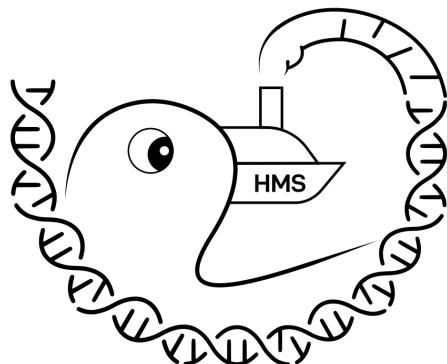


What Would Darwin Do

Prelims Question Paper

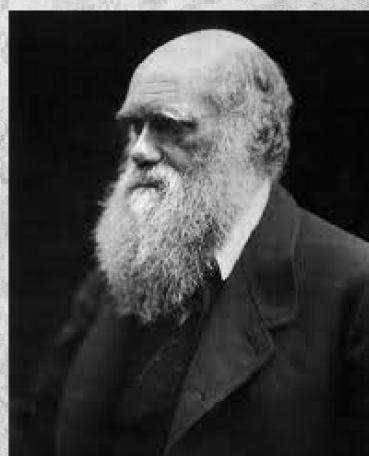


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Part A

Question A Another chance

A natural catastrophe occurs in the niche of a population of organisms which significantly reduces the population size. After a long time, the population recovers, and the selective environment remains the same as before. Which of the following is likely to be observed in the recovered population?

1 mark

- a. High genetic variation
- b. Increased frequency of harmful mutations
- c. Slow return to the gene pool of the original population
- d. Better fitness than the original population

Answer: (b)

Question B Founders

A large population of organisms resides in a niche. A small group of individuals from this population migrates to a very different environment. Which of the following could increase the fitness of the migrating group and its progeny in the long run?

1 mark

- a. Occasional mating among few members of the original population which happen to migrate
- b. Breeding with a different subspecies which is present in the new environment
- c. Breeding habitually and slowly within the migrants
- d. Increased rate of mutation

Answer: (c)

Question C A Fishy Business

There is a large population of organisms. A new beneficial mutation is seen in this population. It is also observed that this mutation gives rise to a dominant phenotype. However, it is noticed that over time (the environment remained roughly constant), the proportion of individuals showing this phenotype does not increase over a small threshold value.

3.1 Which of the following are possible explanations for the above observations?

- a. A selective pressure favouring individuals which possess the mutation is absent 2 marks
- b. A selective pressure against individuals which do not possess the mutation is absent
- c. The new mutation does not confer an exceptional advantage to individuals which possess it
- d. Random chance prevents a considerable increase in frequency of the new trait in the population

Answer: (b), (c), (d)

3.2 If there was a change in the environment which led to an already existing dominant neutral mutation (observed in about 15% of the population) to become beneficial, would you expect any change in the observations? If so, why?

Suggested Answer: In the second scenario, the frequency of the mutation which turned beneficial is already 15%. Genetic drift and random chance are not as important here as natural selection. The frequency of the mutation will increase in the population. In the first scenario, although the mutation is beneficial, its initial frequency is very low (as it just appeared in the population). In such a situation, genetic drift and random chance could completely eliminate the mutation from the population. The role of random chance decreases as the frequency of the mutation increases.

Question D Disturbance and Competition

The seeds of 2 plants have been described below:

Plant A: It produces small and light seeds dispersed by winds over long distances. Seeds are low in energy content. It releases thousands of seeds at a time. The plants grow and mature rapidly and have short lifespans. The plants are small and short in size. The reproductive cycle and generation period have a short duration.

Plant B: It produces large nuts that contain energy-rich seeds. Seed dispersal occurs mainly through fruit consumption by animals. The plants take a long time, about years, to grow and start producing seeds. The plants are enormous and tall when they mature. The reproductive cycle and generation period have a long duration.

Disturbance is defined as any process that removes biomass from the community.

Early Successional species are those that can establish themselves quickly after any disturbance in an area.

Late Successional species are those that can establish themselves relatively much later after any disturbance in an area.

- 4.1 Of the 2 plants, which plant will be able to germinate from its seed and mature best in a location with a high density of plants?

Answer: A

1 mark

- 4.2 Of the 2 plants, which plant will be able to establish itself as an early successional species?

Answer: A

1 mark

Question E Kin Selection

Kin Selection is said to be when at their own cost, an individual helps another individual who is genetically related to them. Suppose there are 3 individuals A, B and C who belong to the same species. While A and B are second cousins, A and C appear to look more like each other even though they are unrelated genetically. In any moment of crisis, whom is A more likely to help?

1 mark

Answer: B

Question F Self-incompatibility

Self-pollination is generally avoided by many flowering plants, and the mechanisms to prevent the same. One of the mechanisms is using Self-incompatibility factors, controlled genetically. When two plants share the same incompatibility allele, they are unable to mate. Certain plants use these mechanisms to prevent self-pollinated seeds-which are generally weaker.

- 6.1 For plants that use these mechanisms to avoid self-pollination, which mode of selection would be active for self-incompatibility genes?

- a. Positive Frequency-dependent selection (The most popular Allele would offer better survival) **1 mark**
- b. Negative Frequency-dependent selection (The less popular allele would be better for survival)
- c. Frequency independent selection by the environment would result in the emergence of one superior gene

- d. Frequency independent selection by the environment would result in the emergence of many polymorphs of the gene.
- e. Selection by a few over-entitled, conceited, and self-indulgent IISc students based on the number of marks they score in the preliminary round.

Answer: (a)

- 6.2 Now, to explore this idea further you try to simulate the essential idea of such a type of simulation using your computer with the following core logic when two gametes meet: (Assume all other aspects of the system have been coded for perfectly.)

```
if Genotype of Self-incompatibility genes of Gamete-1 is equal to
Genotype of Self-incompatibility genes of Gamete-2
    then do not produce a seed
else produce a seed
```

In your results, you notice that mutations, especially duplication mutations for that gene are much more favoured, causing a very unstable population.

Your teacher tells you that your simulation is giving different results compared to real life because you are comparing genotypes instead of phenotypes. Do you agree or not? Elaborate your reasoning in 3-5 sentences.

2 marks

Answer: No plant cell would sequence the genome and compare the genotype of the Pollen and egg. The comparison would be based on some physically observable phenotypes such as proteins on the cell surface or size.

Question G Dynamics of Tropic Chains

Consider a terrestrial ecosystem with five trophic levels occupied by: Species P, Q, R, S, T in some order. We can assume that the influence is unidirectional to predict how a change in one trophic level influences the other trophic levels.

Model 1: In this model, we assume that the change in lower trophic levels causes a change in higher trophic levels. But if the abundance of higher levels is changed, the lower trophic level is not affected. For instance, if we increase the plant growth in a region, the herbivore population should increase.

Model 2: In this model, we assume that the change in higher trophic levels causes a shift in lower trophic levels. But if the abundance of lower trophic levels is changed, the higher trophic level is not affected. For instance, if the predator population in a region is increased, the prey population will decrease.

The abundance of various species in the terrestrial ecosystem is varied, and if we

assume that only one of the models operates at a given time, the following is observed:

Using Model 1:

- When we increased the population of species R, a significant increase was observed in the population of species Q.
- When we altered the population of species T, the number of individuals of species S did not show a significant change.

Using Model 2:

- When we increased the population of species Q, the number of species P species was observed to be much lesser than the initial numbers.
- When we decreased the population of species R, it decreased the population of species S.

Based on the above information, arrange species P, Q, R, S and T starting from the lowest trophic level to the highest trophic level in the chain. (Assume that no other organism interferes with the food chain.)

2 marks

Answer: S, P, R, T, Q

Question H Yeast Growth

An experiment was performed to investigate the growth of two yeast species: *Saccharomyces cerevisiae* and *Schizosaccharomyces kefir* (referred to as A and B, respectively now onwards).

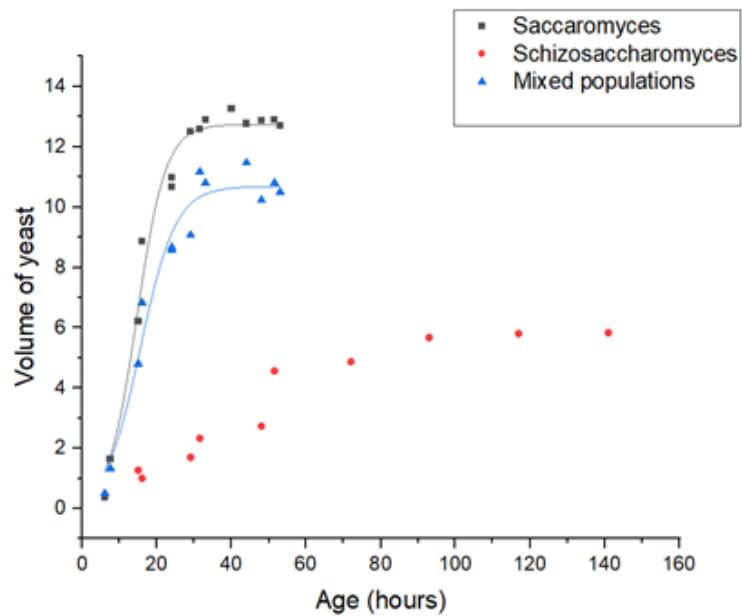
First, we performed a series of experiments to study the growth of two species separately in a nutritive medium. Then the growth was observed for a mixed population, i.e., the two species cultured in the same test tube in the same medium as before.

The growth curves shown below were obtained from the experiment.

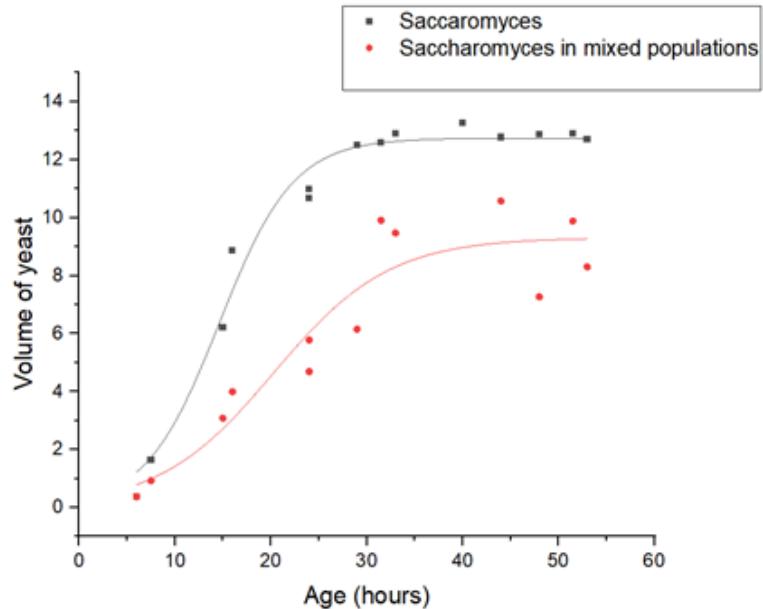
What difference do you observe in the growth pattern of the two yeast species in isolated and mixed populations (not difference in curves of the two species in isolated population/not difference between the growth curves of two species compared to each other.)? What could be the possible reason for your observation?

(Note that you have to analyze the relative volume in isolated and mixed populations as the absolute volume of yeast differs due to differences in saturation value and growth rate of the two species. Assume that the initial volume of each species is equal in each condition.)

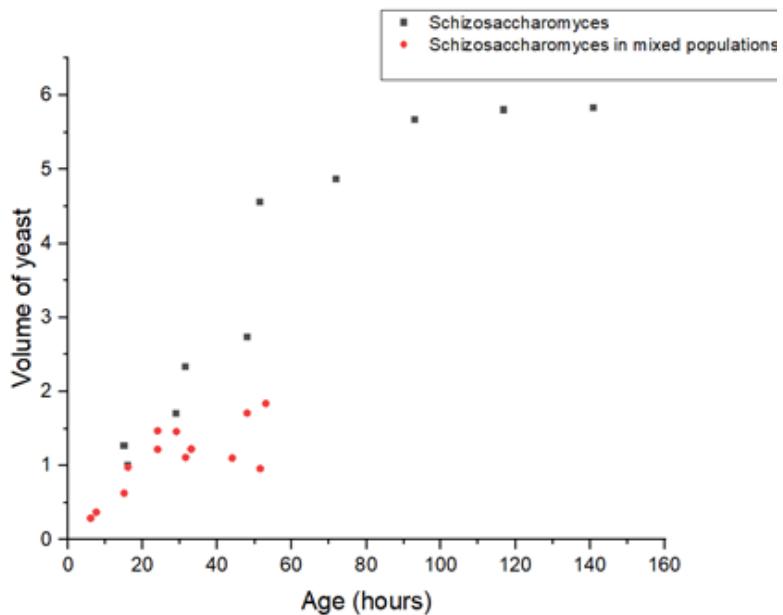
2 marks



The growth of the volume of *Saccharomyces cerevisiae* and *Schizosaccharomyces kefir* and the mixed populations in a nutritive medium according to our experiment.



The growth of the volume of *Saccharomyces cerevisiae* cultured separately and in mixed populations according to our experiment.



The growth of the volume of *Schizosaccharomyces kefir* separately and in mixed populations according to our experiment

Suggested Answer: From figures 2 and 3, we observe that in the mixed population, the population of species A has been reduced by a much smaller amount compared to species B. i.e., species B has been more drastically affected by the introduction of species A. In the mixed condition, there is competition for resources among the two species. Species A dominates over B and competitively excludes it from the population leading to the drastic decline we observe in Figure 3.

Question I Antarctic Marine Food Web

Global warming has led to higher oceanic temperatures. Furthermore, high CO₂ levels in the atmosphere have led to ocean acidification. Both these factors have negatively affected the Krill population, which has witnessed a decline.

Which 3 organisms in the adjoining food web will be affected the most by the decrease in Krill Population?

1 mark

Answer:

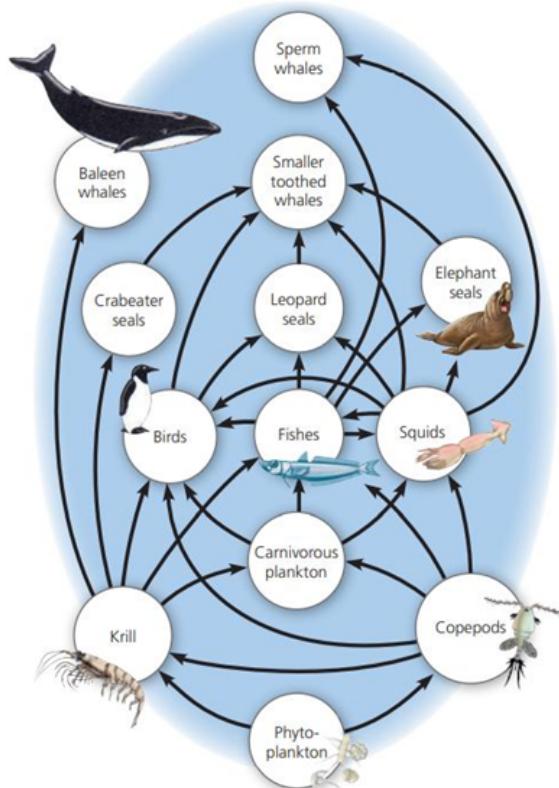
Baleen whales: decrease in population

Copepods: increase in population

Crabeater seals: decrease in population

Question J Speciation

Speciation can occur due to the geographic setting in which gene flow is interrupted between populations of the existing species. In allopatric speciation, the



Antarctic Marine Food Web

populations are geographically isolated, while in sympatric speciation, they are not. In a research study about feeding habits in finches, the observations were as follows:

Case 1: Small ground finches and medium ground finches have similar beak morphologies and presumably eat similarly sized seeds.

Case 2: Small ground finch has a shallower, smaller beak, and medium ground finch has more profound adaptations that favor eating different-sized seeds.

Which of the following is true?

1 mark

- Speciation of small ground finch and medium ground finch is sympatric in Case 1.
- Speciation of small ground finch and medium ground finch is sympatric in Case 2.
- Speciation of small ground finch and medium ground finch is allopatric in both cases.
- Speciation of small ground finch and medium ground finch is sympatric in both cases.

Answer: (b)

Question K Mysterious Allele

Fin Colour in a Fish species: Consider a gene locus in a fish species with 2 distinct molecular alleles A, B and C.

A is dominant over B. B is dominant over C. A and C show intermediate dominance.

Phenotypes (fin colours) corresponding to the genotypes are:

- AA, AB: Red
 - BB, BC: Golden
 - CC: Magenta
 - AC: Rose

Frequency of the above genotypes in a fish population of 1000 individuals is as follows:

Genotypes	No. of individuals
AA	110
AC	140

If this population is in Hardy-Weinberg Equilibrium, what is the number of individuals with golden fin colour?

1 mark

Answer: (a)

Question L Foraging Behaviour

Foraging behaviour is observed across many animals, birds and insects and can be defined as a set of behaviours or methods that helps these organisms obtain and utilize resources in an appropriate manner. This, sometimes, may cause a change in feeding habits and niches as well. For example, some species feed on caterpillar guts that are present on the canopies during summer. The same species, during winters, may descend to feed on seeds of beech trees.

The behaviour may comprise of the following actions (in no particular order):

- searching for food
 - searching for shelter
 - consumption of food
 - arranging food for their offsprings
 - visiting the food patch
 - quitting the food patch

Now, answer the following questions (You need not have an in-depth knowledge of the terms. Understand how attributes in a species can be channelized to a general concept) :

12.1 Organisms will respond differently when exposed to different food patches. The best way to change the quality of the patch is to change its nutritional quality. If we do so, which of the following foraging attributes will be affected the most?

- | | | |
|--------------------------------------|----------------------------|---------------|
| a. Patch visit | c. Patch Quitting Decision | 1 mark |
| b. Behaviour at a patch during visit | d. All of these | |

Answer: (d)

12.2 We define Giving Up Density (GUD) as the number of species quitting a food patch depending on what they obtain there. Also, the foraging patterns and behaviour are affected by how successful they are. In this context, select the true statement(s):

- | | |
|---|----------------|
| a. High-quality diets with higher protein and lower fiber were visited more often but for shorter duration. | 2 marks |
| b. The organisms prefer using their sensory cues to decide whether to visit the patch or not, before visiting the patch. | |
| c. High nutritional diet patch will result in more GUD. | |
| d. Natural selection will favor those who emphasize on quantity and quality of nutrients than those who emphasize on safety and efficiency. | |
| e. Natural selection will favor those who emphasize on quantity and quality of nutrients than those who emphasize on safety and efficiency. | |
| f. Foraging efficiency plays a role in shaping the dynamics of population. | |

Answer: (b), (f)

Question M Understanding 'species' from a closer perspective

Species, a very common term which we hear in our day-to-day life, but what does it mean to be a species? The most simple definition is: Related organisms that share common characteristics and are capable of interbreeding (Biological species). This definition is widely used in biology and related fields of study. There are more than 20 other different species concepts, however.

The following video is about the Meadowlark bird: <https://youtu.be/1ZpkUguH4sg> Currently, there are 2 such meadowlarks - Eastern and Western. However, for earlier biologists, and even for us, simply by looking at the birds, it is not easy

to assert which contingent it belongs to, east or west. This similarity, as shown, according to you, would have possibly given rise to which of the following ideas?

1 mark

- a. Morphological Species Concept
- c. Phylogenetic Species Concept
- b. Ecological Species Concept
- d. Temporal Species Concept

Answer: (a)

Question N Reproductive Isolation

You might have come across the term 'isolation' in species. It can be defined as mechanisms or processes that result in separation between two species, which could otherwise have mated to form a fertile offspring. However, due to species isolation this is prevented, and the two individual species may prosper in their own colonies. There are variety of isolation mechanisms, one of them being reproductive isolation. If we dissect it, this can be further branched into pre-zygotic and post-zygotic isolation.

There are two main categories of reproductive isolation: prezygotic and postzygotic. Prezygotic isolation occurs before the formation of a zygote can take place. In most cases mating does not even occur. Forms of prezygotic isolation include spatial, behavioural, mechanical and temporal isolation. Postzygotic isolation occurs after members of two different species have mated and produced a zygote. The offspring of such a mating is called a hybrid. Hybrids are frequently unable to reproduce themselves, so the production of a hybrid is not considered a successful mating. Hybrids are prevented from reproducing by developmental abnormalities that keep them from sexually maturing, ill health that causes most to die before reaching sexual maturity, or by sterility.

The Red maple and the sugar maple trees are two such species which do not exchange pollen. Try to reason what could be the need of isolation and in what manner can they be isolated. Select the correct reason among the following:

1 mark

- a. temporal isolation, a prezygotic isolating mechanism
- b. zygote mortality, a postzygotic isolating mechanism.
- c. hybrid sterility, a postzygotic isolating mechanism.
- d. habitat isolation, a prezygotic isolating mechanism.

Answer: (d)

Question O Adaptive Radiation

The increase in diversity of life has been significant over the past 250 million years due to adaptive radiation.

Adaptive radiations are periods of evolutionary change in which groups of organisms form many new species whose adaptations allow them to fill different ecological roles, or niches, in their communities.

e.g.: Australian marsupials - A distinctive characteristic common to most of these species is that the young are carried in a pouch.

Well-known marsupials include kangaroos, wallabies, koalas, opossums, wombats, Tasmanian devils, and the extinct thylacine.

15.1 Regional adaptive radiations arise due to which of the following ecological relationships among species?

- a. High mutualism
- b. Low predation
- c. High competition
- d. Low competition

1 mark

Answer: (d)

15.2 In rare cases, long distance dispersal can lead to adaptive radiation. Which of the following is an example of this type of adaptive radiation?

- a. Darwin's Finches of the Galapagos
- b. Hawaiian Honeycreepers
- c. Hawaiian silverswords
- d. Australian marsupials

1 mark



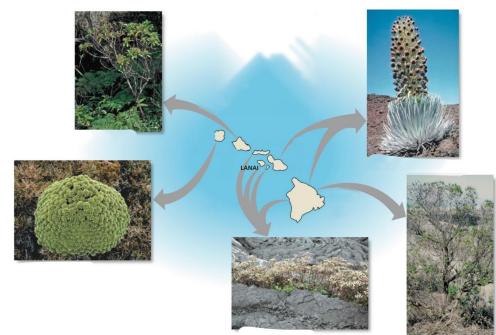
**Darwin's Finches
of the Galapagos**



Hawaiian honeycreepers



Australian marsupials



Hawaiian silverswords

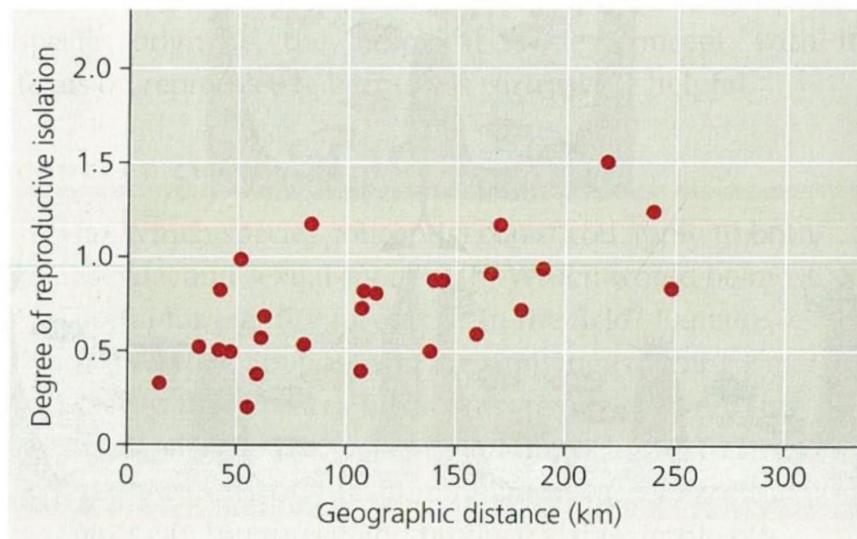
Answer: (c)

Question P Appalachian Mountains

In allopatric speciation the populations are geographically isolated, while in sympatric speciation they are not.

Researchers studied populations of the dusky salamander living on different mountain ranges in the southern Appalachians.

The following plot was the result of the study:



Reproductive isolation increases with distance in populations of dusky salamanders. The degree of reproductive isolation is represented here by an index ranging from 0 (no isolation) to 2 (complete isolation).

This gives rise to a certain type of speciation. Name it. Also, justify your answer concluding the results of this study to the type of speciation.

2 marks

Answer: Allopatric speciation. Allopatric speciation begins when populations become geographically isolated, reducing mating between individuals in different populations and thus reducing gene flow. As distance between populations increase, so will their degree of isolation ultimately leading to Allopatric speciation.

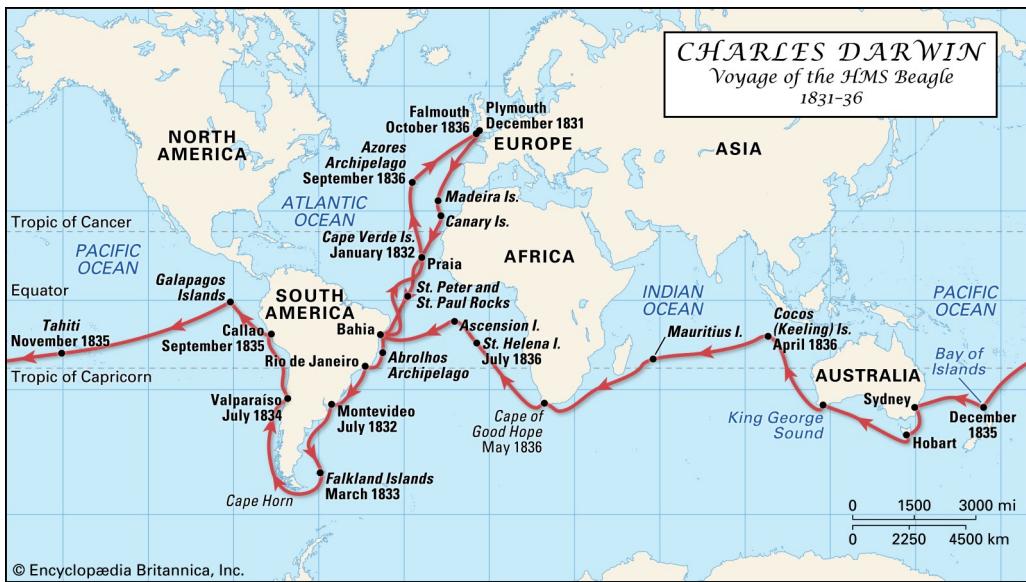
Part B A Journey

You have caught my attention (not for plagiarism) through your answers. I feel you might be a suitable candidate and would like to test your on-field skills.

Pack your bags and get ready for a once-in-a-lifetime opportunity to go on a Voyage around the world with me. You'll get to see thousands of unique organisms in their natural habitat and meet many famous ecologists and nature lovers alike.

Here is a map of the voyage for your reference, I hope to see you at Plymouth.

Darwin



Port of Plymouth

Before leaving on the voyage, Darwin takes all of you on a fishing trip by the River Tamar, which is a common place for all sailors to fill up their stock of large freshwater fishes before setting sail.

Darwin, being a nature lover, tells all of you to immediately release any fish that are smaller than the requirement. As you fish you notice that all the small and large fish look very similar and belong to the same species. "All this selective fishing will cause this fish to speciate", someone laughs. You wonder...



River Tamar

Question A Fish!

There is a species of fish on the brink of speciation, the main differentiating characteristics between two variants of the fish is the size (which varies gradually and is directly correlated to how distinct the species has become.)

Given that fishermen only hunt fish with $\text{size} \geq X$, and that larger fish can go deeper into the pond and escape getting fished only if they can withstand the lower temperature, which is possible if $\text{size} \geq Y$.

1.1 What relation between the sizes X and Y would strengthen speciation?

- a. $X > Y$
 - b. $X < Y$
 - c. $X = Y$
 - d. $X \neq Y$
- 2 marks**
- e. Size doesn't matter (It's all in the fisherman's hand.)

Answer: (b)

“The new pipe coolant pipe is certainly going to make things worse. I bet that by the time we are back, the species would have split into two.” Do you think that is a safe bet to take?

- 1.2 If an outlet pipe from a factory that expels water which is used as a coolant, is connected to the bottom of the lake, would it strengthen the hybrids or cause further speciation?

(Answer in less than 3 sentences. Ignore the effects of BOD.)

2 marks

Answer: Coolant water would warm up the lower layers of the pond. Therefore, fish with a size smaller than Y will be able to go to deeper parts of the pond and mate with the bigger fish. This will strengthen the hybrids.

Into The Americas

Location: Bahia, Brazil

You have finally reached Brazil after a tough time in the Atlantic. The rainforests are dense and wet. You see a dark cave at a distance. A crewmate warns you, “Better stay away, that’s a haven for vampire bats.” Darwin remarks, “They are an intriguing bunch.”

Question B Bats!

Vampire bats feed on cows, pigs and other large hooved mammals (ungulates). There’s plenty of food for the bats if they manage to find these animals resting around.

There are some groups within populations of bats which show an interesting behaviour: Individuals belonging to this group collect more blood than they require and feed bats (not necessarily belonging to the same group) which have not been able to obtain food themselves. It is seen that the bats belonging to this group preferentially feed those bats which have fed them in the past.

- 2.1 Will these groups of bats have a better chance of survival than others?
(Yes/No)

Answer: Yes

1 mark

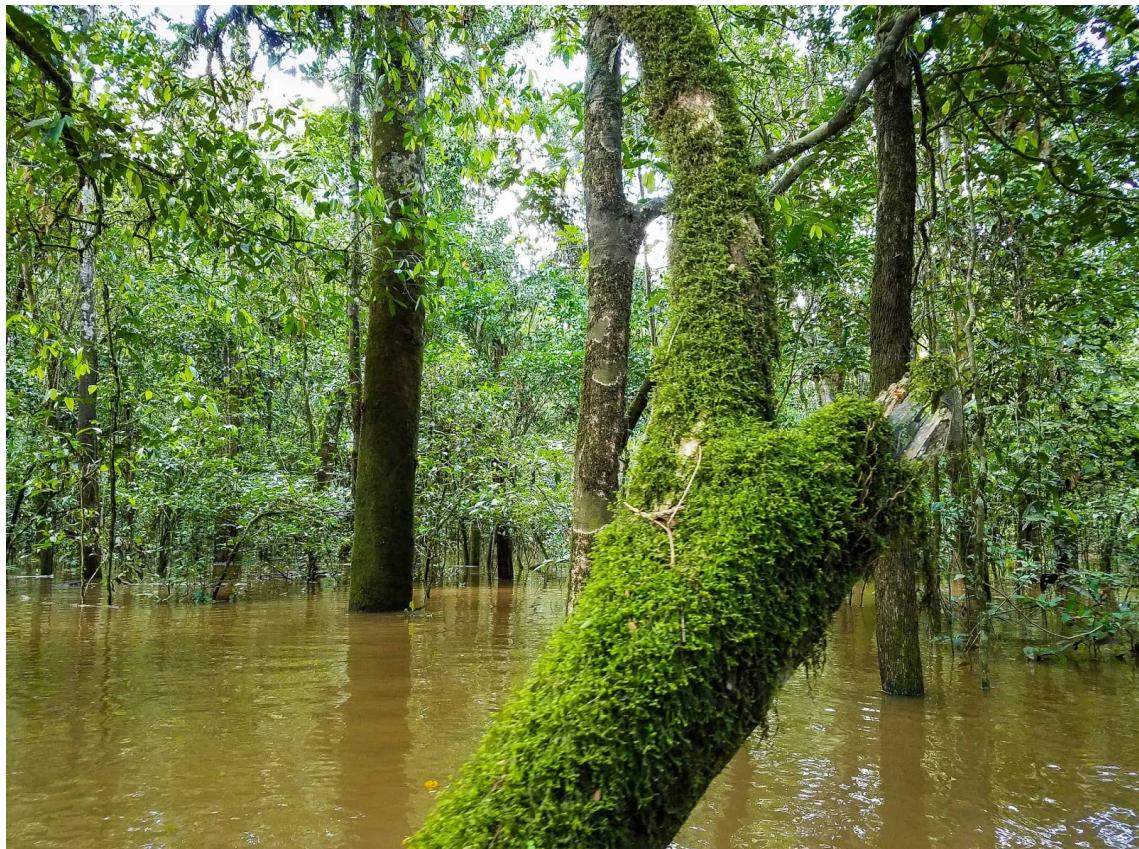
- 2.2 Which of the following observations seen in all bats cannot explain the advantage/disadvantage these groups will have over the other groups which do not show this behavior?)

- a. The bats have a very high metabolism and must feed at least once every other night to survive. **2 marks**
- b. The bats typically rest after hunting and digest their food.

- c. The bats cannot feed in a large excess as they gain too much weight to be able to fly.
- d. The food source is very tough to obtain.

Answer: (b)

Location: Valparaiso, Chile



Valparaiso Mangroves

After visiting Brazil, the team moves around the South American continent to reach the Valparaiso Forest area in Chile. Darwin encourages you to observe the diversity in the lizard population in these jungles. You are amazed by the fact that so many different species coexist together in the jungle.

You know their coexistence is possible because different species occupy different perches, and their niches do not overlap. To verify this, you collect more data.

Question C Watch out for the lizards!

Consider 4 species of tree lizards which live in close proximity in the same community – species A, B, C, D. Under natural conditions, it was observed that:

- Species A occupies the lower branches of the trees (Region i).
- Species B occupies the middle branches of the trees (Region ii).
- Species C and D cohabit the upper branches of the trees (Region iii).

The following observations were made from the experiment:

- When species A was completely removed, C occupied Regions i and iii, B occupied Region ii and D occupied Region iii.
- When species B was completely removed, A occupied Regions i and ii, C and D occupied Region iii.
- When both species A and B were completely removed, C occupied Regions i, ii and iii, and D occupied Region iii.
- When both species A, B and C were completely removed, D occupied only Region iii.
- If a species dominates over and competitively excludes another species from one region, it shows the same effect in other regions.

3.1 On the basis of the above information, match the species with their possible fundamental niches.

Answer:

4 marks

- A - i, ii
- B - ii
- C - i, ii, iii
- D - iii

3.2 Why do you think species D and C can cohabit Region iii?

No suggested answer provided.

1 mark

3.3 Which of the following statements is/are incorrect?

- In Question 3.1, competition between species A and C has led to the exclusion of species C from Region i. **2 marks**
- In Question 3.1, competition between species B and C has led to the exclusion of species B from Region iii.
- If species B and D are completely removed, species A will occupy Regions i, ii and iii.
- Even if the first observation is removed, we can still determine the fundamental niche for species A.

Answer: (b), (c)

Around the Globe

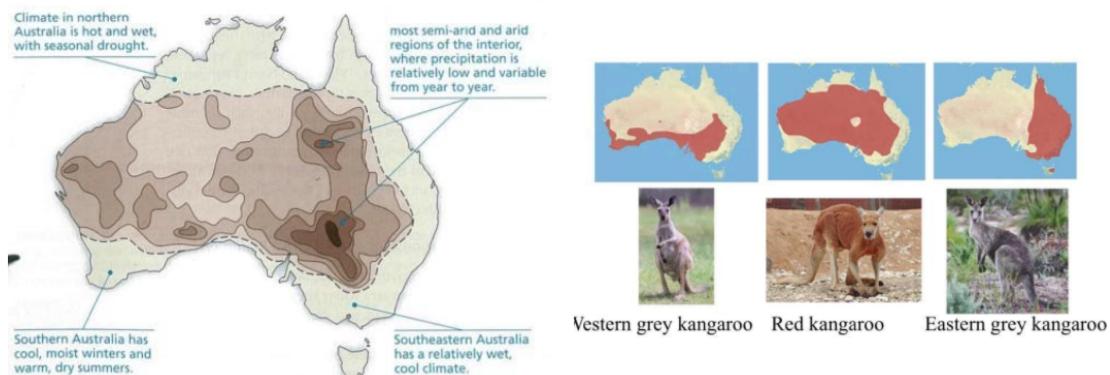
Location: Sydney, Australia

After a long journey of crossing the pacific, Darwin and his crew finally reach Australia.

To celebrate this long journey, you head to a local Saloon. One of your drunk Crewmates says - "I want to get into a Boxing match with one of those Red Kangaroos. I would totally win!". To which one of the locals says - "You wont find any Red Roo's here mate, they're hiding from you Brits in the interior."

Question D Kangaroos!

Intrigued, you and your teammates get onto figuring out the reason for this distribution.



Climate of Australia and the Distribution of various kangaroo species

Can you hypothesise the mostly likely reason why the 3 kangaroo species have different distribution ranges?

2 marks

- The Kangaroos are limited by locomotion, given the large size of the continent.
- The Red Kangaroos are driven to the interior by large predators.
- The respective Kangaroos are better adapted to deal with their climates, and stay in their regions to prevent competition.
- The larger Red Kangaroos choose the interior region because it offers better nutrition.
- All the Kangaroos that move to the interior become Red Kangaroos due to the colour of the sand.

Answer: (c)

Location: Madagascar

Darwin and his team reach the eastern coast of the island of Madagascar. Unable to contain your curiosity you sneak away to the forest with the other interns. While roaming in the forest you observe various lemur species occupying various niches in the ecosystem usually occupied by other primates.

Question E Lemurs!

Darwin, on hearing of this adventure, asks you to analyze the behaviours and diets of various Lemur Species yourself, while he relaxes.

You go to a local Lemur enclosure maintained by a Lemur enthusiast and study the food consumed by various Lemur species, each of which have their own large forest-like enclosures.

One day, Darwin on hearing of your research, asks you to verify your observations in the forest telling you that you'll be surprised.

5.1 Many species of Lemurs consume a certain set of Leaves and Fruits in the regions when they are the only species. But the same species, when co-existing in the forest, have much different diets. Explain in less than 5 sentences why this difference aids in the survival of the Lemurs.

No suggested answer provided.

2 marks

5.2 There are two species of Lemurs that have identical feeding behaviours and diets, but one is weaker than the other. Which behavior is likely to be observed in regions where they co-exist?

- a. They adopt a symbiotic relationship.
- b. The weaker species changes its behavior to become nocturnal.
- c. They team up with a lion, a zebra, a hippo and a Giraffe and a Hippo from New York to beat the Fossas.
- d. They merge into one species.

1 mark

Answer: (b)

Escape to Africa

Location: Tanzania

When in Madagascar, Darwin realizes that the Wildebeest Migration season is approaching, and it would be a waste to miss it after coming this far.

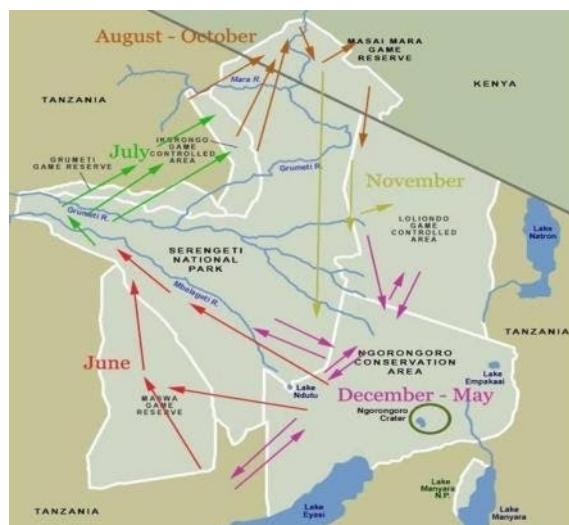
So you take a small detour from your voyage to go inland into the Serengeti, one of the most diverse and amazing ecosystems of the world, to study the amazing patterns of migrations that take place in the world.

(A bunch of penguins might have made a flying machine to help you get amazing aerial data.)

Question F Serengeti Migration of the Wildebeests

Please watch this video to answer the questions:

<https://www.youtube.com/watch?v=aGNn9vOz-Vo>.



**Migration Routes
of the Wildebeests**

- 6.1 As you can see in the video, there are different species of migrant grazers moving together. What do you think can be the possible reason that the migrant grazers of different species (Wildebeests and Zebras to be specific) do not indulge in competitions among themselves? What can be the advantage of moving together? (Answer in less than 5 sentences.)

No suggested answer provided.

3 marks

6.2 Among the 4 carnivorous animals given below, name the one which depends the least on this migration.

- a. Vultures b. Lions c. Crocodiles d. Cheetahs **1 mark**

Answer: (a)

6.3 Select the set of months with the highest death rate observed in the population of grazers.

- a. January, February, March d. August, September, October **1 mark**
b. April, May e. November, December
c. June, July

Answer: (d)

Location: Congo

When you get back to the port from Tanzania, the captain of the ship informs you that a storm ruined the ship, and it would take a few months to repair.

Question G Birds!

To make the most of this time, Darwin takes you to a bird research facility amidst the dense jungles of Congo. You spend many weeks in observing and collecting the following data along with the help of Darwin.

Moreover, Darwin manages to get hold of some data from the previous years for the same bird species in that observatory, and tells you to analyse them.

The numbers of bird males (from a part of the jungle beside a shallow river full of fish and fruit trees) with different morphologies is given in the table below:

Year	Morphology 1	Morphology 2	Morphology 3
A	384	589	124
B	456	789	1012
C	546	124	324
D	621	345	420
E	169	420	356

- 7.1 As observed, over the past few years, the most attractive male morphology for the females of that same species is morphology 3. Arrange the years in chronological order (from the most recent to the earliest) by observing the data provided.

Answer: B, E, C, D, A

2 marks

- 7.2 In the same table, consider that morphology 3 is eliminated from the forest and the remaining data remains the same. The characteristics of the remaining 2 morphologies differ from each other as below. You have to find out in which of the 5 years (A, B, C, D, E) there was a flood in the jungle.

Characteristics	Morphology 1	Morphology 2
Fishing Skill	Weak	Strong
Staple Food	Fruits	Fish
Length of Tail	Longer	Shorter

2 marks

Answer: E

Back on Track

The ship gets repaired and you quickly make your way towards the Cape of Good Hope.

Location: Cape of Good Hope

A local scientist seeks your help to conclude her research. A rodent species is found in abundance with different coat colors and can easily migrate, the reason being the harbor nearby where the vessels that stop by. She wants to determine the effect of the genes playing a role in the coat colour.

Question H Rodents!

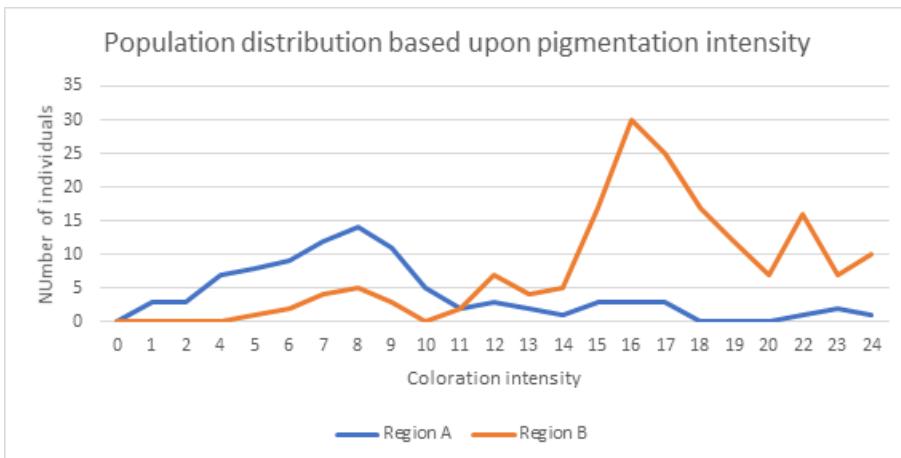
Following is the data she collected.

Region B is the Cape of Good Hope, and Region A is a place she visited last year. Region A and the Cape of Good Hope have many vessels exchanging every year. She happened to find the same rodent species she was studying earlier.

Following is the same data in tabular format:

Also, in her 7 years of research, she collected the following information:

More than one gene controls the pigmentation intensity and the effect of each gene is not affected by the other genes. Each of the genes have two alleles. One of the



Note: More pigment molecules means darker skin pigmentation.

Total Number of molecules (Pigmentation Intensity)	Region A	Region B
0	0	0
1	3	0
2	3	0
4	7	0
5	8	1
6	9	2
7	12	4
8	14	5
9	11	3
10	5	0
11	2	2
12	3	7
13	2	4
14	1	5
15	3	17
16	3	30
17	3	25
18	0	17
19	0	12
20	0	7
22	1	16
23	2	7
24	1	10

alleles for all genes plays no role in synthesizing any molecule. The other allele is responsible for determining the number of molecules synthesized, and each of the alleles code for a different number of pigment molecules.

8.1 Determine the number of genes responsible for controlling the pigment color, considering that they express themselves fully and are not affected by the other genes.

- a. 1 b. 2 c. 3 d. 4 e. 5 f. 9 g. 21 h. 27 **1 mark**

Answer: (c)

8.2 Estimate the ratio of the number of molecules synthesized by each of the alleles, which code for the formation of pigmenting molecules, based on the data and the information provided.

- Answer:** 1:4:7 **4 marks**

8.3 Why are there only 23 observable Phenotypes, instead of the expected maximum?

- a. Because this follows non-Mendelian inheritance. **1 mark**
b. The Allele producing 0 pigment is recessive and is not expressed in heterozygous genotypes.
c. Some genotypes give the same amount of total pigment.

Answer: (c)

Question I Effect of climate on the distribution

Two Rays called α and β are components of sunlight correlated with the pigment distributions in the previous question.

Individuals with lesser pigmentation had better survivability when exposed to β rays, and individuals with higher pigmentation had better survivability when exposed to α rays.

α rays are majorly received in abundance at the lower latitudes and β rays at the higher latitudes.

(Note: These rays have nothing to do with α and β particles.)

- 9.1 It is observed that there is a significant amount of migration of the rodents between the two regions. Yet, the population composition remains nearly the same over the years. What could be the probable reason?
- A gets more α rays.
 - A gets more β rays.
 - Apartheid was not yet banned in South Africa, and the mice segregated themselves.
- Answer:** (b) **1 mark**
- 9.2 It is most likely that these genes of this skin pigment arose due to duplication mutations from a single gene. Given the information that the mice originated in one of the regions, and then a set of mice managed to colonize the other region, where did the mouse originate first?
- Region A, and later spread to Region B
 - Region B, and later spread to Region A
- Answer:** (a) **1 mark**

Location: Azores Archipelago

Your ship docks at your last destination - São Miguel Island of the Azores Archipelago. You see a few Portuguese ships docked there.

Question J Pesky Monarchs and Pesky Bugs!

“Queen Maria II needed a 1000 identical-looking bugs from the Azores for some celebration. Should I go to the Froles island and pick up the darker ones, or the bright green ones up at Lagoa do Fogo?”, he asks Darwin.

“Could all of you look through my notes and tell him where to go? These island ecosystems are very fragile to small changes and I have other matters to attend to. These Monarchs and their crazy requests, the French Revolution should have happened in Portugal”, Darwin chuckles as he walks away.

You can't help but think that Darwin is testing you rather than being short on time.

2 isolated insect species use visual methods to escape predation from a bird. The bird learns to recognise the prey species, mainly using trial and error based on the insects it encounters in its lifetime.

- Insect-1 (Caterpie) - escapes predation through Camouflage and relies on not being seen by the predator.
- Insect-2 (Weedle)- is a slightly poisonous insect. The bird learns to avoid this insect after having accidentally eaten it a few times.



Flores Island



Lagoa do Fogo

Both insects have 2 phenotypes of slightly different colours (red and green here for simplicity), none of which offers any particular advantage and both phenotypes are present in a 1:1 proportion within the populations of each species.

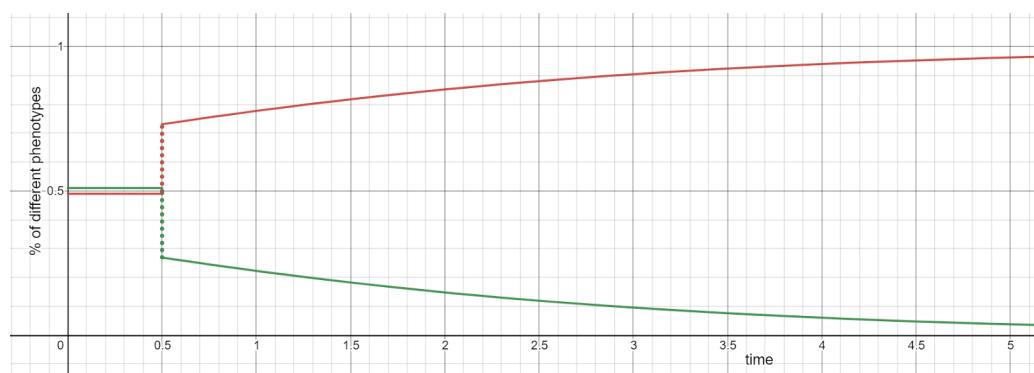
The following are 5 graphs that show the proportion of the different phenotypes (as fractions of the total population) as time (shown in arbitrary units) passes. Choose the correct graphs for species 1 and 2.

2 marks

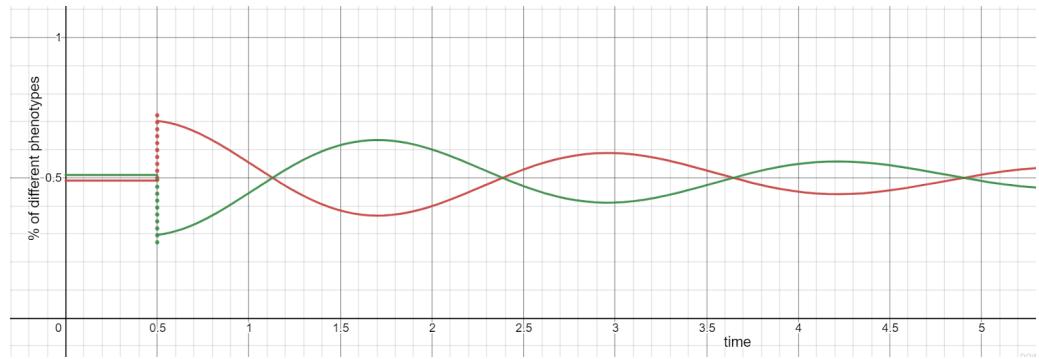
Answer:

Insect-1: Graph 2

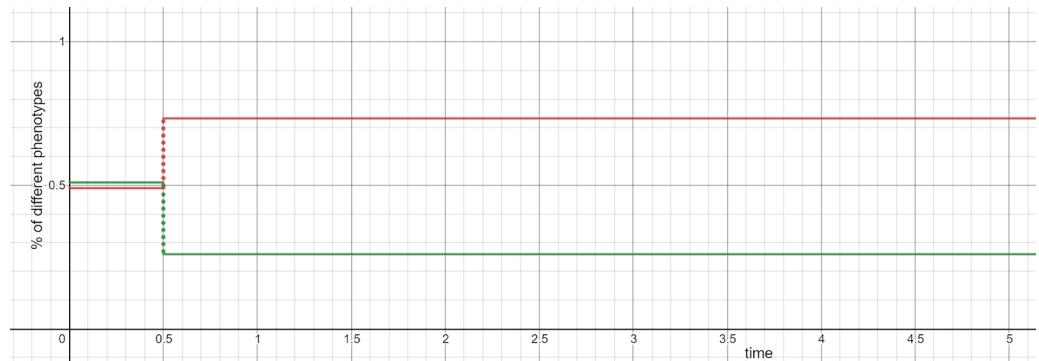
Insect-2: Graph 1



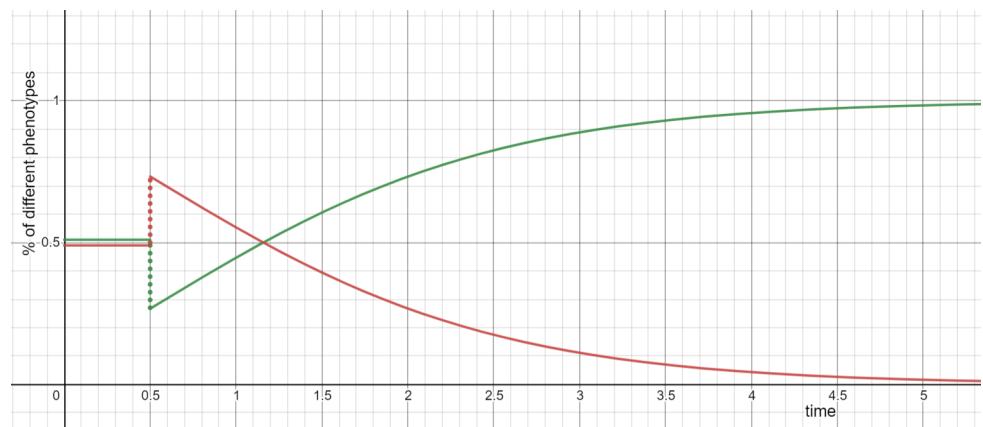
Graph 1



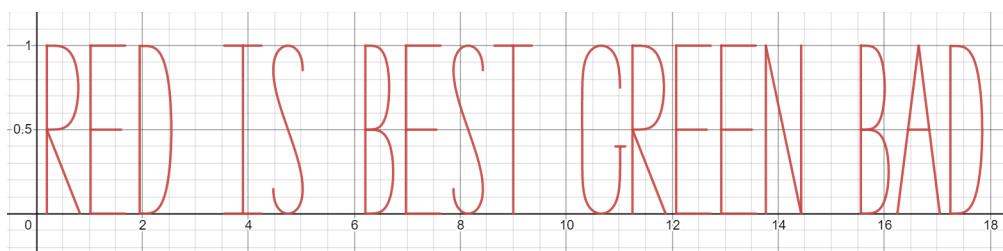
Graph 2



Graph 3



Graph 4



Graph 5

Question K One last test!

Convinced by your logic, the soldiers thank you and go to the appropriate island to pick the bugs.

Months later, as you are about to leave to get back to England, the soldiers say, “There have been reports of many worms escaping from one of the 2 islands to the Terceira island (an island in Azores) and destroying the crops there. We’re thinking of introducing a bird species with much better eyesight to eat them up. What do you think? Would wagtails do the job?”



Terceira Island

Darwin curiously looks towards you for an answer.

Suppose the eyesight of the bird improves significantly. What would happen to the total population sizes of Insect-1 and Insect-2 (from the previous question)?

2 marks

- a. 1 increases a lot, 2 decreases a lot
- b. 1 will increase, 2 will decrease/ remain the same
- c. 1 decreases a lot, 2 increases a lot
- d. 1 will decrease, 2 will increase/remain the same
- e. Both Population sizes decrease
- f. There would be no change in the population sizes
- g. They go extinct as Ash and Red will catch 'em all.

Answer: (d)

Into the realm of Darwin

“Okay, I’ll be sure to check on the exact species before doing something in haste. Thank God I met you. Sorry for being a bother”, he says. “No, it’s fine! Quite the brain teaser actually; enjoyed it plenty!”, you laugh back.

As he leaves, Darwin turns to you and says, “I’m sure, you’ll get your mind teased much more in my island”, he says, handing you a map - “we can drop the others at England, and then be on our way. Sounds good?” he laughs and walks away.

You’re speechless as you stare at the map to what looks like Darwin’s Realm, you can’t believe it...

Did Darwin just ask you to be his successor?