# Pulling It All Together

Lesson 4
Evaluate

## At a Glance

### Overview

In this final lesson, you have an opportunity to assess what students have learned about scientific inquiry. Students continue in their roles as members of the community health department investigative team. The class is divided into two groups. Teams from each group review different data about the same health problem and prepare an investigative report. Teams trade reports, and each team evaluates one prepared by a team from the other group. The lesson allows students to apply what they have learned in the previous lessons and to use critical-thinking skills in performing and evaluating scientific investigations.

### Major Concepts

- Scientific inquiry is a process of proposing explanations.
- Scientific inquiry begins with a testable question.
- Scientific investigations involve collecting evidence.
- The results of scientific investigations are used to develop evidence-based explanations.
- Scientists communicate the results of their investigations to their peers.

### Objectives

After completing this lesson, you will be able to assess students' knowledge of scientific inquiry by having them

- identify a testable question,
- describe the evidence needed to answer the question,
- assess whether or not evidence is adequate to answer the question, and
- display critical-thinking skills as they evaluate alternative explanations.

### Teacher Background

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

3 *Inquiry and Educational Research* (pages 21–24)
4 *Inquiry in the* National Science Education Standards (pages 24–27)

5 *Misconceptions about Inquiry-Based Instruction* (pages 27–29)
6.1 *The Nature of Scientific Inquiry: Science as a Way of Knowing* (pages 29–30)
6.2 *Scientifically Testable Questions* (pages 30–31)
7 *Teaching Scientific Inquiry* (pages 31–32)

## In Advance

| Activity | Web Component? | Photocopies | Materials |
|---|---|---|---|
| 1 | Yes | Master 4.1, *Memo from Director* (Prepare an overhead transparency.)<br>Masters 4.2a and b, *Data from Investigation* (Make 1 copy of Master 4.2a for half of the teams and 1 copy of Master 4.2b for the other half.)<br>Master 4.3, *Report Form** (Make 1 copy per student.)<br>Master 4.4, *Evaluation Form** (Make 1 copy per student.) | No materials except photocopies and transparencies |

* Masters needed for Web version. Print version uses all the masters.

### Preparation

For classes using the *Web-based version*: Verify that the computer lab is reserved for your classes or that classroom computers are ready to use. Bookmark the student Web site at *http://science.education.nih.gov/supplements/inquiry/student*. Make photocopies.

For classes using the *print version*: No preparations are needed except for making photocopies and transparencies.

## Procedure

### Activity 1: *Pulling It All Together*

**Note to teachers:** The following activity again has students playing the role of investigators for the community health department. This time, the students are given data collected by another investigator and asked to write a brief report about the investigation. In the second part of the activity, the students review reports of investigative work of other students and critique them. This activity allows you to evaluate what students have learned about the process of scientific inquiry.

The outbreak of chicken pox that serves as the basis for the investigations in this activity is based on a real outbreak that occurred in 2003 at a school in Michigan.

**Tip from the field test:** Some teachers commented that their students experienced a letdown when they used a print-based lesson after working on the Web during Lesson 3. For this investigation, we have placed the initial memo from the director and the data on the Web site. You can either instruct the students to retrieve this information from the Web site or supply it as print material.

1. **Explain to the class that they are still members of the community health department investigative team. This time, they will analyze data provided by investigators in the field and prepare an investigative report.**

   As before, throughout this activity, you will act as team supervisor for all the student teams.

2. **Display a transparency of Master 4.1, *Memo from Director.* Read the memo aloud to the class.**

   Alternatively, you can instruct students to proceed to *http://science.education.nih.gov/supplements/inquiry/student* and click on "Lesson 4—*Pulling It All Together.*" Students then click on "You Have (1) New Message" and read the memo. Answer any questions students have about the memo.

3. **Divide the students into teams of two. Give half of the teams one copy of Master 4.2a, *Data from Investigation.* Give the other half one copy of Master 4.2b, *Data from Investigation.***

   Alternatively, you can instruct students to proceed to *http://science.education.nih.gov/supplements/inquiry/student* and click on "Lesson 4—Pulling It All Together." Students should then click on either "Case Number 0439-a" or "Case number 0439-b" and review the data.

   Master 4.2a (case number 0439-a) contains data that relate to the probable cause of a disease outbreak at a local elementary school. Master 4.2b (case number 0439-b) contains data that relate to the protection offered by vaccination against chicken pox. The amount of data reviewed by each team is restricted so that you can more easily evaluate the students' abilities to ask appropriate testable questions and use evidence to propose explanations. In a later step, students will evaluate reports prepared by other students. The procedure used during this activity is designed to allow students to use their knowledge about scientific inquiry and to demonstrate critical-thinking skills in preparing and evaluating reports about scientific investigations.


**Content Standard A:** Mathematics is important in all aspects of scientific inquiry. Identify questions that can be answered through scientific investigations. Develop descriptions, explanations, predictions, and models using evidence.

**Content Standard A:** Use appropriate tools and techniques to gather, analyze, and interpret data. Think critically and logically to make the relationships between evidence and explanation. Recognize and analyze alternative explanations and procedures. Different kinds of questions suggest different kinds of scientific investigations.

**Content Standard E:** Science and technology are reciprocal.

**Assessment:** Collecting the report forms and evaluations provides a summative assessment of students' scientific inquiry skills.

4. **Give each student one copy of Master 4.3, *Report Form*. Explain that students are to**
   - **review the data on Master 4.2a or 4.2b, *Data from Investigation*,**
   - **discuss the data's meaning with their teammate, and**
   - **fill out the information requested on Master 4.3.**

   Give teams about 15 minutes to complete their task.

5. **Instruct each team to trade their Report Forms and their copy of the Data from Investigation master with a team that worked with the other data set.**

6. **Give each student one copy of Master 4.4, *Evaluation Form*. Instruct the teams to review the information on the other team's Data from Investigation and their Report Forms and then to answer the questions posed on the Evaluation Form.**

   Give teams about 15 minutes to complete their task. Remind the students that yes or no answers are unacceptable. Students should explain the reasoning behind each of their answers.

7. **After students have completed their tasks, collect all of the Report Forms and Evaluation Forms.**

**Note to teachers:** Students' responses on Masters 4.3, *Report Form*, and 4.4, *Evaluation Form*, give you opportunities for formal assessment. Answers to the questions posed on these forms should reflect students' understandings of the basic aspects of scientific inquiry addressed in this supplement. When assessing students' work, keep in mind the following:

**Testable Questions**

1. Testable questions ask about objects, organisms, and events in the natural world.
2. Testable questions can be answered through investigations that involve experiments, observations, or surveys.
3. Testable questions are answered by collecting and analyzing evidence that is measurable.
4. Testable questions relate to scientific ideas rather than personal preference or moral values.
5. Testable questions do not relate to the supernatural or to nonmeasurable phenomena.

**Evidence**

1. ***School absences:*** At the peak of the illness, 12.6 percent of students were absent from school. Two years ago, a similar percentage of students were absent because of the flu. There is no evidence, however, that the current illness is due to the flu.
2. ***Disease symptoms:*** Most of the symptoms of chicken pox were present in most children. Less than one-third of the ill children had blisters. This could be because blisters are only associated with a severe form of the disease or with a certain phase of the disease process.
3. ***Laboratory tests:*** Samples from only two children were sent for laboratory tests. One of them contained chicken pox virus. This means that just 3 percent (2 of 66) of the ill children were tested. It is possible that these results are not representative of the group of children who became ill. The finding of chicken pox virus in one sample, however, provides evidence that chicken pox is responsible for the illness in at least some of the children.
4. ***Infection rates of vaccinated compared with unvaccinated students:*** Children cannot get chicken pox more than once. This means that 75 percent (15 out of 20) of children who were not vaccinated and had not already had chicken pox became ill. In contrast, only about 11 percent (51 out of 445) of children who had been vaccinated and had not already had chicken pox became ill. The data show that vaccination provides substantial though not complete protection from infection. The fact that over 90 percent of parents report that they were vaccinated is not directly relevant to the cause of the children's illness.
5. ***Severity of the disease:*** The data show that most children who were vaccinated experienced a less severe form of the disease than did children who were not vaccinated. This means that vaccination not only provides protection against becoming infected, it also lessens the disease symptoms when an infection does occur.
6. ***Time of vaccination:*** Children who were vaccinated over four years ago were five times as likely to get chicken pox as were children vaccinated within the past four years. These data suggest that the protective effects of vaccination begin to wear off after about four years.

**Explanation**

1. The most likely explanation for the children's illness is that they were infected with the chicken pox virus. This explanation is consistent with the laboratory tests and doctors' examinations.
2. The most likely explanation for why some children who were vaccinated against chicken pox became infected is that the protective effects of the vaccine wear off after about four years. This explanation is consistent with time-of-vaccination data.


**Content Standard C:**
Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

**Content Standard F:**
The potential for accidents and the existence of hazards imposes the need for injury prevention. Important personal and social decisions are made based on perceptions of benefits and risks. Risk analysis considers the type of hazard and estimates the number of people who might be exposed and the number likely to suffer consequences.

**Content Standard G:**
Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.


**Content Standard G:** Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skills, and creativity.

**Next Steps**

1. Conduct additional lab tests to confirm the chicken pox diagnosis.
2. Survey the medical literature to see whether any other diseases share the same symptoms as chicken pox.
3. Survey the medical literature to see whether similar outbreaks of children vaccinated against chicken pox have been reported.
4. Some of your students may suggest performing experiments on children, such as deliberately infecting them with virus and monitoring infection rates. Be sure to point out that any such experiments are prohibited on legal and ethical grounds!

# Lesson 4 Organizer

| What the Teacher Does | Procedure Reference |
|---|---|
| **Activity 1: Analyze Data** | |
| Explain to the students that they will continue in their roles as members of the community health department investigative team.<br>• This time they will analyze data collected by others and prepare a report. | Page 91<br>Step 1 |
| Display a transparency of Master 4.1, *Memo from Director.* Read the memo aloud. Alternatively, have students access the Web site and read the memo there. | Page 91<br>Step 2 T or |
| Divide the class into teams of two.<br>• Give half of the teams one copy of Master 4.2a, *Data from Investigation.*<br>• Give half of the teams one copy of Master 4.2b, *Data from Investigation.*<br>Alternatively, have students access the Web site and review the data there. | Page 91<br>Step 3 M or |
| Give each student one copy of Master 4.3, *Report Form.* Explain that they are to<br>• review the data on Data from Investigation,<br>• discuss its meaning with their teammate, and<br>• fill out the information requested on Master 4.3. | Page 92<br>Step 4 M |
| After teams have completed their task, instruct them to trade their Report Forms and Data from Investigation with a team that worked with the other data set. | Page 92<br>Step 5 |
| Give each student one copy of Master 4.4, *Evaluation Form.* Instruct teams to<br>• review the information on the Report Forms and<br>• answer the questions posed on the Evaluation Form. | Page 92<br>Step 6 M |
| After students have completed their tasks, collect all of the Report Forms and Evaluation Forms. | Page 92<br>Step 7 |

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

= Involves using the Internet.

# Memo from Director

**MEMO**

**To: Members of the Health Department Investigative Staff**

**From: Director of the Community Health Department**

**About: Disease Outbreak**

The director of our Disease Awareness unit has alerted me to a disease outbreak at one of our elementary schools. Her staff have completed an initial investigation into the outbreak and sent data to us for analysis.

I need you to review the data they have sent and prepare a brief report. You will complete a form based on our *Investigative Report Form.*

# Data from Investigation

**Community Health Department**

**Case Number 0439-a**
**Disease Outbreak at Lincoln Elementary School**

**Results from Initial Investigation**

**I. School absences**
The school has 520 students. The illness occurred over a two-month period. At the peak of the outbreak, 66 students (12.6 percent) were absent from school. Two years ago, a similar percentage of students were absent from what turned out to be the flu.

**II. Disease symptoms**
I interviewed the doctor who treated the ill students. He concluded that 66 students had chicken pox, based have having the characteristic rash and at least two other symptoms. The following table shows how many of these students displayed symptoms of chicken pox.

| Symptom of chicken pox | Number of students with symptom |
|---|---|
| Mild fever | 66 |
| Runny nose | 60 |
| Slight cough | 56 |
| Rash | 66 |
| Blisters | 17 |
| Headache | 55 |
| Sore throat | 54 |

**III. Laboratory tests**
Samples taken from two of the ill students were sent away for lab analysis. One of the two samples was found to contain the chicken pox virus.

# Data from Investigation

**Community Health Department**

**Case Number 0439-b**
**Disease Outbreak at Lincoln Elementary School**

**Results from Initial Investigation**

**I. Infection rates of vaccinated compared with unvaccinated students**
Parents were interviewed to see if the children had been vaccinated. They were also asked if the children had already had and recovered from chicken pox. Children cannot get the disease a second time. Over 90 percent of parents reported having had chicken pox as children.

| | Number of Students | |
|---|---|---|
| **Student breakdown** | **Vaccinated** | **Unvaccinated** |
| Total | 470 | 50 |
| With chicken pox now | 51 | 15 |
| Who had chicken pox before | 25 | 30 |

**II. Severity of the disease**
Two doctors examined the sick children and classified each case as mild, moderate, or severe.

| | Number of Students | |
|---|---|---|
| **Student breakdown** | **Vaccinated** | **Unvaccinated** |
| With mild disease | 43 | 3 |
| With moderate disease | 7 | 9 |
| With severe disease | 1 | 3 |

**III. Time of vaccination**
Parents of children who were vaccinated were asked if their child was vaccinated within the past four years. Children who were vaccinated over four years ago were five times as likely to get chicken pox as were children vaccinated within the past four years.


# Report Form

Investigator name: _____

Date: _____

I have reviewed case number 0439-a / 0439-b (circle one).

| I have identified the following testable question or questions: |
| --- |
| The questions are based on the following evidence: |
| My analysis of the evidence and my conclusions are as follows: |
| I have identified the following questions that could be asked as next steps in the investigation: |


# Evaluation Form

Investigator name: _____

Date: _____

I have evaluated the report by team member _____, who studied case number 0439-a / 0439-b (circle one). My evaluation is presented below.

1. Was a testable question (or questions) identified?

2. Was the evidence collected appropriate for answering the questions?

3. Was there other evidence that should have been used by the investigator?

4. Were proposed explanations supported by the evidence collected?

5. Were there other explanations that should have been considered?