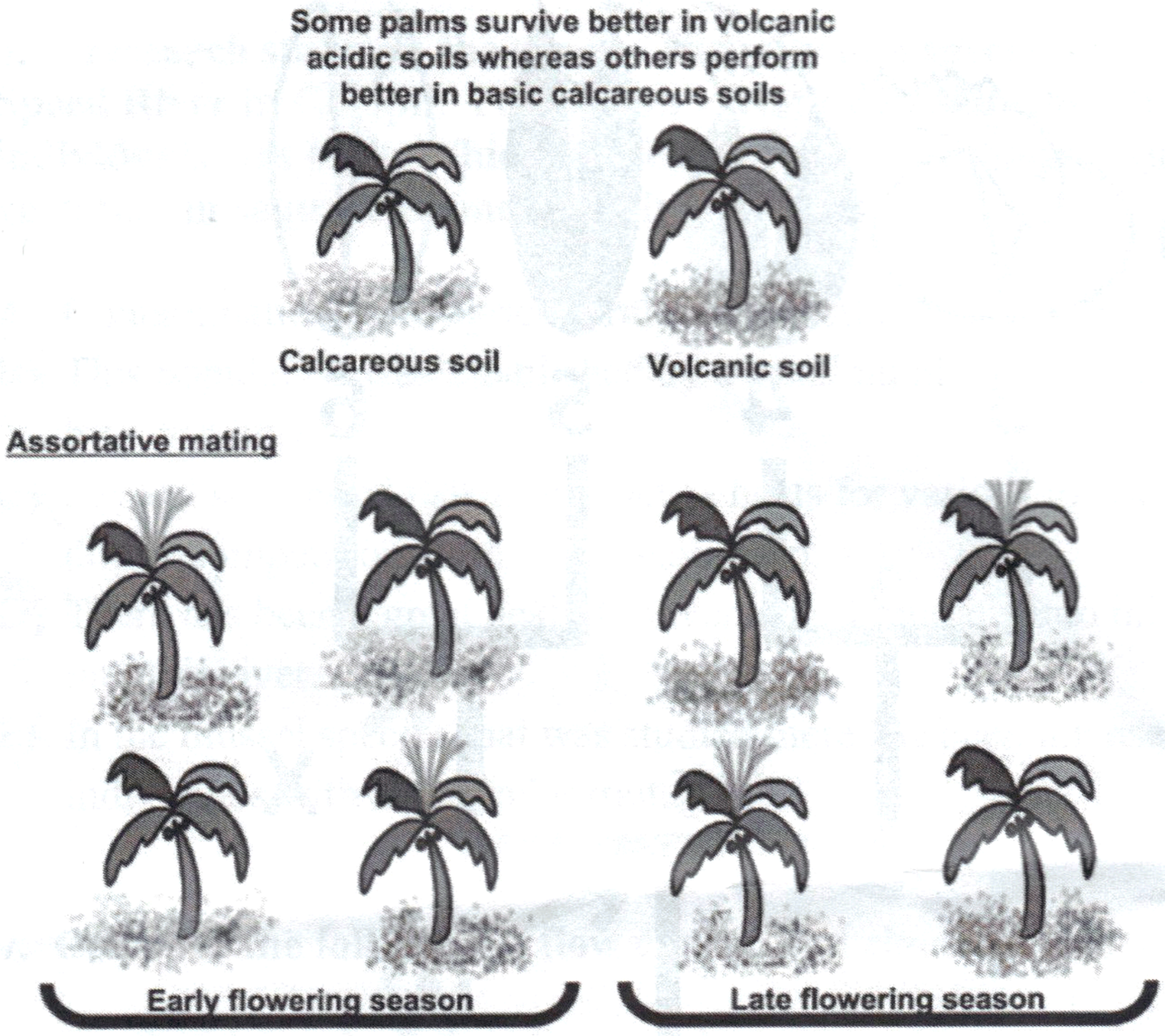
Palms on Lord Howe Island are represented by two distinct morphs that occur on different soil types in the same area and. Researchers have noticed that the two morphs of these palms i) have difference in flowering time (assortative mating), and ii) these two morphs have distinct DNA barcodes. Examine the figure below.



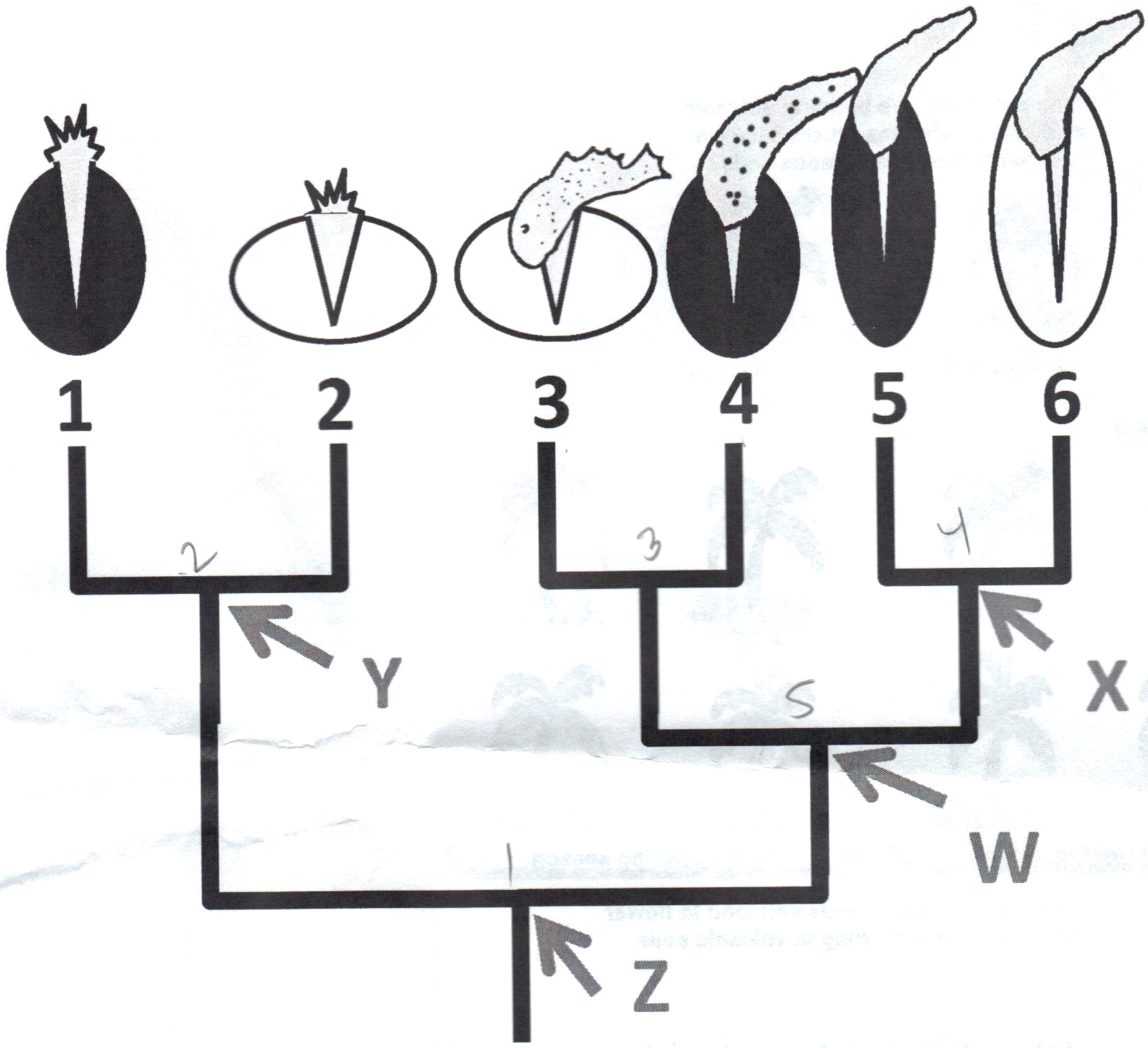
1. The presence of these two morphs are best described as an example of,

A) Sympatric speciation, resulting in two species.
B) Allopatric speciation, resulting in two species.
C) Peripatric speciation, resulting in two morphs of one species.
D) Artificial speciation, resulting in only one species with lots of genetic variation.
E) Allopatric speciation, resulting in one species with lots of morphological variation.

2. Where do we find genes used for barcoding plants?

A) Only in the nucleus of the cell.
B) Only in the mitochondria of the cell.
C) Only in the chloroplast of the cell.
D) In the nucleus and chloroplast of the cell.
E) In the mitochondria and chloroplast of the cell.

Interpret this evolutionary tree of six species of mussels that have variation in color (black & white), shape (elongated, flattened, round) and types of lures. This phylogeny is a diagrammatic depiction of biological entities that are connected through a common ancestor. Use the information in this figure to answer the following 3 questions.



3. Which of the following set of species do <u>NOT</u> form a clade?

A) All species with complex lures (species 3, 4, 5, 6)
B) Species 1 & 2 because they have evolved different shapes.
C) Species 3 & 4 because they are different colors.
D) Species that are black and have complex lures (species 4 & 5).
E) All the species on this tree, because they have different shapes and colors.

4. Which of the following statements is <u>TRUE</u> about this tree?

A) Mussel species 4 is more closely related to mussel species 5 & 6 than it is to mussel species 3.
B) Based on this tree, it is likely that shell color has changed 4 times from ancestor to descendant.
C) If simple lures (such as those depicted in species 1 & 2) is an ancestral trait at node Z, then it is likely that (W) and (X) represent points at which derived traits evolved rather than were lost.
D) There are 4 ancestors in this tree.
E) Mussels 2 & 3 with similar shells (shape & color) are sister taxa.

5. How many clades are shown in this tree?

A) 2 clades
B) 3 clades
C) 4 clades
D) 5 clades
E) 6 clades

6. A research study on the genetic diversity of a species of mussel was conducted on the Speed River in Guelph. Population variation in Mitochondrial DNA sequences among individuals was high. Which of the following is the most plausible explanation for this high variation in sequences among individual mussels?

A) Contamination from agricultural run-off left only a few survivors in this population.
B) This population was established by a small number of larvae that were carried into the river by a fish host.
C) Several species of fish, which act as hosts for various mussel species, have been extirpated due to competition from an invasive carp.
D) There has been a great deal of movement of mussels into this river from tributaries feeding into this river.
E) In the mussel species that was studied there has been intense natural selection favouring individuals with a particular trait.

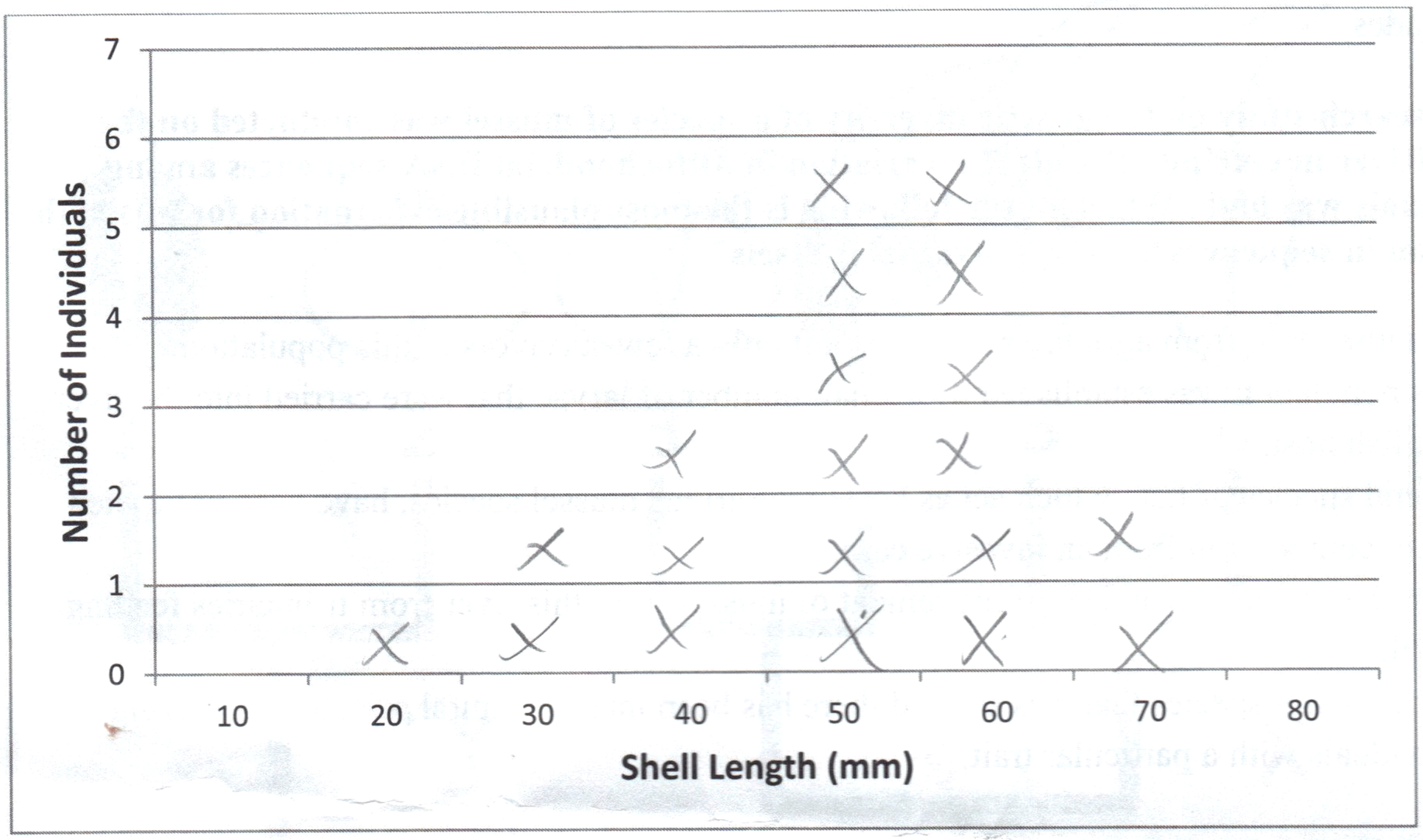
7. Consider the following 2 flow charts, and choose the correct description below:

i) embryo →	glochidia develop in marsupium	→	____(a)____	→	free juvenile mussels in river/lake bed	→
ii) embryo →	____(b)____	→	metamorphosis	→	settled juvenile mussels in river/lake bed	→

A) The two flow charts above describe the early developmental stages of Unionid mussels, where (a) = glochidia attach to fish host gills and (b) = release of fully developed young mussels.
B) Flow chart 1 represents one type of early development in freshwater mussels where (a) = veliger larvae, whereas flow chart 2 shows a very different developmental process where (b) = conglutinates.
C) The two flow charts represent ontogenic variation in freshwater mussels where (a) = glochidia attach to fish host gill and (b) = free swimming veliger larvae.
D) Freshwater bivalves develop in 3 ways; two are depicted above where (a) = the release of fully developed young mussels (free swimming) and (b) = glochidia develop in marsupium.
E) The two flow charts above describe the early developmental stages of Dreissenids (#1) and Unionids (#2), where (a) = veliger larvae and (b) = lures.

As part of your summer job you are asked to measure the phenotypic variation (shell length) of 20 wavy rayed lamp mussel *Lampsilis fasciola* freshwater mussels. Plot the data you collected on the graph below and choose the most correct answer (# 8 below).

Data (in mm) = 60, 50, 30, 40, 50, 60, 70, 40, 40, 50, 60, 60, 50, 60, 50, 50, 60, 20, 30, 70



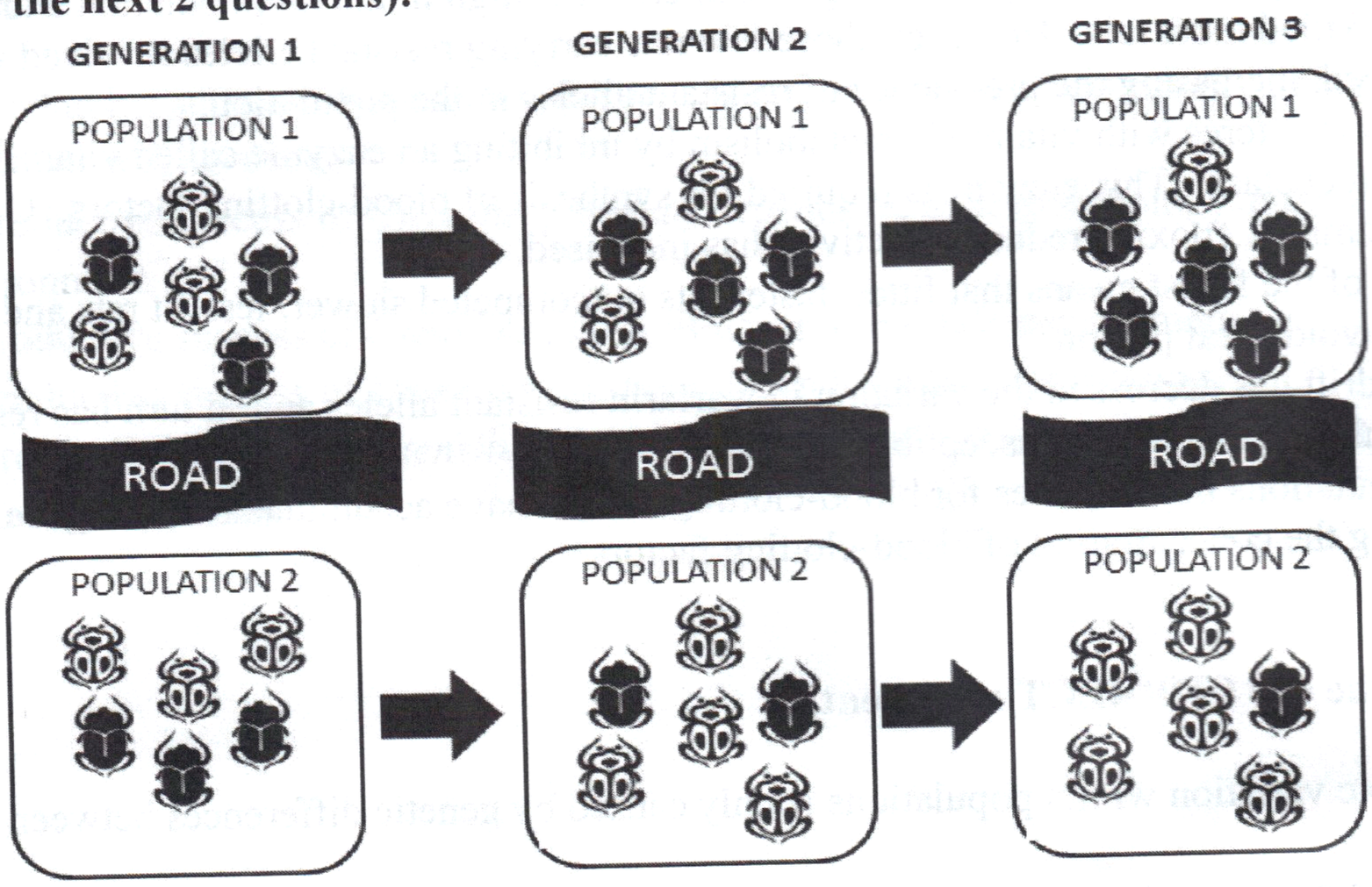
8. Choose the one correct statement.

A) The graph approximates a normal distribution.
B) The graph shows that as shell length increases, so does the number of individuals.
C) The graph approximates a natural curve with a mean shell length of approximately 20 mm.
D) The broad, low curve indicates that very little variation exists among individuals.
E) The slope of the line is equal to the bell shaped curve.

9. Below are some statements related to species extinction. Select the one answer that is INCORRECT (explanation does <u>not</u> make sense).

A) The mussel *Ligumia sadlia* has not been found for over 25 yrs (assumed to be extinct), probably because their native habitat was destroyed by land development.
B) *Obliquaria nexa*, now extinct in the Great Lakes region, ate the same food as zebra mussels. The extinction was caused by competition for food, which was severe due to the large number of invasive mussels.
C) Historically, hickory mussels were prey for only one fish species, but the recent invasion of monster carp (*Carpio monsteri*) has decimated the population to extinction.
D) Pigtoe mussels (*F. piggi*) used to be distributed throughout southern Ontario but gene flow from other populations south of the border drove this species to extinction.
E) The flower mussel (*M. iris*) with a complex lure attracted one species of fish (*O. nerka*), however after the extirpation of *O. nerka* the flower mussel became extinct.

The recent construction of a new road through a forested area has created a barrier between two populations of ground dwelling beetles. There are two morphs in this species, a black morph and a white morph that are feeding on different resources on either side of the road. Colour morphology is a function of various alleles of a gene for body color. You decide to observe the two populations for several generations, and you notice the following (answer the next 2 questions):



10. Which of the following statements is the most PLAUSIBLE based on your observations?

A) There is extensive gene flow between these two populations, which maintains both morphs in the two populations.
B) Founder effects probably account for the differences in the proportion of the black and white morphs in the two populations observed in Generation 3.
C) There may be differences in the types of food that are available on either side of the road.
D) Living conditions in the area where Population 2 is found are much harsher than where Population 1 is found.
E) It is likely that the black morph will eventually become the only morph remaining in this species.

11. The change in frequency of black and white morphs of beetles in these populations is an example of:

A) Mutation, resulting in specialized adaptive traits.
B) Gene flow, resulting in dominant black or white morphs in each population.
C) A genetic bottleneck, resulting in reduced frequency of either black or white morphs in each population.
D) Genetic drift, resulting in reduced frequency of either black or white morphs in each population.
E) Natural selection, resulting in differential survivorship or reproduction of individuals with either black or white morphs.

12. Warfarin, an anticoagulant rat poison, interferes with the metabolism of blood-clotting factors. When first introduced 60 years ago, it was an effective controller of rat populations, however today warfarin is not very effective. Which explanation is most plausible?

A) Sixty years ago the frequency of susceptible alleles was high in the rat population and warfarin killed most rats. However, those few rats carrying resistant alleles survived and reproduced, increasing the prevalence of resistant alleles in the population.
B) Warfarin interferes with vitamin K metabolism by inhibiting an enzyme called vitamin K epoxide reductase. This enzyme is required for synthesis of blood-clotting factors. Over time, vitamin K epoxide reductase activity has increased.
C) Survival of the fittest means that fitter, faster rats outcompeted slower, less fit rats and thereby avoided rat poison.
D) Genetic drift has decreased the variation in warfarin resistant alleles and in turn has resulted in a population that is less susceptible to warfarin.
E) Likely mutations in the alleles for blood-clotting factors have accumulated in the gene pool, increasing the concentration of blood-clotting factors.

13. Choose the one CORRECT statement.

A) Phenotypic variation within populations is only caused by genetic differences between individuals.
B) Organisms or their gametes (e.g. pollen) sometimes move from one population to another; this is called genetic drift.
C) A mutation is a heritable change in DNA, which is beneficial.
D) Adaptation is the accumulation of adaptive traits over the lifetime of an organism.
E) Evolution by natural selection is the consequence of differential survival and reproductive success of individuals in a population, due to differences in their heritable traits.

14. _____(1) is random changes in allele frequencies caused by chance events that can lead to _____(2) genetic variation.

Fill in the blanks above with the correct term from 1 and 2 below.

A)	1. Gene flow,	2. increased.
B)	1. Genetic drift,	2. reduced.
C)	1. Genetic bottleneck,	2. increased.
D)	1. Founder release,	2. reduced.
E)	1. Mutation,	2. reduced.

15. *Utensilus plasticus* feeds on small prey items, especially marshmallows. The population consists of two different head shapes, forks (n = 8) and spoons (n = 8). There is a sudden change in the prey population because an invasive species, the aggressive large sized marshmallow, is now present in a higher number than the typical prey species, the mini-marshmallow. Over the next few generations …. Choose the hypothesis that is most plausible.

A) Reproductive success of *Utensilus plasticus* is non-random and it is equally likely that forks or spoons will succeed.

B) Reproductive success of *Utensilus plasticus* depends on their morphology and their environment.

C) Reproductive success of *Utensilus plasticus* depends on their environment.

D) Reproductive success of *Utensilus plasticus* depends on their morphology.

E) Reproductive success of *Utensilus plasticus* is random and it is equally likely that forks or spoons will succeed.