GENETIC DIVERSITY AND FRAGMENTATION (Part I)

GRADE Grade 9

PART 1 of 3

TOPICS Biodiversity, conservation, habitat

CURRICULAR CONNECTIONS

Grade 9 Science

Unit A – Biological Diversity

2. Investigate the nature of reproductive processes and their role in transmitting species characteristics
    - Identify examples of dominant and recessive characteristics and recognize that dominance and recessiveness provide only a partial explanation for the variation of characteristics in offspring
4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making.
    - Describe ongoing changes in biological diversity through extinction and extirpation of native species, and investigate the role of environmental factors in causing these changes
    - Evaluate the success and limitations of various local and global strategies for minimizing loss of species diversity

OVERVIEW

Students begin this lesson by exploring the importance of biodiversity at different scales, including genetic, species and ecosystem diversity. Through an interactive activity students will understand how increased genetic diversity contributes to the resiliency of a population. Students will then investigate a number of case studies to better understand how a loss of genetic diversity within wild and domesticated animal populations has negatively affected those populations' fitness.

OBJECTIVES

- Students will understand that biodiversity exists at multiple scales
- Students will understand why biodiversity is vital for the survival of life on Earth
- Students will understand how genetic diversity can be lost in populations with small numbers of individuals through inbreeding depression

KEY TERMS

- **Alleles** – different variations of the same gene, which may result in distinct observable traits (e.g. the gene that determines hair colour)
- **Biodiversity** – the variability of living organisms in a particular habitat or ecosystem. This includes the diversity within species, between species and of ecosystems
- **Deleterious alleles** – an allele of a gene whose effects when expressed are likely to result in reduced fitness
- **Fitness** – the ability to survive to reproductive age, find a mate, and produce offspring
- **Genetic diversity** – the number of different alleles within and among individuals of a population and the frequency with which they appear
- **Inbreeding depression** – a reduced biological fitness in a population as a result of breeding with related individuals
- **Phenotype** – the observable physical properties of an organism, including appearance, development and behaviour

GUIDING QUESTIONS

- Why is biodiversity conservation important?
- What problems can arise within a population and for ecosystems at large when genetic diversity declines?

BACKGROUND ESSAY

Biodiversity conservation has been highlighted as one of the most pressing conservation challenges of our time, so much so that the United Nations General Assembly declared the period 2011-2020 as United Nations Decade on Biodiversity. Conserving biodiversity involves much more than protecting the different species on Earth. **Biodiversity** refers to the variability of living organisms in a particular

habitat or ecosystem, including the diversity within species (e.g. different breeds of domesticated dogs) between species (e.g. the diversity of plants and animals that live in the Canadian Rockies) and of ecosystems (e.g. desert, tundra and montane ecosystems).

Biodiversity is critically important for the survival of life on Earth. Some of the benefits of biodiversity include ecosystem services such as nutrient cycling and protection of water resources, biological resources such as food, timber and medicines, and social benefits such as cultural values and recreation. The loss of a single species from a food web can have far reaching effects on the entire ecosystem. This effect is likely to be more pronounced if the species that is lost is a large carnivore like a wolf, which could result in an increase in prey numbers and subsequent deterioration of the habitat due to increased herbivory.

Every single individual, from grizzly bears to snails to humans, possesses a unique set of genes that are the source of its features. **Genetic diversity** refers to the number of different alleles *within* and *among* individuals of a population and the frequency with which they appear. **Alleles** are different variations of the same gene, which may result in distinct observable traits. For example, one gene – or more likely a combination of genes – may be responsible for the fur colour of black bears, and different alleles of that gene could be expressed as white, black, brown or golden coloured fur. The observable physical properties of an organism – in this case fur colour – are known as the **phenotype**. Phenotype is not limited to the appearance of an organism and also includes its development and behaviour. Genetic diversity is *high* when there are many different alleles of all genes.

Species need a variety of genes in order to ensure that they are able to successfully survive and reproduce. Greater genetic diversity increases the resilience of wildlife populations to environmental change, therefore minimizing the risk of collapse of the population. Genetic variation is beneficial to a population because it allows some individuals to adapt to the environment and maintain the survival of the population in the event of a sudden stressor like disease or an environmental change. Once genetic diversity has been lost within a population, it can take a very long time for a population to increase its genetic variation even if population numbers are able to rebound. This means that in order to ensure the long-term survival of species, it is important to consider not just how many individuals make up a population but also the genetic diversity within those populations.

DURATION 15-20 minutes

MATERIALS

- 15-20 index cards with characteristics

ACTIVITY – STUDENT CHARACTERISTICS

In this activity students will participate in a demonstration that illustrates why genetic diversity is so important to the survivability and resiliency of a population.

1. Divide students into two teams. Explain that you have a stack of index cards and that each one has a characteristic that will represent a genetic trait (see list of possible characteristics below). Because it may be challenging to come up with enough truly genetic-based traits, you will need to use other traits in the demonstration such as clothing colour or shoe brand.

2. Explain to the students that once the game starts they are not able to change anything about themselves (e.g. take off shoes, put on a sweater). When you read a characteristic from an index card, any students that has that characteristic will "die" by sitting down. The team with the last person standing is the winner.

3. Repeat Step 2 for 3 or 4 cards. Instruct the students that if there is anyone on their team who is still standing after 4 of 5 cards have been played, the entire team can regenerate and join back in. If both teams have players still standing, play another round of 3 or 4 cards.

4. Discuss the demonstration. Consider if there were characteristics that eliminated more of the students than others. Did one team do better than another? Why or why not?

5. Shuffle the cards and repeat the demonstration with everyone rejoining the game. Tell the students that before you begin, they can make any adjustments they want (e.g. removing shoes, adding or removing layers of clothing). At this point in the game, students should recognize that the more characteristics they exhibit, the more resilient their team will be.

6. Lead a final discussion of the activity. Did the changes that the teams made allow more of their team to survive? What helped or hurt their survival? How could what they learned in this activity be applied to genetic diversity of plant or animal populations? Students should arrive at an understanding that a population that is more genetically diverse will be more resilient to change.

Characteristics

- Light-coloured eyes
- Bent little finger
- Attached ear lobes
- Widow's peak
- Not able to curl tongue
- Wearing a hat
- Not wearing red
- Wearing glasses
- Wearing earring(s)
- Wearing a sweater
- Wearing hair clips
- Wearing a watch
- Shoes laced and tied
- Shoes without laces

This activity has been adapted from "The Gene Scene" from the Illinois Department of Natural Resources, Chicago Wilderness and World Wildlife Fund. View the original lesson plan and other activities for teaching about genetic diversity at www2.illinois.gov/dnr/education/Documents/BioBasics_Activity_1-4.pdf

CASE STUDY

The Florida Panther is the only known population of cougar found east of the Mississippi River. Due to hunting and habitat loss through the 20th century, their numbers had dwindled to fewer than 30 panthers by the 1990s.

The panthers fell victim to inbreeding depression because their numbers were so low, resulting in numerous health issues. These included heart failure, undescended testicles, pathogenic diseases and parasites.

In the mid-1990s, biologists introduced eight female Texas pumas to South Florida in an attempt to save the population and increase genetic diversity. As of 2019, the South Florida panther population had risen to at least 230 panthers.

Read more at www.sciencedaily.com/releases/2019/10/191003111755.htm

DURATION 60+ minutes

MATERIALS

- Computer with Internet connection

BACKGROUND ESSAY

What happens when genetic diversity in a population declines? A **deleterious allele** is an allele of a gene whose effects when expressed are likely to cause a reduction in biological **fitness** (i.e. the ability to survive to reproductive age, find a mate, and produce offspring) when it is expressed. In large, healthy populations, the deleterious recessive allele is present in a very small number of individuals and expressed in even fewer numbers. Dominant traits are expressed when one copy of an allele is present, while recessive traits require two copies of an allele in order to be expressed. When the dominant allele is present, the recessive allele will be essentially *'hidden.'* Individuals that carry a single recessive deleterious allele will be healthy and can easily pass this gene on to their offspring.

Inbreeding depression is the reduced biological fitness in a population that results from breeding between related individuals. As population size shrinks, the likelihood of an individual receiving two recessive deleterious alleles increases. Close relatives might end up mating with one another and these two relatives may carry the same two recessive deleterious alleles (Figure 1). The offspring of those relatives may receive two copies of the recessive deleterious alleles and suffer the consequences of expressing the associated phenotype. Examples of phenotypes that have been seen as a result of inbreeding depression include reduced fertility, reduced birth rate, higher infant and child mortality, smaller adult size, reduced immune function and increased risk of genetic disorder. When there are fewer individuals in a population, the likelihood of inbreeding depression occurring is higher.

ACTIVITY – INVESTIGATION

Students will investigate and summarize one case study where inbreeding is known to have occurred. Students will investigate the factors that led to inbreeding as well as any interventions that occurred to reverse the effects of inbreeding depression.

1. Assign students to small groups to investigate and summarize one inbreeding case study from the following list.
   a. Florida Panther (*Puma concolor coryi*)
   b. Swedish Adders (*Vipera berus*)
   c. Domestic Dogs (*Canis familiaris*)
   d. Thoroughbred Horses (*Equus ferus caballus*)
   e. Holstein Friesian Cattle (*Bos taurus*)

2. Ask students to consider the following questions:
    a. Is the case study a wild or domestic population?
    b. Why has inbreeding occurred?
    c. What are the related health problems?
    d. What was done (if anything) to reverse the health problems?

Figure 1: Example of inbreeding depression among a grizzly bear population