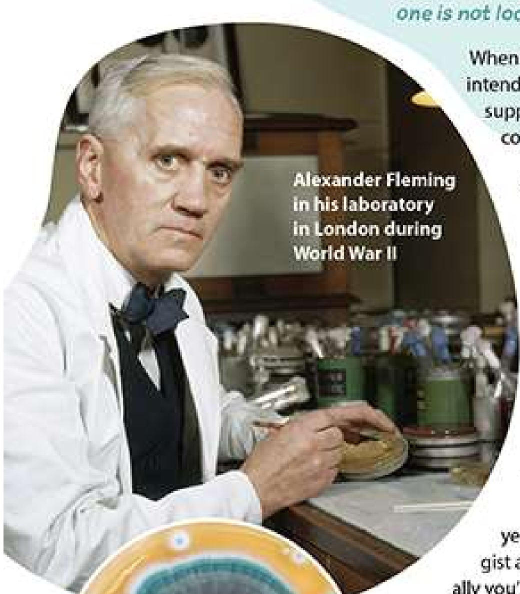
An Unexpected Discovery

"One sometimes finds what one is not looking for."



Alexander Fleming in his laboratory in London during World War II

When Alexander Fleming woke up on September 28, 1928, he wasn't intending to revolutionize medicine, but, as he would later conclude, "I suppose that was exactly what I did." The funny thing is that it was a complete accident.

Alexander Fleming was a Scottish biologist with a reputation for being a brilliant scientist, though he let his laboratory get, well, a bit messy. He returned there after a family vacation and was checking on some petri dishes holding growing bacteria. One culture looked different from the others. An airborne fungus had evidently traveled to the dish and had begun to grow in that culture. It had killed the bacteria growing around it. "That's funny," Fleming remarked. The fungus was *Penicillium*, and this unexpected discovery was the beginning of a new era in medicine. Penicillin, the antibiotic derived from *Penicillium*, would save thousands of people from diseases like scarlet fever, diphtheria, and pneumonia. Fleming received the 1945 Nobel Prize for his discovery.

A *Penicillium* culture

Though you won't be playing with dangerous bacteria this year in biology, you can develop skills to help you work like a biologist at your own level. As you work through this lab manual, occasionally you'll have to think about how to solve a problem on your own without any procedures spelled out in the lab activity. These activities will have the word "inquiring" in the subtitle. You'll learn how to obtain useful data from the tools you have to work with, things as different as smartphone apps, microscopes, and good old-fashioned glassware.

This manual is your guide as you learn to use the tools and think the way a biologist does. Be sure to check the appendixes to learn about safety rules, equipment techniques, and writing formal lab reports. Read through the procedures and follow them. Answer questions interspersed with the procedures. Measure carefully. Ask if you aren't sure what to do; check your textbook for more information. Record data carefully in the tables, drawing areas, and graphing areas provided at the end (usually) of a lab activity. And keep your mind engaged! You never know what you may discover when you do.

But what good is all of this? Why is it important to develop the skills and mindset of a biologist? If you are a Christian, you're not just a student or even a student biologist. A Christian should see science as an amazing tool to glorify God and help people by obeying God's command to wisely use His creation. We should do the work of biology within the context of a Christian worldview and use it as God intended in ways that harmonize with His Word.

So … let's get into the laboratory!

Safety Icons

Pay close attention to these icons whenever you see them.

Animal
Animals that you are to observe or collect may inflict stings or bites.

Body Protection
Chemicals, stains, or other materials could damage your skin or clothing. Wear a laboratory apron or laboratory coat and gloves as directed by your teacher.

Chemical Fumes
Chemical fumes may present a danger. Use a chemical fume hood or make sure that the area is well ventilated.

Electricity
An electrical device (hot plate, lamp, microscope) will be used. Use the device with care and watch for any frayed cords.

Extreme Temperature
Extremely hot or cold temperatures may cause skin damage. Use proper tools to handle laboratory equipment.

Eye Protection
There is a possible danger to the eyes from chemicals or other materials. Wear safety goggles.

Fire Hazard
A heat source or open flame is to be used. Be careful to avoid skin burns and the ignition of combustible materials.

Pathogen
Organisms encountered in the investigation could cause human disease.

Plant
Plants that you are to observe or collect may have sharp thorns or spines or may cause contact dermatitis (inflammation of the skin).

Poison
A substance in the investigation could be poisonous if ingested.

Sharp Object
When using equipment in this lab activity, be careful to avoid cuts from sharp instruments or broken glassware.

1A LAB

A Method to This Madness

Scientific Inquiry

Laura wants to use scientific inquiry to test whether practice can improve reaction times. To be sure that her results are valid, she decides to conduct a controlled experiment. A controlled experiment typically has two groups that are identical except for a single factor, called the *experimental*, or *independent, variable*. The group exposed to the independent variable is called the *experimental group*. The second group, the *control group*, is not exposed to the independent variable. During the experiment, the researcher measures a factor in both groups. This factor is called the *dependent variable*—it results from, or is dependent on, the independent variable. The experiment is designed to determine whether there will be a measurable difference in the dependent variable between the two groups.

Six students at Laura's school agree to be part of her experiment. To consistently measure their reaction times, she decides to use a falling meter stick. The test subject will have to catch the falling meter stick after seeing it begin to fall. The distance that it falls before being stopped will indirectly measure reaction time. She formulates a hypothesis: The reaction time of students who have practiced catching the meter stick will be less than their reaction time before having practiced.

Each of the six students places a thumb and forefinger on the edge of a ring stand and keeps eyes closed. Laura positions the meter stick in the center of the ring stand so that the end is level with the student's fingers. At Laura's instruction, the student opens his or her eyes and Laura drops the meter stick. Her friend records how far the meter stick drops before the student catches it. Laura repeats these procedures with each student and averages the results.

Laura repeats the experiment five more times and plots the six averages on a bar graph to see whether student reaction times have improved with practice. The independent variable is the amount of practice, and the dependent variable is the reaction time.

How do scientists find answers to their questions?

Equipment

meter stick

QUESTIONS

- How can you use scientific inquiry to answer questions?
- What is a controlled experiment?
- How is a controlled experiment used to answer scientific questions?

PROCEDURE

Now it's your turn. You will conduct a different experiment with a different experimental variable. You will test whether a person can catch a meter stick faster if given a heads-up that it is about to be dropped. Your classmates will form both the experimental and control groups.

1. Scientists often start out with a research problem—the question they are trying to answer. What is your research problem?

2. What is your hypothesis?

Your teacher will be the "caller" and will divide the class into teams consisting of a "dropper" and a "catcher." Each team should record its own results. Remember, each lab group is part of two groups: the experimental group and the control group.

3. What are three variables that you need to keep constant?

4. What is the independent variable?

5. What is the dependent variable?

After each pair of droppers and catchers is provided with a meter stick, the droppers will hold it up for the catchers to catch, keeping constant the variables identified in Question 3.

A *Experimental Group:* The caller calls out a sequence such as "1, 2, 3, drop," or "Ready, set, go." This will alert droppers to drop their meter sticks in unison. Record the distance that the meter stick fell before it was caught in the *Trial 1* row of Table 1.

B *Control Group:* The experiment will now be repeated, but the caller will stand where not visible to the catchers and will signal silently to the droppers to drop their meter sticks. Record the distance the meter stick fell in the *Trial 1* row of Table 1.

C Repeat Steps A and B four times, recording the results for Trials 2–5 in Table 1.

ANALYSIS

D For each team, average your experimental group scores and your control group scores and record the averages in Table 1. Make a bar graph of the data in Graphing Area A.

E Copy the averages from Table 1 to the first row of Table 2. Obtain the experimental group averages and the control group averages from your classmates and record them in Table 2. Average these averages and record the results in Table 2. Create a bar graph of the data in Graphing Area B.

6. What conclusions can be drawn from the data?

7. Does the data support the hypothesis? Explain.

PERSONAL OBSERVATIONS

8. Did your repeated trials yield similar results? If not, suggest some sources of error that might have affected your results.

9. What could you do to make the repeated trials of your experiment closer in value?

10. Can you think of any additional changes that need to be made?

11. On the basis of your experience, what other experiments dealing with response time would you like to try?

GOING FURTHER

You read a news article about a scientific study into whether Kentucky bluegrass (*Poa pratensis*) or timothy (*Phleum pratense*) is a better grass for raising horses. A herd of thirty thoroughbreds was pastured in a field of Kentucky bluegrass in Tennessee, and a herd of thirty mustangs was pastured in a field of timothy in Arizona. At the end of the yearlong study the average weight gain of the thoroughbreds was greater than the average weight gain of the mustangs. The study concluded that Kentucky bluegrass is a better fodder for horses.

12. This study has some problems, primarily with keeping the two groups the same except for the experimental variable. Redesign this experiment in a way that corrects these problems.

TABLE 1 Group Data

	Experimental Group Distance (cm)	Control Group Distance (cm)
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Average		

TABLE 2 Class Data (Averages)

	Experimental Group Distance (cm)	Control Group Distance (cm)
Your Averages		
Classmate's Averages		
Classmate's Averages		
Classmate's Averages		
Classmate's Averages		
Average		

GRAPHING AREA A

GRAPHING AREA B

1B LAB

More Than Meets the Eye

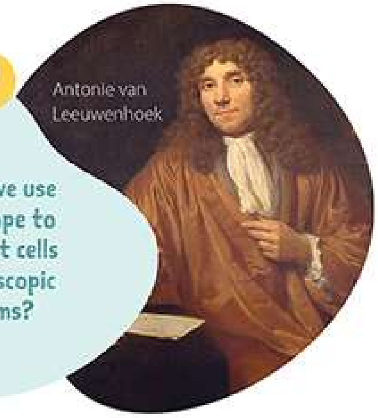
The Microscope

In 1676 a Dutch cloth merchant named Antonie van Leeuwenhoek was investigating what gives pepper its hot taste. His hobby was making lenses, and with them he had already discovered many things too tiny to see with the unaided eye. But on this particular day he saw creatures much smaller than he or anyone else had ever seen before: bacteria.

Van Leeuwenhoek made and used simple (single-lens) microscopes because the low-quality compound microscopes of his day distorted images. His simple microscopes could sometimes render clear images at magnifications four times greater than existing compound microscopes. The secret to van Leeuwenhoek's success was his skill at making lenses, using a technique that he kept secret. But by the middle of the 1800s lens designers had greatly improved the compound microscope, allowing microbiologists to see things with greater clarity. Today almost all light microscopes are compound microscopes; simple microscopes are usually called *hand lenses* or *magnifying glasses*. A compound microscope is a very important tool in almost any field of biology.

In this lab activity you will learn how to use a microscope to study tiny life-forms, much as van Leeuwenhoek did almost 350 years ago.

How can we use a microscope to learn about cells and microscopic organisms?



Antonie van Leeuwenhoek

QUESTIONS

- What are the parts of a microscope?
- What is the proper care for a microscope?
- How is a microscope used?

Equipment

- microscope
- lens paper
- tissue
- preserved slide of desmids or diatoms
- immersion oil

PROCEDURE

The Structure of Your Microscope

As you study the infographic below, find each part on your microscope and check the box that goes with that part.

Adjustment Knobs ☐
Most microscopes have two types of adjustment knobs, one of each on each side of the microscope. The larger coarse adjustment knob allows you to rapidly change the distance between the specimen and the objective. The smaller fine adjustment knob is usually found underneath or centered on the coarse adjustment knob. It allows you to change the distance between the specimen and the objective slightly, producing a sharper focus.

Body Tube ☐
For a compound microscope to function properly, the two lenses must remain a certain distance apart. This long, narrow tube maintains that distance. In microscopes with an inclined body tube, mirrors are used to bend the path of the image.

Eyepiece ☐
This holds the top lens of the two lenses in a compound microscope. It is sometimes called the *ocular lens*.

Arm ☐
This "backbone" of the microscope supports the body tube.

Nosepiece ☐
This rotating disc at the bottom of the body tube holds the objectives, the metal cylinders that contain the bottom lenses of a compound microscope. Most microscopes have several different objectives that you can interchange by rotating the nosepiece. Each objective has a different power of magnification.

Stage ☐
This platform positioned directly below the objectives and above the light source supports the specimen.

Diaphragm and Substage Condenser ☐
These are located between the stage and light source. The diaphragm regulates the amount of light that passes through the specimen. The substage condenser provides a clearer image by bending and concentrating light before it reaches the specimen.

Stage Clips ☐
These fasteners on top of the stage hold the slide containing the specimen firmly in place.

Base ☐
This large rectangular or horseshoe-shaped structure supports the microscope and keeps it steady.

Light Source ☐
This is typically some type of light bulb, and in many microscopes you can adjust the amount of light being produced.