ARMADALE SENIOR HIGH SCHOOL

ATAR Human Biological Science Unit 3

Test 4 Evolutionary Mechanisms: Mutations and Gene Pools

Answers

SECTION A: Multiple Choice **(10 marks)**

1. Charles Darwin proposed a theory of how evolution occurred by a concept known as natural selection. This theory is based on the idea that:

a) Favourable variations gradually become more common in the population
b) Organisms that survive reproduce their favourable characteristics
c) There is a variation within a species
d) All of the above

2. A mutation is best described as:

d) A new characteristics appearing in an organism
d) A permanent change in genetic material
d) A change in the mitotic process
d) Treatment by radiation

3. Which of the following statements is INCORRECT?

a) Mutations are kept at low frequency in the population by the action of natural selection
b) Ionising radiation, such as X-rays, increases the mutation of genes in direct proportion to the radiation dosage
c) Most mutations results in unfavourable characteristics
d) Changes in a physical characteristic of a population can only come about following the mutation of a gene

4. Sickle cell anaemia is a fatal condition that affects the clotting of blood cells in homozygotes. However, the gene for sickle shaped cells has not been eliminated from the gene pool of malaria-affected countries. This is because:

a) The allele for sickle cells is dominant to normal blood cells
b) Individuals homozygous for sickle shaped blood cells are more resistant to malaria
c) Individuals with two alleles for sickle cell usually do not live to reproduce
d) Heterozygous individuals are more resistant to malaria

5. Mutations that affect reproductive cells are called:

a) Chromosome mutations
b) Germline mutations
c) Somatic mutations
d) Gamete mutations

6. **Tay-Sachs is a hereditary disease that occurs in 1 in every 1500 births in the Ashkenazi Jewish population. The incidence of Tay-Sachs in other populations is very low, at around 1 in 500 000 births.**

   Which of the following is NOT considered a reasonable explanation for this frequency of inheritance?

   a) Genetic drift: Jewish populations tend to be small and isolated, thus increasing the chance of allele frequency changes
   b) Founder effect: original migrating populations carried a high incidence of the allele, which has been maintained over subsequent generations
   c) Heterozygote advantage: carriers of the alleles have a survival advantage, so the allele is maintained in the population due to natural selection
   d) Late onset condition: sufferers of the disease are not affected until later in life, after they have already reproduced and passed the allele to their offspring

7. **The Dunkers are a small religious group that moved from Germany to Pennsylvania, in the United States of America, in the 1700s. They mostly chose to marry only the members of their own community. Today, the Dunkers are genetically different from other populations, including those in Germany.**

Which of the following are the most likely explanations for the genetic uniqueness of the current Dunker population?

   a) Natural selection and mutation
   b) Natural selection and genetic drift
   c) Barriers to gene flow and genetic drift
   d) Barriers to gene flow and speciation

8. **Which of the following is a series of events that leads to the formation of two separate species?**

   a) Variation, natural selection, isolation, speciation
   b) Natural selection, isolation, speciation, variation
   c) Isolation, variation, speciation, natural selection
   d) Variation, isolation, natural selection, speciation

9. **A mutation that involves the deletion of a section of specific base pairs of the DNA, known as CCR5-Delta32, is believed to provide a resistance to HIV infection. Individuals with the homozygous condition for the mutation have almost complete resistance to HIV and individuals who are heterozygous for the mutation have a partial resistance to HIV, where the disease progression is slowed.**

   This trait has a frequency of 10% in European populations but has not been found in African, Asian, Middle Eastern or American Indian populations. One theory for the geographical distribution of the mutation is that it also provided resistance to the bubonic plague. Given that European populations were most affected by the plague, the mutation has been inherited in these groups and not others.

   The pattern of occurrence of the CCR5-Delta32 mutation can be best attributed to:

   a) Random genetic drift
   b) The founder effect
   c) Natural selection
   d) A geographical barrier to gene flow

10. **If you were listing items of evidence that supports Charles Darwin's theory of evolution occurring as a result of variation and natural selection, you would include all of the following statements, EXCEPT ONE. Which one is incorrect?**

   a) In an undisturbed area the number of individuals of an established species remains fairly constant
   b) Many animal species alive today show exactly the same characteristics as their ancestors

c) In a population of humans, other than identical twins, no two individuals are exactly the same

d) Small populations show greater differences in allele frequency than the larger population from where they came

11. **In the past, human females with the genetic disease haemophilia often died before they reached reproductive age. Modern medical treatment now allows most haemophiliacs to survive and enjoy a normal life span. What effect would this have on the frequency of the allele responsible for haemophilia?**

a) It will decrease in frequency

b) It will increase in frequency

c) It will not change in frequency

d) It is impossible to predict

12. **Which of the following changes is most likely to result in a mutation in an offspring?**

a) A change to the DNA in a somatic cell

b) The deletion of a gene in the DNA of a sperm cell

c) Crossing over during meiosis

d) A mistake in the replication of DNA during mitosis

13. **'Survival of the fittest' is a term often used in relation to natural selection. It refers to those organisms that:**

a) Are the healthiest

b) Are best suited to the environment

c) Live the longest

d) Produce the most offspring

14. **Genetic drift is most likely to occur in:**

a) Very small populations

b) Very large populations

c) Natural populations

d) Artificial populations

15. **The term ‘gene pool’ refers to:**

a) The allele frequencies in a population

b) All the genes in a population

c) Genotype frequencies

d) Asexually reproducing organisms

16. **Two tribes P and Q inhabit the same region but cannot interbreed because of a geographical barrier between them. However, they are considered to be the same species because:**

a) They share a common gene pool

b) They live in the same territory

c) Their environments are almost identical

d) They look very similar

SECTION B: Short Answer **(29 marks)**

Question 11

a) The major sources of new variations in a gene pool are mutations. Although they can occur in any cell of the body, mutations occurring in only one type of cell result in changes to allele frequencies in a gene pool. Name the type of cell and describe how mutations in these types of cells can cause changes in allele frequencies in a gene pool.

Gametes/sex cells/ovum and sperm/germ line/germ cell (1)
Passed onto next generation (1)

b) Members of a single gene pool become isolated from each other preventing gene flow between the two groups. Eventually the frequencies of two alleles of a particular gene in the two separate gene pools become significantly different from one another.

Explain how natural selection contributes to this difference in allele frequency.
Any 4 of the following:

- Mutation causes variation/variation within gene pool
- Different selection pressures on different gene pools (populations)/different environments
- A different allele is favoured over the other (in the different environments)/ characteristic more suited to the environment
- This characteristic/allele increases in frequency
- Due to increased survival/reproduction of individuals with the favoured allele

c) Name two types of barriers to gene flow that may have caused human populations to become isolated from each other in the past. Provide an example of each type.

	Barrier to gene flow	Example
1.	Geographical/Physical (1)	Oceans/lakes/deserts/mountain ranges/ice sheets (1)
2.	Sociocultural/cultural/social (1)	Religion/language/economic status/ education/social position (1)

d) The change in allele frequencies in gene pools is also affected by another evolutionary mechanisms called random genetic drift.

Describe two ways in which random genetic drift differs from natural selection in its effect on changes in allele frequencies.

Any 2 of the following:

- Chance occurrence
- Non-directional change
- No selection pressures/not related to the environment

- More likely in small population

Question 12

a) **If a person had a karyotype that included the sex chromosomes XXY, what syndrome would they have?**

Klinfelters syndrome

b) Would this person be a male or a female?

male

c) How many chromosomes would this person have in a somatic (body) cell?

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Question 13

Tay-Sachs disease is an autosomal recessive disease that usually kills those who inherit it before they reach 4 years of age. In descendants of central and eastern European Jews known as the Ashkenazim, Tay-Sachs has a higher incidence than in the rest of the population.

a) **Explain how Tay-Sachs could be an example of the Founder effect.**

Occurs in high frequency (1)

Usually small/isolated populations (1)

Increase in inbreeding (1)

b) Explain how natural selection could reduce the frequency of Tay-Sachs in the Ashkenazim people.

sufferers of Tay-Sachs would die before reproductive age, thus not passing on genes (1)

expect incidence to decrease over time (1)

not beneficial to be homozygous recessive (1)

c) Explain why Tay-Sachs has continued to exist in the Ashkenazim people.

survival advantage for heterozygyotes (1)

resistance to tuberculosis in TB prone areas (1)

Question 14

Sickle cell anaemia is a condition found in people throughout the world. Homozygous recessive individuals often die young due to organ failure and infection, yet in the United States there are believed to be over 2 million people who carry the sickle cell condition. Why do so many people carry the sickle cell condition?

Heterozygotes only suffer a mild version of the disease / do not die young (1)

Heterozygotes receive protection from malaria that could kill those homozygous for the sickle cell gene (1)

Question 15

Why is a short stocky build, such as in the Inuit of North America, an advantage in a cold climate?

Long body, short limbs provides smaller surface area to volume ratio (1)

Body heat more likely to be retained in cold environments (1)

Question 16

Indicate on the table below how each event alters gene frequencies.

Event	Increase or decrease gene frequency
Mutation	Increase
Migration	Increase
Random genetic drift	Decrease/increase
Isolation	decrease

SECTION C: Extended Answer **(10 marks)**

Choose one from the following two questions.

22. Genetic testing of natives of Iceland have indicated major differences in allele frequency to Scandinavians and the Celts of Ireland and Scotland from where they are believed to have originated. Describe the ways in which changes in allele frequency can come about in populations such as those found in Iceland.

Variation in allele frequency would have existed in the original Scandinavian and Celt populations (1)
Due to sexual reproduction / meiosis / fertilisation / mutation / sexual selection / random mating (any 2, 1 mark each)
Individuals who migrated to Iceland won't contain all the alleles of the original gene pool (1)
Due to the small numbers who migrated there, the founder effect may have occurred (1)
Whilst there, the population was isolated from other groups by geographical / ocean barriers (1)
Random genetic drift of the Iceland population may occur (1)
And result in random non-directional variation in allele frequency in that population (1)
Mutations / inheritable random changes in DNA may also have occurred in that population (1)
Over time, natural selection would have resulted in some characteristics becoming more common (1)
due to the more favourable alleles being passed on / less favourable alleles dying out (1)

23 a) Explain the difference between genetic drift and natural selection as processes that result in evolution. Explain carefully how you might determine whether observations of evolution were due to selection or genetic drift. (6 marks)

Any of the following points for 6 marks. 1 dot point = 1 mark unless otherwise stated

- Natural selection happens when changes occur, providing a selective advantage to individuals in a population
- Original population separates into two groups
- In different environments
- No gene flow between groups
- They have different selection pressures
- Causing a difference in gene frequencies between populations
- Genetic drift is not caused by selection pressure
- It is caused by random changes in gene frequencies
- Due to the breeding rates of individuals
- Natural selection will cause the entire population to move towards a particular characteristic (2 marks)
- Genetic drift could cause the characteristic of the population to increase or decrease over generations (2 marks)
- Genetic drift occurs in small populations
- Natural selection in any sized population
- Natural selection produces a population adapted to its environment
- Genetic drift conveys no benefit

b) Discuss two circumstances where genetic drift is likely to occur. Explain why.

(4 marks)

Any of the following points for 4 marks. All dot points = 2 marks unless otherwise stated

- Genetic drift in a small population (1 mark)
- Any change in one family will have a bigger impact in a small population that a large
- People are likely to mate with people similar to them producing more offspring with the new variation in the next generation
- The same event may wipe out most of the population with a particular characteristic making it less likely to be passed on to the next generation