ORGANIC EVOLUTION THEORIES

THEORIES OF EVOLUTION

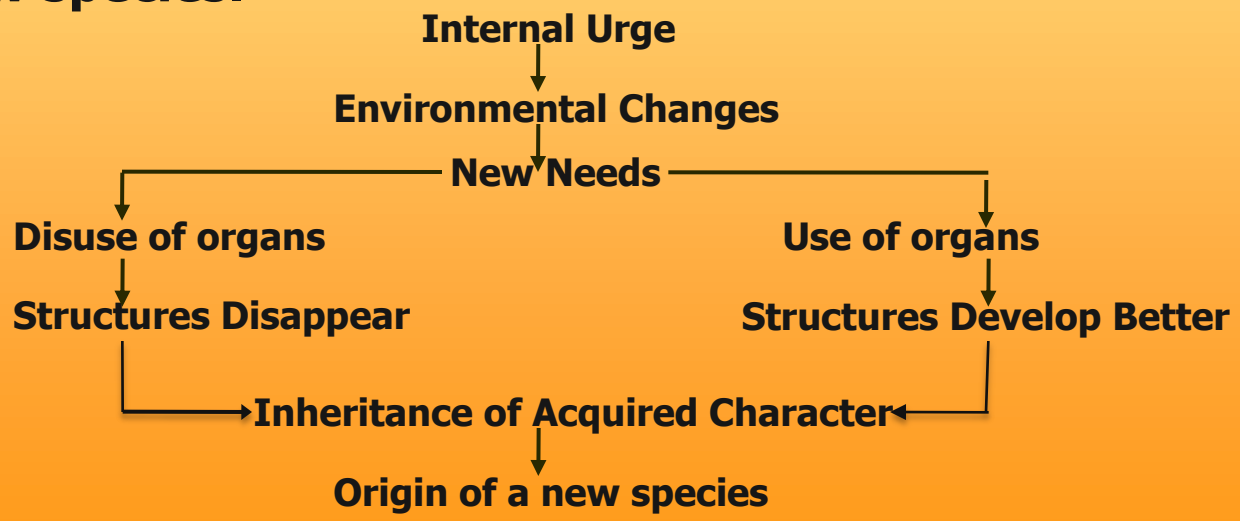
Lamarckism (Lamarck's Theory of Inheritance of Acquired Characters)

- Lamarckism, the first theory of evolution was proposed by jean Baptiste de Lamarck (1744-1829), a French biologist.
- His famous book 'Philosophic Zoologique' was published in 1809, in which, he discussed his theory in detail.
- Lamarck coined the term 'invertebrates' and 'Annelida'.
- The term 'Biology' was given by Lamarck and Treviranus (1802).

Factors of Lamarckism

- Lamarckism includes four main factors:
  - Internal vital force: All the living things and their component parts are increased continually due to internal vital force.
  - Effect of environment and new needs: A change in environment brings about changes in organisms. It gives rise to new needs. New needs or desires produce new structures and change habits of the organisms. Doctrine of desire is called Appetency.

- Use and disuse of organs: If an organ is constantly used, it would be better developed whereas, disuse of organ results in its degeneration.
- Inheritance of acquired characters: Whatever an individual acquires characters in its life time due to internal vital force, environment, new needs and use and disuse of organs they are inherited to next generations. The process continues. After several generations. The process continues. After several generations, the variations accumulated and give rise to new species.



- **Example in Support of Lamarckism**
- **Giraffe: The long necked and long forelimbed modern giraffe was developed due to stretching of neck and forelimbs for feeding on leaves of trees as the supply of grass and herbs was inadequate on ground.**
- **Snakes: To escape from the mammals of that time, snakes started living in narrow holes or crevices and in thick jungles. To accommodate in narrow holes, they could not use their limbs, that is why, limbs were reduced and finally disappeared.**
- **Aquatic birds: Aquatic birds like ducks have evolved from the terrestrial ancestors. Since they had to go to water due to lack of food, some structures like web between the toes developed. The wings were not used for flying so they got reduced.**
- **Flat fishes: They had streamlined body with lateral eyes in their early embryonic stage but later on, became flat with both the eyes on one side to withstand the pressure of water.**

- **Flightless birds: The ancestors of these birds (eg, ostrich) were capable of flying but due to some environmental factors, they had plenty of food and were well protected. They did not use their wings and became vestigial.**
- **Claws of carnivorous mammals: The ancestors of lions, tigers etc , had ordinary claws for tearing the flesh of their preys. Later on, they had to run fast for catching their preys and for this, claws were a hindrance. The animals therefore, developed retractile claws.**
- **Deer: Deer became fast runners on the advent of carnivorous mammals by development of long limbs and streamlined body.**
- **Cave dwellers: The ancestors had normal eye sight. On account of living under continuous dark conditions, the animals lost their power to see.**
- **Emergent hydrophytes: In hydrophytes like *Rannunculus aquatilis*, submerged leaves are dissected while, the emerged ones lobed. When the plant is grown out of water, all the leaves are undissected (lobed). In submerged condition, all the leaves become dissected.**

Criticism of Lamarckism

- Evidences against the inheritance of acquired characters:
  - There is no vital force in organisms, which increases their body parts.
  - The environment can affect the animals but it is doubtful that a need forms new structures.
  - The use and disuse of organs is correct upto some extent.
  - The inheritance of acquired characters is disputed.
- August Weismann (1834-1914), a German biologist was the main opposer of the inheritance of acquired characters. He put forward the theory of continuity of germplasm. According to him, germ cells are only inherited. He cut off the tails of rates for more than 20 generations and allowed them to breed, but tailless rats were never born.
- Boring of pinna (external ear) and nose of Indian women is never inherited to the next generations.

- The Wrestler's powerful muscles are not transmitted to his offspring.
- Chinese women used to wear iron shoes in order to have small feet but their children at the time of birth have always normal feet.
- European ladies wear tight waist garments in order to keep their waist slender but their offspring at the time of birth have normal waist.

- **Neo-Lamarckism**

- It is a modification of the original theory of Lamarck in order to make it more suitable to modern knowledge.
- Neo-Lamarckism does not give any importance to the four factors of Lamarckism.
- The theory stresses on the direct effect of changed environment on the organism.
- Normally only those modifications are transferred to the next generation , which influence germ cells or where somatic cells give rise to germ cells.

- **Evidences in Favour of the Inheritance of Acquired characters**

- **In certain cases, somatic cells can produce the germ cells, which is against Weismann's theory of continuity of germplasm.**
- **Harrison found the occurrence of a dark variety of moth in localities having manganese pollution. He indicated the effect of environment on germ cells through somatic cells.**
- **Tower exposed the young potato beetles to extreme temperature and humidity at the time of the development of their reproductive organs. His observation indicated direct effect of environment on germ cells.**
- **Exposure of organisms with energy radiations (UV-rays, X-rays, gamma rays etc) or feeding them with mutagenic chemicals produces sudden inheritable variations or mutation (example mutation in Drosophila with the help of mustard gas).**
- **Radish is a two year crop in cold countries but completes its growth in one year in tropical areas. Similarly deciduous European peach becomes evergreen in India.**

- Gugar and Smith took the solution of the eye lens of rabbit and inoculated the same into fowl. The fowl's serum containing antibodies was injected into pregnant rabbits. Some of the offsprings were found to have malformed or degenerated eyes.

• Darwinism (Darwin's Theory of Natural Selection)

- The most impressive study on evolution was made by Charles Darwin. His principal publication, 'The Origin of Species' by means of natural selection or the preservation of favoured races in the struggle for life appeared in 1859. Charles Darwin (1809-1882) was an English naturalist. In 1831, he got an opportunity to travel on H M S Beagle (a ship on which be sailed around the world) for a voyage of world exploration. Voyage lasted for five years. He observed numerous things during that period. He explored the fauna and flora of a numbered continents and islands.

- At Galapagos island, Darwin observed great variations among the organisms that lived on these islands. The common bird of Galapagos islands, the finches were markedly different from the finches of the main land. From this island only, he took an idea for his theory of natural selection.
- Darwin was influenced by two books "Principles of Geology" by Charles Lyell; 1832 and 'Essay on Population' by Thomas Malthus (1799), from this he obtained the suggestion which was to sense as the basis for his explanation of evolution. Darwin stated that struggle for existence goes on everywhere in nature. In such situation, favourable variation would be preserved and unfavourable we destroyed and the results would be the formation of new species.
- Alfred Russel Wallace (1823-1913), another English naturalist, also travelled widely and studied the fauna and flora of South America and South East Asia.

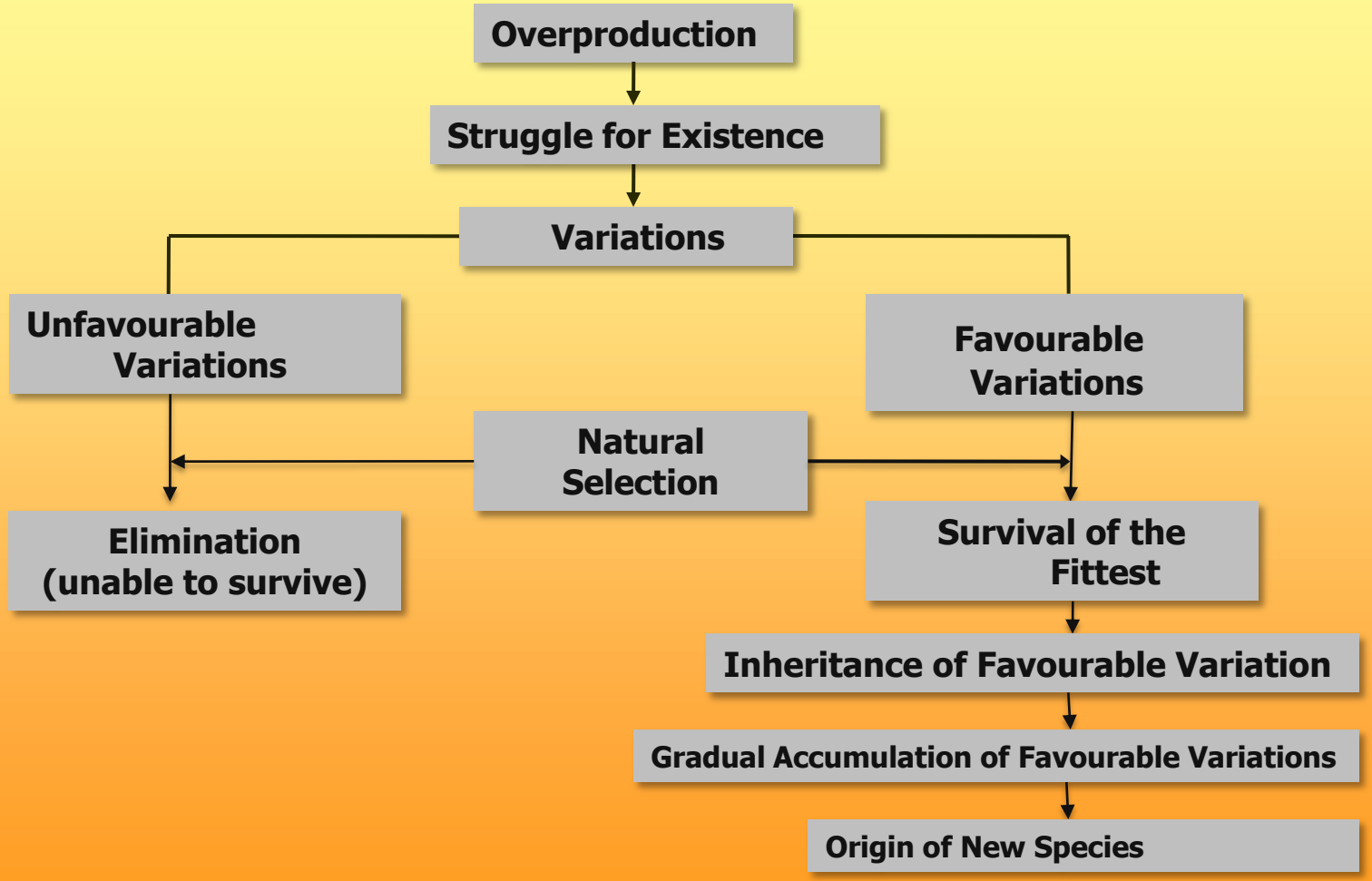
Wallace expressed similar evolutionary ideas in an essay entitled 'On the tendency of varieties to depart indefinite from the original type'. He sent his essay on Darwin. In 1859, Wallace's paper and summary of Darwin theory together appeared in the Journal of the proceedings of Linnaean society.

- In 1859, Darwin published his observations and conclusions under the name 'Origin of Species".

- **Factors of the Darwinism**
  - Over production (Rapid multiplication): All organisms possess enormous fertility. They multiply in geometric ratio (eg, insects lay hundreds of eggs, plants produce thousands of seeds, cod-fish lays several hundred eggs at time). Some organisms produce more offsprings and other produce fewer offsprings. This is called differential reproduction (eg, elephant is the slowest breeder, each female gives rise to about six offsprings).

- **Limited food and space: Despite of rapid multiplication, food and space and other resources remain limited.**
- **Struggle for existence: Struggle for existence can be of three types:**
  - **Intraspecific (Struggle between individuals of same species), e.g., cannibalism (eating the individuals of its own species).**
  - **Interspecific (struggle between members of different species for food and shelter, e.g., a fox hunts rabbit, while fox is preyed by a tiger).**
  - **Environmental struggle (struggle between organism and environmental factors such as drought, heavy rains, heat and cold, earthquakes, diseases etc).**
- **Variations: Except the identical twins, no two individuals are similar and their requirement is different. These differences are variations. According to Darwin, the variations are continuous and those which are helpful in the adaptations, would be passed on to the next generation, while others disappear.**

- **Natural selection or survival of the fittest: The organism with favourable variations would survive because they are fittest to face their surroundings, while unfits are destroyed.**
- **Originally, it was an idea of Herbert Spencer (1820-1903), who used the term "the Spencer (1820-1903), Who used the term "the survival of the fittest", while, Darwin named it as natural selection.**
- **Inheritance of useful variations: the organisms after getting fitted to the surrounding transmit their useful variations to the next generations, while the non-useful variations are eliminated.**
- **Formation of new species: According to Darwin, useful variations are transmitted to the offspring and appear more prominently in succeeding generations. After some generations, variations in the processor would be so distinct that they form a new species.**


Overproduction
Struggle for Existence
Variations
Unfavourable Variations
Favourable Variations
Natural Selection
Elimination (unable to survive)
Survival of the Fittest
Inheritance of Favourable Variation
Gradual Accumulation of Favourable Variations
Origin of New Species

- **Criticism of the Natural Selection Theory**

- **Inheritance of small variations: Small variations, which are not useful are also inherited (eg, small wings in birds).**
- **Over specialization of some organs: Some organs like tusks of elephants, antlers of deer have developed so much that instead of providing usefulness to processor, they give hindrance to them.**
- **Vestigial organs: Some vestigial organs are present in some animals, even when they have no function.**
- **Arrival of the fittest: The theory only explains survival of the fittest but is unable to explain the arrival of the fittest.**
- **Degeneration of organs: The theory does not account for the degeneration of certain organs in animals.**
- **Discontinuous variations: The theory fails to explain the cause of sudden changes in the body. The main drawback of Darwin's theory was lack of the knowledge of heredity.**

- **Evidences in favour of Natural Selection**
  - Rate of reproduction is many times higher than the rate of survival in all organism.
  - Limitation of resources: Food, space and other resources are limited.
  - Abundance of variations: No two individuals of a species are similar, not even the monozygotic twins.
  - Production of new varieties of plants and animals by artificial selection: Man can produce new varieties of plants and animals in a short period. Nature with its vast resources and long time can easily produce new species by selection.
  - Mimicry and protective colouration: They are found in certain animals and are the products of natural selection (e.g., stick insect, leaf insect etc).
  - Correlation between nectaries of flowers and proboscis of insects (Entomophily): Position of nectaries and length of proboscis in pollinating insects are wonderfully correlated.
  - Pedigrees of some animals: Pedigree of horses, camels and elephants support the natural selection theory.

- **Neo-Darwinism**
  - **Neo-Darwinism is a modification of the original theory of Darwin to remove its shortcoming. The theory explains that the number of organisms of different species remains the same despite their high biotic potential and ability to increase by geometrical ratio. It stresses on the role of struggle for existence and natural selection in face of limited resources.**
  - **It explains the role of variations, their origin and accumulation in the formation of new species.**
- **Mutation Theory**
  - **Hugo de Vries (1848 - 1935), a Dutch botanist, put forward his views regarding the formation of new species in 1901.**
  - **According to him, new species are not formed by continuous variation but by sudden appearance of variations, which he Named as mutation. He conducted an experiment on *Oenothera lamarckiana* (evening primrose) and found several aberrant types.**

He found four types of plants, i.e., progressive (had additional characters), retrogressive (loss of one or more characters), degressive (weak plants with limited survival capacity) and inconstant (similar to parents and gave rise to variants).

- The mutation theory states that evolution is a jerkey process, where new varieties and species are formed by mutation that function that function as raw material of evolution. Mutation theory explains both progressive and retrogressive evolution.
- A number of mutations have appeared in the past. Mutations are also induced. They have given rise to new varieties for example:
  - Ancon sheep is a short legged variety, which appeared suddenly in Massachusetts in 1791.
  - Hornless cattle developed as mutation from the horned cattle in 1889.
  - A single mutation can give rise to new variety of plants, eg, delicious apple, Cicer gigas, noval orange, red sunflower.
  - Hairless cats and double toed cats have developed through mutation.

- **Sources of variations**
  - **Mutations**

- **Mutations are sudden inheritable discontinuous variations, which appear in the organism due to permanent quantitative and qualitative change in their genetic material.**
- **The mutation, which occurs in germ cell and can be transferred to progeny are called germinal mutation. The mutations that develop in the vegetative or somatic cell of organism are known as somatic mutations.**
- **Mutations occurring in the genes located on sex chromosome are called sex linked mutations and mutations found in the genes other than sex chromosome are called autosomal mutations.**
- **Mutations occuring in the genes located on sex chromosome are called sex linked mutations and mutations found in the genes other than sex chromosome are called autosomal mutations.**
- **Deleterious mutations are harmful mutation, which result in loss of structure or functioning of traits.**

- Advantageous mutations are useful to the organism, in which, they occur.
- Dominant mutations are able to immediately produce their phenotypic effect since they are able to suppress the normal or wild type of genes.
- Invisible mutations are those, which do not produce any effect on the phenotype even when they occur in homozygous state.
- Macro mutations are large mutations, which show a marked phenotypic effect (eg, ancon sheep).
- Micro mutations are small mutations, which show only a minor phenotypic effect.
- Mutation of a wild type of gene into a new type of gene is forward mutation and conversion of mutated gene into original type through second mutation is reverse mutation.
- A change in single nucleotide may not change the amino acid specificity of the new codon, eg, AGA, AGG, AGC, or AGT is called same sense or silent mutation.

- When a change in nucleotide changes only one codon that produces a new amino acid but at a specific site in polypeptide is called mis-sense mutation.
- Non-sense mutations bring about chain terminator earlier so that short polypeptides are produced.
- A mutation that eliminates gene function because of deletion is called null mutation.
- Very few mutations are useful. Most of them are neutral or harmful as well as recessive. These mutations are also the source of preadaptations that are basic to natural selections.
- The mutations, which appear without exposure to environment, in which, they would be advantageous to organism is pre-adaptive mutation. Pre-adaptive mutations express themselves only in new environment.

- **Recombination**

- **Gene recombination is also important source of variations. It occurs during crossing over of chromosomes, independent assortment of chromosome, during meiosis and random coming together of maternal and paternal chromosome at fertilization. These events recombine characters and cause variation.**
- **Genetic drift is the elimination of genes of certain characters when a section of population migrates or dies because of natural calamity. It changes the gene frequency of the population, which causes variations.**
- **Movement of individuals from one place to another is called migration. Migration may be climatic or reproductive. Sometimes two populations of a species, which were separated, come to close due to migration. The genes of two populations intermingle through breeding and result causes variations in the offspring.**

Modern Synthetic Theory

- The modern theory of origin of species or evolution is known as Modern Synthetic theory of Evolution. It is the combination of Darwinian selection and genetic theory. This concept evolved after a book by Julian Huxley (1942) entitled 'Evolution –The Modern Synthesis'. Theodosius Dobzhansky reviewed the Darwinian concept of evolution by Natural Selection in Mendelian populations.
- The modern synthetic theory of evolution was born in 1937 with the publication of Dobzhansky "Genetics and the Origin of Species", which was supported by Huxley (1942), Mayr (1942), Simpson (1942, 1953) and Stebbins (1950).
- The fundamentals of modern synthesis theory arrived at largely independently by Chetverikov, Fischer, Haldane and Wright between 1926 and 1932.
- E B Bobcock provided botanical support to the Neo-Darwinian theory by studying plant genus *Crepis*.
- Stebbins (1950) provided an account of variations, heredity, isolation and natural selection.

- **Main Postulates of Modern Synthetic**
  - **Theory of Evolution**
    - **This theory recognizes four basic types of processes:**
    - **Gene mutations**
    - **Changes in chromosome structure and number**
    - **Genetic recombination**
    - **Natural selection**
- **Besides these, three accessory processes affect the working of above four basic processes-**
    - **Migration**
    - **Hybridization**
    - **Chance**
- **Gene mutations, change in chromosome structure and number and genetic recombination provide the genetic variability without which change can not take place and natural selection guides populations of organisms for adaptation.**
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- Migration of individuals from one population to another, hybridization between races or closely related species both increase the genetic variability.
- The effect of chance, acting on small population may alter the way, in which, natural selection guides the course of evolution.
- Mutation, genetic recombination and natural selection are equally important.
- All sexually reproducing organisms contain a large gene pool of genetic variability, which maintains a dynamic equilibrium between in flow and out flow of genes.
- Genes may be added to gene pool by immigration from other gene pool and mutation.
- Genes are removed from gene pool by natural selection and chance elimination of alleles, which take place in small population or during reduction of population size.
- Genetic recombination following the principles of Mendelian heredity is constantly reshuffling the gene in the gene pool.

- Natural selection which results from interaction between populations and their environment, may either stabilize gene composition by eliminating most immigrants and mutants or change it in various ways.
- Evolution takes place through alterations of the frequency of genes and gene combinations in the population. Brought about by natural selection.
- Reproductive isolation. Which includes all the barriers to gene exchange between populations has a canalizing effect.
- 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.

- **Hardy-Weinberg Law**
- **Hardy-Weinberg law proposed by G H Hardy, an English mathematician and G Weinberg, German physician in 1908.**
- **The Hardy-Weinberg law states that the gene ad genotypic frequencies in a Mendelian population remain constant generation after generation if there is no selection, mutation, migration or random drift.**
- **Hardy-Weinberg used the binomial expression $p^2 + 2pq + q^2$ to calculate the genotypic and allele frequencies of a population. The original proportions of the genotype in a population will remain constant from generation to generation as long as -**
  - **The population size is very large**
  - **Random mating is occurring**
  - **No mutation takes place**
  - **No genes are input from other sources (i.e. no immigration)**
  - **No selection occurs**

- **Genetic Drift**
  - **Genetic drift or Sewall-Wright effect or Random drift refers to the random changes in the allele frequency that occur in all populations but are much more pronounced in smaller populations.**
  - **Random drift is a random change in gene frequency due to sampling error.**
  - **Random drift occurs in small population because sampling error is greater in a smaller population than in larger population.**
  - **By random drift, the frequency of one of the allele becomes zero and that of other allele become one. The allele with the frequency of one is said to be fixed in population.**
  - **Genetic drift tend to reduce genetic variability within a small population and increase genetic variability between populations.**
  - **Bottleneck effect and Founder effect are two special cases of genetic drift.**

- **Sometimes, a small number of individuals from a large population may migrate away or become isolated from their original population. If this colonizing or founder population consists of only a few individuals, it will probably have a non-representative sample of alleles from the parent populations gene pool. This phenomena is called Founder effect.**
- **Populations may sometime be reduced to low numbers by predation, diseases, adverse periods of climatic earthquakes, floods etc. The few surviving individuals may constitute a random genetic sample of the original population. The resultant alterations and loss of genetic variability is known as bottleneck effect.**

- **Heterozygote advantage**
  - **Heterozygote advantage is a phenomenon, when heterozygote's are favored over homozygote's by natural selection. Instead of tending to remove less successful alleles from a population, heterozygote advantage will favour individuals with copies of both alleles and thus, work to maintain both alleles in the population.**
  - **Two important examples of heterozygote advantage are sickle cell anaemia and malaria.**
- **Industrial Melanism**
  - **Industrial melanism is the evolutionary process, in which, darker individuals come to predominate over lighter individuals since the industrial revolution as a result of natural selection.**
  - **Until 1848 in UK, every individual of peppered moth had light coloured wings (*Biston betularia typica*), which was well camouflaged as its colouration merges with that of the lichens growing on the tree trunks.**

As a result of Industrial revolution in UK, SO_2 pollution from the burning of coal killed off the lichens (lichens are very sensitive to So_2 pollution and used as bioindicators of air pollution) and tree barks become darkened by shot deposits. Consequently in 1848, a black form of the moth (Biston betularia carbonaria) recorded in Manchester and by 1895 about 98% of the peppered moth population in Manchester was black. This black 'melanic' form arose by a recurring random mutation but its phenotypic appearance had a strong selective advantage in industrial areas.

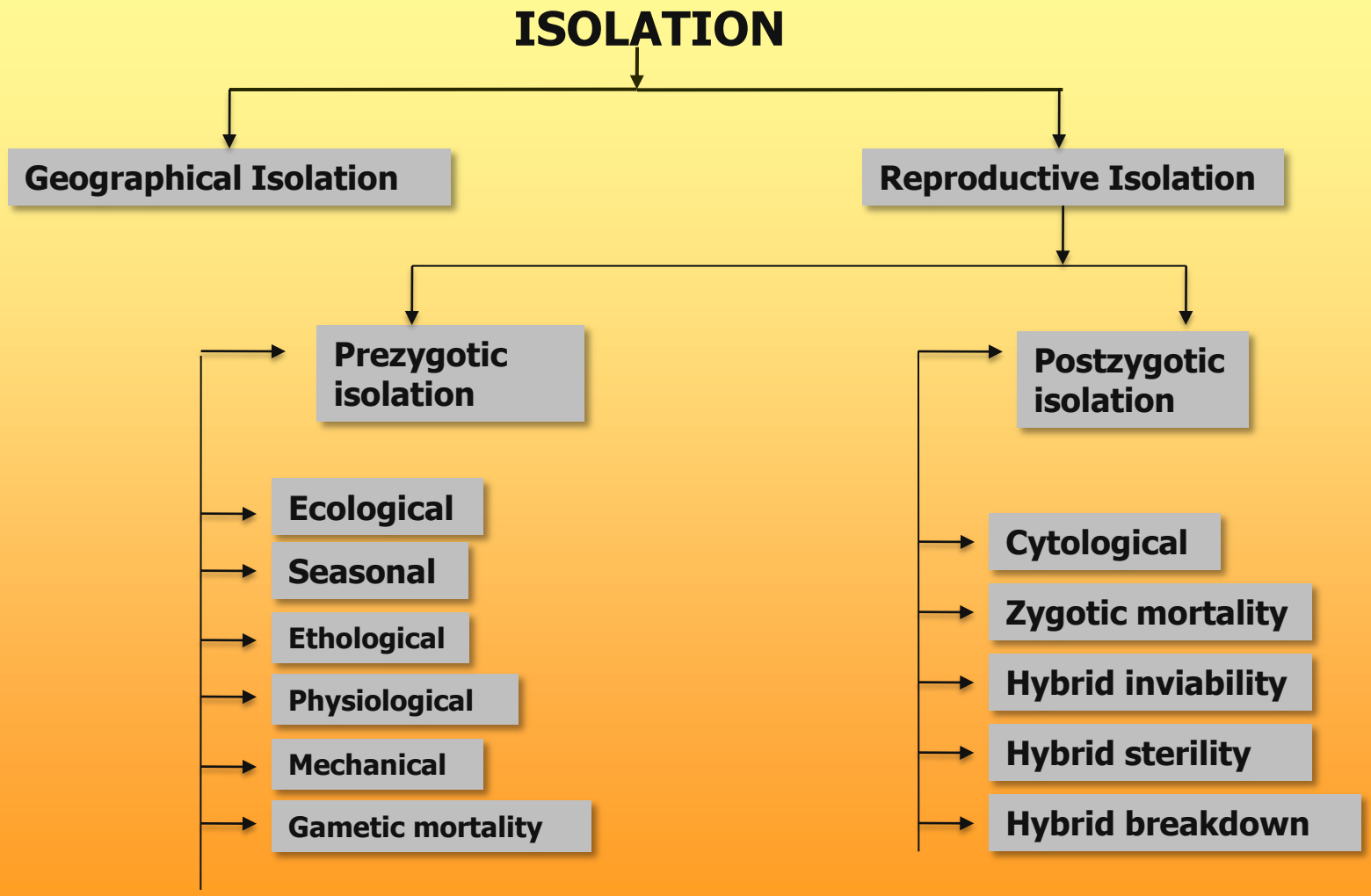
- Hypothesis of industrial melanism was proposed by J W Tutt. This hypothesis was tested by Bernard Kettlewell.
- Since the enactment of clean air lesislation in 1956, in UK, the proportion of non-melanic forms has increased too much higher levels again as the selection pressure on these forms has been reduced in industrial areas.

- **Speciation**

- A species is a group of similar organisms, which can breed among themselves, producing fertile off springs. The members of a species not only share a common gene pool, but also share a common ancestry.
- Origin of a new species from the existing one is called speciation. It is an important aspect of evolutionary process.
- Members of a species generally do not live together as a single large population. Instead they form small inbreeding groups called demes. The demes may occupy adjacent areas or may be distributed in far-off regions. The widely separated demes generally come across varied environmental conditions.
- The term species was coined by John Ray (1693). Ernst Mayr, an ornithologist of Harvard University, proposed the biological species concept, which defines species as "groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups'.

- **Isolation**

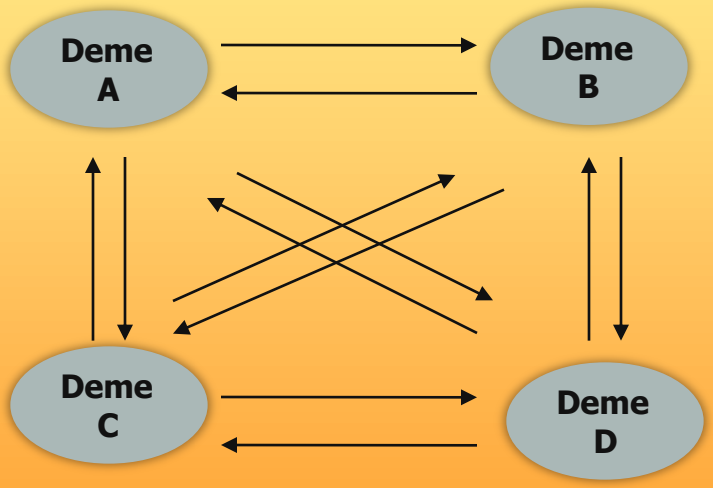
- **Isolation is the prevention of mating amongst inter-breeding groups as a result of physical barriers (ie, ecological, geographical etc) and biotic barriers (ie, physiological, behavioural, mechanical, genetical etc).**
- **The separation of groups of related organisms by geographical barrier like mountains, valleys, glaciers, dense forests, water bodies etc, is called geographical isolation.**
- **The prevention of inbreeding between the populations of two different species is known as reproductive isolation. It leads to the origin of new species. Reproductive isolation may be pre-mating (pre-zygotic) or post mating (post-zygotic).**



ISOLATING MECHANISMS

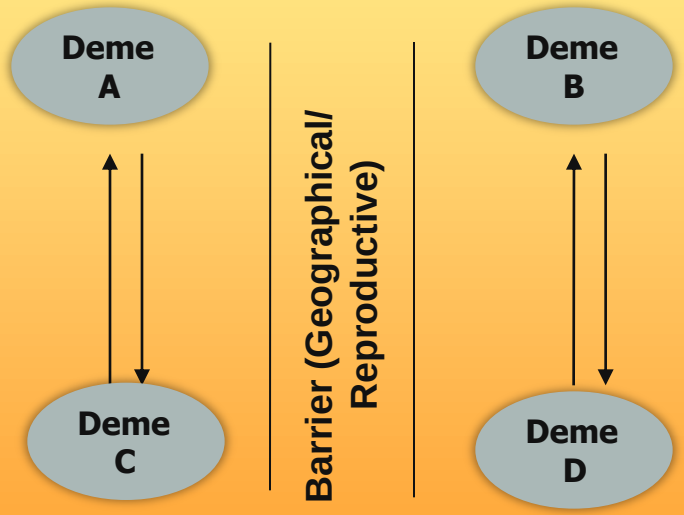
- **Premating or Prezygotic Isolation**
- These come into play in the early stages of the reproductive process itself and prevents the formation of a fertilized egg (zygote). They can be as follows:
  - **Ecological or habitat isolation**
    - The differences found in the habitats occupied by the two populations of the same species, may prevent interbreeding between them. Habitat isolation may not give any opportunity to meet and mate to the isolated populations.
  - **Seasonal isolation**
    - It the isolation brought about due to the differences in the breeding season of the population.
  - **Ethological or behavioural isolation**
    - In some species, differences in the sexual behaviour may prevent inter breeding between the populations.
  - **Mechanical or morphological isolation**
    - It is the isolation brought about by the morphological differences, particularly with reference to reproductive organs (external genital organs).

- **Physiological isolation**
  - ➢ **The physiological differences between individuals may also sometimes bring about isolation.**
- **Gametic mortality isolation**
  - ➢ **In some cases of inter specific mating, the gametes get destroyed in the genital tract due to antigenic reactions.**



No Barrier

There is a free flow of genes between all the demes in a population



A Permanent Barrier

It splits the demes into interbreeding groups, which gradually accumulate genetic variations to become a new species (Gene flow is interrupted)

Speciation by isolation

- **Postmating or Postzygotic Isolation**
- **These are isolating mechanisms that operate after mating occurs in the individuals. Following are some of them:**
  - **Cytological isolation**
    - **It is the situation where after mating, fertilization fails to occur due to differences in the chromosomal number.**
  - **Zygote mortality isolation**
    - **In some cases, even if successful fertilization occurs following an interspecific mating, the zygote may not survive. It may die at any stage of development.**
  - **Hybrid inviability isolation**
    - **Here the hybrid organism resulting from an interspecific breeding fails to survive.**
  - **Hybrid sterility isolation**
    - **Sometime viable hybrids may be formed but may become sterile, failing to produce young ones, example, Mule.**
  - **Hybrid breakdown isolation**
    - **It refers to the inviability or adaptive inferiority of the hybrids in several filial generation or hybrids in back cross.**

- **Drosophila kept in dark for numerous generations still had normal eyes. This observation disapproves Lamarckian Theory of evolution, points to lacunae in Darwinism and is an evidence of germplasm theory.**
- **During embryonic development in mammals heart is first 2-chambered as in fishes, then 3-chambered as in Amphibians and finally becomes 4-chambered. This fact is related with Hardy-Weinberg Law.**
- **Industrial melanism as observed in peppered moth proves that the true black melanic forms arise by a recurring random mutation.**
- **Fitness is the end result of the ability to adapt and gets selected by nature.**
- **Connecting link between Ape and Man is *Australopithecus* .**
- **The modern man differs from the Apes in arms shorter than legs.**
- **The finches of Galapagos islands provide an evidence in favour of biogeographical evolution.**

- **The theory of use and disuse of organs was given by Lamarck.**
- **Lamarck's theory of evolution is called inheritance of acquired characters.**
- **Mutation theory explaining organic evolution was proposed by Hugo de Vries.**
- **Hugo de Vries gave his mutation theory on organic evolution while working on *Oenothera lamarckiana*.**
- **The concept of inheritance of acquired characters was developed by Jean Baptists de Lamarck.**
- **Darwin's finches provide an excellent evidence in favour of organic evolution. These are related biogeography.**
- **Recapitulation Theory was proposed by Haeckel.**
- **Haeckel's Theory of recapitulation means that ontogeny repeats phylogeny.**
- **The phenomenon of 'Industrial melanism' demonstrates natural selection.**

- **In the developmental history of mammalian heart , it is observed that it passes through a two-chambered fish-like heart ,three chambered frog-like heart and finally four-chambered stage. It is approximated by the Biogenetic Law.**
- **Theory of continuity of germplasm was propounded by August Weismann.**
- **The idea of 'Survival of the Fittest' was originally presented by Spencer.**
- **The change of the lighter coloured variety of peppered moth, *Biston betularia* to its darker variety *Biston carbonaria* is due to mutation of single Mendelism gene for survival in smoke laden industrial environment.**
- **The concept that population tends to increase geometrically while food supply increases arithmetically was put forward by T R Malthus.**
- **Prevalence of pesticide resistant insects supports Darwin's concept of natural selection in organic evolution.**

- Overproduction ,constancy of population size, variations and natural selection is the sequence proposed by Darwin and Wallace for organic evolution.
- "Every cell of the body contributes gemmules to the germ cells and so shares in the transmission of inherited characters." This theory is known as 'Theory of Pangenesis'.
- "Survival of the fittest" was given by Herbert Spencer.
- Lake Malawi in the African Rift Valley is home to over a hundred species of cichlid fishes each with a slightly different diet and habits. All these fishes probably evolved from one ancestor are example of adaptive radiation.
- 'Pangenesis Hypothesis' was propounded by Darwin.
- Pangaea was a land mass that broke up to form the present-day continents.
- "Variations will occur in definite lines guided by some undefined or inherent mystical force and these variations will bring evolution". This theory was given by Ernest Haeckel.

- Organisms struggle for their existence and the fittest survive. This idea for organic evolution is the fundamental proposition of theory of natural selection.
- Darwin proposed the concept of intraspecific and interspecific struggle of living organism.
- According to Oparin oxygen was not present in the primitive atmosphere of the earth.
- George Cuvier realized that the history of life is recorded in fossils and believed that the replacement of one species by another is caused by extinctions due to catastrophe such as floods.
- A scientist reared 72 generations of Drosophila in darkness. Even after that the flies had normal vision. This observation disapproved the law of inheritance of acquired characters.
- Darwin's finches show a variety of beaks suited for eating large seeds, flying insects and cactus seeds.

Thanks…