LESSON

Setting the Stage: The Scientific Process in Action

Introduce students to the case study goals and Clinton Epps, the scientist who conducted the research.

What We Are Hoping For: Learning Goals

- Populations
- Inbreeding
- Habitats
- Human Impact
    - A, B, C
- Nature of Science
    - A-E

Learning Goals:

- Engage students in the case study
- Science begins with questions
- Students ask questions about their own environment
- Engage Students in Dr. Epps' motivation for field research
- Science is a human endeavor
- DNA can be used to determine whether populations are isolated from one

---

Checklist for Setting the Stage: The Scientific Process in Action

In this lesson, students will:

- Be introduced to the case study goals and Dr. Clinton Epps, the scientist who conducted the research. **(1 min.)**
- Watch the *Science Bulletin, Highways Block Bighorn Sheep* **(4 min.)**
- Watch the Meet the Bighorn Sheep slide show **(5 min.)** that includes
  - Habitat and mating habits of bighorn sheep.
  - Maps of the bighorn sheep range.
- Watch the Highways Impact slide show **(4 min.)** that includes
  - Why highways between LA and Las Vegas are vital to Nevada's economy.
  - Potential impacts of highways on wildlife (road kill, pollution).
- Discuss natural and human-made barriers. **(5 min.)**
- Discuss the effect of isolation on mate choice. **(4 min.)**
- Watch the video profile of Dr. Clinton Epps, the scientist who conducted the research and discuss: **(14 min.)**
  - Dr. Epps' motivation for his research.
  - DNA collection in the video, and how DNA patterns can reveal levels of breeding.
- Complete an activity that models how DNA can be used to detect isolated bighorn sheep populations. **(5 min.)**
- Complete the *Setting the Stage*: *The Scientific Process in Action* section of the Investigation Booklet. **(4 min.)**

(Times indicated are approximate.)

Science Bulletin: *Highways Block Bighorn Sheep*

This Science Bulletin, *Highways Block Bighorn Sheep*, is based on the scientific research of Clinton Epps. He was interested in understanding if highways built to connect Los Angeles and Las Vegas might affect bighorn sheep populations.

As the human population gets more connected, animal populations become more separated.

Recently, biologists studied 27 groups of desert bighorn sheep, which live on the rocky mountains of the Mojave and Sonoran deserts. The scientists found that sheep populations nearest highways and cities were the most genetically inbred.

The study confirms what scientists have long suspected—that bighorns cannot cross major fenced highways and other urban barriers to join new groups. Without adequate gene flow, the health—and existence—of the bighorn sheep are at risk.

Questions for Thought

Ask students to write any questions they have about the Science Bulletin, while they are watching it. Collect these questions and after class, write the questions on a piece of chart paper that can easily be seen during the course of the unit.

Note: Refer back to these questions throughout the unit and check off questions that have been answered along the way.

Meet the Bighorn Sheep slide show
This slideshow provides background information on the bighorn sheep and its habitat and breeding habits.

- Use the maps to start a discussion on bighorn sheep and their habitat.
- Show pictures of bighorn sheep and describe important elements of their biology. Like:
    i. They live in small mountaintop populations of often less than 50 individuals.
    ii. Males use valleys to travel from one high rocky mountaintop to another, in order to find females to mate.
    iii. Teacher Tip: Make sure that students know that populations are individuals of the same species that live in the SAME geographic location.
- Use the series of maps of bighorn sheep habitat to discuss the 27 mountaintop populations of bighorn sheep. Help students interpret the patterns on the map.

Discussion

Key Idea: Bighorn sheep live in small mountaintop populations in the desert, and they breed with nearby bighorn sheep populations.

Slide of map of bighorn sheep habitat with vegetation
Question: So what are we looking at?
Answer: A close up-view of the bighorn sheep habitat

Question: How would you describe their habitat, the terrain? Use the colors and patterns on the map to help you?
Answer: You can see some green vegetation (along the coast, but that is not the bighorn sheep range), but mostly it looks like a brown desert. The terrain looks very mountainous.

Slide of map of bighorn sheep habitat with vegetation and bighorn sheep range overlaid in brown
Question: Where do bighorn sheep live?
Answer: They live on the mountaintops. You can tell because their range (brown) is now shown and it overlays the mountains.

Slide of map of bighorn sheep habitat with vegetation, bighorn sheep range (brown), and human population centers (black) and highways (yellow)
Question: What are we looking at now? What do the different colors represent?
Answer: The colors represent where people live (black) and show the major highways (yellow) that run through the sheep habitat. Refer to key in the next slide.

Different slide of map of bighorn sheep range that contains the same information in a different representation
Comment: This is the same map as shown previously, only a slightly different representation. Let's go over the key.
Show the next slide with a map that contains a key. This representation is the map that the students will be using in the rest of the unit.

Background on Bighorn Sheep

• There used to be at least 500,000 bighorn sheep in the U.S.

• Now there are less than 200,000 sheep and fewer than 20,000 desert bighorn sheep with some subgroups considered to be endangered.

• The biggest threats to the sheep are thought to be from livestock. Overgrazing and diseases spread from domestic sheep to the wild bighorns have caused major population declines.

• Recent habitat fragmentation caused by urbanization is a new threat to the survival of the bighorns.

• Each population is restricted to its mountaintop and separated from others by the desert below.

• It is thought that mountaintop populations sometimes go extinct, only to be re-established by sheep from other mountains.

• Movement of sheep between mountaintops is critical for the long-term survival of the sheep.

Highways Impact slide show
This slideshow provides background information on the human motivation for building large highways in the region occupied by the bighorn sheep.

Discussion

Key Idea: Highways are important to the tourist economy of Las Vegas.

Use the map of major roads and highways of the same region to introduce why highways are important to the Nevada economy.

Comments:
1. About 50,000 tourists a day arrived from California on Interstate 15 just in the month of July!
2. If those numbers hold steady, Las Vegas will have over 18 million tourists a year arriving from California by car. Almost half of all tourists to Las Vegas arrive by car from California.
3. Also, the tourism economy employs over 260,000 people in Las Vegas alone, which is 30% of the working population.
4. Tourists contribute billions of dollars to the Nevada economy, which helps to fund schools, museums, and city services.

Discussion

Key Idea: There are many potential ways that highways can impact the bighorn sheep or other wildlife.

Use the picture of the Bighorn sheep and highway to connect the highways to the study.

Question: Scientists became curious about whether the highways that are so important to the Vegas economy were impacting the sheep. Can you think of possible ways highways might impact living things that live near you? What are the consequences?
Answers: Cars going at high speed run over animals on the roads; an increase in driving leads to increased emissions and air pollution; cars are loud and can scare away wildlife, etc. Some consequences are disrupted populations that are cut off from each other, diminishing wildlife populations, asthma and other environmental health problems for humans, etc.

Discussion

Key Idea: Humans try to limit road kill by putting up fences.

If students suggest that these roads lead to increases in road kill, point out the fence on image. Fences are designed to limit accidents and road kill on the highways.

Question: What do you notice about this picture?
Answer: Humans have put up a fence between the highways and the terrain.

Question: Why do you think the fences were put up?
Answer: To protect people and their cars from damage occurred when running over animals while driving at high speeds.

Boundaries and Isolation discussion

This discussion explores the difference between natural and human-made boundaries and their effect on isolated populations.


Discussion

Key Idea: Boundaries can be natural or human-made.

Question: What are some boundaries with which you are familiar? Are they Natural? Are they human-made? Or both?

Answers: (The following examples are taken from some northeastern and mid-Atlantic states.)

- Natural Boundaries:
  - National
    - Lake Ontario separates Buffalo from Toronto.
  - State
    - New York State from New Jersey by the Hudson River.
    - New Jersey from Pennsylvania by the Delaware River.
  - New York City - Water is a natural barrier that defines the different boroughs.
    - Staten Island is separated from all the other boroughs by the New York New Jersey Harbor Estuary,
    - Brooklyn from Queens by the Newtown Creek,
    - Manhattan from Queens and Brooklyn by the East River,
    - Manhattan from the Bronx by the Harlem River.
    - The case of Marble Hill: It defies the boundary made by water. Marble Hill is a neighborhood in the borough of Manhattan that sits on the other side of the Harlem River connected to the Bronx. What happened? At one point the Harlem River flowed north of Marble Hill, but people rerouted the River, cutting off Marble Hill from the rest of the borough, but linking it to the Bronx. (see figure below left).

Map of Manhattan Courtesy of GFDL
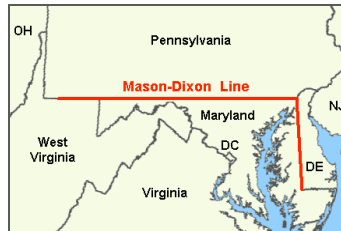
Map of Mason-Dixon Line Courtesy of United States Department of the Interior

- Human-Made Boundaries
  - Some of the US border with Mexico or Canada
  - The rectangular boundaries of the Western states as compared to the jagged borders of the original 13 colonies.
  - Mason Dixon Line is a line that beginning in 1820 began to be seen as marking the cultural boundary between northern and southern states. States north of the line were considered to be northern and states south of the line were considered to be southern (see figure above right).

Question: What are some boundaries in your neighborhood? What marks the borders of where you walk? Is there a big road, a highway, train tracks, a park, a large open space, a big building, water, or something else that limits your movement in your neighborhood?

Answer: Answers will vary depending upon their neighborhood. For example, in New York City, big cross streets like Houston St, 14th St, 34th St. etc. can act as barriers to movement. Hills can also act as borders. Big highways like the Cross Bronx or the BQE are also barriers. Parks often separate neighborhoods too.

Discussion

Key idea: Artificial boundaries can decrease mate choice and isolation.

Question: If you and your neighbors never crossed out of the boundary of your neighborhood and people in nearby neighborhoods did the same, how would that affect the people in your neighborhood?
Answers: It would limit food, mate, and entertainment choices. People would be isolated.

Question: Why is it so bad for populations to be isolated? How would you feel about only being allowed to date the people in this class?
Answers: Limited mate choice – bad for people and other animals! Limited mate choice can lead to having to pick less attractive and/or less healthy mates.

Key Idea: Highways act as barriers preventing the movement of bighorn sheep, leading to limited mate choice.

Question: So we think isolated populations can lead to limited mate choice. How might highways limit mate choice in the bighorn sheep?
Answers: Highways act as barriers to the movement of bighorn sheep between mountaintops. Sheep have limited mate choice because they cannot cross highways to find new mates.

Extension

Key Idea: Just like habitats, neighborhoods can be separated from each other by imperceptible boundaries.

Instructions: Get into a group with 3 other students that live in your neighborhood. Discuss the different boundaries of your neighborhood, and then present your ideas to the class. Maps are a great way to represent your ideas to the class. [You can draw the boundaries of your neighborhood.]

Isolation and Mate Choice discussion

This discussion explores how artificial boundaries can decrease mate choice, with a specific example of highways limiting mate choice for bighorn sheep.

Discussion:
Key idea: Artificial boundaries can decrease mate choice and isolation.

Question: If you and your neighbors never crossed out of the boundary of your neighborhood and people in nearby neighborhoods did the same, how would that affect the people in your neighborhood?
Answers: It would limit food, mate, and entertainment choices. People would be isolated.

Question: Why is it so bad for populations to be isolated? How would you feel about only being allowed to date the people in this class?
Answers: Limited mate choice – bad for people and other animals! Limited mate choice can lead to having to pick less attractive and/or less healthy mates.

Key Idea: Highways act as barriers preventing the movement of bighorn sheep, leading to limited mate choice.

Question: So we think isolated populations can lead to limited mate choice. How might highways limit mate choice in the bighorn sheep?
Answers: Highways act as barriers to the movement of bighorn sheep between mountaintops. Sheep have limited mate choice because they cannot cross highways to find new mates.

Scientist Profile: Dr. Clinton Epps

Watch the video profile of Dr. Epps to learn more about Dr. Epps' research and see the bighorn sheep in their natural habitat. Ask students to record any questions that they have while watching the video.

Discussion

Connect the video profile of Dr. Epps to his motivation for the research and remind students that this case study is based on real scientific data.

Question: How could Clinton Epps make such an impact on science even though he was only a student at the time?

Answer: He had a creative impulse and he did the hard work necessary to pull it off. He also had a group of collaborators to work with as well as guiding him.

Question: What motivated Dr. Epps to do fieldwork outside of his lab and office?

Answer: Dr. Epps needs to feel connected to his research, which he finds difficult to do when he is at a desk. He likes to visualize his research, so he often goes to field sites so that he can really understand the places that he studies.

Question: How common do you think it is for scientists to work outside?

Answer: Depending upon the subject, scientists work outside. Ecologists, Earth scientists, botanists, entomologists, primatologists, all work outside.

Discuss DNA collection in the video in order to understand how DNA patterns can reveal levels of breeding.

Key Idea: DNA from individuals in a population can be collected from animal droppings.

Question: We finished watching the video of Dr. Epps collecting and smelling sheep droppings. Why did he do this?

Answer: Freshness. The fresher the droppings, the easier it is to extract DNA.

Question: How is Dr. Epps using DNA to investigate the effect of highways on bighorn sheep?

Answer: By looking at the genetic material of the different populations of bighorn sheep to see whether they are breeding.

Key Idea: Populations that are isolated from one another will share less DNA than populations that interbreed.

Question: How would you expect the genes of mountaintop sheep populations that are separated by highways to compare to the genes of mountaintop sheep populations that have no highway separating them?

Answer: Bighorn sheep populations separated by highways will share fewer genes than bighorn sheep populations without highways separating them.

How can DNA be used to determine if populations are isolated from one another?

Use popsicle sticks, M&Ms or other colored tokens to demonstrate how DNA can be used to determine whether populations are isolated from one another.

Complete the following demonstration to show students how DNA can be used to determine whether populations are isolated from one another or whether or not they are able to breed with one another. (Note: You can download a Popsicle DNA Diagram to use instead of popsicle sticks.)

Demonstration: How can DNA be used to determine if populations are isolated from one another? (I.e. Whether or not they breed with one another)

Prepare

Set up four different populations of Popsicle sticks or M&Ms. Each population will have a different composition of colored Popsicle sticks or M&Ms, which represent different versions of genes (alleles).

Population A contains:
  1) 15 blue sticks
  2) 12 green sticks
  3) 12 plain sticks
Population B contains:
  1) 10 blue sticks
  2) 15 green sticks
  3) 10 plain sticks
Population C contains:
  1) 5 blue sticks
  2) 15 green sticks
  3) 19 plain sticks
Population D contains:
  1) 1 blue stick
  2) 2 green sticks
  3) 26 plain sticks

Question: Which populations breed the most frequently with one another?
Answers: Population **A** breeds most frequently with **B** and **C**.

Question: Which population appears to be the most isolated? Why?
Answers: Population **D** appears to be the most isolated because it has very few blue and green sticks (or versions of that gene). If individuals from population D bred more frequently with the other populations than the number of blue and green sticks would increase.