The Scientific Method and Protocol Writing Exercise

A. Objectives

1. Recognize the stages of the scientific method as it applies to everyday experiences;
2. Apply the scientific method to biological questions;
3. Design scientific experiments to test hypotheses;
4. Discuss political and social aspects governing scientific inquiry;
5. Discuss multiple hypotheses, chance, and intuition;
6. Practice writing a protocol for a laboratory exercise.

B. Before coming to lab

1. Read "Scientists use two main forms of inquiry in their study of nature" in Campbell et al., *Biology*, pp. 19-24.
2. As you read the assigned pages in Campbell et al., fill out the attached reading guide (Part E).

C. During lab

1. Take notes during your instructor's lecture on the scientific method.
2. In a group of four, complete the exercise in Part F.
3. In a group of two, complete the exercise in Part G, paying special attention to the part on protocols.

D. After lab

Usually, each lab is followed by a review worksheet. You should answer all questions as soon as possible after the lab period. Identify the questions you cannot answer and ask your instructor for clarification at the beginning of the next lab period. You do not need to copy questions or answers to these worksheets to your lab notebook.

Some resources for those curious about the scientific endeavor (let me know if you find good articles or websites on any of the topics covered in lecture or lab):

Begley, S with A. Rogers. *The Science Wars*. Accessed on 7/25/02 at http://maxweber.hunter.cuny.edu/~bseegmil/psych150/sciencewars.htm

Chamberlin, R. *The Method of Multiple Working Hypotheses*. Science 148(754). Available in the BAT lab.

Keller. E. (1983) *A Feeling for the Organism – The Life and Work of Barbara McClintock.* Freeman.

Slowiczek, F. and P. Peters. *Discovery, Chance and the Scientific Method*. Accessed on 7/26/02 at http://www.accessexcellence.org/AE/AEC/CC/chance.html.

E. Reading guide "Scientists use two main forms of inquiry in their study of nature" (fill in before lab)

1. Distinguish between the two main types of scientific inquiry.

2. Distinguish between **qualitative** and **quantitative** data. Give an example of each.

3. Define **inductive reasoning**, give an example.

4. Define **deductive reasoning,** give an example.

5. Which two important qualities must scientific hypotheses have?

6. The scientific method is often described as a series of steps. For each of the steps listed below, write down how this step was applied in the case study "Investigating Mimicry in Snake Populations".
   Observation(s):

   Question(s):

   Hypothesis:

Prediction(s) (*If…then…):*

7. Test:

   Results:

   Conclusion (Are the hypotheses rejected or supported)?

8. Identify the experimental and control groups in this case study. How do they differ?

F. Worksheet (fill in after your instructor's lecture)

1. Which of the following are valid scientific questions? Explain.

    a. Does cigarette smoke cause lung cancer?

    b. Did the uni-bomber hear voices from god?

    c. Is the uni-bomber mentally competent?

    d. Why are leaves green?

    e. Are vitamins good for you?

2. Give an example for the subjectivity of observation from your own life.

3. Give an example for how social context influences scientific research.

4. Define hypothesis.

5. Why is it desirable to formulate multiple hypotheses?

6. Give several examples of factors that might contribute to bias. What measures are taken to avoid bias?

7. Give examples for two other important contributing factors in important discoveries.

8. Define control group, controlled experiment, independent variable, dependent variable and control variable.

9. In the study of mimicry in snake populations identify independent variable, dependent variable and control variable(s).

G. Building models, writing protocols

Models are important tools used by scientists to help them understand nature and predict the outcomes of changing variables.

1. Work in groups of two. The goal is to build the cyclic (furanose) form of a beta-D-ribose molecule. To refresh your memory, Figure 1 depicts such a molecule in the Haworth projection. Remember that in the Haworth projection

    - Carbon is the implicit type of atom. In the figure below, the corners 1 through 4 are all carbon atoms.
    - A thicker line indicates atoms that are closer to the observer. In the example below, atoms 2 and 3 (and their corresponding OH groups) are the closest to the observer, atoms 1 and 4 are further from the observer and finally the remaining atoms (5, etc.) are the furthest.

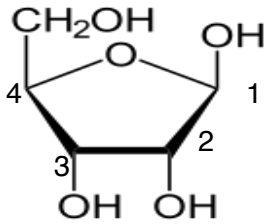

Figure 1: Beta-D-Ribofuranose, Haworth projection (Source: http://www.wikimedia.org)

2. Get the appropriate number of balls representing carbon (black), oxygen (red) and hydrogen (yellow) as well as connectors and put them on your tray.
3. Write a protocol in your notebook for building a ribose molecule with the parts provided in front of you. Refer to Appendix B to refresh your memory on how to write protocols.
4. Exchange your protocol with another group. Carry out their protocol. Make sure you really follow their protocol to the dot - ignore what you know you should do. Let's see whether their protocol will actually lead you to build a beta-D-ribofuranose!
5. Exchange feedback on the protocols with the other group.
6. Completely disassemble your molecules and put the parts back to where you got them from.