Upward and Outward: Scientific Inquiry on the Tibetan Plateau
Teacher Notes for Classroom Implementation of the Film

The Big Ideas Presented in the Movie:

What Is Science? The National Science Education Standards (NSES) and many state standards emphasize "science as inquiry." This standard is part of the fundamental content of science that students should learn—not just the big ideas and overarching themes of biological, physical, Earth and space science, but the ability to do science and the understanding of how science works as a process for building human knowledge. That is, students should "learn science", but they should also "learn to do science" and "learn about science."

This film is designed to support the inquiry standard, by helping students develop understandings about scientific inquiry. Students may develop understandings of inquiry at the same time as they develop the abilities of inquiry through laboratory work and other data-rich activities, but understanding how science works is not an automatic by-product of doing investigations. By making these ideas explicit, the film serves as a reference point for students' own investigative work during the entire course.

Many traditional aspects of "the scientific method" (see Figure 1) are emphasized, such as developing and testing hypotheses, but the film also makes clear that real science is more messy and creative than the idealized, linear method that is often portrayed. Thus the film enriches student understanding of the scientific process.

Figure 1: Traditional View of the Scientific Method

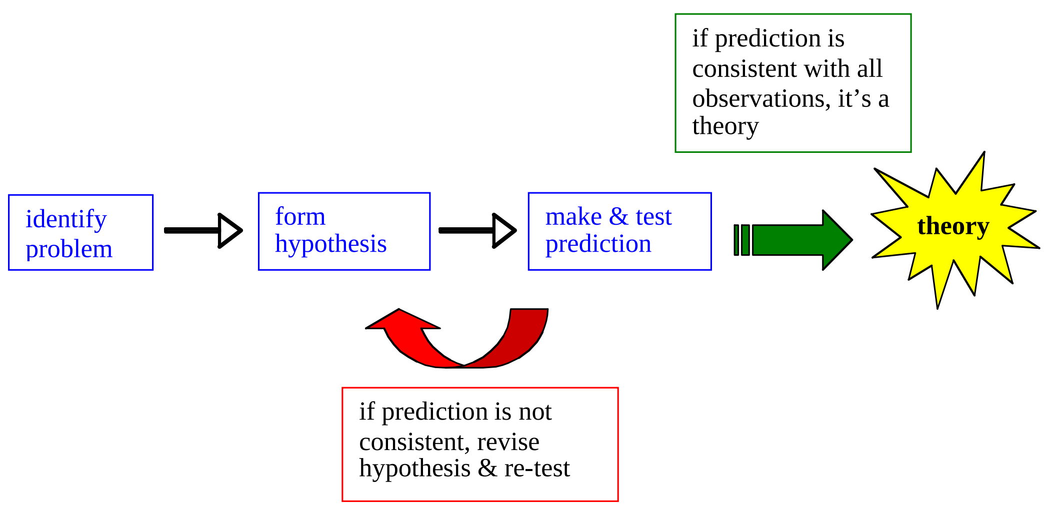
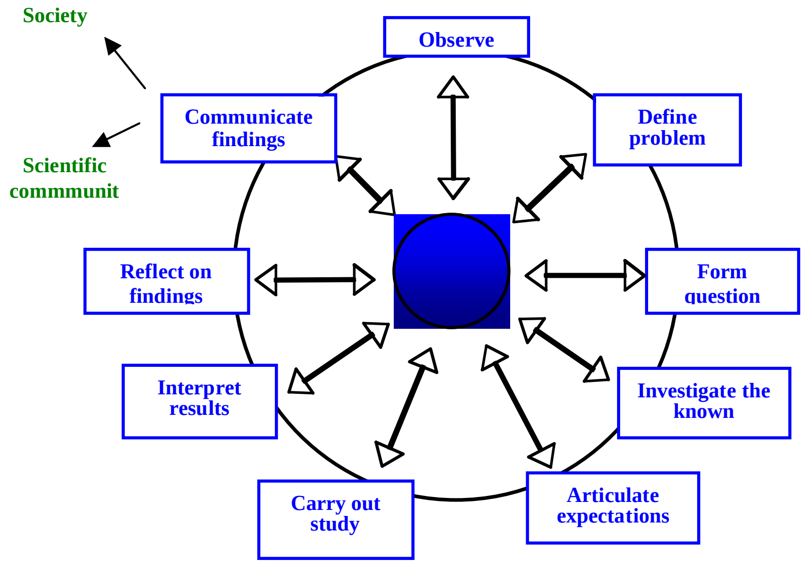


Figure 2 shows an alternative visual representation of the process of science, the Inquiry Wheel. This representation is constructed from interviews with scientists about their everyday work, and emphasizes that scientific studies do not always proceed along a single, linear path. There are many points along the wheel where an investigation may begin, and the process may travel back and forth along multiple spokes of the wheel.

Figure 2: The Inquiry Wheel: Another View of the Scientific Process



Adapted from "A Scientific Method Based on Research Scientists' Conceptions of Scientific Inquiry," R. Reiff, W. S. Harwood, T. Phillipson. Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science.

What Does it Look Like to Do Science? Below, we'll provide you with a list of prompts that can be used before and after the film to probe your student's knowledge of how science is conducted. Below is a list of the main topics explored in the film. Your students should identify some of these topics when explaining or brainstorming about what scientists do and how science is conducted. Hopefully, they will include more of these topics in their discussion after viewing the DVD!

- Diversity of people – in gender, ethnicity, nationality, strengths, and skills
- Interdisciplinary – scientists grounded in different disciplines come together to make a sum that is greater than the parts.
- Many methods are used to conduct science in different settings:
  - making and using maps
  - collecting samples in the field
  - laboratory analyses
  - mathematical analysis and modeling
  - using equipment, instruments, computers
- Work with evidence/data
  - gather, analyze, interpret
- Invention, building, tinkering
- Collaboration (doesn't mean that everyone agrees with each other all the time; there is room for debating and listening)
- Communication
  - keeping a lab notebook
  - attending conferences

  - discussing and debating
  - leaving a lasting legacy – books, scientific papers
- Iterative – scientists don't always come up with the definitive answer. The process of revision – may enter at many points in above list (revise hypothesis, try new method, analyze data in a different way, etc.). In other words, the **Inquiry Wheel** model of conducting science!

<u>Some adjectives to describe science (can be used with ELL students):</u>

Fun, satisfying, stimulating, creative, imaginative, collaborative (friendship), adventurous, arduous, laborious, physical, sedentary, boring, innovative—others?

<u>Why Research Is Important.</u> Some students may question why scientific research is important because they see no practical or applicable linkage between scientific research and their lives. In this case, it may be helpful to prime them for the movie by pointing out the importance of research. Realizing that they too could make important contributions to people's lives through scientific research, may pique their interest in science class! Additionally, students might discover that curiosity motivates scientists. A few questions you might ask are:

- How has science affected your life? (relevant examples follow)
  - Medical benefits - vaccines, medicine, organ replacement, X-rays
  - Communications - cell phones, internet, television, radio and World Wide Web
  - Ecosystem health - clean water and air; need to monitor and remediate
  - Food – fertilizing and irrigating crops, genetically modification, preserving, fortifying, reducing calories and fats
  - Others?
- What issues or activities in your life might science help find a solution?
- Can you describe any cases in which a scientific discovery, motivated by curiosity, benefited humans with a useful product?

After asking these questions, point out all the different facets of science they identified and how they link back to their lives. Add a few more diverse examples before you move onto the *pre-viewing questions* below, so they realize that science is relevant to their everyday lives.

<u>Writing or Discussion Prompts</u>

The following questions can be used to probe your student's knowledge of how science is conducted. We've included questions to ask before viewing the film, as well as questions to ask afterwards. We've mapped the questions to the Colorado Model Content Standards for Science; some of the questions relate to specific benchmarks as indicated. Your own state may have similar standards. We hope the film helps you teach about the scientific process and make science more exciting and relevant to your students.

Standard 5: Students understand that the nature of science involves a particular way of building knowledge and making meaning of the natural world

Pre-viewing questions: Here are some questions you can ask to find out what students' conceptions are on how science is conducted and what scientists do.

- When you think of a scientist working, what do you imagine him or her doing?

- What do scientists do? Where do they work?
- What comes to mind when you hear the word science?

Post-viewing questions: After viewing the video, students should have a richer understanding of what scientists do and how science is conducted. Here are some general questions.

- What are some new insights that you gained about how science is done?
- What did you find surprising? Why?
- Study Figures 1 and 2, which show two different views of the scientific process. What elements of each did you see in the film? Which version do you think matches the film best?
- Many of the scientists in this project conduct field work. How is field work in science different from lab work?
- In school, we often think of experiment and control groups as something we can set up in the laboratory. How is it possible for field scientists to have a “hypothesis” if they can’t do an experiment with a control?
- One of the scientists says that scientists “wallow in uncertainty.” Another says, “We are not gathering facts, but evidence that we can interpret.” What do these scientists mean? What makes something a “fact”? Why do you think uncertainty is important in science?

Questions related to specific benchmarks within Standard 5:

- **Scientific knowledge changes as new knowledge is acquired and previous ideas are modified (grades 6-8; benchmark 2).** What new knowledge will the scientists in the film develop? How can this new knowledge predict what happened in the past?
- **Models can be used to predict change (grades 6-8; benchmark 4).** Some of the scientists in the film develop computer models. How would you construct an experiment and a control in a computer model? (hint: one scientist speaks of building “imaginary worlds”—what does he mean? what can be learned from an imaginary world?)
- **The scientific way of knowing uses a critique and consensus process (grades 9-12; benchmark 2).** The scientists reference using critique and consensus to advance their scientific work. Give an example of critique and consensus that you saw in the film .
- **Scientific knowledge changes and accumulates over time; usually the changes that take place are small modifications of prior knowledge but major shifts in the scientific view of how the world works do occur (grades 9-12; benchmark 5).** Discuss whether you think this project will produce small or large changes in the scientific view of land/climate interactions or the development of the Tibetan plateau.

<u>Viewing tasks</u>

One effective way to focus students’ attention on a film or video is to assign particular viewing tasks. Each student in a group, or each group in a classroom, can be assigned to gather particular information from the film to contribute to discussion. Student answers can be collected on the board after the film, reviewed to be sure everyone has gathered key information from the film, and used as a springboard for discussion. These questions are suggested as viewing tasks.

1. Why are the scientists interested in the Tibetan Plateau for their study?
2. How do the scientists plan and prepare for their study?
3. What kinds of evidence do the scientists gather?

4. What different types of communication skills do the scientists use, and for what purpose?
5. Why do the scientists work as a team?

See http://cires.colorado.edu/education/k12/projects/ to download all written materials and to view additional links.

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