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Course: Life Science 4th sem

Paper: Genetics and Evolutionary Biology

Unit 11 – Macroevolution

MACROEVOLUTION

Definition : macroevolution is broad basic pattern of evolution, occurring above species level resulting in evolution of new adaptive types through a process of population fragmentation and genetic divergence. Macroevolution occurs by **Adaptive Radiation**. Adaptive radiation is evolutionary diverging several descendent population by splitting of a single pre-existing population, by acquiring special adaptations.

Macroevolution is long term porogressive evolution of only one structure of a group organism in one direction (Called Adaptive Trend) but almost always involves a complex of different features. The driving force of macroevolution is natural selection.

History of Macroevolution:

1. According to Goldschmidt (1940), Macromutations or Systematic Mutations; sudden large size mutations above species level resulting in formation of new genera, families and orders, lead to Macroevolution.
2. George Gaylord Simpson (1947, 1953) studied direction of evolution through Fossil records. He complied a great Paleontological evidences for Macroevolution.

3. Bernhard Rensch (1959), did comparative morphology studies to infer patterns of evolution.

Mechanism of Macroevolution:

Macroevolution occurs by Adaptive Radiation or evolutionary divergence. During macroevolution ecologically isolated populations or lineages enter new adaptive zones to occupy diverse habitats and under go adaptive trend to evolve into new adaptive types. These new adaptive zone are very favorable for new populations as there are diverse habitats offering different kinds of foods, lesser number of individuals thereby reducing both the intraspecific and interspecific competitions and provides many new opportunities to be availed. Under these initially favorable conditions, the individuals of new population start adapting themselves to new habitats, accumulate mutations, and new adaptive modifications occur.

Features of Macroevolution:

1. Macroevolution occurs due to macromutations.
2. It occurs in those populations which have entered in new empty habitats.
3. Macroevolution results from evolutionary divergence or adaptive radiations
4. Macroevolution produces parallel adaptations among divergent groups.
5. Macroevolution leads to specialized adaptation in a particular direction called adaptive trend. As a result individuals become strictly adapted to a specialized narrow habitats and reach adaptive peak. This can lead to overspecialization of the individuals and finally extinction as the overspecialized individuals are unable to modify themselves when the habitat conditions change.

Examples of Macroevolution:

1. Evolution of Modern Horse *Equus* : *Equus* , the modern horse lives in grasslands, feeding on grass(grazer), large size and specialized to run fast to escape the carnivore enemies. *Equus* evolved from *Hyracotherium* through macroevolution by adaptive divergence. *Hyracotherium* was of the size of a dog with plantigrade feet, short legs and a browser to feed on soft leaves. *Hyracotherium* evolved by specializing on fast running mechanism (springing mechanism) so that limbs became long, feet evolved unguligrade with hoof and chewing teeth adapted to grind hard grass, to *Equus* through a series of different ancestral species.

2. Evolution of Darwin's Finches: This is a classical example of isolation, competition, adaptation etc leading to adaptive radiation above species level. Darwin's finches occupy the Galapoges Islands and consist of many species differing in ecology, song pattern, morphology and differing mainly in the size and shape of their beaks correlated with the differences in their feeding habits. These finches include species of ground finches, tree finches, warbler finches which diverged along several lines from a single ancestral stock which inhibited the main land.

1. Adaptive radiation in Reptiles: All the modern day reptiles have evolved from the Cotylosaurs by macroevolution. The evolution of reptiles have occurred on six major radiating offshoots from the ancestral anapsid stock. All the living and fossil groups of reptiles exhibit much diversification of their populations

There are various other examples of Macroevolution like adaptive radiation of eutherian mammals to arboreal, aerial, cursorial, fossorial and aquatic habitats. Adaptive radiation of Hawaiian honeycreepers, Cichlid fish, Marsupial mammals etc.

Patterns of Macroevolution

Definition: All the changes, diversification and extinction that happen over the course of evolution of a lineage, taxa or group are called Pattern of Macroevolution.

The patterns include

1. **Punctuated Equilibrium and Stasis** : Supported by SJ Gould and N Eldredge. Most evolutionary changes are rapid bursts of speciation alternating with long periods during which the species remain unchanged. The long period of geologic time during which no significant or very limited morphological changes occur are period of Stasis or Period of Equilibria. The brief periods of active change interrupting the period of equilibria are called Punctuations, during which conspicuous or prominent evolutionary changes occur. During these brief periods the lineages actually branch or split, called punctuated equilibria.

Eg. Lineages of King crab ,*Limulus a* nd Coelacanth fish have changed so little for a long time after they branched of from ancestors.

2. **Directional Character Changes**: Characters in lineages may show directional changes called directional evolution. Eg. Changes in toes and legs during horse evolution to enable the animal to run fast.

3. **Lineage Splitting**: origin of new species by parapatric and peripatric speciation or origin of higher taxa like genus, family, order etc is called lineage splitting. It occurs by following methods:

a. **Frequent Lineage Splitting**: this generates a bushy tuft of lineage branches on the phylogenetic tree due to frequent lineage splitting.
b. **Rare Lineage splitting**: In this case lineage splitting is low or rare and phylogenetic tree is represented by long straight branches with very few twigs.
c. **Burst of Lineage Splitting**: Several lineages may show sudden burst of splitting, almost simultaneously.

4**. Gradualism and Saltation**: persistent accumulation of small changes within a lineage over millions of years is called phyletic gradualism. Thus the descendent population may be recognized as distinct species over time is called anagenesis. But another group of researchers including paleontologist Otto Schindewolf (1950) believed that differences among higher taxa arise discontinuously by saltation, supported by Richard Goldschmidt who also advocated that single large evolutionary step leads to formation of new genetic systems. However, it is now established that higher taxa do not arise in single step by macromutational changes (saltations) but by multiple changes in the genetically independent characters over a period of time and

5. **Extinction**: is total disappearance of a lineage or death of all members of a species. During process of evolution continual turnover of species occurs and new species arise and old ones get extinct. Macroevolution causes lineages to become distributed locally and overspecialized making them vulnerable to extinction during environmental change or destruction of habitats. Also finally intraspecific and interspecific competition also drive species to extinction.

Extinction is of 2 types

a. **Background extinction**: occurs regularly at low or average rate and are caused by normal environmental changes like emerging disease or competition among species.

b. **Mass extinction**: these are rapid extinction occurring at mass scale and has catastrophic episodes that wipe out huge number of species and lineages in a short period of time. Five such mass extinction have been identified during earth history till now.

Microevolution

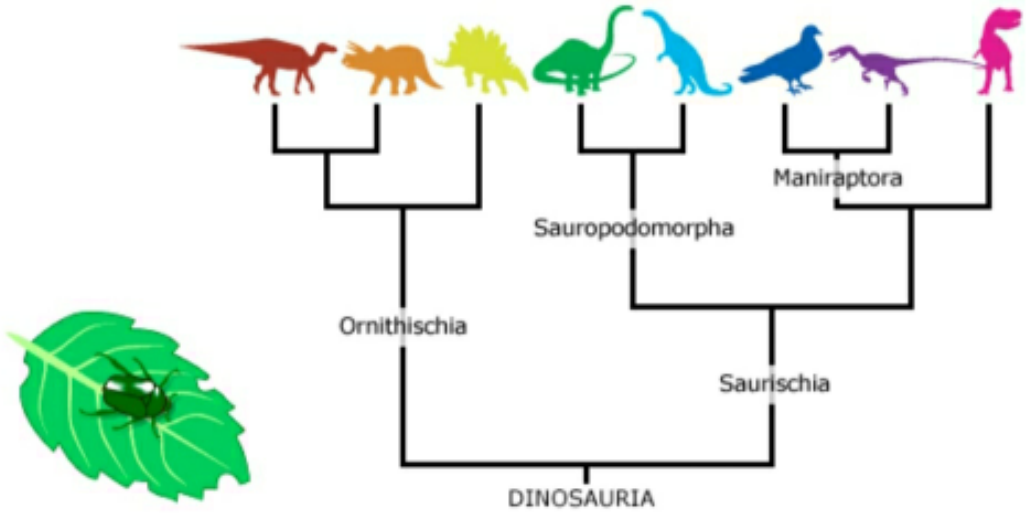
Microevolution refers to change in the allele or gene frequencies in a population over short time period. Microevolution causes the gene pools of closely related populations of a species to diverge and contribute to the origin of new species. It forms the basis of macroevolution.

The mechanism of microevolution involves:

1. Gene mutations
2. Recombination and nonrandom matings
3. Gene flow or gene migration
4. Genetic drift
5. Natural selection

Eg of microevolution:

1. Industrial melanism in peppered moth*Biston betularia*
2. Evolution of resistance to DDT in mosquitoes
3. Bacteria developing resistance to antibiotics



Microevolution Macroevolution

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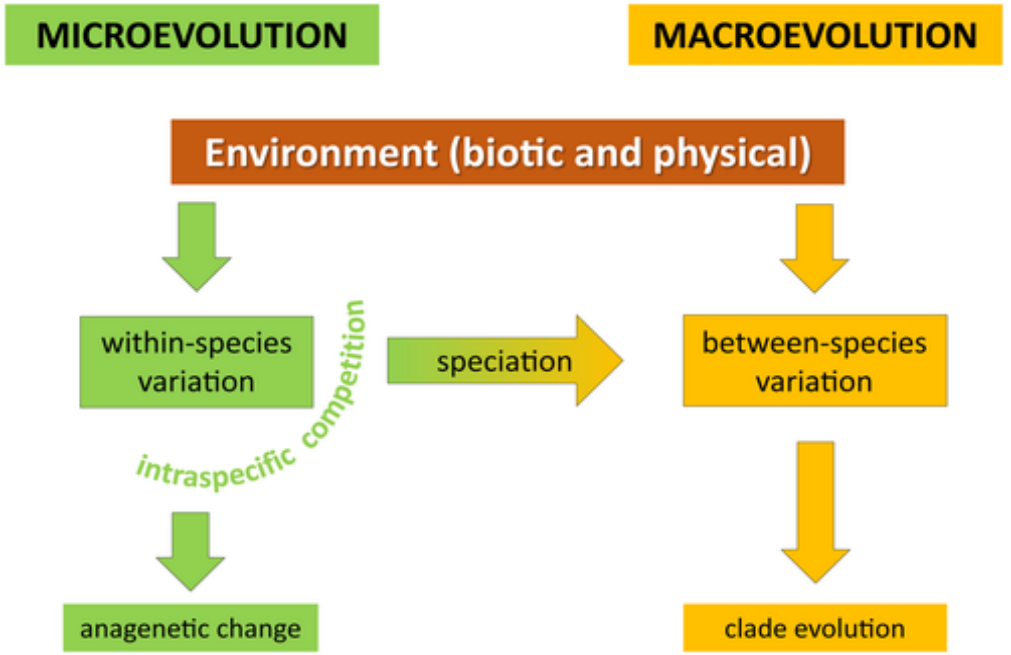

Ref: Frontiers of Paleontology V63, Issue 1