SELECTION AND SPECIATION.

Selection is the process by which those organisms which are physically, physiologically and behaviourally better adapted are favoured to survive and reproduce and pass their genes to the next generations while those organisms not so well adapted either fail to reproduce or die and fail to pass their genes to the next generations.

Environmental factors that determine survival of organisms and keep populations in check are called **selection pressures**. Selection pressures act upon variations within a population and they include,

- Diseases/parasite out break.
- Competition for resources such as food, habitats, mates, etc.
- Predation.
- Lack of light, water or oxygen.
- Changes in environmental temperature.
- 0ver population/over crowding.

TYPES OF SELECTION.

These include the following,

(i) Natural selection.
(ii) Sexual selection.
(iii) Kin and group selection.
(iv) Artificial selection.

NATURAL SELECTION.

Is the process where organisms possessing variations which best adapt them to their environment survive and interbreed to pass their genes to the next generation and therefore selected for by the environment. Where as those organisms possessing variations which are less adapted are not favoured by the environment and they die and never pass their genes to the next generation.

Those organisms best suited to the environmental conditions with characteristics that give them an advantage in the struggle for existence will have the best chance of surviving and producing offsprings, giving them the selective advantage while those with unfavourable characteristics are more likely to die, giving them a selective disadvantage.

There are three different ways in which natural selection acts on the phenotypes in a population. These are,

- Directional selection.
- Disruptive selection.
- Stabilising selection.

TYPES OF NATURAL SELECTION.

DIRECTIONAL SELECTION.

This occurs in response to gradual changes in environmental conditions. When environmental conditions change, there is a selection pressure on species causing it to adapt to the new conditions. Species of organisms which better adapt to the new environmental conditions are favoured by the environment and said to be selected for.

It favours one extreme of the phenotype range and results in a shift of the mean either to the right or to the left. Directional selection brings about evolutionary change by producing a selection pressure which favours the increase in frequency of the new alleles within the population while the frequency of the alleles for less adapted characteristics are eliminated. The long neck of the giraffe is thought to have developed this way. Probably when food was in short supply, only the tallest individuals could reach to obtain enough food to survive. They passed on their genes to the next generations.

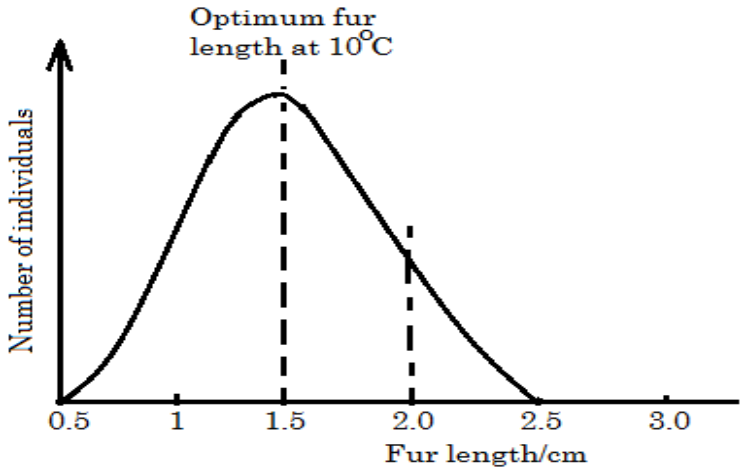
It is also the basis of artificial selection. Where the selective breeding of phenotypes showing desirable traits to humans, will increase those phenotypes within a population.

Other examples include, Drug resistance(resistance to anti-biotics) and industrial melanism.

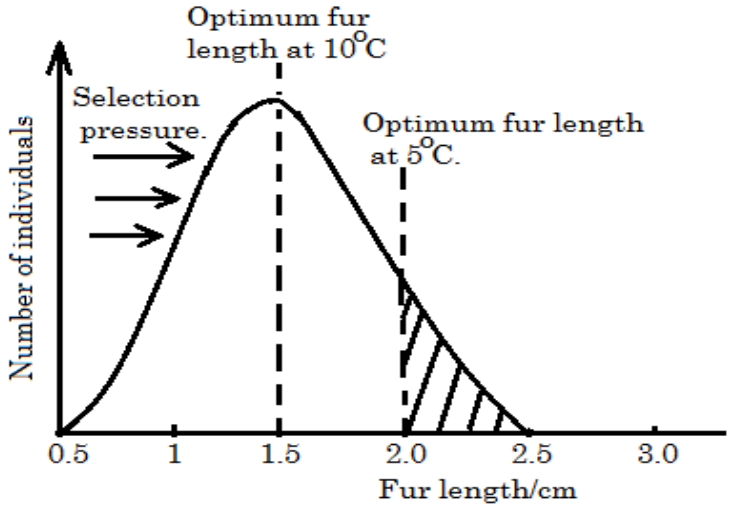
In a population of a particular mammal, fur length shows continous variation, at environmental temperature of $10^{o}C$ the mean fur length is 1.5cm while at $5^{o}C$ the mean fur length is 2cm. The continous variation among individuals form a normal distribution curve, the mean represents the optimum for the existing conditions. When this conditions change, this optimum also changes. At first a few individuals will posses the new optimum and by continous selection, it will in turn predominate. The mean for this character would have shifted.

EXAMPLES.

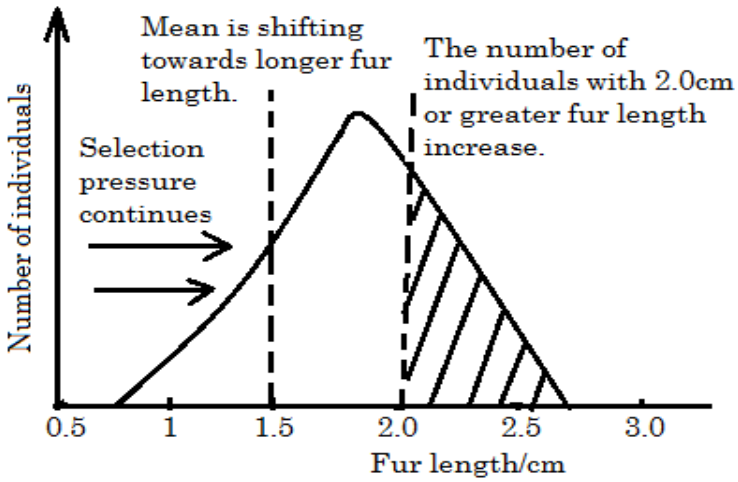
(a) At environmental temperature of 10°C, the optimum fur length is 1.5cm, it represents the mean fur length of the population.



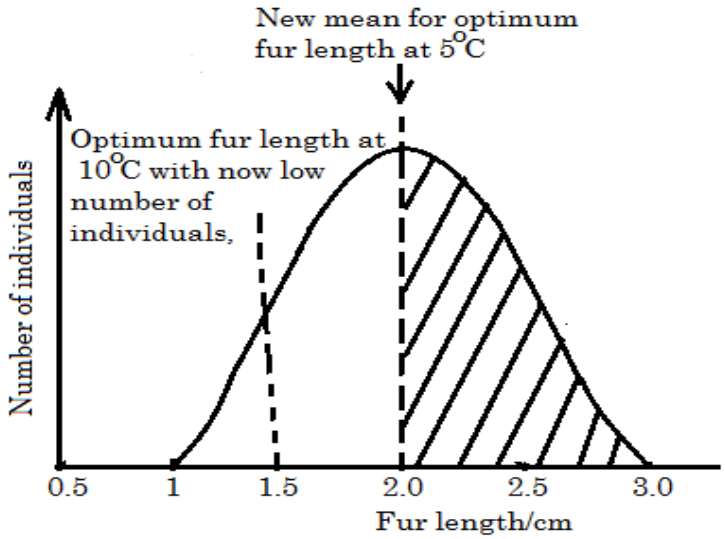
(b) Environmental temperatures gradually changes from 10°C to 5°C. There are a few individuals in this population with a fur length of 2.0cm or greater, this fall in environmental temperatures to 5°C provides a selection pressure that favours those individuals with 2.0cm fur length. These are the better insulated and more likely to survive to breed.



(b) The selection pressure causes a shift in the mean fur length towards longer fur length over a number of generations as the selection pressure continues.



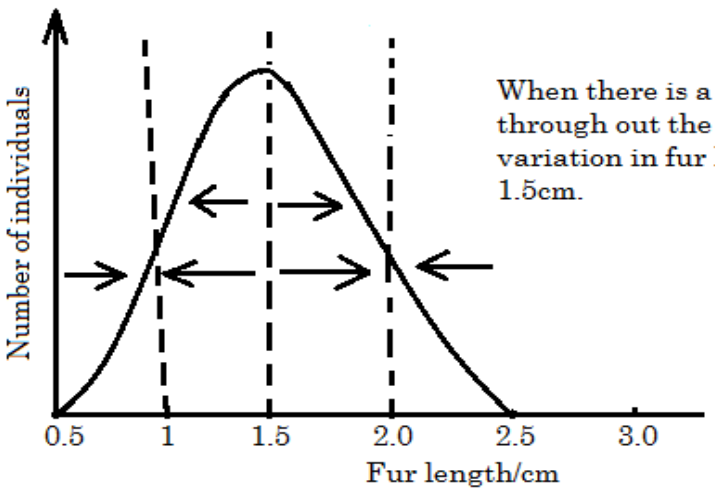
(d) Over many generations, the shift in the mean fur length continues until it reaches 2.0cm, which is the optimum fur length for the prevailing average environmental temperature of 5°C, then the selection pressure ceazes to act on the phenotypes.



DISRUPTIVE SELECTION.

(a) Occurs when an environmental factor takes a number of distinct forms, For example suppose the environmental temperature alternates between 5°C in winter and 15°C in the summer, with no intermediate temperatures occurring. These conditions would favour the development of two distinct phenotypes within the population, One with a fur length of 2.0cm(the optimum for an environmental temperature of 5°C, the other with a fur length of 1.0cm (0ptimum length at 15°C)

(a)



When there is a wide range of temperatures through out the year, there is continous variation in fur length around a mean of 1.5cm.

(b) Where the summer temperature is static around 15°C, and winter temperature is static around 5°C, individuals with two fur lengths predominate, 1.0cm types which are active in summer and 2.0cm types which are active in winter. Such fluctuating conditions within an environment associated with seasons and climate, favour presence of of more than one phenotypes within a population. The selection pressure acting from within the population as a result of increased competition pushes the phenotypes away from the population mean towards the extremes of the population.

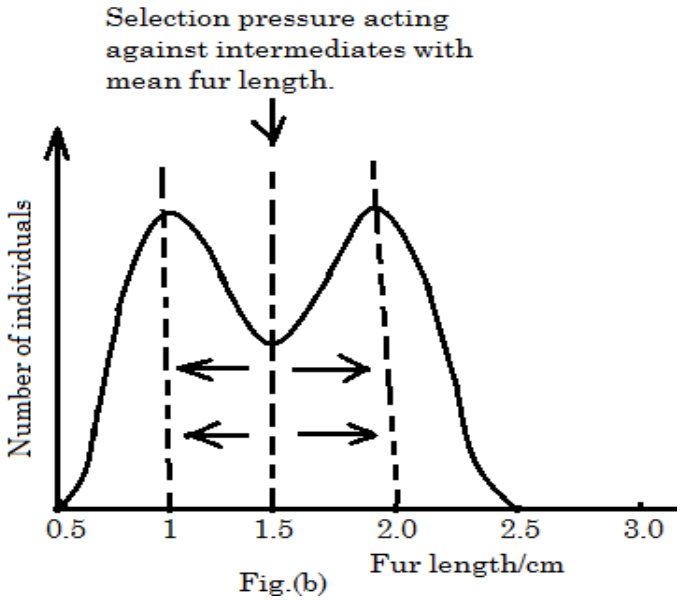


Fig.(b)

(c) For generations, the selection pressures continue to act against the intermediate phenotypes and favour those at the extremes. The population as a result of increased competition pushes the phenotypes away from the population mean towards the extremes of the population. This split a single population into two sub-populations, if gene flow between the sub-populations is prevented due to isolation and the two groups become unable to interbreed after generations, then each population may give

rise to distinct new species. Therefore, disruptive selection much as it is rare, it brings about evolutionary change.

The splitting of a single population into sub-populations that lead to a bimodal distribution (Distribution with two peaks or modes) and two overlapping groups of phenotypes as shown in figure (c) below.

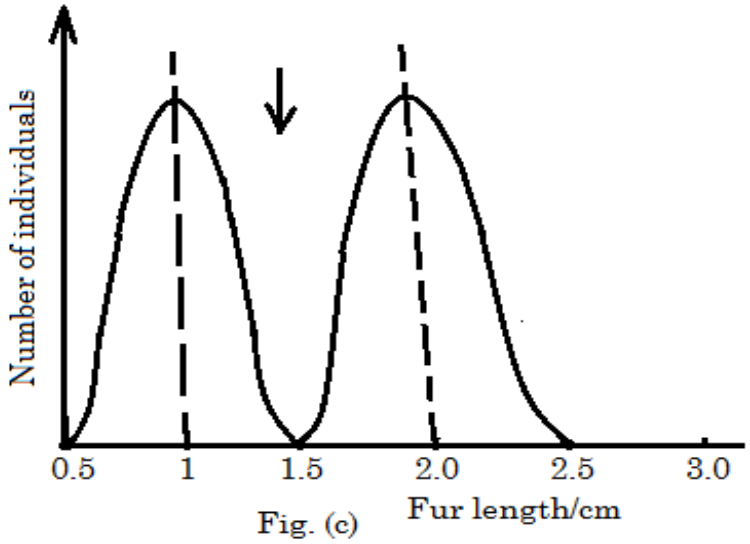


Fig. (c)

Disruptive selection may have contributed to the evolution of Darwin·s finches, because there was competition among the birds inhabiting different islands. In the different islands, finches with short strong beaks had exclusive use of nuts as food source, while those with long slender beakers had almost exclusive use of insects. Those finches with average , unspecialized beaks were out competed by these other two and reproduce less successfully and eventually selected against and wiped out of the islands. This resulted into distinct new species evolving indepently in separate islands.

Disruptive selection may have also contributed to the evolution of Garden snails due to the transient polymorphism.

STABILISING SELECTION.

It occurs when environmental conditions remain unchanging at optimum and remain uniform for prolonged generations. The extremes within the population will be gradually eliminated while the intermediate phenotypes about the mean are favoured and selected for and predominates. It occurs in all populations, reducing variations in a population and hence causes no chances for evolutionary change. But tend to maintain phenotypic stability.

It operates when phenotypic features concide with optimal environmental conditions and competition within the population is not severe.

Stabilising selection occurs in the natural selection of birth mass in humans.There is optimum birth weight of about 3.6kg, Babies heavier or lighter than this optimum weight at birth have a selective disadvantage and a slightly increased rate of mortality.

EXAMPLE.

At 10°C there was an optimum fur length of 1.5cm. Under normal climatic conditions, environmental temperatures will vary below and above 10°C in the course of the year and consequently there will exist within the population, individuals with fur ranging in lengths from 0.5cm to 2.5cm as shown in figure (a) below.

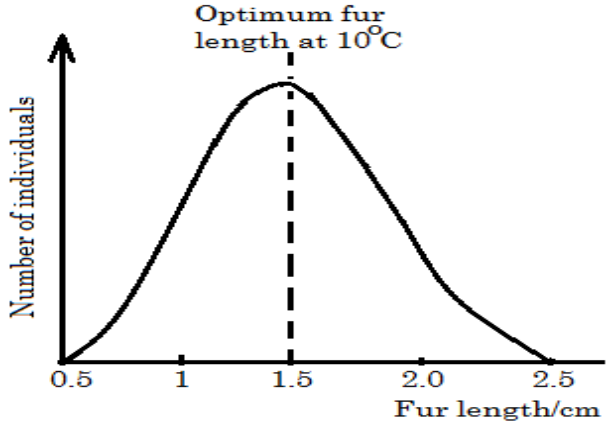
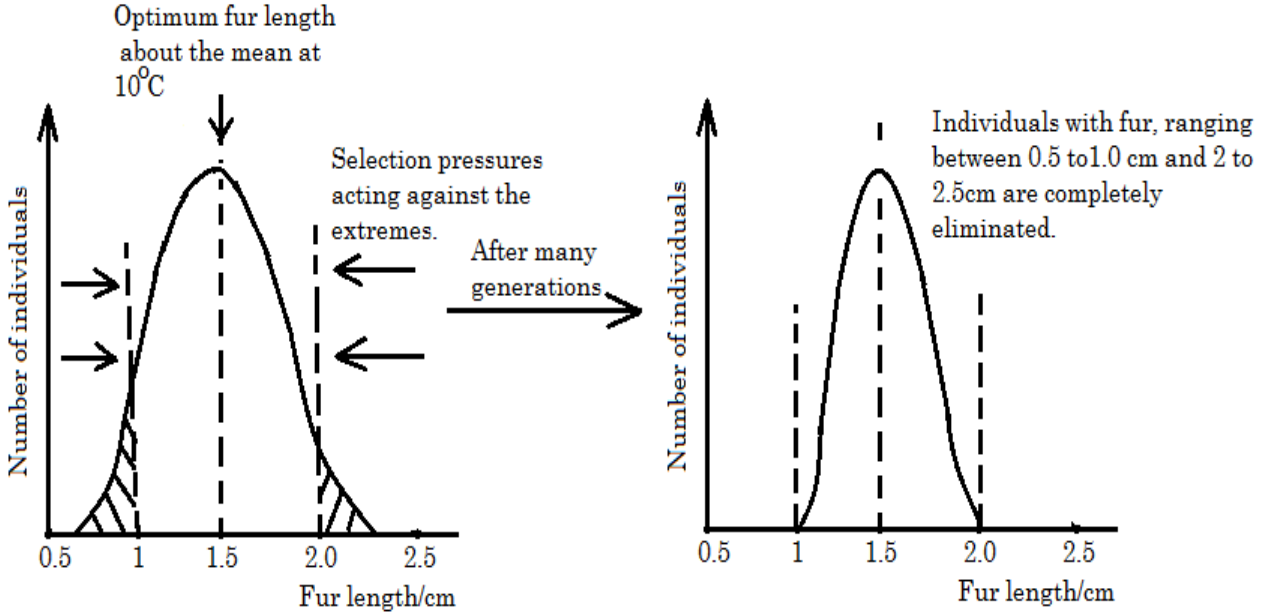


Fig. (a)

When the average environmental temperature is consistently around 10°C with little annual variations, selection pressures will act against the extremes while favouring the intermediates about the mean. In many generations, individuals with very long or very short hair are eliminated from the population over a number of generations and individuals with mean fur length predominates. This is shown in the figures below.



NATURAL SELECTION IN ACTION/EVIDENCES FOR NATURAL SELECTION.

This is a concept which provides evidences that evolution by natural selection is still taking place to the present time and this include the following.

- Polymorphism in the Garden snail.
- Polymorphism in the peppered moth/industrial melanism.
- Drug and pesticide resistance.
- Heavy metal tolerance in plants.

POLYMORPHISM.

Is the existence of organisms of the same species in two or more genetically different forms(morphs) in a population at the same time.

There are two types of polymorphism,

- Transient (unstable) polymorphism.
- Balanced (stable) polymorphism.

TRANSIENT (UNSTABLE) POLYMORPHISM

Is the existence of organisms of the same species in two or more genetically different forms(morphs) in a population at the same time with one form better adapted and increase in numbers and gradually replacing the other form due to strong selection pressures favouring only them until when they become dominant. Example include, polymorphism in the land snails and peppered moths (industrial melanism) are both exhibiting unstable type of polymorphism.

STABLE (BALANCED) POLYMORPHISM.

Is the existence of organisms of the same species in two or more genetically different forms(morphs) in a population at the same time where the genetically two discontinous forms of the same species occur in fairly constant proportion within a given population where each of the members are freely interbreeding and are equally favoured by natural selection and so the two morphs co-exist within the same population. For instance, male and female sex living in the same environment, A, B. and O blood group, Red-green colour blindness, drones and queens in social insects.

POLYMORPHISM IN THE LAND SNAILS.

It is used to demonstrate evidences for natural selection. In the garden snail (Cepacea nemoralis) there are three forms of land snails with distinct colours of the shell, which include yellow, pink, and brown, the shells may also be banded. The colour of the shell and its banding are genetically determined. It is observed that in less uniform background the banded shells are better adapted (have a selective advantage), they camouflage, less conspicuous and makes the snails not easily spotted by the predatory birds. In this case the land snails survive, interbreed to pass their genes to the next generation and therefore favoured and selected for by the environment. Where as the land snails with the unbanded shells are less adapted (have a selective disadvantage) they can camouflage well, become conspicuous and easily spotted by

the predatory birds and more frequently predated upon (suffer greatly selective predation). They never pass their genes to the next generation and their numbers continue to drastically decline and are eventually wiped out of the population and therefore selected against by the environment.
In the same way, where the habitat is light in colour, yellow shelled nails are selected for by the environment, while the brown shelled snails are selected against.

POLYMORPHISM IN THE PEPPERED MOTH (BISTON BETULARIA)/INDUSTRIAL MELANISM.

Industrial melanism is defined as the evolutionary process that resulted into increase in frequency of melanic type of the peppered moth more than that of the light type of the peppered moth in a population due to atmospheric pollution following the industrial revolution in England.
In England two types of peppered moth existed, the original light peppered moth and the mutant dark type of peppered moth called the melanic form. The dark and light colours in the peppered moths were genetically determined.

During the industrial revolution, the many industries produced lots of smoke and polluted the environment. The sulphur dioxide in the smoke killed the lichens on the walls of a tree. Therefore the walls of the building and barks of the trees were blackened. In this cases the melanic type of the peppered moth was better adapted, had a selective advantage over the light type of the peppered moth, the melanic form camouflaged against the black background, they are not easily spotted and not predated upon by the predatory birds, they survived selective predation, they reproduced and passed their genes to the next generation, therefore they are favoured and selected for by the environment. While the light type peppered moth were conspicuous and could not camouflage against the black background, so less adapted, they were conspicuous, easily spotted by the predatory birds. So they were frequently predated upon, they never continue to pass their genes to the next generation, there numbers drastically declined until completely wiped out of the population, and so not favoured and selected against by the environment.

Before industrial revolution or in non-industrial areas like areas so many distances away from the industrial cities, the environment was not polluted, the walls of the buildings were light, and the lichens on the bark of many trees provided light background. In this case the light peppered moth camouflaged against the light background, so, had a selective advantage and better adapted and selected for by the environment. While the melanic/dark type of the peppered moth was less adapted and selected against by the environment.

It then followed that, the frequency or the population of light type of peppered moth remained higher than that of melanic form in non-polluted and non industrial areas of

England, where as in the polluted and major industrial areas of England, the population of the melanic form of peppered moth was higher.

DRUG AND PESTICIDE RESISTANCE/ ANTI-BIOTIC RESISTANCE.

This is where certain mutant type of bacterial cells develop resistance towards antibiotics, which fail to destroy them in the normal way. Resistance is where certain alleles initiate production of enzymes that neutralize thel effects the drug and the fail to destroy them.

Chance mutation produces an individual Bacterium or certain insects with new alleles that determine the production of enzymes penicillinase which deactivates penicillin or enzymes that will deactivate insecticides. This bacterium or insect is immediately resistant as for bacteria they have only one strand of DNA and one copy of each gene, the mutant allele is expressed immediately and is not masked by a dominant allele. The non-mutant bacteria or insects are non-resistant strains with no ability to resist the effects of anti-biotics or insecticides.

The non-resistant strains of bacterial cells survive in high frequency under conditions where there is no use of antibiotics such as the penicillin. Where there is increased use of antibiotics in greater quantities and frequency against population of bacteria, there will be a selection pressure exerted on the two variants, the mutant and the non-mutant types of bacteria. In this case, the mutant type is better adapted, had a selective advantage, and resisted the effects of the antibiotics. The presence of the penicillin in the bacterial cell of the mutant bacterial cell, switched on genes that initiated the production of enzymes which catalysed the breakdown of the penicillin (anti-biotics). The resistant mutant bacteria survived in the presence of the drugs/penicillin, and continued to pass their genes to the next generation and therefore selected for by the environment. The selection pressure favours the resistant bacteria. Where as the non-resistant non-mutant bacteria lack the ability to stimulate genes that initiate production of enzymes that catalyze breakdown of the antibiotics, so are less adapted and do not survive and are destroyed and therefore wiped out of the population and are said to be selected against by the environment.

In environments were there is no frequent use of anti-biotics or penicillin the non-resistant strains of bacteria survive better than the resistant strains of bacteria.

The resistance to antibiotics are believed to be genetically inherited and it,s genes are transmitted to the next generation of bacteria. So, some bacteria become resistant even before the anti-biotics are used against them.

The penicillin/pesticides apply a selection pressure that results in directional selection and a large population of penicillin/insecticide resistant Bacteria/insects evolved.

Note ; The resistance of the plasmodium parasites to anti-malarial drugs such as quinine follow almost the same process.

HEAVY METAL TOLERANCE IN PLANTS.

Certain grasses have developed tolerance to heavy metals such as copper, Zinc and lead. So, they are better adapted to survive and flourish on soils from mines. There population is higher in such areas than grasses which are not tolerant to heavy metals for such grasses are selected against.

In normal soils, grasses less tolerant to heavy metals are selected for and flourish. Where as grasses tolerant to heavy metals are instead selected against.

ARTIFICIAL SELECTION.

Is the selective breeding of organisms showing characteristics or traits which are desirable to humans. Humans continue to rear organisms with favourable characteristics from one gereation to the next. This is achieved through in-breeding and out breeding. Such desirable traits to humans include the following,

- Good meat quantity and quality in cattle.
- High milk production in cow.
- Tenderness of meat in cattle.
- Resistance to disease in plants and animals.
- Resistance to prolonged drought.
- High egg production in poultry.
- Quality wool in sheep.
- Good racing ability in Horses.

Males and females possessing desired characteristics are selected for and allowed to interbreed and pass their genes to the next generations. Organisms lacking the desired qualities are selected against and prevented from mating. This prevention is achieved by,

- extermination (killing of animal) ,
- segregation (isolating the animals from others)
- and sterilization through castration.

In artificial selection humans exert directional selection pressure leading to changes in allele frequency within the population. The allele frequency for desirable characters are maintained high and continued to be transmitted to the next generation, while the allele for undesirable characters are eliminated from the population.

TYPES OF ARTIFICIAL SELECTION.

- In-breeding.
- Out breeding.

IN-BREEDING.

Is the selective mating of closely related individuals. The most extreme forms of individual inbreeding are,

- Self fertilisation.
- Crossing offsprings of the same parents.
- Back crossing offsprings with either of their parents.

The main reason why inbreeding is conducted especially by the livestock farmers is to select and propagate particular desirable characteristics.

DISADVANTAES OF IN-BREEDING

(i) Reduction in size and mass of animals.
(ii) High mortality rate.
(iii) Reduced resistance to diseases.
(iv) Reduced vigour.
(v) Reduced fertility in livestock.
(vi) Leads to high proportions of offsprings being homozygous for some bad recessive alleles eg alleles for sickle cell anaemia, haemophilia etc.

Note: In-breeding is more common in animals than in plants.

OUT BREEDING.

Is the selective mating of individuals who are unrelated or not genetically closely related.

The most common forms of out breeding include.

- Cross fertilization or crossing different but compatible varieties (sub-species)
- Mating between genetically unrelated individuals. Mating between genetically unrelated individuals result in the production of a hybrid.

A hybrid is an offsprings (progeny) from a cross between genetically unrelated parents, with the offspring possessing characteristics superior to either of the parents, such superior characteristics a hybrid possess is referred to as hybrid vigour. These include being tougher, more fertile and having a greater chance of survival.

Some times hybrid vigour is associated with polyploidy. Out breeding result in many of the offsprings being heterozygous, so the bad recessive alleles are masked by their dominant alleles.

ADVANTAGES OF THE HYBRIDS (F1 HYBRIDS)

(i) They are more resistant to pests and diseases.
(ii) Hybrid grain crops give a higher yield per unit area and are of better nutritional values.
(iii) Have increased fertility.
(iv) Hybrid fruits are larger in size.
(v) Hybrid grain crops have shorter stems, giving dwarf varieties, making them easy to harvest.
(vi) Early maturity.
(vii) Hybrid crops show a greater responsiveness to water and fertilizers.
(viii) They are relatively insensitive to day length or temperature with the result that two or three crops can be grown per year.

Out breeding and production of Hybrid vigour, has been successfully made use of and it formed the basis of green revolution. Green revolution is where the practices of out breeding and selection has led to development of new hybrid varieties of food crops like wheat, barley, maize and rice to meet the ever increasing demands of human population.

SEXUAL SELECTION.

Is where only certain males that are better adapted to fight off rivals males and possessing features attractive to females succeed in mating the females in population. The succeeful and better adapted males will have their genes passed to the next generation, while the less adapted and unsuccessful males in mating will have their genes eliminated and not passed to the next generation. The sexual selection explains the existence of sexual dimorphism. These are the differences which exist in the characteristic features between males and females organisms of the same species. For example antlers of male elks only used to fight off rival males and securing a mate. Elaborate courtship behaviours and exotic plumage of male birds.
It is argued that, male attractiveness is a usefull feature, which will be selected for and passed down to the next generation, an idea referred to as “sexy son hypothesis”.

KIN SELECTION AND GROUP SELECTION.

These are kind of ***altruistic behaviour***, where an action of one individual promotes the survival of another at the expense of one’s own. For example one person jumps into a river water to save another person from drowning and himself instead get drowned.
Altruism is a social behaviour whereby one individual puts itself at risk or at personal disadvantage for the good of other closely related members of the species. Altruistic behaviour confers a genetic advantage to closely related organisms by promoting their survival and reproduction. And enables alleles for certain characteristics of the species to be to be perpetuated. Altruistic behaviour appears to apply to closely related relatives (kin) i.e offsprings and siblings (brothers, sisters and cousins) with whom they share certain alleles. So, the adaptive significance of altruistic behaviour is to

increase the frequency of those alleles common to both donors and recipients of the altruistic behaviour. This behaviour is called kin selected.

KIN SELECTION.

Is the action of an individual to promote survival of another closely related one at the expense of his/her own. For example, a sacrifice a parent may make on behalf of their offsprings.

Kin selection is a kind of altruistic behaviour which confers a selective advantage, if the loss of an individual is for the benefits of very close relative. It is therefore important in that, it is a way an individual will ensure survival of his/her genes which will continue to be transmitted to the next generations.

In other animals, kin selection is common among social insects. For example a worker bee attacks and stings intruders when she does so, her gut is ripped off and she dies soon after wards. In this case, she has sacrificed her life for her relatives.

GROUP SELECTION.

Is a behaviour which favour the survival of the species or subdivision at the expense of an individual's own life. Example, in humans it is seen when national army men die in a war to protect his country.

CAUSES OF PRESENT DAY EVOLUTION

Present day evolution is basically explained by modern concept of evolution by natural selection called Neo-darwinism.. Several factors leads to the present day evolution and they include,

- Competition.
- Changes in the environment.
- Mutations.
- Gene recombinations/Gene reshuffling.
- Industrialisation/chemical or drug resistance.
- Artificial selection.
- Polyploidy.

THE ROLE OF MUTATION ON EVOLUTION.

Mutation is the change in amount or structure of DNA on chromosomes. It alters the genotype of individuals, resulting into new characteristics in the individuals. This leads into genetic variation among organisms of the same species. When sudden changes in environmental conditions occur, it exerts a selection pressure on the variations. This selection pressures favour variations which better adapt the organisms to their environment, they survive, interbreed, pass their genes to the next generations and selected for by the environment. Where as variations which less adapt organisms to their environment, the organisms possessing such variations die and do

not reproduce offsprings and therefore selected against. When such sub-populations become isolated for a long period of time, they develop into distinct and separate species.

THE ROLE OF GENE RESHUFFLING/GENE RECOMBINATIONS/SEXUAL REPRODUCTIO.

Gene reshuffling is the gene mixing or exchange of genes, which creates new genetic recombination, arising from particular or certain internal processes of **sexual reproduction**. The sexual processes that lead into gene mixing or gene reshuffling and new combination of alleles that will result into genetic variation include,

• Crossing over that occurs during prophase I of meiosis. It leads to exchange of genes but also separates linked genes. These result into new recombination of alleles.

• Random and independent assortment of homologous chromosomes during Metaphase I of meiosis.

• Random fusion of gametes during fertilisation.

When genetic variation occurs among organisms. It is expressed in their phenotypes or brings about new characteristics in the population. Therefore reshuffling of genes result into continuous genetic variation. Organisms that posses variations which best suit them to the environment, survive and interbreed to pass their genes to the next generation and therefore favoured by the environment and selected for. Where as organisms that possess characteristics or variations which do not best suit them to the environment, die and wiped out of the population, they are selected against by the environment. After many generations the better adapted individuals develop into distinct species.

However, It is noted that, Gene reshuffling has a very limited role in evolution. This is because independent assortment of homologous chromosomes and crossing over may establish a new combination of genes in one generation but unfold it in the next generations particularly in In-breeding; hence gene reshuffling does not provide long term evolutionary changes. In other words, where out breeding is practiced, it enables gene reshuffling to confer desirable characteristics to the offsprings providing basis for natural selection and hence development of new distinct species of organisms (evolution).

ARTIFICIAL SELECTION.

Is the selection for breeding of organisms showing characteristics or traits which are desirable to humans. Such desirable traits such as good meat quantity and quality in cattle, high milk production in cow, resistance to disease in plants and animals, etc.

In artificial selection humans exert directional selection pressure leading to changes in allele frequency within the population. The allele frequency for desirable characters are maintained high and continued to be transmitted to the next generation, while the allele for undesirable characters are eliminated from the population.

SPECIATION BY POLYPLOIDY.

Polyploidy is addition of the whole set of chromosomes into a cell sometimes into a cell which is diploid. Triplod(3n), tetraploid(4n), pentaploid(5n) etc cells are formed. This occurs mainly in plants, it occurs instantly but very rarely. Polyploidy is where the chromosome number in the cells of species of an organism is a multiple of the haploid number. Most polyploids may become isolated from the parent by a barrier of sterility. When variations occur in the population, natural selection takes place. Allele frequency is changed and formation of new species occur.

Polyploid plants are better adapted than non-polyploids, the better adapted individuals are selected for and after many generations they evolve into new species while the less adapted non-polyploids are selected against and eventually wiped out of the population.

Polyploidy is quite more common in many plant species and provide them with some advantageous characteristics, polyploidy in plants is associated with advantageous characteristics and such plants continue to be propagated vegetatively yet rare in animals because in animals it is associated with sterility since the sex chromosomes system of animals such as homologous pairing of chromosomes during meiosis normally breaks down if polyploids are formed, producing completely sterile progeny that may immediately die out.

SPECIATION.

Is the process by which new species are formed. The process of speciation is of different types.

(i) Intraspecific speciation.
This process involve organisms of the same species but giving rise to new species.

(ii) Interspecific speciation.
Is where two different species of organisms are involved, giving rise to new species of organisms.

(iii) Allopatric speciation.
Is where a single species of organisms give rise to new species as a result of their population being isolated/separated by physical barrier or geographical barriers. So, the process occurs when organisms are occupying different areas.

(iv) Sympatric speciation.
Is where a single species of organisms give rise to new species without their population being isolated by geographical barriers but reproductively isolated and the process occurs when the population of the organisms is occupying the same area.

HOW NEW SPECIES ARE FORMED /THE PROCESS OF SPECIATION.
Speciation is a process by which new species are formed. It begins with an originally large population becoming split to form sub-populations. A few individuals may also move away from a parental population and establish a new sub-population at a distance away from the original location to form a sub-population, a phenomenon referred to as ***founder's effect.*** Splitting of large population and founder's effect both lead to formation of two or more separate groups/sub-population of sexually reproducing organisms, freely interbreeding called **ademe**, each deme are totally isolated from one another by any one of the isolating mechanisms which include, Geographical, Ecological, Reproductive, Behavioural isolations. So, no exchange of genes occurs between individuals of isolated demes, the gene flow between the sub-populations is prevented. And if each deme then experiences gene differentiation, by mutation, genetic variation and natural selection all occurs independently. Genetic drift may also take place, the allele frequency is changed, and then each deme evolves along separate lines to form distinct species. **Allopatric speciation** occurs when two populations become geographically isolated; the population evolves and forms new species. In the event of two populations ever coming together again, interbreeding between them fail to take place, due to their genetic isolation.
Sympatric speciation occurs when organisms in the same geographical area become reproductively isolated and can not interbreed.

ISOLATING MECHANISMS.
These are specific factors which act as barriers to prevent interbreeding between populations of organisms and these include,

- Geographical/Ecological/ Allopatric isolation.
- Reproductive/Behavioural isolation.

- Genetic/Physiological isolation.
- Seasonal isolation.

GEOGRAPHICAL/ALLOPATRIC ISOLATION.
Is where the physical barriers such as mountains, lakes keep populations apart, preventing them from interbreeding.

ECOLOGICAL ISOLATION.
Is where populations are kept apart and prevented from interbreeding by environmental conditions or environmental barriers.

In Geographical /Ecological isolation, the populations adapt to different environments, the better adapted organisms survive, interbreed and pass their genes to the next generation and therefore selected for, while the less adapted organisms are selected against. In many generations a better adapted organisms evolve into distinct species.

REPRODUCTIVE ISOLATION.
Is where population fail to interbreed, resulting from non-correspondence of or differences in male and female genitals. It is also referred to as **mechanical isolation**.

BEHAVIOURAL/REPRODUCTIVE ISOLATION.
Is where populations are prevented from interbreeding, resulting from lack of attractiveness between males and females. In this case, the courtship behaviour of one organism fails to stimulate sexual activity of others and mating fails to occur.
For plants, pollination may be impossible between populations due to incompatibility.

In reproductive/Behavioural isolation, the two populations will breed independently, genetic variation occurs, and when selection takes place, formation of new species results.

GENETIC/PHYSIOLOGICAL ISOLATION.
Is where mating between organisms may occur but fertilisation is prevented due to fundamental differences in the genetic constitution of the organisms. Even when fertilisation takes place, zygote may fail to develop or inferior/immature sterile offsprings results.
In genetic isolation, the two populations reproduce successfully only by breeding independently, each population develops its own gene pool, this causes change in allele frequency which will result into formation of new species.
The genetic isolation can take the following different forms,
• Hybrid inviability.
• Hybrid sterility.
• Hybrid breakdown.

Hybrid Inviability
Is where the Hybrid offsprings are produced but fail to develop to maturity.

Hybrid sterility
Is where the Hybrid offsprings produced fail to produce functional gametes or become sterile. For example the mule (2n = 63) results from the cross between the horse ,2n = 60 and the Donkey 2n = 66.

Hybrid breakdown
Is where the Hybrid offsprings of the first filial generation (F1 generation) are fertile or viable but the offsprings of the F2 generations fail to develop or become sterile/infertile.
Seasonal isolation e.g. flowering at different times of the year in plant. Behaviour not accepted by the opposite sex and preventing mating or interbreeding between them.

NOTE : The major processes that lead to evolution include the following,

- Gene reshuffling.
- Mutation.
- Isolation.
- Selection/natural selection
- Speciation.

An important development in the understanding of evolutionary theory was the birth of **population genetics** and the realization that continuous variation may be genetically controlled.

ROLE OF VARIATION IN EVOLUTION.
Variation is the difference in characteristics that exist between individuals or organisms of the same species, living within an area. Variation is caused by,

- Genetic differences/Genetic recombination.
- Environmental influences.

Genetic variations is the main basis of evolution in that, the environment exerts a selection pressure on variation. And , this leads to natural selection.
Variation due to genetic differences among individuals is caused by,

- Genetic Reshuffling.
- Mutations.