Evolution

It is a gradual process by which simple forms of organisms give rise to complex forms over a period of time.

or

It is a gradual process by which a new species of organisms are formed from the pre – existing species over a period of time.

THEORIES OF ORIGIN OF LIFE

1. **Special creation theory**
   It suggests that the earth and the species on it were created by God or supernatural being at a particular time. This theory is supported by most of the world's major religions.

2. **Steady state theory**
   It suggests that the earth and the species on it have always existed therefore life had no origin.

3. **Cosmozoan/ pernspamian theory**
   It states that life arose elsewhere in the universe and arrived on earth by some means.

4. **Spontaneous generation theory**
   It states that life arose from non living matter on numerous occasions.

5. **Biochemical evolution theory.**
   It states that life arose from a combination of simple molecules into complex ones and their evolution via coaservates into cells.

Of the five theories, the biochemical evolution theory is the most widely accepted by present today scientists. They believe that it occurred in 3 stages.

i) Formation of small molecules e.g. amino acids, organic bases and monosaccharides.
ii) Formation of large polymers from small molecules
iii) Intergration of polymers to form cells.

FORMATION OF SMALL MOLECULES.

In the early years, the conditions then were different from those of today, the gases present in the atmosphere then included CO_2, NH_3, CH_4, H_2 and watervapour.

At the same time, the ozone belt that now protects the earth from the sun's ultraviolet radiations hadn't formed. It is thought that these radiations provided a source of energy by which the gases combined to form simple molecules within the atmosphere i.e. amino acids, organic bases and monosaccharides.

Urey and Miller carried out a series of experiments to test this hypothesis by preparing a mixture of gases similar to those originally present on earth and passed electric sparks through the mixture. They produced biochemical substances which were small molecules of amino acids, monosaccharides and organic bases.

FORMATION OF POLYMERS

The simple molecules formed in the atmosphere floated as a thin layer on the surface of oceans. Wind is believed to have caused this layer to drift and concentrate on the surface of estuaries. The concentration was great enough for polymers to be formed by condensation reactions.

Special drops rich in these polymers are believed to have formed and these were called coaservates.

FORMATION OF CELLS

The final stage involved the formation of a lipid layer around the coaservate. This was a primitive membrane. Within the coaservate, were molecules e.g. nucleic acids which were capable of self-replicating.

In the absence of oxygen, the primitive cells were anaerobic and fed by absorption of nutrients from the surrounding environment. These primitive cells were prokaryotic i.e had no membrane bounded organelles.

These heterotrophic cells which fed on the materials in the surrounding would in time incorporate the available simple molecules from their surroundings and no further evolution would have been possible.

However, photosynthetic (autotrophic) organisms must have come out. These utilized the earth's radiations to build up complex organic polymers from simple inorganic molecules. In this way the supply of food for the heterotrophs was constantly improved and replaced.

With time, oxygen producing cells similar to present day blue green algae or cyanobacteria developed. The oxygen produced formed a layer above the earth which now prevents harmful ultraviolet radiations from reaching the earth's surface.

At the same time, aerobic forms of life developed from the newly formed oxygen.

THEORIES OF EVOLUTION

These explain the mechanism by which evolution of the new species took place by gradual adaptation. These include**:**

(i) Lamarck's theory (Lamarkism)
(ii) Darwin's theory (Darwinism)

LAMARCK'S THEORY OF EVOLUTION (Theory of inheritance of acquired characteristics)

It was put forward by Jean Lamarck basing an inheritance of acquired characteristics. He noted that the following three aspects were essential for evolution to occur i.e.

- Influence of environmental factors
- Use and disuse of body parts
- Inheritance of acquired characteristics

He believed that the environment sets the demand of the use and disuse of a particular body organ. The used organs developed fully and the disused ones degenerated to form vestigial organs.

The fully developed organs become the acquired characteristics which were inherited by the offsprings hence the organisms with the acquired characteristics became a complex form compared to the initial simple form of organisms hence a new species thus evolution.

Lamarck's theory therefore states that; **"The characteristics organisms acquire during their life time are transmitted to the off springs."**

NB: *A vestigial organ is one that has become much reduced in size as a result of disuse e.g. the coccyx in man after losing the tail and the appendix in man after losing the caecum.*

HOW LAMARCK EXPLAINED THE DEVELOPMENT OF LONG NECKED GIRAFFES.

It is believed that the ancestors of the present day giraffes had short legs and neck but they stretched these during the period of drought in order to reach the leaves high on the trees since they had eaten all the vegetation at the ground level. In the process, the necks became elongated. Lamarck believed that the offsprings inherited the long legs and neck as a way of survival hence the present day giraffe is acumulative result of many generations reaching out for food high up on the trees.

However Lamarck's theory was XXXproved to be wrong because acquired characteristics can't be inherited.

Short comings of Lamarck's theory

1. Acquired characteristics are brought about by the environment but not genes, therefore cannot be inherited.
2. The use and disuse of somatic cells doesn't influence the reproductive cells therefore can't play a role in inheritance and evolution.
3. Formation of gametes has nothing to do with what the organism does since gametes in females are formed before births in ovaries.

Lamarck however had his contribution towards evolution i.e. he recognized the effect of the environment in evolution by creating needs for which adaptations are made.

He also recognized that the inheritance of characteristics from one generation to another was important in evolution.

DARWIN'S THEORY OF EVOLUTION (EVOLUTION THROUGH NATURAL SELECTION)

This was put forward by Charles Darwin.

Darwin visited Galapagos Archipelagos islands and studied the finches which inhabited the islands.

While they all had general resemblances to those of the main land of equador, he noticed that they were different in certain aspects e.g. beakshape.

He argued that the finches of the Island resembled those at the mainland of equador in South America because they descended from a common ancestor.

They differed from one another because each was adapted to its mode of feeding. He noticed that a few finches had crossed from the mainland to the volcanic island, shortly after their formation and encountered different kinds of food hence each type of finch developed a new shape of the beak depending on the food fed on at the island e.g. seed eating finches had short stout beaks, nectar feeders had long slender beaks, wood peckers had relatively long and sharp beaks, insect feeders had pointed beaks.

All these were due to adaptive radiation of their beaks to suit the new environment different from the mainland finches. Along his voyage, Darwin was trying to find out the mechanism by which these changes occurred.

Independent of Darwin, Alfred Wallace also drew his conclusionson the mechanisms of evolution and he sent Darwin a copy of his findings. Darwin realized that they were the same as his. He then presented the findings to the world. A year later, Darwin published his book on the origin of a new species by natural selection of the favoured race, in the struggle for existence.

DARWIN'S ESSENTIAL FEATURES

1. **Over production of off springs**

He believed that all organisms produced a large number of off springs which if they all survived could lead to an increase in the population size.

2. **Constancy in numbers**

Despite the increase in number due to over production of off springs, most populations maintained relatively constant numbers. The majority of off springs must therefore die before they are able to reproduce.

3. **Struggle for existence**

He concluded on the basis of the above two, that members of the species were constantly competing with each other in an effort to survive. In this struggle only few would live long enough to breed.

4. **Variation among off springs**

Sexually produced off springs of any species show individual variations so that no two off springs are identical.

5. **Survival for the fitter**

Among the variety of off springs, some are better adapted to withstand the prevailing conditions i.e. some will be able to survive long enough to breed.

6. **Like produce like**

Those that survived to breed are likely to produce off springs similar to themselves. The advantageous characteristics which give them a win in a struggle for existence are likely to be passed on to the next generation.

7. **Formation of a new species**

Individuals lacking favourable characteristics are less likely to survive long enough to breed. Over many generations, their numbers decline. The individuals with favourable characteristics breed and consequently increase in number.

The inheritance of one small variation may not by itself produce a new species but development of a number of variations in a particular direction over generations gradually leads to formation of a new species.

DARWIN'S MODERN THEORY OF EVOLUTION / NEO DARWINISM / ORGANIC THEORY OF EVOLUTION.

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HOW DARWIN EXPLAINED THE DEVELOPMENT OF LONG NECKED GIRAFFES.

Initially both short and long necked giraffe varieties existed. Due to exhaustion of food at the ground level, the short ones couldn't reach the tree branches hence starved and died of hunger. The long necked ones survived since they could reach up the tall tree branches for food hence produced the long necked giraffes like themselves.

NATURAL SELECTION

This is the process by which organisms that are better adapted to the environment survive to breed while the least adapted ones fail to do so and die in the process.

The better adapted ones are likely to pass their characteristics to the succeeding generation.

Every organism is therefore subjected to natural selection based on its ability to survive in a particular condition at a particular time. The environment therefore exerts a selection pressure.

The intensity of the pressure varies in space and time. Therefore selection pressure determines the spread of any allele within the gene pool.

NB:

Selection is a process by which those organisms that appear physically physiological and behaviourally fit survive and reproduce while those not so well adapted fail to reproduce or die. The fit ones pass their successful characteristics to the next generation while the unfit ones do not.

When a population increases in size, certain environmental factors become limiting such as food availability in animals and light, water and mineral salts in plants.

This causes competition for resources between members of the population. Those organisms with characteristics that give them a competitive advantage will obtain the resources, survive and reproduce.

Organisms without these characteristics are at a disadvantage and may die before reproducing hence both the environment and population size operate together giving rise to a selection pressure.

Selection pressure increases or decreases the spread of alleles in the gene pool hence changing the allele frequency leading to evolutionary change.

***Question*: Explain how selection leads to formation of a new species.**

TYPES OF NATURAL SELECTION

1. Directional (progressive selection)
2. Stabilizing selection
3. Disruptive selection

DIRECTIONAL SELECTION

It is a type of selection that favours development of one extreme of a particular character at the expense of another hence shifting the mean or optimum of the population in a particular direction.
It operates in response to gradual changes in environmental conditions.
It operates on a range of phenotypes existing within the population and exerts a selection pressure which moves the mean / optimum phenotype towards one phenotypic extreme.
It brings about evolutionary change by producing a selection pressure which favours the increase in frequency of new alleles within a population.
It forms the basis of artificial selection.
When environmental changes favour a new phenotype, then individuals of this phenotype are likely to become numerous in the population at the expense of those not favoured hence the mean shifts to a new one and the composition of the population changes accordingly and progressively in a particular direction.
These environmental changes exert a selection pressure on the species causing it to adapt to new conditions.
Within the population, there is a range of individuals with respect to anyone character. This continuous variation among the individual forms a normal distribution curve with the mean which represents the optimum for the existing conditions.
When these conditions change, so does the optimum necessary for survival. A few individuals would possess thenew optimum and by selection, they in time dominate. This then means that the mean for this particular characteristic will have shifted.

Graphs showing directional selection

(Biological science page 915 – leave 12 lines)

An example is the different fur lengths of organisms that suit different temperature conditions ieif the environmental temperature is 10^0C, the optimum further length is 1.5 cm thus represents the mean fur length in the population.

A few individuals in a population already have the fur length of 2.0cm or greater. If the average temperature falls to 5^0C, these individuals are better insulated and are more likely to survive to breed. The selection pressure thus favours individuals with long fur.

The selection pressure causes a shift in a mean fur length towards long fur over a number of generations.

Industrial mechanism, resistance to antibiotics and selective bleeding are examples of directional selection.

STABILISING SELECTION

It is a type of natural selection where the selection pressure eliminates the extremes favouring the intermediates for a particular character. It operates when the phenotypic features coincide with the optimal environmental conditions and competition is not severe. It occurs in all populations and tends to eliminate extremes from the population hence reducing the viability of the population and the opportunity of evolutionary change.

Stabilising selection pressures do not promote evolutionary change but tend to maintain phenotypic stability within the population from generation to generation.

It ensures that most individuals surviving at those adapted to environmental conditions. Selection pressure therefore is from both directions.

Graphs showing stabilizing selection

(Biological science page 915 – leave 12 lines)

From the earlier example of fur length, individuals within a population have different fur length and at 10^0C, the optimum for length is 1.5cm.

In a warm year, with an average temperature of 15^0C, individuals with short fur are at an advantage as they lose heat more quickly. In such years, the number of individuals with short fur increases at the expense of those with long fur.

In cold years, within an average of temperature of 5^0C, the number of individuals with long fur increases at the expense of short fur which die and decrease in number due to excessive heat loss.

The periodic fluctuations in environmental temperatures thus help to maintain individuals with relatively long and short fur (intermediates) andeliminate those with longest and shortest fur (extremes) thus reducing variation.

With time, when the environmental temperature constantly remains the same at 10^oc, individuals with longest and shortest full will no longer exist in the population, but rather have numbers of individuals with intermediate fur length increase, hence only forming a normal distribution curve with in a population.

An example of stabilizing selection is the inheritance of sickle cell anaemia since individuals at one extreme die of sickle cell disease and malaria at the other extreme. Majority of the heterozygotes survive. (Heterozygous advantage)

DISRUPTIVE SELECTION

It is the type of natural selection where the selection pressure favours the phenotypes towards the extremes and selects against those near the mean leading to splitting of the gene pool.

Two different species thus arise hence causing evolutionary change.

Fluctuating conditions with the environment e.g. associated with season and climate may favour the presence of more than one phenotype within a population.

Selection pressures acting from within the population as a result of increased competition may push the phenotype away from the population mean towards the extremes of the population.The splits the population into two sub populations. If gene flow between the sub populations is prevented, each population may give rise to new species.

In some cases, this form of selection can give rise to the appearance of different phenotypes within a population, a condition called polymorphism.

Graphs showing Disruptive selection.

(Biological science page 915 – leave 12 lines)

When there is a wide range of temperature throughout the year, there a continuous variation in fur length around the mean of 1.5cm.

When the summer temperature is static at 15^0C and winter temperature at 5^0C individuals with two distinct fur lengths predominate i.e. 1.0cm as the mean which are active in summer and 2.0cm mean length which are active in winter. After many generations, two distinct sub populations are formed.

EXAMPLES OF NATURAL SELECTION / EVOLUTION IN ACTION TODAY

1. Polymorphism.

This is the existence of two or more forms of the same species within the same population. It can apply to biochemical, morphological and behavioural characteristics.

Types of polymorphism

a) Balanced / Stable polymorphism

This occurs when different forms coexist in the same population in a stable environment. eg

- ✓ Existence of two sexes in animals and plants.
- ✓ The A, B, AB and O blood groups
- ✓ Colour and banding patterns in some species of the common land snails
- ✓ Colour patterns in grasshoppers

The genotypic frequencies of the various forms exhibit equilibrium since each form has a selective advantage of equal intensity or non has a selective advantage over the other.

b) Transient / Unstable polymorphism

This arises when different forms or morphs exist in a population undergoing a strong selection pressure. The frequency of the phenotypic appearance of each form is determined by the intensity of the selection pressure. It applies in situations where one form is gradually being replaced by another. egmelanic and non-melanic forms of the peppered moth.

Polymorphism in the peppered moth (Industrial melanism)

Moths used to have a light colour but later on, the melanic (black) variety arose as a result of mutation. Thesemutations had occurred before but they were highly against the light background of lichen covered trees and rocks on which they rest.

As a result, the black mutants were subjected to greater predation from insect eating birds because they were conspicuous and got selected against hence their numbers decreased while the light peppered moths easily camouflaged against the light background hence were selected for and had their numbers increasing.

In 1848, most buildings, walls, rocks and trees were blackened by soot of 50years of industrial development. The Sulphurdioxide in the smoke killed the lichens that formerly covered the trees and rocks making the background dark (black).

Against this dark background, the melanic forms camouflaged hence got selected for while the light peppered moths became conspicuous and selected against since they were now eaten by predatory birds. By 1895, 98% of manchestor's population of the moths was of the melanic form. This change in gene frequency was a result of natural selection.

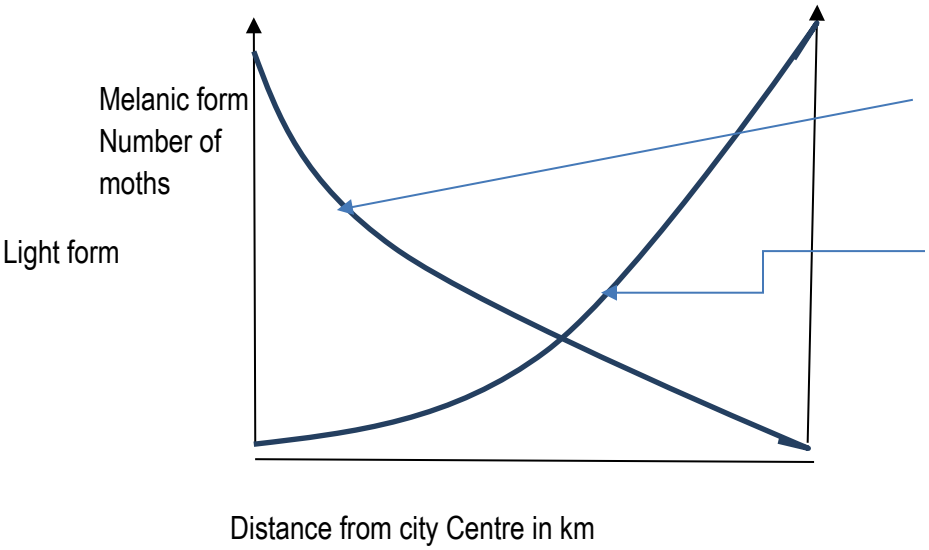
This was prooved by Dr. Kettlewell who bred large stocks of both varieties of the moths. He marked and realized them in equal numbers in two areas i.e.

i) In Bermingham, an area where SO_2 and soot levels were high. 90% of existing moths were found to be of the melanic form.
ii) In the rural areas where soot and SO_2 levels were very low, light from was dominant since it had a selection advantage.

Question: **Explain the term industrial melanism in peppered moths**

It is a process that led to evolution of melanic forms of the moth which took place during industrial revolution through natural selection in a way that mutant forms or melanic forms were favoured against the dark background and hence had a selection advantage, became many and dominant.

Question: The figure below shows the distribution of the light and melanic forms of moths from the city Centre, use it to answer the questions that follow.



(a)Explain the relationship between distance from the city center and the number of each moth form.

(b) Using the above illustration, explain what is meant by polymorphism.

2. Resistance to antibiotics

Following the production of antibiotics, it was noticed that certain bacterial cells developed resistance to antibiotics egpenicilin. This was as a result of mutation that created variation among the bacteria.

The mutant bacteria survive when exposed to the antibiotics hence selected for while the non mutant ones die greatly reducing their numbers, hence selected against.

When the mutant bacteria are subjected to the antibiotics, they switch on a gene synthesis mechanism that leads to secretion of enzymes that break down the antibiotics into the products that don't harm the bacteria. Thus the bacteria survive in presence of that particular antibiotic.

Question: What is micro evolution/ organic evolution?

It is a process where mutation suddenly produces a new phenotype in which the mutant has a selective advantage over other individuals in a population and over many generations, the population gradually changes with individuals containing the mutant allele becoming more frequent.

Question: **Explain how micro evolution of the antibiotics resistant bacteria occurs**

3. Resistance to insecticides

It has come about in a similar way like in bacteria. Apart from being directly harmful to insects, vectorseg mosquitoeshave acquired resistance to insecticides. This explains the rampant preverance of malaria despite the use of insesticides to kill mosquitoes that carry the plasmodium parasites.

4. Resistance to anti malarial drugs

Plasmodia parasites have developed resistance to traditional drugs like chloroquine as a result of mutation in a similar way as bacteria.

5. Heavy metal tolerance in plants

It occurs in soil heaps which contain waste materials from mining activities. Such heaps contain high concentration of heavy metal ions like tin, lead, copper, nickel etc. These materials are toxic to plants. However some varieties of grasses have become generally adapted to survive high levels of these metal ions. Such plants are less competitive where the concentration of these metals are low hence don't always survive but are highly competitive where the concentration of those metals is high and greatly survive.

OTHER TYPES OF SELECTION

1. ARTIFICIAL SELECTION

This is a type of selection where man exerts a selection pressure favouring one group of organisms at the expense of another. Man has bred different organisms selectively. There are two basic methods of selective breeding i.e. inbreeding and out breeding.

INBREEDING

This is the cross between organisms of the same species aimed at retaining particular characteristics for future generation. Organisms are bred with close relatives.

The problem with inbreeding is that it increases the danger of harmful recessive genes exposing themselves (homozygosity), because there is greater risk of a double recessive individual. However it's not occasionally carried out indefinitely in order to avoid these effects.

Its advantage is that the good traits within a species are maintained over several generations.

OUTBREEDING (CROSS BREEDING)

This is a cross made between organisms of different but closely related species. It's done to improve the existing varieties where two individuals have different beneficial features and their combination leads to the production of a better feature.

Out breeding produces stronger individuals with better chances of survival andvigour.

Extreme examples of out breeding occur when individuals of different species are mated but the resulting offsprings are normally sterile e.g. across between a horse and an ass forms mules which have strength and endurance more than either parents but they are sterile.

New genes introduced by out breeding thus cause variation.

The disadvantage of out breeding is that it makes consistent qualities harder to achieve but the advantage remains that stronger and healthier offsprings are formed.

Question: Explain how inbreeding and outbreeding are promoted in plants.

2. **SEXUAL SELECTION**

Some males in a population of animals succeed in mating due to fighting off rival males and attracting females hence their genes get passed to the next generation while the unsuccessful males fail to find females and cannot mate, hence failure of their genes to be passed on.

3. **KIN SELECTION**

This is a behavior that leads to the survival of one's relative at the expense of oneself.

4. **GROUP SELECTION**

This is a behavior that leads to the survival of the species or its subdivision at the expense of one individual.

ISOLATION MECHANISMS

Within a population of one species, there are groups of individuals which breed with one another. Each of these breeding sub units is called a **deme.**

Although individuals within a deme breed with each other most of the time, it's still possible for them to breed with other individuals from other demes therefore it remains a single gene pool but if genes become separated in anyway,the flow of genes between them may sieze.

Each deme may then develop along separate lines. The 2 demes may become so different in a way that each develops features to enable them survive prevailing environmental conditions a process called **adaptive radiation.** If the two demes are reunited they will be incapable of successful breeding with each other. They would thus become separate species, each with its own gene pool, a proces called **speciation.** It depends on the groups within a population becoming isolated.

Forms of isolation mechanisms

a) Prezygotic mechanisms (Barriers to the formation of hybrids)

1. Seasonal isolation

This occurs when two species mate or flower at different times of the year.

2. Ecological / Geographical isolation

This occurs when two species inhabit similar regions but have different habitat preferences. It also occurs when populations are widely separated geographically or divided by impenetrable barriers like mountains, deserts, rivers, oceans, grasslands, forests, lakes,etc

The effectiveness of any one barrier varies from one species to another e.g. A small stream of water may separate groups of slow moving insects e.g. wood lice whereas the whole ocean may fail to isolate some species of birds. A region of water may isolate terrestrial organisms whereas land may isolate aquatic ones.

The environmental conditions on other side of barrier may become different causing organisms on each side to develop features that enable them survive in the new environmental conditions a process called **adaptive radiation.**

This makes the two groups of other side of the barrier physically, behaviourally and physiologically different from each other. This hinders production of offsprings between the two groups hence each becomes a different species as a result of adaptive radiation, a process called **speciation.**

N.B

Adaptive radiation is the process by which organisms develop new physical (structural), physiological or behaviouralfeatures that enable them to survive in the new environmental conditions.

Question: Describe how geographical isolation leads to speciation.

3. Behavioural isolation

It occurs where animals exhibit courtship patterns and mating only results if the courtship display by one sex results in acceptance by the other sex.

Before copulation / mating takes place many organisms undergo courtship behaviours which are stimulated by colour, markings, scents etc on the members of the opposite sex or particular characteristics of a partner.

Organisms of the same species may exhibit particular courtship behavior aimed at attracting organisms of the opposite sex but not of the same sex and not of different species hence ensuring that mating or reproduction only occurs between organisms of the some species.

Small differences may prevent mating e.g. if a female bird doesn't make appreciate response to the action of the male, then mating is not likely to occur between them.

The beak shape of Darwin's finches distinguishes two different species therefore individuals will only mate with partners having a similar beak shape.

The song of a bird or a call of a frog must be exact if it is to bring out on appropriate breeding response from that of the opposite sex.

4. **Mechanical isolation**

It occurs in animals where differences in genitalia prevent successful copulation or mating and in plants where species of flowers are pollinated by different insects.

5. **Genetic Isolation**

Even though mating may be possible, differences in genetic constitution may prevent reproduction from being successful. Thus gametes may be prevented from fusing. Even if fertilisation occurs, the zygote may fail to develop properly.

b) Post zygotic mechanisms (barriers affecting hybrids)

1. Hybrid inviability

This is where hybrids are produced but fails to develop to maturity

2. **Hybrid Sterility**

This is where hybrids fail to produce functional gametes eg a mule from a cross between a horse and the ass.

3. **Hybrid breakdown**

This is where the F_1 hybrids are fertile but the F_2 generation and back crosses between F_1 hybrids and parental stocks fail to develop or are infertile.

Question: Explain how Darwin's Finches showed Adaptive radiation.

The finches developed different shapes of beaks to suit the different environments that they were living in with different food, as a means of survival in the struggle for existence.

The large ground ancestral finches that lived in coastal areas had a short and straight beak for crushing seeds.

The cactus ground finches that lived at the coast or low lands had a long slightly curved split tongue to feed on nectar of the prickly-pear cactus.

The insectivorous tree finches that lived in forests had parrot like beaks to feed on seeds and insects.

The vegetarian tree finches that lived in forests had curved parrot like beaks to feed on fruits and buds.

The warbler finches that lived in forests had a long slender beaks to feed on insects in flights.

The wood pecker finches that lived in forests had large straight beaks to feed on insect larvae.

SPECIATION

This is a process by which one or more species arise from previously existing species.

Forms of speciation

1. Intraspecific speciation.

This is where a single species may give rise to a new species. It is further divided in to:

a) **Allopatric speciation,** where a single species may give rise to a new species while the populations are separated. The separation is usually by geographical barriers
b) **Sympatric speciation,** where a single species may give rise to a new species while the populations are occupying the same geographical area.

2. Interspecific hybridization

This is where two different species may give rise to a new species. A new species is produced by crossing of individuals from two unrelated species eg in many flowering plants.

FACTORS THAT LEAD TO SPECIATION / FORMATION OF A NEW SPECIES

Natural selection

Organisms with adaptive features are selected for but those with non-adaptive features are selected against.

Selection therefore determines the alleles to be passed to the next generation and their spread in genotypes thus changing the gene frequency hence providing an evolutionary effect that leads to formation of new species.

Migration

Immigration leads to coming of members into the population while emigration leads to members leaving a population with their genes. These both cause a change in gene and genotype frequencies of the population hence leading to formation of a new species.

Mutation

It changes the genetic makeup of an organism leading to loss or addition of new genes changing the gene and genotype frequencies hence formation of a new species.

Small population

This leads to inbreeding causing homozygosity. This causes some genes to increase greatly in number while reducing the number of other genes. This then leads to a change in gene frequency within a population thus leading to formation of new species.

Non-random mating / sexual selection

In nature, mating is non-random. Sexual selection occurs where members of the opposite sex make a choice and those individuals with desirable traits have a reproductive advantage and if no further genetic mixing occurs, it leads to a change in the gene frequencies thus forming a new species.

Sometimes, sexual selection occurs through competition or fighting. The weak individuals fail to get access to mates and their genes don't get represented in future generations hence a change in gene frequency leading to formation of a new species.

Genetic drift / Sewall Wright effect.

It is the accidental loss of genes from a population by chance rather than by natural selection. It may happen due to adverse effects like ecological fires, extreme drought, floods etc and the survivors of such occurances may be few thus leading to a change in the gene frequency hence formation of a new species.

Isolation

It reduces the chances of mating between related individuals. Isolation mechanisms separate a group of organisms that used to form a common population with a common gene pool into different populations with different gene pools thus changing the gene frequency. The separated populations may encounter different environmental conditions and undergo adaptive radiation separately leading to formation of new species.

HOW SPECIES BECOME EXTINCT

Extinction is the total wiping out of a particular species of organisms from a population. It is brought about by.

1. Excessive predation where organisms of a particular species are predated up to a level where there is no existing member.
2. Excessive competition causing the less adapted species to continuously reduce in number thus becoming extinct.
3. Diseases and pests where pathogenic micro-organisms attack the major organisms which in turn fail to develop resistance quickly enough and die in large numbers leading to their extinction.
4. Lack of basic nutrients in a given locality causing a link in a food chain to be broken affecting the viability of the species.
5. Natural calamities like drought, floods, volcanic eruptions and pollution. These occur at high levels which organisms of a particular species can not withstand hence causing death to extinction.
6. Destruction of habitats leading to exposure of organisms to predation hence eventually wiping them out of the population
7. Climatic changes leading to new environmental conditions e.g. high or low temperatures that may inturn lead to famine hence death to extinction.
8. Random genetic drift occurring extensively within the population

Question: Suggest reasons why large mammals are more proneto extinction than small ones.

1. Large mammals are usually slow in locomotion hence may fail to easily escape from predators causing excessive predation to them. Also being slow movers, they may fail to catch prey and die due to lack of food hence starvation.
2. Large mammals specialize in feeding on particular food hence a food shortage may occur leading to their starvation and death to extinction.
3. Large mammals need more food than small ones and in conditions of food scarcity they are likely to die which reduces their numbers up to extinction.
4. Large mammals are normally at the end of the food chain hence get less energy and accumulate more stable pesticides e.g. DDT leading their death.

Endagered species

These are species whose numbers have been greatly reduced and are likely to become extinct if the factor causing their numbers to decline is not removed.

How organisms become endagered

1. Habitat destruction through deforestation, bush burning, swamp reclamation
2. Excessive hunting and poaching.
3. Some organisms are massively destroyed due to their being health hazards to man e.g. vectors like mosquitoes and snails are killed because they spread disease causing germs to man.
4. Competition between the exotic and local breeds e.g. in cattle exotic breeds are preferred because of their hybrid vigour reducing the number of local breeds greatly to near extinction.
5. Natural selection where some species are better adapted to the conditions of the environment than others. The less adapted are likely to reduce in numbers.

6. Stiff predation pressure where the predators have a preferred prey. This prey will be over consumed leading to its population decline.
7. Pollution e.g. oil spills, excessive use of fertilizers, industrialization leading to release of dangerous gases. These lead to death of some organisms in large numbers, making them endangered.

How can endangered species be conserved?

1. Development of national parks and national reserves.
2. Legal protectionie coming up with strict laws on conservation of organisms.
3. Commercial farming iedevelopment of farms which produce goods that could be obtained from animals in the wild e.g. sheep and dear farming to produce enough wool and remove the necessity to kill animals in the wild
4. Breeding in zoos and botanical gardens
5. Removal of animals from threatened areas
6. Ecological studies of threatened habitat
7. Control of introduced exotic species so as not to out compete the indigenous species.
8. Pollution control
9. Recycling of wastes
10. Education and sensitization of people about the dangers of habitat destruction.

EVIDENCES OF EVOLUTION

Most evidences are concerned with similarities between organisms and they prove that evolution occurred as a result of gradual change of the pre-existing organisms over a period of time. These were based on Darwin's theory of new organisms evolving as a gradual change. These include:

1. Palaeontology
2. Classification /Taxonomy
3. Comparative anatomy
4. Comparative embryology
5. Comparative biochemistry
6. Geographical distribution

1. Palaeontology

This is the study of fossils. Fossils are any form of preserved remains thought to be derived from living organisms which lived a long time ago. They may include entire organisms, hard skeletal structures, moulds and casts, coprolites (fossilized faecal pellets) etc.

When an organism dies, it decomposes but some remains are left behind.

Most fossils occur in rocks within mud and silt.Such rocks are known as **sedimentary rocks.** The fossils are laid in layers called **strata** with the oldest layer at the bottom and most recent ones at the top.

By carbon dating, it was possible to find the age of organisms that formed the layers.

The layers of the fossils show a gradual change from one to the next i.e. the two adjacent layers show many similarities between them proving that the organisms which formed the fossils where closely related hence one must have evolved from the other.

However, the sequence of fossils is not continuous but there are some missing links. This could be as a result of some intermediate forms not having fossilized e.g.

A missing link between Amphibians and reptiles called **seymoria** and another between reptiles and birds called **Archeopteryx** didn't fossilize. However,palaeontology supports the idea of gradual and progressive change from simpleto complex forms hence agreeing with Darwin's theory.

Criticisms of Palaeontology as an evidence of evolution

- ✓ Many fossils may get destroyed or may not be accessible for study.
- ✓ Some soft bodied organisms do not easily form fossils.
- ✓ Very few organisms die in conditions that favour fossil formation.
- ✓ A small percentage of organisms become preserved after they have died since some decompose quickly and others are eaten by scavengers hence do not form fossils.
- ✓ Only a small fraction of fossils has been unearthed therefore many of them have not yet been discovered

2. CLASSIFICATION

It is the grouping of organisms with similar characteristics.Organisms with related characteristics are put under the some group and this shows that they are related by descent or origin having the same ancestral origin meaning that one group of organisms evolved into another.

Classification puts organisms in the same group like Kingdom, phylum, class, order, family, genus and species.

3. COMPARATIVE EMBRYOLOGY

Embryology is the study of the growth and development of the embryo of different organisms.

The related organisms show resemblance and similar features in their embryonic development suggesting a common ancestry e.g. the embryos of all vertebrates possessgill slits although only fish retain gills as adults. This shows that all vertebrates evolved from a common ancestor.

Annelids and molluscs have similar features within their embryos. This also indicates that they have a common ancestor.

It is assumed that those features are remains of structures found in the organisms' ancestors therefore similarities in embryos indicates an evolutionary relationship where, the greater the similarity, the closer the relationship.

Earnest Haeckel proposed that **'Ontogeny recapitulates Phylogeny'** meaning that during embryological development, an organism repeats its ancestral history. Organismspossess features that were possessed by their ancestors e.g. human embryo passes through the stages with a tail, two chambered heart, single closed circulation and gill poaches / slits similar to the other vertebrates like amphibians and fish.

The developing embryo of a chick passes through stages of excreting ammonia, urea and finally uric acid.

4. Comparative anatomy

Anatomy is the study of body structures of organisms. Comparative anatomy involves the comparison of body structures of organisms .The detailed study of organisms reveals many structures that are similar. These similarities indicate that such individuals had a common ancestor.

It was realized that different organisms have structures with the same basic plan hence a common ancestral origin of the organisms possessing them but modified to perform different functions due to different environments in which they live. Such structures are called **Homologous structures**.

Therefore **Homologous structures are structures with the same basic plan but modified to perform different functions in organisms possessing them due to the organisms living in different environments** e.g. pentadactyl limbs common to all vertebrates except fish but during evolution they became modified for a number of functions e.g.

- ✓ In primates like man, fore limbs are modified in to hands for grasping.
- ✓ In birds, the fore limbs are modified into wings for flight
- ✓ In whales,fore limbs are modified into pedals for swimming.

Such kind of evolution is called **Divergent evolution which is a form of evolution where organisms have structures with the same basic plan hence a common ancestral origin of the organisms possessing them but they develop differently to perfom different functions to suit the different environmental conditions where the organisms live.**

Other examples of Homologous structures include:

- ✓ Pericarps in fruits
- ✓ Beaks in birds
- ✓ Mouth parts in insects

Further comparison of structures of organisms shows that some other different organisms possess different structures with different basic plans hence different ancestral origin of the organisms processing them but serve the same function because the organisms having them live in the same environment. Such structures are called **analogous structures.**

Therefore **Analogous structures are structures with different basic plans anddifferent ancestral origins of the organisms possessing them but modified to perform the same functions due to living in the same environment**.e.g.

- ✓ Wings of birds and insects
- ✓ Legs of arthropods and vertebrates
- ✓ Eyes of different animals
- ✓ Thorns and spines in plants and animals respectively.

Such type of evolution is called **Convergent evolution which is a form of evolution where different organisms have structures with different basic plans hence different ancestral origin of the organisms possessing them but perform similar functions after encountering the same environmental conditions.**

5. Comparative Biochemistry / cell biology

Different organisms were compared for their chemicals of life and found to have the same chemicals like water, proteins, lipids and nucleic acids. They also have similar other compounds like haemoglobin and cytochrome indicating a common ancestral origin.

The following similarities were also revealed in chemical reactions of different organisms.

(i) ATP is asource of energy in all biochemical reactions
(ii) Distribution of blood pigments such as haemoglobin, haemocyanin andhaemoerythrin (all contain iron) andchlorocruorin (containing copper) in different organisms suggest a common ancestor.
(iii) Serological tests and immunological reactions also show biochemical similarities based on blood proteins i.e .antibodies and antigens.

When serum of animal A is injected into animal B , animal B forms antibodies against the antigens serum of animal A. These antibodies are specific to the proteins found in animals.

If the serum of animal A is injected into animal B, animal B forms antibodies against the antigens in the serum of animal A.These antibodies are specific to the proteins found in animal A.

If the serum from animal B which contains the produced antibodies is mixed with serum from animal C, the antibodies will react with their specific proteins. These cause precipitates to form hence agglutination.

If animal C has the same proteins as animal A, there will be maximum precipitation (100%)

If animal C has similar proteins to animal A, the amount of precipitation will be less.

In other words, the more closely related any two animals are, the more similar their proteins and the more precipitation that occurs.

(Leave 3/4 a page for diagram from Functional Approach page 579)

6. Geographical distribution / species distribution

Plant and animal species are not evenly distributed throughout the world. Some zones have their own flora and fauna due to existence of different environmental conditions.

Initially, the whole world was a single land mass with a common gene pool having common species of organisms but due to geological reactions in the earth's crust, it led to the continental drift where the land mass got separated in to different continents each with a particular group of organisms.

Organisms in each continent then encountered different environmental conditions and they underwent adaptive radiation hence each group evolving differently giving rise to different species of organisms in different continents but all having a common ancestor e.g. elephants are found in Africa and India but the habitats are different and they are of different species.

END