"Every individual alive today, the highest as well as the lowest, is derived in an unbroken line from the first and lowest forms".
August Fredercik Lopold Weismann (1834-1914)

"From the remotest past which Science can fathom, up to the novelties of yesterday, that in which Progress essentially consists, is the transformation of the homogeneous to the heterogeneous".
Herbert Spencer (1820-1903)

1. The table below shows changes in frequency of allele A for two populations of Darwin's finches on the Galapagos Islands over 10 generations after the effect of two different evolutionary mechanisms on the two populations.

In **Population 1**, after a storm passed through the Galapagos, a few finches ended up on an island where no finches were found before, mated and established a new population on that island.

In **Population 2** of Darwin's finches on an Island in the Galapagos, severe drought favoured one phenotype over the other in a population of birds that had both thin and thick size beaks.

Generations		1	2	3	4	5	6	7	8	9	10
Frequency of allele	Population 1	0.65	0.55	0.45	0.40	0.35	0.30	0.20	0.10	0.00	0.00
	Population 2	0.50	0.30	0.70	0.20	0.40	0.80	0.30	0.70	1.00	1.00

a) Present the data above on suitable graphical form.

b) Describe the pattern in frequency of allele A over the 10 generations in,

i. Population 1.

ii. Population 2.

c) With reference to results, explain the evolutionary mechanism that caused changes in allele frequency observed in the two populations upto the 9th generation.

d) Suggest reasons for the observed results in the allele frequency from the 9th to the 10th generation for the two populations.

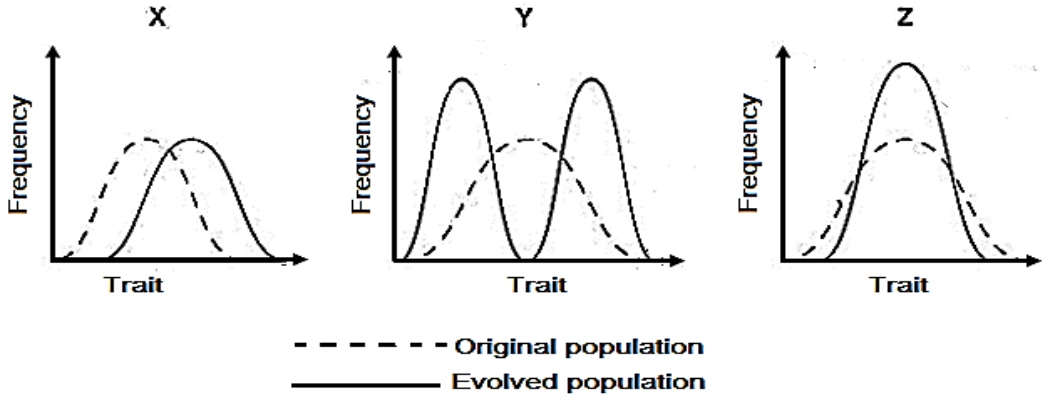
e) Briefly describe other two evolutionary mechanisms that may lead to change in allele frequency in a small population.

f) Explain the following observations.

i. Genetic drift is much likely to change allele frequency in a small population rather than large population.

ii. Populations experiencing disruptive selection pressures are prone to evolutionary change.

2. Figures X, Y and Z show three forms of natural selection that occurs in a population of organisms.***



a) Describe how the different forms of selection affect the frequency of traits of the original population.
   i. Figure X
   ii. Figure Y
   iii. Figure Z

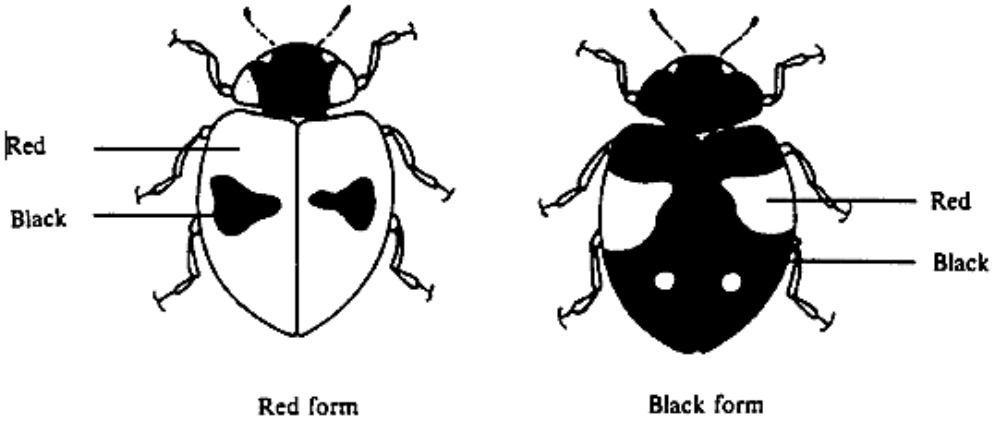
b) With examples, explain how the different forms of natural selection arise and contribute the phenotypic frequency of the evolved population.
   i. Figure X
   ii. Figure Y
   iii. Figure Z

c) Explain the genetic basis and evolutionary significance of the following;
   i. Sickle cell anaemia.
   ii. Pesticide resistance.
   iii. Formation of new species by allopolyploidy.

d) How does selective inbreeding affect the phenotypic frequency of a population?

3. (a) 'Woolly hair' is common among Norwegian families: the hair is tightly kinked and very brittle. The allele for woolly hair (H) is dominant over that for normal hair (h). The alleles for Hand h have frequencies p and q respectively. In a certain population of1200 people, 1092 individuals have woolly hair. Assuming that the Hardy-Weinberg principle applied, calculate the frequency of occurrence of each of the genotypes HH, Hh and hh. Show all your working clearly.

(b) The two-spot ladybird exists in the two different colour forms shown in the diagram.



Red form Black form

These forms are controlled by a single gene with the allele for black, B, dominant to that for red, b recessive.

Use the Hardy-Weinberg formula to predict the frequency of red and the frequency of black ladybirds in a population if the frequency of alleles Band b are the same.

(c) Outline the conditions under which the Hardy–Weinberg operates

(d) Discuss the mechanisms by which a new species may originate and a species become extinct.

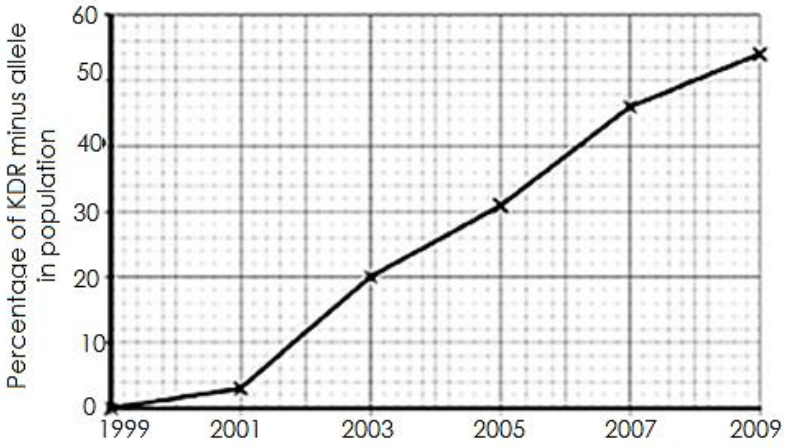
4. When a new road system was constructed, it split a population of a rare snail species into three smaller populations, A, B and C. As a result, each of these populations became reproductively isolated. The Hardy-Weinberg was used to calculate the relative allele frequencies, p and q, of a dominant and recessive allele respectively in each population. The table below shows the values of p and q, and the estimated sizes of these three populations.

Snail population	Estimated population size	Immediately after road building		10 years after road building	
		p (frequency of dominant alleles)	q (frequency of recessive alleles)	p (frequency of dominant alleles)	q (frequency of recessive alleles)
A	1000	0.50	0.50	0.52	0.48
B	100	0.49	0.51	0.63	0.37

C	10	0.40	0.60	0.20	0.80

a. Explain how the above type of isolating mechanism among the three snail populations leads to emergence of new species in a population?
b. Describe the form of speciation which occurs upon the new road construction.
c. Determine the changes in number of the heterozygous snails in the three populations. Clearly show your working
d. (i) The habitat for these populations did not change over the ten years. Explain the term used to describe the random changes in allele frequency in a small population.
(ii) Outline the factors which alter the allele frequency in the above populations in (d) (i) above.
e. Explain which of the snail populations in table above experienced most genetic change.
f. With relevant examples, describe the post zygotic forms of reproductive isolating mechanisms which may occur in a population of organisms.

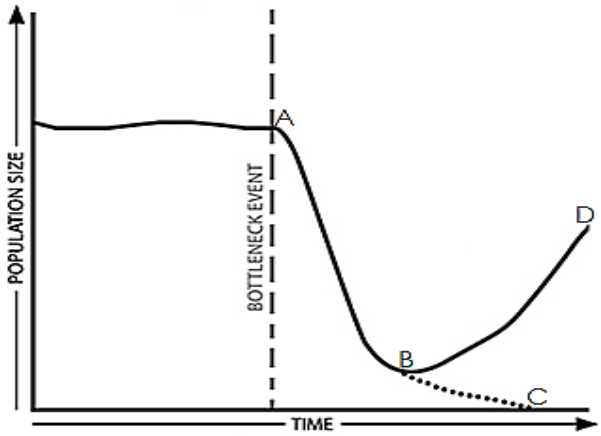
5. Malaria is a disease that is spread by insects called mosquitoes. In Africa, DDT is a pesticide used to kill mosquitoes, to try to control the spread of malaria. Mosquitoes have a gene called KDR. Today, some mosquitoes have an allele of this gene, KDR minus, that gives them resistance to DDT. The other allele, KDR plus, does not give resistance. Scientists investigated the frequency of the KDR minus allele in a population of mosquitoes in an African country over a period of 10 years.



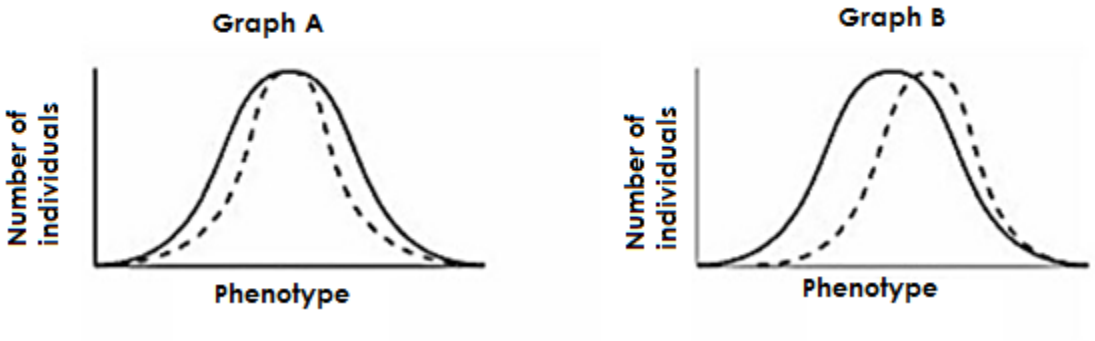
a. Use the Hardy-Weinberg equation to calculate the frequency of the mosquitoes heterozygous for the KDR gene in this population in 2003. Clearly show your working.
b. Determine the genotypic frequencies of KDR minus and KDR plus in this population.
c. Account for the observed trend in percentage of KDR minus allele over the generations.
d. KDR plus allele codes for the sodium ion channels found in neurones.
e. (i) When DDT binds to a sodium ion channel, the channel remains open all the time. How does this explain the action of DDT in killing insects?
(ii) Suggest how KDR minus allele gives resistance to DDT.
f. Under what conditions must the Hardy-Weinberg principle remain viable?
g. Explain how each of the above mentioned conditions may affect the genetic equilibrium.

6. The figure below shows the changes that occur to a population of individuals before and after a bottle neck event.

a) What does region BC and BD represent?
b) Suggest explanations to possible effects of the bottleneck event to the population in regions,
   i. AB
   ii. BC
c) Describe three examples of bottleneck effect that may naturally occur.
d) Population before bottleneck is less susceptible to changes in allele frequency by genetic drift unlike population at B.
e) Compare bottle neck effect and founder effect.

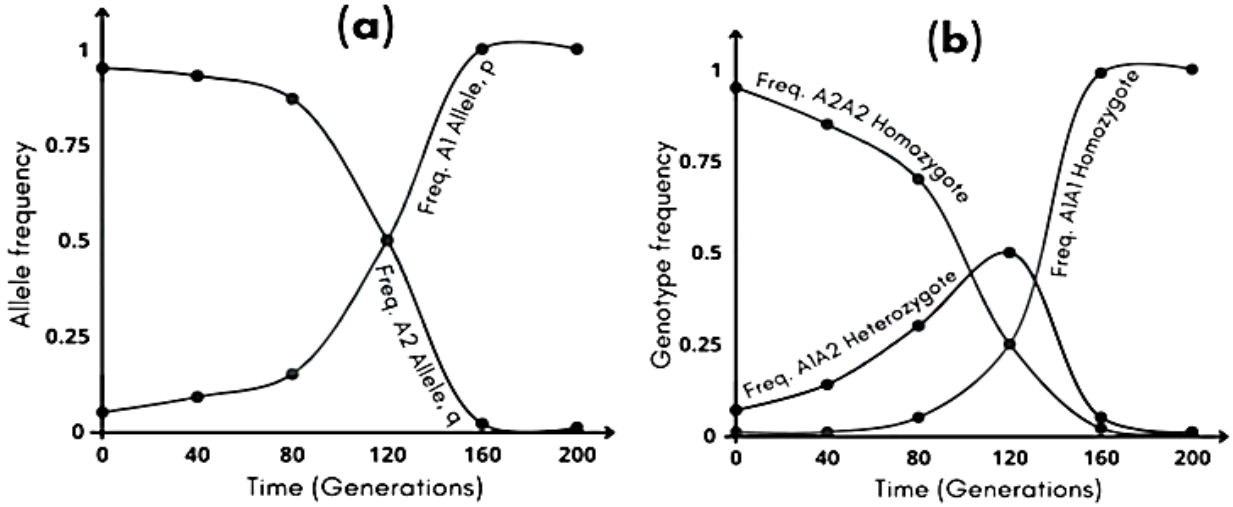


7. In the graphs below, the solid line represents normal distribution of phenotypes.



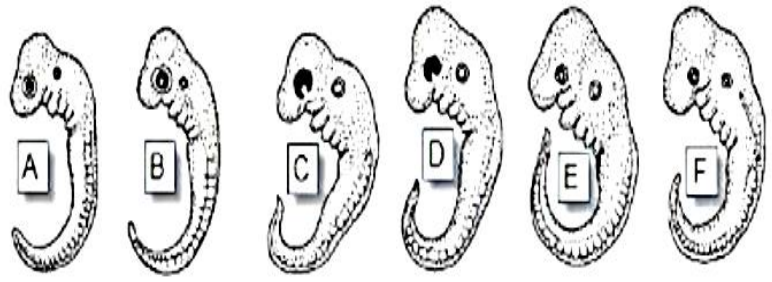
(a) Identify and compare the types of natural selection represented by graphs A and B.
(b) Describe relevant examples of each of the two types of natural selection.
(c) Suppose a population of squirrels became separated by a flooding river that a deep canyon between the two groups. Describe the events of speciation that might occur.

8. The figure below shows the allele frequency trajectories for two alleles being studied by population geneticists. This study investigated the Hardy-Weinberg phenomenon in an infinite large population, involving one gene that has only two possible alleles. Graph (a) represents the change in allele frequency of A1 (p) and A2 (q) under selection for A1 as a recessive. Graph (b) represents the change in genotype frequencies, A1A1 (p2); A1A2 (2pq) and A2A2 (q2) associated with allele frequency changes.

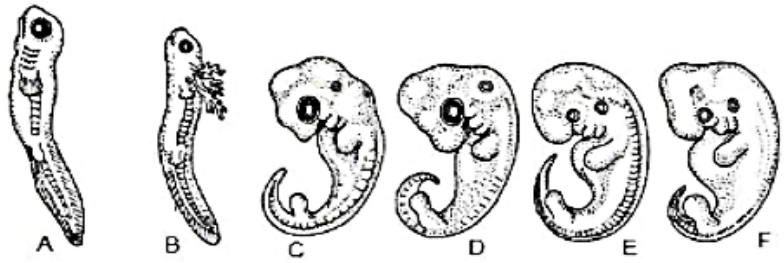


a) From the figure above, describe:
   i. The changes in allele frequency over several generations.
   ii. The relationship between allele frequency and genotype frequency over several generations.
b) With reference to the figure above, explain
   i. The major factors that affect allele frequency in a population over long periods of time.
   ii. Why the frequency of the A2 allele persisted in the population.
c) Explain how frequencies of alleles and genotypes would change in a small population.
d) Suggest why it is important to track allele frequencies in populations over time.
e) Relate changes in the gene frequency to evolution.

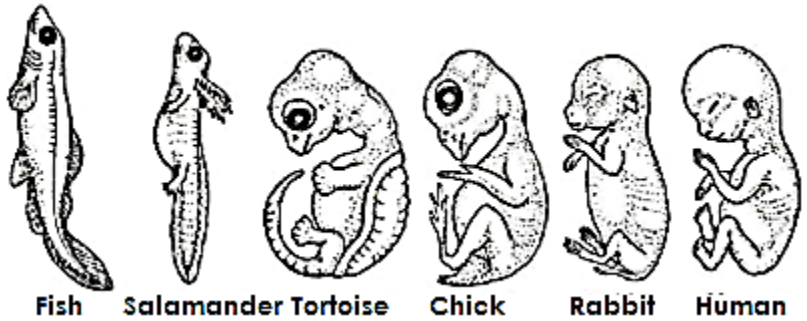
9. The figures 9.1 A to D below show six different embryos of six organism.



Figures 9.2 below show older, more developed embryos from the same organisms

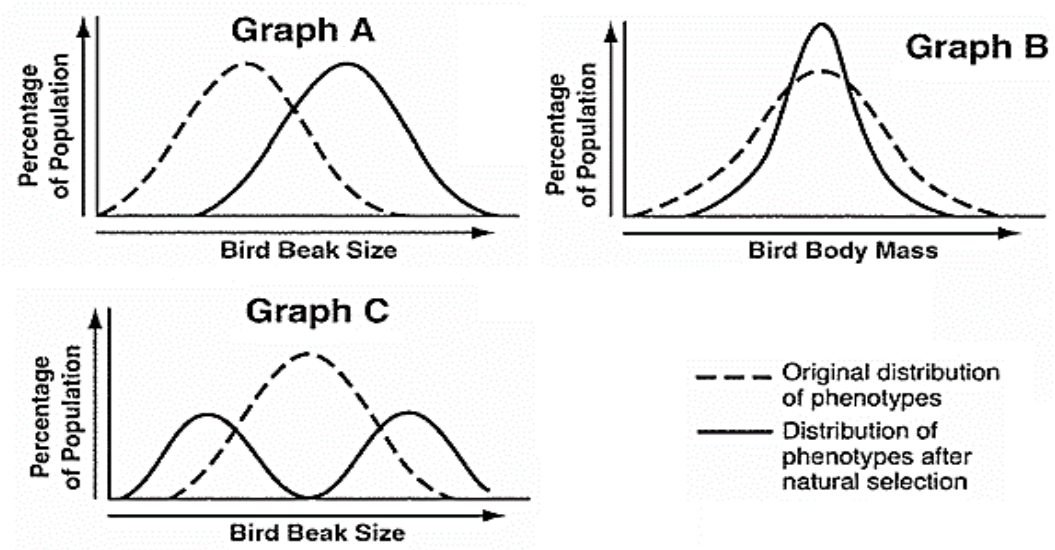


Figures 9.3 below show the same embryos at their most advanced stage, shortly before birth.



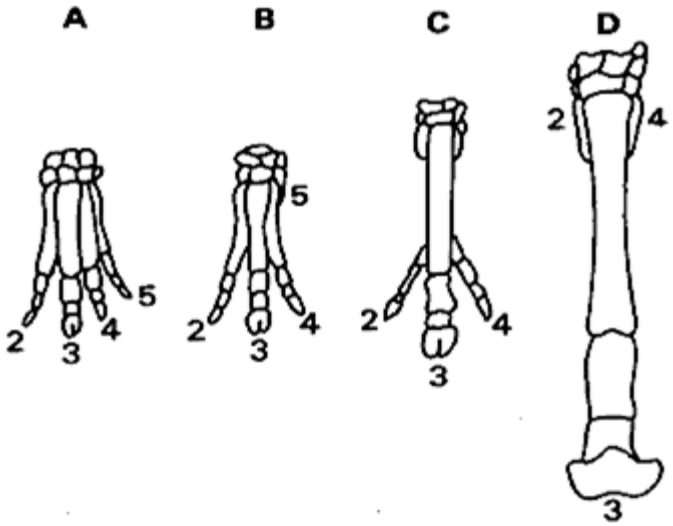
(a) Describe how the embryos changed for each of these organisms from their earliest to the latest stages.
(b) Observe clearly the six embryos in their earliest stages. Describe physical similarities that exist among the six embryos.
(c) Explain how these embryos can be used as evidence of evolution from a common ancestor for the six organism.

10. The following graphs depict three different types of selection a population of Darwin's finches in Galapagos Island. Carefully study them to answer the questions that follow.



(a) Distinguish the effects of selection in graphs B and C.
(b) Use a likely scenario to describe how factors or conditions that may have led to the changes shown the graphs A, B and C.
(c) Explain how the following observations support the theory of evolution by natural selection.
   i. Animals found on islands look similar to animals found on neighbouring islands and the closest continent.
   ii. Related species will live in diverse environments in one area (for example, South America) but can vary different from the species in similar environments in another area (for example, Asia)

11. Figure below shows, in chronological sequence from A to D, fossils of the forelimb skeletons of four related mammals.



(a) Describe briefly the structural changes seen in the fossil sequence.
(b) What were the possible adaptive advantages of these structural changes?
(c) Explain how the chronological sequences of the fossils in the figure above provide evidence for evolution.
(d) How might each of the following be used as support for the theory of evolution?
   i. Human beings possess an appendix which seems to have no function.
   ii. Marine sharks retain urea in their blood, thus maintaining their osmotic pressure close to that of the surrounding sea water. Fresh-water sharks show the same phenomenon.
   iii. Viral DNA has the same basic structure as human DNA.

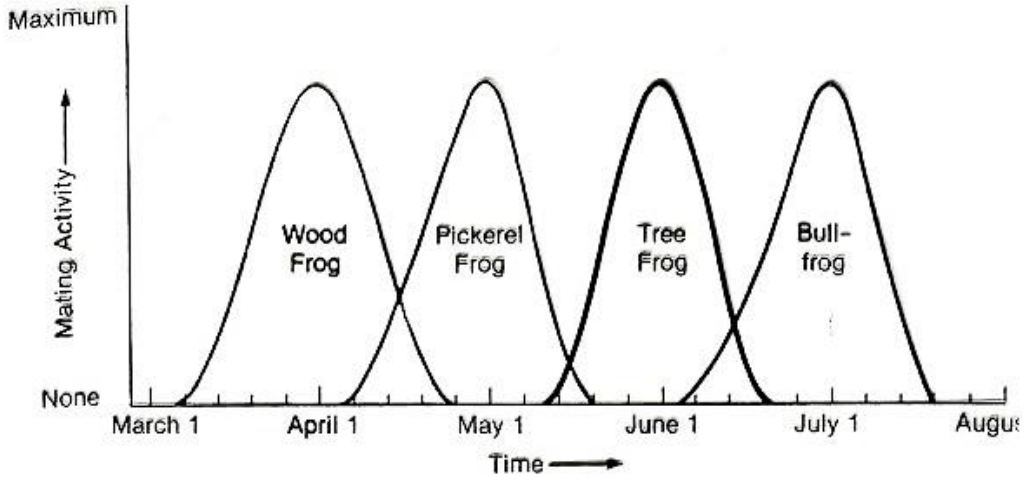
12. (a) Below are some vestigial structures found in humans. For each suggest what its function may have been.

Structure	Possible function
Appendix	

Muscles for moving the ear	
Body hair	
Little toe	
Tail bone	

(b) How are the vestigial structures an example of evidence of evolution?

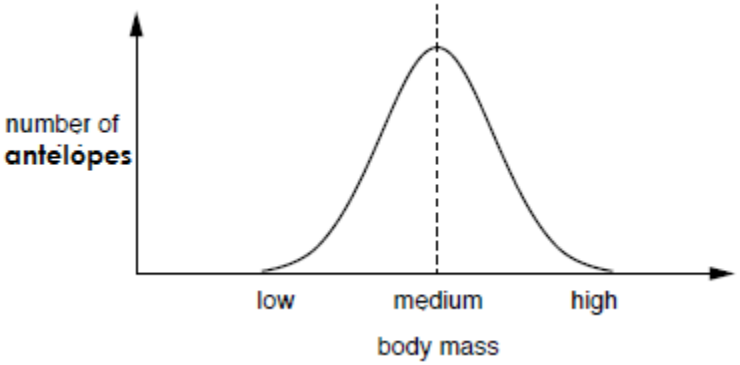
13. The figure below shows the times when four different frog species carry out their mating activity.



(a) Identify the type of isolating mechanism in the figure above.
(b) What is the significance of the trends observed in the breeding times of the four frogs?
(c) Explain how the difference in the breeding times results into formation of new species.
(d) Which type of speciation occurs among the above frog population?
(e) Describe the possible barriers that may occur to hybrids when Wood frog and Pickerel frog successfully breed.

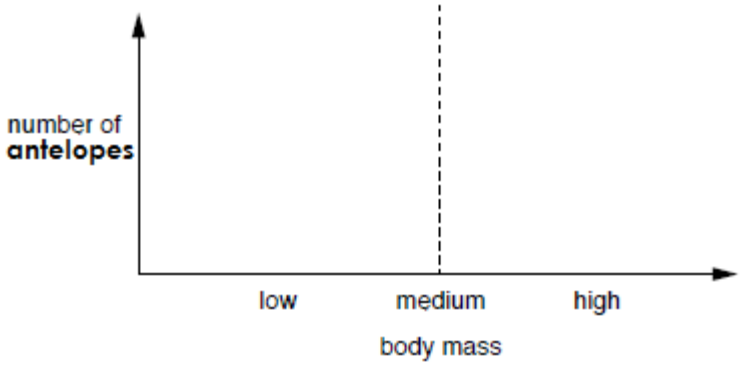
14. The number of antelopes in the Murchison falls park increased from 135 000 in 1960 to 360 000 in 2010. Environmental factors affect the population size of antelopes so that numbers do not continue to increase.

(a) Suggest environmental factors that may prevent further increases in the size of red deer populations.
(b) The body mass of antelopes shows wide variation within a population.



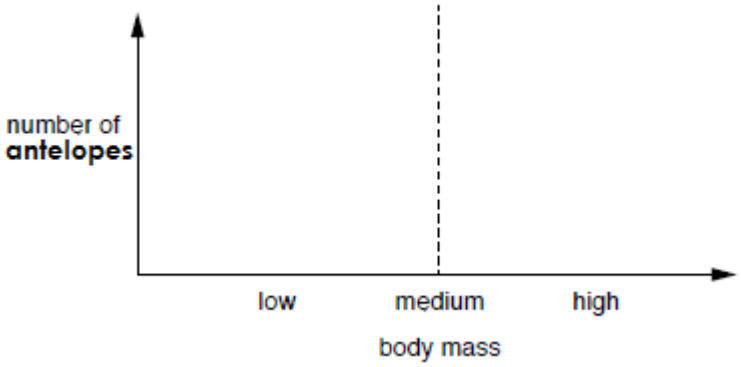
A selection pressure acted consistently over many years against antelopes of **low** body mass in a population.

i. Sketch a curve on Figure below to show the pattern of variation of body mass in this antelope population after this time.



ii. Name the type of force of natural selection that is acting on this population.
iii. Compare the distribution of body mass phenotypes before and after selection.

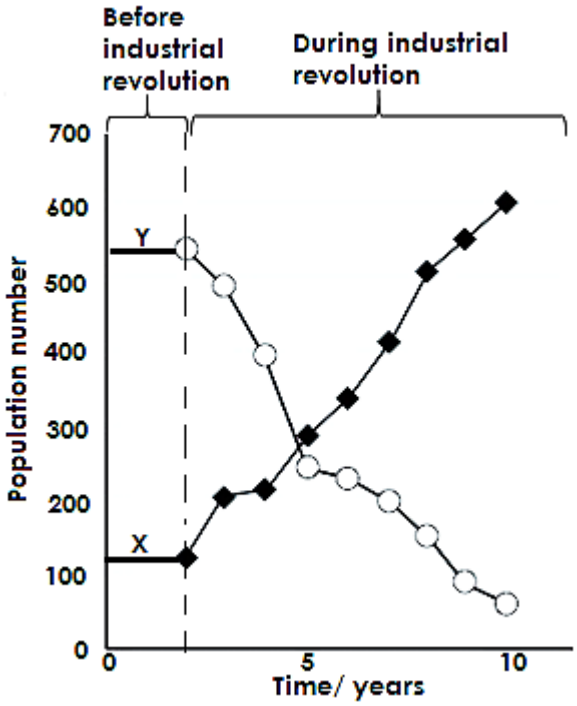
(c) A selection pressure acted consistently over many years against antelopes of **medium** body mass in a population.
i. Sketch a curve on Figure below to show the pattern of variation of body mass in antelope population after this time.



ii. Name the type of force of natural selection that is acting on this population.
iii. Compare the distribution of body mass phenotypes before and after selection.

(d) How does the selection in (i) provide evidence for evolution.

15. The graph below shows the population size of polymorphic forms of same species of peppered moth (Biston betularia) before and during the industrial revolution as studied by Benard Kettlewell (1953). The data was obtained by setting traps to capture moths for 10 consecutive years. Traps were located in same area each year.



a) Identify the morphic forms of Biston Betularia represent by letter X and Y.
b) Calculate the percentage change in population of the two morphic forms the 10 years period.
c) Account for the population size of two morphic forms in (a) above;
   i. Before industrial revolution
   ii. During the industrial revolution
d) Describe how the type of selection and the responsible selection pressure operate to distribute the morphic forms of the peppered moth.
e) How does distribution of morphic forms after industrial revolution provide evidence for evolution?

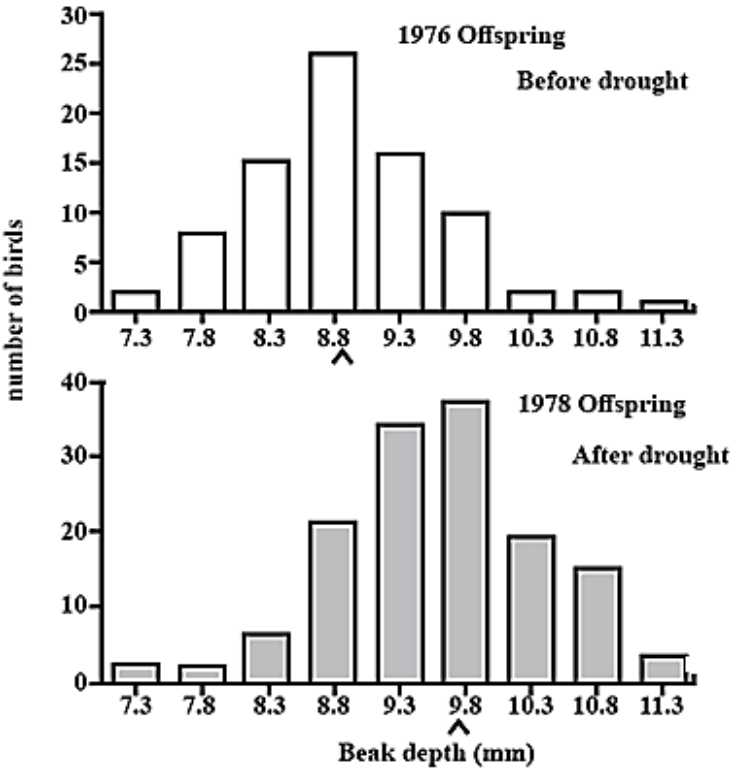
f) Suggest an explanation for why traps were located in the same area each year.

16. The results in table below shows mosquito resistance to DDT. Mosquitoes were considered resistant to DDT if they were not killed within 1 hour of receiving a dose of 4% DDT.

Month	0	8	12
Mosquitoes Resistant to DDT	4%	45%	77%

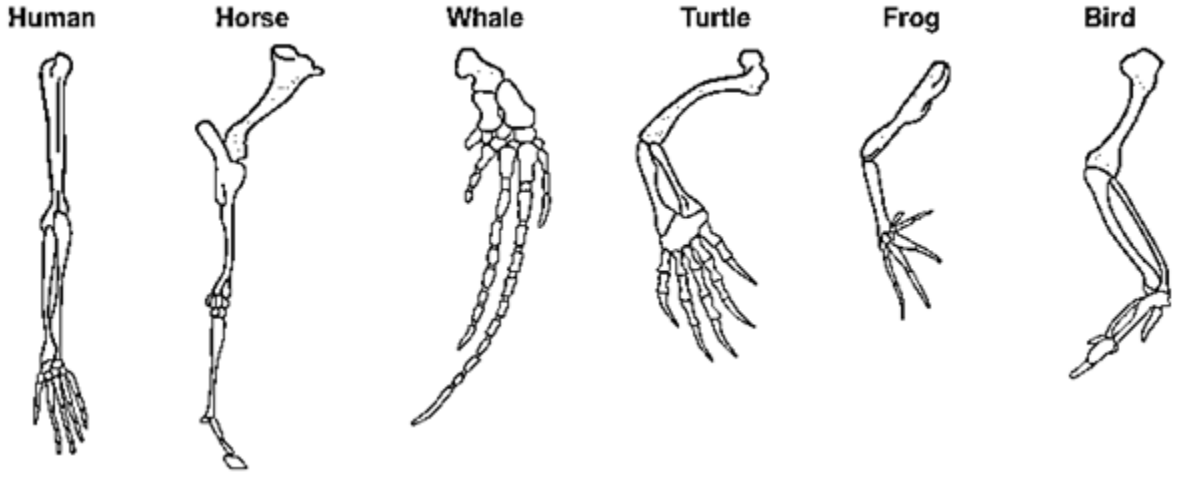
a) Suggest explanations for the results obtained,
   i. On first spray.
   ii. On the 12th month.
b) How would the knowledge of selection pressure be used to reverse the results obtained on the 12th month?
c) Explain how resistance to DDT by mosquitoes provides evidence for evolution.
d) Bacteria undergo microevolution due to antibiotic resistance, Explain how this occurs.

17. The figures below shows the distribution of finches of varying beak depth before and after drought on the Galapagos Island.



(a) Compare the results before and after drought.
(b) Suggests explanations for the differences in (a) above.
(c) How do the results of 1978 provide evidence for evolution?

18. Figures below show the skeletal structure of the front/ fore limbs of 6 animals: human, horse, whale, turtle, frog and bird. Each animals has a set of bones.



a) For each animal, state the type of movement(s) each limb is responsible for.
b) State the structural and functional differences between each and that of the human arm
c) How do the structural features provide evidence for evolution?

19. A factory emitting smog contains sulphur dioxide and carbon dioxide was cited in a rural district. The table below give distances and directions of;
(i) Number of moth species
(ii) Concentration of Sulphur dioxide in smog in different directions from the factory chimney.

Table 1

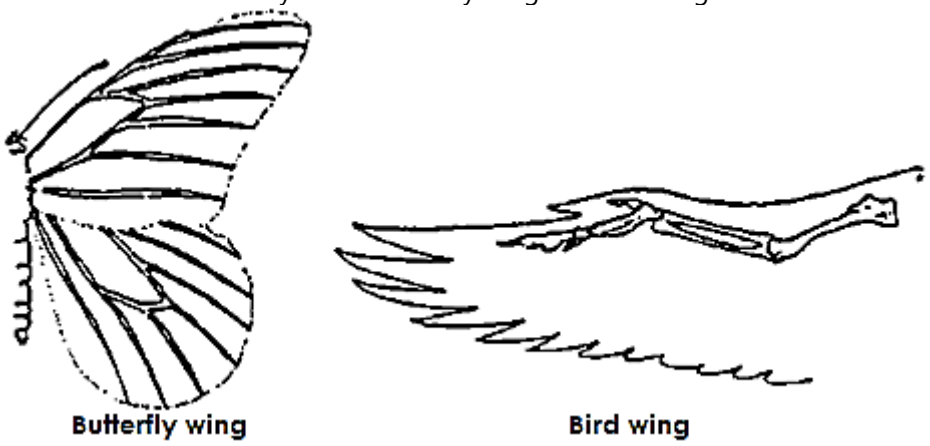
Distance from the factory in a South South West (SSW) direction/ miles	1	2	4	8	12	16	28
Number of moth species	0	1	2	3	7	9	14
Sulphur dioxide concentration (ppm)	28	27	26	23	19.5	16	2

Table 2

Distance from the factory in a North North East (SSW) direction/ miles	1	2	4	8	12	16	28
Number of moth species	1	2	3	4	4	5	5
Sulphur dioxide concentration (ppm)	27	26.5	25	24	23	22	19

(a) Represent the information to show the relationship between the moth species and the sulphur dioxide concentration on the same axis.
(b) Explain the difference in the results between those obtained for the SSW direction and those obtained for the NNE direction.
(c) Explain why the number of moth species increases with increasing distance from the factory.

20. The figures below show the anatomy of the butterfly wing and bird wing.



Butterfly wing

Bird wing

a) Identify the role of each of the structures above.
b) State the difference in structure of the wings.
c) How do the above forms of wings provide evidence for evolution?