Full Name:	Civics group: 21S	Index no.:	Date:

Biological Evolution

Natural Selection and Evolution
Tutorial 14

1	2	3	4	5	6	7	8	9	10	11	12
C	B	A	C	D	A	A	B	B	C	A	A

1 A population of squirrels is preyed upon by small hawks. The smaller squirrels can escape into burrows. The larger squirrels can fight off the hawks. After several generations, the squirrels in the area **tend to be very small or very large.** What process is responsible for this outcome?

A Stabilizing selection
B Directional selection
C Disruptive selection (conditions favor individuals at both extremes of a phenotypic range over individuals with intermediate phenotypes.)
D Balancing selection

2 Birds with average sized wings survived a severe storm more successfully than other birds in the same population with longer or shorter wings. If severe storms occur regularly, then over time, one should expect these storms to bring about

A the bottleneck effect
B stabilizing selection extreme phenotypes are selected against
C artificial selection
E disruptive selection

3 Which type of selection maintains stable frequencies of two or more phenotypic forms in a population?

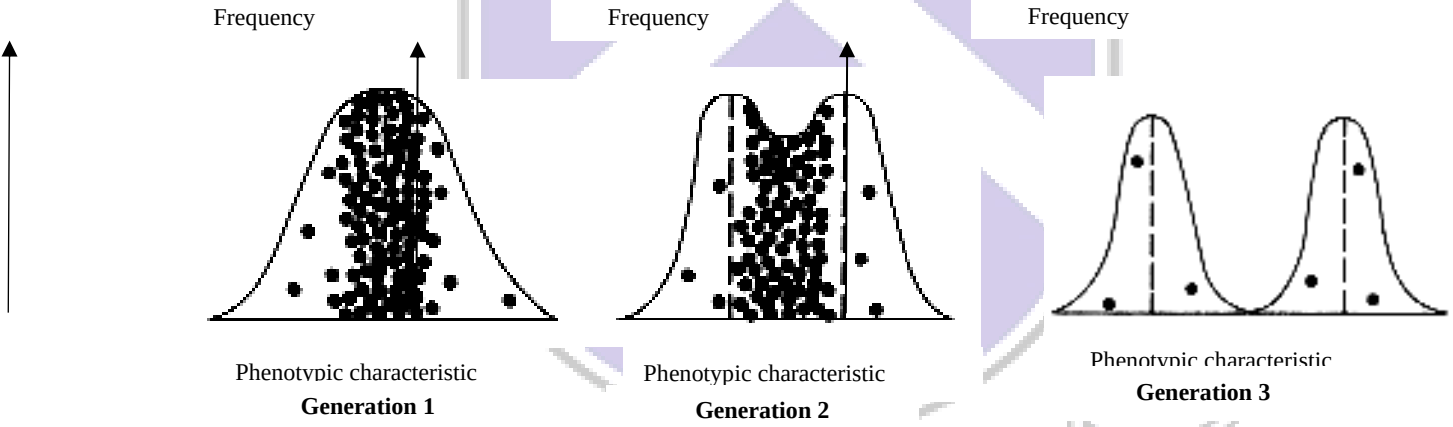
A Balancing selection
B Neutral variation
C Heterozygote advantage
D Stabilizing selection

4 A number of mosquito populations today are resistant to insecticides that were once effective. Biologists think that insecticide resistance evolved in mosquitoes because

A individual mosquitoes **built up immunity** to an insecticide after being exposed to it.
B mosquitoes **needed to develop insecticide resistance** to survive after the insecticide was used. (development of insecticide resistance arose due to spontaneous mutation, not because of a need)
C a few mosquitoes were probably resistant to the insecticide before it was ever used and these individuals were more likely to survive and reproduce.
D use of insecticides induced mutations in mosquitoes, resulting in resistance to these insecticides (development of insecticide resistance arose due to spontaneous mutation. it is a random process and it is not something that can be controlled)

Comment: Options A, B & D are indicative of Lamarck's theory and hence are incorrect.

5 The diagram shows a form of selection operating within a population over three generations, 1, 2 and 3. Organisms in the shaded areas are selected against.



What can be concluded from these results?

A Loss of individuals with phenotypes close to the most common value suggests that the variation in the phenotypic characteristic has an environmental cause. (cannot tell, could be due to artificial selection)
B One species is split, in three generations, into two species that are reproductively isolated from one another. (cannot tell if the two populations are reproductively isolated from one another)
C The population is divided into two groups in three generations because the selection is artificial. (cannot tell, could be due to natural selection)
D Two groups of individuals are formed in three generations whose ranges of variation for the phenotypic characteristics do not overlap.

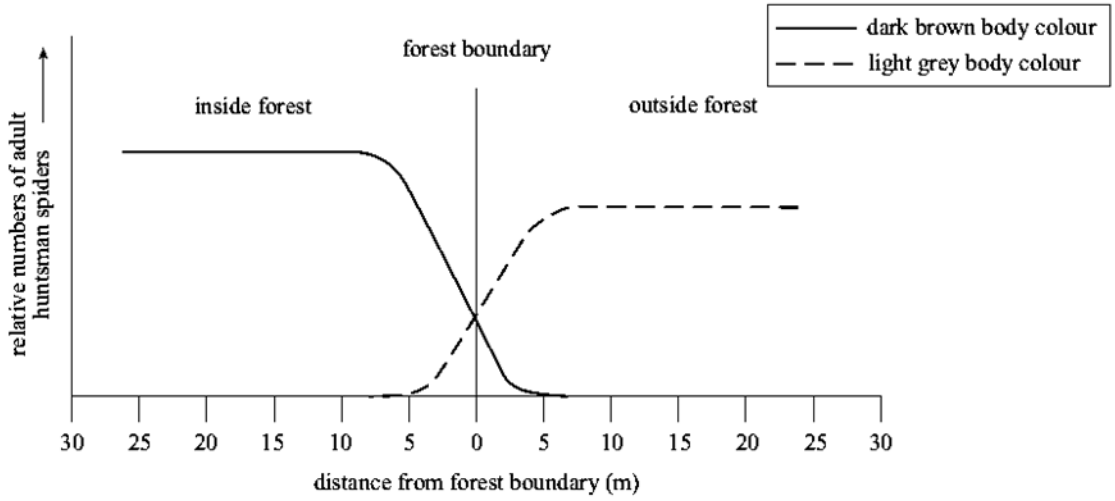
6 Zebras with some horizontal stripes are bitten less frequently by tsetse flies than those with only vertical stripes. The flies carry diseases that infect zebras.

Which combination of statements could explain an increase in the proportion of individuals with horizontal stripes in a population of zebras over several generations?

1 Tsetse flies are the selection pressure. (true, the presence of flies will select for zebras with horizontal stripes. Zebras with horizontal stripes have a selective advantage over zebras with only vertical stripes)
2 Compared with other zebras, zebras with horizontal stripes are less likely to get diseases from tsetse flies. (true as these zebras are bitten less frequently)
3 On average, zebras with horizontal stripes live longer and produce more offspring than other zebras. (true as these zebras are less likely to get diseases carried by tsetse flies)
4 Zebras with horizontal stripes pass the alleles responsible for these stripes to their offspring. (true, fit individuals will produce similar offspring as alleles encoding for the beneficial trait will be passed down to the next generation)

A 1, 2, 3 and 4
B 1, 2 and 4 only
C 1, 3 and 4 only
D 2 and 3 only

7 The graph below shows the distribution of huntsman spiders at a forest boundary:



One species of huntsman spider (*Isopeda isopedella*) varies in body colour from dark brown to light grey. In one community at the forest boundary, two populations of this species were found. Some were found living inside the forest and others were found living just outside the forest. The relative numbers of dark brown adult spiders and light grey adult spiders found at certain distances from the forest boundary are shown in the graph above.

Which of the following can be **least** inferred from the graph?

A At the forest boundary, the selection pressure is stronger than that either inside the forest or outside the forest. (typically results in directional selection)

B The plateau in the population number as seen inside the forest and outside the forest is due to competition among the adult spiders for resources. (competition helps to stabilise the population numbers)

C The lower plateau of spider population outside the forest compared to that of inside the forest is due to the presence of additional selection pressure existing outside the forest. (additional selection pressure further population numbers)

D Dark brown huntsman spiders are not eaten by birds inside the forest as their colour allows them to camouflage and hence provides a selective advantage. (able to survive till maturity and reproduce, that is why their numbers are higher inside forest)

8 Tay-Sachs disease, which is lethal, results from having the homozygous recessive condition of the responsible gene. Which one of the following statements is true?

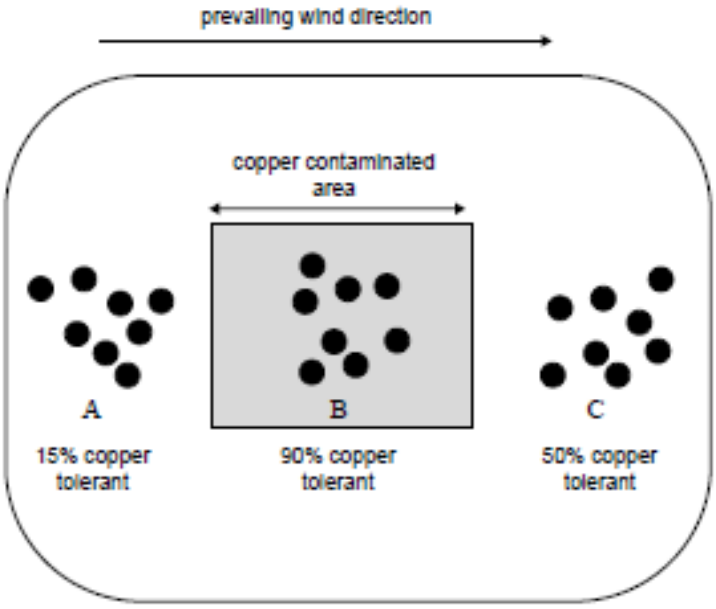
A Only homozygous dominant individuals will be able to survive and reproduce. (heterozygous individuals can also survive and reproduce)

B Heterozygous individuals will survive and may pass the recessive allele on to their offspring.

C In the heterozygous condition, the dominant allele will overcome the recessive allele and only the dominant allele will be passed on to offspring. (50% chance that dominant allele will be passed on, 50% chance that recessive allele will be passed on)

D Homozygous dominant individuals will be more likely to reproduce than heterozygous individuals. (both do not exhibit disease phenotype, hence both are equally fit – ie able to survive till maturity and reproduce)

9 The figure below shows an aerial view of a region which included a section of copper contaminated soil (shaded grey on the diagram). The black circles represent populations of grass growing in areas A, B and C. The figure also includes the percentage of copper resistant plants in areas A, B and C. Tolerance to copper in the soil is genetically determined.



It is reasonable to conclude from the information that

1 most plants in the copper contaminated area would be homozygous at the gene locus for copper tolerance. (Cannot conclude if allele for copper tolerance is dominant or recessive. If dominant, heterozygous plants will also be able to survive)

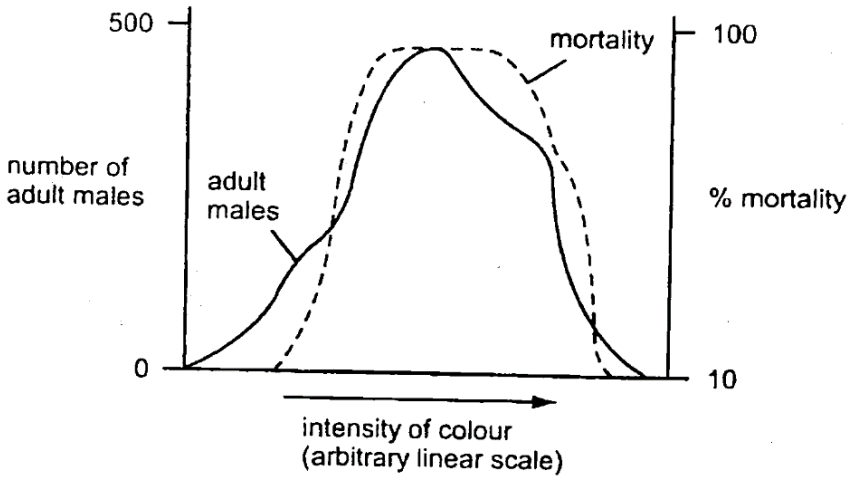
2 high levels of copper tolerance would be a selective disadvantage for plants in uncontaminated areas. (lesser copper tolerant plants observed in uncontaminated area)

3 the difference in copper tolerance between populations in areas **A** and **C** is the result of mutation. (spontaneous mutation is rare, unlikely that it could result in 35% increase in copper tolerant plant due to mutation alone)

4 gene flow is occurring between populations in areas B and C. (that is why there is relatively high copper tolerance in population C – this population has the allele for copper tolerance. This allele was derived from gene flow occurring between B&C population)

A 1 and 3 only
B 2 and 4 only
C 3 and 4 only
D 1, 2 and 4 only

10 The graph was drawn from data on a population of a species of moth which shows considerable variation in color intensity.



Which conclusion can be made from this graph?

A Color variation is environmentally induced (cannot be concluded from graph, could be artificially induced)
B Color variation is genetically determined (cannot be concluded from graph)
C Extreme forms are favored by selection (regions with lower mortality are circled)
D The species shows discontinuous variation with respect to color (shows continuous variation as there is a range of phenotypes)

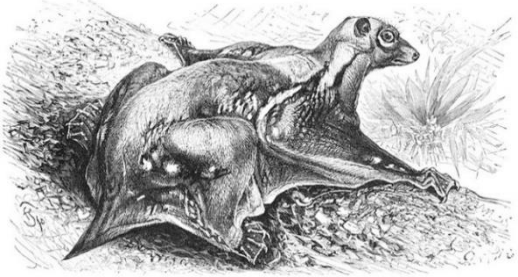
Comment: From the graph, it is observed that the number of adult males is highest when mortality is highest. One possible explanation is that the numbers represent the situation before selection is completed.

11 Approximately 1 in 20 Europeans are heterozygous for a recessive allele responsible for the genetic condition, cystic fibrosis (CF). People who are homozygous for CF have a reduced life expectancy. Heterozygotes are more resistant to some bacterial infections of the gut, such as typhoid fever, than homozygotes for the normal, dominant allele.

What could explain the high incidence of the recessive CF allele in the European population?

A Natural selection favouring heterozygotes
B Natural selection favouring homozygotes for the recessive CF allele.
C Lack of genetic drift in the European population.
D Mutation

12 The Malayan Colugo is a forest dwelling creature that relies on closely spaced trees to glide from one area to another in the primary forest. They do this by a thin membrane that stretches from the side of the neck to the tips of the fingers and toes, and down to the tip of the tail.



The population of the Malayan Colugo in Singapore are **descendants from a small population of Colugos that were over-hunted** and had their habitats destroyed post-1819 when 90% of primary forests in Singapore were cleared leaving only pockets of rainforests fragments separated from each other by urban developments.

Which of the following best describes the evolution of the Malayan Colugo in Singapore over two centuries?

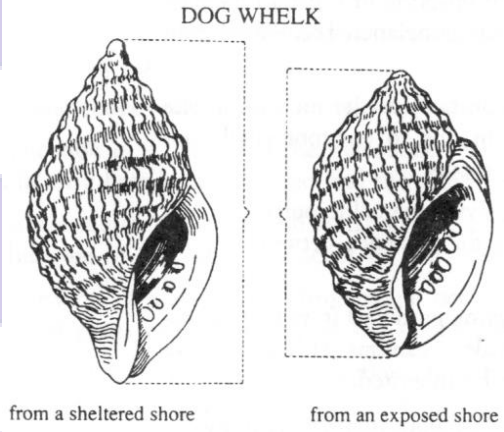
	Genetic variability	**Evolutionary process**
A	low variability	population bottleneck
B	low variability	founder effect
C	high variability	disruptive selection
D	high variability	population bottleneck

STRUCTURED QUESTIONS
QUESTION 1

The dog whelk (*Nucella lapillus*) is commonly found on rocky sea shores around the coasts of the British Isles. Considerable variability of its shell thickness and shape occurs on shores exposed to different wave action. On sheltered shores they have a high, thick shell and a relatively small aperture for attachment to rocks; on exposed shores the shell is thinner and stubbier, so that they are better able to hold on to the rocks they inhabit when subjected to the pounding of waves. The main predators of dog whelks are crabs, which will be active almost entirely on sheltered shores. Shell thickness is clearly protective here.

Describe the role of natural selection, in maintaining the shell shape and thickness of populations of dog whelks on:

(a) sheltered rocky shores,
(b) exposed rocky shores



(a) Sheltered rocky shores

…… [4]

1. There is genetic variation (with regards to shell thickness and shape) due to mutation.
2. **Selection pressure** is exerted by predation by crabs, which are found on the sheltered shores
3. Dog whelks with high, thick shells have a **selective advantage** because their shells are more difficult for crabs to break through
   / the small aperture provides more protection from crabs which cannot reach in to the mantle
4. They can survive till maturity to reproduce and pass down the alleles to offspring
5. Over time, **changes in allele frequencies** will cause a greater abundance of dog whelks with high, thick shells on sheltered rocky shores

(b) Exposed rocky shores

…… [4]

1. There is genetic variation (with regards to shell thickness and shape) due to mutation.
2. **Selection pressure** is exerted by the action of waves on the exposed shores
3. Dog whelks with stubbier shell have a **selective advantage** because their shells experience less force from wave action than the thinner shells

/ the larger aperture offers stronger attachment to rocks, enabling the dog whelks to better withstand strong wave action

4. They can survive till maturity and reproduce and pass down the alleles to offspring;
5. Over time, **changes in allele frequencies** will cause a greater abundance of dog whelks with thin, stubbier shells in exposed rocky shores

QUESTION 2

Mammoths are extinct mammals related to elephants. About three million years ago, the ancestors of mammoths migrated from Africa into Europe and Asia. There, about 1.7 million years ago, the steppe mammoth (*Mammuthus trogontherii*) evolved and became adapted to the cooler conditions. Then, about 700 000 years ago, as the climate changed and the Arctic became much colder, the woolly mammoth (*Mammuthus primigenius*) evolved. Woolly mammoths showed a number of obvious adaptations to reduce heat loss, including thick fur, small ears and small tails.

(a) Explain how the evolution of the woolly mammoth of small tail, small ears, and thick fur came about.

…… [4]

1. Genetic variations are present within the mammoth population due to mutation.
2. When the Arctic became much **colder**, the temperature exerted a selection pressure on the mammoths
3. Mammoths with thick fur, small ears and small tails are better adapted at reducing heat loss to the environment, hence are at selective advantage (to those with thin fur, large ears and large tails).
4. They are better able to **survive to reproductive age and reproduce**, **passing these advantageous alleles** to their offspring
5. Over many generations, **allele frequencies change** and mammoths with thick fur, small ears and small tails became the predominant phenotype.

QUESTION 3

According to the Red Queen hypothesis, sexual reproduction persists because it enables many species to rapidly evolve new genetic defences against parasites that attempt to live off them. *(Offspring of sexually reproducing organisms have much greater genetic variation than asexually reproducing organisms due to crossing over/independent assortment/random fertilisation)*

Scientists have tested this idea by observing different groups of small fish *Poecilopsis* species (Gila topminnow) in Mexico. Some populations of the topminnow reproduce sexually, while others practice parthenogenesis. Parthenogenesis occurs when females produce offspring without any male contribution and the female's gametes develop directly into female offspring. *(Parthogenesis is a form of asexual reproduction → offspring will be identical copies of the female fish)*

Topminnows are constantly parasitized by 'black spot disease' caused by a trematode (parasitic flatworm) that encysts in the skin. *(selection pressure)* Parasitized topminnows rarely survive. The researchers found that identical populations ("clones") of the asexually reproducing topminnows harboured many more black-spot worms

(selectively disadvantaged) than did those producing sexually *(selectively advantaged)*, a finding that fit the Red Queen hypothesis: The sexual topminnows could devise new defences faster by recombination than the asexually producing clones.

(a) Explain why the cloned fish were more heavily parasitized than the sexually reproducing topminnows.

..... [4]

1 Cloned/asexually reroducing fish are **genetically identical**/ have identical alleles at all loci, while there is **genetic variation** in sexually reproducing fish
2 Sexually reproducing fish populations have genetic variability **through crossing over and independent assortment of homologues during meiosis and random fusion of gametes during fertilisation**
3 which can create new genotypes/combination of alleles and phenotypes thus **there is a higher chances of having individuals that are resistant to parasites** amongst sexually reproducing fish
4 There is no genetic variation for natural selection in cloned fish but there is genetic variation in sexually reproducing fish for **natural selection to act on to select for resistant individuals.**
5 Individuals resistant to parasites have a **higher survival and reproduction rate**, hence were able to **pass down the favourable alleles** encoding the resistance to parasites to their offspring.

After a drought, it was found that there were few topminnows left in the habitat *(drastic reduction in population due to chance → bottleneck effect)*. A survey of the survivors revealed that the sexually reproducing topminnows were more heavily parasitized than the cloned topminnows.

(b) Name the evolutionary event that has occurred.

..... [1]

1 Bottleneck event; which resulted in a genetic drift

(c) Suggest why there was an increase in the number of parasitized sexually reproducing topminnows.

..... [4]

1 There is a **loss of genetic variation** through **genetic drift**, where parasite-resistance alelles may be lost in the bottleneck event (i.e. almost all of sexually reproducing fish who have parasite-resistance alleles perished in the drought)
2 Hence now, the sexually reproducing fish that are not resistant to parasites are **over-represented** while sexually reproducing parasite-resistant fish are **under-represented** in the remaining population.
3 Inbreeding (among sexually reproducing fish without parasite-resistance alelles) produces more offspring that are also not resistant to parasites, hence are heavily parasitised.
4 Reduced gene pool also decreases the chances of evolving resistance by natural selection

Legend:

 Sexually reproducing resistant fish	 Sexually reproducing parasitized fish

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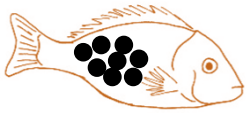
<tr>
<td> 
Asexually reproducing fish (parasitised)</td>
<td> 
Sexually reproducing non-resistant fish that is not parasitised</td>
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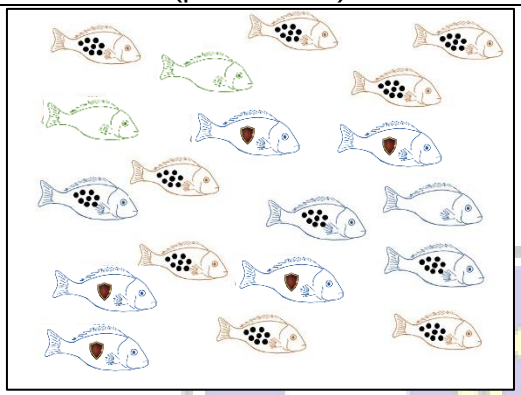
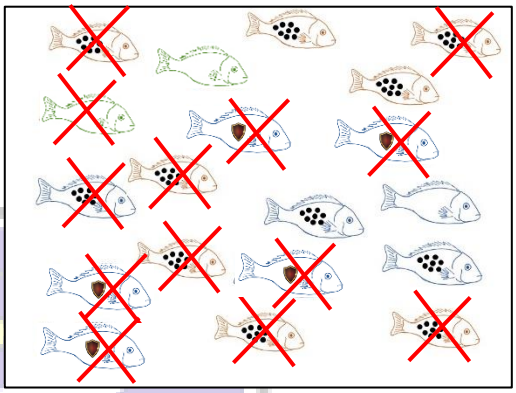
<tr>
<td> 
Population of sexually and asexually reproducing fish
- All asexually reproducing fish are clones hence all are parasitized
- There is genetic variation amongst the sexually reproducing fish hence some are parasitized while majority are resistant</td>
<td> 
Due to a drought, there is a drastic reduction in population size and individuals are randomly eliminated. Some genotypes are under-represented while some are over-represented.</td>
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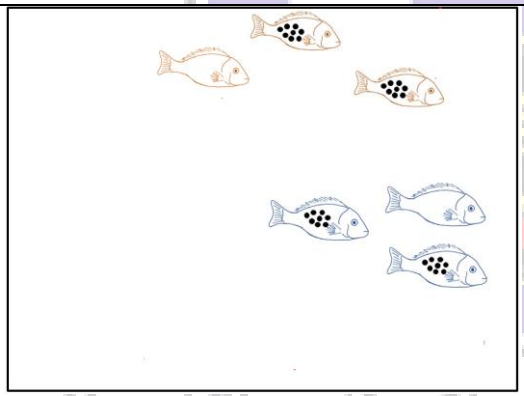
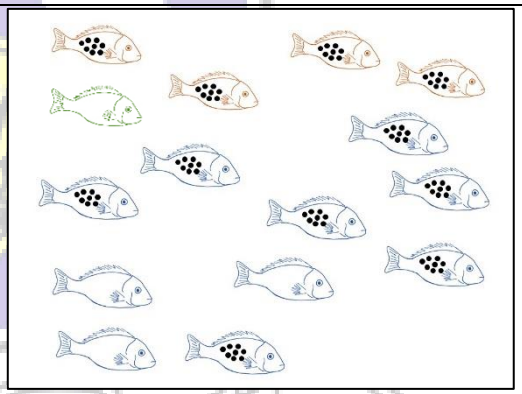
<td> 
The sexually reproducing non-resistant fish are over-represented due to the bottleneck event (parasite resistance alleles are lost)→ change in allele frequency of the population due to chance i.e. genetic drift has occurred.</td>
<td> 
Inbreeding of sexually reproducing non-resistant fish will produce offspring which are also non-resistant, hence leads to increase in frequency of parasitized fish in the population.</td>
</tr>
</table>

(d) Suggest one microevolutionary mechanism that can counteract this effect. Explain your answer.

…… [2]

1 Mutation/ Create new alleles by point mutation/ base substitution that can encode for resistance to parasites

2 Gene flow between populations to introduce new alleles encoding resistance to parasites via migration of individuals between populations

Reject: Natural selection – not an immediate mechanism to introduce resistant allele back into the gene pool.

QUESTION 4

Two closely related species of frog, *Hyla ewingi* and *Hyla verrauxi* live in South Australia. The figure below shows the distribution of the tree frogs in Southern Australia.

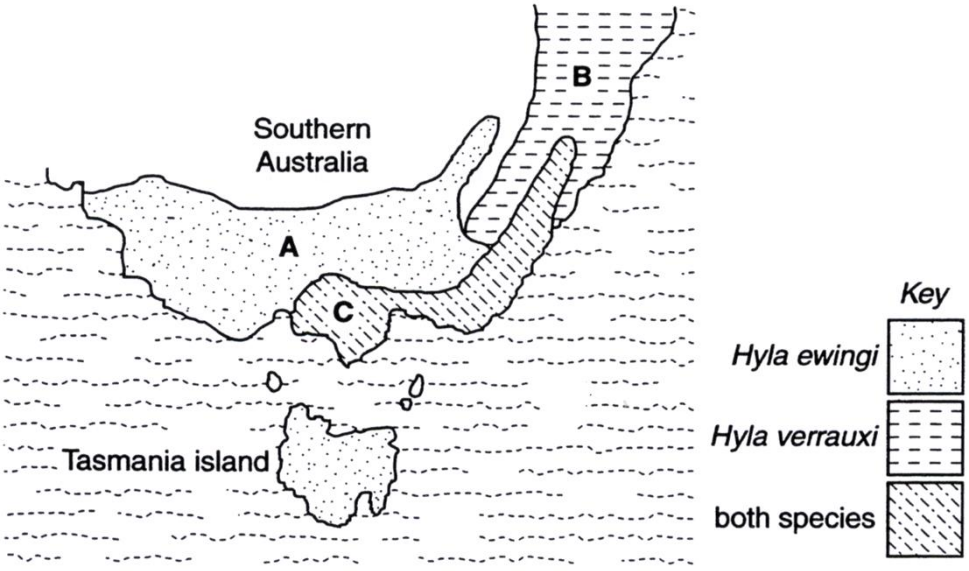


Fig. 1

Hyla ewingi and *Hyla verrauxi* are two closely related species of tree frogs from southern Australia. Research from breeding studies and DNA sequence data has shown that they have weak genetic incompatibility.

Male frogs attract females of the same species for mating by their pulsing call. The pulse rate of the male calls of the two species is almost identical. However, when both species coexist within the same region, the calls of *H. ewingi* are quite different than those of *H. verrauxi*.

Fig. 2 shows the calls of *H. ewingi* and *H. verrauxi* from three regions, A, B and C. The male advertisement calls were recorded and played back electronically to produce the pattern shown

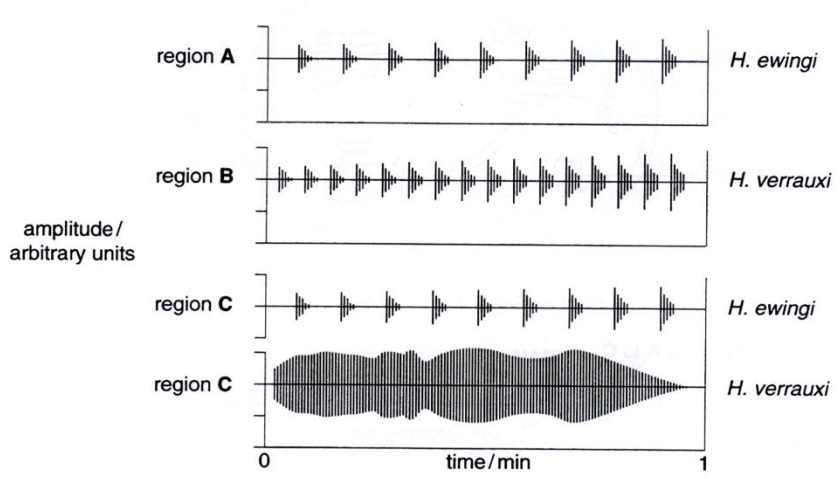


Fig. 2

Some female frogs of the species *H. verrauxi* were transferred from region B to region C. Observations shown that they were not attracted by the calls of the males in region C.

(a) Suggest why this is so.

…… [2]

1 The male advertisement calls by H. verrauxi in region C are no longer pulsatile / discontinuous;
More continuous without any interval in C;
2 Amplitude of the sound waves also differ;
Sound intensity of male call in region B is from soft to loud compared to loud to soft in C;

[Any 2]

(b) Explain how the process of natural selection could have led to the different male advertisement call in *H.verrauxi* in region C.

…… [6]

1 Variation in male advertisement calls in population of *H. verrauxi* frogs in region C arose due to spontaneous mutation.
2 As *H. ewingi* and *H. verrauxi* have similar advertisement calls, there is a **competition for mates** between these two species in region C
3 *H. verrauxi* females *(selection pressure)* which select males with the continuous calls *(selective advantage)* compared to males with a pulsatile call are **more likely to mate with males of their own species rather than males of *H. ewingi***
4 They will **produce viable and fertile offspring,** the females of which will also tend to select males with continuous calls as mates
5 Hence, *H. verrauxi* males with continuous calls will be at a selective advantage over males with pulsating calls, and be able to produce more offspring
6 They will **pass down their alleles** that code for such continuous calls to the next generation

(Resulting in higher and higher frequency of males which produce continuous calls)