CHAPTER

2

Science Fiction, Bad Science, and Pseudoscience

Water, Biochemistry, and Cells

OBJECTIVES

Teaching Goals

This chapter introduces an invisible world that students often find difficult to grasp. Descriptive imagery and graphic representations are the basis for understanding atoms and cells. As a teacher, you must connect this invisible world to the visible world that students can see. Carbohydrates, proteins, and fats make more sense when seen on a food label, for example. Cells become real when connected to forensic evidence left at the scene.

Student Goals

By the end of this chapter, students should be able to accomplish the following learning objectives:

- Describe the properties associated with living organisms.
- List the components of water and some of the properties that make it important in living organisms.
- Describe how atomic structure affects chemical bonding.
- Discuss the importance of carbon in living organisms.
- Compare and contrast hydrogen, covalent, and ionic bonds.
- Describe the structure of carbohydrates, proteins, lipids, and nucleic acids and the roles these macromolecules play in cells.
- Compare and contrast prokaryotic and eukaryotic cells.
- Provide a general summary of the theory of evolution.

LECTURE OUTLINE

2.1 A Definition of Life

A. All organisms operate using the same biological molecules, are composed of cells, and use feedback mechanisms to maintain homeostasis. **(Figure 2.1)**
Lecture Activity 2.1: Living Things Frayer Model

2.2 The Properties of Water

A. Atoms and subatomic particles play a role in chemical reactions and bond formation. **(Figure 2.3)**

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B. Water is essential to life, and its properties are based on its polarity. **(Figure 2.4, Figure 2.5, Figure 2.6)**
Lecture Activity 2.2: Properties of Water PEOE

2.3 Chemistry for Biology Students

A. Life on Earth is based on the carbon atom and its bonding capabilities. (**Figure 2.7, Figure 2.8**)
B. Chemical bonds between atoms and molecules involve attractions that help stabilize structures. (**Figure 2.10, Figure 2.11)**
C. Acids, bases, and salts play a role in chemical reactions. (**Figure 2.12)**
Lecture Activity 2.3: Understanding Chemical Bonding

2.4 Biological Macromolecules

A. Macromolecules (carbohydrates, proteins, lipids, and nucleic acids) are made of various subunits to create biological structures and support biological processes. **(Figure 2.13, Figure 2.14, Figure 2.15, Figure 2.16)**
Lecture Activity 2.4: Molecular Twenty Questions

2.5 An Introduction to Evolutionary Theory

A. Cells are the basic unit of life on Earth.
B. Cells are either prokaryotic or eukaryotic. Prokaryotic cells, such as bacteria, do not have a separate nucleus and are less complex than eukaryotic cells. **(Figure 2.18)**
C. The diversity of cells and organisms is based on evolutionary theory. **(Figure 2.19)**
Lecture Activity 2.5: Cell Venn Diagram

Lecture Activity 2.1: Living Things Frayer Model

Estimated Time to Complete: 15–20 minutes

Introduction: Characteristics that are common in living things may also be found in non-living items. This activity encourages students to better understand the distinctions between living things and non-living things through observations and discussions of a Frayer model.

Materials:

- Demonstration of "glue monsters" or images of living and non-living things
- Lecture Activity 2.1 Handout: Living Things Frayer Model

Procedures:

1. Engage students with a demonstration, video, or related images depicting living and non-living things in various stages. If an overhead projector is available, apply a dab of modeling glue to a water-filled petri dish to create a "glue monster." Online videos of this demonstration are also available.
2. Students should make observations of the demonstration, video, or images and consider the qualities that are necessary for life.
3. Individually or in small groups, students should complete each section of the Frayer model with information about living and non-living things.
4. After students have completed the handout, discuss their answers and summarize the definitions, characteristics, and examples of living things. Ensure that students understand how non-living things (such as the glue monster) may exhibit some, but not all, of the qualities necessary for life.

Assessment Suggestions: Students may participate in small group discussions to share the information on their Frayer models. The handouts may be displayed and then collected for evaluation.

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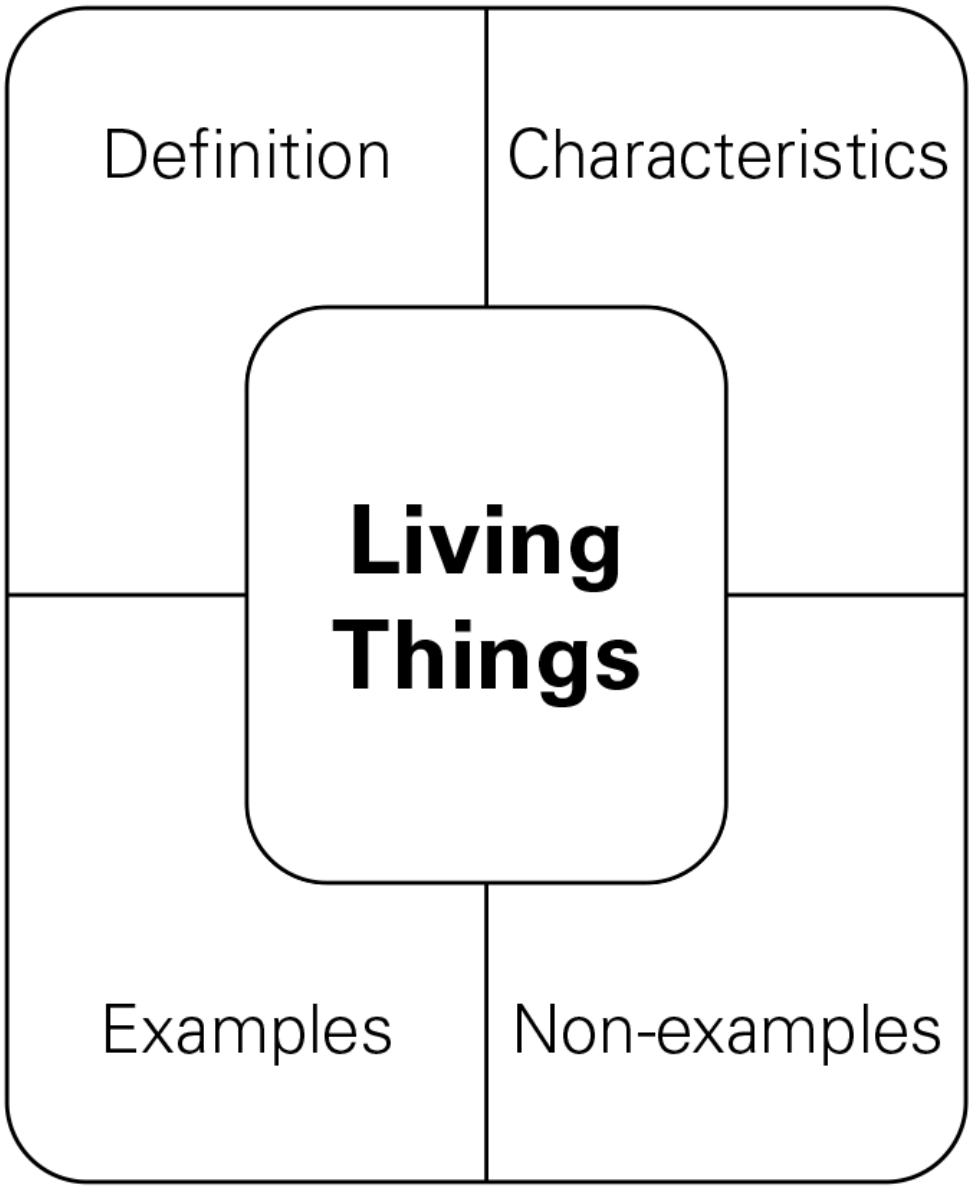
Lecture Activity 2.1 Handout: Living Things Frayer Model

Directions: Complete each of the sections on the Frayer model with information about living things.



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Lecture Activity 2.2: Properties of Water PEOE

Estimated Time to Complete: 15–20 minutes

Introduction: Water is a very important liquid on Earth and a necessary support for biological systems. Water has various properties that promote its usefulness to the environment and living things. This activity encourages students to observe and explain specific qualities of water.

Materials:
- Demonstration of "scared pepper" or video of demonstration
- Lecture Activity 2.2 Handout: Properties of Water PEOE

Procedures:
1. Explain the set-up of the "scared pepper" demonstration to students: A large container of water has ground pepper sprinkled over the surface. Later, the surface will be touched with a soapy finger.
2. Students should complete the "Predict" portion of the PEOE handout to answer the question: What are your predictions for the water demonstration?
3. Students should complete the first "Explain" portion of the PEOE handout using their own prior knowledge and textbook information to answer the question: What properties of water support your prediction?
4. Complete the demonstration or show students a video of the process available online.
5. Students should complete the "Observe" portion and the final "Explain" portion using evidence to support the explanation of their observations.
6. As a whole class or in small groups, discuss the student explanations of the demonstration and how the properties of water contributed to the final result.

Assessment Suggestions: Students may participate in small group discussions to share the information on their PEOE handouts. The handouts should be collected for evaluation.

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Lecture Activity 2.2 Handout: Properties of Water PEOE

Predict: What are your predictions for the water demonstration?

Explain: What properties of water support your prediction?

Observe: What did you see happening during the water demonstration?

Explain: Why did the water demonstration occur in that way?

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Lecture Activity 2.3: Understanding Chemical Bonding

Estimated Time to Complete: 10–20 minutes

Introduction: This activity is a basic introduction to the concept of chemical bonding. It is a short, in-class exercise that can follow the first discussion of atomic structure and bonding. Students will take the number of their birth month as their atomic number. Given this information, they will be able to determine the configuration of their electrons. They will then be able to determine how they, as atoms, will interact with other atoms, if at all. Students will form "bonds" with other students to make ions or molecules.

Material:
- Lecture Activity 2.3 Handout: Understanding Chemical Bonding

Procedures:
1. Briefly explain to the students what they will be expected to do on the worksheet.
2. Each student will complete a worksheet alone, but you can allow students to work together if you like.
3. Pass out worksheets, and circulate around the room to ensure that students get started correctly; answer questions that come up.
4. After they know which type of partner they need, encourage students to get out of their seats and walk around to find someone suitable.

Assessment Suggestions: Collect and grade the handouts. Use this assignment as the basis of a homework or test question.

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Lecture Activity 2.3 Handout: Understanding Chemical Bonding

1. What is the number of your birth month? (January = 1, February = 2, etc.) This is your atomic number.

2. Draw your appearance as an atom. Around the nucleus, put the correct number of electrons in their correct valence shells.

3. Which type of bond would you like to form to become stable?

4. Find one or more other students to bond with so that you form a stable bond. Draw the ion or molecule that you all formed.

5. Explain why you are stable in this configuration.

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Lecture Activity 2.4: Molecular Twenty Questions

Estimated Time to Complete: 10–20 minutes

Introduction: In this activity, students get an opportunity to test their knowledge of biological molecules. The students will form groups of three to four. Each student will secretly receive the name of a biological molecule. The other students in the group will then take turns asking yes or no questions until one of them is able to correctly guess the identity of the molecule in question.

Material:
- Names of different molecules on pieces of paper cut from the bottom of this page.

Procedures:
1. Divide students into groups of three to four. Explain how the game will work, and have the students determine who will go first in each group.
2. Pass around a hat or box containing small folded pieces of paper each with the name of a molecule. In a small class, you can pass out the papers initially to only one student in each group, and then have other students come up for another piece after each round. In a large class, have everyone take a paper at the same time.
3. The person going first in each group silently reads his or her molecule's name, and then the other group members take turns asking a yes or no question to try to identify the molecule.
4. When students have a guess about the molecule, they must wait until it is their turn to say it.
5. Other members of the group then answer questions about their molecules until all members have had a turn, or until the allotted time is up.

Assessment Suggestion: You may have the students keep track of how many molecules they guess correctly, and give out a grade or extra credit for those who score above a certain number.

Molecule Names

DNA	**Glucose**	**Cholesterol**
Water	**Phospholipid**	**Polysaccharide**
Fat	**Sucrose**	**Protein**
Amino acid	**Nucleotide**	**Water**

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Lecture Activity 2.5: Cell Venn Diagram

Estimated Time to Complete: 15–20 minutes

Introduction: All cells share certain structures and characteristics. Prokaryotic and eukaryotic cells differ in their cellular structures and levels of complexity. Completing a Venn diagram allows students to better understand the commonalities and distinctions between these two types of cells.

Material:

- Images or video examples of various types of prokaryotic and eukaryotic cells
- Lecture Activity 2.5 Handout: Cell Venn Diagram

Procedures:

1. Engage students by displaying the images of the prokaryotic and eukaryotic cells, encouraging students to note the similarities and differences between the various types of cells.
2. Individually or in small groups, students should use the image observations, their prior knowledge, and textbook information to complete the 3 sections of the Venn diagram.
3. When the diagrams are completed, request student responses and summarize the characteristics listed on the Venn diagram, ensuring that the main similarities and distinctions between the cells are highlighted.

Assessment Suggestions: Students may participate in small group discussions to share the information on their Venn diagram handouts. The handouts should be collected for evaluation.

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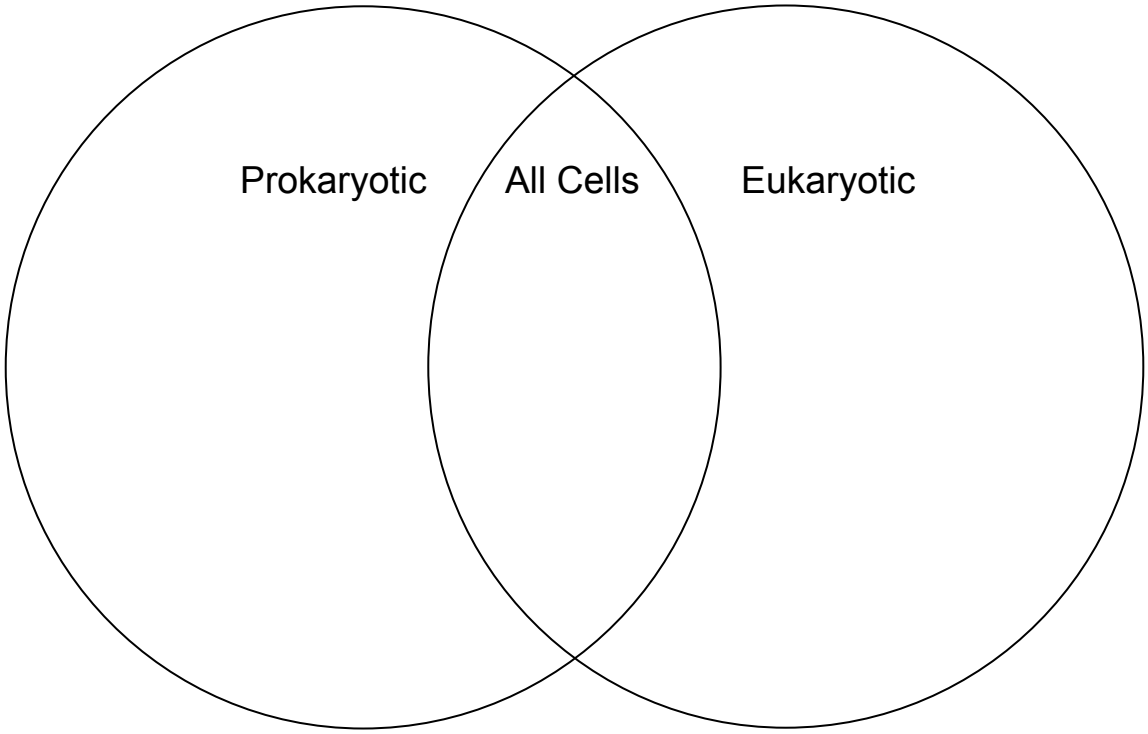
Lecture Activity 2.5 Handout: Cell Venn Diagram

Directions: Complete the Venn diagram using the characteristics of all cells, prokaryotic cells, and eukaryotic cells.



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Other Resources for Chapter 2:

- *Biochemistry: Chemistry of Life*, The Biology Project, University of Arizona (http://www.biology.arizona.edu/biochemistry/biochemistry.html)
- *Biology Simulations (Molecule Polarity)*, PhET, University of Colorado (http://phet.colorado.edu/en/simulations/category/biology)
- *The Chemistry (and Meaning) of Life*, Evolution and the Nature of Science Institutes (ENSI) http://www.indiana.edu/~ensiweb/chem.life.intro.html
- *Encyclopedia of Life* (http://eol.org/)
- *How Polarity Makes Water Behave Strangely*, TED Ed (http://ed.ted.com/lessons/how-polarity-makes-water-behave-strangely-christina-kleinberg)
- *Plant, Animal and Bacteria Cell Models*, Cells Alive (http://www.cellsalive.com/cells/3dcell.htm)
- *Water Properties and Measurements,* USGS (http://water.usgs.gov/edu/waterproperties.html)

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