Using Inquiry to Teach Microscope Skills

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Introduction

One of the first lab activities often done in a high school biology course is learning to use the microscope. As it is typically described in laboratory manuals, there is no inquiry involved in this activity. Students learn the parts of the microscope and information explaining its operation. There may be a review of the metric system. Then students examine cells, often to observe the difference between plant and animal cells. Students may be instructed to prepare wet mounts and do simple staining. All of these are important skills to have in order to use the microscope correctly, but it doesn't give students the chance to *do* science.

This activity introduces students to the inquiry process as they learn about and practice using the microscope. Current national science standards state that all students should participate in scientific investigations as well as understand about the nature of science inquiry (NRC 2012; NGSS 2012). The activity described in this paper asks students to design and carry out a simple experiment about the thickness of hair. Students collect evidence through experimentation in which they ask a question, design a procedure to answer that question, record data, analyze the data, and draw conclusions.

The Class Activity

Students are introduced to the compound microscope, learning its parts, proper use, magnification, and how to measure. If the microscopes do not have ocular micrometers, a clear, thin plastic ruler with millimeter markings can be set in the field of view so that hair can be lined up for measurement. Students can practice using the microscope and measure their own hair thickness.

Students formulate a question about the thickness of human hair that can be answered with the available lab equipment. If you have access to non-human hair, this can be included as well. (Note: Some students may be allergic to the dander in pet hair.) Sidebar 1 gives ideas that can help students formulate a question. The teacher should review each student's question to ensure feasibility.

Sidebar 1. Possible Sources of Hair

Hair may be obtained from your own head or body, or (if willing) from many classmates' and teacher's head. The hair may be moussed, sprayed, dyed, bleached; curly, straight, wavy; red, brown, black or some variation.

Next, students design their experiment. Information on the hallmarks of good experimental design (see sidebar 2) includes dependent, independent, controlled variables and experimental validity. This sets the stage for some simple statistical analysis, such as mean, median, and mode. In advanced classes, standard deviation and the use of t-tests can also be included. There are many educational web sites that explain how to do these statistics with Microsoft Excel, for example, as well as online resources.
http://www.vassarstats.net/
http://easycalculation.com/statistics/standard-deviation.php
http://studentsttest.com/

With this information, students construct an experimental protocol that will answer their question.

Students can collect hair samples outside of class for the next lab period. After students make measurements, they calculate the mean, median, and mode of their data. Depending on the experimental question, students may calculate the standard deviation, do a paired t test, or a one-sample t-test. For example, if a student question was to find the thickness of hair on his or her head, standard deviation would be calculated. The standard deviation tells how far an individual hair measurement is from the mean value of the hair measurements. If the question was whether black hair is thicker than blonde hair, students would use the two-sample *t*-test to determine if the two population means are equal. If the question was to see whether or not there is a difference in arm hair thickness compared to head hair thickness taken from the same individual, the paired-sample t-test would be used.

Sidebar 2. Hallmarks of Good Experimental Design
(Modified from McCormick, B. and C. MacKinnon, 2004)

Dependent variable. This is the factor that you are measuring. It is the one thing in the experiment that you can't control. Changes in the dependent variable depend on what you do when setting up the experiment.

How will you measure the dependent variable?

Independent variable. This is the factor in the experiment that you choose to change. It is the one thing that is different between the samples being studied. The choices made in selecting the independent variable and decisions on how to change it should be considered in relation to how they address the research question.

How will you change the independent variable?

Controls. There are many things that can be altered between samples in an experiment. A well-designed experiment has as few variables as possible. In addition, a good experiment controls all of the factors that can be controlled, so that the changes in the dependent variable can be attributed to the changes you made in the independent variable.

What will you do to make sure there are controls?

Validity. Accuracy and precision are important in experimental results. In many types of experiments, you will need to make multiple measurements to show that your results are both accurate and precise. The use of statistics shows how consistent your data are.

How can you be as certain as possible that your conclusions are reliable?

Sidebar 3. How do Scientists Report on Their Findings?

(Modified from Pechenik, 2012).

Now that you have some evidence that supports a conclusion about hair thickness, what do you do with this? Ultimately, scientists put their evidence and conclusions in front of their peers to be reviewed and either accepted or rejected. The most common way is through publication in a peer-reviewed journal. Now, we won't do this with your hair data, but we will learn about the highly stylized form of writing that is done for this kind of journal.

There is a conventional format to follow in communicating your findings to the scientific community. Below you will find a brief description of that format and the requirements of each section.

Title

The function of the title is to succinctly convey the important points uncovered by your experimentation. The title should be short and unambiguous.

Abstract

This is a short summary of the important points of the paper. This can be general statements telling your reader the importance of this work. A statement of rationale is often found in this section: why you performed the work described in the paper. Also, a brief statement of conclusion is given: the important findings that are described in the paper. Data should not be presented in an abstract. Neither should experimental methods be presented here, unless the paper is concerned with the development of an important, new technique. An abstract should be no longer than about two hundred words.

Introduction

The function of the introduction is to provide background and rationale for your research. Background is provided by writing short review of the literature in the field of your research. State the question being asked and answered. You may also include your expectations prior to performing the experiment.

Materials and Methods

This section is used to give the procedural details of your work. It should be written so that any well-versed reader could easily repeat your experiment by following what you wrote. This section is written as a narrative in the past tense, not like a recipe. You should also include descriptions of analyses performed on data.

Results

The writing in this section is often quite brief. Here is where the experimental evidence is stated. Present your data; do not interpret or discuss its significance in this section. Often data are presented in a table or figure. Report your data only once, do not make both a table and a figure for the same set of data.

Tables and figures should be constructed as if they will stand alone. This means that each table and figure needs to be titled, given labels and a figure legend, and clearly report the results of your research. The reader should be able to quickly view a table or figure and be able to draw conclusions. Within the text of this section can be found brief explanations of figures and tables as well as the presentation of other data. Report results of statistical analysis (if any). Give statistical test used, test statistic, degrees of freedom and/or sample size, significance level, and probability value.

Discussion

Interpretation of your work is done in this section. Draw conclusions from your data as well as suggest further hypotheses that can be tested to clear up any discrepancies or ambiguities. It is good to close the circle; return to the introduction section to remind the reader of the importance of your work and then state the importance of your addition to the joint knowledge of the scientific community.

References

It is important to give credit to sources for the ideas and information that they have provided to you. Firstly, it is helpful to allow your reader to know all of the resources that you have used in the creation of your experiments and conclusions. Secondly, it is unethical to take credit for somebody else's works ideas, or findings. This is called plagiarism.

Assessment

There are many choices for assessment. One possibility is to have students write a report (see Sidebar 3) which asks the students to draw a conclusion from their data, and to give evidence that supports this conclusion.

Conclusion

Adding an inquiry on hair thickness may seen like a lot of effort compared to simply learning how to use the microscope, but it sets the stage for continuing inquiry in your class. And hair is a topic that can be revisited when your class moves into the study of proteins; as they see how the amino acids twist to form hair protein, you can refer to this lab.

References

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