Notes

Biology 101, Winter 2007
Dr. Karen Bledsoe
http://www.wou.edu/~bledsoek/

Topics: Nature of Science, Scientific Inquiry, the Study of Life

Reading: Chapter 1

> *I have a friend who's an artist, and he sometimes takes a view which I don't agree with. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree. But then he'll say, "I, as an artist, can see how beautiful a flower is. But you, as a scientist, take it all apart and it becomes quite dull." I think he's kind of nutty... There are all kinds of interesting questions that come from a knowledge of science, which only adds to the excitement and mystery of a flower. It only adds.*
>
> Richard Feynman, *What Do You Care What Other People Think?* (1989, p. 11)

Main concepts:

- Life can be studied at many different levels, from the atomic level to the community level.
- Scientific knowledge is developed through scientific inquiry. Inquiry seeks natural causality and relies on empirical evidence (data from the natural world) to support claims.
- Science assumes that the world is real and knowable, and that there is an objective reality. Not all forms of academic study share this assumption.
- In spite of what the book says, there is no one single set of steps called "the scientific method." Inquiry can occur through controlled experiments as described in this chapter. It can also take the form of descriptive studies and correlative studies. What these have in common is hypothesis testing.
- A hypothesis is an initial explanation for some observation. Hypotheses are tested by making predictions, then carrying out a study to see if the prediction holds true or not. Science is not about trying to "prove" hypotheses.
- A scientific theory is a well-founded, evidence-supported explanation of a natural phenomenon. A scientific law is an evidence-supported description of a natural phenomenon. The boundaries between these two are often fuzzy, but both are valid products of science. Both drive scientific inquiry, since predictions can be made based on both laws and theories.
- Evolution is the unifying theory of modern biology. Evolution refers to the change in the genetics of a population of organisms over many generations. Evolution has been studied for nearly 200 years, and the genetics of evolution have been studied for over a century. There is abundant evidence that the genetics of populations change across generations, though exactly how it changes and how this leads to speciation is an active field of study, especially at the molecular level.
- Defining life is not as easy as it sounds. Living things share a set of characteristics. While non-living things may share a few of the characteristics, the more characteristics that something has, the more likely it is to be alive. The question of "what is life?" is still an open question in the field of Astrobiology.
- Living things are currently classified into three domains: Archaea, Bacteria, and Eukarya. Archaea and Bacteria lack nuclei and other membrnae-bound cell parts. These two domains are often described as *prokaryotic* (i.e. lacking a nucleus). Eukarya have nucleli and membrane-bound cell parts. Organisms in this domain are described as *eukaryotic* (having a nucleus). "Nucleus" in this context refers to a structure inside the cell, surrounded by a membrane, containing the cell's DNA.
- All living things in all three domains have DNA and have a cell membrane.

Common misconceptions:

- Most people use the word "theory" in everyday language to mean "guess," and think it means the same thing in science. This causes a lot of people to believe that scientific theories are only guesses, when in fact theories are well-supported explanations based on data from many, many studies.
- People often believe that scientific laws are unbreakable, and that "proven" theories become laws. However, laws are descriptive while theories are explanatory. Both are valid products of science, and both can change as new discoveries are made.
- Many students confuse atom, molecule, and cell, viewing them all as "microscopic things." Atoms are the basic building blocks of molecules. Thousands of molecules make up a cell.

- Students are often confused about the difference between the nucleus of an atom and the nucleus of a cell, and may believe that an atom has DNA in its nucleus. Since DNA is a huge molecule made up of many atoms, this would be impossible.
- Many people have the idea that evolution is something that scientists "believe" in and are trying desperately to "prove." The evidence that evolution occurs is abundant and compelling, and the body of evidence has been growing for over 150 years. Evolutionary change underlies nearly all that we understand about modern biology, from shared genetic characteristics between organisms, to antibiotic resistance among bacteria, to trying to understand how best to save endangered populations. How traits of a population change over time is an active field of study.

Reading notes:

- List the levels of organization outlined in Figure 1-1, starting with the atom. Describe the difference between atoms, molecules, and cells. Which is the smallest of the three?
- Describe what is meant by "natural causality" and "natural laws."
- List the operations of the "scientific method" described in the book. Describe the differences between a question, a hypothesis, and a prediction.
- Explain what a scientific theory is, and how the meaning of "theory" in science differs from the way the word is used in everyday language. (This is important. The differences between loose, everyday uses of certain words and the very specific meanings of those same words in science causes a lot of confusion for science students.)
- Explain what evolution is and why it is the underlying theory of modern biology. (READ THE BOOK to answer this. Don't skip this section and jot down what you think you know.) Explain the importance of genetic variation, and what effect natural selection has on a population.
- List the characteristics of living things described in section 1.3. For each characteristic, try to think of non-living things that share that same characteristic. For example, living things maintain take in and use materials and energy. A car also takes in and uses energy.
- Describe the differences between the three domains. Define what is meant by "prokaryotic" and "eukaryotic." Describe what a nucleus of a cell is. (To be absolutely clear, also define what the nucleus of an atom is, and how it is different from the nucleus of a cell. Note how the same term is used to mean two different things. Why?)

Useful websites:

- "The State of Science Education: Subject Matter Without Context" (http://ejse.southwestern.edu/original%20site/manuscripts/v3n2/articles/guest%20editorial/lederman.html)has an excellent discussion of the Nature of Science, Scientific Inquiry, and the definition of Theory and Law, as well as thought-provoking ideas about science education. The author is a leading figure in the study of Nature of Science in science education.
- "Astrobiology" (http://astrobiology.arc.nasa.gov/) is a NASA website with discussions of what scientists are looking for when the look for life "out there."