Dr. Bbosa Science

Evolution—History of life.

Evolution is the process by which new species are formed from pre-existing one over a long period of time. It is believed that life exists only on earth of all planets.

Specific objectives
The learner should be able to

- Explain the theories related to the origin of life

Theories for origin of the earth

1. **Stead – state.** Cosmologist maintain that the earth and universe never had origin, has always been able to support life, has change remarkably little if at all, and that the has 5,000 $x10^6$ years based on radioactive decay rates.

2. **Other hypothesis** suggest that the universe may have began as a ball of neutrons exploded in a 'big bang' emerged from one of several black holes

3.It was a design of a creator.

Theories for origin of life on earth

1. Special creation; life was created by a supernatural being at a particular time. Genesis 1; 1- 26
2.Spontaneous generation; life arose from non- living matter on numerous occasions.
3.Steady- state. Life has no origin
4.Cosmozoan; life arrived on this planet from elsewhere.
5. Biochemical evolution; life arose according to chemical and physical laws.

Modern view.
Modern geologists believe the earth is over billion years old. They speculate that the mountains deserts and oceans of today formed from slow, gradual but continuous process of erosion and uplifting. The about 3.5 billion year ago, life began From simple unicellular organism, new life forms arose and changed in response to environmental pressures producing the past and present biodiversity [evolution]

Theories of evolution.

Evolution is an overall gradual development which is both ordered and sequential. In terms living organism it may be defined as; the development of differentiated organism from pre-existing less differentiated organism over the course of life.

Lamarckian theory.

The French biologist Lamarckian proposed, in 1805 a hypothesis to account for the mechanism of evolution based on two conditions; The **use** and **disuse** of parts and inheritance of acquired characteristics. Changes in environment may lead to changed pattern of behavior which necessitate new increase use or disuse of certain organism /or structure. Extensive use would lead to increased size and or efficiency whilst disuse would lead to degeneracy and a trophy. These traits acquire during the lifetime of individual were believed to be heritable and thus transmitted to off spring.

According to Lamarckism, as the theory came be to known, the long neck and legs of the modern giraffe were the results of generation of short necked and legged giraffe ancestor feeding on leaves at progressively higher levels trees. The slightly longer necks and legs produced in each generation were passed on the subsequent generation until the size of the present-day giraffe was reached.

Darwin, Wallace and the origin of species by natural selection

Darwin and Wallace proposed that natural selection is the mechanism by which new species arise from pre-existing species. This hypothesis / theory is based on three observations and two deductions which may be summarized as follows:

Observation 1; Individuals within a population have a great reproduction potential, e.g., American oyster produces 10 eggs per season.

Observation 2; The number of individual in a population remain approximately constant.

***Deduction 1*;** Many individuals fail to survive or reproduce. There is a '**struggle for existence**' with the population

Observation 3. Variations exists within all populations.

Deduction 2: In the 'struggle for existence' those individuals showing variation best adapted to their environment have a 'reproductive advantage' and produce more off spring than less adapted organism.

Natural Selection

This is a natural mechanism by which those organisms which appear physically, physiologically and behaviorally better adapted to the environment survive and reproduce. Those organisms not so well adapted fail to reproduce or die. The former organisms pass on their successful characteristics to the next generation.

Variation.

The term variation describes the differences in characteristics shown by organism belonging to the same natural population or species.

Types of variation

1. **Continuous variation.**
   Variation is said to be continuous when there is a **gradual change** of character from one individual to another e.g. skin color, length of leaves, and height of individuals. i.e. it is quantitative.

2. **Discontinuous variation**
   In discontinuous variation, there is a **clear – cut difference** between the characteristics e.g. blood groups, tongue- rolling, sex etc.

Variation and selection

Selection is the process by which those organisms which appear physically, physiologically and behaviorally well adapted to the environment survive and reproduce. They pass on their successful characteristic to the next generation while the less adapted die.

Therefore, selection can be seen to operate through the process of differential mortality and differential reproduction potential. Selection has an adaptive significance in perpetuating those organisms most likely to ensure survival of the species and depends upon the existence of phenotypic variation with the population.

Selection pressures include food availability in animal and light in plants. This produces competition for resources between members of the population. Those organisms exhibiting characteristics which give them a competitive advantage will obtain the resources, survive and produce organism without those characteristics are at a disadvantage and may die before reproducing.

Both environmental limiting factors and population size operate together to produce a selective pressure which can vary in intensity and from time to time and from place to place.

Importance of natural selection

- organisms that are best adapted to a particular environment are allowed to survive and reproduce
- population size of a given environment is regulated to supportable limit.
- undesirable genes are eliminated from a population
- leads constant improvement of the population to better species

Types of selection.

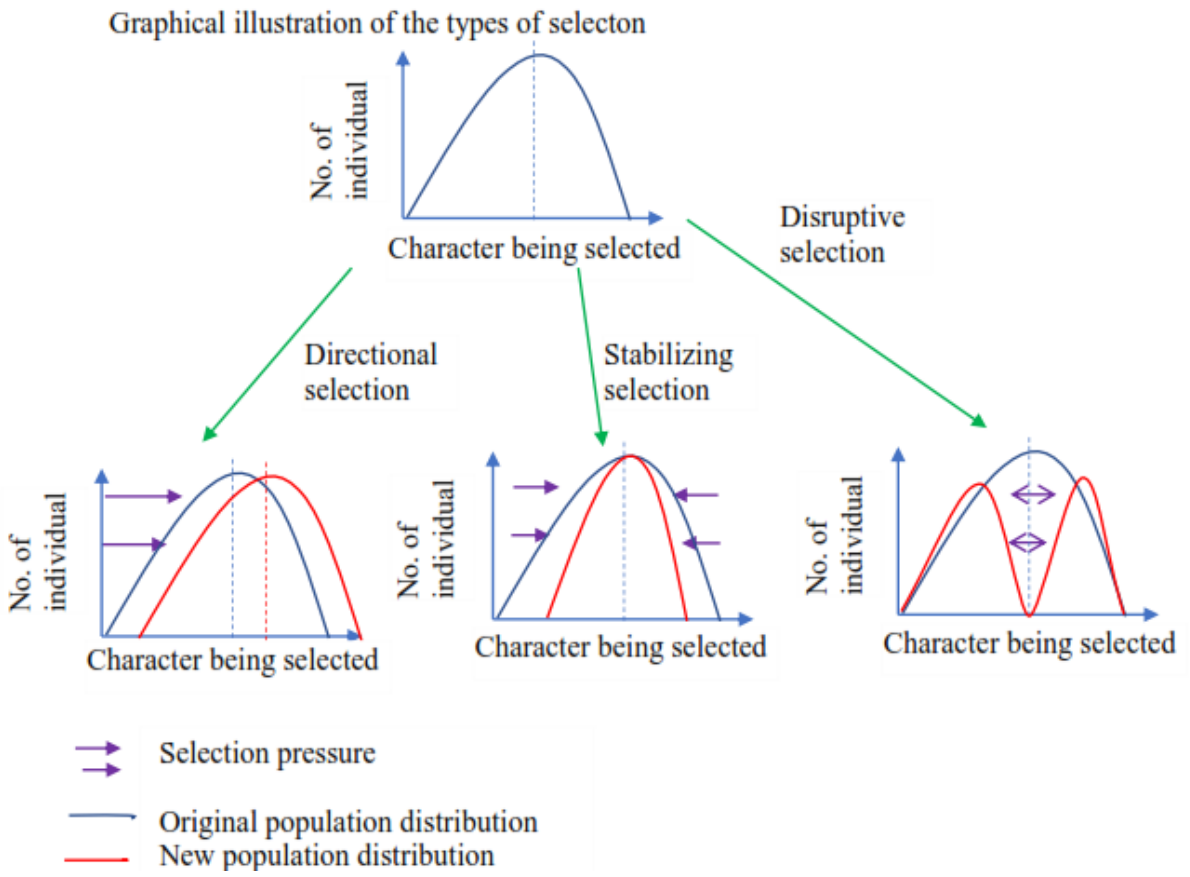
Three types of natural selection

1. Directional selection
2. Stabilising selection
3. Disruptive selection

1. **Directional selection** occurs when an extreme phenotype is favored. Such a shift occurs when a population is adapting to changing environment. E.g.,
   a. **The gradual increase in size of a modern horse** with change in environment from forest-like [which required penetration of thicket] condition to grass land [which required escape from the predator] conditions.
   b. **Industrial melanism**; the gradual increase in darkened peppered moth with increasing pollution that accompanied the industrial revolution in UK. Which enabled darkened form to hide easily on blacked walls and tree trunks.
   c. **Emergence of bacteria and insects resistant to chemicals** following prolonged indiscriminate use of antibiotic and pesticides
   d. **Increase in proportion of mammals with long fur** when the average environment temperature decreases to increase insulation of the animal or increase in proportion of mammal with short fur when the average environmental temperature increases.

2. **Stabilizing selection** occurs when an intermediate phenotype is favored. It can improve adaptation of a population for those aspects of the environment that remain constant. With stabilizing selection extreme phenotypes are selected against and individuals near the average are favored e.g. birth weight in human infants. Babies heavier or lighter than 3.6 kg in London are at selective disadvantage and have a slightly increased rate of mortality.

3. **Disruptive selection**; Here two or more extreme phenotypes are favored over any intermediate phenotype. Fluctuating condition in an environment, say associated with season and climate may favor the presence of more than one phenotype within a population. Selection pressure acting from with in the population as a result of increased competition may push the phenotype away from the population mean towards the extremes of the population.



Effects of disruptive selection

(i) It split the population into two subpopulations, each which may give rise to a new species
(ii) It can lead to appearance of different phenotypes within the population, i.e. polymorphism.

Polymorphism

This is the existence or more forms of the same population and can be applied to biochemical morphological and behavioral characteristics e.g., land snail cepaea nemoralis, the shell species may be yellow, brown or various shades

Types of polymorphism.

1. **Transient 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 selection pressure, e.g., melanic and non-melanic form of peppered moth. Transient polymorphism usually applies in situation where one form is gradually replaced by another

3. **Balanced polymorphism.**

This occurs when different forms co-exist in the same population in a stable environment.
E.g.

(i) Existence of the two sexes in animals and plants
(ii) Existence of A,B,AB and O blood group in human.

Causes of variation

Variations are caused by both genetical and environment differences. From the evolution point of view genetic variations are more important because they can be transmitted from parents to off springs.

The causes of genetic variations

1. Gene reshuffling

a. Independent assortment of genes at meiosis I allow gene reshuffling in in two ways

- ***orientation on the equator in metaphase I***

During metaphase I of the first meiotic division homologous chromosomes came together in pairs and subsequently segregate into a daughter cells independently of each other. The result of this independent assortment is the production of the wide variety of different gametes depending on which particular chromosome end up with one another in each cell.

- ***Crossing over***

In prophase of the first meiotic division, homologous chromosomes came together and make intimate contact with each other. Chromatid of homologous chromosome may break and rejoin at any place called chiasmata.

b. **Fertilization**

Union of gametes at fertilization results in alleles present in one gamete being united with alleles in another. If a population consist of large number of out breeding individual, the amount of variation that may result from this is again virtually infinite.

Despite the tremendous amount of variation these three processes may generate, they play only a limited role in evolution. The reason is that although they may establish a new combination of alleles in one generation, they do not generate long lasting variation of a novel kind.

2. Mutation

This is a change in the amount or structure of DNA of an organism. This produces a change in the genotype which may be inherited by cells derived by mitosis or meiosis. Individuals showing the new characteristics are referred to as mutants. Mutants arise spontaneously and in no sense 'directed' by the environment, although the environment greatly influence the mutation rate.

Factors or agents that speed up or lead to mutations are called **mutagens** include; Gamma rays, ultraviolet and a number of chemicals e.g., mustard gas, colchicine in plants

Effect of mutation

1. Mutations are persistent; they tend to be transmitted through many generation without further change.
2. The vast majority of mutation confers disadvantages on organism that inherit them.

Causes of mutation
Ultraviolent light
Chemicals
Freezing of cells

Types of mutation.

1. Chromosomal mutation

This may be the result of changes in the number or structure of chromosomes

a. **Change in number of chromosomes.**
This is usually due to errors occurring during meiosis and mitosis. The changes may involve the loss or gain of single chromosome a condition called **Aneuploidy** or the increase in entire haploid set of chromosomes a condition called euploidy[polyploidy]

Aneuploidy

In this condition where half of the daughter cell produced have an extra chromosome [n + 1], [2n + 1] and so on, while the other half have a chromosome missing [n- 1], [2n- 1] and so on. An aneuploidy can arise from the failure of a pair or pairs of homologous chromosome to separate during anaphase 1 of meiosis. If this occurs both sets of chromosomes pass to the same pole of the cell and separation of homologous chromosomes during anaphase II may lead to information of gametes containing either one or more chromosome too many or too few. This is known as non-disjunction.

One of the commonest form of chromosomal mutation in human resulting from non-disjunction of the G 2, chromosome is Dawn's syndrome [2n +1] characterized by mental retardation, reduced resistance to disease, congenital heart abnormalities a short stocky body and thick neck and the characteristic fold of skin over the inner corner of the eyes. Dawn's syndrome and other related chromosomal abnormalities occur more frequently in children born to older women. Klinefelter's syndrome is due to non-disjunction is sex chromosomes, which may result into individuals who have genetic constitution, XXY, XXXY, or XXXXY. These individuals are phenotypically male but have small testes and no sperm in the ejaculate. There may be abnormal breast development and the body proportions are generally female. Y is the cause of maleness.

Turner syndrome [2n- 1]: individual inherit a single X-chromosome (XO). Individuals with this condition often do not survive pregnancy and are aborted. Those that do are phenotypically female, but small in stature and sexually immature. Despite having a single X chromosome, like males, they are female, indicating again that the Y chromosome is the cause of maleness

Polyploidy

This occur when there is an increase in the entire haploid sets of chromosomes; i.e., 3n triploid], 4n [tetraploid]

Polyploidy is rare in animals but common in plants. Polyploidy is often associated with advantageous characteristics such as increased sized and greater, hardness of seeds, though such advantages are sometimes offset by reduced fertility. Polyploidy is sometimes induced by **colchicine** an alkaloid substance extracted from the crocus colchicum.

b. Structural change in chromosomes

These include loss, multiplication or changes in the sequence of bases on a chromosome

(i) Deletion; This involved loss of a piece of chromosome together with its genes.
(ii) Inversion; Here a chromosome breaks in two places and the middle piece then turns around and joins up again so that the normal sequence of gene is reversed.
(iii) Translocation; a section of one chromosome break off and becomes attached to another chromosome.
(iv) Duplication; a section of a chromosome replicates so that a set of gene is repeated.

2. Gene mutation

Gene mutation arises as a result of a chemical change in an individual gene and it 's thought to be very important in generating evolutionary change. An alternation in a sequence of nucleotide in a gene may change the order of amino acids making proteins. This may affect the fitness of the organism. It includes.

(i) **substitution**; here one base is substituted with another e.g., sickle cell anemia
(ii) **insertion;** here an extra base nucleotide is inserted into the genetical code.
(iii) **deletion;** here a base is lost from the genetic stand
(iv) There may be a change in the sequence of nucleotides in the gene

3. Somatic mutation.

Here mutation in non-reproductive cells of an organism. The resulting genetic change will present in all descended cells from the original mutant cell and may have profound effect of individuals.

However, as the genetic change is only in non-reproductive cell, it cannot be transmitted to feature generation.

Gene pool

A gene pool is the stock of different genes in an interbreeding population

Species with small **gene pools** may be easier to wipe out due to a natural event that favors one trait over the other. A **large gene pool** means variety of genes which prevents this

The composition of gene pool may be constantly changing from generation to generation as a result of natural selection or may be static in a stable environment.

Allele frequency

This the fraction of organisms in a population carrying a particular allele.

Genotype frequency

This is the fraction of organisms in a population carrying a particular genotype. The frequency of dominants and recessive allele in a population will remain constant from generation to generation provided the following conditions exist.

i. The population is large
ii. Mating is random
iii. No mutation occurs
iv. All genotype is equally fertile so that, no selection occurs
v. There is no emigration or immigration from and into the population, that is, there is no gene flow between population.

Any change in allele or genotype frequencies must therefore result from the alteration of one or more of the condition above. These are factors that significant in producing evolutionary a

Factors producing change of genotype are allele in population.

1. non- random breeding

Nonrandom mating occurs when the probability that two individuals in a population will **mate** is **not** the same for all possible pairs of individuals.

Sexual selection occurs whenever the presence of one or more inherited characteristics that increases likelihood of bringing about successful fertilization of gametes of some organisms and not in other.

There are many structural and behavioral mechanism in both plants and animals which prevent mating from being random, e.g. flowers possessing increased size of petals and amount of nectar are likely to attract more insects and increase the likelihood of pollination.

Thus, sexual selection, as a mechanism of non- random mating ensures that certain individual within the population have an increased reproductive potential so that their alleles are more likely to be passed to the next generation.

Examples of nonrandom mating;

(i) Inbreeding - individuals are more likely to mate with close relatives (e.g. their neighbors) than with distant relatives.
(ii) Large blister beetles tend to choose mates of large size and small blister beetles tend to choose small mates

2. Genetic drift.

This refers to the fact that variation in gene frequencies with populations can occur by chance rather than by natural selection. E.g., chance events such as premature accidental death prior to mating of an organism in a small population which is the sole possessor of a particular allele would result in the elimination of that allele from the population.

Note that

- **Genetic drift** is a mechanism of evolution in which allele frequencies of a population change over generations due to chance (sampling error).
- Genetic drift occurs in all populations of non-infinite size, but its effects are strongest in small populations.
- Genetic drift may result in the loss of some alleles (including beneficial ones) and the **fixation**, or rise to 100\%100%100, percent frequency, of other alleles.
- Genetic drift can have major effects when a population is sharply reduced in size by a natural disaster (**bottleneck effect**) or when a small group splits off from the main population to found a colony (**founder effect**).

Genetic load

This is the existence within a population of disadvantageous alleles in heterozygous genotype e.g. sickle cell trait in region where malaria is endemic.

Gene flow.

It's the movement of alleles from one population to another as a result of interbreeding between members of the two population.

Heterozygotes as a reservoir of genetic variation (the Hardy-Weinberg principle)

For a particular character in a population, the dominant form expresses itself more often that a recessive form, for example normal skin color is more common than albino. In a large population, proportion of dominant allele and recessive alleles of a particular gene remain constant. It is not altered by interbreeding. This constancy is known as the Hardy-Weinberg principle is expressed by a mathematical law

$P^2 + 2pq + q^2 = 1$

Where p = frequency of allele for dominant character
q = frequency of allele for recessive character

The formula can be used to calculate the frequency of any allele in the population. For example, imagine that a particular metal defect is the result of a recessive allele. If the number of babies born with the defect is 1 in 20000, the frequency of the allele can be calculated as follow:

The defect will only express itself in individual who are homozygous recessive. Therefore, the frequency of these individuals (q^2) = 1/20000 = 0.00005

The frequency of the allele q = $\sqrt{0.00005}$ = 0.007

Since P + q = 1

The frequency p of the dominant allele = 1- 0.007 = 0. 997

From the Hardy-Weinberg formula, the frequency of heterozygotes is 2pq
i.e., 2 x 0.997 x 0.007 = 0.014

in other words, 14 in 1000 or 280 in 20000 are carriers (heterozygotes) of allele.

This means that in a population of 20000 individual, one individual will suffer the defect and about 280 will carry the allele. The heterozygotes are acting as a reservoir of the allele, maintain it in the gene pool. As these heterozygotes are normal, they are not specifically selected against, and so the allele remains. Even if the defective individuals are selectively removed, the frequency of the allele will hardly be affected. In our population of 20000, there is one individual who has two recessive alleles and 280 with one recessive allele- a total of 282. The removal of the defective individual will reduce the number of alleles in the population by just 2, to 282. Even with the removal of the defective individual, it would take thousands of years just to halve the allele's frequency.

Occasionally, as the sickle cell anemia the heterozygotes individual have a selective advantage. This is known as heterozygote superiority.

Conditions that allow Hardy-Weinberg principle to be true

1. No mutation
2. The population is isolated i.e. there in no immigration or emigration
3. There is no natural selection or individuals are equally fertile
4. The population is large and mating random

Speciation

Speciation means the development of different genetic traits in an isolated sub population leading to a species distinctly different from original parent population. Or speciation is the process by which one or more species arise from previously existing species.

A species is a group of organisms which are potentially able to breed amongst themselves but not any other species.

A single specie may give rise to new species [intraspecific speciation] or as is common in many flowering plants two different species may give rise to a new species [(interspecific hybridization). If intraspecific speciation occurs whilst the population are separated it is

termed **allopatric speciation**. E.g. Galapagos island. If the process occurs whilst the population are occupying the same geographical area it is called sympatric speciation

Intraspecific speciation this will occur when gene flow with population is interrupted and each subpopulation is genetically isolated. Then change in allele and genotype frequencies with in each subpopulation as a result of natural selection on the range of phenotype produced by mutation and sex recombination lead to the formation of race and subspecies. If genetics isolation persists over a long period of time the subspecies may form new species

Speciation will only occur as a result of the formation of barrier which lead to reproductive isolation between members of the population.

Isolation mechanisms

An isolating mechanism is a mean of producing and maintaining isolation within a population. This can be brought about by mechanisms acting before or after fertilization.

(a) Prezygotic mechanism [barrier to the formation of hybrids]

(iii) **Seasonal isolation**; occurs when two species mate or flower at different time of the year. E.g., California Pinus radiata flowers in February whereas Pinus attenuata flowers in April

(iv) **Ecological isolation;** occurs where two species inhabit the similar regions but have difference habitat preference e.g., Viola arvensis grows on calcareous soil whereas viola tricolor prefers.

(v) **Behavioral isolation;** occurs where animals exhibit courtship patterns, that attract one individual for sex but not another.

(vi) **Mechanical isolation;** occur in animal where difference in genitalia prevent successful copulation and in plant where related species of flower are pollinated by different animals.

(b) Postzygotic mechanism [barrier affecting hybrids]

(i) **Hybrid in-viability;** Hybrid are produced but fail to develop to maturing. E.g. hybrid formed between northern and southern race of the leopard frog [Rana pipens] in North America.

(ii) **Hybrid sterility**; hybrid fail to reproduce functional gametes; e.g., the male [2n= 63] result from the cross between the horse [Equus hernionus 2n = 66]

(iii) **Hybrid breakdown;** F1 hybrid are fertile but the F2 generation and back crosses between F1 hybrid and parental stock fail to develop or and infertile i.e., hybrid formed between species [genus Gossypium].

Allopatric speciation.

This is characterized by occurrence at some stage of spatial separation. Geographical barriers such as mountains range, seas, river or habitant preference may produce a barrier to gene flow

because of spatial separation. This inability of organism or their gametes to meet leads to reproductive isolation. Adaption to new conditions lead to change in alleles and genotype frequencies. Prolonged separation of population may result in them becoming genetically isolated even if brought together. In this way new species arise.

Sympatric speciation
This is the speciation that occur within the population in the same geographical areas where reproduction isolation may result from structural, physiological behavior of individuals within a population, e.g. polyploidy in plants.

Artificial selection: This when breeders' animals and plant select individuals with the characteristic that are wanted and allow them to interbreed, individual lacking the desire qualities are prevented from breeding. By rigorous selection over many generation special breed or varieties may be developed for particular purpose.

Animals that have been subjected to artificial selection include.
-cow for beef and milk
-Sheep for wool and meat
-horse for racing and holing
-pig for bacon and lard production
-dog for beauty

Among plants crops such as wheat, barley and potatoes, have been bred for higher yield, greater resistance to disease and drought.

Inbreeding.
This is the crossing of closely related individuals. Inbreeding leads to a loss of fitness known as in breeding depression. This is because an individual produced as a result of the crossing of the close relatives is more likely to have two copies of harmful or ever lethal recessive alleles.

Hybrid.
Is the result of cross between individuals belonging to two different varieties [out breeding] such individuals show hybrid vigor. This is because hybrid tend to be heterozygous at many of their loci. Any harmful allele therefore has their effect masked by healthy ones.

The green revolution
This is the production of new varieties of the world major food crop such as rice, wheat, maize and barley by agriculturalist in the recent past.

In general, the new varieties display some or all the following advantage over the older one.

1. There stems are shorter, resulting in dwarf varieties which are less likely to be flattened by wind and rain and can be more easily harvested.

2. They give a higher yield per unit area

3. They show a greater response to water & fertilizer.

4. They are relatively insensitive to day length and or imperative, with the result that two or even three crops may be grown per year.

5. They are more resistant to pests and disease.

The disadvantage of green revolution.
New varieties required high level of fertilizer which are expensive and not always available in developing countries introduction of these species in developing world concentrates wealth in the hands of the minorly of farms able to afford artificial fertilizer.

EVIDENCE OF EVOLUTION.

1. Geographical distribution
2. Comparative anatomy
3. Embryology
4. Taxonomy
5. Paleontology

1. Geographical distribution

The earth is believed to have been composed of one continent from which different day present continents involve apart. For instance, the following provide evidence that the eastern coast of south America was once in contact with the western coast of Africa.

a. The two coastlines of the two continents are complementary.

b. Presence of fossil deposit of mosasaurs [fossil reptile] only on the eastern part of Africa with no evidence of migration.

The distribution of animals and plant on different continent provide due to the possibility of evolution as described in the following;

Example

a. The Northern hemisphere where continents are close together and where evidence point that there was a continuous land bridge linking them in the geological past; mammals on these continents are very similar. It possible that mammals that evolved to give rise to new species and generally some which moved from North America to Euroasia or vice versa. In other words, different mammals evolved in these two continents but the geographical closeness of the two regions kept their faunas together and prevented them from diverging greatly.

b. The southern hemisphere where the continents were widely separated from each other there is a sharp contrast in mammal that inhabit Africa [lion, giraffe], Southern America [e.g., tapir, puma and Australia [kangaroo]. The wide separation meant that only very rarely was there exchange of mammals between them, so the mammals each evolved independently along their own.

c. Oceanic Islands [islands that originated from volcanic eruption and never had any contact with the main land]

i. Species on these islands had close similarities to those on the mainland but plants and animals on the islands such as the giant tortoise were noticeably larger in most case probably because they lacked competition from larger and more dominant, Advanced species which were absent from the islands but which co- habited with smaller related species on the main land.

ii. The competition for food, space and mate between the a abundant Iguana lizard on the Galapagos island probably lead to evolution of the two species one on land and another in water. The aquatic form had adaption for locomotion in water such as a laterally-

flattened tail and well-developed webs of skin between the toes of all for limbs and feeds on marine algae.

iii. The competition for food probably lead to evolution of finches' beaks shape to enable different finches to feed on different food e.g. Darwin found finches with beaks for crushing seed, eating insects, sucking nectar, catching insect in flight and others for eating insect larvae or Galapagos island

2. Comparative anatomy

Comparative study of the anatomy of groups of animals and plants[morphology] released that certain structural features are basically similar. For example, the basic structure of all flower consists of sepals, petals, stamen, stigma, style and ovary, yet the size number of parts and specific structure are different for each individual. Similarly, the limb- bone pattern of all tetrapod from amphibian to mammal has the same structural plan; called the pentadactyl limb. These common basic structures on organism suggest common ancestry. In each case, structure are modified for a particular function in a particular environment. Some homologous structure that fail to develop full functions and/or structure are referred to as vestigial organs.

Homologous structure

These are organs that have a similar basic structure, similar topographic relationship as structure in other species the same histological appearance, similar embryonic development but showing adaptation to different environmental condition and modes of life. E.g., wings of bird and arms of man, Halters of Diptera [housefly] and hind wing many flies.

Adaptive radiation

This is a term used to describe the differentiation of homologous structure to perform a variety of function e.g., mouth parts of insects consist of the same basic structure but maxilla in butterfly is modified for suckling and manipulating food in grasshopper;

Adaptive radiation is the relatively fast evolution of many species from a single common ancestor. **Adaptive radiation** generally occurs when an organism enters a new area and different traits affect its survival. An **example** of **adaptive radiation** is the development of mammals after the extinction of dinosaurs

Divergent evolution.

Divergent evolution is the process whereby groups from the same common ancestor **evolve** and accumulate differences, resulting in the formation of new species.

Analogous structure

These are structure of organism bearing no close phylogenetic link but showing adaptation to perform the same function e.g.,

-wings of insects and bats
-the jointed legs of insects and vertebrates

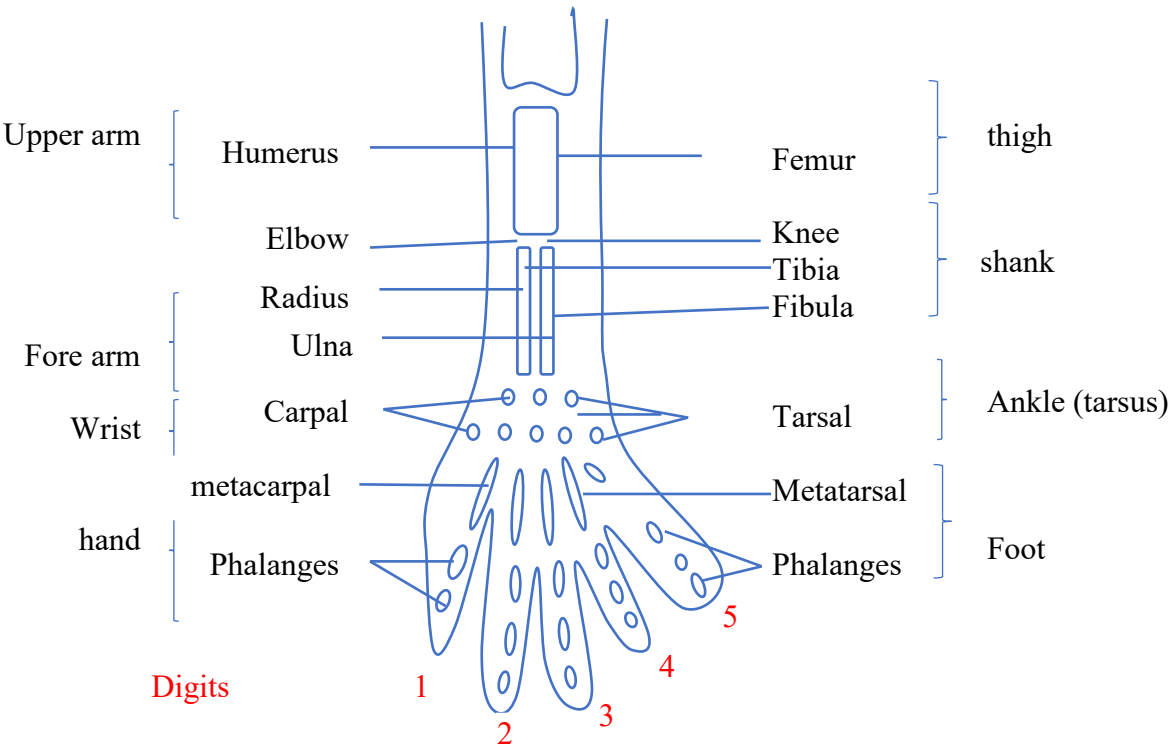
Convergent evolution

This is the evolution where structure believed to have different ancestry origin are modified to perform the same basic function. E.g. wings of bird and insects

Vestigial structures.
These are structures that have been greatly reduced or lost from organisms. For example, the third digit in birds wings is very much reduced while the fourth and fifth are missing. The existence of vestigial structure has been used as evidence for evolution. It is thought that vestigial structure performed a function in the ancestor but have since been reduced to such an extent that they are lost or greatly changed their original function.

Pentadactyl limb.
It is so called because typically has five digits is formed in all four classes of terrestrial vertebrate [amphibian, reptile, birds and mammals] some of the limbs bone can even be traced back the fins of certain fossil fishes from which the first amphibians are thought to have evolved.

Generalized (pentadactyl limb)
Fore arms



Through divergent evolution the pentadactyl limb have become adapted for different function in some species some or all the foes or finger have been lost eg

Seal - for swimming
Human - for manipulation / grasping
Horse - for running
Mole - for digging

Bat or bird - for flight

3. Molecular biology / Biochemistry / cell biology

The following examples of comparative molecular biology / Biochemistry provide evidence for evolution.

(i) The presence of similar biological molecules such as nucleotide, ATP, cytochrome and certain organelles such ad ribosome in all living organism support the view that all living organism had a common ancestry.

(ii) The differing degree in amino acid sequence of proteins from one species or another is also used to show evolution. The closure species in evolution the closure the similarities in the amino acid sequences in their proteins

(iii) Like with proteins close evolutionary species show close similarities in their DNA base sequences, the comparison carried out by a technique of DNA hybridization.

(iv) Embryology; Similarities in embryonic development stage in thought to have evolutionary significance. Species believed to have a close evolutionary past have been found to show similar embryonic stages. For example, presence of branchial groves and segmental myotomes in human embryo is suggestive of a fish ancestry.

4. Embryology

Similarities in embryonic development stages is though to have evolutionary significance

Species believed to have a close evolutionary past have been found to show similar embryonic stages. For example, presence of branchial groves and segmented myotomes in human embryo is suggestive of a fish ancestry.

5. Paleontology

This is the study of animals and plants of the past as seen in the fossil records. Fossils are any form of preserved remains through to be derived from living organism. They include entire organism, hard skeletal structure, moulds and casts, petrifactions, impression , imprints and coprolites [fossilized fecal pellets]

(i) There is evidence from fossil that there has been progressive increase of complexity of organism which denies the fixity of species. The oldest fossil bearing rock contain very few types of fossilized organism and they all have a simple structure. Young rocks contain a greater variety of fossils with increasing complex structures.

(ii) Throughout the fossil record many species which appear at an early stratigraphic level disappear at a later level. This is interpreted in evolutionary term as indicating the time at which species originated and became extinct.

(iii) Geographical evidence suggest that geographical regions and climatic conditions have varied throughout the earth's history. Since organism are adapted to particular environment, the constantly changing condition may have favored a mechanism for evolutionary change that account 4 that progressive change in the structure of organism as shown in fossil record.

Ecological consideration also fit in with the fossil evidence. e.g. Plants appeared on land before animals, and insects appeared before insect pollinated flowers

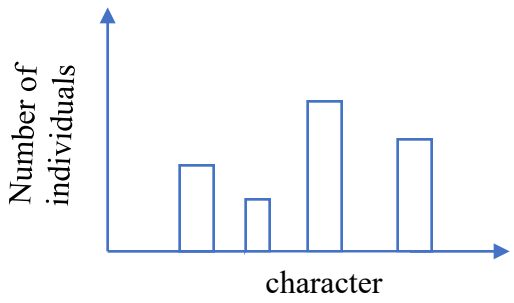
6. **Taxonomy**
   This is the study of principals, rules and methods of classification. The system of classification proposed by Linnaeus before the time of Darwin and Wallace, based on phylogenetic similarity and differences between organism may suggest existence of evolutionary process. There are similarities and differences between organism may be explained by organism with each taxonomic group to particular environmental conditions over a time.

Numerical taxonomist, working mainly from comparative phenotypic characters have found it possible to construct **phenetic classification** system which in consistent, to the extent of present knowledge with the concept of evolution organism that have close evolutionary relationship share very many similar characteristics.

Objective questions

1. The gene for albinism is recessive to that form normal skin pigment in human. In a population where the frequency of albinism is 10%, the expected proportion of albinos in the population would be
   A. 0.1
   B. 0.01
   C. 0.8
   D. 0.9
2. Insect and vertebrate living on land have jointed limbs for locomotion. This is an example of
   A. Convergent evolution
   B. Adaptive radiation
   C. Divergent evolution
   D. Natural selection
3. Which one of the following factors is **least** likely to contribute to the development of new species?
   A. Gene mutation
   B. Reproductive isolation
   C. Geographical isolation
   D. Stabilizing selection
4. Which one of the following may cause adaptive radiation to a variety of species?
   A. Stabilizing selection
   B. Directional selection
   C. Cessation of selection
   D. Disruptive selection
5. Which one of the following may occur to a community of organism as a result of natural selection?
   A. Increase in the number of species
   B. Adaptive to the environment by all organism
   C. Extinction of species
   D. Reduction in the level of mutation
6. Which one of the following pairs of structures are not homologous?
   A. Arms of humans and wings of birds
   B. Legs of insects and those of mammals
   C. Ponds of bean and pericarp of maize grain
   D. Pectoral fins of fish and arms of humans
7. From the following sources of variation, which one has the highest chance of producing new species
   A. Crossing over
   B. Independent assortment
   C. Mutation
   D. Random fusion of gametes

8. Which one of the following is likely character in mammalian population illustrated in figure 1?



A. Height
B. Ear size
C. Blood group
D. Finger length

9. Which one of the following results when a gamete with non-disjunction is fertilized?
A. Duplication
B. Translocation
C. Monosomy
D. Polyploidy

10. Which one of the following is least likely to occur when organism of similar species competes for some limited resource?
A. Range restriction
B. Aggression towards each other
C. Extinction
D. Coexistence

11. Individuals lacking desired qualities are prevented from mating during artificial selection using the following methods except
A. Extermination
B. Segregation
C. Sterilization
D. Cross breeding

12. Structures of common origin modified in various ways to adapt animals to different modes of life is an illustration of
A. Homologous structure
B. Convergent evolution
C. Analogous structure
D. Cooperative anatomy

13. Which one of the following is likely to cause a faster rate of evolution?
    A. Stabilizing selection
    B. Directional selection
    C. Disruptive selection
    D. Slow changing environment

14. The more the variation in population, the greater is its potential to
    A. Give rise to gene flow
    B. Adapt to new changes in environment
    C. Produce more offspring
    D. Grow fact

15. Functional resemblance of wings of butterfly and a bird although from different origin, is an example of
    A. Homology
    B. Autology
    C. Analogy
    D. Phylogeny

16. The following are trisomic conditions except
    A. Klinefelter's syndrome
    B. Turners syndrome
    C. Down's syndrome
    D. XXX female

17. Which of the following is not likely to bring evolutionary change in a population?
    A. Crossing over
    B. Migration
    C. Mutation
    D. Genetic drift

18. Which one of the following structures is **not** homologous with the rest?
    A. Bat wing
    B. Human fore arm
    C. Insect wing
    D. Bird wing

19. Which of the following conditions result from gene mutation?
    A. Klinefelter's syndrome
    B. Turners syndrome
    C. Sickle cell anemia
    D. Dawn's syndrome

20. Which of the following factors would contribute least to the development of new species?
    A. Gene mutation
    B. Chromosomal mutation
    C. Geographical isolation

D. Environmental stability

21. Insects have different mouth parts modified to suit their different modes of feeding. This shows:
    A. Speciation
    B. Convergence evolution
    C. Divergent evolution
    D. Development of analogous structures

22. Which of the following maintains the highest level of genetic uniformity?

    A. Interbreeding
    B. Selective breading
    C. Random breeding
    D. inbreeding

23. A possible explanation for occurrence of gill slits on a human embryo is that

    A. gill slits are required for respiration at early stages
    B. human may have evolved from fish
    C. human and fish have a common ancestry
    D. evolution still occurs

24. Among the following sets of organs; which contains homologous structures only?
    A. bat wing, bird wing, human fore arm
    B. fish pectoral fin, human for arm, insect wings
    C. bird wing, bat wing, insect wings
    D. fish pectoral fin, bat wing, human forearm

25. Which one of the following would not lead to evolution?

    A. Better suited phenotype in a specific environment increasing in number
    B. The environment remains stable for a long time.
    C. Organism producing more offspring than the environment can support
    D. A large number of offspring dying before reproduction.

26. Which of the following is not a form of inbreeding?

    A. Cross-breeding offspring of the same parent
    B. Self-pollination
    C. Back crossing
    D. Test crossing

27. The camel family is found only in North Africa, Asia and South America. This is an example of

    A. Adaptive radiation
    B. Convergence radiation
    C. Divergent evolution

D. Discontinuous distribution

28. The study of gross morphological and histological appearance of an organism in ecology is best described as

A. Comparative physiology
B. Comparative embryology
C. Comparative anatomy
D. Cell biology

29. The appearance of a gene of evolutionary advantage is a function of

A. Chance
B. Environmental demand
C. Needs of organism
D. Nature plan

30. Which one of the following would cause phenotypic variation among organisms of the same genotype?

A. Exposure to different environment
B. Continuous variation within the species
C. Different sex
D. mutation

31. The phylogenetic approach to classification is used because it groups together all animals that show

A. analogous structures
B. homologous structures
C. convergent evolution
D. Adaptive radiation

32. Which of the following may be a result of inbreeding?

A. Improved fertility
B. Accumulation of lethal gene
C. Polyploidy
D. Increased mutation rate

33. Which of the following is not a likely result of polyploidy in plants?
A. Increased hardness
B. Resistance to diseases
C. Decreased hybrid vigour
D. Formation of seedless large fruits

34. Two population of a given species could only evolve into two distinct species if they are subjected to

A. Disruptive selection
B. Geographical isolation
C. Stabilizing selection
D. Genetic isolation

35. The pastoralist usually retains which his herd, a bull whose ancestor have got desirable characteristics. This is an example of

A. Inbreeding
B. Natural selection
C. Cross breeding
D. Artificial selection

36. The existence of different castes within termite is an instance of

A. Polymorphism
B. Genetic drift
C. Melanism
D. natural selection

37. Which one of the following effects of deforestation will least affect the gene pool of a population in a forest?

A. Accumulation of carbon dioxide in the atmosphere
B. Decrease in the number of individual at each trophic level
C. Loss of habitat for animal species
D. Decrease in the number of trophic levels in the forest ecosystem

38. The occurrence of a genetic defect among individuals of an isolated population in a percentage higher than expected is likely to be a result of

A. Natural selection
B. Speciation
C. Adaptation
D. Genetic drift

39. Which one of the following does not lead to change in allele frequency of a population?

A. Mutation
B. Selection
C. Sexual recombination
D. Genetic drift

40. The similarity of the skeletal structures of mole, monkeys and whales lead to the conclusion that they

A. Belong to the same class
B. Originate from the same environment
C. Descend from a common ancestor
D. Evolved converging

41. Which one of the following would lead to genetic death in animal population?
A. Hemophilia in a population
B. Sickle cell trait in a population
C. Infertile males in a population
D. Albinism in a population

42. The following can result in some variation of the offspring **except**

A. Haploid parthenogenesis
B. Fragmentation
C. Conjugation
D. Self-fertilization

43. Which of the following show divergent evolution?

A. Wings of a cockroach and a bat
B. Skeleton of a mouse and cray fish
C. Fore limbs of a pigeon and a monkey
D. Eyes of a locust and a kite

44. The possession of similar structures in an organism having different ancestral origin is a result of

A. Convergence evolution
B. Divergence evolution
C. Adaptive radiation
D. Parallel evolution

45. Which one of the following may occur to a community of organisms as a result of natural Section?

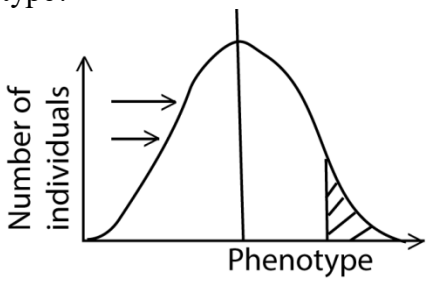
A. Increase in the number of species.

B. Adapting to the environment by all the organisms.

C. Extinction of species.

D. Reduction in the level of mutation,

46. Which one of the following would happen to individuals of the population in the shaded area in the figure below if selection pressure continued for generations acting on the phenotype?



They would

A. Develop onto two distinct population
B. Die off and become extinct
C. Evolve into new species
D. Multiply in numberl.

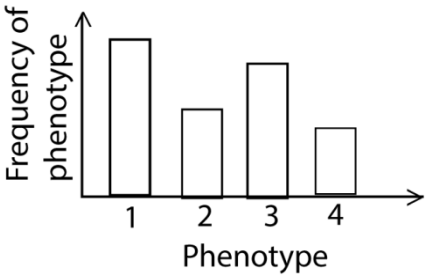
47. Which one of the following genetic abnormalities does not result from non-disjunction?

A. Klinefelter's syndrome
B. Turner's syndrome
C. Hemophilia
D. Down's syndrome

48. Variation among organisms which reproduce by fission can be due to

A. Crossing over
B. Mutation
C. Random fertilization
D. Independent assortment

49. The figure below shows he frequency of a trait among a group of students



The difference in the phenotype s is due to

A. The altitude where individual live
B. Genetic make up
C. Frequency of disease among individual
D. Different diet among individuals

50. In breeding , the propagation of a variety with desirable characteristics is referred to as

A. Hybridization
B. Artificial selection
C. Cross breeding
D. inbreeding

51. Human eye and octopus' eye are examples of
    A. Homology
    B. Divergent evolution
    C. Analogy
    D. Adaptive radiation

52. Which one of the following pairs of structures are not homologous?

    A. arms of humans and wings of birds.

    B. Legs of insects and those of mammals.

    C. pods of beans and pericarps of maize grains.

    D. pectoral fins of fish and arms of humans.

53. From the following sources of variation, which one has the highest chance of producing new species?

    A. crossing over B. Independent assortment

    C. mutation. D. Random fusion of gametes.

54. (a) Distinguish between hybrid and hybrid vigour

    (b). Explain how each of the following may alter the gene frequency

    (i) Closeness of population

    (ii) Small population size

55. In human albinism is caused by an autosomal recessive allele. On average 1 in 10,000 is an albino.
    (a) Give two characteristics of an albino (2marks)
    (b) Using Hardy Weinberg formula p2 +2pq + q2 = 1, determine
        (i) the frequency of the albino allele in human population (2marks)
        (ii) Frequency of heterozygous genotype in the population (2mars)
    (c) Explain why it is difficult to eliminate recessive alleles from a population (4mark)

56. When extensive lakes that existed in Bunyoro were reduced to isolated pools many years ago, four species of fish evolved as a result
    (a) Suggest how the drying up of the lake system to isolated pools have resulted in evolution of the four new fish species. (4marks)
    (b) Describe how environmental factors act as stabilizing forces to natural selection in an isolates pool after the evolution of a new species. (03marks)
    (c) Suggest what would happen to the fish species if water levels rose and the isolated pools once again formed an extensive lake system. (03marks)
57. (a) Explain the meaning of the Hardy- Weinberg equilibrium principle (1mark)
    (b) State four conditions that must be fulfilled in order the principle to hold true (2marks)
    (c) Brown eyes in a human population is caused by a dominant allele. If in a population, 84% of the people have brown eyes, using Hardy-Weinberg formula, determine the percentage of the population who are
    (i) Heterozygous for eye color. Show your working (4marks)
    (ii) Homozygous dominant for eye color. Show your working. (3marks)

58. (a) Outline the cause of gene reshuffling
    (b) In what way may variation resulting from gene reshuffling differ from that caused by mutation?

    (c) What is the importance of variation in a population?

    (d) Explain how constancy of species may be maintained through natural selection

59. (a) State three ecological problem which arise from the accumulation of domestic waste in urban communities
    (b) Give two ways reducing domestic waste.

(c) Figure 8 show lichen species growing along a 20km transect from urban Centre.

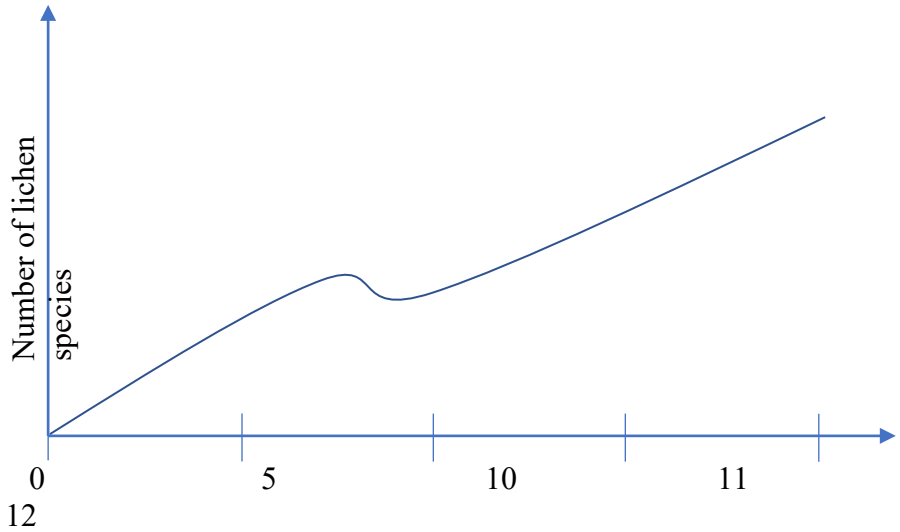


Fig. 8

(i) Explain the trend in the lichen species with distance

(ii) Suggest an explanation for the observed number of lichen species at a distance of 10km from the urban Centre.

60. (a) How does resistance of malarial parasite to antimalarial drugs occur?

(b) How may each of the following lead to speciation
(i) genetic drift
(ii) Un random mating

61. (a) Using examples. Give the meaning of adaptive radiation of species? (2marks)
(b) State the ecological importance of adaptive radiation (2marks)
(c) How do adaptive radiation and homologous structures give evidence of evolution?
(i) Adaptive radiation (3marks)
(ii) Homologous structures (3marks)

62. (a) (i) What is meant by natural selection? (2marks)
(ii) How does it occur? (6marks)
(b) What is the importance of natural selection? (2marks)
63. (a) What do you understand by gene pool? (2marks)
(b) What may cause a gene pool of a population to be static? (2mk)
(c) (i) state three factors that may contribute to change in frequency of dominant and recessive alleles in a population. (3marks)

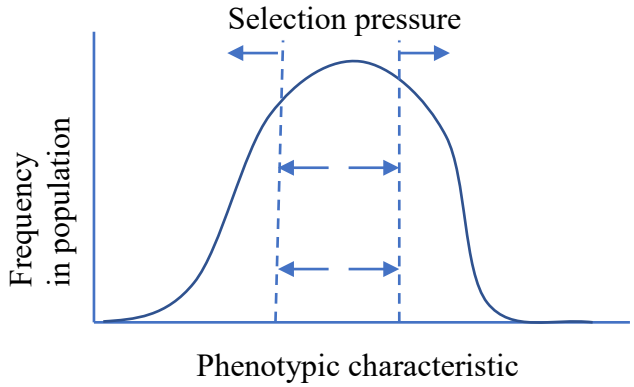
(ii) Explain how each factor stated in c(i) above may cause change in the frequency of dominant and recessive alleles in a population. (3marks)

64. (a) State Darwin's theory natural selection.
(b) State three observations and two deductions from which Darwin derived this theory.
(c) How does the modern view on evolution differ from Darwin's View?

65. (a)(i) What is mutation?
(ii) State the possible causes of mutation
(b) What is the role of mutation in evolution of new species?

66. Explain what is meant by each of the following concepts:
(a) Continental drift
(b) Divergent evolution
(c) Industrial melanism
(d) Vestigial organs

67. The figure below illustrates selection pressure acting on a population of butter fly



(a) State the type of selection being exhibited in the figure (1mark)
(b) Explain how this type of nature selection affect the phenotypic characteristics of the population.
(c) (i) In the space below sketch the distribution curve that would result after many generations of this type of natural selelction shown in (a)
(ii) What ecological effect does the above type of selection have on the population? (3marks)
(d) State the importance of genetic variation in natural selection? (2marks)

68. (a) Distinguish between hybrid and hydbrid vigour (2marks)
(b) Explain hwo each of the following may alter the gene frequency.
(i) Closeness of population. (4marks)

(ii) Small population size (4marks)

Assay questions

69. (a) What is meant by genetic drift (04 marks)
(b) How can the genetic equilibrium of a population be upset? (9marks)
(c) Explain how humans influence the evolution of species (7marks)

70. (a) What is meant by the term natural selection? (3marks)
(b) Describe the role of each of the following in natural selection
(i) Mutation (5marks)
(ii) Meiosis (8mars)
(c) Fertilization (fertilization) (4marks)

71. (a) Explain what is meant by variation. (2marka)
(b) How does meiosis contribute to variation? (07marks)
(c) Describe the role of variation in evolution. (11marks)

72. (a) Explain the following
(i) Genetic isolation (2marks)
(ii) Reproductive isolation (3marks)
(b) Explain how the gene frequency of a population may be altered. (15marks)

73. (a) (i) Giving an example, explain what is meant by discontinuous variation? (3marks)
(ii) How does sexual reproduction cause variation? (8marks)
(b) Explain how the environment influences the process of natural selection? (9marks)

74. (a) Give the different forms of isolation of species (3marks)
(b) How may each of the forms of isolation given in (a) above lead to formation of species (17marks)

75. (a) What is meant by the following phenomena?
(i) Natural selection
(ii) Reproductive isolation
(iii) Polyploidy
(4marks)
(b) Explain the role played by each of the phenomena in (a) above in evolution of new species (11marks)
(c) How may species become extinct? (5marks)

76. Describe how new species of organism may arise

77. (a) State five evidences of evolution.
(b) To what extent do the evidences you have stated in (a), support the theory of evolution?

78. (a) Distinguishes between continuous and discontinuous variation. (02marks)
(b) Explain how each of the following causes variation in sexually reproductive organism.

(i) crossing over during mitosis (03marks)
(ii) independent assortment of chromosomes during meiosis (05marks)

79 (a) Giving examples, explain effect of
(i) Increasing selection pressure on a population (07marks)
(ii) Stabilizing selection pressure on a population (07marks)
(b) Explain hoe comparative anatomy supports the process of evolution (06marks)

80. (a) Table 1 shows the number of individual with a given length of fur in a population of terrestrial mammalian species for two different generation. The prevailing climatic temperature during the two generations changed from 15^0C to 10^0C.

Length of fur (cm)	Number of individuals	
	At 15^0C	At 10^0C
1.00	0	0
1.25	25	0
1.50	60	0
1.75	120	20
2.00	155	60
2.25	120	130
2.50	60	155
2.75	25	130
3.00	0	60
3.25	0	20
3.50	0	0

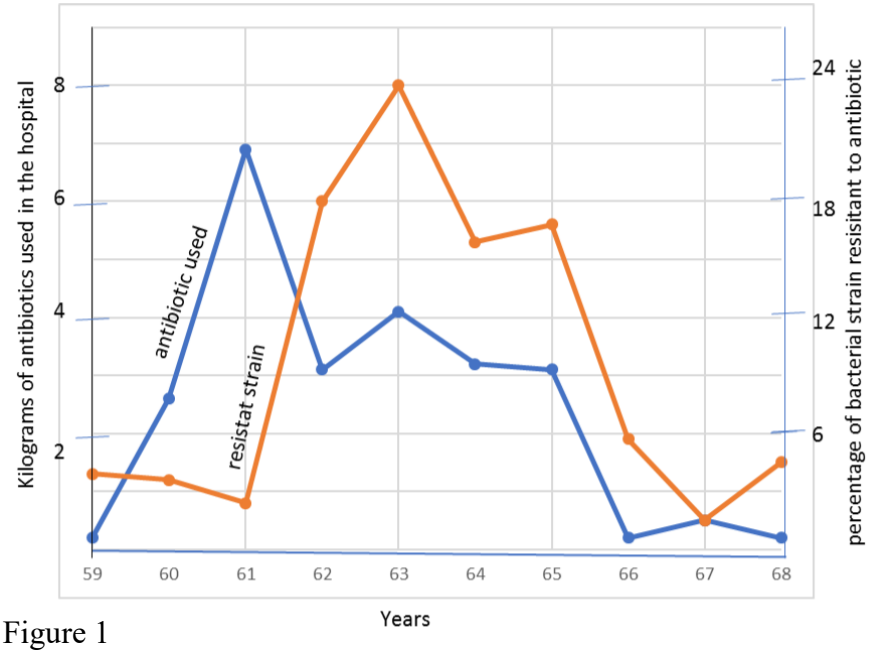


Figure 1

(a) Draw a graph of the relationship between fur and number of individuals at the two temperatures (08marks)

(b) What is the optimum length of fur at each temperature? (2marks)

(c) (i) What is the effect of temperature on fur length among the individuals? (03marks)

(ii) Suggest an explanation for the effect of temperature on fur length. (05marks)

(d) (i) From figure 1, describe the trend of resistant strain with amount of antibiotics used (3marks)

(iii) Suggest an explanation for the observed trend of resistant strains with the amount of antibiotic used (03marks)

(e) A bacterium is a haploid organism that produce asexually by fission, twice every minute on average. Using this information, explain the rapid emergence of resistant strain (06marks)

(f) The data in table 1 and figure 1 illustrate the process of natural selection. State the selection pressure in each case (02marks)

(g) Giving a reason in each case, predict what the effect of each of the following would be

(i) If the use of antibiotics was stopped for a year. (05marks)

(ii) If the generation of the terrestrial mammal at a prevailing temperature of 10^0C was supplied with an abundance of food (03marks)

Answers to objective type questions

1	B	11	D	21	C	31	B	41	C
2	A	12	A	22	D	32	B	42	B
3	D	13	B	23	C	33	C	43	C
4	D	14	B	24	A	34	D	44	A
5	C	15	C	25	B	35	D	45	C
6	B	16	B	26	D	36	A	46	C
7	C	17	A	27	D	37	A	47	C
8	C	18	C	28	C	38	D	48	B
9	C	19	C	29	A	39	C	49	B
10	D	20	D	30	A	40	C	50	B

51. C 52. B 53. C

54. Solution:

(a) A hybrid is an offspring of a cross between two closely related but genetically distinct populations.

A hybrid vigour, on the other hand, refer to phenotypes of hybrids showing characteristics which are superior to either of the parental stock.

(b) Gene flow occur between closely related population as a result of interbreeding between members of the two population. The **random introduction** of new alleles into the recipient population and their removal from the donor population affects the allele frequency of both populations and leads to increased genetic variation.

((ii) In a small population, not all the allele which are representative of that species may be present. It is very possible for new alleles to appear and present ones to disappear simply by chance, a phenomenon called genetic drift. Chance events such as accidental death prior to maturity of an organism which is the sole possessor of a particular allele would result in elimination of the allele from the population, reducing its frequency. Equally possible. An allele may drift to a higher frequency simply by chance.

55. Solution

(a) Light coloured skin

White hair

Others:

Pink eyes.

(b) (i) frequency of the albino allele = q

Frequency of albinism (q^2) = $\frac{1}{10000}$

i.e. q^2 = 0.0001

= $\sqrt{0.0001}$

Q = 0.01

Hence the frequency of the albino allele in the human population is 0.01.

P + q = 1

P + 0.01 = 1

But p + 2pq + q = 0.99

But $p^2 + 2pq + q^2$ = 1

$(0.99)^2 + 2pq + (0.01)^2$ = 1

0.9801 + 2pq + 0.0001 = 1

2pq = 1- 0.9802

2pq = 0.0198.

Hence the frequency of the heterozygous in the population is 0.0198.

(c) A large proportion of the recessive alleles in a population exist in the carrier heterozygote's. As a result, very few can be eliminated from the population in each generation. Only alleles present in the homozygous recessive organism will be expressed in the phenotype and so be exposed to environmental selection and possible elimination.

(d) Also, certain recessive alleles confer extra advantage to organism containing then I heterozygous state. The maintains the allele in the population. For example, the sickle cell allele.

56. Solution:

(a) Isolated pools form different geographical micro-environments. This causes geographic isolation of fish in different pools. It prevents interbreeding and thus no gene flow occurs.
Since conditions are different in the different pools, different characteristics are selected for in the pools.

(b) When environmental conditions in each pool change, fish which is better adapted to the condition in each pool survive while fish with unfavorable characteristics are selected against and do not survive. Since the pools have different conditions, different strains of fish evolve.

(c) All the different fish species mix up again and:
Competition between species may reduce the number of some species of fish. The better adapted will survive while others die and may become extinct.
If restricted to different area (niches of the lake, there will be less competition. As a result, most or all species may survive so that a lake with different species of fish is formed.
There may restriction of interbreeding so that the different species exist separately in the lake.
If interbreeding occurs, more new species of fish evolve in the lake.

57. **Solution**

(a) Provided there are no disruptive influence such as mutations or selection, the frequency of alleles in a population remains constant, generation after generation.
There is continued movement of gene (gene flow) within the population due to breeding but the overall gene frequencies remain constant. This stability is referred to as genetic equilibrium.

(b) No mutation occurs
Mating must be random
The population must be large.

No emigration or immigration from or into the population should occur

Others

Generations should not overlap

All genotypes should be equally fertile, so that no selection occurs.

(c) Let the allele for brown eyes be B

The allele for other eye colour be b

Frequency of allele B be p

Frequency of allele b be q

Given BB+ Bb constitute 84%

The hardy-Weinberg equation states

$P^2 + 2pq + q^2 = 1$

given $p^2 + 2pq = 0.84$

$q^2 = 1 - 0.84$

$q^2 = 0.16$

$\Rightarrow q = 0.4$

Also $p + q = 1$

$P = 1-0.4$

$P = 0.6$

$\Rightarrow (0.6)^2 + 2pq = 0.84$

$2pq = 0.84-0.36$

$2pq = 0.48$

Hence 0.48% of the population are heterozygous.

(ii) from above

$P = 0.6$

$\Rightarrow$ BB = p2 = (0.6)2

.; BB = 0.36

% 0f BB = 36%

hence, the percentage of individual homozygous dominant for eye colour is 36%

58. Solution

(a) - Crossing over prophase 1 in meiosis
- independent assortment at metaphase 1 of meiosis
- Random fusion of gametes from two parents during fertilization.

(b) - Gene reshuffling new combination of the same alleles and as a result leads to variation in combinations of the same characters.

- Mutations lead to formation of completely new alleles leading to production of completely new characters.

(c) – May lead to emergence of new species.

- Increase chances of organisms to survive in different habitats.

-Increase chance of resistance of organisms to diseases and toxic substances.

- increases chance of population size control by natural selection

-Reduces competition for natural resources.

(d) - Species in a population show variation in characteristic. These act as the basis for genes of the next generation.

Individuals with characteristic favored by the environment survive to pass on their genes to the next generation.

Those with unfavorable characteristics are weeded out.

This naturally controls the population size as selection pressures are constantly changing as do the adaptations of organisms from time to time.

59. Solution

(a) Untreated sewage may end up in water bodies, causing eutrophication

Destruction of habitats for living organism in place where it is piled.

Decay of the waste in absence of oxygen produces methane a greenhouse gas

Others:

Leads to transmission of deadly communicable diseases that may lead to destruction of lives.

Causes air pollution.

(b) Recycling of non-biodegradable materials in domestic waste.

Burying biodegradable rubbish.

Others;

- Burning rubbish to treating it with chemicals to reduce bulk.
- Use of organic waste to generate power (biogas)
- Use of organic waste to produce fertilizers. use of biodegradable packaging

(c) (i) The number of lichen species generally increases with distance from the urban centre

Explanation

The level of pollution from industries in the urban centre reduces with increased distance from the urban centre. This leads to reduced levels of sulphur dioxide gas promoting lichen growth.

There is a reduction in the number of lichen species at a distance of 10km from the urban centre. This is due to dumping of waste in the area, presence of an industry or small town and bush burning

60. **Solution**

(a)

(i) Failure of the parasite to absorb the drug

(ii) Formation of inaccessible forms during its development life cycle in man (tissue hypnozoites)

(iii) Parasite may use alternative biosynthetic pathway not affected by the drug.

(iv) The parasite tissue may become tolerant to drug molecules

(b)(i) Genetic drift

- **Genetic drift** is a mechanism of evolution in which allele frequencies of a population change over generations due to chance (sampling error).
- . Lose of gene from or increase in allele frequency of gene in population may alter the selection pressure in a population leading development of new species.
- Although genetic drift happens in populations of all sizes, its effects tend to be stronger in small populations

(ii) non random mating

- un random mating or sexual selection occur naturally when the presence of heritable characteristic increases the likelihood of bringing about successful fertilization.
- Traits that lead to more mating for an individual lead to more offspring and through natural selection, eventually lead to a higher frequency of that trait in the population.
- If the gene for the characteristic increase in successive generation a new species may develop.

61. Solution

(a) It is specialization of homologous structures to serve different functions. For example, the fore limbs of man (arms) are modified for manipulation while those of bird (wings) for flight.

(b) It enables organisms with the structures to exploit different ecological niches hence reduce competition.

(c) (i) Presence of homologous structure which have been modified to perform different functions in apparently similar organisms to adapt different environmental conditions and modes of life, is an indication of evolution from common ancestor.

(ii) Presence of structures with the same basic plan or fundamentally similar in different organism, though, modified to serve different functions in different environment is an indication of evolution from common ancestor.

62. Solution

(a) (i) Natural selection the process whereby organisms better adapted to their environment tend to survive and produce more offspring.

(ii) Because resources are limited in nature, organisms with heritable traits that favor survival and reproduction will tend to leave more offspring than their peers, causing the traits to increase in frequency over generations.

(b) **Impor**tance of natural selection
- organisms that are best adapted to a particular environment are allowed to survive and reproduce
- population size of a given environment is regulated to supportable limit.
- undesirable genes are eliminated from a population
- leads constant improvement of the population to better species

63. solution

(a) A gene pool is the stock of different genes in an interbreeding population

(b) Gene pool remain static when there is no mutation, genetic drift, immigration, emigration or when variation is inadequate to bring about natural selection.

(c)(i) Factors that may contribute to the change in frequency of dominant and recessive alleles in a population

- Natural Selection,
- Genetic Drift,
- Mutations the ultimate source of new **alleles** in a **gene** pool
- Gene Flow.
- Nonrandom mating

(ii) How factors in (c)(i) above contribute to the change in frequency of dominant and recessive alleles in a population

- Natural selection increase alleles for favorable traits in a population and eliminates unfavorable alleles
- Environmental change cause alteration in selection pressure
- Mutation introduces new genes in a population
- Genetic drift leads to change in allele frequencies due to chance

- Nonrandom mating leads to selection of individuals with particular alleles to be passed on in the next generation.

64 (c) How does the modern view on evolution differ from Darwin's View?

Darwin's view explains evolution by inheritance of acquired variations which are favored by natural selection pressure while modern view explains evolution by genetically determined variations.

65. (b) **Mutations** are essential to **evolution** because it introduces genetic variations in a population that form a basis of natural selection.

66. (a) Continental drift

The theory of **continental drift** proposes that our **continents** are **drifting** away from each other because they are located on tectonic plates that make up the Earth's crust - the part we are standing on right now. These plates are constantly moving around on the Earth's surface, like rafts in a pool.

(b) Divergent evolution

Divergent evolution is the process whereby groups from the same common ancestor **evolve** and accumulate differences, resulting in the formation of new species.

(c) Industrial melanism

Industrial melanism is an evolutionary effect prominent in several arthropods, where dark pigmentation (**melanism**) has evolved in an environment affected by **industrial** pollution, including sulphur dioxide gas and dark soot deposits.

Or

Industrial melanism is the term used to describe increase in the frequencies of pale and melanic morphs in a variety of insect species, primarily cryptic moths, that have been noted since the advent of industrialization in many parts of the world

(d) Vestigial organs

Vestigial organs are non-functional **organs** in an organism which are functional in related animals and were functional in the ancestors.

There are 90 **vestigial organs** in the human body and mainly include coccyx (tail bone); nictitating membrane (3rd eyelid); caecum and vermiform appendix ; canines ; wisdom teeth etc.

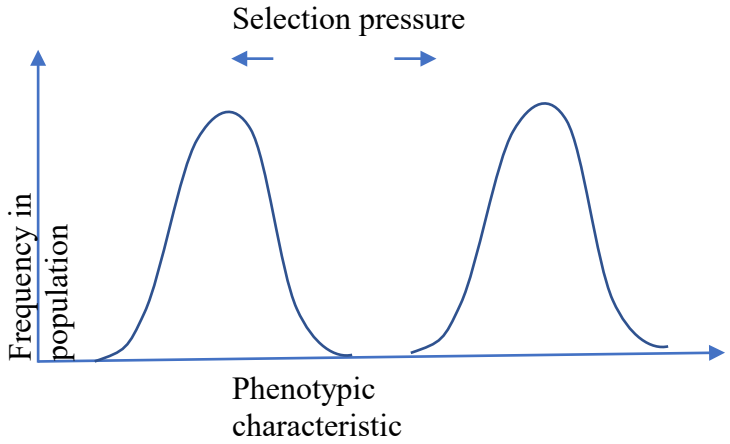
67. Solution

(a) Disruptive selection

(b) Selection pressure acting from within the population as a result of increased competition may push the phenotypic characteristics away from population mean towards the extremes of the population

Thus the intermediate phenotypic characteristics are selected against in favour of the two extremes of the phenotypic characteristics.

(c) (i)



(ii). It split the population into two subpopulations, each which may give rise to a new species

It can also lead to appearance of different phenotypes within the population, i.e. polymorphism.

(d) Genetic variation leads to phenotypic within a population, upon which natural selection acts.

Note: selection is the process by which those organisms which are physically, physiologically and behaviourally better adapted to the environment survive and reproduce: those organisms not well adapted either fail to reproduce or die.

There are 3 types of selection:

- Stabilizing selection
- Direction selection
- Disruptive selection

68. Solution:

(a) A hybrid is an offspring of a cross between two closely related but genetically distinct populations.

A hybrid vigour, on the other hand, refer to phenotypes of hybrids showing characteristics which are superior to either of the parental stock.

(b) Gene flow occur between closely related population as a result of interbreeding between members of the two population. The **random introduction** of new alleles into the recipient population and their removal from the donor population affects the allele frequency of both populations and leads to increased genetic variation.

(ii) In a small population, not all the allele which are representative of that species may be present. It is very possible for new alleles to appear and present ones to disappear simply by chance, a phenomenon called genetic drift. Chance events such as accidental death prior to maturity of an organism which is the sole possessor of a particular allele would result in elimination of the allele from the population, reducing its frequency. Equally possible. An allele may drift to a higher frequency simply by chance.

69. Solution

(a) Genetic drift is a change in the genetic makeup of a population which occurs by chance (random) events. It is common mainly in small isolated populations or when few individuals mate. It usually causes alteration in the frequency of small populations, by chance.

(b) When there is non-random mating; this increases the likelihood of some alleles in the population especially as a result of sexual selection. Individual with certain characteristics become more likely than others to mate and successfully fertilize their gametes. Alleles held such individuals will increase in the population while the others will reduce.

- When population size is small, leading to genetic drift; in this case, changes in allele frequencies occur simply by chance. For example, it is possible for chance events such as accidental premature death prior to mating of an organism which is the sole possessor of a particular allele to result in the elimination of that allele in the population. Also it is possible for the frequency of an allele to increase population, simply by chance.
- When gene flow occurs between populations; gene flow may occur in close populations as a result of interbreeding between members of the two populations. The random introduction of new alleles into the recipient population and their removal from the donor population affects

the allele frequency of both population and leads to increased genetic variation.

- When genotypes are not equally fertile so that there is a genetic load. Harmful recessive alleles usually exist in heterozygous genotypes as the genetic load of a population. Through harmful in homozygous state, they may be carried in the heterozygous genotype and confer selective advantage on the phenotype in certain environmental conditions so that they are more favored.

(c). Through artificial selection

Human beings are able to select and allow breeding of animals or plants with characteristics at the expense of others. This may lead to emergence of bred animals or plants with the desired characteristics and extinction of the others.

- Through pollution

Pollutants such as pesticides and industrial chemicals act as a selection pressure on the survival of organisms in the environment. Organisms often develop characteristics which allow them to survive the pollution. As a result, a new strain of organisms may arise.

- Through genetic engineering

Man has developed a number of techniques through which he may introduce new allelesinto population of organisms. Such organisms usually exhibit characteristics which make them better adapted to the environment than the others an therefore selected for.

- Through man-made major environmental disruptions.

Fire outbreaks, over grazing, over fishing, swamp reclamation and bomb blasts may lead to death of organisms which are sole possessor of certain genes in the population leading to their extinction. On the other hand, some organism may develop characteristic that allow them to withstand these stresses and therefore survive and reproduce leading to evolution of a new strain of organisms.

70. Solution

(a) Natural selection is the process by which organisms that are better adapted to their environments survive and reproduce while the least adapted are wiped out of the population.

(b) (i)

- Mutation changes the nature of genes in an organism and causes inheritable variations. The altered genetic material passes over to the offspring which then inherit the resulting variations.
- A selection pressure acts on these variations; organisms with more favorable variations survive and reproduce while the less suitably adapted organisms die and may be weeded out. This may lead to emergence of new strains of organisms with favorable variations

(ii)

- During prophase I of meiosis, crossing over occurs between homologous chromosomes and exchange of chromosome segments occurs. This separates linked genes and provides a source of genetic recombination.
- During metaphase 1 of meiosis, chromosomes are distributed randomly at the equatorial region and subsequently segregate independently during anaphase1. This leads to further mixing of genes which are then expressed in the gametes. The genetic rearrangement which occurs passes into the gametes and is manifested as phenotypic variations among the organisms of a population.
- A selection pressure acts on these variations; organisms with more favorable variations survive and reproduce while the less suitably adopted organisms die and maybe wiped out. This may lead to emergence of new strains of organisms with favorable variation.

(iii) During fertilization, genes from different parents are mixed independently indifferent combinations. This introduces variation in the genetic constitution of the offspring.

- As a result of variation organisms become efficiently adapted to survive in different environmental conditions.

- A selection pressure acts on these variations; organisms with more favorable variations survive and reproduce while those with unfavorable variations die and maybe weeded out. This may lead to emergency of new strains of organisms with favorable variations.

71. Solution

(a) Variation refers to the existence of different functional, physical or behavioral characteristics among organisms of a population. It may arise by gene mutation, chromosomal mutation or recombination

(b) Crossing over between chromatids of homologous chromosomes occurs during prophase I of meiosis. This shuffles linked genes and provides a source of genetic recombination.

During metaphase I of meiosis, chromosomes are distributed randomly at the equator and subsequently segregate independently during anaphase I. this leads to further mixing of genes which are then expressed in the gametes.

(c) In the presence of variation, organisms respond to change in different ways.

- In presence of a selection pressure, organisms which are more suitably adapted with survive i.e. with favourable variation, survive and reproduce while organism with unfavourable variations die and may be weeded out. As a result, a new strain of organisms with favourable variations arises.

- Also certain variation may limit successful sexual reproduction among organisms of a population. As a result, the population may be split into two differently intern-breeding populations which may later evolve into a new species of organisms.

- Some variations may be so lethal that organisms containing them do not survive to the next generations, even without a selection pressure. As a result, such organisms become extinct in the subsequent generations, leaving a strain of organisms with non-lethal variations.

72. Solution

(a) (i) Genetic isolation occurs when mating can occur but fertilization is not possible and/or even when it occurs, the product is a sterile or inferior offspring. This is due to incompatible genetic constitution between organisms of a population.

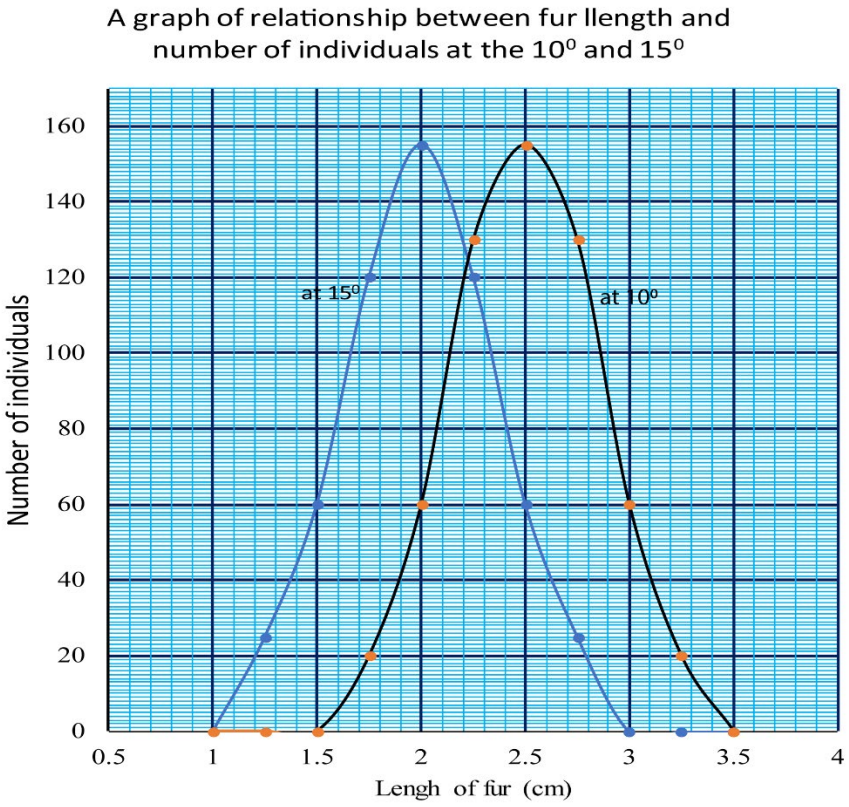
(ii) Reproductive isolation involves failure of interbreeding among organisms of population. This may be as a result of lack of attractiveness between males and females or non-correspondence of genitals.

(b) Change in gene frequency of a population occurs when;

- There is non-random breeding. In such cases sexual selection occurs whenever the presence of one or more inherited characteristics increases the likelihood of bringing about successful fertilization of gametes. As a result, the frequency of some genes increases while that of others reduces in the population.
- The population is small and leads to genetic drift. There is usually chance appearance or disappearance of genes in a small population, leading to change in frequency of the gene in question.
- Genotypes are not equally fertile. In this case, the more advantageous (fertile) alleles are transferred to offspring at the expense of other alleles. This leads to change in frequency of such genes.
- Gene flow occurs between populations. Interbreeding between populations always leads to flow of genes within the populations involved. This causes instability in the gene frequency of the populations.
- Mutations occur. Occurrence of a mutant gene in the population can lead to change in frequency of the gene over generations.

Gene reshuffling occurs. During meiosis, crossing over occurs that results in new gene recombination. At fertilization, these altered alleles are transmitted to offspring and over generations, the allele frequency of a gene changes.

80. Solution



(b) at 10^0C, optimum length is 2.5cm

At 15^0C, optimum length is 2.0cm

(c). (i) temperature directly affects the length of fur among the individuals.

High temperature induces growth of short fur while lower temperature induces growth of long fur among the individuals.

(ii) Fur in animals is an adaptation for temperatures regulation.

The erector Pilli muscles in the skin contract and make the fur stand on end during the cold conditions. This traps a layer of air which is an insulator between them and so prevents heat loss from the body by conduction.

The longer the fur the greater the amount of air trapped and the more efficient the insulation process.

This explains why animals in the cooler environments have developed longer fur as they have a greater tendency to lose heat than those in the warmer environment.

(d) (i) the number of resistant strains reduces gradually as the amount of antibiotics increases rapidly in the 59 to 61 years period.

Thereafter, the number of resistant strains increases very rapidly to a peak as the amount of antibiotics is reduced in the 61 to 63 years period.

Finally, the number of resistant strains reduces as the amount of antibiotics used is reduced.

(ii) The number of resistant strains reduces initially because of the susceptibility the bacteria to the antibiotics being used.

The number then increases rapidly, thereafter, because the present resistant strains reproduce rapidly to produce rapidly offspring that are not affected by the antibiotics used.

Reduction in number of resistant strains the amount of antibiotics is reduced is due to increased competition for food and space.

(e) Bacteria occur in such large numbers that there is a high chance of a resistant strain eventually appearing in the population due to random mutations.

As soon as this happens, use of antibiotics acts as the selection pressure, causing the vulnerable bacteria to die and leaving the resistant strains, with a survival advantage to continue growing.

Due to their high reproductive rate, the resistant strains rapidly multiply and exponentially increase in number.

(f) In table 1, the selection pressure is temperature variation.

In figure 1, the selection pressure is the antibiotics used.

(f) (i) the number of resistant strains of bacteria would decrease drastically.

Explanation

Resistant strains are mutants and therefore few in the general population of the bacteria.

They develop by chance and are given better survival advantage by the presence of antibiotics.

Stopping antibiotics for 1 year removes the selection pressure.

Non-resistant strains then survive better than the resistant strains.

The number of resistant strains then reduces as a result of competition for food and space.

(ii) there would be reduction in length of fur.

Explanation

Abundant food supply provides enough raw materials for metabolism and therefore production of enough heat energy to counter the heat loss. The role, earlier performed by long fur, would be taken over by metabolism and so long fur would not be necessary.