Lesson: Simulate a Genetic Bottleneck

OVERVIEW
In this lesson, history meets science as students investigate whether an event in the 1860s that limited genetic variation among Navajos may have led to both children of a modern-day Navajo couple being born with a rare genetic disease.

Students will begin by watching a video clip of the Nez family, whose members have struggled with the heartbreaking mystery of why both children had a one-in-a-million disease called XP (the abbreviation for xeroderma pigmentosum). They learn that the risk of getting XP is much higher among Navajos than among the general population (one in 30,000 rather than one in 1 million), possibly due to the Long Walk, a tragic event in United States history that reduced the Navajo tribe to approximately 2,000 adults of reproductive age. According to a theory of geneticist Robert Erickson, this “genetic bottleneck” increased the frequency of adults with certain recessive genes and caused a higher incidence of XP among the 300,000 Navajos who descend from this limited pool of ancestors.

To investigate this theory, students will use a basic simulation model to track gene frequencies across multiple generations. They will then write paragraphs that explain how a genetic bottleneck may have increased the prevalence of the rare genetic disease XP among Navajos.

The video clips used in this lesson are from the film Sun Kissed, a documentary that tells the story of a Navajo couple who seek to discover why their children have XP, which causes skin cancer from any exposure to sunlight. Please note that portions of the film have English subtitles.

POV offers a lending library of DVDs that you can borrow anytime during the school year—FOR FREE! Get started by joining our Community Network.

OBJECTIVES
By the end of this lesson, students will:
- Describe what happened to Navajos on the Long Walk.
- Use a model to simulate a genetic bottleneck.
- Analyze the data collected during the simulation.
- Discuss the impact of a genetic bottleneck on a population’s gene pool.
- Explain how the Long Walk may have affected the prevalence of the rare genetic disease XP among Navajos.

GRADE LEVELS
9-12
SUBJECT AREAS
Biology, U.S. History, Current Events

MATERIALS
- Internet access and equipment to show the class online video
- Handout: Study Guide: Genetic Bottlenecks (PDF file)
- Small objects (e.g., marbles, beads, math manipulatives, beans, pompoms) that come in three different colors but are otherwise identical. For each group, you will need 40 of one color and 30 each of two other colors.
- Containers that can hold 100 small objects, one for each group

ESTIMATED TIME NEEDED
One or two 50-minute class periods

FILM CLIP
Clip 1 “Meet the Nez Family” (length: 3:21)
The clip begins at 2:45 with Yolanda Nez taking care of her daughter, Leanndra. It ends at 5:26 when she says, “…two kids with XP.”

Clip 2: “Genetic Bottleneck” (length 2:30)
The clip begins at 38:27 with Yolanda and Dorey Nez walking into a hotel. It ends at 40:57 with the words “…to be human is to carry recessive genes.”

Clip 3: “The Long Walk” (length 3:13)
The clip begins at 26:12 with the group shaking hands. It ends at 29:25 with the words “…make them part of Americans.”

ACTIVITY
Note: This lesson assumes that students already have a basic understanding of genetics and evolution.

Prepare: Put 100 objects in a container, 40 of one color and 30 each of two other colors. Mix well. Repeat for each group of students you plan to have in your class.

1. Begin the lesson by giving each student a copy of Study Guide: Genetic Bottlenecks. Explain that you would like to introduce them to Yolanda and Dorey Nez, a Navajo couple who live on a reservation with their daughter, who has a rare genetic disease called XP. Then, play Clip 1 and ask students to watch and listen for the definition of XP so that they can describe it on their handouts.

2. Tell students that Yolanda and Dorey discovered that while the occurrence of XP in the general U.S. population is one in 1 million, on the Navajo reservation, it is one in 30,000. (Have students note these ratios in the related areas of their handouts.) They wondered why the risk among Navajos was so much higher and why their family had two children with such a rare genetic disorder. As part of their search for answers to these mysteries, Yolanda and Dorey met with geneticist Robert Erickson, who described an
interesting theory. Play Clip 2 and have students complete questions four and five on their handouts.

3. Explore further the concept of a “genetic bottleneck” by dividing the class into groups of two to four students. Give each group one of the containers of 100 objects that you prepared before class. Instruct groups to work through the activity outlined in Study Guide: Genetic Bottlenecks. Circulate among the groups to provide support as needed.

4. When students have completed the activity, have groups report their findings to the class. Discuss:
   - What impact does the size of a population have on genetic drift?
   - How is a genetic bottleneck different from natural selection?
   - How does genetic variation help to protect a population?
   - Describe the implications of generating a large population from a small population with low genetic diversity.

5. Conclude the lesson by asking students to reflect further on the Nez family seen in the video clips and assign each to write a paragraph that explains how a genetic bottleneck could have affected the prevalence of the rare genetic disease XP among Navajos. Students should reference their findings in the group activity to support their ideas.

EXTENSIONS

1. Modify the simulation activity for the lesson to be more inquiry-based. After watching and discussing the film clips, provide student groups with the materials for the simulation and a data table template and have students design and write out an appropriate procedure. Alternatively, invite the class to evaluate the provided simulation activity, discussing both the merits and problems with the model, and then challenge students to develop an improved activity. Students should then perform the simulation they designed and share data.

2. Study the Long Walk and its lasting effects on the Navajo people. Have the class watch Clip 3 (length 3:13) and note details about what happened during this terrible experience. Then, have the class read all or part of “The Long Walk: Tears of the Navajo” (http://www.kued.org/productions/thelongwalk/film/interviews/jenniferNezDenetdale.php), an interview transcript with University of New Mexico history professor Jennifer Denetdale. Ask each student to select one aspect of the tragedy and develop a poem, essay, monologue, painting, sculpture or other creative work that describes that aspect of this little-discussed episode in U.S. history. Consider hosting an exhibit of these student creations to help raise community awareness about the Long Walk. Note: Many Navajo oral teachings advise against discussing the Long Walk. Please be sensitive to the diverse points of view that may exist in your classroom.

3. Examine how people with disabilities are treated at your school. In Sun Kissed, Dorey says that his daughter’s condition and needs “freak out” his relatives, so they don’t visit. Discuss how disability can create isolation. If appropriate, invite a student with disabilities to address this topic with your class. Work together to develop activities, an awareness campaign, a buddy system or other approaches geared to decreasing feelings of isolation among those with disabilities.
4. Learn how personal experiences can influence career choices. Yolanda is an advocate with the Native American Disability Law Center. She helps families and children with disabilities in the areas of special education and civil rights. Her experiences with her children influenced her choice of employment. Have students interview their parents or other adults in your community to find out what shaped their career paths. Students can then give oral reports to share what they learned.

5. Explore additional POV and PBS films relating to Native American experiences or health issues. For each film, video, background information, and classroom resources are provided online.

- **Up Heartbreak Hill** ([http://www.pbs.org/pov/upheartbreakhill/](http://www.pbs.org/pov/upheartbreakhill/)) follows two Navajo high school students during their senior year as they struggle with forming their identities, managing family relationships and making decisions about their futures.
- **Standing Silent Nation** ([http://www.pbs.org/pov/standing/](http://www.pbs.org/pov/standing/)) documents a Lakota family’s struggle to grow industrial hemp on a South Dakota reservation as a means of earning a sustainable living.
- **In the Light of Reverence** ([http://www.pbs.org/pov/inthelightofreverence/](http://www.pbs.org/pov/inthelightofreverence/)) describes the struggles of the Lakota in the Black Hills, the Hopi in Arizona and the Wintu in California to protect their sacred sites.
- **Arctic Son** ([http://www.pbs.org/pov/arcticson/](http://www.pbs.org/pov/arcticson/)) tells the story of a Native American father and son reunited in the Canadian Yukon after almost 25 years apart.
- **In the Family** ([http://www.pbs.org/pov/inthefamily/](http://www.pbs.org/pov/inthefamily/)) depicts a woman struggling with heart-wrenching decisions about her health after learning that she carries the BRCA gene that predisposes her to develop cancer.

**RELATED RESOURCES**

**The Long Walk: Tears of the Navajo**
This film transcript provides details and insights about the Long Walk and other aspects of Navajo history.

**NPR: “The Navajo Nation’s Own ‘Trail of Tears’”**
This 2005 radio story details the Long Walk and notes that a memorial center has opened “to pay homage, to mourn the dead and celebrate the tribe’s ultimate survival.”

**PBS: The Navajo’s Ancient Roots**
This website page provides an overview of Navajo history from the period before American colonialism to modern times.

**POV Background: XP and the Long Walk**
This resource provides details about the causes, prevalence and effects of the rare genetic disorder XP. In addition, it includes a general description of the Long Walk and its impact on the Navajo nation.

STANDARDS


ELA-Literacy.RST.9-10.3 Follow precisely a complex multi-step procedure when carrying out experiments, taking measurements or performing technical tasks, attending to special cases or exceptions defined in the text.

ELA-Literacy.RST.11-12.3 Follow precisely a complex multi-step procedure when carrying out experiments, taking measurements or performing technical tasks; analyze the specific results based on explanations in the text.

ELA-Literacy.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

ELA-Literacy.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

SL, 9-10, 11-12.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on [grade-appropriate] topics, texts and issues, building on others’ ideas and expressing their own clearly and persuasively.

W. 9-10, 11-12.2. Write informative/explanatory texts to examine and convey complex ideas, concepts and information clearly and accurately through the effective selection, organization and analysis of content.

W. 9-10, 11-12.4. Produce clear and coherent writing in which the development, organization and style are appropriate to task, purpose and audience.

WHST. 9-10, 11-12.4 Produce clear and coherent writing in which the development, organization and style are appropriate to task, purpose and audience.

**Content Knowledge**: ([http://www.mcrel.org/standards-benchmarks/](http://www.mcrel.org/standards-benchmarks/)) a compilation of content standards and benchmarks for K-12 curriculum by McRel (Mid-continent Research for Education and Learning).

Behavioral Studies, Standard 1: Understands that group and cultural influences contribute to human development, identity and behavior.

Geography, Standard 10: Understands the nature and complexity of Earth’s cultural mosaics.
Geography, Standard 13: Understands the forces of cooperation and conflict that shape the divisions of Earth's surface.

Language Arts, Standard 1: Uses the general skills and strategies of the writing process.

Language Arts, Standard 9: Uses viewing skills and strategies to understand and interpret visual media.

Science, Standard 4: Understands the principles of heredity and related concepts.

Science, Standard 7: Understands biological evolution and the diversity of life.

United States History, Standard 9: Understands the United States territorial expansion between 1801 and 1861, and how it affected relations with external powers and Native Americans.

ABOUT THE AUTHOR
Cari Ladd, M.Ed., is an educational writer with a background in secondary education and media development. Previously, she served as PBS Interactive’s director of education, overseeing the development of curricular resources tied to PBS programs, the PBS TeacherSource website (now PBS Teachers) and online teacher professional development services. She has also taught in Maryland and northern Virginia.