Bottleneck Genes

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Nebraska Rare Species Educator Packet

grades 5-12

OBJECTIVES

Students will (1) describe biodiversity as it relates to natural systems, species, or individuals; (2) articulate that genetic diversity is essential to the health of a species because it facilitates adaptation to change and provides sources for new genetic material; (3) explain how natural selection favors individuals with traits adapted to their environment; and (4) explain that for a wildlife population to sustain itself, there must be enough habitat to support a healthy-sized population that will carry a healthy-sized gene pool.

METHOD

Students will simulate the gene-pool analysis of a population of black-footed ferrets using colored beads.

MATERIALS

- a bottle or bag to hold beads
- several sets of the "Key to Environmental Situations" cards (one set for each group)
- several copies of the "Key to Genetic Characteristics" (one for each group)
- several copies of the "Black-Footed Ferret Bottleneck Scenario" worksheet (one for each group)
- 10 or more of each color of beads - yellow, black, orange, pink, blue, green, purple, red, and white

Subject Areas: Science, Environmental Education, Math

Duration: one 40-minute session

Group Size: any

Setting: indoors

Vocabulary: genetic diversity, gene pool, adaptations, population bottleneck

BACKGROUND

Diversity is essential to the survival of a species. There are three kinds of biological diversity found in an individual, diversity within a species or given population; and diversity within ecosystems. The ability of an individual to survive changes in the environment comes from the extent of genetic diversity the individual has, thus giving it the ability to adjust to those variations. Diversity within a population means that there are enough organisms to continue producing a variety of genetic combinations within the group. The third type of diversity, biodiversity, deals with ecosystems. A diverse ecosystem provides a variety of food sources for those living there, which allows for a higher survival rate.

In the world of "survival of the fittest," an organism must have the genetic resources that allow it to survive immediate changes in its environment that allow the species to adapt to long-term changes. The only way to ensure this will happen is to make sure that the genetic options in the population are numerous enough to have the greatest variety of attributes passes along to individuals in the next generation. The best way to ensure a large and healthy population with enough gene options is to have sufficient habitat to support it. When the

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number of individuals decreases, the genetic pool also decreases, causing what is called a "bottleneck" in the population, or a decrease in the variety of gene options in the gene pool.

The purpose of this activity is to demonstrate the importance of genetic variability to the health of a population and its ability to survive ecosystem changes over time. Students will simulate what happens when a population of black-footed ferrets begins to decrease in size, and they will examine how this decrease affects the genetic diversity within the group. Following the simulation, the students will look at the effects of a limited genetic diversity on the population in a changing ecosystem over the period of a year.

NOTE: For information on the black-footed ferret, visit www.blackfootedferret.org.

PROCEDURE

1. Divide students into groups of two to four students. Give each group a copy of the "Key to Genetic Characteristics," a set of "Key to Environmental Situations" cards, and a "Black-footed Ferret Bottleneck Scenario" page.

2. Review the terms "genetic diversity,""biodiversity," and "population bottlenecks" as found in the background section.

3. Review the gene color key. Discuss the benefits of the different attributes.

4. Place all the genes (colored beads) into the glass bottle. Shake gently to mix the colors. Explain to students that the genes will be distributed randomly, as would be found in a real population.

5. Distribute a small handful of beads to each group. These beads represent the genes available in the population of black-footed ferrets for each group. Have the students match their genes to the gene key and circle the colors of genes on the "Key to Genetic Characteristics" for their population. (Please note, the students must be given only a small amount of beads to ensure that they do not receive all nine colors).

6. Have groups choose five Environmental Situation Cards randomly from the deck.

7. Have students use the "Black-footed Ferret Bottleneck Scenario" worksheet to:
a. Calculate the genetic diversity of their population.

b. Describe their population according to its current genetic makeup.

c. Develop and write a prediction of the survival of their population for a period of one year given the environmental situations described on the cards the group selected. The address the following:

- Is the population genetically equipped to survive in this environment? How well or how poorly?

- How does a high or low percentage of genetic diversity affect the population's survival?

- How do random changes in the environment affect the population? (remind students that for this questions, they are concerned with how many beads of each color they have.)

8. Each of the groups should present their results to the class.

9. Discuss the following questions:
a. Why does genetic diversity help protect a population?

b. Why would a small population have a higher risk of being eliminated that a large population?
c. Why do you think smaller populations have a harder time surviving disease? (Inbreeding depletes the gene pool that provides a variety of traits. If there are fewer genes that help an animal fight off disease, the population becomes more susceptible to pathogens.)

EXTENSIONS

1. Discuss the impact of dominant versus recessive traits. Recessive traits have a much lower probability of becoming evident in the population unless the population becomes small enough to inbreed an bring forth those recessive traits, or unless that trait makes the animal better able to survive in its environment. Repeat the activity using two colors for each genetic characteristic (to represent dominant and recessive traits). For instance, dark blue beads could represent healthy jaw formation and light blue beads could represent a jaw malformation or deformity. also, use separate containers for each characteristic, and have students pick two beads from each of those containers. If the group receives only recessive color beads for a characteristic, they the recessive trait will be expressed. If the group receives only dominant color brads or if they receive a mix of dominant and recessive color beads for that characteristic, then the dominant trait will be expressed. (If the color selection of beads is limited, another type of token, such as colored paper squares, may be used.)

2. After the initial round, randomly pair the groups to see how combining genes from different populations affects diversity. Discuss how this prelates to habitat fragmentation.

3. Visit a local zoo and talk to staff members about their attempts to ensure genetic diversity with their breeding animals. Discuss any attempts they may ben involved in to re-establish endangered species in the wild.

4. Have students choose a Nebraska endangered or threatened species and design a plan for breeding that would ensure, or greatly improve, the chances for genetic diversity and, therefore, survival.

EVALUATIONS

1. Steps 6 through 9 in the Procedure can be used as an evaluation tool.

2. Have students research a threatened or endangered species found in their area. Students can determine whether genetic diversity within the species had an effect on its depletion. They should also examine whether the species was placed on the threatened or endangered species list because of degradation or loss of habitat. Have students check their conclusions with the Nebraska Game & Parks Commission or the U.S. Fish and Wildlife Service Mountain-Prairie Region office.

RELATED WEBSITES

Black-footed Ferret Recovery Implementation Team
www.blackfootedferret.org
A great website for background information and videos of black-footed ferrets in the wild.

U.S. Fish & Wildlife Service, Nebraska Field Office
www.fws.gov/nebraskaes
A great Nebraska-specific site for all federally listed threatened and endangered species.

Nebraska Game & Parks Commission, Wildlife Species Guide
outdoornebraska.ne.gov/wildlife/wildlife_species_guide/ferret.asp
A Nebraska-specific guide to Black-footed Ferrets including management and outlook for the species.

Prairie Wildlife Research
www.prairiewildlife.org
A great site for information on many shortgrass prairie wildlife species, especially the black-footed ferret.

National Wildlife Federation, eNature
www.enature.com/fieldguides/detail.asp?recNum=MA0161
A simple site to find information on many wildlife species including the black-footed ferret.

BOOKS & PRINTED MATERIAL

Phantom of the Prairie: Year of the Black-Footed Ferret by Jonathan London and Barbara Bash. 1998. ISBN-13: 978-0871563873

Wild and Free: The Story of a Black-Footed Ferret (Smithsonian Wild Heritage Collection) by Jo Ellen C. Bosson. 1994. ISBN-13: 978-0924483684

Saving the Prairie Bandit (Wildlife Conservation Society Books) by Dorothy Hinshaw Patent. 2002. ISBN-13: 978-0531165676

Explore the Grasslands (Explore the Biomes series) by Kay Jackson. 2007. ISBN-13: 978-0736896283

The Prairie Builders: Reconstructing America's Lost Grasslands (Scientists in the Field Series) by Sneed B. Collard. 2005. ISBN-13: 978-0618396870

A Walk in the Prairie (Biomes of North America) by Rebecca L. Johnson and Phyllis V. Saroff. 2001. ISBN-13: 978-1575055305

PERMISSIONS & CREDITS

Key to Genetic Characteristics

Yellow	camouflage
Black	precise vision
Orange	accurate sense of smell
Pink	strong claws and forearms
Dark Blue	inclination to disperse
Green	high agility
Purple	acute hearing
Red	healthy rate of reproduction
White	strong immune system

Key to Environmental Situations

1. A farmer has been trying to protect his wheat fields by exterminating prairie dogs. Very little prey is available. Given its genetic makeup, how would your ferret population survive?

2. A golden eagle hunts from high above and will prey on available animals such as the black-footed ferret. Does you population have the gene for precise vision to avoid being captured? Given its genetic makeup, how would your ferret population survive?

3. Black-footed ferret kits disperse from their home territory and are able to establish new populations in prairie dog towns. Given its genetic makeup, how would your ferret population survive?

4. An interstate highway has been built near your prairie dog town. How does this road affect your black-footed ferret population? Given its genetic makeup, how would your ferret population survive?

5. Fleas carrying bacteria which causes sylvatic plague have infested your prairie dog town. Biologists have not yet vaccinated the black-footed ferrets in your population. Given its genetic makeup, how would your ferret population survive?

6. A new generation of captive-born black-footed ferrets have been preconditioned to live in the wild and are ready to be released in a nearby reintroduction site. Given its genetic makeup, how would your ferret population survive?

7. A plague has hit your prairie dog town, and most of the prairie dogs die from the disease. How does your black-footed ferret population adapt to a reduction in food supply? Given its genetic makeup, how would your ferret population survive?

8. As a coyote silently prowls nearby, only its odor might warn of its presence. Does your population have the gene for acute sense of smell to detect and avoid the coyote?

9. Black-footed ferrets ear prairie dogs and use prairie dog burrows for shelter. Does you ferret population have the agility gene to catch an aggressive prairie dog in its dark, narrow, winding tunnel system? Given its genetic makeup, how would your ferret population survive?

10. Black-footed ferrets are nocturnal creatures that leave their burrows at night to feed. Does your ferret population have the camouflage gene to keep well hidden from the bobcat hunting for its dinner? Given its genetic makeup, how would your ferret population survive?

11. A badger is moving quietly around the prairie dog town. Does you population have the gene for acute hearing to detect and avoid this predator? Given its genetic makeup, how would your ferret population survive?

12. A prairie dog colony has just been established in a state park only a few miles away. How does the colony affect your population of ferrets? Given its genetic makeup, how would your ferret population survive?

13. It will be difficult for your population to take over and adapt to prairie dog burrows in hard soils without the gene for strong claws and forelegs. Given its genetic makeup, how would your ferret population survive?

14. Humans who are building homes have wiped out a prairie dog town three miles away. The surviving black-footed ferrets from that area are moving into your territory. Given its genetic makeup, how would your ferret population survive?

Black-footed Ferret Bottleneck Scenario

Names of Team Members: _____

On your "Key to Genetic Characteristics," circle the COLORS and GENES that your population received when it passed through the population bottleneck (the beads it received).

1. Calculate the percentage of genetic diversity of you population.

Nine colors represent 100% genetic diversity in the original population.

_____ genes received ÷ 9 original genes = _____ (decimal) x 100 = _____ %

2. List the genetic characteristics that your population received when it passed through the population bottleneck (the beads it received).

3. List the genetic characteristics that your population lost when it came through the bottleneck (the beads it did not receive).

4. Using the five environmental situations, write a prediction about what will happen to your population of ferrets during the coming year.

Is the population genetically equipped to survive in its environment? How well or how poorly? How does a high or low percentage of genetic diversity affect the population's survival? How do random changes in the environment affect the population?