Archaeology
Middle Level Lesson Plan

Topic The nature of science

Grade Levels 7-8

Overview

This QUEST episode, *Archaeology*, invites viewers to tag along with several professional and amateur archaeologists as they unearth pieces of northern New England's past. How do archaeologists know where to look for the artifacts left by past civilizations? What tools do they need, and what methods do they use to excavate archaeological sites? What information about a society can archaeologists infer from the artifacts they uncover? In what ways are archaeological excavations similar to other scientific investigations? This teaching unit will help your students discover why archaeologists study what they do, while learning about the kinds of clues archaeologists piece together to interpret human life and culture from bygone eras.

Introduction

An understanding of what science is, what it can and cannot do, and how it works is an integral part of becoming a scientifically literate person. In addition to acquiring the knowledge and skills of science, scientific literacy also requires understanding the habits of mind that characterize this discipline. Using the context of archaeology, this series of lessons encourages middle school students to begin thinking about various aspects of the nature of science.

At the end of this teaching unit, students will be able to:

- Distinguish between an inference, an observation, and an interpretation based on evidence.
- Describe the roles of inferences, observations, and evidence in the realm of science.
- Describe the nature of science.
- Compare and contrast the work of archaeologists with that of scientists.

Time Allotment Five to seven 45-minute class periods.

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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Accessing Prior Knowledge

Students of middle school age have been exposed to science and scientific ideas. They have had considerable experience "doing" science. They have become more sophisticated at designing and conducting their own investigations and at explaining their findings. Draw upon these valuable prior experiences to help students reflect on the nature of science – its general methods and aims.

Concepts to Clarify

According to research summarized in Benchmarks, students generally recognize that scientific knowledge changes, but they typically think that these changes occur due to the invention of improved technology. Students fail to understand that changes in theories are often linked to new observations, or the reinterpretation of previous observations.

Students also often have difficulty interpreting evidence. They tend to make inferences linking cause-and-effect relationships based on a single occurrence. In addition, students tend to accept only evidence that is consistent with their prior beliefs; they may even ignore, distort, or fail to gather any evidence contrary to their ideas.

Students in middle school initially tend to see things in terms of black and white, "right" and "wrong." They have difficulty with the idea that scientists can legitimately hold different explanations for the same set of observations. Research does show, however, that with adequate instruction, students can understand this aspect of the nature of science. Students progress in stages, first seeing things as "a matter of opinion," and eventually as "informed," supported by reasons.

Science as a discipline is viewed by students of all ages as an enterprise designed mainly to invent things or solve practical problems. Most students do not view science as a vehicle for exploring and understanding the world.

CONNECTIONS TO THE STANDARDS

National Science Education Standards	Benchmarks for Science Literacy	Maine Learning Results	New Hampshire Curriculum Framework	Vermont Learning Standards
A. Science As Inquiry/ Understandings About Scientific Inquiry (5-8) 1. Different kinds of questions suggest different kinds of	Chapter 1B: Scientific Inquiry (6-8) 1. Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no	Science K. (5-8) – Examine the ways people form generalizations. – Support reasoning using a variety of evidence.	Science as Inquiry: 1a. Standard 8 (Grade 6) – Construct explanations, including the development of simple models, for observations made.	Scientific Method (5-8) 7.1.bb: Seek, record, and use information from reliable sources, including scientific knowledge, observation, and experimentation.

CONNECTIONS TO THE STANDARDS cont.

scientific investigations… 2. … Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding. 5. Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories….	fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising a hypothesis and explanations to make sense of the collected evidence. Chapter 12A: Values and Attitudes (6-8) 3. Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct.. Chapter 12E: Critical-Response Skills (6-8) 3. Be skeptical of arguments based on very small samples of data, biased samples, or samples for which there was no control sample. 4. Be aware that there may be more than one good way to interpret a given set of findings.	– Construct logical arguments. Social Studies/ Geography: B. Human Interaction with the Environment (5-8) – Explain how cultures differ in their use of similar environments and resources.	Standard 10: (Grade 6) – Discuss the relationship between evidence and explanation. History Standard 16 (Grade 6) – Demonstrate an understanding that people, artifacts, and documents represent links to the past and that they are sources of data from which historical accounts are constructed. – Display historical perspective by describing the past through the eyes and experiences of those who were there, as related through their memories, literature, diaries, letters, debates, arts, maps, and artifacts. (Grade 10) --Analyze historical documents, artifacts, and other materials for credibility, relevance, and point of view.	7.1.dd: Describe, explain, and model, using evidence that includes scientific principles and observations. 7.1.gg: Propose, recognize, and analyze alternative explanations.

Materials Needed

- TV with VCR
- QUEST *Archaeology* video
- Access to the Internet
- Access to a library
- 100 mL of isopropyl rubbing alcohol
- 100 mL of water
- Ice cubes in a small container
- 2 glass beakers that can hold 250 mL
- Plastic wrap
- Overhead transparency of Fossil Footprints found at *http://bob.nap.edu/html/evolution98/evol6-e.html*
- 1 index card (3" x 5") per student
- Motel of the Mysteries by David Macaulay
- One copy per student of each of the following reproducible handouts
  - Student Handout 1: Nature of Science – Truth or Myth Quiz
  - Student Handout 2 Compare and Contrast
  - Student Handout 3:The Dating Game

1. Introducing the Concepts

In this introductory activity, a quiz about the nature of science engages students in thinking about the general methods and aims of the scientific enterprise. Students will also learn to differentiate between observation and inference through two demonstrations.

Activity 1: Inference or Observation?

Note: Advance preparation – Set up the classroom before students arrive by following the procedure outlined here:

1. Pour 100 mL of water into one 250-mL beaker. Cover the beaker with clear plastic wrap. Label it beaker A.
2. Pour 100 mL of isopropyl rubbing alcohol into the second 250-mL beaker. Cover the beaker with clear plastic wrap. Label this beaker B.
3. Let the contents sit for a few hours or overnight. Dislodge any air bubbles by gently tapping beakers on the table. Just before students arrive, place two similarly sized ice cubes in the small container.

Step 1

Distribute copies of Student Handout 1 (Nature of Science: Truth or Myth Quiz). Explain that the purpose of this quiz is to see what ideas students currently have about the way science works. Allow time for students to complete the quiz.

Step 2

When students have finished the quiz, collect and save the handouts for use in Activity 4.

Step 3

Discuss with students the role of observation in science. Ask the class the following questions, writing them on the board or on chart paper:

- What is an observation?
- How are observations made?
- What is the importance of observation in scientific work?

Explain to students that in a few moments they will be asked to record their observations of the contents of two beakers. Elicit students' ideas about what an observation is. Jot their ideas down on the board or on chart paper to create a working definition.

Step 4

Show students the contents of beaker A. Walk around the classroom so that students can get a close look at the material inside the beaker. Ask students to record five observations about the contents of beaker A. When they are done, have them share their observations with the class. Record their ideas on the board. (**Note:** At this point, accept all comments as observations unless contested by students.)

Step 5

Now show students the contents of beaker B. Again, have them record their observations, then share them with the class. Record their ideas as described in Step 4.

Step 6

Review the lists of observations on the board. Ask students to examine these lists critically. Ask, "Are these all truly observations, or are they something else?" (For example, students probably will have listed water on their individual observation lists. At this point, they may not recognize that they have included inferences on their lists.)

Go through each item on the class list, and ask whether the observation could be disputed – in other words, is it a fact that would be agreed upon by everyone? Discuss with students the concept of observation as being a foundational part of science. Explain that what we observe and how we observe it determine the questions we ask. Discuss the ways in which observations can be made – through detailed descriptions, sketches, and measurements. Ask if any students made observations using one of these methods.

Step 7
Revisit the listed items one by one. Place a checkmark next to each item that students feel is not a strict observation.

Step 8
Explain that now you will be adding an ice cube to each of the beakers. Tell students that they will need to make a few more observations.

Add an ice cube to beaker A. Have students make and record observations, then share their ideas using the method described above. Next, add an ice cube to beaker B, and repeat the process above. (Students will be amazed that the ice cube sinks in beaker B. They will suddenly realize that they were inferring that the contents of beakers A and B were the same.)

Step 9
Revisit the lists on the board. Go through each of the items, helping students to determine which items are observations and which are inferences. Explain that an inference is a rational explanation of an observation. Wrap up the activity by discussing with students the role of both observations and inferences in scientific work, using specific examples. (Be sure that students understand that both inference and observation have a role.)

Optional: Have students complete step 1 of Activity 2 here. This will expedite the next day's activities.

2. Exploring the Concepts

Through a series of investigative tasks, students will explore the roles of observation and inference. They will be asked to make inferences based on a limited number of facts in two scenarios. While learning about the importance of inferring, students will also consider its limitations and pitfalls.

Activity 2: The Role of Inference (Part 1)

Step 1
Distribute a 3" x 5" index card to each student. On their cards, tell students to list 10 of their personal possessions that would survive a fire. (Possible answers might include parts of things, such as the pulls on a chest of drawers, etc.) Do not have students put their names on their cards. You may even want to include a card for yourself as well.

Step 2

Collect the cards, shuffle them, and redistribute them randomly. Be sure that no student gets his or her own card.

Step 3

Have students take turns reading the items on the cards aloud. Ask the class if they can make any inferences about the creator of each card simply by hearing which items this person chose to list. Ask the following questions to help students form their answers:

- Can you tell the age or gender of the person?
- Can you tell this person's likes and dislikes?
- Can you determine the kinds of activities or hobbies this person engages in?
- What things does this person value or treasure?

Point out to students that the items listed on the cards could be artifacts that scientists might observe someday. Say, "These listed items are only part of the picture, though. Based on the 'evidence,' or our examination of these listed items, we can infer some things about the person who chose them." Discuss the following questions with the class:

- What else could we look at to gather more information about a particular person?
- What else could we examine to help us interpret the "fragmentary evidence?" In other words, what might give us more clues and a bigger picture?
- In what other ways could we check the validity of our inferences, without (of course) actually interviewing the person?

Students may suggest that they could look at public school records, yearbooks, and newspaper clippings. They may also suggest talking with other people who knew the person, or consulting wills, deeds, census information, and so on.

Activity 2: The Role of Inference (Part 2)

Step 4

Ask students to imagine that they are exploring in a remote jungle. They have come to a wide clearing, where they see an interesting rock formation containing the following markings. (**Note:** Show students the overhead transparency of Fossil Footprints found at http://bob.nap.edu/html/evolution98/evol6-e.html.)

Follow the Instructional Strategy as outlined on the Web site. The main goals of this activity are (1) to reinforce the difference between observations and inferences and (2) to make the distinction between observations, inferences, and interpretations based on evidence. This exercise also brings up another

important aspect of the nature of science: often, different explanations can be given for the same evidence, and it is not always possible to tell which one is correct. Be sure to reinforce this concept with students.

Activity 2: The Role of Inference (Part 3)

Step 5

Share with students David Macaulay's book *Motel of the Mysteries*. Set in the year 4022, this is the story of a grand archaeological discovery which is told through words and pictures. During an excavation, amazing artifacts are unearthed and are grossly misinterpreted. Unbeknownst to the scientists, what they have actually uncovered is a common, ordinary, budget motel.

Step 6

Close this multifaceted activity by engaging students in a discussion about the importance of being able to make inferences in scientific work. Help them consider this issue thoroughly by asking the following questions:

- What value is there in making an inference?
- What should people be cautious about when making inferences?
- Do you think an inference can explain an observation and still be incorrect? What might be some reasons for incorrect inferences?
- Which of your five senses do you think is least likely to trick you? Why do you think so?
- Could something like the *Motel of the Mysteries* actually happen? Does science work this way?
- How would we know if our interpretations were so erroneous or off base?
- Do scientists know with certainty that their interpretations of phenomena are 100% accurate?
- Does the nature of science include any "safety measures" to prevent or avoid such misinterpretations of evidence?

3. Developing the Concepts

In the next activity, students will view the QUEST *Archaeology* video. They will use a visual organizer to help them compare and contrast the work of archaeologists with the work of other scientists.

Activity 2: QUEST *Archaeology* video

Step 1

Tell the class that they will be watching a video that features an archaeologist at work. Ask students to share what they know about the field of archaeology. Have them respond to the following questions:

- What does an archaeologist do?
- How are archaeologists like scientists? Are archaeologists scientists?
- What scientific skills do archaeologists use?

Step 2

Give each student a copy of Student Handout 2 (Compare and Contrast). Review the handout with students, and explain that they will be using the organizer to help them collect information from the video. Stress that they will be recording similarities and differences between the work an archaeologist does and the work that another scientist (preferably in a discipline familiar to them) does. (For other disciplines, consider examining the work of a biologist, chemist, astronomer, physicist, geologist, botanist, microbiologist, geneticist, or zoologist, for example.) Students may need or wish to do additional research to gather sufficient details about the particular type of scientist chosen.

Step 3

Play a segment of the QUEST *Archaeology* video. (A recommended segment is the section that introduces Dick Boisvert's New Hampshire work and runs through to the atlatl workshop.) Pause the tape periodically so that students have time to record information on the handout.

Step 4

Have students share their findings with partners. Then reconvene as a large group. Have students share some of the observations they made while watching the video. Ask them if they would conclude that archaeologists use scientific skills as scientists do. Ask students to cite specific evidence from the video that has led them to their interpretations.

4. Synthesizing and Applying the Concepts

In the following activity, students will revisit the Truth or Myth quiz (Student Handout 1) which they took at the beginning of this teaching unit. After doing further research and applying what they have learned from the video, students will present their new findings to the class.

Activity 4: Truth or Myth?

Note: Advance preparation—Print out a clean copy of Student Handout 1. Cut the quiz into strips so that each strip contains just one question. Place the strips in a container so that students can randomly select one question at a time. (**Note:** If you have a class larger than 22 students, you may wish to have students work in pairs on the questions or you may wish to add additional questions to the worksheet prior to the lesson.)

Step 1

Pass back to students their own copies of Student Handout 1. Explain that now students will be selecting, at random, one question to further investigate. Then they will present their findings to the rest of the class in a three-minute (informal) presentation. Tell students that they will each need to support their Truth or Myth claim with evidence. Encourage the class to incorporate specific examples (historical data, evidence from the video, and so on) to illustrate and defend their points.

Step 2

Direct each student to randomly select one question from the container. Provide class time for students to research their questions. Assist and guide them in finding relevant information to use as proof, including the use of online resources and/or print materials from the school or local library. (**Note:** This is an excellent activity in which to enlist the help of a school librarian!) The Resources section that follows contains a list of possible Web sites for students to investigate.

Step 3

Have students share their findings with the class. As the Truth or Myth statements are presented, have the rest of the class write notes on their own handouts so that everyone has the most detailed information possible.

Step 4

Close the activity by discussing any surprises and/or difficulties students encountered in terms of their understanding the nature of science. Revisit the idea of archaeologists as scientists, reinforcing the concepts students learned from the video and other activities in this teaching unit.

5. Extending the Concepts

In the following take-home activity, students will research some of the techniques that are used to help archaeologists determine the age of artifacts.

Activity 5: *QUEST* at Home

Step 1

Distribute copies of Student Handout 3 (The Dating Game). Review the handout with the class to make sure that everyone understands the assignment.

Step 2

Set a due date for students to return to class with their completed work. Provide assistance and encouragement along the way as needed. (**Note:** You may wish to create a portal to appropriate Web sites and/or suggest other resources to help students with this assignment. There are a number of possible Internet resources listed in the Resources section that follows.)

Step 3

Have students share their findings with the class, including any new techniques that are not found on the list.

Community Connections

– As the QUEST *Archaeology* video points out, many of the people involved in an archaeological dig are volunteers. To get involved in a dig in their area, students can check with local historical societies, state agencies, colleges, universities, and/or other associations devoted to investigating and preserving the past.

– Arrange a visit to a museum with artifact displays, or take a guided field trip to a historic site. New England has a number of interesting places to choose from. Some Web sites that describe archaeological sites in northern New England include the following:

http://www.abbemuseum.org/pages/activities.html
This site provides a listing of activities at the Abbe Museum in Bar Harbor, Maine.

http://www.archaeologychannel.org/content/videoguide.asp
Video clips of digs all over the world can be seen here, including Fort Popham Colony in Bath, Maine. Students can take virtual field trips to famous and not-so-famous sites.

Career Opportunities

– Invite a local archaeologist, paleontologist, museum curator, or historian into the classroom to share his or her work with students.

– Find out what happens to artifacts after they are removed from the site. Artifacts are often put on display in a museum or historical society. A number of interesting jobs requiring special skills and talents accompany this work. For example, artists often make sketches or replicas of the items that are found; reconstructivists attempt to put items back together; designers work on displays to accurately portray the setting of particular artifacts; others work on documenting finds—cataloguing, describing, and photographing artifacts. Arrange a "behind the scenes" tour at a local museum or historic site for your class.

Resources

http://www.nmnh.si.edu/anthro/outreach/edrandom.html
This activity was adapted from the Smithsonian Institution's Anthropology Outreach Office.

http://www.indiana.edu/~ensiweb/natsc.fs.html
Several well-developed activities on the nature of science can be found here. Many activities could be modified to work with middle-level students. This is a great resource for developing the teacher's background knowledge as well.

http://www.project2061.org/tools/sfaaol/chap1.htm
This site offers background reading for teachers, particularly Chapter 1: AAA's Science for All Americans.

http://www.digonsite.com/index.html
By DIG magazine, this site includes a state-by-state listing of archaeological digs. It is an excellent source of articles for children ages 9 and up.

http://rla.unc.edu/lessons/Lesson/L103/L103.htm
This site includes a lesson on observation and inference using archaeology as the context. It was developed by the Research Laboratories of Archaeology at UNC-Chapel Hill.

http://www.bbc.co.uk/history/archaeology/index.shtml
This comprehensive site, sponsored by the BBC, delves into various archaeology specialties.

http://observe.arc.nasa.gov/nasa/exhibits/ubar/ubar_0.html
In this Web adventure by NASA's Observatorium, students look for the ancient city of Ubar (Oman) while learning how modern remote-sensing technology is applied to traditional sciences like archaeology.

http://www.learner.org/exhibits/collapse/copan/index.php
This site contains lessons that are designed to simulate archaeological fieldwork. Students look for clues about why the civilization of Copan collapsed. This is based on the Annenberg/CPB video series Out of the Past.

http://www.sciencenetlinks.com/lessons.cfm?DocID=128
This Hollywood Dinosaurs lesson from AAA's ScienceNetlinks focuses on the uses of relevant evidence and logical reasoning. It engages students in examining recent evidence that challenges a prevailing dinosaur theory.

http://www.smithsonianeducation.org/idealabs/ap/index.htm
This site provides a link to Artifacts and Analysis–A Teachers' Guide to Interpreting Objects and Writing in History.

http://www.archaeologychannel.org/content/TR_Group.asp?category=276640&name=Lesson%20Plans
A listing of archaeology lesson plans from the Archaeology Channel is located here.

http://www.projectexploration.org/index.htm
Project Exploration's "living classroom" Web site contains resources for teachers and students. It currently features paleontology finds.

http://teacherlink.org/content/science/class_examples/Bflypages/timlinepages/nosactivities.htm
These lessons are designed around discrepant events to teach the concept of observation versus inference.

Macaulay, David. Motel of the Mysteries. Boston, Massachusetts: Houghton Mifflin, 1979.

Nature of Science — Truth or Myth Quiz

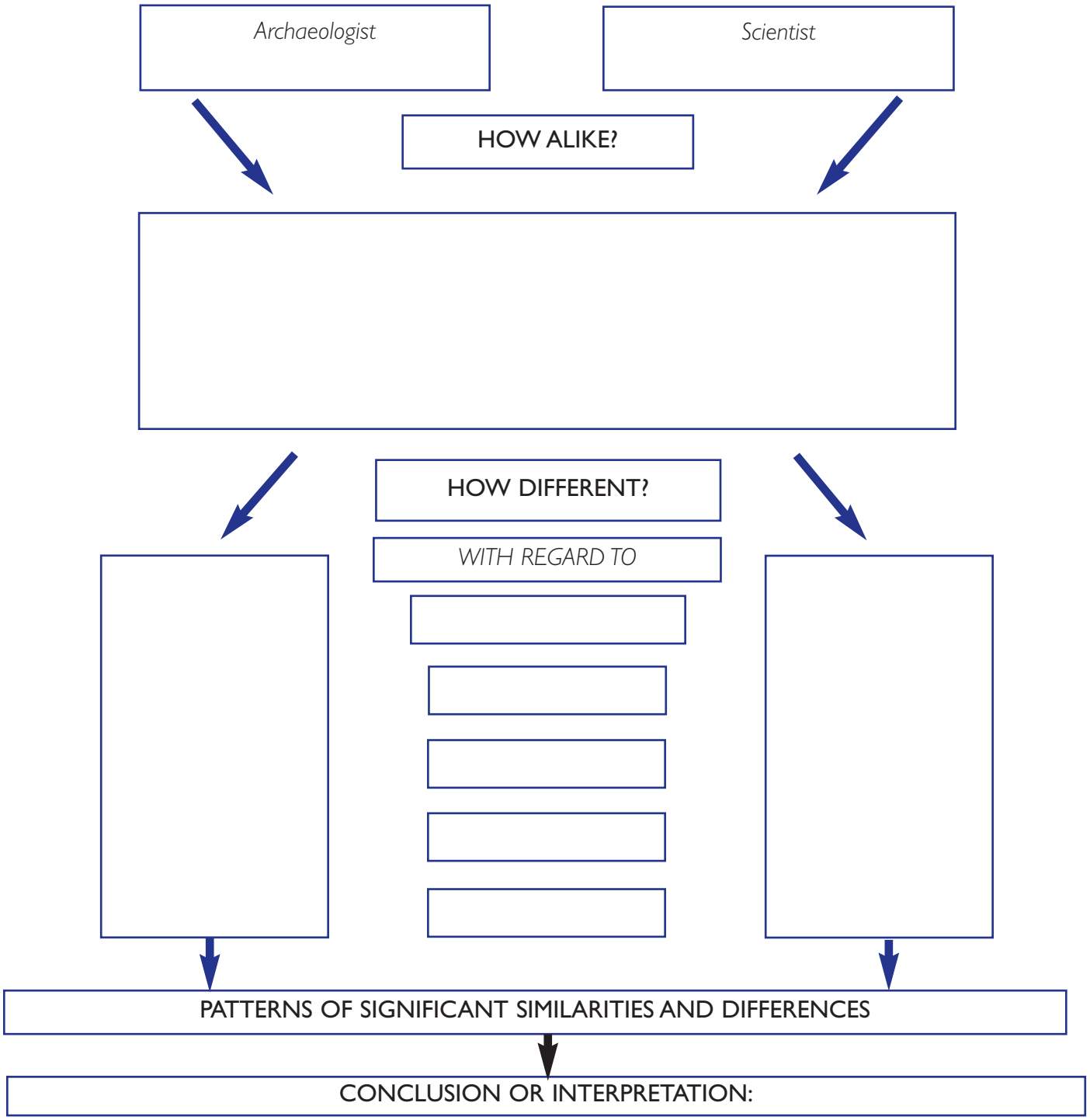
Directions: Read each statement below about the nature of science. Place a T next to items you believe are "truths." Place an M next to statements you feel are "myths," or untrue. This quiz will help you check your current understanding. It will not affect your grade.

_____ 1. Science is a body of knowledge—a collection of facts that have been proven true over and over again.
_____ 2. Science can prove anything, solve any problem, and answer any question.
_____ 3. Much of the growth of science has come from the gradual accumulation of knowledge over many centuries.
_____ 4. Scientific knowledge and ideas are subject to change.
_____ 5. Science can provide complete answers to all questions.
_____ 6. Science is a process for producing knowledge.
_____ 7. Scientific concepts emerge automatically through the collection and analysis of data.
_____ 8. A hypothesis is an "educated guess" about something.
_____ 9. Hypotheses become theories, which eventually become laws.
_____10. All work in science is reviewed to keep the process "honest."
_____11. All scientists follow one scientific method.
_____12. Sometimes discoveries in science are made unexpectedly or accidentally.
_____13. Scientists are unbiased and especially objective.
_____14. Creativity and imagination play a part in science.
_____15. Science allows people to study things and events from millions of years ago.
_____16. Scientists have solved most of the major mysteries of nature.
_____17. Something that has been "proven scientifically" is fact. It will no longer be subject to change.
_____18. Different scientists may get different solutions to the same problem.
_____19. Science follows a set of rules that distinguishes science from other disciplines.
_____20. People do science mainly because they are trying to invent new things.
_____21. Anything done scientifically can be counted on to be accurate and reliable.
_____22. The heart of science is in its methods of investigations and ways of thinking, not in specific facts and results.

References/Adapted from: Science Knowledge Survey *http://www.indiana.edu/~ensiweb/lessons/sci.tst.html* and AAA's Science for All Americans.

Compare and Contrast

Adapted from: Infusing the Teaching of Critical and Creative Thinking Into Secondary Science by Robert J. Swartz et al.



The Dating Game

You're on a Quest!

Directions:

There are a number of techniques being used in the field of archaeology—some traditional, some quite new. Using the Internet and library resources, investigate the techniques listed below that help archaeologists find and date artifacts. If you find other interesting techniques that are not listed, you can add them in the spaces available.

Technique	How It Works	Why It Is Useful in Archaeology
Radiocarbon dating		
Stratigraphy		
Global Positioning System (GPS)		
Metal detecting		
Sonar		
X-ray		
DNA		

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