Lecture 01: Intro to Science

1. What is science?
    a. Method of understanding natural world
        i. Physical, material universe
    b. Other non-scientific methods of understanding the natural world, too
        i. Experience, teaching, intuition, many more
        ii. Useful for daily life; not so useful for advancing human knowledge
    c. Testing ideas is key – process of experimentation and hypothesis formation
    d. Scientific Method
        i. Make Observations
        ii. Form Hypothesis
            1. Testable, tentative answer to a question
            2. Must be falsifiable
            3. Null hypothesis
        iii. Test Hypothesis
        iv. Analyze Results
            1. Use of probability and statistics
            2. *P*-value: likelihood of incorrectly rejecting the null hypothesis
                a. Lower *P* "better," in the sense that it is a lower likelihood of incorrectly rejecting the null
            3. Null hypothesis: statement of no effect/interaction
                a. If null (no effect) is rejected, alternate hypothesis (some effect exists) is supported
            4. By convention, $P \leq 0.05$ is considered significant
                a. (In other words, likelihood of incorrectly rejecting null hypothesis is less than or equal to 5%)
            5. Example of hypothesis testing: relationship between grade and class attendance
        v. Report Results
            1. Peer Review
                a. Science relies on incremental process of hypothesis testing; builds upon itself

b. Because science is progressive, important that "bad" science is detected and rooted out
c. In peer-review, scientific work is submitted to non-affiliated, anonymous reviewers, who check for quality

vi. ?? Societal Outcomes??
1. Results of individual experiments can be incorporated into framework of understanding

e. Hypothesis vs Theory
i. Theory is unifying, consistent, well-supported explanation for some natural phenomenon
ii. Based on accumulated <u>facts</u> (hypotheses which are so highly supported, it would be irrational to deny them)
iii. To establish theory, requires hypotheses which are thoroughly tested, resulting in scientific facts. Many scientific facts are drawn together to create scientific theory.
1. Example: facts establish theory: approximate age of earth
iv. Law: statement that something will occur, based on repeated observation
v. In order of levels of understanding, theory > law > fact > hypothesis

f. Limits of Science
i. Some ideas cannot (currently?) be tested—if so, not useful as hypotheses. Can't 'science' them.
ii. Useful only when testing the natural world
iii. Fails at investigating supernatural phenomenon, morality, etc.

Focal Questions:

1. What is science? How does it work?
2. What are the components of the scientific method? Understand what is meant by each part.
3. What is the difference between a hypothesis and a null hypothesis?
4. How do scientists analyze data? What is a *P*-value?
5. Why is the peer review process important in science? How does it work?
6. What is the difference between a "theory" in the common parlance, and a scientific theory?

7. What is the relationship between a hypothesis, a fact, a theory, and a law?
8. In what cases is science useful? When is science not useful?