QualityCore™

# Biology

## Unit 3
## The Five-Second Rule: A Rule to Live by, or a Myth to Bust?

ACT®

QCB-3.2.0

## Note

QualityCore™ instructional units illustrate how the rigorous, empirically researched course objectives can be incorporated into the classroom. For more information about how the instructional units fit into the QualityCore program, please see the *Educator’s Guide* included with the other QualityCore materials.

ACT recognizes that, as you determine how best to serve your students, you will take into consideration your teaching style as well as the academic needs of your students; the standards and policies set by your state, district, and school; and the curricular materials and resources that are available to you.

## Unit 3 The Five-Second Rule: A Rule to Live by or a Myth to Bust?

## Purpose

To reach the goals of the National Science Education Standards, students must be encouraged to investigate the natural world and taught methods of scientific inquiry. This unit is designed to engage students in developing these important skills and is intended to introduce students to the study of biology through scientific inquiry.

## Overview

This is a two-week unit that is best started on a Wednesday. It suggests a student-centered approach to building understanding of the process of scientific inquiry.

Through student and teacher collaboration, trial and error, and thoughtful redirection students will conduct an investigation while actively engaged in developing a meaningful understanding of the inquiry process.

## Time Frame

This unit requires approximately ten 45–50 minute class periods.

**Tips for Teachers**

Beginning this unit on a Wednesday allows both the guided and independent inquiry activities to incubate over the weekend.

*For students to develop the abilities that characterize science as inquiry, they must actively participate in scientific investigations, and they must actually use the cognitive and manipulative skills associated with the formulation of scientific explanations.*
—National Research Council (NRC) (1996, p. 173)

*Public discussions of the explanations proposed by students are a form of peer review of investigations, and peer review is an important aspect of science. Talking with peers about science experiences helps students develop meaning and understanding. Their conversations clarify the concepts and processes of science, helping students make sense of the content of science.*
—NRC (1996, p. 174)

# UNIT 3

# THE FIVE-SECOND RULE: A RULE TO LIVE BY OR A MYTH TO BUST?

## Prerequisites

- Able to participate constructively in group projects
- Have basic microscopy skills
- Know the steps involved in scientific inquiry

## Selected Course Objectives

The primary objectives, which represent the central focus of this unit, are listed below and highlight skills useful not only in Biology, but in other disciplines as well. Secondary objectives are listed in Appendix E.

### *A.1. Scientific Inquiry*

a. Identify and clarify biological research questions and design experiments
b. Manipulate variables in experiments using appropriate procedures (e.g., controls, multiple trials)
c. Collect, organize, and analyze data accurately and precisely (e.g., using scientific techniques and mathematics in experiments)
d. Interpret results and draw conclusions, revising hypotheses as necessary and/or formulating additional questions or explanations
e. Write and speak effectively to present and explain scientific results, using appropriate terminology and graphics
f. Safely use laboratory equipment and techniques when conducting scientific investigations

### A.3. Science in Practice

c. Recognize and apply criteria that scientists use to evaluate the validity of scientific claims and theories

### A.4. Foundations

c. Design and conduct investigations appropriately using essential processes of scientific inquiry

### English 10 B.2. Modes of Writing for Different Purposes and Audiences

e. Craft first and final drafts of workplace and other real-life writing (e.g., job applications, editorials, meeting minutes) that are appropriate to the audience, provide clear and purposeful information, and use a format appropriate to the task

### English 10 B.3. Organization, Unity, and Coherence

b. Organize writing to create a coherent whole with effective, fully developed paragraphs, similar ideas grouped together for unity, and paragraphs arranged in a logical sequence

## Research-Based Strategies

- Think-Pair-Share (pp. 7, 10)
- Wait-Time (p. 7)
- Experimental Inquiry (pp. 5–14)
- Cooperative Learning (pp. 7–8)
- Reflective Questioning (p. 8)
- 3-2-1 Assessment (p. 12)
- Reading Strategies: Previewing, Questioning, Synthesizing, Making Connections (pp. 15–16)

## Essential Questions

1. How does scientific inquiry affect our daily lives?
2. What qualities must an experiment have in order for the data to be trustworthy?
3. Based on your experimental results, what are the implications of the five-second rule for society?

## Suggestions for Assessment

Except where otherwise noted, assessments can be given a point value or they can simply be marked off as completed.

### Preassessment

*Writing*—In students' class notebooks have them write a sentence or two about how the skills used during the process of scientific inquiry can be used in everyday life. (Day 1)

**Tips for Teachers**

The essential questions and the primary course objectives for this unit should be prominently displayed in the classroom.

## Embedded Assessments

*Worksheet*—Asking questions throughout the process of designing an experiment (Research Plan, p. B-3) is both a method for the creation of a student-centered classroom and a means for a teacher to examine the beliefs students currently hold about science and the natural world. “A critical component of successful scientific inquiry in grades 9–12 includes having students reflect on the concepts that guide the inquiry” (NRC, 1996, p. 174). (Day 2)

*Worksheet*—After completing their guided inquiry experiments, students should record their experimental results and conclusions (Probing Ideas and Understandings, p. B-6). This worksheet provides insight into students’ thinking. (Day 4)

*Homework*—Students evaluate a high school student’s experimental procedure, crafting an answer to a constructed-response prompt (Laura’s Experiment, pp. B-7–B-9). Use the scoring criteria, rubric, and exemplary response not only to score students’ responses, but also to assist students in understanding what they need to do to move their responses to the next level. (Day 5)

*Rubric*—The Experimental Design Rubric (p. C-2) should be generated through collaboration between students and teacher. When teaching multiple sections of the same class, it is an option to create a master rubric by taking the best ideas from all of the class periods. (Day 7)

*Research Plan*—Collect the research proposal (Research Plan, p. B-3) developed by each group, and grade the proposals based on the rubric that was developed on Day 7.

*Worksheet*—After completing their independent inquiry experiments, students should record their experimental results and conclusions (Probing Ideas and Understandings, p. B-6), thereby demonstrating their understanding of scientific inquiry. (Day 9)

*Worksheet*—The questions for this assessment are adapted from the following passages from the National Science Education Standards developed by the NRC (1996, p. 174):

> Data manipulation and analysis strategies need to be modeled by teachers of science and practiced by students. Determining the range of the data, the mean and mode values of the data, plotting the data, developing mathematical functions from the data, and looking for anomalous data are all examples of analyses students can perform. Teachers of science can ask questions, such as “What explanation did you expect to develop from the data?” “Were there any surprises in the data?” “How confident do you feel about the accuracy of the data?” Students should answer questions such as these during full and partial inquiries.
>
> Teachers of science should engage students in conversations that focus on questions, such as “How do we know?” “How certain are you of those results?” “Is there a better way to do the investigation?” “If you had to explain this to someone who knew nothing about the project, how would you do it?” “Is there an alternative scientific explanation for the one we proposed?” “Should we do the investigation over?” “Do we need more evidence?” “What are our sources of experimental

error?" "How do you account for an explanation that is different from ours?"

Students should have one 45–50 minute class period to answer the questions appearing in Analysis of Data and Interpretation of Results (p. C-3). (Day 10)

### Unit Assessment

*Homework*—Have each student write a response, approximately one page long, to the Centers for Disease Control (CDC) Memo (CDC Response Letter, p. C-4). Students should use a standard business letter format (it may be possible to collaborate with their English teachers on this project). The letters should include a description of the research that was carried out, the results of the experiment(s), and the students' conclusions about the validity of the five-second rule and its implications to society. A suggested rubric for grading the letters is included (CDC Response Letter Rubric, p. C-5). (Day 10)

## Unit Description

### Introduction

The "five-second rule" is commonly invoked after food items have fallen to the floor. The rule claims that if food is retrieved from the floor in less than five seconds, then it is still safe to eat. Students will test this rule and determine if it is a myth to be busted or a rule to live by!

**Tips for Teachers**

To introduce the concept of scientific inquiry and to engage students, show an episode (or part of an episode, if time is short) of the popular Discovery Channel TV show *MythBusters*. Episode 12, which focuses on the bacteria in toothbrushes, is particularly applicable to biology. Information about *Mythbusters* can be found online at the website of the Discovery Channel.

Some questions for students to consider while watching the show include:

- What questions are the researchers asking?
- What is the researchers' hypothesis?
- What factors are varied during the experiment?
- What controls were used, and why?
- How did the researchers know their results were valid?

# *Suggested Teaching Strategies/Procedures*

## Days 1–5

*This guided inquiry is intended to facilitate students' understanding of the importance of a controlled experimental design. Depending on students' past experiences, the inquiry may fail to generate reliable, usable data. The data itself is not important. What is important is that students develop the experiment themselves and, through trial and error, learn what makes a good research plan and trustworthy data.*

### Materials & Resources

- ❑ CDC Memo (p. B-2)
- ❑ Microorganism Sampling Kit*
- ❑ Class notebooks*
- ❑ Research Plan (p. B-3)
- ❑ Hot plate and water bath or microwave* (for making the sterile agar petri dishes that students will need on Day 3)
- ❑ Petri dishes containing sterile agar*
- ❑ Permanent markers* (for labeling petri dishes)
- ❑ Tape*
- ❑ Disinfectant spray and/or wipes*
- ❑ Sterile swabs*
- ❑ Food samples* (e.g., gummi bears, cereal)
- ❑ Access to floors with different surfaces* (e.g., tile, carpet, concrete)
- ❑ Clock or watch*
- ❑ Autoclave or bleach*
- ❑ Disposal bags*
- ❑ What Are Microbes? (p. B-4)
- ❑ Interpreting Plates (p. B-5)
- ❑ Hand lenses and/or microscopes*
- ❑ Rulers* (for measuring colony diameter)
- ❑ Probing Ideas and Understandings (p. B-6)
- ❑ Laura's Experiment (pp. B-7–B-9)

*Materials or resources not included in the published unit

### Day 1

Before class, following the directions included in the Microorganism Sampling Kit, make the petri plates that students will need to conduct their experiments on Days 3 and 8.

Both as a preassessment of students' knowledge of scientific inquiry and as a warm-up for the unit, have students write in their class notebooks a sentence or two addressing Essential Question 1: "How does scientific inquiry affect our daily lives?" Students will revisit their responses at the end of the day and the end of the unit after their understanding of inquiry has deepened.

**Tips for Teachers**

If you have little experience in microbiology, biological supply companies like Carolina Biological and Ward's Natural Science have a wealth of easy-to-use materials and information to assist you in the safe handling of microbes in your classroom. Order an environmental microorganism sampling kit at least two weeks in advance to guarantee that the kit arrives prior to the investigation. These kits usually contain petri dishes, sterile agar, sterile swabs, disposal bags, and teacher information. Petri dishes may be divided into sections so that multiple samples can be tested on one dish. One petri dish per group will suffice, allowing a classroom kit for thirty students to be stretched to cover multiple classes. You will need to prepare the petri dishes and study the guidelines for sterile technique.

**CDC Memo**

**To:** America's High School Teachers

**From:** Centers for Disease Control and Prevention

**RE:** Food Safety Concerns

As a public service to our nation's citizens, it is imperative that the Centers for Disease Control and Prevention (CDC) determines the validity of the "five-second rule," which claims that food that has fallen on the floor can still be safely eaten if it is picked up within five seconds.

Due to budget constraints and downsizing, the CDC is severely understaffed. Therefore, we are unable to dedicate staff and resources to researching the safety of this controversial rule. The CDC is in need of scientific data to determine if the rule is correct. If this rule is incorrect, the CDC must warn citizens of potential health hazards associated with employing the five-second rule.

It is our hope that you understand the importance of this scientific study and are willing to volunteer your classroom resources and students' expertise to help us in this matter. A prompt reply is appreciated.

Sincerely,

Dr. Rosalind Blackwell

Dr. Rosalind Blackwell
Program Director
Centers for Disease Control and Prevention
www.CDC.gov

**Figure 1**

Then, distribute the CDC Memo handout (p. B-2). (See Figure 1.) After giving the students a few minutes to read it, ask the following questions:

- Who has heard of the five-second rule?
- What assumptions does the five-second rule make?
- Are there any variations of the five-second rule? What are they?
- Why should we care about the five-second rule?
- What may make food unsafe to eat after it has fallen on the floor?

Have students, in small groups, brainstorm potential answers. Reiterate the rules for brainstorming that were outlined in Unit 2, *Demystifying the Nature of Science*. Depending on the backgrounds of students, their answers will vary. If they are only considering that the food might get dirty, ask "What are some reasons it matters if food gets dirty?"

Continue questioning students until they consider the transfer of microbes from the floor to their food. Two research-based teaching strategies, which were emphasized in Unit 2, will keep students actively involved:

- Employ the Think-Pair-Share strategy (Lyman, 1981) by having students independently brainstorm answers to the questions you

ask, and then share those ideas with a partner or small group before reporting their responses to the class.
- Effectively use wait-time (Rowe, 1986) after calling on a student or group (e.g., wait at least 5 seconds before calling on another student).

In addition, effective use of communication skills by both instructors and students is conducive to the development of positive interaction in the classroom. Important nonverbal communication strategies include maintaining eye contact with students while they are talking, using affirmative nonverbal gestures, and listening without interrupting. More information about strategies for wait-time, nonverbal responses/gestures, as well as verbal responses can be found online at the website of the University of Illinois at Urbana-Champaign's Center for Teaching Excellence (2006).

When students have reached a consensus about the dangers of microbes encourage them to extend their thinking. Ask, "What factors may affect the number of microbes on food after it has rested on the floor for five seconds?" Have students work independently and then with a partner or group to come up with potential answers. Likely responses will include:

- The number of microbes on the floor
- The type of food dropped
- The material that the floor is made from

Finally, have students share their factors with the class. Continue to use wait-time and other verbal and nonverbal response strategies to help students generate a master list of factors. Add to the list as necessary (or better yet, ask additional questions that spark critical ideas). The key is to use expectant behaviors that encourage students to think and propose ideas. Record students' factors on the chalkboard. Then, ask "Which of the factors listed may have the biggest impact on the number of microorganisms on the food after five seconds?" Students will most likely narrow the list down to what is on the floor, floor type, and/or food type. As the facilitator, narrow the inquiry to floor type and food type.

Wrap up the lesson by asking students to return to their responses to Essential Question 1. Each student should draw a line underneath the original response and add new thoughts beneath the line (this may be completed as homework if necessary).

## Day 2

To continue to build upon concepts from Unit 1, *Introduction to Biology*, warm up by asking students to determine if investigating the five-second rule is an example of basic science, applied science, or technology. Encourage students to justify their responses.

Second, organize the class into groups of four students each. When forming and observing student groups, the North Central Regional Educational Laboratory (n.d.) recommends using the following procedures:

- Establish heterogeneous groups that include students of mixed abilities.
- Designate group work areas.
- Provide clear directions, rules, and procedures.
- Ensure that all group members are participating.
- Facilitate the exchange of information between groups.
- Praise and support positive and effective work within and between groups.

Additional information about small group and cooperative learning can be found online at the website of the North Central Regional Education Laboratory.

Each group should develop a research plan based on the list of factors (ideas) that were proposed and discussed on Day 1. If you say, “Each group needs to write a plan for the investigation prior to receiving materials,” students will naturally ask, “What do we need to include in our plan?” Instead of providing a step-by-step form, work with them to generate a plan so that they are mentally engaged and understand its importance. Remember, this activity is intended to develop a meaningful understanding of all parts of scientific inquiry, from planning the experiment, to conducting the experiment, to the analysis and reporting of data. If students need extra help determining what their research plans should include, use reflective questioning to focus their thinking:

- What question will you test?
- How will you test your question?
- What materials will you need to test your question?
- What do you think will happen?
- What information would a different class need to be able to understand what you did, and why?

In their groups, students should complete the Research Plan worksheet (p. B-3). At the end of class, to ensure students' safety when they conduct their investigations, collect the research plans and review them before the next class period. As you review the plans, keep a list of the most common errors made by students. For example, when you encounter a research plan that lacks a detailed procedure, place a “1” at the top of the paper; every time you encounter a plan where the prediction does not connect with the research question place a “2” at the top, and so forth. When you return the research plans, place an annotated list of the common errors and their number codes on an overhead projector. In this way, students can compare the numbers on their papers to your list and know what corrections they need to make.

Wrap up the lesson by asking students to consider Essential Question 2, “What qualities must an experiment have in order for the data to be trustworthy?”, and write a brief response to the question in their class notebooks (this may be completed as homework if necessary).

Because students will be discussing sterility tomorrow, your textbook may have a section on sterile technique that students could be asked to read for homework. There are also many websites available that describe the importance of sterile technique and discuss common laboratory procedures.

## Day 3

Return the research plans and give students time to make any necessary corrections. Meanwhile, collect students' responses to Essential Question 2 and review them.

Next, facilitate a discussion of sterile collection techniques to encourage students' success in the laboratory. Specifically, ask them the following questions:

- What is sterile technique?
- Why is it important to avoid touching the inside of petri dishes with your fingers?
- What is the purpose of sterilizing your desk before conducting experiments?

- Why is it necessary to soak petri dishes in bleach at the end of the experiments?

Students should now be ready to collect food samples and, using the Microorganism Sampling Kit, conduct their experiments as described in their research plans. If inoculation of the petri dishes containing agar happens on a Friday, students will be able to view the results on Monday. Remind students to tape their petri dishes shut when they are finished setting up their experiments. Wrap up with a brief discussion about what each group predicts will happen in their experiments, and why.

For homework, have students read the What Are Microbes? and Interpreting Plates handouts (p. B-4 and p. B-5, respectively).

**Tips for Teachers**

Lids should never be removed from inoculated petri dishes because the bacteria and fungi are potential pathogens. The used petri dishes should be sterilized using an autoclave or by soaking in a 50% bleach solution for 15 minutes prior to being placed in a disposal bag in the trash.

## Day 4

Warm up by asking students to hypothesize about the kinds of microorganisms they think will be most common on their petri dishes, and why. (At this point, students' reasons may not be very sophisticated, but it is important to encourage them to develop the habit of supplying rationales for their ideas.) After 2–3 days of room-temperature incubation, the petri dishes can be viewed. Colonies of bacteria and fungi will have begun to grow. Conduct a brief discussion about what microbes are and how to distinguish between the different types of microorganisms (e.g., bacteria, fungi). Remind students that they can use the Interpreting Plates handout to help analyze the results of their experiments. Students should use dissecting microscopes and/or hand lenses to view the colonies.

Students will usually ask questions concerning what they need to write as observations. For example, "Do we need to draw what these look like?" If they do not begin to ask questions, call on them individually to describe their petri dishes. At this time it is appropriate to discuss the differences between quantitative and qualitative data and the need for various measurement tools, such as rulers. During the discussion, have students generate lists of quantitative (e.g., number and diameters of colonies) and qualitative (e.g., color, texture) factors. Record both lists on the chalkboard. Have students copy the lists into their notebooks and use them as they record their results on the Probing Ideas and Understandings worksheet (p. B-6). This is a good opportunity to remind students of what they learned about observations and inferences in Unit 2, *Demystifying the Nature of Science*. Ask them to differentiate between their observations about the petri dishes and the inferences they can now make about the validity of the five-second rule.

As a wrap-up, ask students to write in their class notebooks a brief response to Essential Question 3: "Based on your experimental results, what are the implications of the five-second rule for society?" If necessary, have students complete their responses as homework.

## Day 5

As a warm-up, ask students to write a brief response to the question "How are bacteria different from fungi?" Discuss their responses. This will help them not only as they try to differentiate between the microorganisms on their petri dishes, but also as they analyze their results—important tasks for when they write their response letters to the CDC.

Groups should compile their results on the chalkboard. When all of the data has been collected, ask: “What conclusions can you draw from the investigation?”

Direct students to complete a Think-Pair-Share. Make your way around the classroom, listening as students discuss problems in comparing the data. They will often begin to point out the differences in their protocols: for instance, students in one group may have laid the petri dish lid on the ground and students in another group may have held the lid in their hands. This discussion can take the form of finger-pointing, and students may start to argue about which is the “correct” method. The students may have begun to point out the variables in the investigation that were not controlled and therefore led to data that is unusable and/or data in which they have little confidence. However, if students do not make these connections on their own, then ask more questions:

- What were some differences in how each group carried out the investigation?
- How might these differences have had an effect on the data?

Continue discussing problems with students’ first investigation and ideas they may have to fix these problems. During this problem-solving session, ask students to return to their responses to Essential Question 2 for ideas. If the class needs extra help, direct students’ thoughts by asking one or more of the following questions:

- How can you tell whether the bacteria or fungi growing on the plate are from the floor or whether they were already present on the food before it hit the floor?
- Which variables did you control (independent variables)? Which variables were not directly controlled by you (dependent variables)?
- What would happen if more than one variable was changed in each trial?
- What sorts of errors are present in your experiments? For example, did everyone open the petri dish in the same way? Was each piece of food left on the floor for the same amount of time? Was everything done exactly the same way in each trial?

Make a list of the students’ ideas on the chalkboard. Use these ideas to help students determine what worked and what didn’t in the initial experiment.

Students should now be ready to go back to the drawing board and follow the rules for controls and multiple trials. They may become frustrated during this work; keep in mind that their errors demonstrate how they are learning and growing.

During the next class period, groups will develop an independent research plan. They can repeat the original investigation, or they can design their own investigations, varying a different factor (e.g., location in the school, time spent on the floor) to determine the validity of the five-second rule.

Wrap up the lesson by having students again consider Essential Question 2 by writing in their class notebooks (journals) for a few minutes. Ask them how their responses have changed based on what they learned during the guided inquiry.

For homework, have students complete Laura’s Experiment (pp. B-7–B-9), a brief passage about an experiment on the growth of *Escherichia coli* (*E. coli*) bacteria at different temperatures. It is an opportunity for students to apply their new knowledge of scientific inquiry to a novel situation. It also provides students practice with creating clear and concise responses to constructed-response questions. Use the exemplary response, scoring criteria, and rubric to score students’ responses.

## Days 6–10

*In the independent inquiry students use the lessons learned in the guided inquiry to develop their own research questions and procedures. Students also develop a rubric identifying what should be included in their research plans, conduct independent research, analyze their results, and write a letter responding to the CDC Memo handout.*

### Materials & Resources

- ❑ Class notebooks*
- ❑ Research Plan (p. B-3)
- ❑ Index cards*
- ❑ Experimental Design Rubric (p. C-2)
- ❑ Hot plate and water bath or microwave* (for making the sterile agar petri dishes that students will need on Day 8)
- ❑ Petri dish containing sterile agar*
- ❑ Permanent markers* (for labeling petri dishes)
- ❑ Tape*
- ❑ Materials for Independent Inquiry
  - ✓ Disinfectant spray/wipes*
  - ✓ Sterile swabs*
  - ✓ Food samples* (e.g., gummi bears, cereal)
  - ✓ Access to floors with different surfaces* (e.g., tile, carpet, concrete)
  - ✓ Clock or watch*
  - ✓ Autoclave or bleach*
  - ✓ What are Microbes? (p. B-4)
  - ✓ Interpreting Plates (p. B-5)
  - ✓ Hand lenses and/or microscopes*
  - ✓ Rulers* (for measuring colony diameter)
- ❑ Probing Ideas and Understandings (p. B-6)
- ❑ Analysis of Data and Interpretation of Results (p. C-3)
- ❑ CDC Response Letter (p. C-4)
- ❑ CDC Response Letter Rubric (p. C-5)

*Materials or resources not included in the published unit

### Day 6

As a warm-up, begin the independent inquiry with a 3-2-1 Assessment to gauge students' current levels of understanding. Have students write three things they now understand about scientific inquiry, two things they'd like to know more about it, and one big issue in scientific inquiry that still needs to be addressed. Base instruction, group discussions, and your questions throughout the rest of the unit on students' responses to the 3-2-1 Assessment. Before moving on, ask students to hand in their homework and tell them that they will be discussing their responses to the constructed-response item on Day 7.

Students should now have developed the understanding necessary to generate a controlled scientific experiment. As groups design their experiments using the Research Plan worksheet, act as a facilitator and monitor progress. Maintain high standards and expect thoughtful planning before allowing students to proceed with the experiment on Day 8. Continue to ask questions that guide students in correcting errors in their experimental design. Such questions might include:

- What question are you asking?
- What materials will you need?
- How will you set up and perform your experiment?
- How will you quantify your results?
- How can you be sure your results are valid?

Wrap up the planning session by telling students that tomorrow they will generate a rubric that identifies the essential components of a research plan. Instruct each student to write on an index card, as homework, two components to include in the rubric.

## Day 7

As a warm-up, return students' scored constructed-response homework. Give students time to compare their responses to the exemplary response, to study the scoring criteria and rubric, and to ask questions. Because they'll be designing their own rubric, encourage students to ask questions about rubrics. Conduct a brief class discussion about what a rubric is and how it will be used in this activity.

Now that students have thought through the design of their experiments, using their homework and the Experimental Design Rubric worksheet (p. C-2), they can generate a rubric outlining how the experimental proposals should be graded. Asking "What must be a part of everyone's experimental planning in order to have reliable results?" will help students to brainstorm the requirements for their research plans. Additionally, you might ask students what should be included in a research proposal that would earn a grade of "A," what should be included to earn a "B," and so forth. Guide students to include in the rules a hypothesis, a researchable question, controls, multiple trials, and methods to collect and organize data.

Following the creation of a list of requirements, the students can suggest a point value for each component of the research plan. It may be a good idea to start with a 4-point scale where 3 points is exceptional and 0 points indicates that the student did not turn in the assignment. Examples of similar rubrics can be found online at the website of the University of Washington Extension. (Wagar, n.d.).

Having students generate the rubric is another way of teaching them how to think critically. Through the interactive development of a rubric, they also have the opportunity to add ideas and become collaborators in the evaluation process.

Following the creation of a research proposal rubric, for homework each student should create a clean copy of the group's proposed research plan. This clean copy will be used to guide their investigations and to complete the unit assessment. Students may request a clean copy of the Research Plan worksheet or type the research plan on a plain sheet of paper.

Wrap up the class by giving groups time to revise their research plans to include the components listed in the rubric. Then, as before, collect the groups' copies of the research plans to ensure that students' experiments are safe and that the appropriate supplies are available.

## Day 8

Warm up by reminding students about the principles of sterile technique and safe handling procedures for microorganisms. Using many, if not all of the materials from the guided inquiry (e.g., petri dishes, sterile swabs, food samples, floors with different surfaces), for the rest of the day students will conduct their independent inquiries. Remind students to tape their petri dishes shut when they have finished their experiments.

## Day 9

If the unit began on a Wednesday, this will be Monday. The plates will have incubated over the weekend. Using appropriate equipment, students should observe and analyze the results of their independent inquiry activities. Have them complete the Probing Ideas and Understandings worksheet. Although students may work with their groups, each student should complete the worksheet.

Wrap up by asking each group to share the real-world implications of the experiment (e.g., do their results address the concerns mentioned in the CDC Memo). For homework, students should revisit their responses to Essential Question 1, drawing a line beneath the previous entry before recording their new thoughts.

## Day 10

Warm up by discussing the Probing Ideas and Understandings worksheet. Ask if anyone has questions about their results. Then, have students complete, in groups, the Analysis of Data and Interpretation of Results worksheet (p. C-3). It addresses important concepts in scientific inquiry. What will serve students best is to discuss the worksheet with their group members and you while they use the information generated during their experiments to develop their answers.

Wrap up by discussing with the class how to use their results and answers to the worksheet questions to respond to the CDC memo. Then, for homework, each student should each compose a brief reply (approximately 1 page) to the memo from the CDC. Each reply should be in a standard business-letter format and should describe the experiments that were conducted to test the five-second rule, the results of the experiments, the student's conclusions about whether the five-second rule is valid, and the implications of the five-second rule in society. Distribute the CDC Response Letter homework (p. C-4) and the CDC Response Letter Rubric (p. C-5) before students leave for the day.

Additional information by Lindsay Trawick (2001) about writing a business letter can be found online at the website of the Online Writing Lab at Purdue University.

# Enhancing Student Learning

## Selected Course Objectives

### *A.3. Science in Practice*

c. Recognize and apply criteria that scientists use to evaluate the validity of scientific claims and theories

### *English 10 A.2. Reading Strategies*

a. Apply strategies before, during, and after reading to increase fluency and comprehension (e.g., adjusting purpose, previewing, scanning, making predictions, comparing, inferring, summarizing, using graphic organizers) with increasingly challenging texts
b. Use metacognitive skills (i.e., monitor, regulate, and orchestrate one's understanding) when reading increasingly challenging texts, using the most appropriate "fix-up" strategies (e.g., rereading, reading on, changing rate of reading, sub vocalizing)

### *English 10 A.6. Persuasive Language and Logic*

a. Distinguish between fact and opinion, basing judgments on evidence and reasoning

## Unit Extension

### *Suggested Teaching Strategies/Procedures*

**Materials & Resources**

- ❑ "If You Drop It, Should You Eat It?: Scientists Weigh In on the 5-Second Rule" by Phyllis Picklesimer (pp. D-2–D-3)

Have students read the article, "If You Drop It, Should You Eat It?: Scientists Weigh In on the 5-Second Rule" (pp. D-2–D-3), about Jillian Clark, a high school student who conducted experiments to test the five-second rule. Students can critique Clark's experimental design, compare her results with their results, and discuss whether or not the class agrees with Clark's findings.

Use the following reading strategies to help students understand the article.

- *Previewing the Text*: Students should preview the articles, noting the title, author's name, and date of publication. In addition, the students and should scan the article, noting topics introduced and the organizational structure(s) used. Students should also search for words and phrases that are italicized as well as those that stand out as intriguing or unfamiliar.
- *Asking Questions*: Students should generate a list of questions based on a preview of the text. Revisiting the questions after reading, students can identify which questions are and are not sufficiently answered by the text.

- *Asking Metacognitive Questions*: Help students develop the metacognitive skills that allow them to know when they do and do not understand a text by modeling a range of strategies to help their comprehension. Encourage students to ask and answer three questions as they read the articles: “What kinds of things am I doing to help myself understand the articles?” “Why am I doing these things?” “How do they help me, if at all?”
- *Synthesizing*: Invite students to take the information or skills they have learned and apply it to a new situation.
- *Making Connections*: Students can compare the article to a textbook or other source. Students should recognize and determine similarities (consistencies and agreements) and differences (inconsistencies and contradictions) between the texts.

## Reteaching

### *Suggested Teaching Strategies/Procedures*

Students may need additional practice problems and activities to reinforce the concepts learned in this unit. A scientific method quiz by Sandy Lautz (2001) can be found at the website *A Science Fair Handbook*. The quiz provides students with an opportunity to review the basic steps of scientific inquiry that should be included in an experiment or problem-solving activity.

Additional inquiry activities can be found at the science education website sponsored by the National Institute of Health. *Lesson 1—Inquiring Minds* (2005a) asks students to think like scientists as they examine a mystery cube and a biological cube. In *Lesson 3—Conducting a Scientific Investigation* (2005b), students are given a letter from a middle school principal describing a possible health problem. They are then asked to investigate the situation using their scientific inquiry skills.

## Reflecting on Classroom Practice

- How engaged were students in the activities?
- Did the questions you asked guide students’ thinking and aid them in making connections between activities in this and previous units?
- How well were students able to relate the activities to their daily lives?

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## Contents

# Unit Assignments and Assessments

Name: ______________________________ Period: ________________ Unit 3: The Five-Second Rule

**Directions:** Prior to starting the unit, complete the log on the next page according to the example below and distribute it to students as an organizational tool.

| Day Assigned | Assignment/Assessment | In Class | Home-work | Date Due | Feedback (Completed/ Points) |
|---|---|---|---|---|---|
| 1 | Journal Writing | X | X | | |
| 2 | Research Plan worksheet | X | | | |
| 3 | Read the What Are Microbes? and Interpreting Plates handouts | | X | | |
| 4 | Probing Ideas and Understandings worksheet | X | | | |
| 6 | Research Plan worksheet | X | | | |
| | Laura's Experiment homework | | X | | |
| 7 | Proposal of Experimental Design Rubric | X | | | |
| | Revision of Research Plan | | X | | |
| 9 | Probing Ideas and Understandings worksheet | X | | | |
| 10 | Analysis of Data and Interpretation of Results worksheet | X | | | |
| | CDC Response Letter homework and CDC Response Letter Rubric | | X | | |

# Unit Assignments and Assessments

Name: ______________________________ Period: _________________ Unit 3: The Five-Second Rule

| Day Assigned | Assignment/Assessment | In Class | Home-work | Date Due | Feedback (Completed/ Points) |
|---|---|---|---|---|---|
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## Contents

# CDC Memo

**To:** America's High School Teachers

**From:** Centers for Disease Control and Prevention

**RE:** Food Safety Concerns

As a public service to our nation's citizens, it is imperative that the Centers for Disease Control and Prevention (CDC) determines the validity of the "five-second rule," which states that food that has fallen on the floor can still be safely eaten if it is picked up within five seconds.

Due to budget constraints and downsizing, the CDC is severely understaffed. Therefore, we are unable to dedicate staff and resources to researching the safety of this controversial rule. The CDC is in need of scientific data to determine if the rule is correct. If this rule is incorrect, the CDC must warn citizens of potential health hazards associated with employing the five-second rule.

It is our hope that you understand the importance of this scientific study and are willing to volunteer your classroom resources and students' expertise to help us in this matter. A prompt reply is appreciated.

Sincerely,

Dr. Rosalind Blackwell

Dr. Rosalind Blackwell

Program Director

Center for Disease Control and Prevention

www.CDC.gov

# Research Plan

Name: ________________________________________ Period: ________ Date: ______________

**Directions:** Write a research plan in the space below. Explain the plan fully by including the details another group would need to recreate the experiment. You may write on the back if necessary. After receiving feedback, you will have an opportunity to revisit and revise your plan.

# What Are Microbes?

Microbes are the oldest form of life on earth. They include bacteria, archaea, fungi, and protists. You will likely encounter one or more of these types of microbes in your study of the five-second rule. Adapted from "What is a Microbe?" ©1999 by The American Society for Microbiology.

**Bacteria**

Bacteria fall into a category of life called the Prokaryotes. Prokaryotes' genetic material, or DNA, is not enclosed in a cellular compartment called the nucleus. Bacteria and archaea are the only prokaryotes. All other life forms are Eukaryotes, creatures whose cells have nuclei.

There are thousands of species of bacteria, but all of them are basically one of three different shapes. Some are rod- or stick-shaped and called bacilli. Others are shaped like little balls and called cocci. Others still are helical or spiral in shape. Some bacterial cells exist as individuals while others cluster together to form pairs, chains, squares or other groupings.

Bacteria live on or in just about every material and environment on Earth from soil to water to air, and from your house to arctic ice to volcanic vents. Each square centimeter of your skin averages about 100,000 bacteria. A single teaspoon of topsoil contains more than a billion (1,000,000,000) bacteria.

**Archaea**

Archaeans are single-celled creatures that join bacteria to make up a category of life called the Prokaryotes. While archaeans resemble bacteria and have some genes that are similar to bacterial genes, they also contain other genes that are more like what you'd find in eukaryotes. Furthermore, they have some genes that aren't like any found in anything else.

**Fungi**

Fungi are eukaryotic organisms—their DNA is enclosed in a nucleus. Many of them may look plant-like, but fungi do not make their own food from sunlight like plants do.

Fungi include single-celled creatures that exist individually—the yeasts—and multicellular bunches, such as molds or mushrooms. Yeast cells look like little round or oval blobs under a microscope. They're too tiny to see as individuals, but you can see large clusters of them as a white powdery coating on fruits and leaves.

Molds are described as filament-like, or filamentous, because they form long filament-like, or thread-like, strands of cells called hyphae. These hyphae are what give mold colonies their fuzzy appearance. They also form the fleshy body, or mushroom, that some species grow.

Fungi usually grow best in environments that are slightly acidic, and they can grow on substances with very low moisture. Fungi live in the soil and on your body, in your house and on plants and animals, in freshwater and seawater. A single teaspoon of topsoil contains about 120,000 fungi.

**Protists**

The category of Protists includes many widely ranging microbes, including slime molds, protozoa and primitive algae. They are all eukaryotic creatures, meaning their DNA is enclosed in a nucleus inside the cell, unlike bacteria, which are prokaryotic and have no nucleus to enclose their DNA.

# Interpreting Plates

Adapted from Beatrice Leung and Shijun Liu, "Interpreting Plates." ©2006 by the Kenneth Lafferty Hess Family Charitable Foundation.

Bacteria grow tremendously fast when supplied with an abundance of nutrients. Different types of bacteria will produce different-looking colonies. Some colonies may be colored, some colonies are circular in shape, and others are irregular. The characteristics of a colony (shape, size, pigmentation, etc.) are termed the colony morphology. Colony morphology is a way scientists can identify bacteria.

Although bacterial and fungi colonies have many characteristics and some can be rare, there are a few basic elements that you can identify for all colonies:

- **Form**—What is the basic shape of the colony? For example, circular, filamentous, etc.
- **Elevation**—What is the cross sectional shape of the colony? Turn the petri dish on end.
- **Margin**—What is the magnified shape of the edge of the colony?
- **Surface**—How does the surface of the colony appear? For example, smooth, glistening, rough, dull (opposite of glistening), rugose (wrinkled), etc.
- **Opacity**—For example, transparent (clear), opaque, translucent (almost clear, but distorted vision, like looking through frosted glass), iridescent (changing colors in reflected light), etc.
- **Chromogenesis (pigmentation)**—For example, white, buff, red, purple, etc.

Please note that three additional elements of morphology should be examined only in a supervised laboratory setting: consistency, emulsifiability, and odor.

Refer to Figure 1 for illustrated examples of form, elevation, and margin.

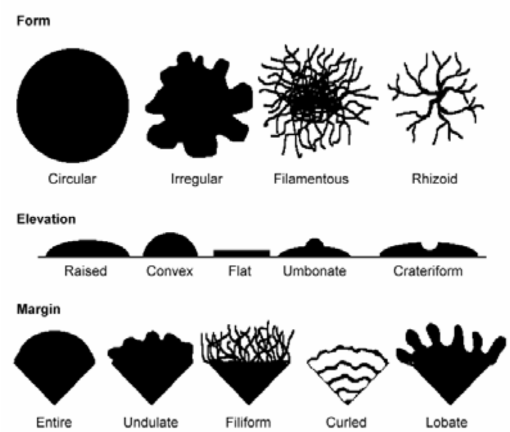


**Figure 1: Colony Shapes**

### What Can Grow on a Nutrient Agar Plate?

- **Bacteria**—Each distinct circular colony should represent an individual bacterial cell or group that has divided repeatedly. Being kept in one place, the resulting cells have accumulated to form a visible patch. Most bacterial colonies appear white, cream, or yellow in color, and fairly circular in shape.
- **Yeasts**—Yeast colonies generally look similar to bacterial colonies. Some species, such as *Candida*, can grow as white patches with a glossy surface.
- **Molds**—Molds are actually fungi, and they often appear whitish grey, with fuzzy edges. They usually turn into a different color, from the center outwards.
- **Other Fungi**—Moss green colonies, a white cloud, or a ring of spores can be attributed to the growth of *Aspergillus*, which is common in such fungal infections as athlete's foot.

# Probing Ideas and Understandings

Name: __________________________________________ Period: ________ Date: ______________

**Directions:** List the quantitative and qualitative aspects of the data from your experiment in the chart below. Compare the results of different trials. At the bottom of the page (you may write on the back if necessary), describe the conclusions that can be drawn from your data. Be prepared to defend your conclusions based on your research procedure.

| **Trial** (Include brief description) | **Quantitative Aspects of the Data** (e.g., number of colonies present, diameter of each colony) | **Qualitative Aspects of the Data** (e.g., color of the colonies, texture of the colonies) |
|---|---|---|
| **1** | | |
| **2** | | |
| **3** | | |
| **4** | | |

## Conclusions

# Laura's Experiment

Name: ________________________________________ Period: ________ Date: ______________

## Stimulus/Task

Laura knows how *Escherichia coli* (*E. coli*) bacteria will grow at room temperature, so she decides to test the hypothesis that growing *E. coli* at different temperatures will affect bacterial growth rates. Laura sets up an experiment with 6 petri dishes. She first applies an even layer of *E. coli* cells to sterile nutrient agar in 3 petri dishes. She labels these dishes A, B, and C. Then, Laura applies an even layer of distilled water to sterile nutrient agar in the remaining 3 petri dishes. She labels these dishes X, Y, and Z. Laura incubates dishes A and X at room temperature (25°C), dishes B and Y at body temperature (37°C), and dishes C and Z at refrigerator temperature (4°C). After 24 hours of incubation, Laura observes the differences in the maximum bacterial growth occurring in each dish. The results of her experiment are below.

**Directions:** Using your understanding of experimental procedure, evaluate Laura's experiment. As part of your answer, be sure to:

**Results from Laura's Experiment**

| Petri dish | Number of colonies after incubation |
|---|---|
| A | 40 |
| B | 75 |
| C | 0 |
| X | 0 |
| Y | 0 |
| Z | 0 |

- Identify the independent and dependent variables for the experiment.
- Identify which petri dishes are the best controls to test Laura's hypothesis that growing *E. coli* at different temperature will affect bacterial growth rates. Explain why the selected petri dishes are the best for this control.
- Identify which petri dishes are the best controls to make certain that the bacteria grown in the experiment came from the *E. coli* cells placed in the dishes and not from a contaminated piece of equipment. Explain why the selected petri dishes are the best for this control.
- Predict how *E. coli* might grow in food that is refrigerated, food that is left on a countertop, and food that is left in a warm place. Use evidence from the experiment to support your answer.

## Exemplary Response

The independent variable is temperature. The dependent variable is the amount of bacterial growth. The dishes labeled A and X are the best controls to test Laura's hypothesis. A control provides a basis for comparison for the variables being tested in an experiment. In this experiment, Laura hypothesized that growing *E. coli* at different temperatures will affect bacterial growth rates. The petri dishes (A and X) left at room temperature can be used as her standard for comparison because she already knows how *E. coli* grows at room temperature, but not at body temperature or at refrigerator temperature.

The dishes labeled X, Y, and Z are the best controls to make certain that the bacteria came from the *E. coli* cells. The dishes labeled X, Y, and Z are treated with distilled water to make certain that the bacteria grown in the experiment came from the *E. coli* cells placed in the dishes and not from a contaminated piece of equipment. If the control dishes grow a similar amount of bacteria as the experimental dishes, then the bacteria is coming from a different source, most likely a contaminated piece of equipment.

Food that is refrigerated should have less bacterial growth than food that is left on a countertop. Food that is left on a countertop should have less bacterial growth than food that is left in a warm place. I can make this prediction because bacterial growth decreases as the temperature decreases. I can see from Laura's experiment that at higher temperatures, there is more bacterial growth and at lower temperatures there is less bacterial growth. It seems that this same principle would apply to food left in a warm place (where temperatures are higher) and food that is refrigerated (where temperatures are lower).

## Scoring Criteria

**A 4-point response must include, but is not limited to, the following:**

**Identification of the independent variable:** The independent variable is temperature.

**Identification of the dependent variable:** The dependent variable is the amount of bacterial growth.

**Identification of the best controls to test Laura's hypothesis:** The dishes labeled A and X are the best controls to test Laura's hypothesis.

**Explanation of why the answer is correct:** A control provides a basis for comparison for the variables being tested in an experiment. In this experiment, Laura hypothesized that growing *E. coli* at different temperatures will affect bacterial growth rates. The petri dishes (A and X) left at room temperature can be used as her standard for comparison because she already knows how *E. coli* grows at room temperature, but not at body temperature or at refrigerator temperature.

**Identification of the best controls to make certain that the bacteria came from the *E. coli* cells:** The dishes labeled X, Y, and Z are the best controls to make certain that the bacteria came from the *E. coli* cells.

**Explanation of why the answer is correct:** The dishes labeled X, Y, and Z are treated with distilled water to make certain that the bacteria grown in the experiment came from the *E. coli* cells placed in the dishes and not from a contaminated piece of equipment. If the control dishes grow a similar amount of bacteria as the experimental dishes, then the bacteria is coming from a different source, most likely a contaminated piece of equipment.

**Prediction of how *E. coli* will grow in different situations:** Food that is refrigerated should have less bacterial growth than food that is left on a countertop. Food that is left on a countertop should have less bacterial growth than food that is left in a warm place.

**Evidence from the experiment to support your answer:** I can make this prediction because bacterial growth decreases as the temperature decreases. I can see from Laura's experiment that at higher temperatures, there is more bacterial growth and at lower temperatures there is less bacterial growth. It seems that this same principle would apply to food left in a warm place (where temperatures are higher) and food that is refrigerated (where temperatures are lower).

## Rubric

| | |
|---|---|
| **4** | ■ A response at this level provides evidence of *thorough* knowledge and understanding of the subject matter.<br>■ The content of the response is correct and thorough, with no significant errors.<br>■ The response contains elaboration and/or detail that demonstrates insight into scientific concepts and principles, and contains no misconceptions.<br>■ The explanation in the response is clear and is enhanced by correct use of appropriate scientific terminology to communicate understanding. |
| **3** | ■ A response at this level provides evidence of *competent* knowledge and understanding of the subject matter.<br>■ The content of the response is generally correct and complete.<br>■ The response contains some elaboration and/or detail that demonstrates sufficient understanding of scientific concepts and principles, and it may contain a few minor misconceptions.<br>■ The explanation in the response is mostly clear and is supported by some correct use of appropriate scientific terminology to communicate understanding. |
| **2** | ■ A response at this level provides evidence of *basic* knowledge and understanding of the subject matter.<br>■ The content of the response is partially correct, and it may be incomplete.<br>■ The response contains a little elaboration and/or detail to demonstrate some understanding of scientific concepts and principles, but it may contain some significant misconceptions.<br>■ The explanation in the response is sometimes clear and sometimes demonstrates correct use of appropriate scientific terminology to communicate understanding. |
| **1** | ■ A response at this level provides evidence of *minimal* knowledge and understanding of the subject matter.<br>■ The content of the response is mostly incorrect, and it is incomplete.<br>■ The response contains little or no elaboration or detail to demonstrate understanding of scientific concepts and principles, and it contains evidence of significant misconceptions.<br>■ The explanation in the response is mostly unclear and demonstrates little or no correct use of appropriate scientific terminology to communicate understanding. |
| **0** | ■ A response at this level is not scorable. The response is off-topic, blank, hostile, or otherwise not scorable. |

## Contents

# Experimental Design Rubric

Name: ________________________________________ Period: ________ Date: ______________

**Directions:** Use the form below to write suggestions for components to be included in your research plan. When the final list is complete, keep track of it as well as the point value for each component.

| Research Plan Components | Importance Rating and Rationale | Class Agreed to Include This Component (Yes/No) | Rationale (Why/Why Not?) | Point Value (100-Point Scale) |
|---|---|---|---|---|
| | | | | |
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# Analysis of Data and Interpretation of Results

Name: ________________________________________ Period: ________ Date: ______________

**Directions:** After completing the independent inquiry, answer the following questions.

1. What was your hypothesis?

2. What explanation did you expect to develop from the data?

3. What explanation can you develop from the data?

4. What about your results surprised you, and why?

5. How confident do you feel about the accuracy of the data? Explain.

6. What would be a better way to conduct the investigation?

7. If you had to explain this experiment to someone who knew nothing about it, how would it be done?

8. What would be an alternative scientific explanation for the one you proposed in question 2?

9. What additional evidence would you like to have to support your conclusion?

10. What are your sources of experimental error?

Adapted from the National Research Council, “National Science Education Standards.” ©1996 by the National Research Council.

# CDC Response Letter

Name: ________________________________________ Period: ________ Date: ______________

**Directions:** Compose a brief (1 page) reply to the memo from the CDC that explains the experiments you conducted and your conclusions about the validity of the five-second rule. Use your experimental results to defend your conclusions. The letter should be typed in a standard business-letter format and should contain no grammar or spelling mistakes. The CDC Response Letter Rubric details what should be included in your letter and how the letters will be graded.

# CDC Response Letter Rubric

Name: ________________________________________ Period: ________ Date: ______________

| Component of Letter | Criteria: 1 Point: Beginning | 2 Points: Developing | 3 Points: Accomplished | 4 Points: Exemplary | Points Awarded |
|---|---|---|---|---|---|
| **Format** | Not formatted as a letter | Formatted as a letter (e.g., contains inside address, salutation, body, closing), but not business style | Uses business style (e.g., contains inside address, salutation, body, closing), but some components may be missing or incorrect | Uses business style (e.g., contains inside address, salutation, body, closing), and necessary components are present and correct | ____ × 1 |
| **Grammar** | Many grammatical and/or spelling errors | Some grammatical and/or spelling errors | Very few grammatical or spelling errors | No grammatical or spelling errors | ____ × 1 |
| **Description of Experiment** | Description of what was done in the experiment(s) is lacking | Description is present but misses many important components and details | Description is present, and most details are included | Description is present, and all important details are included | ____ × 2 |
| **Experimental Results** | Results are not included | Some results are included, but data is not well organized and is confusing | Most results are included and data is well organized, but some details may be missing | A complete description of experimental results is included and data is well organized | ____ × 2 |
| **Conclusions** | Includes no ideas that support an understanding of how the data relates to the five-second rule | Includes some ideas that support an understanding of how the data relates to the five-second rule | Clearly shows how the data collected relates to the five-second rule | Clearly shows how the data collected relates to the five-second rule and draws logical conclusions about the validity of the five-second rule | ____ × 2 |
| | | | | **Total** | /32 |

## Contents

# If You Drop It, Should You Eat It?: Scientists Weigh In on the 5-Second Rule

Phyllis Picklesimer, "If You Drop It, Should You Eat It?: Scientists Weigh In on the 5-Second Rule." ©2003 by the Board of Trustees of the University of Illinois.

URBANA—High-school student Jillian Clarke investigated the scientific validity of the "5-second rule" during her apprenticeship in Hans Blaschek's University of Illinois lab this summer. You know the rule: If food falls to the floor and it's in contact with the floor for fewer than 5 seconds, it's safe to pick it up and eat it.

According to Clarke, a senior at the Chicago High School for Agricultural Sciences, the 5-second rule dates back to the time of Genghis Khan, who first determined how long it was safe for food to remain on a floor when dropped there. Khan had slightly lower standards, however; he specified 12 hours, more or less.

Among Clarke's findings:

- Seventy percent of women and 56 percent of men are familiar with the 5-second rule, and most use it to make decisions about tasty treats that slip through their fingers.
- University floors are remarkably clean from a microbial standpoint.
- Women are more likely than men to eat food that's been on the floor.
- Cookies and candy are much more likely to be picked up and eaten than cauliflower or broccoli.
- And, if you drop your food on a floor that does contain microorganisms, the food can be contaminated in 5 seconds or less.

A participant in the College of Agricultural, Consumer and Environmental Sciences' summer Research Apprentice Program, Clarke began by swabbing 1-inch squares of floors in a variety of locations on the U of I campus, including floors in high-traffic areas.

"We were shocked," said Meredith Agle, a Ph.D. candidate in Blaschek's food microbiology labs, who helped Clarke with the experiment. "We didn't even find a countable number of bacteria on the floor. We thought we might have made a mistake, so we tried again with the same result.

"Then we went back to look for spore-forming organisms, such as Bacillus, something that would resist dry conditions, but we couldn't find any spores either," Agle said.

Clarke then purchased smooth and rough 2-inch tiles from the hardware store so she could experiment with different surfaces and a good supply of gummy bears and fudge-striped cookies from the grocery store. Clarke's survey showed that people were more likely to retrieve cookies or candy because they value them more highly. Cookies and candy also have low levels of naturally occurring microflora, unlike fresh vegetables, meat, or cheese.

The next step was sterilizing the tiles and inoculating them with *E. coli*, then placing 25 grams of cookies or gummies on the tiles for 5 seconds. In all cases, *E. coli* was transferred from the tile to the food, demonstrating that microorganisms can be transferred from ceramic tile to food in 5 seconds or less. More *E. coli* were transferred to gummy bears from smooth tiles than from rough tiles.

To examine the surfaces of the tiles and the food, Clarke enlisted the help of Chas Conway at the University of Illinois' Beckman Institute for Advanced Science and Technology. He showed her how to use scanning electron microscopy (SEM) and environmental scanning electron microscopy (ESEM) to look at the tiles, cookies, and bears in minute detail.

Because SEM preparation causes dehydration in the sample, SEM gummy bears were especially shriveled and shrunken, resulting in an inaccurate image. Clarke was able to obtain a much more realistic image of the gummy bear surfaces with ESEM, which led her to conclude that ESEM technology, which allows foods to be imaged in their natural, hydrated state, is a more useful tool for examining such specimens.

The College of ACES' Research Apprentice Program is an intensive seven-week laboratory and academic summer program that provides hands-on science experience for talented high school juniors and seniors who are interested in careers in the food, agricultural, and environmental sciences.

## Secondary Course Objectives

A *primary course objective*

- is the central focus of the unit and
- is explicitly assessed in an embedded assessment and/or in the summative assessment.

A *secondary course objective*

- is less important to the focus of the unit, but is one that students need to know and use when completing activities for this unit and
- may or may not be explicitly assessed by the summative assessment or an embedded assessment.

Course objectives considered primary for this unit are listed on pages 1–2. Below is a list of secondary course objectives associated with this unit.

## Selected Secondary Course Objectives

### *A.3. Science in Practice*

a. Describe the fundamental assumptions of science

### *E.3. Relationships Among Organisms*

e. Distinguish between and among viruses, bacteria, and protists, and give examples of each

### *English 10 B.1. Writing Process*

b. Analyze writing assignments in terms of purpose and audience to determine which strategies to use (e.g., writing a letter to the editor endorsing need for a dog park)

c. Revise, refine, edit, and proofread own and others' writing, using appropriate tools (e.g., checklists, writing conferences, student-developed and professional rubrics or models), to find strengths and weaknesses and to seek strategies for improvement

### *English 10 B.5. Conventions of Usage*

a. Correctly spell commonly misspelled/confused words

b. Correctly choose verb forms in terms of tense, voice (i.e., active and passive), and mood for continuity

c. Make subject and verb agree in number, even when there is some text between the subject and verb

d. Use pronouns correctly (e.g., appropriate case, pronoun-antecedent agreement, clear pronoun reference)

## Course Objectives Measured by Assessments

This table presents at a glance how the course objectives are employed throughout the entire unit. It identifies those objectives that are explicitly measured by the embedded and unit assessments. The first column lists course objectives by a three-character code (e.g., A.1.a.); columns 2–6 list the assessments.

| Coded Course Objective | Embedded Assessments | | | | | Unit Assessments |
|---|---|---|---|---|---|---|
| | Research Plan | Probing Ideas and Understandings | Laura's Experiment | Experimental Design Rubric | Analysis of Data and Interpretation of Results | CDC Response Letter |
| A.1.a. | X | | | X | | |
| A.1.b. | X | | X | | | |
| A.1.c. | | X | X | | | X |
| A.1.d. | | X | X | | X | X |
| A.1.e. | | X | | | X | X |
| A.1.f. | X | | | | | |
| A.3.a. | | | | | X | |
| A.3.c. | | | | | X | X |
| A.4.c. | X | | | X | | |
| E.3.e. | | X | | | | |
| English 10 B.1.b. | | | | | | X |
| English 10 B.1.c. | | | | | | X |
| English 10 B.2.e. | | | | | | X |
| English 10 B.3.b. | | | | | | X |
| English 10 B.5.a. | | | | | | X |
| English 10 B.5.b. | | | | | | X |
| English 10 B.5.c. | | | | | | X |
| English 10 B.5.d. | | | | | | X |