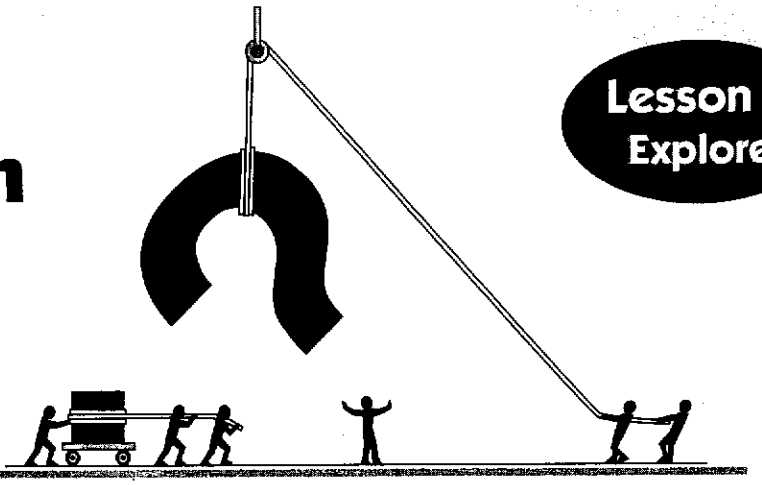
Working with Questions



Lesson 2
Explore

At a Glance

Overview

In Lesson 2, students explore questions in a scientific context. They consider what makes questions testable. Students evaluate questions and then pose testable questions about scientific problems. After reading short scenarios, students come up with their own testable questions about the reading. They also consider the types of evidence needed to answer their questions.

Major Concepts

- Scientists ask questions that can be answered through scientific investigations.
- Testable questions are answered by collecting and analyzing evidence and developing explanations based on that evidence.
- Questions that cannot be answered through scientific investigation are those that relate to personal preference, moral values, the supernatural, or unmeasurable phenomena.

Objectives

After completing this lesson, students will be able to

- identify questions that depend on personal preferences or moral values, or that relate to the supernatural or phenomena that cannot be measured;
- identify questions that can be tested;
- ask questions that can be answered through investigations; and
- identify the type of evidence needed to answer the questions.

Teacher Background

Consult the following sections in Information about the Process of Scientific Inquiry:

4 *Inquiry in the* National Science Education Standards (pages 24–27)
6.2 *Scientifically Testable Questions* (pages 30–31)
6.3 *Scientific Evidence and Explanations* (page 31)

In Advance

Activity	Web Component?	Photocopies	Materials
1	No	Master 2.1, *Working with Questions* (Make 1 copy per student and prepare an overhead transparency.)	No materials except photocopies and transparencies
2	No	Master 2.2, *Letters to the Editor* (Make 1 copy per student.) Master 2.3, *Question and Investigation Form* (Make 1 copy per student.)	No materials except photocopies

Preparation

No preparations are needed except for making photocopies and transparencies.

Procedure

Note to teachers: The goal of this lesson is to help students appreciate that although we all ask questions about the world, scientists ask questions in ways that are testable. The question, How is bug blood different from human blood? is an interesting one, and it does define a general problem. As stated, this question is not specific enough to be tested directly. However, one can ask a number of testable questions that can be investigated to produce data (evidence) that answer the more specific questions. For instance, a scientist might ask, "Do bug blood and human blood contain the same things? Do they contain the same kinds of cells? Do they contain the same chemicals?" Of course, there are some questions that simply ask for information. Are you going to the movies Saturday night? is a question that implies no problem about which testable questions can be asked.

In this module, students learn how to ask testable questions—questions that can be answered through investigations. The intention is not to present a complex set of criteria that define a scientific question, but rather to introduce students to the idea that scientists identify a problem, ask testable questions, collect and analyze evidence, and reach conclusions based on that evidence. If this module is taught near the beginning of the school year, it can serve as an introduction to scientific ways of thinking that students will practice and refine throughout the school year and into the future.

Activity 1: *What's the Question?*

1. **Remind students that they asked questions about cubes in the first lesson. Ask students, "Why do you ask questions?"**

   Students likely will respond, "To get answers or to get more information."

2. **Explain that scientists also ask questions to get answers, but they must ask their questions in ways that can be tested through a scientific investigation. This means that some questions are more easily answered than others. Ask students, "To a scientist, what makes a question a good question?"**

   Accept all answers. Write student responses on the board or on an overhead transparency. Some students may believe that good questions do not ask about something really obvious, ask only about things that are real, or allow us to gain necessary information. The objective is not to be overly critical, but rather to engage student thinking about questions.

3. **Explain that scientists continually ask questions and that they try to ask questions that can be answered through investigations. Challenge students to describe some questions that are not suitable for a scientific investigation.**

   Students' answers will vary. Write some of their responses on the board. Try to elicit the following characteristics of questions that are not scientifically testable:
   - Their answers depend on personal preference.
   - Their answers depend on moral values.
   - They relate to the supernatural.
   - They relate to phenomena that cannot be measured.

4. **Explain that in this activity, students will investigate how to ask questions in the ways that scientists do.**
   - **Divide the class into teams of three.**
   - **Give each student one copy of Master 2.1, *Working with Questions*.**
   - **Display a transparency of Master 2.1 at the same time.**
   - **Read the list of questions with the students.**

   Each question defines a general problem. As written, none of the questions is directly testable. Two of the questions (3 and 6) are not appropriate for a scientific investigation because they involve personal preference (Question 3) and moral values (Question 6). The other questions are appropriate to scientific investigation but need to be rephrased in a more specific form.

Assessment:
Through questioning, you can assess your students' previous knowledge and misconceptions.

Content Standard A:
Students will develop the abilities necessary to do scientific inquiry.

5. **Explain that scientists may ask questions that have to be rephrased in the form of specific questions that can be tested through investigation.**

   To get students started, give them one example of a testable question such as, Does what you eat influence the appearance of pimples? or, Does eating chocolate contribute to acne?

6. **Assign each team a question from Master 2.1. Ask the teams to do the following:**
   - **Decide whether their question can be answered through a scientific investigation.**
   - **If their question can be answered through an investigation, come up with two testable questions that relate to the problem described in their assigned question.**
   - **If their question cannot be answered through an investigation, be able to explain why not and come up with two testable questions that relate to their question's topic.**

   Give student teams 5 to 10 minutes to work with their questions. Students probably do not have the background to generate questions that show insight into each of the scientific problems. Students working with the same question may ask different testable questions. The purpose of this step is to develop critical-thinking skills and to give students practice writing testable questions. Because the purpose of this lesson is to develop students' understanding of testable questions, avoid critiquing the problems they identify. Instead, focus on the students' ability to phrase a question in a way that makes it testable. Look for questions that focus on the natural world, scientific ideas, and quantitative relationships. Questions should not relate to personal beliefs, moral values, or the supernatural.

Assessment:
Determine students' depth of understanding of how scientific questions are formulated and evaluated.

7. **Reconvene the class. Ask teams first to state whether or not their question can be answered through a scientific investigation. If they determined that their question can be answered through an investigation, what two testable questions did they ask?**

   Write the teams' questions on the board or a transparency. As questions are put on the board, ask students if they agree that the question is testable. If they do not agree, ask that they restate the question so that it is testable.

Note to teachers: Questions 3 (Is rock music better than hip-hop music?) and 6 (Is vegetarianism better than eating meat?) imply a preference and as such are not testable. However, when students are confronted with questions expressing or implying a preference, they should probe deeper to be able to generate a testable question. For instance, if students are told or if they read that vegetarian diets are

better than meat-containing diets, they might begin by asking, "Better in what ways?" This may lead to the notion that one diet is better than another in terms of nutritional content or long-term health consequences. From these clarifications, students can generate testable questions. Students can treat the issue of "better music" in a similar manner. In what ways might one type of music be better than another? Does one produce greater sales or greater alertness?

Tip from the field test: Some questions generated by teachers for this activity include the following:

- Do all bugs have blood?
  Does bug blood contain white blood cells and red blood cells?
  What is the composition of bug blood?

- What happens to your fingers if you soak them in other liquids, such as dish-washing detergents?
  Do fingers wrinkle faster in hot or cold water?
  How long do you have to soak your fingers before they wrinkle?

- Does rock music make more money than hip-hop music?
  How do music sales vary by geographical distribution and by type of music?
  How do music sales vary by age and gender of the buyer and by type of music?

- What physiological changes trigger sneezing?
  Do sunglasses prevent sneezing?
  Does breathing through your mouth versus breathing through your nose make a difference in sneezing when you are exposed to bright light?

- Are septic workers unhappy? (subjective)
  Changed to: Do results of psychological tests designed to measure happiness show that sanitation workers score lower than other types of workers?
  Do people who work in florist shops have fewer psychological problems than those who work in less pleasantly fragrant environments?

- Do vegetarians experience fewer heart attacks than meat eaters do?
  Does a vegetarian diet contain the same vitamins and minerals as a meat-containing diet?
  How do vegetarian and meat-containing diets compare nutritionally?

A teacher-generated question related to Question 5 on Master 2.1 was considered "subjective." This question was changed so that its answer

doesn't rely on asking people a general question about their own feelings. These examples point out what you should look for with your students' questions: are they stated specifically enough to be tested as stated, or are they too general and not testable directly? If a question is too "big," students may have to break off a smaller piece in the form of a more specific question.

8. **Lead a discussion asking students to list characteristics that distinguish testable questions from questions that cannot be tested.**

   Guide the discussion to focus on the following criteria:
   - Testable questions ask about objects, organisms, and events in the natural world.
   - Testable questions can be answered through investigations that involve experiments, observations, or surveys.
   - Testable questions are answered by collecting and analyzing evidence that is measurable.
   - Testable questions relate to scientific ideas rather than personal preference or moral values.
   - Testable questions do not relate to the supernatural or to nonmeasurable phenomena.

Note to teachers: Students need to come away with the understanding that scientifically testable questions are centered on objects and phenomena in the natural world. These objects and phenomena can be described and explained by scientific investigations. Testable questions do not relate to the supernatural. Testable questions lead to scientific investigations that gather measurable evidence. Mention to students that different kinds of investigations may be appropriate depending on the question. Some questions lead to observations, while others lead to experiments.

Activity 2: *Questions . . . More Questions*

Note to teachers: In Activity 2, students practice analyzing readings and writing questions as an introduction to the next lesson. This activity provides an opportunity to assess students' understanding of testable questions. To save time, you may select just one of the readings and discuss it with the class. Alternatively, you may assign the activity as homework.

1. **Give each student one copy of Master 2.2, *Letters to the Editor*, and Master 2.3, *Question and Investigation Form*. Explain that each of the three letters on Master 2.2 features an individual expressing a different point of view about the same topic.**

2. **Instruct students to**
   - **read each of the three letters,**
   - **select one letter and develop two scientific questions that relate to the point of view expressed in the letter, and**
   - **for each question, describe an investigation and the evidence that could be used to answer it.**

Look for questions that meet the criteria given in Step 8 of Activity 1. Student questions should be worded in a way that suggests that they can be answered through investigations. Their questions should not be based on opinions or personal beliefs. Examples of acceptable questions and investigations follow.

Fast Food and Cancer?

Example Question: Does food served at Quick and Tasty contain chemicals that can lead to cancer?

Example Investigation: Test food from Quick and Tasty for chemicals that are associated with cancer.

Example Question: Is cancer more common today than in the past?

Example Investigation: Compare the incidences of several types of cancer today and 20 or 50 years ago.

Healthy Diet? It's Up to You!

Example Question: Do obese people select different food items at Quick and Tasty compared with people of normal weights?

Example Investigation: Observe and record the food choices at Quick and Tasty of obese and normal-weight people.

Example Question: Are the salads served at Quick and Tasty as nutritious as similar salads served at more expensive restaurants?

Example Investigation: Obtain comparable salads from Quick and Tasty and several more expensive restaurants. Analyze them for their nutritive content.

NSES

Content Standard A: Students will develop understandings about scientific inquiry.

Content Standard E: Students will develop understandings about science and technology.

Content Standard F: Students will develop an understanding of science and technology in society.

Content Standard G: Students will develop an understanding of the nature of science and of science as a human endeavor.

Assessment:
Evaluating students' questions and investigations allows you to determine their understanding of scientific questioning.

Weight a Minute!

Example Question:	Does a typical meal at Quick and Tasty contain more calories than recommended for an average person?
Example Investigation:	Determine the number of calories in several of the Quick and Tasty meals and compare this with recommended calorie intakes.
Example Question:	Are the food portions served at Quick and Tasty larger than those recommended for a healthy diet?
Example Investigation:	Obtain various food items from Quick and Tasty. Compare their portion sizes with the recommended ones.

Lesson 2 Organizer

What the Teacher Does	Procedure Reference
Remind students that they asked questions about cubes during the first lesson. Ask, • "Why do you ask questions?"	Page 49 Step 1
Explain that scientists ask questions that are answerable through scientific investigations. • Ask, "To a scientist, what makes a question a good question?" • Challenge students to describe questions that cannot be answered through scientific investigations.	Page 49 Steps 2 and 3
Divide the class into teams of 3. Give each student a copy of Master 2.1, *Working with Questions*. • Display a transparency of Master 2.1 • Read the list of questions aloud.	Page 49 Step 4 **M** **T**
Explain that questions may have to be rephrased in the form of a more specific question that can be tested through investigation.	Page 50 Step 5
Assign each team a question from Master 2.1. Ask teams to • decide whether their question can be answered through a scientific investigation and • come up with two testable questions that relate to the problem described in their assigned question.	Page 50 Step 6
Reconvene the class. Ask several teams to share their conclusions. • What two testable questions did they ask?	Pages 50–52 Step 7
Ask students to list characteristics that distinguish testable questions from questions that cannot be tested.	Page 52 Step 8
Give each student a copy of Master 2.2, *Letters to the Editor*, and Master 2.3, *Question and Investigation Form*.	Page 52 Step 1 **M**
Instruct students to • read each letter, • select one letter and write two testable questions that relate to it, and • for each question, describe an appropriate investigation and the evidence needed to answer the question.	Pages 53–54 Step 2

M = Involves copying a master. **T** = Involves making a transparency.

Working with Questions

Name:_____ Date: _____

1. How is bug blood different from human blood?

2. Why do your fingers wrinkle after you take a bath?

3. Is rock music better than hip-hop music?

4. Why does bright light cause some people to sneeze?

5. Do smells affect people's moods?

6. Is vegetarianism better than eating meat?

Letters to the Editor

The Daily Bugle Newspaper

Letters to the Editor

Readers Sound Off about Proposed Quick and Tasty Restaurant:

Fast Food and Cancer?
When are Americans going to wake up to the dangers of restaurants like Quick and Tasty? The food they serve contains many chemicals known to cause cancer. It is no coincidence that as more people eat at these restaurants, more cases of cancer are being reported. Americans need to learn that organic foods are better than processed foods.

Signed, A Health-Conscious Reader

Healthy Diet? It's Up to You!
I for one will welcome Quick and Tasty to our neighborhood. Their food tastes great, is reasonably priced, and is good for you. People who say otherwise just eat too much or pick the wrong items. Their salads are just as good as those served at fancy restaurants but are much less expensive. I regularly eat at the Quick and Tasty near my business, and I'm in great shape.

Signed, Marathon Man

Weight a Minute!
Quick and Tasty is the last thing our community needs. The nation is in the midst of an epidemic of obesity, and fast-food restaurants are the biggest reason why. The food they serve has too many calories, and their portions are way too large. Society must be protected from companies like Quick and Tasty. They are more interested in making money than in the health of their customers.

Signed, Lean and Mean

Question and Investigation Form

Name: _____ Date: _____

Select one of the letters from Master 2.2, *Letters to the Editor*. Develop two scientific questions related to the letter. Then describe an investigation and the evidence you could gather to answer each question.

Letter you chose: _____

Question 1

Investigation

Question 2

Investigation