter the way in which natural selection guides the course of evolution.
- (2) All sexually reproducing organisms contain a large gene pool of genetic variability, which maintain a dynamic equilibrium between in flow and out flow of genes
- (3) Genes may be added to gene pool by immigration from other gene pool and mutation.
- (4) Genes are removed from the gene pool by natural selection and chance elimination of alleles, which take place in small population or during reduction of population size
- (5) Genetic recombination following the principles of mendelian heredity is constantly reshuffling the genes in the gene pool.
- (6) Natural selection, which results from the interaction between populations and their environment, may either stabilize gene composition by eliminating most immigrants and mutants or change in various way
- (7) Evolution takes place through alternations of the frequency of genes and gene combination in the population brought about by natural selection
- (8) Reproductive isolation, includes all the barriers to gene exchange between the populations has a canalizing effect
- (9) The populations that are reproductively isolated from each other are almost certain to evolve in different directions while those that are not so isolated because of gene exchange will evolve in the same direction

#### MECHANISM OF EVOLUTION

##### Hardy – Weinberg Law

- Hardy-Weinberg Law was proposed in 1908 by the independent contributions of two scientists, Hardy ( England) and Weinberg ( Germany)  
A clear understanding of gene pool and gene frequency
- Gene Pool  
Gene pool is defined as “the sum total of genes present in a population ” or “A gene pool comprises diverse from of a gene combination and recombination by the process of sexual reproduction.”

- Gene frequency

The ratio of gene in a gene pool or in a population is called gene frequency

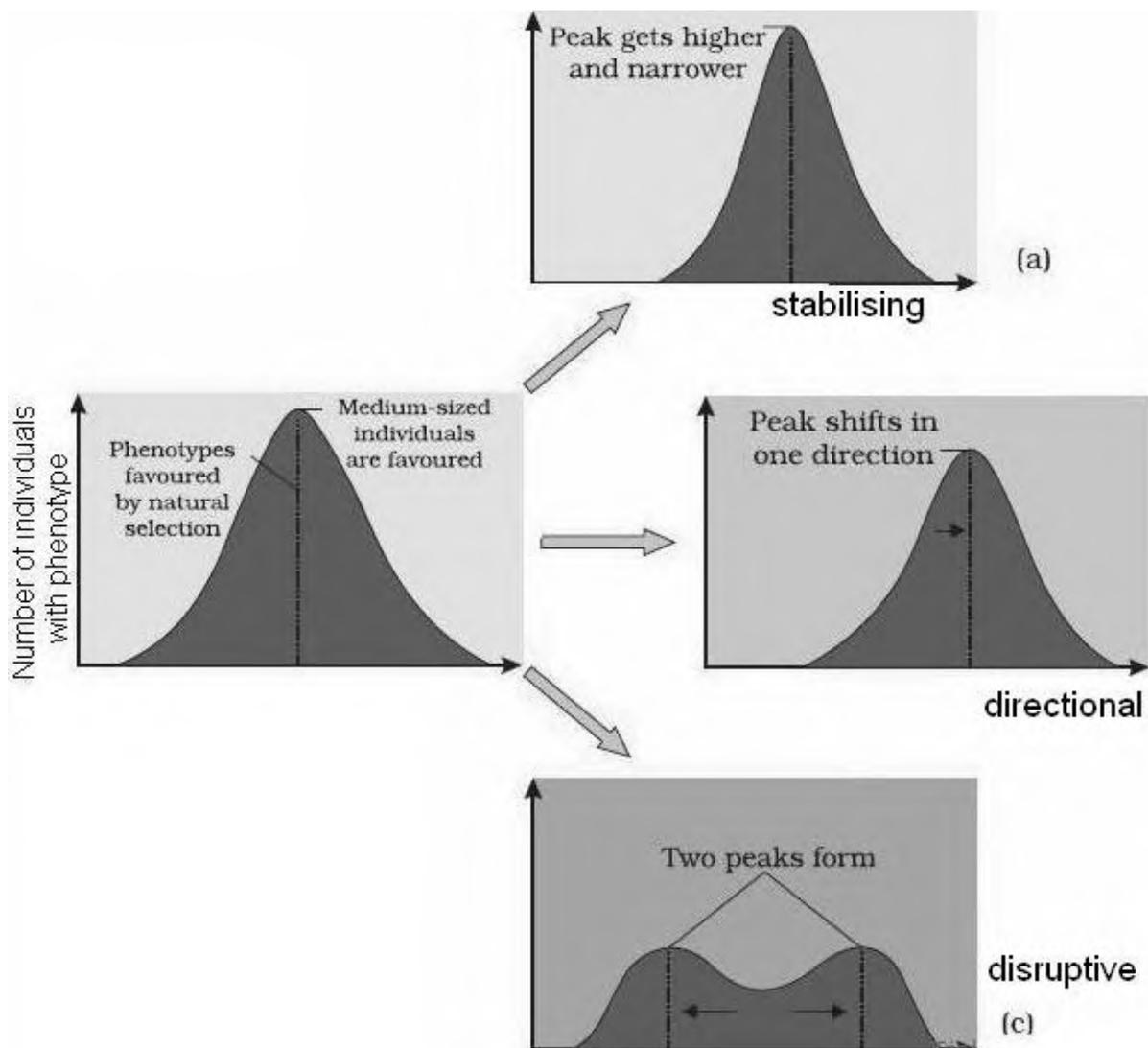
When the gene frequency of other allele in the population can be calculated by applying simple formula. If the gene frequency of A – allele is p and a-allele is q, the  $p+q = 1$

The frequency of AA individual in population is  $p^2$ , of aa is  $q^2$ , of Aa is  $2pq$ .

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

## Significance

- This law states that the gene frequencies in large population remains constant generation after generation where there is no selection and mutation. In small population, this equilibrium cannot be maintained
- When the population is large and in equilibrium rate of evolution is zero as there is not possibility of evolutionary change



- Gene flow

Animals are not static. They have tendency to migrate and mate with inmate of the population. Thus the genes of one population are transferred into another population. This is called gene flow and are important source of genetic variation

- Genetic drift

Genetic drift is an evolutionary force operating in small population

The change in the frequency of gene purely by chance is called genetic drift

## HUMAN EVOLUTIONARY TRENDS

The gradual evolution of man from ape is fully supported by available fossils

1. Propliopithecus: It was an ape like primate, but in the possession of short arms, it resembled man. It lived, about 30 million years ago
2. Aegyptopithecus: It is similar to propliopithecus. It is believed that it was ancestral of Dryopithecus
3. Dryopithecus: It is a group of apes that lived about 20 million years ago. Their forelimbs were shorter than hindlimbs. It is also ancestor of modern apes like Chimpanzee and Gorilla
4. Oreopithecus : In the structure of teeth and erect walking, it resembles man, but having long forelimbs, it resembles apes. Straus and simpson suggest that man and oreopithecus have parallel evolution and hence are not ancestral to man.
5. Ramapithecus: It lived 12 to 12 million years ago. The dentition is more identical to dentition of man and their fossil were collected from Africa and India
6. Kenyapithecus: It is closely related to Ramapithecus. Its fossil is collected from East Africa.
7. Australopithecus: It is connecting link ape and man. It lived 2 to 5 million years ago. The characters of Australopithecus like man and ape are as below
  - Man like characters: Erect posture, bipedal locomotion and dentition is like that of man
  - Ape like characters: Teeth were larger than modern man, absence of chin, eye brow ridges projected over the eyes
8. Homo erectus: It is erect ape man. They are commonly called Java man because their fossils were collected from Java. They lived about 5,00,000 years ago. The main characters of Homo erectus are

- They has upright bipedal locomotion
- They were slightly taller than Australopithecus.
- The face are chinless
- They used fire and variety of tools

### 9. Homo sapiens

(1) Neanderthal man: They existed about 75,000 years ago. The main character are

- Their eyebrow ridges were heavy and protruding
- Their teeth were large
- They had no chin
- Their cranial capacity was about 1400 cc

(2) Rhodesian man: The fossils were collected from Rhodesia. The cranial capacity was about 1300 cc

(3) Cro-magnon man: These were the men who lived in Europe during the last 30,000 years. They possessed all characteristics of modern man

(4) Modern man: They were originated 8000 years ago. The cranial capacity of modern man is 1450cc

The main human races are:

- (a) Caucasoid race
- (b) Negroid race
- (c) Mongoloid race
- (d) American race
- (e) Australian race
- (f) Indian race



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