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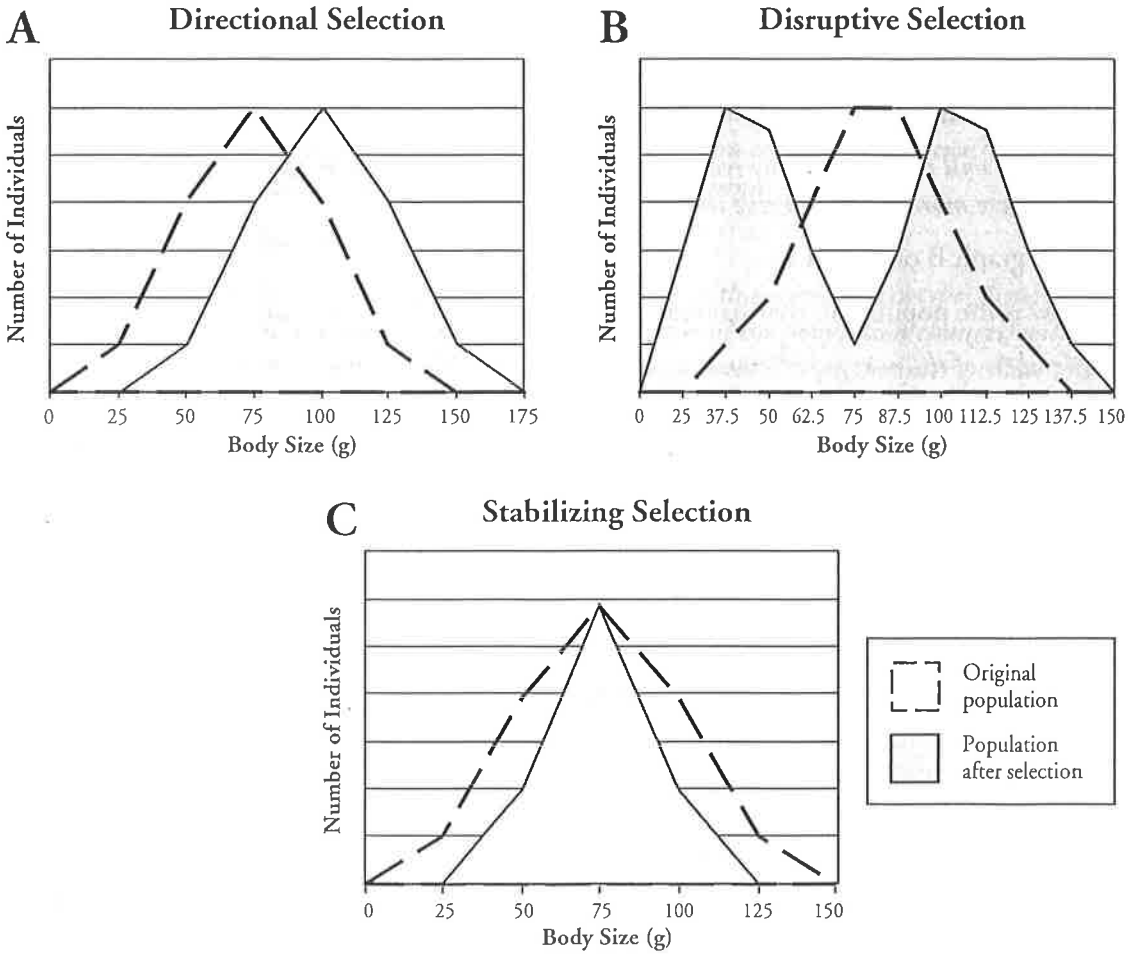
Selection and Speciation

How can changes in a population result in the formation of a new species?

Why?

Have you ever wondered how the great diversity of life on Earth has come about or how a single new species forms? Environmental pressures may cause populations to change over time or evolve. This is because an organism's ability to live to adulthood in its current environment will determine its reproductive success and ability to pass on its genes. But changes within a population can occur without creating a new species. At what point do scientists start thinking of a new name for a species?

Model 1 – Three Types of Selection



1. What variables do the graphs in Model 1 compare?

   Body size and number of individuals.

2. What are the three types of selection illustrated in the graphs in Model 1?

   Directional, disruptive, and stabilizing.

3. According to the graphs in Model 1, there is variation in the body mass in the original population. Using your knowledge of genetics, describe how this variation is possible.

   Answers may vary. Different alleles are possible within the population due to random mutations that may occur. In addition, the food supply may differ from one organism to another causing different body mass.

4. Refer to graph A of Model 1.

   a. How is the population that has experienced selection different from the original population?

   The individuals in the new population are larger on average than those in the original population.

   b. **Fitness** is defined as the relative ability of an individual (or population) to survive, reproduce, and pass on genes. Which individuals in the original population appear to display better fitness?

   Those with larger body mass.

   c. As a group, propose some characteristics of the environment that could lead to the population changes illustrated in graph A.

   Answers will vary, accept any reasonable answer, such as climate became colder so those with more mass were more able to survive the cold weather.

5. Refer to graph B of Model 1.

   a. How is the population that has experienced selection different from the original population?

   Members of the new population are either larger or smaller than the majority in the original population. There are very few individuals of intermediate size.

   b. Which individuals in the original population appear to display better fitness?

   Those with either a very small or very large body mass.

   c. As a group, propose some characteristics of the environment that could lead to the population changes illustrated in graph B.

   Answers will vary, accept any reasonable answer, such as protection from predators. Small animals can hide better while large animals can flee faster.

6. Refer to graph C of Model 1.

   a. How is the population that has experienced selection different from the original population?

   Most of the individuals in the new population are intermediate in size and there are fewer individuals of large or small size.

   b. Which individuals in the original population appear to display better fitness?

   Those with an intermediate body mass.

   c. As a group, propose some characteristics of the environment that could lead to the population changes illustrated in graph C.

   Answers will vary, accept any reasonable answer, such as better able to fit into the chosen shelter.

7. As a group, define the following terms in grammatically correct sentences. Each definition should contain the following words: population, selection, fitness, and environment.

   a. Directional selection

   Due to the environmental conditions, individuals with a phenotype at one end of the spectrum or the other demonstrate more fitness. Over time, selection occurs and the structure of the population changes, with more individuals having the desired phenotype.

   b. Disruptive selection

   Due to the environmental conditions, individuals with extreme phenotypes demonstrate more fitness. Over time, selection occurs and the structure of the population changes, with more individuals exhibiting the extreme phenotypes and fewer having the intermediate phenotype.

   c. Stabilizing selection

   Due to the environmental conditions, individuals with the intermediate phenotype demonstrate more fitness. Over time, selection occurs and the structure of the population changes, with more individuals having the intermediate phenotype.

8. In each of the following examples, describe the likely outcome due to the environmental pressure and state the type of selection. Justify your choice.

   a. Finches with a small beak cannot crack open seeds.

   A population with a larger beak will eventually be selected because they can more easily open the seeds. Directional selection.

   b. Human babies with very high or very low birth weights have a higher mortality rate.

   Conditions will favor intermediate weight babies and so will result in stabilizing selection.

   c. A population of seed cracker finches feeds on seeds available in two sizes, small or large.

   Two populations will emerge if different beak types are best for the different sized seeds. Disruptive selection.

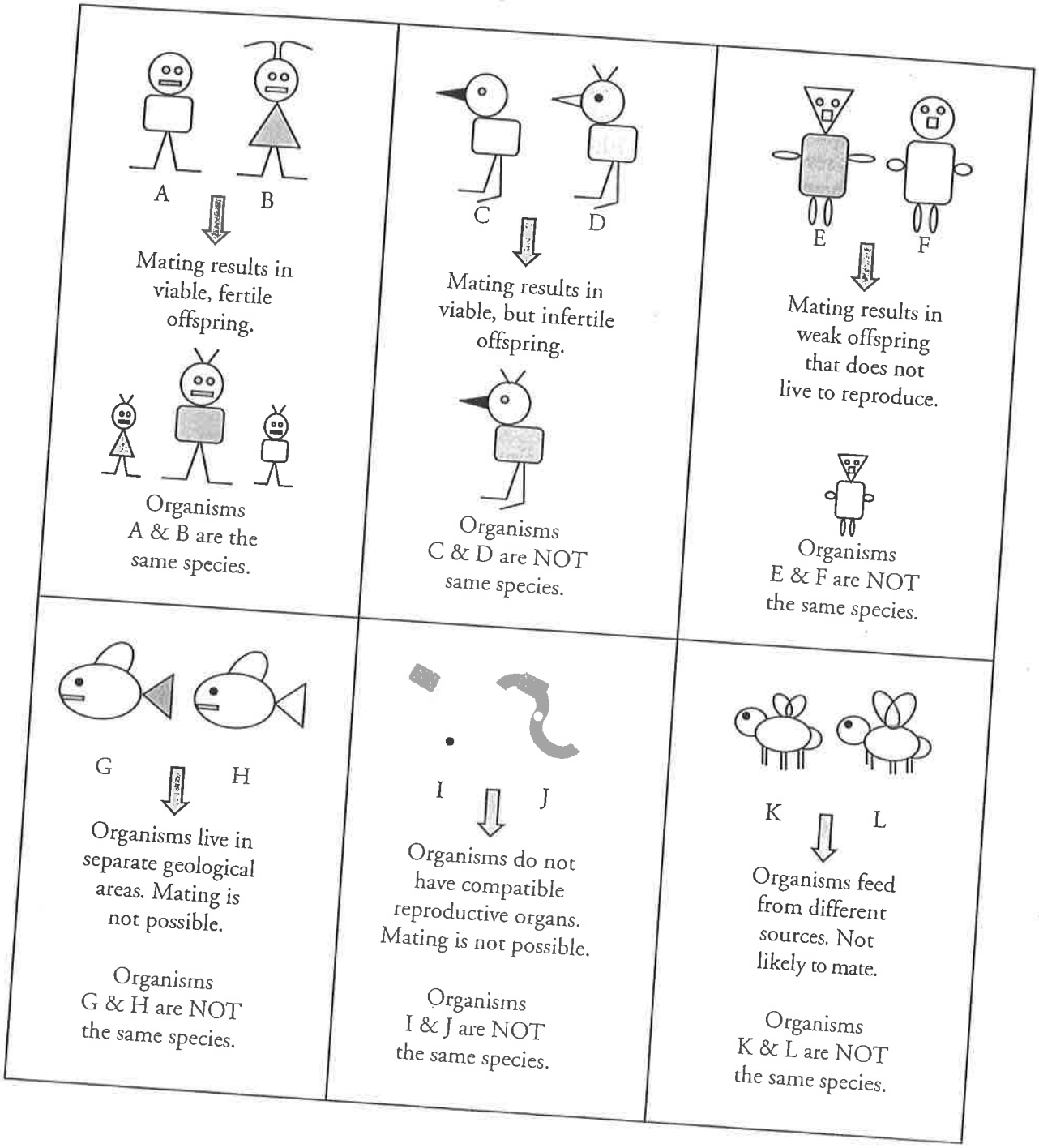
   d. Overfishing occurs in two rivers in British Columbia, Canada, where larger salmon are preferentially caught.

   Small size will become an advantage because they are not harvested so the population size will shift from large to small. Directional selection.

Read This!

Natural selection, the improved fitness of certain individuals in the population that allows for survival and reproduction, is the primary mechanism by which populations change over time. Other mechanisms include the introduction of a mutation in the population and **artificial selection** (the effect of humans purposefully breeding animals to select for desirable traits). But at what point does a change in the population develop a new species? Data have been collected showing that the average height of an American adult is increasing, but that does not mean the American population has evolved into a new species.

Model 2 – Reproductive Isolation



9. Refer to Model 2. Identify the pairs of organisms that are able to produce offspring.

   Organisms A/B, C/D, and E/F are able to produce offspring.

10. Which pair of organisms in Model 2 are members of the same species?

    The only pair that is the same species are organisms A and B.

11. Consider all of the pairs of organisms in Model 2 that are not of the same species. What criterion are missing in all cases that could be used to define a species?

    The pairs of organisms that are not the same species cannot produce viable, fertile offspring.

Read This!

The primary criteria for animals to be classified as different species is that there must be **reproductive isolation**, meaning for some reason organisms from the two populations cannot pass on their genetic code through reproduction for several generations. Other criteria such as differing morphology (appearance and body structure) and how much DNA the organisms share are also used to make a final determination when comparing two similar organisms.

12. A common farming practice is to breed a female horse with a male donkey. The result is a very robust animal – the mule. Most mules however are sterile, and therefore cannot reproduce. Are horses and donkeys members of the same species? Justify your answer with a specific example from Model 2.

    No, horses and donkeys are different species because when they mate their offspring is infertile. This is similar to the organism pair C/D in Model 2.

13. Many species of birds have elaborate mating rituals that include bird calls, nest construction, and courtship displays. A researcher is comparing two populations of birds with similar morphology that live in similar niches. Male birds in one population build a nest before attempting to court a female, while males in the other population build the nest in cooperation with the female. Is it likely the researcher will classify these birds as the same species? Justify your reasoning.

    No, these two birds would not be classified as the same species because it is unlikely that they would be able to mate due to the difference in their mating rituals.

14. Could directional selection lead to the creation of a new species? Justify your reasoning using what you've learned from Models 1 and 2.

    Yes, directional selection could lead to a new species if the population changed to the point that members of the original population could no longer mate with members of the new population and produce viable, fertile offspring.

15. Could disruptive selection lead to the creation of a new species? Justify your reasoning using what you've learned from Model 2.

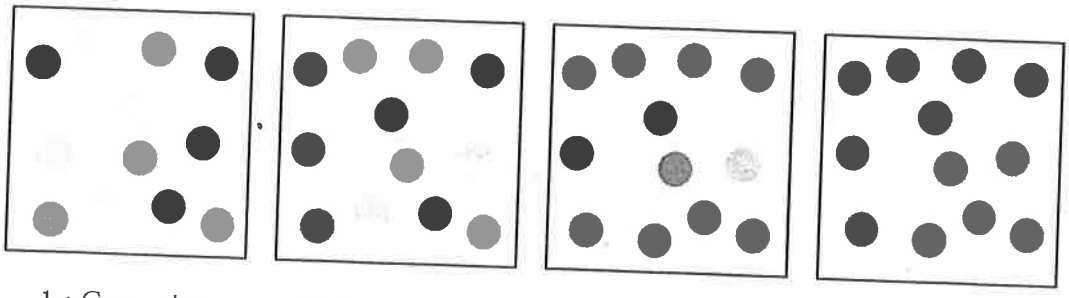
Yes, disruptive selection could lead to a new species if the two resulting populations were not able to mate and produce viable, fertile offspring.

16. Could stabilizing selection lead to the creation of a new species? Justify your reasoning using what you've learned from Model 2.

No, the individuals within the species just become more alike/less diverse. It is unlikely that this would change the ability to mate within the population to produce viable, fertile offspring.

Extension Questions

Model 3 – Genetic Drift



1st Generation 2nd Generation 3rd Generation 4th Generation

17. Refer to Model 3. Fill in the table below with the number of alleles of each type in each generation.

	1st Generation	2nd Generation	3rd Generation	4th Generation
Light	*4*	*2*	*1*	*0*
Medium	*4*	*5*	*5*	*6*
Dark	*4*	*5*	*6*	*6*

18. Compare the frequency of the three alleles in the 1st generation of the small population illustrated in Model 3.

Each of the three observed alleles is equally represented in the population.

19. In the scenario illustrated in Model 3 two of the light alleles were lost (through the death of the individual who had these two alleles) before reproduction occurred in the 1st generation. How did this affect the distribution of the three alleles in this small population?

There were fewer light alleles in the next generation because that particular allele was not passed on as often.

20. The phenomenon illustrated in Model 3 is called genetic drift. It mainly occurs in small, isolated populations. Propose an explanation for why the light allele disappears from the population by the fourth generation.

Since fewer organisms have the light allele, the chances that future generations will have that allele is reduced, so eventually the population will no longer have organisms with that allele.

21. Will the light allele ever reappear in this population? If yes, describe the circumstances that would need to occur for the light allele to reappear.

No, with the current population the light allele will never reappear. There are no organisms that contain that sequence of DNA to pass it on to future generations. The only way that the light allele could reappear is if a light-allele containing organism from another population joined this population and successfully mated with an organism in this population.

22. If the population in Model 3 had been very large (hundreds of organisms), would the loss of two alleles from that population have led to the disappearance of that allele? Justify your reasoning.

If the population had been large, it is unlikely that a death of a very small percentage of its individuals would have led to the disappearance of their alleles. The random fluctuations in the large population would eventually have stabilized the allele frequency once again in future generations.