OIEE Workshop Lesson Plan - **Emily Adams** - June 2009

I. Title: How the scientific process works - leaves of steel
Age group: 9th grade biology
Duration: 3-4 50-minute class periods

II. Lesson goals: The primary goals of this study are to:

A. introduce students to the scientific method, including the process, vocabulary, methodology, mathematics, and peer review,
B. introduce students to the graphing procedures in the Upper School,
C. practice written communication skills, and
D. get students to explore the school environment and begin thinking about Walker's biodiversity

Curriculum standards (based on the National Science Education Standards):

- Content Standard A (Science as inquiry)
    - identify questions and concepts that guide scientific investigations
    - design and conduct scientific investigations
    - use technology and mathematics to improve investigations and communications
    - formulate and revise scientific explanations and models using logic and evidence
    - communicate and defend a scientific argument
    - understandings about inquiry
- Content Standard C (Life science)
    - Cells have structures that underlie their functions

III. Materials

A. # of students: 100; # of classes: 6; # of groups: 5 per class (note - two of these classes will be mine, the other classes will be taught by my colleagues; I anticipate that we will all do this activity together)
B. Materials needed for each group:
- 3 plastic cups, 24 oz.
- 1 small paper clip
- Cotton string
- Single hole punch
- 1 gallon jug of water
- 1000mL graduated cylinder
- Scissors
- Lab instructions
- Graph paper

C. Materials needed for the whole class:
- Extra cups
- Extra paper clips
- Post-it paper
- Markers
- Supply of leaves from campus
- Pruning shears

- White board and markers
- Copies of rubric

IV. Setting up the investigation

A. Engaging students

This lesson will take place during the first week of school, while students are still learning the expectations of the class and how to work with each other. To engage the students and to assess their prior knowledge about the scientific process, I will have students do a "gallery walk." In this activity, there will be several large post-it sheets on the walls around the room, each with its own question and a supply of markers. Students will have 10-15 minutes to walk around at their own pace and answer each question. Once all students have finished, students will be divided into five groups (by counting off) and each group will be assigned a particular question. They will have a few minutes to read and summarize the responses, then share them with the class. As we discuss, I will write up any commonalities and points of interest on the board. This discussion will allow me to assess where my students are in their knowledge of scientific process and help me better guide the following investigation.

Questions:

1. Write the job description for a scientist.
2. What do you think is the most important step in the scientific method? Why?
3. Describe one scientific investigation you've done in the past.
4. What is a difference between a hypothesis and a prediction?
5. Why are communication skills important for a scientist?

After our discussion, I will step back into more of a "biology conversation" and ask students what all life depends on to exist. A few will mention energy, the sun, oxygen, or food, and I will draw that back to plants. As plants and other producers provide the energy link between the sun and most other life forms (including us), it makes sense for us to learn more about these organisms that make our life possible and to see what types of them are around us at Walker. As such, each group is going to design and carry out its own experiment to learn more about the plant leaves on campus using a tool called a tough-o-meter. At this point, the class will go outside to the courtyard to take a tour of our nearby trees. I will name each species and have students sketch the different leaves as well as take observations using their other senses - touch and tear the leaves, smell them, etc. When we return to the classroom, each group will brainstorm a list of questions that they would like to investigate about the leaves. Each group will study a different question. I will walk the class through the scientific method for this experiment. First, the students will write down their questions. Then they will write a hypothesis. Why can't we make a prediction yet? Groups will devise their procedure. Realistically this will take us to the end of the first period. The homework assignment for the night will be a short internet assignment about leaf structure.

B. Questions

1. Introductory questions - see engagement activity

2. Expected or possible student questions
    Why do we have to do labs this way?
    When/how would I use this in real life?
    Are there alternative versions of the scientific method?
    Can we do the steps out of order?
    Why would one plant be stronger than other?
    Which parts of the leaf provide it with the greatest strength?
    (I can also see general questions about plants as well)
3. Inquiry/student-driven questions
    Which is stronger - tree A or tree B?
    Which is stronger - a younger leaf or an older one?
    Which is stronger - a leaf in the sun or in the shade?
    Which is stronger - a leaf higher up on the tree or lower down on the tree?

C. Possible hypotheses:

- I think an older leaf will be stronger than a younger leaf.
- Leaves in the sun will be stronger than leaves in the shade.

V. Methodology for designing and implementing the investigation

A. Experimental design

At the beginning of the second class, we will head outside with our materials and the groups will carry out the experiments they planned on the first day. I will assist with gathering leaf samples if necessary.

- How many replicates and samples? Each group will do three replicates and will have two different types of leaves (samples).
- What and how are students going to measure and record? Students will measure the mL of water it takes before the cup in the tough-o-meter falls. They will do this using a graduated cylinder.
- How is the equipment set up? The first class will create the tough-o-meters following the "Leaves of Steel" OIEE activity.
- How are data collected and recorded? Students will measure the initial amount of water in the graduated cylinder before they test their leaf. They will measure the amount of water remaining in the graduated cylinder after the cup falls. Each group will create its own data table. A sample table is shown below:

Leaf type	mL water required	Average
Old 1		
Old 2		
Old 3		
Young 1		
Young 2		
Young 3		

- How are data to be analyzed? After the experiment, groups will average their replicates for each sample. Then each student will make a graph of their group's data using the data table they created and filled out during the experiment. Students will be provided with questions to assist them in interpreting the graph.
- How are student teams organized? Students will remain in the groups from the engagement activity, which were organized by students counting off 1-5.
- Are there safety considerations? Not specifically. I will advise students to keep their feet out of the way of the falling cups. If students wish to wear a lab apron to prevent getting their clothes wet, they may do so.

B. Sampling sites

Groups will take samples from the third wing courtyard and possibly the second wing courtyard. These sites were chosen because they are closest to the classroom and sites where students naturally congregate. The third wing courtyard has older growth trees and a wider variety of species than the second wing courtyard does. The third wing is also more open and receives more sun than the second wing, which is blocked on all sides by buildings.

C. Sample predictions

- IF older leaves are stronger than younger leaves, THEN the older leaf will require more water to break it than the younger leaf.
- IF leaves in the sun are stronger than leaves in the shade, THEN the sunny leaf will require more water to break it than the shady leaf.

D. Analysis and communication

Students will analyze their results by averaging the replicates for each sample from their data. Then they will create graphs based on their data (I'm also teaching our department's graphing procedures during this lesson). Before moving on with the rest of the analysis, students will be given a graphing rubric to critique each other's graphs. At that point, groups will answer the following questions for the analysis section of their lab report (first three questions based on Leaves of Steel lab):

- Using your results from your data table and graph, which type of leaf was the "toughest"? Use evidence to defend your answer.
- Why do you think these differences exist? Or why do you think the leaves were similar in toughness?
- What could you do to continue your investigation (i.e. to learn more about these leaf structures)?
- Return to your hypothesis and prediction. Were they supported or falsified by your data? What does that mean?
- If you were to do this experiment again, what would you do differently? "Nothing" is not an acceptable answer...

On the final day of the lesson, groups will verbally share their results with the rest of the class. They will describe their question, hypothesis, prediction, results, and conclusion. If time and technology permits, team graphs can be scanned into the computer and shown on the projector while students are presenting. For the final portion of the lesson, each group will have to give its written procedure to another group. Each group will have to carry out the experiment **exactly as written** by the other team. When finished, each group will critique these procedures with the help of the rubric I've provided. The groups will exchange the feedback and I will end the lesson with a discussion about the importance of communication (particularly written for this lesson) in science and common strengths and areas for improvement that they found. I will write these on a post-it note and place on the wall for our reference the rest of the year.

VI. Resources

- "Science Content Standards." National Science Education Standards. Washington, D.C.: National Academy P, 1996. 181-99.
- Inquiry and the National Science Education Standards A Guide for Teaching and Learning. New York: National Academy P, 2000.
- "Leaves of Steel." Adapted from Winett-Murray et al. 1989 Draft, Ecological Education in the Schoolyard Activities.
- Workbook I have on graphing - at school, can't remember name - something like "great graphs"
- Bishop, G. N. Native Trees of Georgia. Athens: Georgia Forestry Commission, 2001.
- Book that Eloise mentioned about cultivated plants to help identify trees in the courtyards

VII. Budget

• Plastic cups (approximately 60)	Approximately $10
• Cotton string	Approximately $10
• Post-it paper	$32.99 for 2 pads - Office Depot - recycled
• Gallon jugs of water	Free if I can get them from other teachers, otherwise $10

VIII. Extensions

My plan is to use this lesson not only as a springboard for the other labs I will do with my students this year, but as a foundation for our plant/schoolyard studies. During the unit on cells and cell structure, I plan on making hand sections of the leaves students have tested for their microscope study. I envision revisiting this lab during our photosynthesis unit when students formally learn leaf structure. In the spring when we are going through organism classification and learn about plants, I would do some of the tree identification activities that Eloise did with us during the workshop. At this point, students will gather and prepare leaves for the leaf decomposition exercise we did. I will bury them (possibly in my home compost pile) and approximately a month later we will be discussing energy and nutrient cycling in ecosystems. We will follow up with the analysis of the results of this lab at that point.

Introduction to the scientific process: Leaves of steel

Question - what scientifically testable question are you trying to answer?

Hypothesis - what do you think is the answer to your question?

Experimental design - How are you going to test your hypothesis? What is your procedure? Remember - a hallmark of good science is that results can be replicated by someone else.

Prediction - how will you know (what evidence will you use) if your hypothesis is supported?

Data - Create and fill in a data table for your experiment's results. You need to include your variables, replicates, and averages.

Graph - Use the directions from class to create a complete graph for your data.

Analysis - Use your observations and data to answer the questions below.

1. Using your results from your data table and graph, which type of leaf was the "toughest"? Use evidence to defend your answer.

2. Why do you think these differences exist? Or why do you think the leaves were similar in toughness?

3. What could you do to continue your investigation (i.e. to learn more about these leaf structures)?

4. Return to your hypothesis and prediction. Were they supported or falsified by your data? What does that mean?

5. If you were to do this experiment again, what would you do differently? "Nothing" is not an acceptable answer...

Communication evaluation

Today you are going to repeat the tough-o-meter lab… with a twist.

1. You are going to carry out the procedure of the group I've given you **EXACTLY AS WRITTEN**. Do not read into the instructions, but carry them out **AS IS**. Fill out a data table for your results.

2. Now that you have completed this procedure, it's time to evaluate it. Remember, two important characteristics of good science are:
    - results can be replicated by other people
    - clear written and verbal communication

Go through the procedure you followed today with a yellow highlighter and highlight the <u>phrases</u> that are unclear. Repeat this process with another color highlighter for phrases that are especially clear. Then complete the rubric below (place a check in the box that you feel is most appropriate for each criteria).

Category	Criteria	Exceeds criteria	Meets criteria	Does not meet criteria
Big picture	Procedure gives a clear idea of the goal of the experiment			
Transitions	It easy to follow the procedure from one step to another			
Qualitative detail	Procedure provides clear, vivid descriptions of what you are supposed to do			
Quantitative detail	Where appropriate, procedure uses specific numbers and units to explain what you are supposed to do			
Two strengths of this procedure are: 1. 2.		One recommendation for next time is:		