LABORATORY 1

Introduction to Biology and the Scientific Method

SCENARIO: CAFFEINE CAUSES CONTROVERSY?

REPORT 1:

PERSONAL TIME/YOUR HEALTH DECEMBER 6, 1999 VOL. 154 NO. 23

JAVA MAMA, BEWARE Put down that mug! A huge study of 42,000 pregnant women concludes that consuming lots of caffeine—the amount in five or more cups of coffee a day—doubles the odds of a miscarriage. Unlike previous studies, researchers didn't rely on what women said they drank. Instead they measured a byproduct of caffeine found in blood, called paraxanthine. Going cold turkey may not be necessary though: one or two cups daily seems fine.

Source: New England Journal of Medicine (11/25/99).

REPORT 2:

Cosponsored by: The Association of Women's Health, Obstetric, and Neonatal Nurses, July 1998.

MISCARRIAGES

The association between caffeine and miscarriages continues to be researched. Recently, researchers from McGill University in Montreal published a study showing a relationship between caffeine intake and miscarriage. While caffeine intake before and during pregnancy appeared to be associated with increased fetal loss, the authors failed to account for a number of factors that could result in a false association, including effects of morning sickness or nausea, the number of cigarettes smoked and amount of alcohol consumed.

Just prior to the McGill study, a research team from the U.S. National Institute of Child Health and Human Development conducted a study of 431 women. The researchers monitored the

women and the amount of caffeine they consumed from conception to birth. After accounting for nausea, smoking, alcohol use and maternal age, the researchers found no relationship between caffeine consumption of up to 300 mg per day and adverse pregnancy outcomes, including miscarriage. [Note: 300 mg caffeine is about the amount contained in three cups of coffee.]

Reprinted from http://www.time.com/time/magazine/article/0,9171,35107,00.html and http://ificinfo.health.org/brochure/caff-wh.htm 1/2001.

DISCUSSION:

1. Are you inclined to believe one of these reports more than the other? Which one and why?

2. Would you want to know additional information before deciding which to believe? What questions would you ask?

3. How would your opinion change if one of the studies had been sponsored by Starbucks or Folgers?

4. What would you advise if you, or someone close to you, were pregnant?

Laboratory Investigations

OBJECTIVES:

From this experience, you should be able to

- differentiate between the steps in the scientific process
- define hypothesis and list the characteristics of a good scientific hypothesis
- define control and distinguish between positive and negative controls
- define variable and distinguish between dependent and independent variables
- list the five biological kingdoms and give the principle characteristics of each
- identify example cells from each kingdom

INTRODUCTION: THE SCIENTIFIC METHOD

Biology is the study of life. Biologists are scientists who observe life, ask questions about what they see, design experiments to answer those questions, and ultimately try to explain what they observe. Biology is not simply a collection of facts, but a systematic study of living phenomena. A technique known as the scientific method is used by many scientists, including biologists, to augment the body of scientific knowledge. This method is a somewhat different approach than the way other disciplines, such as history, music, or art, answer questions and add to the knowledge in those domains. The scientific method uses the following four steps to attempt to understand natural phenomena.

In order to answer a scientific question, sometimes it is only necessary to observe: for example, "How do dogs and cats look different?" For other questions, you want explanations for what you observed. To do that you propose an hypothesis: a tentative answer to the question. A "good" hypothesis is one that restates a question with a possible explanation for what was observed. Hypotheses state possible causes and reflect past experience with similar questions. Sometimes they are referred to as guesses; but, at the very least, they must be "educated" guesses. One of the most important characteristics of a good hypothesis is that it is testable by an observation or an experiment. An hypothesis that states "DNA was brought to the planet by aliens" is not a testable hypothesis.

The scientist designs an experiment to test the hypothesis in a controlled way, meaning that the design must contrast an experimental group with a control group. The two groups are treated exactly alike, except for the one variable (characteristic) being tested (called the **independent variable**). Finally, the results of the experiment must be interpreted and compared to the hypothesis. If the hypothesis is eliminated, one should propose an alternative hypothesis that is also testable and is compatible with the observed results.

CATEGORIES OF LIFE

DOMAIN/ KINGDOM	CELL TYPE	CHARACTERISTICS	NUTRITION	EXAMPLES
Domain Archaeae	Prokaryote	Simplest structure. No nucleus. No membrane-bound organelles. Can exist in extreme environments.	Autotrophs ("self-feeding" – make their own food) or Heterotrophs	Thermophiles Halophilic (salt-loving) organisms
Domain Bacteriae (Formerly Kingdom Monera)	Prokaryote	Simplest structure. No nucleus. No membrane-bound organelles. Can be filamentous.	Autotrophs or Heterotrophs (Eat other organisms)	Bacteria Cyanobacteriae (blue green algae)
Eukarya/ Protista (Under reclassification)	Eukaryote	Single-celled organisms. Membrane-bound nucleus. May have chloroplasts.	Autotrophs or Heterotrophs	Euglena Paramecium
Eukarya/ Fungi	Eukaryote	Membrane-bound nucleus. Often produce spores. Usually filamentous.	Heterotrophs	Yeast Penicillium
Eukarya/ Plantae	Eukaryote	Membrane-bound nucleus. Chloroplasts. Cell wall. Central vacuole. Multicellular.	Autotrophs	Flowering Plants, Algae
Eukarya/ Animalae	Eukaryote	Membrane-bound nucleus. No cell wall. Centrioles. Multicellular.	Heterotrophs	Insects Mammals

INVESTIGATION I: OBSERVATION AND CLASSIFICATION

OBJECTIVE:

To classify various cells according to their observed characteristics and compare that to their classification into biological categories (kingdoms or domains).

MATERIALS:

- microscope
- slide and coverslip
- methylene blue stain
- 4 prepared slides of unknown cells

PREDICT:

You will observe 5 cells under the microscope, representing different categories of organisms.

1. How might you expect these specimens to be different?

2 How might they be similar?

PROTOCOL:

Work in groups of up to six. One member of your group will prepare a sample of cheek epithelial cells as follows.

1. Place a drop of methylene blue stain on a slide (see Figure 1-1).

2. Using the broad end of a flat toothpick, gently scrape the inside of your cheek.

3. Cover with a coverslip and view under the microscope using the low power (4x) objective; adjust the focus. Find a single cell that is flat, not folded over, by moving the slide on the stage.

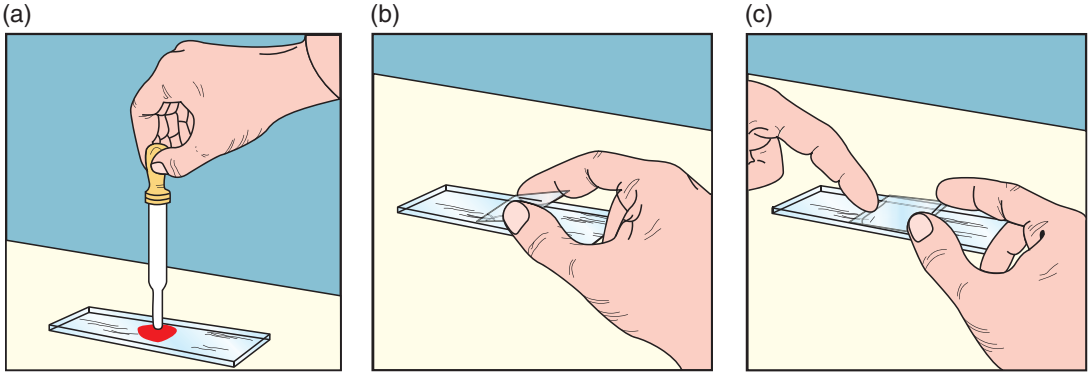

Figure 1-1. Wet mount technique.

4. Keeping the specimen in the center of the field, move the 10x objective into place; focus, and then move the high power objective into place.

5. Record characteristics of the specimen, such as color, shape, etc., on the response/data sheet in Table 1-1, including any intracellular structures that you can identify. Put any other notable observation, such as whether the organism is moving, etc., under the column headed "Other."

6. Repeat Steps 4 and 5 for the remaining specimens that have been prepared for your observation.

7. Compare the various characteristics of the cells and propose a classification system based on their similarities and differences. Compare the appearance of each specimen and decide which organisms might be appropriately grouped together. Record your proposed groupings in Table 1-1.

QUESTIONS:

1. Which of the cells would you classify together because of similarities? Why?

2. Which cells would you classify separately because of their differences? Why?

3. How can you tell if the sizes of the cells are different?

Using the materials available in lab, label the major cellular structures in your drawings, such as nucleus, cell membrane, etc. (See Figure 1-2.)

HYPOTHESIZE:

Using your observations, the table entitled "Categories of Life," and Appendix A, generate hypotheses regarding the biological category to which each of the five cells belong. Several may belong to the same kingdom, while some kingdoms may not be represented. Record your hypotheses about which kingdoms the organisms are members of in Table 1-1.

Be ready to defend your hypotheses based on your observations.

SHARE:

Check with your instructor regarding the results of your experiment. Using the video microscope available in class, share the results of your investigation with your classmates.

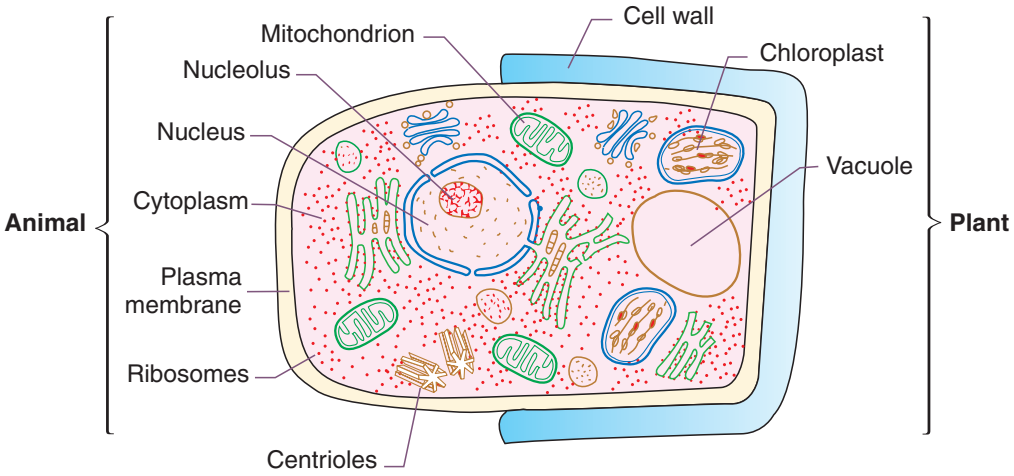

Figure 1-2. Typical cell structures.

INVESTIGATION 2: MAKING CONCLUSIONS BASED ON INDIRECT EVIDENCE

OBJECTIVE:

To demonstrate that in many scientific investigations you are unable to directly make observations about what you are studying, but must rely on instruments or alternative methods of investigation to draw conclusions.

MATERIALS:

- 3 Ob-scertainer® boxes, containing 1 steel ball each

PROTOCOL:

1. Obtain the bag containing three Ob-scertainer® boxes marked with your group's number. Share the boxes among the members of your group, but work independently to determine the inside shape of your boxes.

2. Write down the number of each of your three boxes on Figure 1-4 on your response sheet. These are located on the bottom of each box.

3. Try to determine the shape inside each box by tilting, shaking, and rolling the ball inside. DO NOT OPEN ANY OF THE BOXES. Do not spend more than 5 minutes on any of the boxes.

4. On Figure 1-4, under the column entitled "Hypothesis," draw what you think is the interior shape of your Ob-scertainer® box.

5. After everyone has drawn their hypothesis, your instructor will display a chart showing all the possible shapes inside the Ob-scertainers®. Select the shape that most closely matches your drawing, and write the letter of the shape you've chosen next to your drawing.

6. Test each box again to see if it matches the shape you have selected, and draw it in the second circle under the column labeled "Revised Hypothesis."

7. At the end of class, your instructor will show you the actual configuration for each box number. Draw this shape in the last circle.

QUESTIONS:

1. How confident were you in your designations?

2. Were you correct?

3. If not, what led you to be incorrect?

SHARE:

Compare your results with those of others in your group. Were some shapes easier to determine than others? Why or why not?

MAKE CONNECTIONS:

1. How does this method of investigation differ from the method in Investigation 1?

2. Is this one more or less reliable than that method?

INVESTIGATION 3: EXPLORING VARIABLES THAT AFFECT RECOVERY OF PULSE RATE

OBJECTIVE:

To design an experiment to test the effect that certain variables may have on pulse rate recovery. When designing an experiment, you determine a **dependent variable** and an **independent variable**. An independent variable is the characteristic you control and manipulate between two or more groups. The dependent variable is the outcome you measure. You know independent variables in advance—you choose the independent variable for each experiment. For example, a drag-race can be an experiment. The question is: "Which car is the fastest?" The independent variable is car type (Toyota vs. Honda, for example); the dependent variable would be time (to complete a ¼-mile race).

MATERIALS:

- platform or step, 8-inches high
- clock with second hand
- metronome, set at 132

QUESTION:

As a class, formulate at least two or three questions about variables that may affect cardiovascular fitness: for example, "Does cigarette smoking have an adverse effect on fitness?" Write your questions on the response sheet, focusing on questions that are testable by experimentation.

HYPOTHESIZE:

From the list of questions, generate an hypothesis about cardiovascular fitness that all teams will investigate. Make sure that this is an hypothesis that can be tested during today's lab. Write it on the lab response/data sheet.

Test your hypothesis using the protocol below.

PROTOCOL:

1. Two students from your group will be the subjects (students with health problems, especially heart or respiratory disease, should not volunteer).

2. Determine which of your two subjects will serve as the control and which will be the experimental subject, based on your hypothesis.

3. The remaining members of your team should be timers and recorders (pulse-takers).

4. Measure the subjects' pulse rate for 30 seconds and multiply by 2. Record the initial pulse rate in Table 1-2.

5. Both subjects step up and down on the platform for 3 minutes at a rate of 30 steps/minute; use a metronome set to 132 to help you step at the right rate. (See Figure 1-3.)

6. Measure the subjects' pulse rate immediately after completing the step test. Record this rate in Table 1-2.

7. Measure the subject's pulse rate at intervals of 1 minute (measure 30 seconds, wait 30 seconds) until pulse returns to normal.

8. Record the time it took for the pulse to return to normal for your two subjects in Table 1-2.

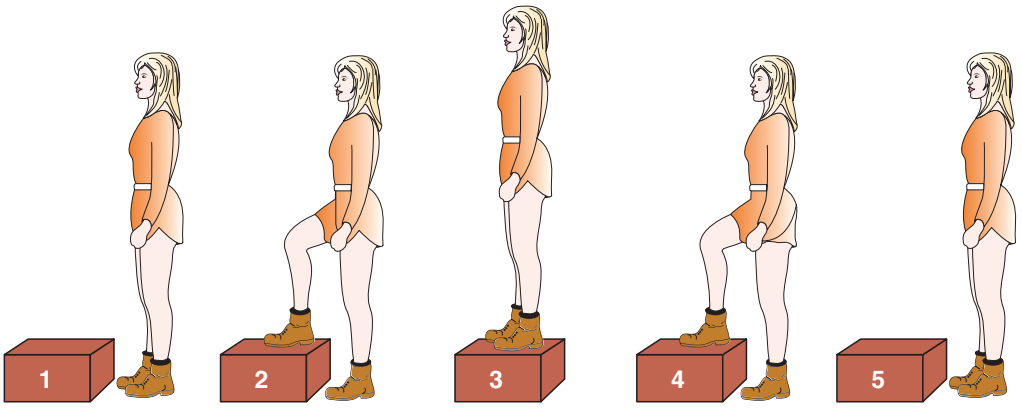

Figure 1-3. Step test procedure.

QUESTIONS:

1. What was the dependent variable for this experiment (the outcome you measured)?
2. What was the independent variable (the characteristic that differed between the subjects)?
3. What were other potential variables you attempted to control (factors that you hold constant so as not to affect the outcome)?

SHARE:

Record the results of all 4 teams' experiments into Table 1-2, and average.

MAKE CONNECTIONS:

1. What conclusions can you draw from this experiment?
2. Does your data support or reject your hypothesis? Why?
3. How does this experiment differ from those in the previous investigations?
4. Are there other variables that could have affected your measurements?

DISCUSSION:

1. Returning to the introductory scenario:
   a. What are the reasons that different studies can provide contradictory results?
   b. What are the important factors to keep in mind when designing an experiment?

Student Name _____

Date _____ Group _____

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Response/Data Sheet

SCENARIO DISCUSSION QUESTIONS—CAFFEINE:

1.

2.

3.

4.

INVESTIGATION 1: OBSERVATION AND CLASSIFICATION

PREDICT:

1.

2.

Table 1-1.

Cell#	Shape	Color	Intracellular Structures	Other	Kingdom
1					
2					
3					
4					
5					

QUESTIONS:

1.

2.

3.

INVESTIGATION 2: MAKING CONCLUSIONS BASED ON INDIRECT EVIDENCE

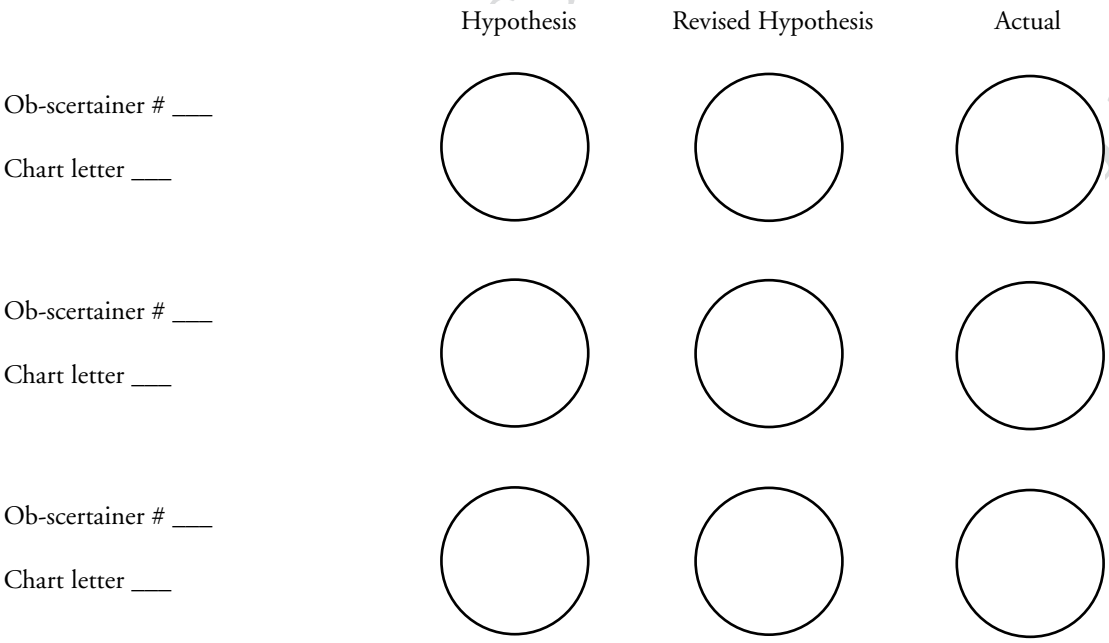

Figure 1-4. Observation based on indirect evidence.

QUESTIONS:

1.

2.

3.

MAKE CONNECTIONS:

1.

2.

INVESTIGATION 3: EXPLORING VARIABLES THAT AFFECT RECOVERY OF PULSE RATE

POSSIBLE QUESTIONS FOR INVESTIGATION:

1.

2.

3.

HYPOTHESIS:

Table 1-2.

Independent Variables	Dependent Variable	Team 1	Team 2	Team 3	Team 4	Avg.
Subject 1 Control	Initial Pulse Rate					
	3-Minute Pulse Rate					
	Pulse Recovery Time					
Subject 2 Experimental	Initial Pulse Rate					
	3-Minute Pulse Rate					
	Pulse Recovery Time					

QUESTIONS:

1.

2.

3.

MAKE CONNECTIONS:

1.

2.

3.

4.

DISCUSSION:

1a.

1b.