Theories of organic evolution

Lamarckism

- living organism and their components parts tend to increase in size continuously due to internal forces of life
- the formation of new organ in the body is the result of a new need and a new movement which this new need initiates and maintains in the body
- Constant use of an organ results in its better development, while disuse causes its reduction and degeneration
- Characters acquired by the individual during its lifetime are inherited by its offspring .
- It means changes are cumulative over a period of time

First law and reaction to environment

- Environment modifies plants and animals, which have a tendency to increase in size.
- Living organisms tend to react to external environment and become modified

Second law and the effects of needs

- change of habits may bring about new needs and in accordance with the new needs new structures develop or existing structures undergo modifications

Third law and use and disuse

- certain organs of a creature could be strengthened or weakened by use or disuse

Fourth law and inheritance of acquired characters

- characters that an organisms acquire during its lifetime are preserved and transmitted to the offspring
- if the offspring are also exposed to and influenced by similar environment stress as faced by parents the characters become more pronounced

Examples in favour of Lamarckism

- The long neck of giraffe
- Loss of limbs of snakes

Criticisms against lamarckian theory

Arguments against the first law

- evolution is not due to internal forces of life

Arguments against the second law

- Humans no wing

Arguments against the third law

- Nerve or blood vessel do not increase in life

Arguments against the fourth law

- biceps muscles of a blacksmith increases in strength and bulk due o constant use
- But his children do not inherit that acquired character
- Scars are not acquired
- Weismann conducted experiments on mice for 22 generations by cutting their tail
- None was bone without tail

Germ plasm theory of Weismann

- August Weismann
- A German biologist he differentiated between somatoplasm and germplasm, which was the hereditary material carried from generation to generation.

He believed in

the continuity of germplasm

- Death of an organism as insignificant ,since life consisted of the germplasm forming the egg and sperm

Immortality of germplasm

- every animal is potentially able to contribute its germ plasm to the next generation even before its death
- Germplasm immortal and somatoplasm mortal

Concept of determinants

- the determinants of Weismann are comparable to the gees of modern genetics

Darwin's theory of Natural selection

- Populations will grow exponentially
- Increase in number leads to struggle for existence
- Struggle for existence leads to survival of the fittest and natural selection

1. Overproduction

- The high rate at which the all organic beings tend to increase
- the exponential rate of uncontrolled population increase is very evident in the case of pest and parasites
- But ordinary animals and plants do not increase in this way
- There is some mechanism to check the increase in number

2. Struggle for existence

- Thomas Malthus noted populations as a whole to grow exponentially
- Whereas natural resources grow arithmetically

three types of struggle

Intraspecific struggle

- competition between members of same species
- It is very rigorous since the needs of members of the same species always the same

Interspecific struggle

- Competition between members of different species
- when the niches of two different species overlap there will be competition
- Nature does not always favor interspecific competition because it can lead to extinction of weaker species

Environmental struggle

- struggle by organisms against abiotic factors of the environment
- This is density dependent

3. Variations

- individuals vary from each other in morphological, anatomical, physiological, behavioral and number of characters
- Variations may be harmful or advantageous
- Individuals possessing more profitable variations likely to win
- Variations are the basis prerequisite for evolution

4. Survival of fittest

- Struggle for existence leads to survival of fittest and elimination of unfit
- Fittest individuals are those with profitable variations and are better adapted to survive in the environment

Eg., Ancestors of giraffe showed variation in length of neck and leg

Those with long neck and legs survived others eliminated

5. Natural selection and origin of species

- Natural selection acts upon the existing variations in a population
- those individuals with more profitable variations to suit the changed environment are selected to continue and reproduce more
- After a number of generations descendants of markedly different and distinct ancestor in the original population giving rise to new species

Theory of sexual selection

- In many species males develop prominent secondary sexual characteristics
- eg., peacock tail, colouring pattern in male birds voice calls of frogs, flashes in fire flies
- sexual selection is natural selection operating on factors that contribute to an organism's mating success
- A male who lives a short time, but finds a mate effectively and produces many offspring is much more successful than a long lives one that produces few
- The formers gee will eventually dominate the gene pool of his species
- in species where female choose, males compete by displaying striking phenotypic characters or courtship behavior
- The females then mate mate with males that most interest them usually the one with most outlandish displays

Contributions of Alfred Russel Wallace

- Father of biogeography
- co- discoverer of natural selection

Wallace line

- That divide the Indonesian archipelago into two distinct parts
- one in which animals closely related to those of Australia are common
- Other in which the species are largely of Asian origin

concept of warning coloration in animals

- conspicuous colouring that warns a predator that an animal is unpalatable or poisonous.

Wallace effect

The **Wallace effect**, is a hypothesis developed by British naturalist Alfred Russel **Wallace** which posits that natural selection can contribute to the reproductive isolation of incipient species by evolving barriers against hybridization.

Mutation theory

- Hugo de vriesinEvening primrose *Oenothera lamarckiana*
- Mutations appear among individuals of a naturally occuring population or species from time o time
- The individuals with mutations are known as mutants
- These are strikingly distinct from their parents
- Are heritable and form new species
- Are large and sudden occur in any direction and are subjected to natural selection
- Mutations appear full-fledged from the beginning, there is no incipient stages in the development of an organ

Criticism

- Darwin-evolution is due to small useful heritable variations over along series of generations
- Morgan-most of mutations are recessive, expression only in homozygous recessive state, some lethal too

- Sewall Wright- can never a driving creative force, rare occurences and gene mutation is extremely low

Modern concepts of organic evolution
(Neo-darwinism)
It recognizes five basic types of processes

- Recombination
- Mutation
- Gene flow
- Natural selection
- gene frequency changes

Genetic basis of variations

- The offspring resemble their parents through heredity but always differ from through variation

Genetic vs somatic variations

- Variations can be heritable or non heritable
- acHeritable variations are genetic variations that are passed on from one generation to the next
- Non heritable variations are acquired by an organism during its lifetime under the influence of the environment
- Such variations are not passed

Discontinuous vs continuous variations

- Variations may be of two kinds
- Discontinuous and continuous variation

Profitable vs unprofitable variations

- any variation that an individual should be adaptive in nature
- It should provide some advantage to carrier
- Such variations are called profitable
- Many variations arise in the population, which do not offer any advantage to the carriers
- Such variations are called unprofitable variations

How variations occur

- during the struggle for existence individuals with profitable variations are selected by nature or unprofitable are eliminated
- if the genetic composition of a population remains the same then the population is said to at genetic equilibrium and there is no evolution
- Whenever the equilibrium is disturbed that will lead to evolution
- Thus evolution can be defined as a change in the genetic composition of a given population over time

Three univ questions
a. Modern concepts of organic evolution
b. Neo-darwinism
c. Genetic basis of evolution

1. Recombination (new combination of old genes)

- genetic variations may be produced in populations whenever there is mixing and shuffling of genes that already exist
- These will never produce new genes, but generate new genetic combinations and bring about variations

- While mutations create new genes, recombination makes their spread through the population

2. Mutation

- Mutations occur in DNA during replication so that there are differences between original DNA and the replicated DNA
- there for mutation is any heritable changes in the makeup of organism
- The process of mutation provides each generation with many new genetic variations
- It is mutation that is responsible for completely new genetic material being added to a gene pool
- The allelic variants present in an existing population have already been subject to natural selection
- They are present in the population because they improve adaptation of their carriers
- their alterative alleles have been eliminated or kept at low frequencies by natural selection
- A mutation that proves useful or advantageous to an organism survival is likely to b passed on and spread through out the gene pool of that species

Neutral theory of molecular evolution

- Was introduced by Motoo kimura in late 1960s
- It states that the vast majority of evolutionary changes at the molecular level are caused by random drift of selectively neutral mutation

neutral mutation

- some mutation in the DNA triplet or codon do not change the amino acid it codes
- some mutations change the existing amino acid to a chemically similar amino acid that functions in a similar way as the original one
- neutral substitutions create new neutral alleles
- Through genetic drift these new alleles may become more common within population
- They may be lost or in rare cases become fixed that the new allele becomes standard in the population

3. Gene flow

- Gene flow also contributes to the variability in populations
- New organism may enter a population by migration from another population
- If they mate within population the can bring new alleles to the local gene pool this is called gene flow
- gene flow can also occur when there is migration
- The loss or addition of individuals can easily change gene pool frequencies even if there are no other evolutioary mechanism operating

4. Natural selection

- It is non random, differential survival (mortality) and reproduction of individuals (genotypes) carrying alternative inherited traits, which results in a change of the relative frequency of genotypes due to differences in the ability of their phenotypes to obtain representation in te next generation
- It is the differential reproduction and survival of individuals carrying alternative inherited traits

Mechanism of natural selection

- All species are capable of geometric or exponential growth
- Population must experience high mortalities among young population
- Population size remain more or less constant
- Population show variations
- And lead to differential probability of survival
- The traits for a greater probability of survival passed from surviving adults to off spring by inheritance
- Those adults that produce greeter number of offspring have a greater probability of having some offspring survive to maturity

5. Gene frequency

Gene pool

- all the genes that the members of a population may contribute to the next generation constitute the gene pool
- Every individual represents a random sample of this gene pool
- The frequency of any gene in a population relative to its allele at the same locus is known as **gene frequency**
- **Genotype frequency** is the total number of one kind of individuals in a population exhibiting similar characters (genotype) in respect to the locus. It can be determined by dividing the number of individuals having one kind of genotype by the total number of individuals in a population.

Hardy –Weinberg equilibrium

- States that in large randomly mating population, no changes occur in the gene frequencies in the absence of mutation, natural selection, genetic drift, nonrandom mating gene flow etc.
- It was postulated independently in 1908 by G.H Hardy a British mathematician and G. Weinberg, a German geneticist
- They demonstrate that the original variability would be maintained in the population in the absence of forces that tend to decrease or increase this variability
- Is applicable only to a theoretical population
- No population is free from mutation, selection or gene flow

Factors that upset Hardy-Weinberg equilibrium

Mutation, natural selection, genetic drift, nonrandom mating gene flow

Genetic drift

- If the population is small gene frequencies will tend to fluctuate purely by chance and smaller the population the greater will be the fluctuation
- genetic drift or allelic drift or Sewall wright effect is the process of change in the gene frequencies of a population due to chance events
- It is non directional and never at increasing and decreasing the frequency of one allele
- It can sometime causes the one allele to be zero
- The magnitude of the gene frequency changes due to genetic drift is inversely related to the size of population

(Smaller population-greater effect

Larger population- smaller effect)

- Genetic drift describes random fluctuations in the numbers of gene variants in a population.

- Genetic drift takes place when the occurrence of variant forms of a gene, called alleles, increases and decreases by chance over time.
- These variations in the presence of alleles are measured as changes in allele frequencies.

- **Natural selection** is that force which produces systematic heritable changes in a population from generation to generation, creating evolution.
- Thus it may become a directional phenomenon, producing changes in a definite direction, giving rise to new species. Natural selection may be very fast or very slow depending upon the environmental demands and rate of genetic changes.
- American naturalists K. Mather & J.M. Theoday (1953) divided natural selection into 3 categories, viz., stabilizing or normalising selection, directional or balancing selection and disruptive selection.

Natural selection

1. Stabilizing selection

- Occurs when selection favors the intermediate trait value over the extreme value
- Natural selection tends to wed out both extremities of a range of phenotypes resulting in the reproductive success of those near the mean
- Occurs only when the environment remains constant

Eg., In humans incidence of infant mortality is higher for very heavy or very light babies

Eg., Siberian husky is designed to move through dense snow

if had heavier muscle sink in snow, if had too light muscle not enough to pull sledge

So stabilizing selection has chosen Siberian husky with a mean size in between the two extremes

2. Directional selection

- Normally occurs when the environment changes
- Favors one particular advantageous mutation resulting in a change in phenotype in that direction
- The population will be shifted to the direction of environmental change and individuals who possess adaptive characters to suit the changed environment will survive and produce more off spring
- DDT resistance Bistonbitularia

3. Disruptive selection

- Most unusual type
- Individuals at both extreme of a range of phenotype s are favored over those in the middle
- Gene pool may become split into two new pools
- tends to increase genetic variability
- maintains balanced polymorphism

R-selection and k-selection

- Proposed by Mac Arthur and Wilson 1967
- The terms used to classify populations
- in r/k selection theory selective pressures are hypothesized to drive evolution in one of two stereotyped directions; r or k selection

R-selection

- In unstable or unpredictable environments r-selection predominates, as the ability to reproduce quickly as crucial

Traits that are thought to be characteristic of r-selection

- high fecundity
- small body size
- short generation time or life span
- High mortality rate
- High investment in producing large number of offspring
- ability to disperse offspring widely
- Below carrying capacity little or no parental care

Organisms whose life history is subjected to r-selection referred to as **r-strategists or r-selected**

K-selection

- In stable or predictable environments k-selection predominates
- the ability to compete successfully for limited resources is crucial
- Populations of k-selected species are very constant

Traits characteristics of k-selection are

- Large body size
- Long life spa
- Low mortality rate
- High investment in maintenance and survival of adults
- Extensive parental care
- At or near carrying capacity

Organisms whose life history is subjected to k-selection are referred to as k-strategists or k selected

Paleontology

- Study of fossils
- Determine organisms evolution, interactions with each other and their environments

Geological time scale

- Have divided the geological time into define intervals each one characterized by significant events both organic and inorganic
- The major division-era
- Each era divide to periods
- Which are further divided to epochs

The division of geological time into successive eras periods and epochs are called ecological time scale

Significance of fossils

1. Know earths distant past
2. Explore oil
3. How life evolved on earth
4. Catastrophic extinction of earth
5. Drastic climatic change
6. Sediments

Fossilization is a rare phenomenon, which takes place under specialized conditions.

Unaltered preservation

- fossils that have undergone little or no change in structure and composition

1. Original skeletal material

- hard tissues preserved as the original material

2.Encrustations

- Occur in caves where water with a high concentration of dissolved minerals seeps constantly
- The minerals remain when water evaporates and preserves organisms that die there

3.Tar impregnation
Tar pits create a sticky material which organism cannot escape
Minimal bacterial decompition
4. Amber entombment

- A sticky resinous pitch from coniferous trees
- Resin hardens to form amber many small insects and other small organisms occasionally become trapped in the resin
- Most of the insect fossils are fossilized in this way

5.Refrigeration

- occurred primarily during Pleistocene, when ice sheet covered much of northern hemisphere
- freezing can occur if an organism is trapped in freezing soil, snow or ice that does not thaw over time
- Ice is a good preservative even of softer body parts. If animals are buried deep in snow that never melts, then they are preserved entirely for a long time.
- Fossil of woolly mammoth from the permafrost in Siberia is an excellent example of preservation in ice, in which even flesh, skin and hair are preserved.

6.Mummufication

- Occurs in very arid environments
- The animals remains dehydrate or desiccate quickly and preserved

Altered remains

1. **Permineralization**

- Pores of many body parts become filled with mineral deposits in the soil or ground water

2. Petrifaction or replacement

- Petrifaction is molecule-by-molecule replacement of organic matter by inorganic compounds, viz. silica, calcium carbonate or iron pyrites.
- It literally means “turned into stone”
- takes place in buried situations, particularly at the bottom of lakes, ponds or sea, where there are sediments rich in calcium carbonate and silica

3. carbonization

- a chemical reaction where water transforms organic material of plant or animal to a thin film of carbon on the surface
- It leaves an outline of organism
- Organism often preserve body this method is fish, leaves and woody tissues of plants

4.Recrystallization

- the composition of mineral does not change
- Only the crystal structure changes
- Many shells originally composed of calcium carbonate in the form of the mineral aragonite recrystallize into the more stable form of calcium carbonate called calcite

5. **Authingenic preservation**

- Occurs when a mold or form of an animal is made after it decomposes in sediment and is replaced by material that hardens into casting of the original animal likeness

Trace fossils

1..Mould and casts

- very common type of indirect preservation
- the dead remains of an organism have been buried and cemented within sediment
- water percolating through the sediment leaches out the original fossil
- This leaves a cavity in the rock, called mould
- Cast then forms when the mould is filled up with another substance such as calcite or quartz or loose sediment

2. compressions

- Impressions of body parts, skin, feathers, leaves etc. are formed when they are pressed hard against the soft clay, which subsequently hardens to form rock

3.Burrows and borings

Annelid worms, arthropods and molluscs make burrows in soil or bore into hard wood, rocks or corals. These are preserved as the soil hardens to form rock.

4. Coprolites

- Sometimes excreta of animals is buried and fossilised, which gives an indication of the diet of animals.

5. Gastroliths

- Are smooth polished stones that are found I the abdominal cavity of skeletal fossils of dinosaurs and large mammals

6. **Gnawings**

- are the result of rodent marsupial and other animals that chewed bones or trees

7. Preservation of footprints

- When animals walk on wet soil and sand, they leave trail of footprints or limbless animals and worms may leave tracks and trails in mud.
- If these footprints are covered by volcanic ash, they can be preserved for a long time as the clay containing footprints and the volcanic ash covering it will harden to form different types of rocks

Isolation and isolation mechanisms

Isolation,

- in evolutionary term, isolation means segregation of different populations into smaller units by certain mechanism so as to prevent interbreeding among individuals
- Dobshanky in 1937first recognized the significance of isolating mechanism

Extrinsic mechanism or geographic isolation

- When the populations are separated by a geographical barrier, such as river, sea, mountain, deserts and for aquatic animals land, they are physically prevented from interbreeding.
- Such populations are termed as **allopatric** and are forced to evolve independently and accumulate genetic differences.
- Geographical isolation may be different for different species.
- For example, a small stream may be an effective barrier for land insects and small mammals while for birds even mountain and oceans may not be barriers.
- Classical example Darwin's finches
- Another eg., fauna of Australian region
- Australia ,Africa and south America in southern hemisphere
- Mammalian fauna of three region entirely different

- Australia have pouched mammals, which is absent in Africa, but in S. America represented by Opossum
- Australia is poor in placental mammals
- The fauna of Eurasia and N. America
- The Northern hemisphere and Souther hemisphere connected by land bridges
- Mamals evolved in Northern hemisphere and started to migrate to souhernhemispher through land connections of South East asia
- But before the more recent carnivorous placental mammals could reach Australia the land connection between Australia and SE Asia got submerged
- **Intrinsic mechanism or reproductive isolation**
- . It is the property of individuals that prevents interbreeding in populations that are actually **sympatric** (living in the same area).
- **Classification of reproductive isolating mechanisms**
- **A. Premating mechanisms**
- They prevent interspecific crosses in sympatric populations.
- **Ecological isolation or Habitat isolation*:***
- in which potential mates do not meet each other due to differences in habitats, requirements of food, space, climate etc.
- Potential mates live in different areas and therefore do not come in contact with one another.
- For example spawning grounds of riverine fishes or frogs are in different tributaries, which prevents interbreeding.
- ***2.*** **temporal isolation, Seasonal isolation*:***
- in which potential mates do not come in contact with each other because of differences in breeding seasons of two species
- e.g. different flowering seasons in plants. *Bufo americanus* breeds in early rainy season (May), while *Bufo fowleri*breeds in late rainy season (July) in USA.

3. **Ethological isolation:**

- most potent for of reproductive isolation
- It is a behavioral isolation, in which potential mates meet but cannot mate, due to differences in courtship displays or other specific signals that are necessary rituals before mating.
- Eg., *Hyla versicolor* and *Hylafemoralis*

4. **Mechanical isolation*:***

- In this case copulation is impossible between animal species because to mechanical problems such as in compatible shape and size of the structure of genitalia.

5. Morphological Isolation

- Difference in the size and shape of different species
- Eg., Bufo quercicius and Bufo vallicpes

Post mating isolation

- Isolation mechanisms take effect after mating and reduce the viability of gametes or fertility of hybrids or their progeny

Gametic isolation

Gamete mortality:

- Mating and sperm transfer takes place but egg is not fertilized.

- In *Drosophila* vaginal wall swells killing spermatozoa should interspecific crosses take place.
- If mating takes place between *Bufo fowleri*and *Bufo valliceps,* sperms cannot penetrate the egg membrane of each other, leading to mortality of gametes.

Postmating mechanisms

- These reduce the success of interspecific crosses.
- In case premating mechanisms fail to prevent mating then several postmating mechanisms prevent the success of mating and hybridization.
- ***1. Zygote mortality or hybrid inviability:*** Egg is fertilized but the zygote dies. Eggs of many species of fishes may be present in the spawning grounds and some may be fertilized by the sperms of different species forming zygote but such zygotes fail to develop due to differences in chromosomes.
- ***3. Zygote inviability:*** Zygote develops and hybrid is produced but is physically weak and inviable due to physiological disturbances in the body. It fails to survive for long and prematurely dies.
- ***4. Hybrid sterility:*** Hybrid is viable, physically strong and physiologically sound but is sterile due to differences in chromosomes and different gene arrangements. Mule is a cross between male donkey and female horse and Hinny between female donkey and male horse and both are sterile, albeit physically strong.

Speciation

- speciation is the evolution of a new species from the pre-existing one by gradual modification.
- Since species are reproductively isolated populations, creation of a new species demands a mechanism that will produce reproductive isolation between two populations.
- Speciation can be classified into two categories

Allopatric speciation:

- Also called **geographical speciation**.
- A physical barrier divides the population into smaller units, as happens during interglacial period when sea level rises and separates islands from the mainland.
- The separated populations on the islands evolve differently by constant genetic changes, translocations, inversions etc.
- They change into races, then subspecies and if time is long enough, into species.
- Thus geographic isolation leads to reproductive isolation
- Once two populations are reproductively isolated they are free to follow different evolutionary paths and they are likely oto differentiate into two different species

Sympatric speciation:

- This type of speciation takes place in freely interbreeding populations which have no geographical isolation but sometimes host preferences may create pockets within the same area.
- Refers to the formation of two or more descendent species from a single ancestral species all occupying the same geographic location
- Occurs when two subpopulations become reproductively isolated without first becoming geographically isolated
- Speciation through hybridization and polyploidy

- Reproductive isolation is therefore produced by polyploidy or hybridization. Polyploidy is very common in plants. Approximately 47% of all angiosperms are polyploids. But it is rare in animals and has been reported in some asexually reproducing shrimps, isopods, bagworm moths, weevils and flies.
- Hybridization normally produces sterile offspring but sometimes fertility is possible by introgressive hybridization (offsprings backcrossing with the parents). Also if hybrids become polyploids, then they will have full complements of all chromosomes and therefore will be fertile and can create a new species instantly.

Tempo of Evolution

- Evolution has never proceeded with a uniform speed over long periods but its rate has fluctuated due to environmental changes, geological upheavals, mutation rates and selection pressures operating differently in different situations.
- Both internal as well as external factors determine the rate of evolution in organisms.
- In a non-changing environment, evolution is always slow as the population is adapted to the existing conditions and emergence of new types is not favoured by natural selection.
- A high rate of mutation upsets genetic equilibrium and modifies the gene pool.

Tempo of evolution

Gradualism

- two species from common ancestor gradually become more and more structurally different acquiring adaptations unique to each
- big changes occur by the accumulations of many small ones
- Darwin supports this
- Most biologist today reject this

Punctuated equilibrium

- Niles Eldredge and Stephen Jay Gould
- A new species arises through major chnges in the beginning and then remain constant for long periods (stsis) before changing again
- It states that evolution of life has involved long periods of stasis punctuated by relatively short period of rapid morphological changes
- Ginkgo biloba and limulus living fossils an evidence for punctuated equilibrium

Rates of Evolution

Bradytely

- G.G Simpson
- Refers to slow gradualist rate of morphologic change over time
- An effect produced but the prevalence in some groups of organisms of lines with extremely low rates of evolution
- or with changes fluctuating o a small scale and not appreciably cumulative

Tachytely

- G.G Simpson
- refers to rapid rate of morphological change over a short period of time
- evolution at exceptionally fast rate cannot endure
- A tachytelic line soon become horotelic bradytelic or extinct
- Eg., birds evolved from reptiles in Jurassic after Triassic mass extinction

Horotely

- In stable or gradually changing environmental conditions, when

selection pressure is minimal the rate of evolution seems to be average even if mutation rate is high.

Orthogenesis

- orthogenetic evolution, progressive evolution or autogenesis,
- straight-line evolution.
- refer to evolutionary changes that take place in a definite and straight direction through a programmed path to reach a predetermined goal
- ie., species A to species B without side branches

Eg, evolution of horse and evolution of Irish Elk

Criticism- Simpson-evolution of horse

ORTHOSELECTION. :

- natural selection promoting the progress and continuance of an adaptive trend in biological evolution and thus simulating orthogenesis
- is the hypothesis that life has an innate tendency to evolve in a unilinear fashion due to some internal or external "driving force".

ANAGENESIS

- The Progressive Evolution
- Evolution of species involving entire population
- Transformation occurring within a single lineage, as a population develops new characteristics
- the single phylogenetic lineage in which a primitive ancestral species gradually acquires complexity and specialization in response to the environmental stimuli

Horoschizia

- This is moderate rate of splitting of phyletic lines under moderately changing environmental conditions when natural selection is not too harsh.
- Splitting takes place after long intervals.

Bradyschizia

- A lineage persists without splitting for a long time and the evolution is slow, but a split can happen after a long gap and some branches may survive while the others become extinct.
- The rate of speciation can be measured as an average of several branching lineages, which would include both surviving and extinct ones.

Evolution at species level

- Microevolution
- Any evolutionary change below the level of species
- It bring in variability of individuals within a population or species
- It does not result in origin of new species
- Microevolution causes collective accumulation of small changes with a species that occur over a relatively short time span
- changes happens with in a group but the decedents is clearly of the same time as ancestor
- the effects of microevolutionary processes although very little in magnitude, can accumulate over time and can some times result in the divergence of populations and result in the birth of new species
- the disadvantageous individuals either fail to survive or fail to reproduce.

Eg: Industrial melanism in *Bistonbetularia(* explain in detail)

Evolution above the level of species

Macroevolution

- Refers to larger events in the course of evolution that occurs at the level above species

Cladogenesis

- It the splitting of a species into two
- Anagenesis change in a species over time to another
- Any changes that occurs at higher levels such as evolution of new families,phyla or genera is also therefore macroevolution
- it mat be synonymous with adaptive radiation
- It may involve fragmentation of species into groups and invasion of these groups into different habitats

Examples

1. Radiation of trilobites in Ordovician era

2. Evolution of mammary gland in true mammals
3. Evolutionary trends in horse family

- In macroevolution unit of selection Is species
- The source of variation is rapid speciation
- In macroevolution a failure in adaptive changes result in extinction of that species or group or taxon
- If a new taxon that emerges out of macroevolution is not favored by natural selection that taxon undergoes extinction altogether

Megaevolution

- it brings about new combinations of characters that lead to origin of new systems of biological organizations
- Are usually associated with changes in habitat as a shift from aquatic to terrestrial and terrestrial to arial

Examples of Megaevolution

1. Origin of amphibians and tetrapods

- Amphibians evolved from Rhipidistian fish in the late Devonian period
- Major evolutionary changes was the emergence of feet at the ends of fins
- It allowed the animals to move over dry lands in a shrinking aquatic environment

- Diversification of limbed vertebrates led to the evolution of tetrapods

2. Origin of reptiles
   - The ancestral amphibians evolved along divergent lines
   - Some of them become similar to primitive reptiles
   - These developed two important adaptations
   - Development of impermeable skin to prevent desiccation on land and a cleidoic egg to enable the young to develop on land

3.Developmengt of feathers
   - avian feathers are homologous to reptilian scales
   - Evolution of avian feathers can be considered as a megaevolutionary change
   - Along with the development of feathers sudden changes in the forelimb to produce wing which enabled them to invade air.