Unit V: Phyletic gradualism and Puncated equilibrium

Macro and Micro evolution

Micro-evolution refers to the alteration in a gene pool of the population over time, resulting in small changes of an organism in the same species. On the other hand.

Macro-evolution refers to the alteration in organisms, and these changes gradually give rise to completely new species, which is different from their ancestors.

Macro-evolution is different from micro-evolution, as there are many observations of variation in case of micro-evolution and do not requires any statistically significant increase of functional genetic information; but in case of macro-evolution, the genetic change requires a statistically significant increase of functional genetic information, which is difficult to achieve.

Comparison Chart

BASIS FOR COMPARISON	MICRO-EVOLUTION	MACRO-EVOLUTION
Meaning	The evolution which occurs on a small scale and within a single population is micro evolution.	The evolution that occurs on a large and surpasses the level of the single species is macro evolution.
It gives rise to	Changes in the gene pool, which results in a few changes in the same species also called Intra-species genetic change.	The macroevolution results in the formation of new species.
Occurs	The changes in micro evolution occur over short timescales.	The changes observed in macro evolution occurs over long-time scales.
Genetic information	Genetic information gets altered or rearranged.	There is the new addition, deletion in the genetic structure, resulting in the new species.
Creationists support	As this process has been experimentally proven and so creationists support this type of	As there are many barriers in providing experimental proof and so creationists do not support this kind

BASIS FOR COMPARISON	MICRO-EVOLUTION	MACRO-EVOLUTION
	evolution.	of evolution.
Example	The peppered moth, new strains of flu viruses, Galapagos finch beaks, etc.	Origin of different phyla, development of vertebrates from invertebrates, development of feathers.

Definition of Micro-Evolution

Micro-evolution can be defined as the alteration in the gene frequency which occurs over time within a population of a species. As this process happens on a short time scale, it is often observed. The reason for the changes is the mutation, genetic drift, gene flow, insertions/deletions, gene transfer, and natural selection.

Gene flow or gene migration is transfers of genes through the physical movements of the alleles within the population, which means that gene flow occurs when any individuals emigrate or immigrate between populations. The gene flow increases the genetic diversity of a population.

Genetic drift is seen in small populations, where evolution occurs due to random changes in the allele frequency within a population. The Bottleneck effects say that the gene pool randomly drifts when the population gets reduced by any calamity, that kills unselectively. The Founders effects, where the few numbers of individuals got separated from their population, may result in genetic drift.

Mutations are considered as one of the most likely causes of the variations, which results in new alleles. Mutations occur due to replication errors, UV radiations, viruses, and mutagenic chemicals. Natural selections take thousands of years to happens and bring noticeable changes. Selectin can be natural or artificial.

Definition of Macro-Evolution

It can be defined as the evolution that occurs above the species level. Macro-evolution is considered as **large scale changes**, that are observed in a different organism, but these changes take thousands of years to take place.

Let’s take an example of Asian Elephant and the African Elephant; these species cannot mate due to reproductive isolation. Here the main factor is macroevolution which describes the difference between two closely related though distinct species. This is called as **speciation**, which occurs through the various mechanisms.

The term macroevolution also follows a concept of Universal Common Descent, where it explains the common shared ancestry between all living organisms. It also shows the variation among organisms of larger clades of organisms, like the different taxonomic groups within primates.

Macro-evolution is derived from the microevolution only; the difference is in the time-scale and the kind of gene alteration.

Key Difference Between Micro-Evolution and Macro-Evolution

Given below points are the essential one to distinguish between micro-evolution and macro-evolution:

1. The **heritable change** in the gene frequency is called as evolution when the evolution occurs on a small scale and within a single population is **micro-evolution**, while the evolution that occurs on a large and surpasses the level of the single species is **macro-evolution**.
2. Micro-evolution gives rise to changes in the **gene pool**, which results in few changes in the same species also called **Intra-species genetic change**, whereas the macro-evolution results in the formation of new species.
3. The changes in micro-evolution occur over short-time scales, whereas the changes observed in macro-evolution occurs over long-time scales.
4. **Genetic information** gets altered or rearranged in micro-evolution, whereas there is the new addition, deletion in the genetic structure, resulting in the formation of new species in macroevolution.
5. **Creationists** support micro-evolution as this process has been experimentally proven and is observed frequently, although there are many barriers in providing experimental proof and so creationists do not support this kind of evolution as it takes a lot of time to occur.
6. **Example** of the micro-evolution are the peppered moth, new strains of flu viruses, Galapagos finch beaks, etc. and Origin of different phyla, development of vertebrates from invertebrates, development of feathers are the examples of macro-evolution.

Microevolution

This is also called **Sequential evolution,** which involves a continuous and gradual change in an interbreeding population, usually giving rise to new subspecies and geographical races. Basic process involves changes in gene frequencies in a population from one generation to the next. Microevolution is produced by stabilizing or normalizing natural selections that operate in stable environmental conditions and in short time span.

<u>Examples:</u> Rowe has discovered several lines of descent in sea urchin, *Micraster,* where he found gradual change in characters from *M. corbovis* to that of *M. cor-anguinum,* mainly in

the shape of the test, structure of oral opening and the form of ambulacra. The changes took place in a more or less stable environment. Similarly Fenton has described gradual replacement of one species by another in brachiopod, *Spirifer* ,Darwin flinchers.

- Example: Different species of there birds live on different islands in the galapagos archipelago located in the pacific ocean of south America.
- Finchers isolated from one another by the ocean. Millions years ago.
- Each spesies of finch developed to the kind of food it eats.
- Some finches have large, blent beaks that can cracked the hard shells of nuts and seeds,
- others finches have long,thin beks that can prob into cactus flowers with out the bird being pocked by the cactus spines.
- others finchers have medium size beaks that catch and graps insects .

Macroevolution

This may also be called **Adaptive radiation,** which includes evolutionary changes above the species level that may result in the production of new adaptive types through genetic divergence. The changes are on account of large gene mutations or macromutations and result in the establishment of new genera, families and orders. Macroevolution takes place in individuals that have entered a new environmental zone, which is free of competition. Darwin called such directional changes **Orthogenesis.**

Examples: Evolution of horse is a perfect example of macroevolution, in which there was an increase in the size of body and legs and in the enlargement of teeth. All body changes were related to life in open grasslands, fast running and feeding on harsh grasses, eventually leading to new adaptive types. Other examples of macroevolution are: adaptive radiation in Darwin’s finches, divergence of reptiles and evolution of camel and elephant.

Evolution of horse dates back to Eocene epoch, about 60 million years ago. Primary center of evolution were Great Plains of North America, from where species migrated to Europe and Asia from time to time. For some reasons horses became extinct in North America by the end of Pleistocene epoch but their offshoots in Europe and Asia flourished.

Evolution of horse was triggered by a change in the climate and vegetation during lower cenozoic period, when grasslands in most parts of the world replaced forests. The main modifications in the body of horses from small forest-dwelling animals to large, grazing and fast-running animals can be outlined as follows: ·

- Increase in the size and height of the body from a small, rabbit-like animal to 6 feet tall grassland animal.
- Gradual enlargement and better development of the third digit (median digit) and reduction of the other lateral digits.
- Reduction of ulna bone in the fore leg and fibula in the hind leg and strengthening of radius and tibia.
- Change from digitigrade to unguligrade locomotion for fast running.
- Elongation of the preorbital or facial region of the skull and migration of eyes to the top of head.
- Modification of teeth from brachydont (low-crowned) to hypsodont (high crowned) to withstand tougher food (grass).
- Increase in the size and complexity of the brain for superior intelligence.
- Reduction in pectoral girdle and disappearance of the weak clavicle.
- Body became streamlined, muscles tight, without loose fat, for long and sustained running.
- Nostrils became wide to allow more air into strong lungs and stamina increased.

Phylogeny

Eocene horses

Hyracotherium* or *Eohippus: Fossils of *Hyracotherium* were found in Europe and those of *Eohippus* in North America (Wyoming and New Mexico). Height was about 2 feet. Facial region was short and eye-orbits located about in the middle of the length of the skull. Dentition was brachydont (low-crowned) and bunodont (low cusps) to feed on soft vegetation. Premolars were simpler than molars. Ulna in the foreleg and fibula in the hind leg were complete. Fore foot had 4 digits and hind foot had 3 digits, all touching the ground.

Orohippus and ***Epihippus:*** Both are related genera and do not differ much from the preceding species. There were four digits in front foot and three in the hind foot. Median digit became larger and lateral ones shorter but all touched ground and carried the body weight.

- **Oligocene horses**

Mesohippus and ***Miohippus:*** There is enlargement in size to about 24 inches. Three functional digits in fore as well as hind foot, all touching the ground but the median toe was much stronger than the others. Ulna and fibula became thin and slender. All premolars became molariform, as a pre-adaptation to harsh diet.

- **Miocene horses**

Parahippus and ***Merychippus:*** There were three digits in each foot but the middle one was larger and stronger and the lateral digits did not reach the ground. Preorbital region of the face became elongated. All premolars became molariform and dentition became hypsodont but the milk teeth were still low-crowned. Central toe ended in a large convex hoof.

- **Pliocene horses**

Pliohippus: Lateral digits reduced to vestiges. Skull had elongated. Crown of teeth was similar to modern horses but they were curved and pattern of ridges was not so advanced. Facial fossae were deep. It had acquired unguligrade gait of swift locomotion.

Dinohippus: Lived about 12 million years ago in North America. Its fossils have been discovered recently and it showed remarkable similarities with modern horse, much more than *Pliohippus* does. It had straighter teeth and reduced skull fossae. It is believed to have given rise to modern horses.

Hypohippus: Fossils were recorded from North America and China. Size was 40 inches, similar to pony. It was a 3-toed browsing horse, with well-developed lateral hooves and vestiges of the first and 5^{th} digits still present in the fore leg.

Hipparion: Size about 40 inches. There were three toes in each foot but lateral digits were small. They migrated from North America to Old World through Alaska and Siberia.

Protohippus: It was a 3-toed grazing horse that had low crowned teeth.

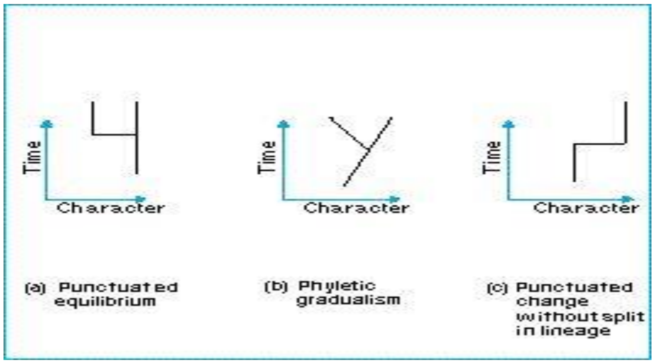
Hippidion: It had short and stout feet having only one toe. Head was large with long and slender nasal bones.

Pleistocene horses:

Because of the harsh climate of the Pliocene and glaciations of Pleistocene epoch, horses became extinct in North America. Only one genus, ***Equus***, survived in northern Africa, Asia and Europe. It soon spread to different parts of Asia, Africa and Europe and diversified into 5 distinct species, namely, *Equus caballus, E. zebra, E. hemionus, E. assinus* and *E. przevalskii.*

UNIT V: PHYLETIC GRADUALISM AND PUNCHATED EQULIBRIUM

Phyletic gradualism



Phyletic gradualism is a hypothesis about the pattern of evolution. In contrast to the theory of punctuated equilibrium, it states the following:

• Evolution has a fairly constant rate.

• New species arise by the gradual transformation of ancestral species.

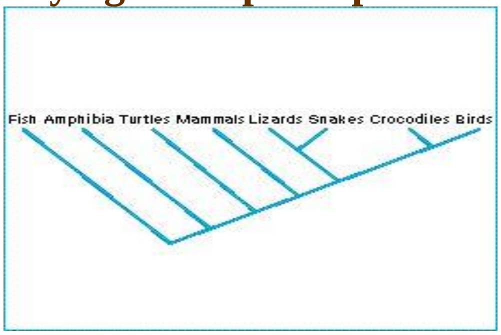
• The rate of evolution during the origin of new species is much like that at any other time.

For gradualists, the fact that fossil evidence shows species suddenly appearing with little signs of any transitional forms is due to the incompleteness of the fossil record.

There is a historical controversy as to whether Darwin himself was committed to gradualism. It is most likely that he was a gradualist about the evolution of adaptations, not about the pattern of evolutionary rates.

Figure: the crucial difference between punctuated equilibrium and phyletic gradualism concerns the rate at, and between, splitting events. (a) Punctuated equilibrium. (b) Phyletic gradualism. (c) Under a strict interpretation of punctuated equilibrium, sudden change without splitting contradicts the theory.

Phylogenetic principle



The phylogenetic principle of classification is an evolutionary principle: in contrast to the phenetic principle, it classifies species according to how recently they share a common ancestor.

Two species that share a more recent common ancestor will be put in a group at a lower level than two species sharing a more distant common ancestor.

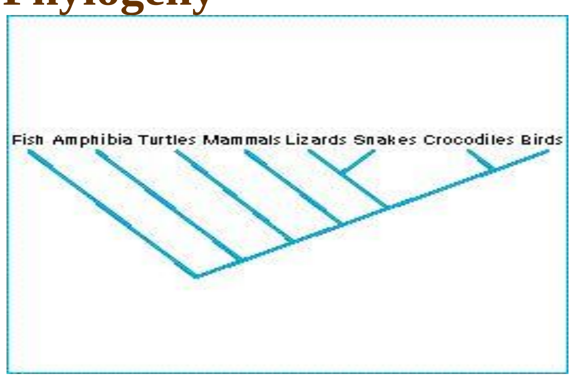
As the common ancestor of two species becomes more and more distant, they are grouped further and further apart in the classification.

In the end, all species are contained in the category the set of all living things which contains all the descendants of the most distant common ancestor of life..

Cladism and evolutionary classification are the two taxonomic schools which make use of the phylogenetic principle to differing degrees.

Figure: a phylogenetic classification of the main vertebrate groups.

Phylogeny



A phylogenetic tree, also known as a tree of life or simply a phylogeny, describes branching relationships among species, showing which species shares its most recent common ancestor with which other species.

A phylogeny implicitly has a time axis, and time usually goes up the page. Phylogenetic relations have to be inferred using homologies because the splitting events and common ancestors existed in the past and cannot be directly observed.

There are two methods of phylogenetic inference:

1. Parsimony. Species are arranged in a phylogeny such that the smallest number of evolutionary changes is required.

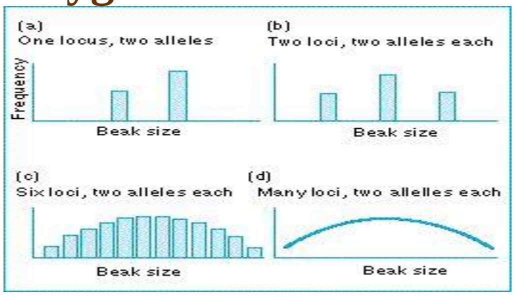
2. Distance (or similarity.) Species are arranged in a phylogeny such that each species is grouped with the other species that it shares the most characters with.

Figure: a phylogenetic tree of the main vertebrate groups. Lizards and snakes share a more common ancestor than other species and so are grouped together.

Pleiotropy

- Pleiotropy is the condition in which a gene influences the phenotype of more than one part of the body.
- A trivial instance would be that the gene influencing the length of the left leg also influences the length of the right leg.
- The growth of legs probably takes place through a growth mechanism controlling both legs.
- Pleiotropy exists because there is not a one-to-one relationship between the parts of an organism that a gene influences and the parts of an organism that we recognize as characters.
- Genes divide up the body in a different way from the human observer. Genes influence the developmental process, and a change in development will often change more than one part of the phenotype. This sometimes places a developmental constraint on the adaptation of organisms.
- This Hawaiian happy faced spider illustrates the concept of pleiotropy. Here the length of matching legs is controlled by the same genes, giving the spider its symmetrical appearance.

Polygenic character



Many characters that display continuous variation are controlled by genes at many loci.

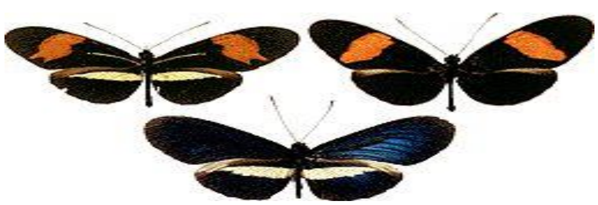
Characters influenced by a group of genes are called polygenic characters. The number of genes involved in the control of some trait is commonly around 10, but may be as large as 100 or so in some cases.

Figure: characters involved by many genes often show continuous variation. In (a) the phenotypic character, such as size, is controlled by one locus with two alleles (A and a), where A is dominant to a. There are two discrete phenotypes in the population.

(b) The character is controlled by two loci with two alleles each (A and a, B and b); there are three discrete phenotypes.

(c) and (d) it is shown that as the number of loci increase, the phenotype frequency distribution becomes increasingly continuous.

Polymorphism



Polymorphism is a condition in which a population possesses more than one allele at a locus. Sometimes it is defined as the condition of having more than one allele with a frequency of over 5% in the population.

There may be several causes of polymorphism:

• polymorphism can be maintained by a balance between variation created by new mutations and natural selection (see mutational load).

• genetic variation may be caused by frequency-dependent selection.

• multiple niche polymorphism exists when different genotypes should have different fitnesses in different niches.

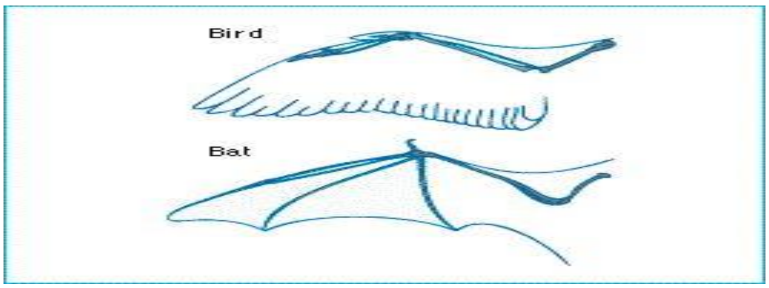
• heterozygous advantage may maintain alleles which would otherwise be selected against.

• if selection is operating, migration can introduce polymorphism into a population.

These are all sources of polymorphism which make use of the mechanisms of natural selection. Genetic drift is also a possible source of genetic variation.

The Heliconius erato butterfly is a species with a high degree of polymorphism for genes encoding wing color.

Polyphyletic group



Polyphyletic groups are formed when two lineages convergently evolve similar character states.

Organisms classified into the same polyphyletic group share phenetic homoplasies as opposed to homologies. The key difference between paraphyletic and polyphyletic groups is that paraphyletic groups contain their common ancestor, whereas polyphyletic groups do not. Polyphyletic groups are recognized by pheneticists but not by cladists or evolutionary classifiers.

An example of a polyphyletic group is bats and birds: both have wings, but they have evolved separately.

Population genetics

- The theory of population genetics is concerned with gene frequencies and genotype frequencies and with the processes influencing these frequencies.
- Population genetics is the most important, most fundamental body of theory in evolutionary biology.
- It is the proving ground for almost all ideas in evolutionary biology: the coherence of an evolutionary hypothesis will usually remain in doubt until the hypothesis is expressed in the form of a population genetics model.
- Given frequencies in generation an elementary population genetics model can be used to predict frequencies in generation n +1.

Population genetics model

Given genotype frequencies in generation n, an elementary population genetics model can be used to predict frequencies in generation n+1. This model has four steps, starting with the frequencies of genotypes among the adults in generation n.

1. The first step is to specify how these genotypes combine to breed (called a mating rule);

2. The second step is to apply the Mendelian ratios for each type of mating;

3. We then add the frequencies of each genotype generated from each type of mating to find the total frequency of the genotypes among the offspring, at birth, in the next generation;

4. If the genotypes have different chances of survival from birth to adulthood, we multiply the frequency of each genotype at birth by its chance of survival to find the frequency among adults.

When the calculation at each stage has been completed, the population geneticist's question has been answered.

Figure: the general model of population genetics.

Population subdivision

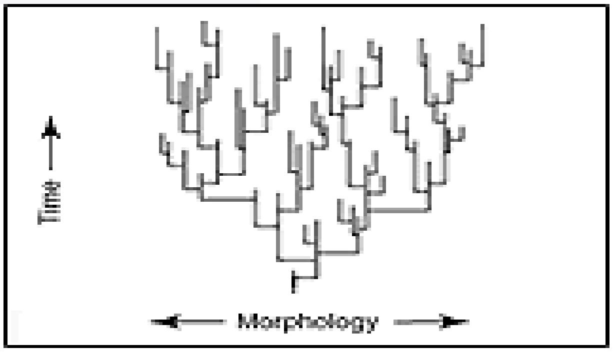
A species with a number of more or less independent subpopulations is said to have population subdivision.

- In nature, a species may consist of a number of separate populations, each more or less isolated from the others.
- The members of a species might, for example, inhabit a number of islands, with each island population being separated by the sea from the others; individuals might migrate between islands from time to time, but each island population would evolve to some extent independently.
- An important consequence of population subdivision is the Wahlund effect: the frequency of homozygotes higher in populations which contain subdivisions than in fused populations.

PUNCTUATED EQUILIBRIUM:

However, Niles Eldredge and Stephen Jay Gould (1972) accepted the sudden appearance of new forms as a scientific fact and explained it with their theory of **Punctuated Equilibrium.**

The relative importance of punctuated and gradual patterns of evolution is a subject of debate and research.



- That is certainly true in many cases, because the chances of each of those critical changing forms having been preserved as fossils are small. But in 1972, evolutionary scientists Stephen Jay Gould and Niles Eldredge proposed another explanation, which they called "punctuated equilibrium." That is, species are generally stable, changing little for millions of years.
- This leisurely pace is "punctuated" by a rapid burst of change that results in a new species and that leaves few fossils behind.

- According to this idea, the changes leading to a new species don't usually occur in the mainstream population of an organism, where changes wouldn't endure because of so much interbreeding among like creatures.
- Rather, speciation is more likely at the edge of a population, where a small group can easily become separated geographically from the main body and undergo changes that can create a survival advantage and thus produce a new, non-interbreeding species.

Punctuated equbliriumis:

- Punctuated equbliriumis a term that refers to the evolutionary changes of plants and animals in a relatively static way.
- In contrast to the concept that life forms change slowly over time in response to their environment, punctuated equilibrium is a theory that those changes occur in spurts of time periodically.
- This theory stands in contrast to Darwin's more dynamic model of evolution. Punctuated equilibrium states that evolution only takes place in bursts of time that are rapid. However, the term "rapid," in evolutionary terms should be understood to mean approximately 500,000 years in some circumstances.
- Prior to the change which is often caused by an environmental factor, the life form's species or class lives in "stasis" or an unchanged state for many, many years because it does not have a need for change.
- Once the change happens, quite quickly, the species re-enters stasis with its new evolutionary adaptation.

- Examples of punctuated equilibrium include

- A species of sea animals lives, breeds, and dies for thousands of years. Suddenly, the sea level changes and the animals must adapt. Their bodies develop in order to accommodate the environmental change, and from then on are evolutionarily different from their ancestors.
- A species of birds exists in stasis for many thousands of years. Suddenly, a bacteria causes their primary tree of sheltering choice to die. The birds must adapt within the environment to trees that are much higher requiring more wing strength. Some birds die. The remaining birds' bodies adapt as necessary and they return to a state of stasis.
- A species of worms lives in the soil in a particular climate and is in a state of stasis. Climate changes cause the pH of the soil to change. The change in pH causes some worms to die, but those that survive adapt and reproduce with new ability to withstand the pH change in the soil. The species returns to stasis.