Scientific Foundations
Spring 2008

Physics, Chemistry, Geology & Biology

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Syllabus

- This is a list of all the dates of the classes, all the assignments and other important information.
- Your syllabus is also online and may get updated be sure to go to this website to see it and to get class notes: http://www.faculty.umb.edu/yvonne_vaillancourt
- Notice there is one primary text book, ***Science Matters***, always keep up with the reading in that book.
- You have a quiz every Tuesday, except for this week and the week after the midterm exam.
- In week one, your first two assignments are to read the introduction and chapter one in your text book. Then review your notes from the first two lectures.

Science Introduction

Study & training within the sciences involves learning:

- terminology,
- natural laws,
- theories that define our understanding of the natural world.

Science is fueled by:

- Problem solving,
- Curiosity,
- and the desire to determine the truth about how the natural world operates.

Technology

- is the application of gained knowledge to improve our lives, mostly regarding work.

Who does science?

Senior Scientists

These are researchers hired by Universities, Institutions and the Uniformed Services (FDA,NASA,NOAA,NIH…& the Military) to conduct research, many teach but not all. They plan large, long term studies and oversee other researchers. (their experiments are carried out by post Docs, fellows, graduate students and undergrads)

Researchers

There is a lot of science in industry.

Scientists in training

Those at the advanced level have 4 year degrees already (BA, BS) and have entered a program of graduate study (Masters or PhD) for advanced study and become very specialized. Experimentation, research and teaching is carried out by such graduate students.

Undergraduate students

2 or 4 year degree seeking students (associate or bachelors) also can be involved in research projects.

To see what is going on in peoples labs you can also check out:

The internet (edu gov org com)

- Individual academic lab websites http://www.umb.edu
  http://www.whoi.edu
- Posted publications
  http://www.sciencemag.org/
- Agencies http://www.nasa.gov
  http://www.nih.gov

Walk the hallways of institutions

(like this one) and view posters hanging on the walls next to science labs

Quest for answers and understanding:

How do you formulate a question out of chaos?

- Define and articulate components
  - Limit confusion
  - Limit possibilities or variables potentially contributing to an outcome
- Observations yield patterns
  - It becomes quite interesting when a system doesn't fit an expected pattern.

The Answers

How do you answer a question?

- Form a theory about how something works based on known information
- Create a guess or hypothesis, of what you would expect to happen following a certain scenario
- Testing your hypothesis
  - When you test, or experiment, how do you know the result is not just by chance?
    - » You test a lot!
    - » You use probability tables to determine chance: that what statistics is all about

What we already know

- In order to communicate new ideas and have productive discussion regarding future technologies, people ought to learn currently accepted terminology and theories.
- Much of the natural world at our scale, has been defined and articulated well:
  - this is why we spend a lot of time learning specific definitions.
  - It makes communication possible.
  - It makes understanding each other's theories possible.

Technology is fast, Science is slow

- It takes a lot of work, often a long time, just to answer one very specific question.
- Larger questions and problems are solved in numerous tiny steps.
- The best experiments are repeatable and have tested the hypothesis rigorously.
- This takes time.
- Once a system is understood applications are possible.

Scientific Communication

- Scientists have meetings and conferences to share new findings and to foster new ideas.
  - Discussions within the community (very current information)
- Publish reports and results in journals (most common)
  - Most current completed work (undergoes peer review)
- Write books (texts or theoretical explanations)
- Internet lists, daily global interactions among colleges within a discipline

Presenting and Writing

- Formal communication is similar globally.
  - Journal publications are often outlined or have the same components of the academic format called a “lab report” used in many courses.
  - Presentations often use a similar format
    - Thesis to finish a degree
    - Communication to get a job
    - Talks at scientific conferences
  - Summaries and reviews are also common but differ in format to the explanation and reporting of experimentation.

The Format of Lab Reports

- It is not one long essay.
- There are specific parts to a report.
- You can locate them because they each have a heading printed above them.
- Each section has a distinct purpose.
- This structure allows researchers to **reproduce** experiments, get background information from references and efficiently locate information.

Lab Report Sections

- **Title page:** First page, informative title, date, author's name and course information
- **Introduction:** Background information leading to an explanation of the hypothesis.
- **Materials and methods**: what was used & what was done, written so the reader could repeat the procedure
- **Results:** graphical display of data with text describing the outcome, not explaining it
- **Discussion:** offers an explanation or interpretation of results with supportive information
- **Conclusion:** summary of the experiment (basically one sentence summing up each section)
- **References:** list of supportive information cited

Example Question

- Does using fertilizer improve the garden harvest?
  - Easier to look at one crop:
    - Tomatoes

Does using more fertilizer produce better tomatoes?

What do you mean by improve?

Quantity (more)?

Size : Larger, smaller, ideal mid-range

Shape

Better Tasting : sweeter, less acidic

Longer shelf life

Quicker growth

More dense

Keep it simple and focused to get an answer

- Easier to look at one aspect:
  - Number of tomatoes

- How would you try to answer this question?
  - Frame a testable question, it will have a comparison in it.

Does fertilizer increase cherry tomato yield?

This is a testable question with a yes or no answer.

Simply count the tomatoes produced, or how would you set this up?

Experimental design

What do you need to do to get an answer? What is your set up for testing?

- You need a control group (what's that?)
  - tomatoes grown similar in all ways except for fertilizer
- What else may effect your experiment (variables)
  - sun, soil and water : must be taken into account and be constant
  - This allows you to control for chance effects.
- You count all tomatoes per plant and do what?
  - Get an average per plant
  - Compare between control and other treatments of fertilizer
- Is the average number of tomatoes produced per plant larger with fertilizer ?

Null hypothesis

- This is perhaps easier to do using a **null** hypothesis. Where you state no difference is expected.
- “Fertilizer does not make a difference in number of tomatoes produced.” With this null hypothesis you expect equal averages among treatments.
- You accept or reject a hypothesis based on data.