

Spring 2-1-2018

BIOO 105N.00: Introduction to Botany

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BIOO 105: Introduction to Botany

Meeting times and place

Monday and Wednesday 10:10-11:00 am, Stone Hall 304

Lecture Instructor

Edwin J. Burke

105 Stone Hall

Phone: 243 - 5157

email: edwin.burke@uconnect.edu (*please write BIOO 105 in email subject*)

Office hours: Wednesday 1:10-3 pm and by appointment

Laboratory Instructors

Stephanie Berry stephanie.berry@umconnect.umt.edu

Gerard Sapes gerard.sapes@umconnect.umt.edu

Course Lecture and Laboratory Times and Locations

Lecture- Monday and Wednesday 10:00-10:50 am; Stone Hall 304

Laboratory- Sect. 2, 08:00-09:50; Sect. 3, 10:00-11:50; Sect. 4, 13:00-14:50; Sect. 5, 15:00-16:50;

Natural Sciences (NS) 202

Lecture text-“Course Pack”

There is a printed course pack that will accompany the lecture. There are many color plates, micrographs, diagrams and photos that increase the price slightly over a black and white/greyscale rendition, but the added cost is worth it when it comes to linking lecture and lab with lecture and laboratory gross and microscopic visuals.

In addition to the course pack, textbooks can be useful resources to review class notes and to study. For that purpose, I recommend that you periodically use one of the several different texts in the Mansfield Library. Note, however, that I will not follow any particular text in lectures, although all topics I will cover in lecture are also covered in introductory Botany texts.

Laboratory manual

BIOO 105 Introduction to Botany Lab Guide, to be used in conjunction with the Lecture Guide, will be available on Moodle.

General Course Content

BIOO 105, Introduction to Botany, is a one-semester exploration of the world of plants that combines lectures and laboratory exercises. Plant Biology (Botany) is a very broad, yet it is a discipline serving as a base of knowledge for several other fields of study. In this course we will address some of the principal areas of botanical sciences, including a general understanding of plants from molecular, cellular, physiological and diversity perspectives. An emphasis will also be placed on the societal uses of plants.

While the lecture and labs complement each other, the lab portion is a stand-alone component of the course. Some laboratory exercises will follow what has been covered in lecture, but others will not. Therefore, it is very important that you *read the lab manual in advance*. Laboratory materials and expectations will be discussed in lab. *Attendance in lectures and laboratories is mandatory*; you cannot pass the course without a lab grade, and *if you miss three labs or more you will not get a lab grade (i.e. you will fail the course)*.

Course Learning Objectives and Outcomes

1. Learn and appreciate the importance and biological beauty of plants
2. Acquire a basic understanding of the structure and function of plants

3. Learn and appreciate the extraordinary diversity of organisms within the plant kingdom.
4. Learn and appreciate the remarkable ability of terrestrial plants to grow, survive and reproduce despite the fact that they cannot move to search for food, shelter or mates.
5. Learn how plants cope with their surrounding environment (including the presence of other organisms)

Exams and Grading

Please note, this class is offered for traditional letter grade only, it is not offered under the credit/no credit option.

There will be 2 regular session exams and a final. The final will be partly comprehensive, but with an emphasis on the material covered after exam II. Each of the first two exams will be worth a total of approximately 125 points and the final's contribution will be approximately 250 points. The lab portion of the grade will total approximately 250 points (about 33% of the total grade). The lab portion will be comprised of reports, in-lab assignments, papers, collections and any other material submitted for grading. Your overall final grade for BIOC 105 combines lecture and lab scores. Again, recall you cannot pass the course if you have missed more than three labs.

Please note, this class is offered for traditional letter grade only, it is not offered under the credit/no credit option

Letter grades will be assigned as follows:

A \geq 90.00

B = 80.00 – 89.99

C = 70.00 – 79.99

D = 60.00 – 69.99

F \leq 59.99

Suggestions for success

Regular attendance in lecture and lab is critical and mandatory. Students will get the most out of lecture and lab time if they prepare in advance. It is critical that you take good notes and remain engaged in class. Learning is not simply the accumulation of information, but the ability to process this accumulation of information and to place and use it in a broader, relevant context. A very effective way to do this is to take good notes in class and then review these notes after class. Students should ask questions any time during lecture. This type of student participation in class leads to spontaneous class discussions and the opening of new avenues for learning in a less-restrictive and interactive teaching/learning environment. Study groups and discussions are extremely helpful and you are encouraged to develop formal study groups and develop mock exams, quizzes and lectures. While working in groups is beneficial, students are expected to work alone during all exams, lab quizzes and completion of lab worksheets.

Office Hours

My office hours are Wed 1:10-3:00 PM. Please, come and see me if you need any help. If I am not in my office, 105 Stone Hall, check for me just down the hall in the Wood Science Lab, Room 102. If my office hours conflict with your schedule please let me know via email or after lecture and we will set up a different time. In your email subject area, please write BIOC 105, so I know you are a Botany student requesting information. This will allow me to answer your request ASAP.

Special circumstances

Makeup exams are discouraged, but sometimes you have no control over situations that preclude you from getting to the exam. If you must miss an exam, compelling evidence must be provided, preferably in written form in advance of the scheduled time of the exam. If you are too sick or otherwise prevented from getting to the exam, drop me an email for the record, and I will work with you. I will attempt to schedule makeup exams will take place at one time only, for all those missing the exam, within approximately one week

following the scheduled exam. NOTE: there will be NO early or makeup final exams, so please plan your travel ahead of time.

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. If you have a disability that adversely affects your academic performance, and you have not already registered with Disability Services, please contact [Disability Services for Students](#) in Lommasson Center 154 or call 406.243.2243. I will work with you and Disability Services to provide an appropriate modification. Only students registered with DSS will be considered for accommodation during exams. Please contact me *one week before* each exam if you require any service through DSS.

Drops, withdraws, change of grade status

Important Dates Restricting Opportunities to Drop a Course Spring 2017 (See also [Spring 2018 Official Dates and Deadlines](#) calendar):

Deadline	Description	Date
To 15 th instructional day	Students can drop classes on CyberBear with refund & no “W” on Transcript	February 9 = last day
16 th to 45 th instructional day	A class drop requires a form with instructor and advisor signature, a \$10 fee from registrar’s office, student will receive a ‘W’ on transcript, no refund.	February 12 through April 2
Beginning 46 th instructional day	Students are only allowed to drop a class under very limited and unusual circumstances. Not doing well in the class, deciding you are concerned about how the class grade might affect your GPA, deciding you did not want to take the class after all, and similar reasons are not among those limited and unusual circumstances. If you want to drop the class for these sorts of reasons, make sure you do so by the end of the 45 th instructional day of the semester. Requests to drop must be signed by the instructor, advisor, and Associate Dean (in that order) and a \$10 fee applies. Instructor must indicate whether the individual is Passing or Failing the class at the time of request.	April 3 – May 4

Student Conduct Code

All students must practice academic honesty. Academic misconduct is subject to an academic penalty by the course instructor and/or a disciplinary sanction by the University. All students need to be familiar with the [Student Conduct Code](#).

BIOO 105 Tentative Lecture Schedule

Date	Lecture topic
22 January	Introduction
24 January	Chemical Constituents and Architecture of Cell Walls
29 January	Cell Wall Structure (cont.)
31 January	Plant Cells-Cytoplasm and Organelles; Plant Cell Types, Tissues and Organs
5 February	Plant Cell Types, Tissues and Organs (cont.)
7 February	Plant Body-Meristems and aerial stems
9 February	Last Day to Drop Classes on CyberBear
12 February	Meristems and aerial stems (cont.)
14 February	Plant Body-Roots, Holdfasts; water and nutrients
19 February	Presidents Day (Holiday)
21 February	Roots, water and nutrients (cont.)
26 February	Exam I
28 February	Leaf structure, morphology, arrangement
5 March	Photosynthesis and respiration
7 March	Photosynthesis and respiration (cont.)
12 March	Reproduction in Plants: Lower plants-Bryophytes; Reproduction in Gymnosperms
14 March	Reproduction in Plants: Angiosperms
21 March	Plant Genetics:
23 March	Plant Hormones
26-30 March	Spring Break
2 April	Exam II
	Plant Phylae- <i>Bryophyta</i> (mosses), <i>Hepatophyta</i> (liverworts) and <i>Anthrocerophyta</i> (hornworts).
4 April	Plant Phylae <i>Lycopodiophyta</i> (club mosses) and <i>Pteridophyta</i> (ferns); structure and life cycles
9 April	Plant Phylae- Superdivision <i>Spermatophyta</i> (seed plants); Divisions <i>Cycadophyta</i> , <i>Ginkgophyta</i> and <i>Gnetophyta</i>
11 April	Plant Phylae- Superdivision <i>Spermatophyta</i> (seed plants); Division <i>Coniferophyta</i>
16 April	Division <i>Coniferophyta</i> (cont.)
18 April	Division <i>Angiospermae</i>
23 April	Division <i>Angiospermae</i> (cont.)
25 April	Gymnosperm and Angiosperm Identification and Ecology; Campus walk for Tree Identification- 5 species
30 April	Gymnosperm and Angiosperm Identification and Ecology; Course Evaluations and Review for Final Exam
2 May	Identification test
9 May	Final exam (10:10am – 12:10pm Wednesday 9 May 2018)

BIOO 105. Introduction to Botany. Laboratory Syllabus. Spring 2018

Meeting place and times

Natural Sciences (NS), room 202. Tuesdays.

Sect. 2, 9:00-10:50; Sect. 3, 11:00-12:50; Sect. 4, 13:00-14:50; Sect. 5, 15:00-16:50

Lab Instructors

- Stephanie Berry stephanie.berry@umconnect.umt.edu
- Gerard Sapes gerard.sapes@umconnect.umt.edu

Lab Manual

Introduction to Botany Laboratory Manual. Spring 2017. Printed Course Pack available from Burke

Overview

The laboratory component of this course provides an opportunity for hands-on learning. Your lab grade will contribute to about 40-50% of your overall course grade. Your laboratory instructor will explain student responsibilities for the lab during your first meeting. Be sure to read the laboratory exercise in the manual before each lab.

Grading

Grading will be based on three scientific reports (detailed instructions and example will distributed). In addition, weekly worksheets submitted at the end of each lab and weekly quizzes covering the previous week's laboratory and all of the lecture material to that point, will be conducted in laboratory. Some simple questions in the weekly quizzes will be germane the lab to be conducted the current week (**suggestion; read the manual ahead of time**).

Homework

Worksheets completed during a lab are due at the end of that lab session. The formal lab reports are due at the beginning of the next week's lab session. Late reports will be penalized with a 10% reduction of the grade per day late. These late reports are to be turned in to your lab instructor.

Lab Grading

Type	Number	Points each	Total Points
Worksheets	9	10	90
Quizzes	9	10	90
Reports	3	20	60
TOTAL			240

Lab attendance

There are no "make-up" labs, so attendance is essential and mandatory. *If you miss three or more labs you will not pass the class.*

BIOO 105 Introductory Botany Course Laboratory Schedule

Date	Manual	Topic	Assignment Due Today
23-Jan		Introduction; Plant Products.	
30 Jan	Lab 1	Planting. Data Management	Worksheet
6-Feb	Lab 2	Experimental manipulations; Microscope	Quiz Report Lab 1 Worksheet
13-Feb	Lab 3	Plant cells and tissues	Quiz Worksheet
20-Feb	Lab 4	Plant structure: leaves, stems and roots	Quiz
27-Feb	Lab 5	Secondary Growth and wood types	Quiz Report Lab 4 Worksheet
6-Mar	Lab 6	Reproductive structures	Quiz Worksheet
13-Mar	Lab 7	Photosynthesis	Quiz Report Lab 5 Worksheet
20-Mar	Lab 8	Non vascular plants	Quiz Worksheet
27-Mar		<i>No lab: Spring Break</i>	
3-Apr	Lab 9	Seedless vascular plants	Quiz Worksheet
10-Apr	Lab 10	Gymnosperms; Plant ID	Quiz Worksheet
17-Apr	Lab 11	Angiosperms I	Quiz
24-Apr	Lab 11	Angiosperms II; Plant ID	Worksheet
1-May	Lab 12	Plant ID	

First Laboratory Meeting

HOW TO WRITE LAB REPORTS

Some of the experiments or exercises in the lab portion of this course will require a short written scientific report. These reports need only be 2 pages in length at the most (excluding figures and tables) and should be **typed and double-spaced**. All reports are due at the laboratory session following the one in which the exercise was completed. **Late reports will lose 10% of the grade per day. The short scientific reports must follow the following format.** It should have the following five main sections clearly labeled: Introduction, Materials and methods, Results and Discussion. Do not include a cover page. For the purpose of this class it would be an unnecessary waste of paper.

The Title should be short and informative. Avoid titles like: “Measurement of the growth of plants”. Rather, a title with a statement (e.g. “Low light influences plant growth and morphology”) is much more informative. If results are not clear enough to allow a statement-type title, then an acceptable alternative title would be: “Effect of light intensity on the growth and morphology of plants”.

The Introduction should provide some **general background** and include a general description of the problem or topic being studied. Also make sure to identify the **objectives** or purposes of the experiment. When appropriate, outline the specific **hypotheses** the experiment is designed to test (a proposed explanation of the phenomenon under investigation). Hypotheses should never come as a surprise. Rather, they are a natural progression from the background provided. Every hypothesis should be followed by a specific **prediction**. A prediction is a more specific statement forecasting what will happen under *certain* conditions, typically expressed in the form *If X ..., then B ...*. For instance: Hypothesis: The size of tomatoes produced by a tomato plant is positively related to light availability. Prediction: tomato plants grown under low light will produce smaller tomatoes than plants grown under high light. Null hypothesis: Light intensity will show no effect on tomato size. Statistics do not prove hypotheses. When properly used, they only lead to rejection of a null hypothesis).

The Materials and Methods of a scientific paper usually describe the methods in enough detail to allow someone else to duplicate the experiment. For class purposes a brief explanation of the design of the experiment (what we have done and how) and the ‘things’ (variables) that we have measured will suffice. If appropriate, include any modifications you made to the procedures (both deliberate and accidental).

The Results section should contain a brief description of your findings. Since you have already done the work and collected the data, viewed the results and formed conclusions, use the past tense. This section should include tables or figures of the *summary* results attached at the end of the paper. **Do not include raw data in the results**, only final, interpretable data (e.g. treatment averages). Usually the data are presented in graphical form (the instructor will let you know if a Table should replace a graphic). The text of the results should briefly describe the information in the tables or figures. For example: ‘fertilization increased the total plant biomass (Figure 1)’. If more than one table or figure are necessary, number them sequentially (e.g. Table 1, Table 2 etc., or Figure 1, Figure 2, etc.). Unless unitless, all results need to be reported according to the **SI units** (e.g. g, Kg, cm, m) instead of English units. Results in tables and figures should be presented clearly. A table legend appears above the table and a figure legend appears below. A graph is referred to in the text as a figure (not graph, chart or any other term). An array of numbers or attributes should, likewise, be called a table and not anything else. Do not interpret your results in this section. Just describe what they are.

The Discussion section should include a summary of your main findings together with an **explanation or interpretation**. What conclusions can you draw with regard to the objectives described in the Introduction? Did the results come out as you expected in the hypotheses? If the experiment did not work or produced unclear or questionable results, try to discuss what might have gone wrong and how could have affected the results. You may also discuss what would you do differently in the future to improve the results or additional experiments to test your hypothesis.

Example Laboratory Report

(Note: shaded text portions of this report are for explanation only; they are not to be included in the report)

Double spaced, 1 inch margins minimum, Arial or Times New Roman 12 font, black ink.

Name, student ID, course and section

Ray Parenchyma

7901122345

Introduction to Botany, BIOO 105 (Section 3)

Title: if possible use a statement title that is informative

Road salts cause plant cells to lose water

Introduction: A very general statement that highlights the relevance of the study: All organisms need water to survive. The following narrows it down and provides the rationale for the specific study and objectives: Cells of living organisms are surrounded by a semi-permeable membrane that allows the diffusion of water but not of dissolved salts. As any substance, water always moves from regions of highest to lowest concentration. When salts are added to distilled water, the concentration of water decreases. Plant cells are full of water and when they are placed in a solution where the concentration of salts is higher than that in the cell, water will freely diffuse from inside the cell (less salts, higher water concentration) to the solution (more salts, lower water concentration) via osmosis (diffusion of water across semi-permeable membranes). Plant cells also have a rigid cell wall outside the cell membrane, which also allows the free diffusion of water. The cell wall allows the water in the cell to be under turgor pressure against the wall. However, when water from inside the cells diffuses via osmosis to the outside solution (with more salts) the. The loss of water causes a decrease of the turgor pressure and may eventually lead to a decrease of the cell volume and plasmolysis: the separation of the cell membrane from the cell wall. **The objectives of the experiment:** In this experiment we tested whether road salts cause onion cells to plasmolyze. **The specific hypothesis or prediction:** We predicted that a concentrated solution of road salts would cause onion cells to plasmolyze.

Materials and Methods: Briefly explain what you did, and how. Include number of replicates: Three thin peels of fresh red onion were placed in a Petri dish with tap water, and three peels in a Petri dish with

concentrated road salt solution. After 15 minutes, cells in the sections were examined for plasmolysis under the microscope.

Results: Describe the main results and refer to the figure(s). Use past tense: Red onion cells in road salt water experienced much higher percentage of plasmolysis than those in the tap water solution (Figure 1). (Figure 1 or Table 1, in parenthesis is how you refer the reader to the results

Discussion: Interpretation of the results: As expected, the road salt solution caused cells to plasmolyze indicating that water diffused from inside the cell, where the water concentration was highest (lowest salt concentration), towards the solution where water concentration was lowest (more salt). Although tap water caused much less plasmolysis than road salt water, a small percentage of cells exhibited some plasmolysis. This indicates that even in tap water, some cells experienced diffusion of water to the external solution, and therefore that tap water has lower water concentration (more salts) than the water inside the cell.

Possible general implications of the results: The results of this experiment have implications for the addition of salts in roads to prevent freezing. If these salts accumulate in the soil they may cause root cells of roadside plants to lose water which could negatively affect their growth.

If room allows place the figure and figure legend in the same page (to save paper)

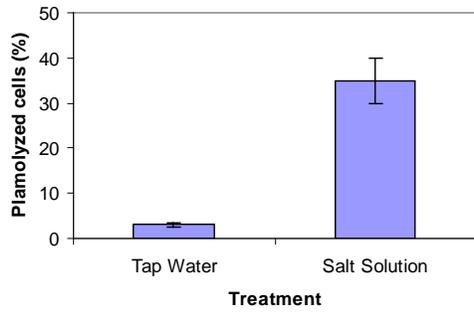


Figure 1. Description of the graph with sample sizes (number replicates) and what the error bars mean; note this is not necessarily your): Percent plasmolyzed onion peel cells in tap water and a road salt solution. N=3. Error bars represent standard deviations of the mean.

BIOO 105 Introduction to Botany Quiz and Exam Study Strategy

This section should serve as an example of how to organize your lecture and lab material into sections that you prepare summaries for and develop question sets to practice listing, diagraming and differentiating facts for each of the topic areas. The following numbered sections are examples of how to develop questions and answers for a wide variety of material using a variety of methods and techniques.

Study groups also enhance learning, especially when all members prepare quizzes and exams for the other group members. Mini lectures to the group is also a well-established method of developing better understanding of the material to be learned. Use of a classroom with an available board for lists and diagrams is an important activity that will enhance the study group's work product.

Finally, providing learning assistance to fellow classmates who are struggling to understand and retain the information is, perhaps, the most effective way to really learn the subject material, as you are going to explain the material, repeat diagrams, chemical pathways, mathematical formulae and put together lists in more than one way. Remember, you do not truly learn the material until you teach it to someone else.

One last suggestion that was given to me by Master Sergeant Myron Hakala, one of my most effective coach/instructors:

“Practice does not make perfect; PERFECT PRACTICE makes perfect”

1. Plant Characteristics

Five main characteristics of organisms in the plant kingdom that when combined help define organisms within the plant kingdom. Try not to memorize but think what each characteristic means and why it is important. For instance:

- a. Eukaryotic multicellular organisms → made of many cells (later you will think of the different types of cells), each with the genetic material in a nucleus which is surrounded by a membrane (in contrast to bacteria cells, which evolved much earlier and are much simpler).
- b. Photosynthetic → they perform photosynthesis (an incredibly important process for human kind)
- c. Cellulose-rich cell walls → each cell is surrounded by a cell wall (see below).
only bacteria and fungi have cell walls, a rigid structure that surrounds the cell, but the cell wall in plants is made of cellulose). This is important because it gives rigidity → even herbs can stand up without a skeleton!
- d. Adapted to live on land → they must have adaptations to survive outside water
- e. Sessile → they cannot move! So they must be very good at adapting to the environment so they do not dry out.

2. Photosynthesis. Write out the basic general formula and interpret it. Photosynthesis is a process by which water and CO₂ are combined using light energy to make carbohydrates releasing oxygen in the process. (Understand the formula; do not only memorize it). For instance, where does the CO₂ come from? The air (later we learn that it enters de leaf through stomata). Where does the water come from? The cell, which is full of water. Ultimately, water in cells comes from the soil. Why is photosynthesis such a big deal? Your answer could be summarized as the following:

- a. Photosynthesis makes carbohydrates (and this is a big deal in itself; only autotrophic organisms such as plants can do this). Animals, fungi and many Protista don't sit in the sun and make carbohydrates. They need to eat plants to get them.
- b. Photosynthesis absorbs CO₂ from the air

- c. Photosynthesis releases oxygen to the air which we all need to breathe.

Why is the ability to make carbohydrates using light energy so important? Because:

- a. carbohydrates (e.g. candy, potato starch) store the energy that came from the sun. And all organisms need energy to maintain their cells alive, move stuff in and out of cells, make new molecules, etc. and allow their bodies to function properly (See later on where in the cell energy from carbohydrates is extracted)
- b. carbohydrates are the basic chemical 'scaffolding' necessary to make the four main building blocks that make up all organisms on earth: other carbs, proteins, nucleic acids like DNA, and fats .
- c. Chemically C, H and O are the most abundant elements. They come from CO₂ and H₂O (made into carbohydrates during photosynthesis). Carbohydrates are combined with other elements taken by roots from the soil (e.g. nitrogen, etc.) and 're-shaped' to make proteins, fats and nucleic acids (e.g. DNA). Carbohydrates, proteins, fats and nucleic acids, make up cellular structures (cell membranes, cell walls, chromosomes), which assemble to make cells, which assemble to make tissues, which assemble to make organs, which assemble to make entire plants.

3. Meristems

Meristems are zones of cell division where plant growth starts. Where are they located? At the tip of shoots and roots (apical meristems), and in woody plants surrounding the stem (lateral meristems).

4. Evolution Theory for Plants.

From which principal group of organisms are plants theorized to have evolved? Green algae, which are aquatic.

5. Plant Phylae.

- a. What are the four principal groups of plants and how do they differ? Think about evolution theory, which leads from simpler to more complex organisms and the types of adaptations that came with the development of each major group. Bryophytes (mosses) are theorized to have that evolved from algae. They are small, live in moist places and do not have vascular tissues to transport water and food. Thus they are non-vascular plants.
- b. Next, the ferns developed. They are larger, with taller stems and photosynthetic appendages than mosses. and therefore requiring vascular tissues.
- c. Then the gymnosperms are thought to have come next, including pines, firs, spruces and other plants, many with scale or needle-like leaves. The big innovation of gymnosperms was seeds (increased dispersal).
- d. Lastly, the angiosperms, the most abundant group by far, and the presence of true flowers and fruits surrounding the seeds. The addition of flowers increased pollination by animals and greatly aided in the increased production of more-highly dispersible seeds.
- e. The study of the different types of plants shows a pathway of complexity and innovations to increase survival (e.g. cope with a dry environment on land) and dispersal (recall that plants are sessile so the evolution of flowers to increase pollination and dispersal was huge).

6. Cell Wall Architecture.

- a. Diagram and label the transverse section of a plant cell with a secondarily-thickened cell wall (gymnosperm tracheid for example)
- b. Cells are surrounded by a membrane AND a cell wall (outside the membrane). The membrane and the cell wall are two very different things! Membranes are bilayers of phospholipids, with integral and peripheral proteins interspaced. They are semipermeable, a very important property: they allow the diffusion of water but not of large substances or charged ions; therefore membranes allow the generation of chemical (energy) gradients: higher concentration of a substance on one side of the membrane than on the other. The membrane proteins serve to transport ions and larger substances across the membrane. The phospholipids can be saturated (they solidify at room temperature) or unsaturated (have kinks in their tails, which provide more fluidity and prevent solidification at room temperature)
- c. The cell wall is mainly made of cellulose, whose microfibrils are precisely aligned to perform various functions for the cell and the plant as a whole. The cell wall can be primary (1°-formed in growing cells) and secondary (deposited on the inside of the primary cells wall, where materials are arranged in an architecture that allows for wall expansion and flexibility. The primary wall also incorporates the wax-like polymer pectin (used in fruit preserves, jellies and jams) which contains a lot of water, and that serves to maintain the internal structure of the cytoplasm. Many plants have tissues that are often secondarily thickened, with three layers in the secondary wall made up of many separate laminations of a combination of cellulose, lignin and hemicellulose. This secondary (2°) cell wall is much more rigid, and is found in abundance in the xylem and phloem, tissues that are critical to support and water transport. Frankly, without lignin and the secondary plant cell wall, plants taller than a few centimeters would not be present on earth. It is also likely that higher forms of animal life would also be absent. Home Depot would not have any lumber for building houses. Thinking further about no secondary plant cell walls, there wouldn't be any people on Earth needing lumber that Home Depot didn't have. Not a good business plan.

LAB 1. DATA ANALYSIS AND GRAPHS-Week 2

Introduction and Overview

Data management, statistics and graphing is an extremely important aspect of scientific research. In this exercise we will use existing data on growth, cone production and seed characteristics of ponderosa pine trees subjected to different treatments: control stands that have not experienced fire in the past century, stands that were thinned, stands that were thinned + burned in the spring, and stands that were thinned + burned in the fall.

The instructor will provide a brief introduction of the ecology of ponderosa pine forests and the importance of natural fire. He will also provide a brief summary of a study carried at Lick Creek in the Bitterroot valley to assess the effect of restoration treatments in ponderosa pine forests.

Objectives

- Learn how formulate hypothesis and make predictions
- Analyze data collected to test predictions (collected by a graduate student): calculate basic statistics and plot the results in graphical form using excel
- Write a short scientific report
- You will also learn about the ecology of fire in low elevation forests and tree responses to fire

Note: For some students this may be a very challenging lab. So please pay attention and ask questions. If you see someone at your table struggling and you can help them, take the opportunity. Both of you will benefit.

Procedure

The instructor will give a short presentation of the importance of low intensity, frequent fire in low elevation ponderosa pine forests and the consequences of actively suppressing fires in the landscape. He will present an experimental study to evaluate the effects of different forest management treatments. Students will then be asked to formulate hypotheses of expected responses to experimental treatments.

Students will be supplied with data collected from these experimental treatments (i.e. you will analyze results from a real project).

The instructor will provide guidelines on what type of summary data and graphs we need to evaluate treatment effects and test the hypotheses postulated.

Here are the instructions for calculating basic statistics and making graphs .

Data Analysis and Plots

Use a computer that has excel 2010 (e.g. the DBS or Forestry computer labs).

Open the data file. Double click at the 'sheet1' tab and write 'original data' and press enter

The first thing when dealing with data, is to enter them into Excel in a way that is consistent with the results you want to analyze and visualize in a graph. In this case, we are interested to see if the different treatments affect growth, cone production and seed traits. Therefore we want to calculate the averages and standard

deviations (a measure of variability between replicates within a given treatment) of the different variables and then plot these averages so the differences are easy to visualize. For each variable, we want a column graph, where the vertical axis (y axis) represents the values of the variable in question and the horizontal axis (x-axis) the different treatments. The arrangement of the data has already been done. The data set has one column that indicates the treatment, one that indicates the replicate measurements within each treatment (in this case, units of length, number, etc.) and some additional columns with the variables whose values we want to compare among treatments.

Working with the data set --- statistics and graphs

(Note: Excel has alternative ways to execute the same command; the following describes one of these methods)

First, it is always a good idea to keep the original data sheet intact and make copies for subsequent analysis. This way you can always go back to the original data if something goes wrong. To copy a page of spreadsheet into a new page left click the mouse on the tab “original data” and, while holding, press the Ctrl key. While holding both (left mouse and crt key) you will see a small black triangle and a small sheet icon with a + sign. Move the mouse where you want the copy (usually next to the first page) and release. Rename the copy (right click on the tab, select “rename,” and write the new name and press return).

In this case the data are already sorted by treatments, so you do not need to sort the set (so you can skip to the next paragraph). If for future reports you need to sort the data, highlight the entire data set (all columns and rows, including column titles). Then click ‘Sort & Filter’ on the home taskbar; choose “custom sort” from the drop down menu that appears. Make sure that ‘My data has headers’ on the upper right is checked to indicate that you have the column headings—this will make sorting easier. Highlight the column names you want to sort. Note that you can command excel to sort ascending or descending (A to Z or Z to A)—sort ascending (A to Z and Smallest to Largest) so that your data are arranged from oldest to newest observation, which is how we want to display the data in a graph. Click ‘OK’.

The data given to you for this first exercise are ready for the calculation of averages and standard deviations. You will need room to add these numbers. Add a row below each treatment set of rows where you will add the average (see below). To insert a new row place the cursor on the row number on the left of the spreadsheet corresponding to the first row of the next treatment set; make sure that only the next treatment row is highlighted (left click on the row number); right click and select insert (note that excel inserts rows above the row you select). Repeat this for the rest of the treatments. You will also need to add a column next to each variable measured where you will add the standard deviation (see below). To add a column place the cursor on the column immediately on the right of the one you want to average, right click and select insert.

To calculate averages for each treatment, place the cursor in the empty cell at the empty row that separates treatments and at the column of the desired variable (whose name is at the first row). Type: ‘=average(‘ and then highlight the three values above by sliding over them with the cursor. Then type ‘)’. (note: the text you need to type is enclosed within the ‘’). Press enter (excel automatically puts the ‘)’). The average value will show. Move one cell to the right and type ‘=stdev(‘. Highlight the three values that you just averaged (on the column immediately on to the left), and press enter. The standard deviation is now calculated. Repeat this step for all variables and treatments.

For each average row enter the corresponding treatment label (c, T, SB or FB) in the corresponding empty cells in the treatment column.

Copy the entire page into a new page as before: left click and while pressing, click the 'ctrl' key, hold, and move the mouse to the right).

Highlight the entire page by clicking the cursor on the uppermost left corner of the spreadsheet. The whole spreadsheet should be highlighted. Then press the copy icon (two little pages) from the home tab at the top of the screen (you can move from tab to tab by just clicking on them). The whole page is highlighted. Then press the small black arrow below the "paste" icon on the home taskbar. Select the option "paste values", with just the numbers 123. The new table will have the same averages as before, but it will no longer have the formulas for the averages and standard deviations. It is very important that you do this 'paste values' command. Otherwise you will get error messages later.

For each treatment (C, T, SB and FB) you will need to delete the rows with the individual unit values to only keep the average row: highlight the three rows with the individual unit values by scrolling the cursor over the row numbers. Right click and select delete. Repeat step for the remaining treatments. If you forgot to use the 'paste values' option above, you will get 'REF' in each formula cell instead of the values because the formula now refers to cells that are no longer there. If so, go back and repeat the steps.

The column labeled 'unit' on the average rows for each treatment will be empty and can be erased (highlight that column, right click and 'delete').

You should now have a spreadsheet with 5 rows (the title row and one row for each treatment) and 9 columns (the treatment column, and each of the four variables with their standard deviation). You are now ready to create the first plot (bar graph).

Create a graph

To create a graph, you will need to select the data you want to graph: the treatments and the corresponding values for each treatment. First, highlight the treatment names: place the cursor to the first treatment (C) and scroll it down to the last (FB). Then press the 'ctrl' key and, while pressed, move the cursor to the first cell of values for a given variable (e.g. seed number) and scroll down to the last value. At this point you should have highlighted ONLY the treatment names (C, T, SB and FB) and their four values. Do not click on the cursor anywhere within the spreadsheet because you will lose the highlighted area. If so repeat the steps above to highlight what you want to plot. Once the data of interest (the four treatment names and their values) are highlighted, go to the 'insert' tab on top of the screen by just clicking on the tab, then select 'column' in the chart sub menu, and, finally, select the first 2-D chart. The chart appears automatically. If necessary, drag it down by clicking on the outer edges of the graph (to select the whole graph), and while holding down on the left mouse button, drag the graph as a unit to a free space where it does not cover any other data. You can make further modifications by right-clicking over different portions of the figure:

Modify the appearance of the chart:

- Gridlines. The gridlines, if they appear, are not necessary. You can remove them by right clicking on any one of them (they will be selected) and selecting 'delete' from the box that appears. Right clicking gets you everywhere, yeah?
- Plot Area. Some older excel versions automatically have a gray background. Make it white so we do not waste toner ink. Plus, the graph will be clearer. Right click somewhere above the legend so the whole plot is selected (and not just the area with the columns), select 'format chart area', select 'solid fill' and select white.

- Axis titles. Click somewhere within the chart so that the entire chart is highlighted. Notice that the “chart tools” heading opens up at the top taskbar. Click on ‘layout’ and then the drop down the ‘axis titles’ button. Select first ‘primary horizontal axis title’ and then ‘Title below axis’. Write the title (in this case: ‘Treatment’) in the upper right bar above the column letters and press enter. Do the same for the vertical axis (‘Axis’ Titles’; ‘Primary vertical axis’; ‘rotated title’). Make sure to include the variable name and proper units in parentheses (this should be the same as the variable title in the top row; e.g. ‘Seed Mass (mg)’). You can later modify the title on an axis by highlighting the text in it (scroll the mouse through the text so it becomes highlighted) and typing the new text.
- Column fill. If you’d like to change the color or pattern of the columns, you can right click on them and select “Format Data Series”. Click the “Fill” option, select solid (simpler is better) and the color. (Note the use of lighter colors saves toner ink)
- Y-Error Bars. These indicate the variation. On the ‘layout’ tab of the ‘chart tools menu’, click on ‘error bars’ (tiny box on the right hand side). Select ‘more error bars options’. A box appears (‘Format error bars’). Select ‘both’. Then click on the outside borders of this box to select it and drag it down so it does not cover your data. Then click on ‘custom’, ‘specify value’ and select ‘both’. Don’t worry if excel starts putting strange error bars all over everything, you can fix this later. A new box appears (‘custom error bars’), and you will have to get comfortable with this one. Click on the weird square symbol under ‘positive error value.’ The box shrinks, and now you can select the standard deviation values for each treatment on the right of the average column (i.e. the standard deviation column, without the title, for the variable you want to plot) by moving the cursor through them. Click again on the weird square icon under the ‘positive error value’. You’ve just inserted error bars *above* your data point. Do the same for the ‘Negative error value’. Then click on OK in the ‘Custom error bars’ box and close the ‘Format error bars’ box. You will now see the graph with error bars. These bars indicate 1 standard deviation above and below your mean value on the chart. If the bars for different treatments overlap, it is very likely that the average values are not statistically different.
- Figure size. You can change the size of the figure by first highlighting the whole chart (click on the borders), then placing your cursor on a corner of the figure. Once the icon changes to a diagonal double-arrowed line, you can press and drag the chart in the direction of the size you want (i.e. smaller or bigger). Changing the chart from the corner keeps the same proportions; when you change the size just from one side or the other, the chart can become distorted. Size the chart *before you copy and paste it somewhere else*—this will make the chart look better. By the way, when you paste the graph into another document, use ‘paste special’ and select ‘windows metafile.’
- Y-axis scale. You can change the y-axis scale by right clicking on the numbers and selecting format axis. Under the “Axis options” tab you can select the minimum and maximum values of the range you want the axis values to cover (e.g. for percent, 0-100) and how many values it will show. For example, if you want the graph to show every 20%, you would type 20 into the major unit box.
- Font Size. Font size of any text in graphs should be at least 12 point. To change the font of any text, left click on the text (a box will then enclose the text) and press the ‘Home’ tab. There, you can select the font by either selecting it from the drop down options below the number box next to the font type or by selecting the larger icon ‘A’ with a tiny triangle pointing up..
- Get rid of the legend: The x axis label already describes the variable names, so we do not need a legend. Click on it and press delete on the keyboard.
- Remove the graph border. If you click on any cell of the exccel where the graph is (but not inside the ggraph) you will see that the graph has a border, which we do not want it in our final word document

where we will past the graph. Select the whole graph by clicking somewhere on the lower left corner. Right click and select 'format chart area'. Select 'border color' and 'no line'. Close.

Paste your figure in word for the report.

Open your word document and press a couple time 'return'. Then go to your excel with the figure. Select the whole figure by clicking somewhere in the lower left corner. Right click and select copy. Go to your word document (the cursor will be where you were when you opened it and pressed return). Right click and select the last icon of the paste options which pastes your figure as a picture (you can also just paste, but this makes it more difficult to resize). On word, click on the figure, right click and select 'wrap txt' and the 'top and bottom'. To resize the graph click on it, place cursor on one of the corners and then drag to resize.

Add a legend.

All figures in the report must be numbered and have a legend that describes the figure. In this case the legend should be: Radial growth Ratio (growth nine years after treatment relative to growth nine years before treatment) in the different management treatments. Control: C, Thinning: T; Spring burn: SB; Fall Burn: FB. Error bars represent the standard deviation of the mean.

Below is an example of a figure and the legend written below it. Figures for the remaining treatments should look very similar but with different y-axes labels.

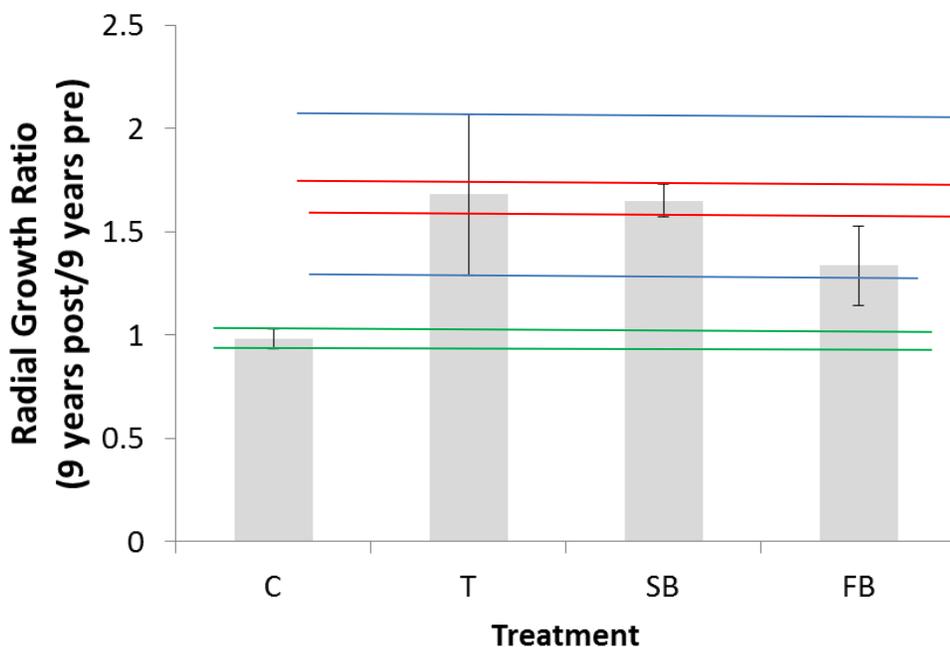


Figure 1. Radial growth Ratio (growth nine years after treatment relative to growth nine years before treatment) in the different management treatments. Control: C, Thinning: T; Spring burn: SB; Fall Burn: FB. Error bars represent the standard deviation of the mean.

Complete the graphs for the rest of the variables.

When error bars do not overlap horizontally, it is likely that differences in mean growth values are statistically significant. In Figure 1, we see that the error bars for the control do not overlap those of any of the treatments. Therefore, it is likely that each of the three treatments had an effect on growth of the plant. Further scrutiny shows that a particular treatment is not likely to have different effects on growth rate compared to another treatment, it may be different than a third. This is the case when comparing the Fall

Burn treatment with Thinning (overlapping error bars indicate no likely statistical difference) and with Spring Burn treatment, where the error bars do not overlap, indicating a likely statistical difference between the efficacy of Fall Burning vs. Spring Burning. You end up being able to say that all three treatments are likely to improve radial growth rate in ponderosa pine compared to doing nothing. You will also be able to say that it is likely that thinning and spring burning have about the same impact, and the results are more variable with thinning. Thirdly, comparing fall burning to the other two treatments we can infer that it is likely that the thinning and fall burning have very similar impacts but that the spring burning is likely to do a better job of increasing growth rate than does fall burning. As the notable Jedi scientist Yoda would opine, “pretty cool, this statistics stuff is”.

However, to finalize these conclusions and disprove your null hypothesis, a proper statistical test would need to be performed. Remember, disproving a null hypothesis is the correct use of the statistical method in your data analysis. This final step is not part of this laboratory exercise, and requires a bit more statistical knowledge on the student’s part.

Report

Write a short report following the format given (or posted on Moodle). Although the primary goal of this exercise is to learn how to organize, analyze and plot results, write the report as if the only objective was to determine treatment effects on growth, cone production and seed traits.

Refer to the “Writing Lab Reports” section of the Course Pack for ideas on how to get this task started and finished. Seek help from Burke, your instructor or study group mates.