Science as Inquiry: *Discussion Guide*

Overview

Scientists are detectives, whether they are trying to predict a volcanic eruption, understand ancient people, or explore the biology of the brain. Provide students with role models of scientists involved in scientific inquiry, and get them involved in scientific inquiries of their own!

Classroom Activities

- **Pre-Video Activity:** Get students excited about the idea of solving scientific mysteries. Point out a crime reported in the newspaper currently, and discuss how crime fighters solve the mystery with scientific methods. Also have students cite their favorite crime-fighters on TV and methods they use to solve crimes. Note that scientists use similar methods and this unit will help them learn how.

1. Show the video segment "Scientific Investigation: Who Was the Iceman?" from *Science Investigations Life Science: Investigating Cells and Genetics*.

    - **Inquiry Method:** Introduce students to the science inquiry method by creating a diagram to project on the overhead, write on the chalkboard, or post on the wall. Make sure that students understand the following procedures of scientific inquiry:
        - identify a question
        - observe
        - predict (or form a hypothesis)
        - design an investigation
        - gather evidence
        - model a solution based on evidence
        - make inferences and state a conclusion
        - communicate results

      Discuss how archaeologists used the above methods in studying the iceman.

    - **Literature:** Read to the class a short Sherlock Holmes detective story by Sir Arthur Conan Doyle, and discuss what methods of scientific inquiry Holmes uses to solve the crime, as well as the logical reasoning involved. Ask students to compare Holmes's logical methods to those used in the iceman case.

- **Map and Timeline:** Using a map, have students locate the Alps, where the iceman was found. Then have students create a timeline of the human race, placing the ice man at the appropriate point on the timeline.

- **Scientific Vocabulary:** Encourage students to create flashcards defining these scientific terms: archaeologist, modeling, inference, technology, predict, data.

- **Modeling:** Provide students with information about how archaeologists work and important archaeological discoveries. Then have students take the role of archaeologists and determine what they would do to investigate the following imaginary discoveries using scientific inquiry:
  - Unusually large fossils are dug up in California.
  - Carbon dioxide is found on another planet, an indication that there may be microscopic life.
  - Pieces of jars are discovered in an uninhabited area of Siberia.
  - A male body is found in Sweden wrapped in plants that grew thousands of years ago.

- **News Writing:** Guide students in writing news articles announcing the discovery of the iceman. Tell students that news stories usually tell who, what, when, where, why, and how about a news event. Invite students to bring to class news clippings about current-day scientific discoveries, and post them on a classroom bulletin board.

- **Inquiry:** Explore with your students the continuing inquiries into the iceman and his life. For example, www.pbs.org/wgbh/nova/icemummies/iceman.html details scientific examination of the iceman's last meal and what it reveals. Have students design an investigation they would like to conduct to answer a specific question about the iceman. Discuss how scientists could go about conducting the investigation.

- **Experiment:** Help students to design their own simple experiments into human behavior, such as on the following questions: What is the favorite piece of equipment on the school playground? Is it quicker to take stairs or an escalator? Who goes to a zoo? (Tell students of the need to keep conditions the same to control variables.)

- **Research:** Point out that the iceman puzzle still hasn't been solved, like many scientific investigations, which encounter obstacles to success. Have students research the obstacles encountered by these famous scientists: Thomas Edison, Sir Isaac Newton, Albert Einstein, Marie Curie, Jonas Salk, Copernicus, Louis Pasteur, Galileo.

2. Show the video "Volcanology: The Science of Predicting Volcanoes" from *Earth Science: Volcanoes.* (Access to *unitedstreaming* is required.)

- **Atlas:** Have students use an atlas to locate Montserrat, West Indies, which is mentioned in the video. Also have them find a few other well-known volcanoes, such as Mount St. Helens, Washington; Vesuvius, Italy; Mt. Pelee, Martinique; Kilauea, Hawaii; Maroa, New Zealand; and Mt. Oyama, Japan.

- **Discussion:** Discuss these questions: How is volcanologist Tari Mattox a role model of scientific inquiry? How does she collect data for predicting volcanoes? Help students to see how Mattox models essential procedures of scientific inquiry.

- **Demonstration:** Have students demonstrate the three main methods for predicting volcanic eruptions: 1) probing skylights, or holes, in a volcano, 2) testing the chemistry of water samples, and 3) listening to seismic devices. Also, review how new technology, such as lasers and satellites, helps in predicting volcanoes.

- **Vocabulary:** Invite students to create volcano glossaries that define these terms from the video: volcano, lava, seismic devices, lasers, satellites, skylights, plate tectonics.

- **Research:** Ask students to probe this question: Why do volcanoes erupt? First, show photographs of volcanic eruptions and the town of Pompeii, where Mt. Vesuvius erupted. Then display a diagram of the molten rock held under the earth's crust and the tectonic plates that shift on the earth's surface. Point out that there are about 1,500 volcanoes, 500 of which are active. Finally, invite groups of students to research the three main types of volcanoes (cinder, composite, shield) and the cause of volcanic eruptions. Have groups report to the class.

- **Inquiry:** Direct students to design and carry out a simple physical science experiment to answer a question such as one of the following: Which side of the school is warmest? Does liquid expand or contract when it freezes? Does something heavier drop faster than something light? What objects does a magnet attract?

- **Reading a Newspaper:** Encourage students to locate an article about earth science and report to the class on how the scientists use the inquiry method. Post these articles on the classroom bulletin board.

- **Speaker:** Invite a physical scientist to class to talk with the students about his or her current research.

3. Show the video segment "Memory as a Biological Process" from *Through the Lens.* (Access to *unitedstreaming* is required.)

- **Pre-Video Activity:** Discuss the questions "What is memory? Can science change memory?" Ask students if they think memory is biological, in other words, a function of the body, and how scientists could design an experiment to answer that question.

- **Diagram:** Advise students to diagram the experiment that scientists designed with flies to test whether memory was biological.

- **Vocabulary:** Have students look up definitions for Kreb gene, long-term memory, training chamber, and genetic engineering. Ask them to explain these terms, commenting on how genetic engineering is a new field that involves changing genes to alter physical makeup or functioning. Provide examples from recent medical news.

- **Mock Trial:** Hold a mock trial debating the question of whether it is ethical to alter people's memory.

- **Newspaper:** Invite students to bring to class news clippings about current-day biological discoveries, and discuss how scientific inquiry was used. Post the articles on a classroom bulletin board.

- **Inquiry:** Help students to design an experiment on memory. For example, they might test one of the questions below with a simple memory game, such as showing subjects a tray of objects and then removing it and asking them to write down as many items as they can remember within two minutes.
  - Do males or females have a better memory?
  - Do young or old people have a better memory?

  Remind students that all factors except the one variable they are testing for must be kept the same. After students collect adequate data, encourage them to make inferences.

4. Show the video segment "The Golden Age of Astronomy" from *Greatest Discoveries with Bill Nye: Astronomy*. (Access to *unitedstreaming* is required.)

- **Discussion:** Have students summarize how the inquiry method is being used during the Golden Age of Astronomy. Review some of the great questions that are the subject of scientific inquiry in modern astronomy:
  - What are gamma ray bursts, and how are they found? (Orbiting satellites detect these bursts of energy from objects like pulsars, quasars, and black holds.)
  - Do planetary systems beyond the solar system exist, and how do we know? (Yes, powerful telescopes can detect them.)
  - What causes the acceleration of the universe? (This mystery might be solved by launching new higher-powered telescopes.)

  Ask students: Do you think other planetary systems exist? What do you think is the most important discovery by astronomers? How did it come to be?

- **Comparison:** Compare Saul Perlmutter and Geoff Marcy to detectives, and discuss how they demonstrate scientific inquiry in astronomy. What mysteries are they trying to solve? How do they observe, make predictions, and gather data? How can astronomers learn more about unknown features of the cosmos? How does technology assist astronomers?

- **Definition:** Help students to create diagrams that define these terms: astronomy, planet, solar system, supernova, pulsar, quasar, black hole, satellite, gamma ray bursts, telescope, cosmos, Doppler effect, dark energy.

- **History:** Invite students to take the role of famous astronomers and reenact the following landmark discoveries that led to modern understandings of the universe:
  Copernicus – sun-centered solar system
  Kepler – laws of planetary motion
  Galileo – Milky Way, sunspots
  Discuss how these early scientists applied the inquiry method in astronomy.

- **Experiment:** Have students conduct a demonstration that gives them an idea about how scientists determine if there is microscopic life on other planets by checking for carbon dioxide. The experiment involves mixing yeast, water, sugar in a water bottle and placing an uninflated balloon over the opening. Students will see the balloon inflate from the gas produced.

- **Vocabulary:** In the video Saul Perlmutter is identified as a cosmologist. Ask students what a cosmologist does, pointing out the combination of *cosmos-*, meaning "universe" and *-logist*, meaning "one who studies." Using a dictionary, have students define other names of scientists such as these: geophysicist, geneticist, astronomer, microbiologist, biochemist, bacteriologist, geologist.

- **Discussion:** Perlmutter says that as a child he wondered, "Are other earths out there?" Brainstorm for questions students have about the universe, such as "Why is the sky blue?" or "Why are stars small?" Help students to recognize several alternative answers and to see how inquiry helps scientists answer such questions.

- **Research:** Invite students to investigate a phenomenon in astronomy, such as how to spot Venus, how to view an eclipse, or when a comet will appear.

Academic Standards

This discussion guide addresses the following national standards:

National Science Education Standards
www.nap.edu/readingroom/books/nses/html/

- Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Mid-continent Research for Education and Learning (McREL)
http://www.mcrel.org/compendium/browse.asp

- Language Arts
  - Writing: Uses the general skills and strategies of the writing process, uses the stylistic and rhetorical aspects of writing

- Science
  - Understands the nature of scientific knowledge