



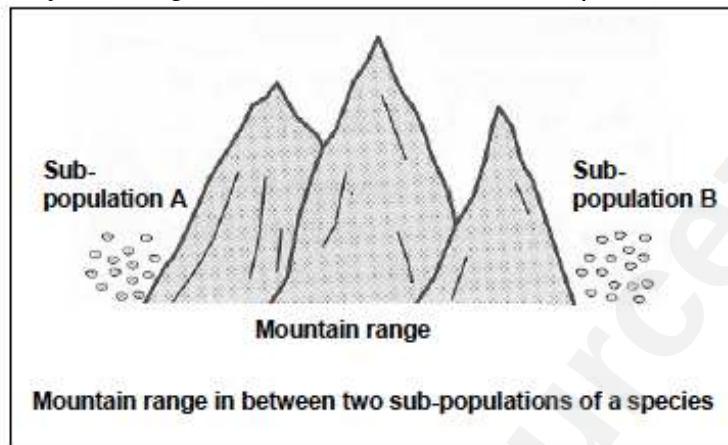
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DIVERSITY: VARIATION AS AN EXPANATION OF EVOLUTION

Learner Note: Please learn terms like Sympatric and Allopatric speciation, variation, fixed, neutral and lethal mutations, inbreeding, outbreeding, artificial selection and natural selection, geographical barriers and link this to allopatric speciation. Check the Additional Content notes.

SECTION A: TYPICAL EXAM QUESTIONS**Question 1: 8 minutes***Taken from DoE Preparatory Examination 2008 Paper 2)*

Study the diagram below and answer the questions that follow.



- 1.1. Define a *species*. (3)
- 1.2. Describe how sub-population B could form a new species. (6)

Question 2: 9 Minutes *(Taken from WC DoE September 2009 Paper 2)*

Darwin discovered two different varieties of tortoises on two different islands on the Galapagos Islands. One had a domed shell and short neck and the other one had a longer neck. The two islands had very different vegetation. One of the islands (island X), was rather barren, dry and arid. It had no grass but rather short tree-like cactus plants. On the other island (island Y), there were no cactus plants but it had a good supply of water and grass grew freely across the island. The diagrams below show the two main varieties of tortoises on the Galapagos Islands.

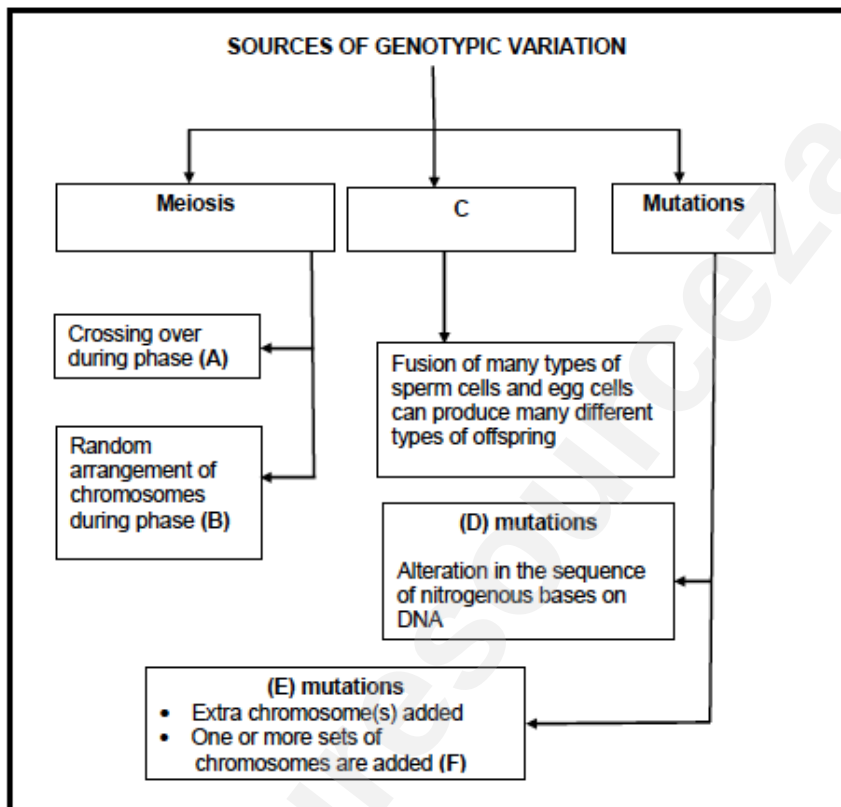
**Tortoise A****Tortoise B**

Two main varieties of tortoises on the Galapagos Islands

- 2.1. Which tortoise (A or B) would have been found on
- (a) island X (1)
- (b) island Y (1)
- 2.2 Explain your answer to QUESTION 2.1 (b) (2)
- 2.3 Describe the concept of allopatric speciation as it applies to the two tortoise types. (5)

Question 3: 10 Minutes (Taken from DoE Additional Exemplar 2008 Paper 2)

The flow diagram below shows various sources of genotypic variation.



- 3.1. Name the process labelled C that is a source of genotypic variation. (1)
- 3.2. Name the phases of meiosis, labelled **A** and **B**, respectively. (2)
- 3.3. Name the TWO types of mutations, labelled **D** and **E**, respectively. (2)
- 3.4. Describe how the process labelled **F** can lead to the formation of a new species of plants. (3)
- 3.5. State what is meant by each of the following:
- (a) Lethal mutations (1)
- (b) Neutral mutations (1)
- (c) Fixed mutations (1)

Question 4: 8 Minutes

(Taken from DoE Exemplar 2008 Paper 2)

The following questions are based on mutation.

- 4.1. Define a *gene mutation*. (2)
- 4.2. Name TWO factors that can cause mutations. (2)
- 4.3. Differentiate between *neutral* and *lethal mutations*. (4)

SECTION B: SOLUTIONS AND HINTS**Question 1:**

- 1.1 A species is one or more populations whose members actually or potentially interbreed
✓ under natural conditions, produce fertile offspring ✓ and are reproductively isolated
✓ from other such groups. (3)
- 1.2 Geographic speciation ✓
 - Physical isolation such as mountains turns a single population into two ✓
 - Once two populations are reproductively isolated, they are free to follow different evolutionary paths ✓
 - Different geographic regions are likely to have different selective pressures ✓ such as temperature, rainfall, predators and competitors are likely to differ between two areas ✓
 - Thus, over time, the two populations will differentiate ✓ to the point that reunion of the two populations does not occur if contact is re- established ✓
 - The fate of the populations depends upon time and factors related to their different environments ✓

Any 6 (6)**Question 2:**

- 2.1 (a) Tortoise B □ (1)
- (b) Tortoise A □ (1)
- 2.2 Short - necked tortoise A can feed on grasses □ at ground level
Grasses are found on island Y □ (2)
- 2.3 Allopatric speciation occurs when new species evolve □ because populations are physically separated from the original population □
In the case of the tortoises (A and B) they were physically separated from the original mainland population □ and from each other on separate islands. □
The two island populations adapted to their particular environments □ and changed genetically and physically (phenotype) □ over a long period of time became reproductively isolated □.

Any 5 (5)**Question 3:**

- 3.1 Reproduction/Fusion □ (1)
- 3.2 A Prophase I □
B Metaphase 1 □ (2)
- 3.3 D – Gene mutation □
E – Chromosome mutation □ (2)
- 3.4 During meiosis the chromosomes fail to separate □ gametes have diploid set of chromosome □ offspring have additional sets of chromosome □ (3)

- 3.5 (a) **Lethal:** the mutated organism dies and the harmful characteristics are not passed on to the next generation □ (1)
 (b) **Neutral:** has no effect on the structure and functioning of the organism □ (1)
 (c) **Fixed:** advantageous □/sometimes the advantageous mutation wipes out all the other alleles controlling the same characteristic within the population (1)

Question 4:

- 4.1 A mutation is a mistake □/alteration due to a change in the composition of DNA □
OR
 Sudden change □ in the structure of a gene □ (2)
- 4.2 - by accident during meiosis □
 - some chemicals □/mutagens/high energy radiation (2)
(Mark first TWO only)
- 4.3 **Neutral mutation** - these are of no benefit □ to the organism and they are not harmful to the organism □ and are not affected by natural selection □ **any 2 (2)**
Lethal mutation - they are harmful □/ cause the death of the individuals that inherit □ them because natural selection selects against them □ **any 2 (2)**

SECTION C: ADDITIONAL CONTENT NOTES**Modern Theory**

The modern theory is called **neo-Darwinian** evolution and is based on Darwin's principles of variation, natural selection and over-production of offspring.

Today, scientists agree that individual organisms **change to adapt** to the environment.

Sometimes this process occurs when genes mutate by accident. If the mutation is good the individual survives by natural selection and breeds so the 'good' genes are passed on to the next generation.

Lethal mutations:

Sometimes, mutations are not good and do not assist the organism like **lethal mutations**, which are lethal and result in the death of the organism. Somatic cell mutations result in cancer, which is lethal in the **malignant form**. In nature, an albinos' chances of survival are bad. They do not have the camouflage necessary to avoid attracting predators. Tay Sachs disease is as a result of a mutant gene that is hereditary and occurs mainly in the Jewish communities, resulting in death at an early age.

In the heterozygous form, the gene causing the lethal mutation will be present in the **genotype**, but not the **phenotype**. During a heterozygous cross, there is a 25% chance of the recessive trait coming forward in the phenotype.

Fixed mutation:

A **fixed mutation** provides an organism with a better chance of survival. The mutation becomes fixed when an organisms survives and carries the mutant gene, passing it on to the future generations, e.g.: tuberculosis (TB) bacteria. The TB bacteria has developed a resistance to the antibiotics used to kill it because the resistant bacteria reproduced and a new strain evolved. New antibiotics had to be developed to fight the new pathogen strain. The HIV/AIDS virus is a retrovirus that has evolved and mutated to adapt to survive in the human

body. The virus slowly destroys the host and is passed on to various other hosts, to ensure survival. The theory extends to characteristics that may be **an advantage** in one environment but **a disadvantage** in another, for example sickle-cell anaemia, as discussed in Grade 11. Fixed mutations result in natural selection.

Neutral mutation:

A mutation is termed a **neutral mutation** when it has no effect on the organism and is not observable. It is passed on to offspring over many generations and does not give an organism any advantage, but can assist survival if the environment changes. This will result in the organism being able to adapt to the change and so doing, ensure its survival and natural selection.

When Scientists intervene and create varied species, it is called **artificial selection**.

Artificial selection in plants and animals

Artificial selection is used to produce **hybrid** plants and animals to suit our needs. This can be classed as an evolutionary mechanism because it results in **new breeds** (animals), **strains** (micro-organisms) and **varieties** (plants). Hybrid have the following advantages:

- increased size of fruit
- increased size of body (cows, pigs, sheep)
- increased production of eggs, offspring or seeds
- increased resistance to disease
- it will reach maturity quickly (plants and chickens).

Commercially viable organisms can be developed by selecting and breeding **desired traits**. The organism would be **homozygous** for all the genes involved, whether they are dominant or recessive for their effects.

Inbreeding is the breeding of two closely related organisms. The strain may become **homozygous** for multiple defective traits, e.g.: certain dog breeds like German shepherds are known for their vulnerability to weak hips and congenital femur dislocation. Fighting dogs like the South African Boerboel often go mad as adults and must be put down for fear of attacks on people and other animals.

Outbreeding is the mating of organisms of totally unrelated strains. This leads to offspring that are better adapted for survival than either of the parents. This phenomenon is termed **hybrid vigour**. Examples of outbreeding include the following:

- **Mongrel dogs** are a cross between two different dog sub-species and are far stronger and hardier than highly pedigreed purebreds.
- **Mules** are a cross between a horse and a donkey. Mules are much stronger and better suited to many more tasks than either parent.

The disadvantage of interspecies crossing is that the offspring are **unable to reproduce** because the chromosomes cannot form homologous pairs during meiosis and results in hybrid sterility.

Artificial Selection in Humans

Scientific advances have increased the understanding of genetic codes and mechanisms of heredity. Scientists are able to **predict and eliminate** genetic defects. Genetic counselling is used to inform couples with a family history of genetic abnormalities of the risks involved in having children.

Inbreeding in humans increases the possibility of congenital birth defects like physical defects and retardation. This is why marriages with close relatives are forbidden by law, e.g.: we may not marry a brother, sister or first cousin.

Outbreeding in humans occurs in groups that have a **restricted gene pool**. When new genes are required, individuals are encouraged to bring in suitable individuals from outside of the group to strengthen the gene pool and add diversity. Examples of this would be some of the religious and ethnic groups where people may only marry people who belong to the same group. Marriage to an 'outsider' requires conversion by the individual outside the group and an appeal to the elders of the group for approval.

Natural Selection and Speciation

A species is defined as a group of organisms that are similar in appearance, share the same DNA sequences, perform the same mating rituals and interbreed. The term speciation means **the origin of a species from another species**. There are two types of speciation:

- **Allopatric speciation:** this is speciation that takes place when one population is divided into two by a geographical or physical barrier.
- **Sympatric speciation:** when a new species develops after behavioural, ecological or genetic barriers arise within the boundaries of a single population. Geographical or physical barriers are NOT involved.

Each new species will have developed new characteristics as the gene frequency in the DNA changes. The changes in the new species will prevent it from interbreeding with the old species. **Macro-evolution** results when a new species is formed. Remember that evolution is change over time. Diversity is the result of change over time.

Speciation results because of :

- **Geographical separation** by water, mountain range – an example of **Allopatric speciation**.
- **Polyploidy** is a change in the gene frequency, which changes the chromosome numbers. In animals, a hybrid results like in the cross between a donkey and a horse. The offspring is called a mule and is **infertile**. Polyploidy is common in plants and does not affect reproduction but does result in a new species.
- **Reproductive isolation** is an example of **Sympatric speciation** (when a new species develops after behavioural, ecological or genetic barriers arise within the boundaries of a single population). Reproductive isolation can result because of:
 - **Ecological isolation** when animals live in different habitats, so they cannot breed with one another
 - **Behavioural isolation** when animals behave in different manners during mating rituals, so females are not responsive and no mating takes place.
 - **Gamete isolation** when genes change and gametes become chemically altered
 - **Seasonal isolation** when reproduction takes place at different times of the season or year
 - **Mechanical isolation** when male and female reproductive parts change so that gene transfer cannot take place like in flowers, the stigma of the female whorl releases enzymes to stimulate the growth of the pollen tube. In this case, the enzyme will not stimulate the growth and the pollen grain will not grow. In animals, the genitals change and the sperm cannot be transferred into the female should mating be attempted.

SECTION D: HOMEWORK

Learner Note: As you attempt the homework, you MUST stick to the time frames. If you get stuck refer to either the additional notes or your class teacher.

Question 1: 6 Minutes *(Taken from WC DoE September 2009 Paper 2)*

Habitat destruction is one of the ways in which humans contribute to the loss of biodiversity. A South African environmental protection agency completed the following study in a forest to find out if leaving some patches of undisturbed forest will help to preserve the bird species in that area.

In an area of forest which was being cut down for human development, the scientists left two areas (A and B) of different sizes as undisturbed habitat. They then counted the number of bird species in these areas before, and at different times after the removal of the forest around them.

The results of their investigation are shown in the table below:

TIME	NUMBER OF BIRD SPECIES	
	AREA A (One hectare patch of undisturbed land)	AREA B (10 hectare patch of undisturbed land)
Before removal of forest around patch	30	23
6 weeks after isolation in patch	58	30
36 weeks after isolation in patch	20	25
66 weeks after isolation in patch	18	20
96 weeks after isolation in patch	17	21

- 1.1 Suggest ONE reason why you think that the number of bird species caught in the two areas increased in the few weeks after the surrounding forest was cut down, compared with before. (1)
- 1.2 Explain why the number of bird species in each area gradually decreased to below the original levels. (2)
- 1.3 Explain what these results suggest about the usefulness of isolated patches of undisturbed habitat as wildlife reserves. (3)

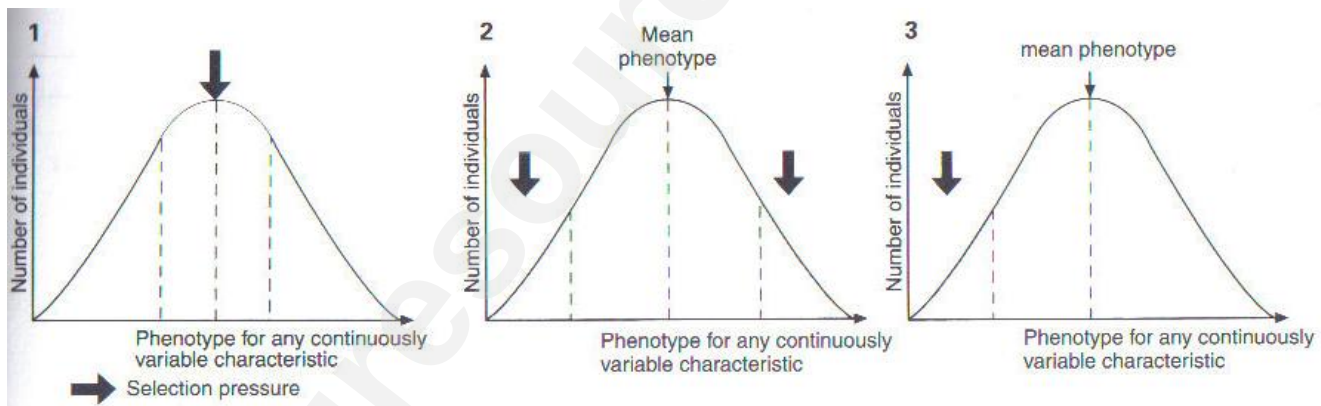
Question 2: 7 Minutes

(Taken from St Mary's DSG September 2009 Paper 2)

- 2.1. The following table compares sympatric and allopatric speciation. Put a tick in the appropriate column if the phrase applies, and a cross if it does not. (4)

	<u>Sympatric speciation</u>	<u>Allopatric speciation</u>
The most common type of speciation in animals		
Hybrids may result		
Occurs in populations living in the same geographical area		
Breeding is between members of the same species		

- 2.2. Name the selection pressure in operation in the graphs 1, 2 and 3 shown in the figures below. (3)

**Question 3: 8 Minutes** (Taken from DoE November 2009 Paper 2)

The shell of the banded snail, *Cepaea nemoralis*, displays a wide variety of both colour and banding (rings). Birds, such as thrushes, eat these snails. The birds break open the shells by striking the snails against a stone.

It was found that there were equal numbers of light- and dark-banded snails in a specific grassland habitat where no thrushes were found. A population of thrushes was then introduced to this grassland habitat.

An investigation was done to determine which colour snails (dark-banded or light-banded) were eaten most by the thrushes. The results are shown below:

Time (days)	Number of dark-banded shells found around stone	Number of light-banded shells found around stone
Day 1	2	1
Day 2	3	0
Day 3	5	1
Day 4	7	0
Day 5	8	1

- 3.1. Write a possible hypothesis for this investigation. (3)
- 3.2. What phenomenon does this investigation illustrate? (1)
- 3.3. Which snails were better adapted to prevent them from being eaten by the thrushes? (1)
- 3.4. Explain your answer to QUESTION 3.3. (2)
- 3.5. Why can the number of snails at the start of the investigation be considered a controlled variable? (1)

Question 4: 10 Minutes*(Taken from DoE November 2008 Paper 2)*

Scientists believe that variation in populations can lead to the formation of new species.

- 4.1. List FOUR sources of variation in populations. (4)
- 4.2. Explain how speciation occurs if a population becomes separated into two groups by a geographical barrier such as a mountain. (6)

SECTION E: SOLUTIONS TO SESSION 23 HOMEWORK

- 1.1 3 900 ✓ million years ✓ old (2)
- 1.2 25% fossil would be 2600 million years old ✓ therefore it is younger ✓ therefore it will be less deeply ✓ buried as the older fossil. (3)
- 1.3 1% of 10 000 = 100 ✓ (method)
So the fossil could be any age between 9 900 ✓ and 10 100 ✓ years old. (3)
2. Adaptive radiation ✓: homologous structures ✓ which show evolution from a common ancestor ✓ of different types of organisms each adapted to its environment ✓. Human arm for use on land and porpoise flipper for swimming ✓. (5)
- 3.1 Evolutionists believe that this is biological evidence ✓ for evolution ✓
OR
All evolved ✓ from a common ancestor ✓ (2)
- 3.2 A ✓ (1)
- 3.3 Vertebrates thought to develop from aquatic form ✓ which breathes by means of gills ✓ (2)
- 4.1. B
- 4.2. D
- 4.3. B
- 4.4. C
- 4.5. B (1 Mark each = 5)