Workshop - Carbon, nutrients, and life

OKD Fall 11

Introduction: This workshop introduces the formal process of scientific experimentation. You will propose a hypothesis for one of the factors that influence plant seedling growth, then, using an experiment similar to ones used by NASA, when they were trying to determine how to grow food in space. You will learn about the scientific method, why seed germinate and why seedlings grow.

Key concepts:

- The scientific method
- Nutrients and other requirements for life

OVERVIEW

D2L Workshop 1 Definition: (5 pts multiple choice)

In class (bring paper & pencil) you will be assigned to groups to define the word "hypothesis." Your definition must include **five** words: *control, measurement, methods, prediction* and *replication*. Before you leave, write it down. You will *not* hand it in, but you will use it to answer D2L workshop questions. Answer 5 questions about the correct use of the five words.

D2L Workshop 1 Experimental Hypothesis: part 2 (5 pts hypothesis) Cut-and-paste your hypothesis into the space provided at the bottom of the D2L quiz, saying ***why*** one environmental factor influences seedling germination or growth. It will be graded by your GTA. In addition to experiment results, they will grade your writing.

Grading Rubric (total 5 points)

__ Not a hypothesis (up to -5)
__ Incomplete sentences (-1)
__ Poor grammar (-1)
__ Wrong capitalization (-1)
__ Wrong spelling (-1)

After class, begin your seedling experiment at home as soon as you have a hypothesis stating ***why*** one selected environmental factor influences seedling germination or growth. See http://www.geo.arizona.edu/Antevs/nats104/wk1_lect.html on p. 2.

I**n order to be eligible for credit for D2L Workshop 1,** you must first show your seedlings to your GTA (the one grading your section).

HYPOTHESES: What influences plant growth?

Water and nutrients: All life needs water and nutrients to survive. Nutrients that exist in such low levels, relative to their need, are often called "**limiting nutrients**" because these nutrients are what control plant growth. For plants, nitrogen and phosphorus are often limiting nutrients.

Light: Plants are primary producers, which means they use an energy source, the sun, to make their own food. Like nutrients and water, the amount of available light can control how fast a plant grows.

Temperature: As temperature increases, growth rates increase at first, then decrease. Thus, temperature plays an important role in controlling plant growth. Plants in polar regions of the world tend to grow slowly whereas plants that live in the tropics grow much faster. However, this assumes that the environment provides all the other requirements for growth! Although Tucson is warm, plants grow slowly because the lack of water limits plant growth.

Materials: fertilizer, markers, paper towels, rulers, seeds, tape, aluminum foil, plastic sacks, table, light stand, lights. see http://www.geo.arizona.edu/Antevs/nats104/wk1_lect.html

1. Wheat seed growth experiment

You are going to conduct an experiment to study the influence of temperature, light, and nutrients on plant growth. Basically, you are asking 'What is the best way to grow wheat seeds?' The list below provides the possible experimental treatments you can apply. Some of them can be combined, for example, if you want to see whether fertilized seeds grow better in the light or in the dark. Select one of the following parameters for your experiment (or check with TA or Prof.)

1. light (vs. dark)
2. tap water (vs. tap water with fertilizer or other substances mixed in)
3. amount of water in bag
4. heat (vs. room temperature)
5. air in bag (vs. no air in bag)

A. Forming hypotheses

First, think about what you would like to test. Are you interested in the effects of light on seed growth? One of the other factors? Based on the introduction and your personal experience, explain why the factor you choose influences plant growth – this is called a '**hypothesis**'. What are the implications of this hypothesis? Predict how lesser or greater amounts of the physical factors will influence plant growth. Formulate a specific **prediction** about your experimental manipulation of the results. The hypotheses should be stated in complete sentences, describing cause and effect. For example, if you were interested in

the effect of temperature on baking cookies, and you turned the oven up to its maximum temperature your hypothesis might be “The cookies will burn when the oven is really hot” or “The cookies will bake really fast when the oven is really hot”.

Think of how you will test your prediction! You will need to measure something! **Write your hypothesis and prediction on p 6. (Remember, everything must be in your own words. Never copy from someone else.)**

B. Methods Measurements and Control

To properly test your hypothesis, you need to be as careful as possible about the conditions and measurements of your experiment. In the cookie example, it makes a big difference how long we leave the cookies in the oven. If we leave them in for a short time, they might not burn, but if we leave them in for as long as the recipe says we are supposed to, they might. Record the date and time your experiment begins: show it to your GTA as soon as it's started.

Part of the experiment is eliminating confounding variables – factors that were not intended to influence the results of the experiment. The easiest way to do this is to have two copies of the experiment that differ only in the amount of the key factor. The copy without the key factor is the experimental **control**. For example if your hypothesis involves nitrogen fertilizer, the control would not contain the nitrogen fertilizer but would be the same in all other regards – for the cookie example, you would have two identical ovens, one turned on, the other not turned on at all.

An important aspect of experimentation is **replication**. To avoid accidents and improve measurements, run two identical trials of your prediction. For the cookie example, have two hot ovens, not just one.

How will you measure the amount / level of the variable you manipulate? If it’s temperature, frequently record the temperature where the experiment takes place. For the cookie example, you would record BOTH the temperature of the hot oven AND the temperature of the cold oven (the control).

Instructions (see illustrations at http://www.geo.arizona.edu/Antevs/nats104/wk1_lect.html)

These are examples of how to conduct an experiment. You can obtain the **materials** from your GTA or Prof. Davis, or buy your own at the supermarket or hardware store. Either way, you’ll need to list your materials in your report. For example if you don’t use wheat seedlings and ziplock bags, you’ll need to write down the names of the seeds, kind of bag, etc.

These are examples of **methods**: **Label** the ziplock bags (example: two controls and 2 replicates) with your name, the date, and the treatment it will receive. Fold

a paper towel in four and place it inside the ziplock bag, lying it on its side. Moisten the towel (less than 25 ml of the appropriate liquid [record the amount]) – the entire paper towel will absorb the water in a few seconds. Carefully place 10 seeds on the paper towel. Put the towels containing the seeds in the labeled ziplock bags and place them in the experimental locations.

Results (final report submitted to TurnItIn.com)

Collect your samples. **How might you determine which wheat seedlings are the 'biggest'?** (i.e. How do you define 'biggest'?) How will you measure the length of the seedling? Since the seed will not change in length, will you include the seed length in your measurement?

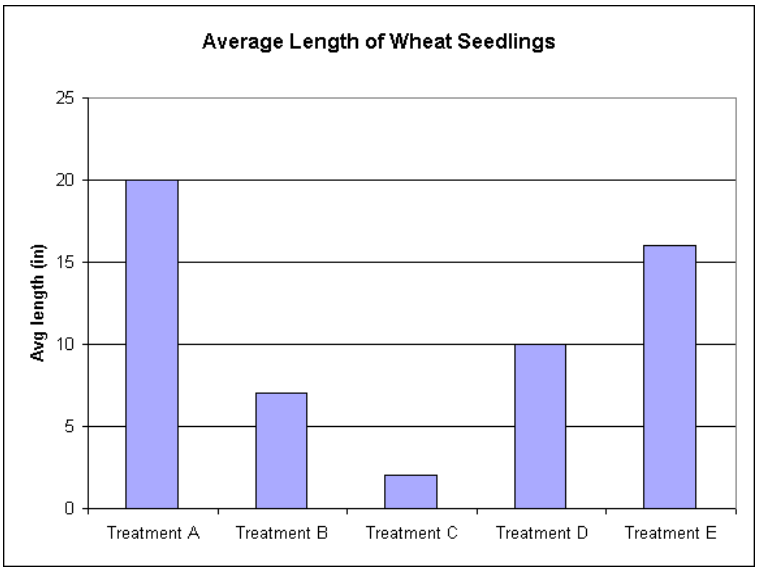
Seven days after the beginning of the experiment (record date and time of beginning and end) measure the full length of **each** of the seedlings, including the root. Create a table on a separate sheet of paper to display your measurements. To better compare the effect of different treatments, scientists often compare the *average* value for a treatment. **Calculate the average length for each treatment as follows**:

$$\text{average length} = \frac{\text{length}_1 + \text{length}_2 + \ldots\ldots + \text{length}_{10}}{\text{total number of seedlings}}$$

Include the averages with the other measurements, in your table. Example:

Control average length (10 seeds)	5.2 mm
Replication 1 average length (10 seeds)	9.2 mm
Replication 2 average length (10 seeds)	9.3 mm

A bar graph (like the figure below) is optional. It may help you to interpret and explain your results. **If** you plot a figure, it needs to be part of your report.



PARTS OF YOUR PAPER

Hypothesis Explain why the factor you chose influences seedling growth. Cite supporting observations or publications (1/10)

Prediction What influence should the active factor will have on seedling growth. Include measurement and direction and magnitude of change (1/10)

Experiment Methods and Measurements. Include enough information (a table) about your materials and procedures so that someone else could repeat your experiment. (1/5)

Results (include table) Summarize and discuss your measurements as shown in the **table and optional graph** (5 pts). You should state the **average growth** for each bag's seedlings in your written explanation and compare the treatment with the control. (1/5 text + 1/5 table)

Conclusions: What did you learn from your experiment? Do the results support your hypothesis? What would you do differently if you did it over again, and what factor would you like to test next? (1/5)

Writing Exercise Grading Rubric (TurnItIn.com)

Type your experimental results using p. 6 as a template and save it in a file format your GTA can read. Your write-up should include a data table and your conclusions as to whether the experiment supported your hypothesis.

SCIENTIFIC CONTENT **(add up to max 30 points)**

Hypothesis correct form **(5 pt)** ____
Prediction measurable **(5 pt)** ____
Methods & Measurements adequate **(5 pt)** ____
Results clear and supported by data **(5 pt)** ____
Data table, averages (optional graph) clear **(5 pt)** ____
Conclusions (not illogical, pop-science, implications) **(5 pt)** ____

Sub Total __/30

SPELLING, GRAMMAR **(add up to max 20 points)**

Spelling, homonyms, confusing pairs **(5 pt)** __ __
Punctuation **(5 pt)** __ __
Sentence structure: fragments, run-ons, incorrect word usage **(5 pt)** __ __
Paragraph construction (topic sent.,1 idea per para., para.cohesion) **(5 pt)** __ __

Sub Total __ __/20

TOTAL __ __/50