Organic Evolution

- Evolution is descent with modification
- Organic Evolution is the origin of new species of organisms, including humans, from ancestors who previously lived on the earth.
- There are two different types of development in organisms viz., ontogeny, and phylogeny.
- "Ontogeny" is primarily concerned with the history of development of individual organisms – growth & development
- "Phylogeny" deals with the evolution of a genetically related group of organisms, in contrast to the development of the individual organism.
Pre Darwinian Phase

• In the fourth century B.C., Theophrastus, a Greek, has written a book on seed germination.

• Some early Greeks believed that heredity among humans was a question of which sex dominated in the sex act.

• Preformation - Every organism must therefore contain in its reproductive organs an infinite series representing all of its future descendants”.

• Ovists believed the female possessed this future of the series, and the spermists insisted it was the male.

Pre Darwinian Phase

• Linnaeus suggested a two-layered theory, which held that “the outer layer including the vascular system is derived from the father, the inner layer including the nervous system comes from the mother”.

• That plants lacked sexuality was the conventional wisdom of the day.

• End of the seventeenth century - the presence of sex organs in plants demonstrated by Rudolph Camerarius.

• Hybridization experiments, finally culminated in Universal Law of Genetics by Mendel
Theory of Inheritance of Acquired Characters

- Jean Baptiste de Lamarck

- *Modifications which the organism acquires in adaptation to the environments which it meets during its life time are automatically handed down to its descendants and so become part of heredity.*

- "Philosopie Zoologique" - 1809

Lamarckism

**Four propositions**

1. Living organisms and their component parts tend continually to increase in size.

2. Production of a new organ result from new need and from the new movement which this need starts and maintains.

3. If an organ is used constantly, it will tend to become highly developed, whereas disuse results in degeneration.

4. Modification thus produced by the above principles during the life time of an individual will be inherited by its offspring.
Lamarckism

- Lamarck believed that organic changes seen in animals are a result of the influence of environment on species.
- Species respond to the environment because they have an inherent tendency to become more and more perfect.
- Ex. Long neck of Giraffe, blindness in moles, webbed feet of the duck.
- Lamarckian theory was simple and it had some appeal as it provided a way in which changes in organisms could come about.
- It was the first complete comprehensive theory that was offered.
- Thus, Lamarckian theory enjoyed popular acceptance for about 70 years, because it was exemplified by many common examples.

Critical Analysis of Lamarckism

- All four propositions fail the test of empirical validity.
- Experiments disproved Lamarckism – August Weismann.
  - Somatoplasm Vs Germplasm.
Darwinism

• Charles Darwin and Alfred Russell Wallace
• 1859 – “Origin of Species & the Preservation of Favored Races in the Struggle for Life”

Theory of Natural Selection

• "The change in species by the survival of an organismal type exhibiting a natural variation, that gives it an adaptive advantage in an environment, thus leading to new environment equilibrium, is evolution by natural selection".

Darwinism

Five Postulates

1. Universal occurrence of variation
2. Excessive natural rate of multiplication (prodigality)
3. Struggle for existence
4. Survival of the fittest
5. Inheritance of variation
## Critical Analysis

- A veritable storm broke out with the publication of this book
- Was opposed primarily on ethical and religious grounds
- “Survival of the Fittest” – erroneously interpreted by people as “tooth and claw”, “kill or be killed” kind of struggle
- Led to rationalizations like “every man for himself” in social and economic lives – **materialistic doctrine**
- Greatest weakness – did not account for inheritance – pangenesis hypothesis – disproved by Galton

### Critical Analysis

1. Talks about survival of the fittest but not arrival of the fittest
   2. Overspecialization in certain organisms – cannot rationalize with natural selection
   3. Natural selection did not account for degeneration
   4. Dilution – loss of traits without intervention of selection
   5. Indirectly accepted Lamarckism – inheritance of acquired characters
Post Darwinian Phase

- Between later 19\textsuperscript{th} and early 20\textsuperscript{th} century – a number of important ideas were forwarded to explain inheritance
- **Gene Theory** of Thomas Hunt Morgan
- Discovery of Mendel’s laws of inheritance by Correns and Tschemark
- Hugo de Vreis – **Mutation theory**
- Wagner – role of geographical isolation in speciation
- Research in population genetics proved that Darwin’s struggle for existence between individuals is not a very significant force in evolution

Post Darwinian Phase

- Unit of evolution is recognized as POPULATION and NOT INDIVIDUAL as Darwin believed
- **What is a Population?** A group of individuals living within a circumscribed area and interbreeding
- Population is also called a **Deme**
- The next larger unit of population in nature is the **species**, composed of a series of inter-breeding demes.
The Modern Synthesis

• All the modern understandings in cytology, genetics, cytogenetics, population genetics, and evolution gave a way for the formulation of a coherent theory called "Modern Synthesis" around 1930s.


• It is a "synthesis" of "mutationist" and "selectionist" views of evolution
What is Evolution?

Evolution is a two stage process

1. Production and redistribution of variation
2. Action of natural selection on variation
   • Evolution is defined as change in the allelic frequencies in a gene pool of a given population from one generation to the next
   • The gene pool is the sum total of all the alleles of genes in a population
   • Evolution is also the sum total of genetically inherited changes in the individuals who are members of a population’s gene pool

Unit of Evolution

• Alleles – variants of a gene
• Variation in population – because of the presence of alleles and their inheritance
• The allele frequencies refer to only the whole group of individuals i.e. populations.
• Individuals do not have allelic frequencies; they have genotypes which are fixed at birth
• Therefore, an individual cannot evolve; only a group of individuals – a population – can evolve over time.
• Population is the smallest unit where evolutionary change is possible
**Example**

- For instance, let us assume that there is a trait that is determined by the inheritance of a gene with two alleles--B and b.

- If the parent generation has 92% B and 8% b and their offspring collectively have 90% B and 10% b, evolution has occurred between the generations.

- The entire population's gene pool has evolved in the direction of a higher frequency of the b allele.

- Thus, the population has evolved.

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**Macro & Micro Evolution**

- Evolution is an incredibly common phenomenon and may occur between every generation – micro-evolutionary change.

- Over a period of time, the relative proportions of alleles in the population will change, some may increase, and some decrease and still others may remain the same.

- Over a short run of just a few generations, such changes in inherited traits may be only very small, but over a very long period of time, they may produce spectacular kind of adaptations and whole new variety of life – macro-evolutionary change.
Factors producing variations

• Primary Evolutionary Forces
  1. Mutations
  2. Migrations
  3. Genetic Recombination
  4. Genetic Drift / Random Drift / Sewall Wright Effect

Role of Natural Selection

• What enables populations to adapt to environment? - Natural Selection

• Genetic variations are created by primary evolutionary forces

• Some of these variations influence reproductive success (number of offspring successfully raised)

• If, as a result of genetic variation, some individuals contribute more offspring to the next generation than the others, it is the role of natural selection

• Thus, natural selection is differential net reproductive success
Role of Natural Selection

- A result of natural selection is a change in allele frequency relative to specific environmental factors.

- Such a **functional shift in allele frequencies is called adaptation** (more on this in Genetic Polymorphism).

- **Unit of selection is individual:** It is individuals who reproduce or do not reproduce and who attempt to maximize their own reproductive success.

- **Extinction:** If the total reproductive success of all members of a population continuously falls below replacement value (where more individuals die than are born in a generation) the population will become extinct.

Evolution at Species Level

- A species is defined as a group of interbreeding organisms that are reproductively isolated and, therefore, cannot successfully interbreed with other groups (species).

- A species is composed of subunits that are breeding communities, which are populations.

- All members of a species can potentially interbreed, and some degree of interbreeding (migration) is theoretically possible between all populations of that species.
Evolution at Species Level

- The net result of all forces of evolution acting on all populations determines the fate of the species as a whole.
- If sustained over a long period of time, gradual changes in allele frequencies between member populations can eventually lead to sufficient genetic differences, so that fertile reproduction is no longer possible.
- We then may recognize a new form of life having arisen from one species “splitting” and producing new species, a process called speciation.

Isolation & Speciation

- A number of isolation mechanisms may also prevent organisms from interbreeding amongst each other
  - Geographic isolation
  - Behavioral / social isolation
  - Mechanical isolation
- Reproductive isolation is thus an important force that maintains biodiversity
- It also contributes to formation of new species by preventing interbreeding of two populations of the same species
- Speciation – Two types- Adaptive Radiation & Successive Speciation
Adaptive Radiation

• The progressive diversification of a species into two or more species as groups adapt to different environments.

• Natural selection is usually the principle mechanism driving adaptive radiation.

• First step is the separation of a species into distinct breeding populations, as a result of geographic or social isolation.

• Over time, the gene pools of the isolated populations diverge from each other by gradually acquiring different mutations and sometimes as a result of random genetic drift.

• When the populations are in dissimilar environments, environmental stresses are often not the same.

• As a result, nature selects for different traits existing within the gene pools of the now cut off populations.

Adaptive Radiation

• Over time, the populations genetically diverge enough so that they can no longer reproduce with each other.

• At this point, they have become separate species and usually continue to diverge in subsequent generations.

• In intermediate stages, the two newly or about to be separated species may be able to interbreed and produce children, but most of them are likely to be sterile Ex. female horses and male donkeys--i.e., mules.

• Eventually, however, species genetically diverge so much that they are unable to produce any offspring – sheep and cattle

• The process of adaptive radiation results in a branching evolutionary pattern known as cladogenesis
Adaptive Radiation

Adaptive radiation resulting in cladogenesis

Adaptive Radiation

Darwin's Finches

ADAPTIVE RADIATION

Leaves
Insects

Sweds

Buds / Fruit

Tool Using Finch
**Successive Speciation**

- The evolution of species by **successive speciation** occurs within a **single evolutionary line** without the branching of adaptive radiation.
- This takes place when the members of a species consist of a single breeding population for many generations.
- Descendant generations experience continuous spontaneous mutations and new directions of natural selection as the environment changes.
- This results in progressive changes in the gene pool frequencies of the population.

<table>
<thead>
<tr>
<th>Successive Speciation</th>
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<tbody>
<tr>
<td>At any one time, all members of the population are the same species.</td>
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<tr>
<td>However, as generations subsequently replace each other, the gene pool is transformed—i.e., it evolves.</td>
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<tr>
<td>Eventually, the changes are great enough that if descendants could go back in time to mate with their distant ancestors, the genetic differences would prevent them from producing fertile offspring—i.e. they would be different species</td>
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<tr>
<td>The process of successive speciation results in a non-branching evolutionary pattern known as <strong>anagenesis</strong>.</td>
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Modern Synthetic Theory - Summary

- Synthesis of Selectionist and Mutationist Models / Gradualism and Punctualism
- Evolution - Change in Allelic Frequencies in a Population
- Micro and Macro Evolution
- Evolution – 2 Stage – Variations and Selection
- Variation
  - Mutations
  - Recombinations
  - Migrations
  - Drift

Successive speciation resulting in anagenesis
### MST - Summary

- Natural Selection acts on variations – Differential Net Reproductive Success
- Isolation – Bio Diversity – Behavioral, Mechanical and Geographical
- Speciation (adaptive radiation and successive speciation) and extinction

### Basic Concepts in Evolutionary Biology

**Convergence**

- Similar evolutionary development in **unrelated organisms or those that differ in direct ancestry**
- Could be similar characteristics or adaptations
- **Ex.** Flying habits of humming bird and humming moth – common search for nectar in flowers – hovering over flower
- Convergence ordinarily applies to one or two characteristics and not the overall makeup of organisms
- Only rods in retina – deep sea fish, bats, some lizards, lemurs
### Basic Concepts in Evolutionary Biology

#### Parallelism
- If convergence is similar evolutionary behavior in organisms which are unrelated in ancestry…
- Parallelism is similar adaptations in organisms which **share common ancestry**
- The term is usually applied to two species of organisms that were similar in origin, and that remained similar as they evolved into two different species.
- Ex. Old World Monkeys & New World Monkeys – separated 35 million years ago from a prosimian ancestor

#### Homology & Analogy
- Organs which are similar in origin and not function are **homologous**
- **Ex. Forearms of vertebrates** – Forelimbs of vertebrates
- Organs which are similar in function and not origin are **analogous**
- **Ex. Wings of birds and wings of insects**
- **Serial Homology** – two structures within the same organism
- **Ex. Hands and Legs** in man
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<td><strong>Cope’s Rule</strong> – Lamarck’s First principle</td>
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<td><strong>Gause’s Principle</strong> – Principle of Competitive Exclusion – if two organisms occupy the same trophic level in the ecosystem, they try to reach equilibrium through different strategies reducing the other to point of extinction</td>
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<td><strong>Mosaic Evolution</strong> – Evolution of parts and not wholes – Hominization – Bipedalization followed by Encephalization</td>
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