Scientists
High School Lesson Plan

Topic
The nature of science

Grade Levels
9-12

Overview
This QUEST episode, *Scientists*, explores the world of research and the role of scientists who conduct this kind of work. Two current areas of research are highlighted in the video: marine mammals and nanotechnology. Scientists who are conducting studies in these fields discuss their careers. They reveal how they became involved in their work, how they have balanced work and family, and the culture of scientific research.

Introduction
In this teaching unit, students will examine their own ideas about who scientists are, what they do, and their impact on society. To begin, students will complete a questionnaire that will reveal their possible misconceptions about scientists. After taking notes while watching the QUEST *Scientists* video, the class will begin to clarify their perceptions of the careers and roles of scientists. Working in pairs, students will next examine a current societal issue and identify the scientific research that may be needed to address the problem. They will then link this to the content of their own studies in science. This will help the class identify how they might apply their own learning to current issues; it will also help them relate to the scientists in the video as they discuss their careers.

Time Allotment
Five 45-minute class periods.

Accessing Prior Knowledge
Students will not need specific content background for this lesson. It is a process of exploring their own ideas about science and the individuals who have chosen science as a career.

Concepts to Clarify
Many students, even high school students, feel that people who work in the field of science are brilliant and dedicated. However, when asked to describe scientists on a more detailed level, these same students tend to portray such individuals as boring, bearded, and working alone in laboratories.

Views of the nature of science are also potentially skewed by stereotypes held by the general public. Science is perceived as the pathway to solve society's problems, or to invent new products, rather than the exploration of how nature works.

High school students also usually believe that scientists know enough to make the best decisions about issues that might affect the public. They feel that these professionals know all the facts and are not influenced by personal motivations or interests.

QUEST: Investigating Our World is a regional public television series seen on Maine Public Broadcasting Network, Vermont Public Television, and New Hampshire Public Television

Maine Public Broadcasting Network · New Hampshire Public Television · Vermont Public Television · PBS

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1450 Lisbon Street, Lewiston, Maine 04240 · 207-783-9101 · 800-884-1717 · Fax 207-783-5193 · mpbn.net

CONNECTIONS TO THE STANDARDS

National Science Education Standards	Benchmarks for Science Literacy	Maine Learning Results	New Hampshire Curriculum Framework	Vermont Learning Standards
Science as a Human Endeavor Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.	**The Scientific Enterprise** Scientific disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet, and that some subdisciplines spin off to become new disciplines in their own right.	**Science and Technology:** Communications 2: Use journals and self-assessment to describe and analyze scientific and technological experiences and to reflect on problem-solving processes.	**Science, Technology and Society** 2e: Students will demonstrate an increasing ability to understand that science and technology can affect individuals, and that individuals in turn can affect science and technology. Describe immediate and long-term consequences of various alternative solutions for science- and/or technology-related issues, e.g., natural catastrophes, interactions of populations, resources and environment, health and disease.	**Roles and Responsibilities** 7.5: Students analyze the roles and responsibilities of scientists, mathematicians, and technologists in social, economic, cultural, and political systems. This is evident when students: 7.5.aaa: Analyze the impact of scientific, mathematical, and technological investigations into and findings about human society, including the ethical issues involved (e.g., the dangers and benefits of genetic engineering).

Materials Needed

- TV with VCR
- QUEST *Scientists* video
- Student resources for researching current scientific issues (e.g., articles or Web postings)
- 1 copy per student of each of the following reproducible handouts:
  - Student Handout 1: Images of Science
  - Student Handout 2: QUEST *Scientists* Viewing Guide
  - Student Handout 3: What Research Is Needed? Understanding Current Issues in Science
  - Student Handout 4: Gallery Walk of Current Scientific Issues
  - Student Handout 5: *QUEST* at Home: Becoming a Citizen Scientist

1. Introducing the Concepts

Activity 1

In the following activity, students will reflect on their own images of science and scientists.

Step 1

Distribute copies of Student Handout 1 (Images of Science). Review this brief quiz with the class. Then divide students into groups of four.

Step 2

Assign each team one to two questions from the handout to answer. Explain that each team member should first respond to the questions individually, next discuss their answers as a team, and finally present their responses to the class. Allow teams about 10 minutes per question to respond and discuss in their small-group setting.

Step 3

When teams have finished their group discussions, have them take turns presenting their responses to the whole class. Allow time for the class to discuss their peers' ideas. Conduct the discussion as a scientific dialogue, where disagreement is encouraged, but where different positions must be justified with sound ideas, not just opinions.

Student Handout 1: Answer Key

Part 1: Answers will vary.

Part 2: 1) False
2) False

Highest degree[1]	Percentage employed in science and engineering careers
High School	5%
Associate's Degree (2-year college)	17%
Bachelor's Degree (4-year college)	48%
Master's Degree	21%
Doctorate	7%
Professional Degree (law, medicine)	2%
TOTAL	100%

3) False. Less than 50% of those employed in the fields of science and engineering are females. However, there are still more than 1 million women employed as scientists or engineers. The primary reason is one of opportunity rather than capability. Women are fully capable of exceeding in any science or engineering field.

Career[1]	Percentage male	Percentage female
Life and Physical Science	61%	39%
Engineering	87%	13%
Computer Science	73%	27%
All Science & Engineering	77%	23%

[1] Tsapogas, *John. More Than One-Fifth of All Individuals Employed in Science and Engineering Occupations Have Less Than a Bachelor's Degree Education.*
Accessed at: *http://www.nsf.gov/sbe/srs/infbrief/nsf04333/start.htm*

4) False. Scientists are usually following prescribed procedures when conducting labs, but they are ones that they have determined are appropriate. They are not told by others which procedures to use. Scientists are most often following their own lab or field procedures, which are guided by international norms for conducting certain types of measurements. These have been tested by other scientists, tried in the field and in labs, and are known to work. Scientists work as peer evaluators of each other's work.

5) False. Scientists have just as many personal opinions as nonscientists. Therefore, they may sometimes be prejudiced in their reporting of information. However, a key scientific principle is to be ethical and honest when reporting data, and to be as objective as possible when drawing conclusions. If the facts presented are prejudiced, the scientific community will examine the scientist's work and will identify any flaws in procedure or logic.

6) False. Scientists study the world around them. Engineers work to apply science to provide devices that will help the public. Many engineers do study science as well. Likewise, many scientists are applying their knowledge to create technological solutions to the world's problems. The discipline of science involves exploring the interactions of things in the world.

7) True. Science involves many disciplines: chemistry, biology, physics, astronomy, and others. Each discipline is rich in the array of concepts it includes. However, many scientific studies require the understanding of more than one scientific discipline. This may require collaborating with others who are familiar with these other disciplines, since many issues facing the world today require a background in too many disciplines for any one scientist to master.

8) False. Scientific concepts form the basis of engineering. However, a person who is planning to become a civil engineer and build bridges, roads, and buildings will not be required to have a strong biology background. Moreover, many students can move from a two-year associate's degree into engineering.

Ideas for the quiz are adapted from: Chiappetta, Eugene L., and Thomas Koballa. "Myths of Science Quiz," *The Science Teacher.* (National Science Teachers Association, 2004).

2. Exploring the Concepts

Activity 2

In the next activity, students will view the video QUEST *Scientists* video. As they watch the film, they will record their responses to a series of questions about scientists. Afterward, first in teams and then as a whole class, students will discuss their responses to clarify their ideas about what research is, who scientists are, and what scientists do.

Step 1

Give each student a copy of Student Handout 2 (QUEST *Scientists* Viewing Guide). Review the handout with the class. Then direct students to rejoin the teams they formed during Activity 1. Each team should appoint two members to watch for information on the Allied Whales research, and the remaining two members to watch for information on research in nanotechnology.

Show the first half of the video, stopping at the section in which Allied Whale is going out to sea to do their studies. (**Note:** You may have to pause the video at times to allow students to record their responses.) Direct the two pairs of students on each team to complete their sections of the handout individually, then share their responses with their partners. Next, they should share their ideas with the rest of the team. The second half of the video can be shown, but is not essential for completing the rest of the activities.

Step 2

Lead a whole-class discussion about students' responses to the questions on Student Handout 2. The discussion should include information about where the projects are being done, what kinds of questions

the researchers are exploring, how long they have been studying these questions, and why their research is important to society.

Step 3

For homework, ask students to find a newspaper or magazine article, a report or article posted on the Web, or an excerpt from a nonfiction book that describes a current scientific issue of interest. Examples might include medical issues or environmental problems. Each student should read his or her chosen article, then write a summary report that identifies three key points made in the article or report. Students should be prepared to bring their articles to class and share their findings with their teams.

3. Developing the Concepts

Activity 3

In the activity that follows, students will analyze the news report they selected for Activity 2. They will reflect on their own learning in science by trying to identify any parts of their science classes that would help them if they were actually conducting research to address the scientific issues raised in their chosen articles. As a final product, students will create individual posters that show their findings, and they will share these with the rest of the class.

Step 1

Begin by having students share their selected articles or reports with their team members. Once they have familiarized each other with their scientific issues, have pairs of students choose one issue to analyze further.

Step 2

Using class discussion notes, their handouts with the video viewing guide notes, and their homework, student pairs will now dissect their chosen issue. Distribute copies of Student Handout 3 (What Research Is Needed? Understanding Current Issues in Science). Review the chart on the handout with the class, then have student pairs complete the chart. They will need to write, in one or two sentences, a problem statement. Next, they will identify who is most affected by the problem. Ask students to describe how they themselves might be affected by the issue.

If any solutions to their chosen issues are currently being proposed, have students record them. For each solution, they should try to identify what further research may be necessary. Finally, have student pairs identify what topics they have studied in science that would help them if they were the actual researchers conducting the further studies on this topic.

Step 3

After completing Student Handout 3, each student pair should create a poster that depicts their issue, analyzes the issue, and shows their related article.

4. Synthesizing and Applying the Concepts

Activity 4

Students will display their posters during the next activity. They will tour the classroom to see their peers' posters, taking notes on those issues of interest to them. Students will then use their notes during a class discussion on research. Finally, they will reflect on how their views of research have changed during the course of this teaching unit.

Step 1

Help students display all of the posters made during Activity 3. Then distribute copies of Student Handout 4 (Gallery Walk of Current Scientific Issues). Tell students to do a "gallery walk," during which they review each poster and take notes on their classmates' creations, using the handout as their guide.

Step 2

When students have completed their gallery tours, lead a class discussion about the data they have gathered. Consider asking some of the following questions, and remind students to use their notes as they form their responses:

- What is the range of scientific disciplines being applied to solve the issues that are being presented here?
- Who is affected by these issues?
- Which of the issues you learned about affect you the most?
- What, if any, are the possible solutions being proposed for the issues that concern you the most?
- Will any of these solutions potentially create more danger?
- What scientific research needs to be done to minimize any further negative impact of the solutions that are currently being implemented?
- What topics in science have you begun to learn about that would be of value in trying to solve this problem?

Step 3

Ask students to reflect back on the quiz they took at the beginning of the teaching unit (Student Handout 1). Have them take five minutes to write about how their image of researchers and the role they play in society have changed.

5. Extending the Concepts

QUEST at Home

Distribute copies of Student Handout 5 (*QUEST* at Home: Becoming a Citizen Scientist). Review the handout with the class, clarifying as needed. Agree upon a due date for students to return to class with their findings.

Community Connections

Regional fish and wildlife biologists are continuously doing research on the populations of wildlife in their areas. Their studies include fish counts, bear habitat surveys, deer population studies, and so on. Ask one of these researchers to visit the classroom to share with students their ongoing work.

Weather station operators are often volunteers who have received training to maintain automated weather stations. Often they may be partners with the National Weather Service or a local TV station. Ask one of these people for a tour of the weather station, or have one of them come to class to share what he or she does. You might also consider visiting Mt. Washington, one of the most famous weather research stations in the country.

U.S. Geological Survey and state environmental departments have water specialists who monitor the water quality and quantity in streams, reservoirs, and wells throughout northern New England. Identify where the closest USGS stream gauge or state water monitoring well is located. Find out when someone will be testing the site, and see whether this person would consider visiting your classroom to discuss the job and some scientific data.

Lake and shore water quality monitoring volunteers are on almost every lake and shoreline in northern New England. Many have been taking water quality measurements for a decade or more. Ask one to come and share his or her work and data with the class.

Career Opportunities

Hydrologists study the flow of water through a watershed. In an effort to maintain high water quality, they analyze what happens to water once it hits the ground, how it flows both on the surface and underground, and how it moves through streams.

Meteorologists study the weather in a region and around the world. They determine how weather is affected by geographic landforms in the region. They analyze weather data to get a picture of the long-term climate as well as any changes in trend in the climate.

Air monitors study the air quality in a region. Sensors are placed throughout northern New England to test for the amount of light reaching the earth's surface, ozone levels, the amount of particulate matter in the air, and the level of haze diffracting light away from the earth's surface.

Marine biologists study the interactions among ocean currents, marine organisms, and ocean productivity. Part of their research is conducted on the open ocean, and part may be done remotely through the use of sensors deployed on buoys. These can relay data about water temperature, water currents, winds, and nutrients back to scientists on shore.

Resources

New England Aquarium Research
http://www.marinegis.org/rwhale.html
At this site, students can learn about the study of whale populations in the Gulf of Maine.

New England Climate Initiative
http://www.neci.sr.unh.edu/overview.html
This University of New Hampshire site explains an investigation into changing climate patterns.

Bigelow Laboratory for Ocean Sciences
http://www.bigelow.org/science.html
This site describes the work of a group in Maine who are studying marine ecosystems in the Gulf of Maine and worldwide.

Whale Center of New England
http://www.whalecenter.org/research.htm
This group is documenting whale populations and movement in New England.

Famous Scientists
http://www.crystalinks.com/scientists.html
This Web site includes a broad list of famous scientists, along with brief biographies.

The Faces of Science: African Americans in Science
http://www.princeton.edu/~mcbrown/display/faces.html
Here is a great Web site that depicts historic and contemporary African-American scientists.

Physics Web: Famous Scientists
http://www.pucp.edu.pe/~fisica/espec/personas/fscientists.htm
This is another good site for biographical information about scientists – mostly historical, some recent. There is also good information on the scientific community in sixteenth- and seventeenth-century Europe.

Manomet Center for Conservation Sciences
http://www.manomet.org
Current research projects on bird populations in the eastern flyway, as well as information about forestry in Maine, can be found here..

Senator George Mitchell Center for Environmental and Watershed Research
http://www.umaine.edu/WaterResearch/research/index.htm
This University of Maine site offers current research on environmental issues and watersheds in Maine and New England.

University of Vermont Research
http://www.uvm.edu/research

Images of Science

Part 1: Describe your image of someone who conducts research in science.

Part 2: Complete the following questions by answering **T** (***True***) or **F** (***False***).

1) The majority of scientists have gone to college and have received a doctoral degree.
True_____ False_____

2) If you do not complete college, you will not be able to work in the field of science or engineering.
True_____ False_____

3) Very few women have careers in science and engineering.
True _____ False _____

4) Scientists follow specific written directions for performing all laboratory experiments.
True _____ False _____

5) Scientists are always objective and can be trusted to know what is right.
True _____ False _____

6) If you have a problem with a piece of equipment, a scientist will know how to fix it.
True _____ False _____

7) If someone is a biologist, he or she will not know much about chemistry.
True _____ False _____

8) A person has to take a lot of science courses before becoming an engineer.
True _____ False_____

QUEST *Scientists:* Viewing Guide

As you watch the QUEST *Scientists* video, respond to the following questions. For this activity, you will be working in teams. Half of each team will be focusing on the researchers from Allied Whale, and the other half will be looking at the researchers from Nano Group.

1) List three descriptors of characteristics of the researchers from either Allied Whale or the Nano Group.

2) What is your group researching? What question are they trying to answer?

3) Why is the question they are asking important to them and to society?

4) How did the individuals in your group get interested in their research?

5) What science discipline(s) are the researchers applying? (biology, physics, chemistry, earth science, etc.)

6) What do these individuals do besides research as part of their careers?

7) Where do the scientists do their research?

8) Are there any possible negative effects of their research?

What Research Is Needed?
Understanding Current Issues in Science

Problem statement	
Interesting ideas in article	
Who is affected by this problem?	
How are you affected by this problem?	
What are some solutions being proposed?	
What scientific research is needed?	
What scientific concepts that you have studied might be applied in solving this problem?	

Gallery Walk of Current Science Issues

As you read or hear about the issues your classmates have analyzed, complete the table below for three of the issues that are of interest to you.

	Issue #1	Issue #2	Issue #3
Scientific issue/problem			
Interesting idea			
Who is affected?			
How are you affected?			
Scientific discipline/topic of needed research			

Becoming a Citizen Scientist

You're on a Quest!

Scientists have many roles in our region. They study wildlife, test water quantity and quality, teach, track the spread of disease, and forecast the weather. In doing research, however, many scientists cannot travel to all of the areas in which they would like to gather data. Instead, they are beginning to seek the help of volunteers who are interested in becoming "citizen scientists."

Explore the programs below on the Internet. Use the Resource Survey table to compile information you have gathered from the programs that interest you. Note the types of data that need to be collected in each program, when scientists need the data collected, how many volunteers collect the data, whether they have data about your neighborhood, and whom you would contact to volunteer. After visiting a few sites, decide if there is a program you would like to become a part of in order to have your family become citizen scientists.

Citizen Scientist Programs

Maine

Maine Audubon Citizen Science Projects: *http://www.maineaudubon.org/conserve/citsci.shtml*
Maine Shore Steward Program: *http://www.ume.maine.edu/ssteward/programs.htm*
Maine Entomological Society: *http://www.colby.edu/MES/*

New Hampshire

Great Bay Coast Watch: *http://www.gbcw.unh.edu*
University of New Hampshire Cooperative Extension Volunteers:
http://ceinfo.unh.edu/Volunt/Volunt.htm

Vermont

University of Vermont Watershed Alliance: *http://www.uvm.edu/%7Ewatershd*
Vermont Bald Eagle Restoration Initiative: *http://www.cvps.com/eagles/help.shtml*
Vermont Institute of Natural Science VerMonitors: *http://www.vinsweb.org/cbd/citizensci.html*

National

The Citizen Scientist: *http://www.sas.org/tcs*
The Society of Amateur Scientists: *http://sas.org*
Laboratory of Ornithology at Cornell University Citizen Science:
http://home.twcny.rr.com/allenz/citizen_scientist.htm

RESOURCE SURVEY

Citizen Science Program	Types of Data	When Collected	Our Area

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