

Topical test evolution

1. (a) Distinguish between hybrid and hybrid vigour. (02 mark)

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) Explain how each of the following may alter the gene frequency

- (i) Closeness of population. (03 mark)

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) Small population size. (03 mark)

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.

2. 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)

- Light coloured skin
- White hair.
- Pink eyes.

- (b) Using Hardy Weinberg formula $p^2 + 2pq + q^2 = 1$, determine

- (i) the frequency of the albino allele in human population. (2marks)

$$\begin{aligned} \text{frequency of the albino allele} &= q \\ \text{Frequency of albinism } (q^2) &= \frac{1}{10000} \\ \text{i.e. } q^2 &= \frac{0.0001}{\sqrt{0.0001}} \\ q &= 0.01 \end{aligned}$$

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

- (ii) Frequency of heterozygous genotype in the population. (2marks)

$$\begin{aligned} P + q &= 1 \\ P + 0.01 &= 1 \\ \text{But.} \\ p + 2pq + q &= 0.99 \\ \text{But} \\ p^2 + 2pq + q^2 &= 1 \\ (0.99)^2 + 2pq + (0.01)^2 &= 1 \\ 0.9801 + 2pq + 0.0001 &= 1 \\ 2pq &= 1 - 0.9802 \end{aligned}$$

$$2pq = 0.0198$$

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

- (c) Explain why it is difficult to eliminate recessive alleles from a population. (4marks)
- 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.
 - Also, certain recessive alleles confer extra advantage to organism containing them in heterozygous state. This maintains the allele in the population. For example, the sickle cell allele.
3. 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)
- 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) Describe how environmental factors act as stabilizing forces to natural selection in an isolated pool after the evolution of a new species. (03marks)
- 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) Suggest what would happen to the fish species if water levels rose and the isolated pools once again formed an extensive lake system. (03marks)
- 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 be 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.*
4. (a) Explain the meaning of the Hardy-Weinberg equilibrium principle. (1mark)
- 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) State four conditions that must be fulfilled in order for the principle to hold true (2marks)
- No mutation occurs
 - Mating must be random
 - The population must be large.
 - No emigration or immigration from or into the population should occur
 - Generations should not overlap
 - All genotypes should be equally fertile, so that no selection occurs.

- (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)

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

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

$$\text{given } p^2 + 2pq = 0.84$$

$$q^2 = 1 - 0.84$$

$$q^2 = 0.16$$

$$\Rightarrow q = 0.4$$

$$\text{Also } p + q = 1$$

$$p = 1 - 0.4$$

$$p = 0.6$$

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

$$2pq = 0.84 - 0.36$$

$$2pq = 0.48$$

Hence 0.48% of the population are heterozygous.

- (ii) Homozygous dominant for eye color. Show your working. (3marks)

from above

$$p = 0.6$$

$$\Rightarrow BB = p^2 = (0.6)^2$$

$$\therefore BB = 0.36$$

$$\% \text{ of } BB = 36\%$$

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

5. (a) Outline the cause of gene reshuffling. (03 mark)

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

(b) In what way may variation resulting from gene reshuffling differ from that caused by mutation? (02 mark)

In Gene reshuffling new combination of the same alleles and as a result leads to variation in combinations of the same characters. While in Mutations lead to formation of completely new alleles leading to production of completely new characters.

(c) What is the importance of variation in a population? (02 marks)

- *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) Explain how constancy of species may be maintained through natural selection. (03 marks)

- *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.*

6. (a) State three ecological problem which arise from the accumulation of domestic waste in urban communities. (03 marks)

- *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*
- *Leads to transmission of deadly communicable diseases that may lead to destruction of lives.*
- *Causes air pollution.*

(b) Give two ways of reducing domestic waste. (02 marks)

- *Recycling of non-biodegradable materials in domestic waste.*
- *Burying biodegradable rubbish.*
- *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) Figure 8 show lichen species growing along a 20km transect from urban Centre.

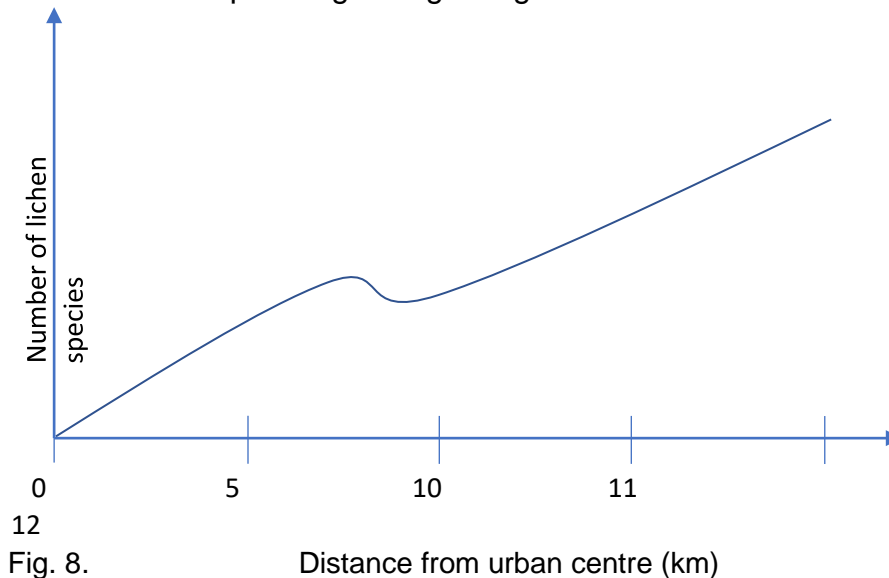


Fig. 8.

- (i) Explain the trend in the lichen species with distance. (04 marks)

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*

- (ii) Suggest an explanation for the observed number of lichen species at a distance of 10km from the urban Centre. (01 marks)
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7. (a) How does resistance of malarial parasite to antimalarial drugs occur? (04 marks)

- *Failure of the parasite to absorb the drug*
- *Formation of inaccessible forms during its development life cycle in man (tissue hypnozoites)*
- *Parasite may use alternative biosynthetic pathway not affected by the drug.*
- *The parasite tissue may become tolerant to drug molecules*

- (b) How may each of the following lead to speciation

- (i) genetic drift. (03 marks)

Genetic drift is a mechanism of evolution in which allele frequencies of a population change over generations due to chance (sampling error). These leads to

- *Lose of gene from or increase in allele frequency of gene in population which may alter the selection pressure in a population leading development of new species.*

- (ii) Un random mating. (03 marks)

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.*

8. (a) Using examples. Give the meaning of adaptive radiation of species? (02 marks)

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) State the ecological importance of adaptive radiation. (02 marks)

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

- (c) How do adaptive radiation and homologous structures give evidence of evolution?

- (i) Adaptive radiation. (03 marks)

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) Homologous structures. (03 marks)

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

9. (i) What is meant by natural selection? (02 marks)

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

- (ii) How does it occur? (06 marks)

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.

- (iii) What is the importance of natural selection? (02 marks)

- *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*

10. (a) What do you understand by gene pool? (02 marks)

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

(b) What may cause a gene pool of a population to be static? (02 marks)

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) state three factors that may contribute to change in frequency of dominant and recessive alleles in a population. (03 marks)

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

(ii) Explain how each factor stated in c(i) above may cause change in the frequency of dominant and recessive alleles in a population. (03 marks)

- *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.*

11. (a) State Darwin's theory natural selection. (02 marks)

Darwin theory states that natural selection is the mechanism by which new species arise from pre-existing species

(b) State three observations and two deductions from which Darwin derived this theory. (05 marks)

- **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 offspring than less adapted

- (c) How does the modern view on evolution differ from Darwin's View? (03 marks)

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.

12. (a)(i) What is mutation? (01 mark)

This is a change in the amount or structure of DNA of an organism

- (ii) State the possible causes of mutation. (03 marks)

- *Ultraviolet light*
- *Chemicals*
- *Freezing of cells*
- *Highly electropositive cells*
- *Gamma radiations*

- (b) What is the role of mutation in evolution of new species? (01 marks)

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

13. Explain what is meant by each of the following concepts:

- (a) Continental drift. (2.5 marks)

*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. (2.5 marks)

***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. (2.5 marks)

***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.*

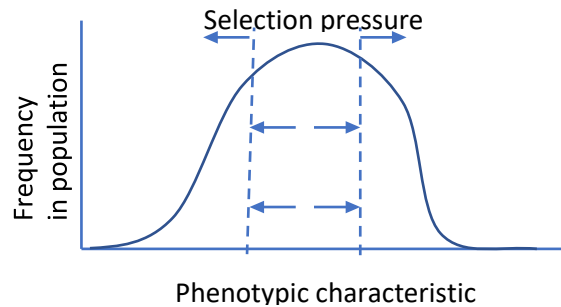
Or

***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. (2.5 marks)

***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.*

14. The figure below illustrates selection pressure acting on a population of butterfly



- (a) State the type of selection being exhibited in the figure. (01 mark)

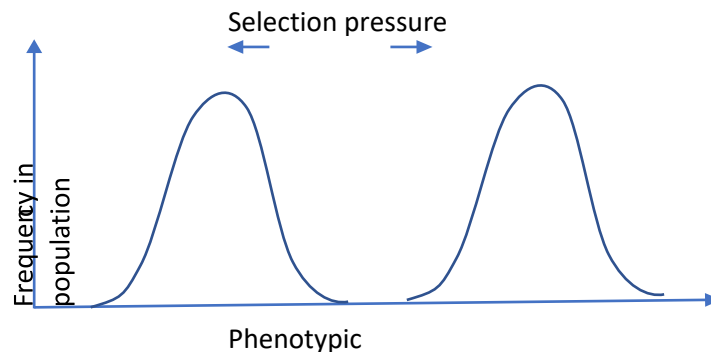
Disruptive selection

- (b) Explain how this type of nature selection affect the phenotypic characteristics of the population. (02 marks)

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) In the space below sketch the distribution curve that would result after many generations of this type of natural selection shown in (a). (02 marks)



- (ii) What ecological effect does the above type of selection have on the population? (3marks)

- 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) State the importance of genetic variation in natural selection? (2marks)

Genetic variation leads to phenotypic variation 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.*

END