

Biology 105 -- Environmental Biology  
Pima Community College, Downtown Campus

Worksheets for Unit 2: Environmental Systems: Connections, Cycles, Flows, and Feedback  
Loops

UNIT 2 LEARNING OBJECTIVES

Define ecology. Define matter, and describe the law of conservation of matter. Define energy. Distinguish between kinetic energy and potential energy, and give examples of each. Distinguish between heat and temperature. Distinguish between high-quality and low-quality energy, and give examples of each. Distinguish between the first and second laws of thermodynamics, and define entropy. Define element and atom. Name and describe the three components of an atom. Distinguish between atomic number and atomic mass. Define ion, isotope, molecule, and compound. Define acids and bases. Describe the pH scale, and where acids and bases are located on the pH scale. Name the four major classes of organic biochemical compounds, and list examples of each class. Describe why cells are the fundamental units of life. Define enzymes and metabolism. Describe the seven unique qualities of water. Name the source of energy used by all living organisms. Describe the electromagnetic spectrum. Describe the process of photosynthesis. Name the organelle in plant cells that carries out photosynthesis. Name the molecule that captures light energy in photosynthesis. Write the balanced chemical equation that summarizes the process of photosynthesis. Define cellular respiration, and write the balanced chemical equation that summarizes cellular respiration. Define species, population, community, and ecosystem. Distinguish between biotic and abiotic factors of the environment. Distinguish between open and closed communities. Define biomass, productivity, producers, consumers, food chain, food web, trophic level, herbivores, carnivores, omnivores, autotrophs, and heterotrophs. Given a food chain or food web, identify the organisms using the terms above. Define scavengers, detritivores, and decomposers, and give examples. Describe three reasons why the trophic structure in most ecosystems is shaped like a pyramid, with most of the energy stored in producers. Describe the average amount of energy at one trophic level that is carried up to the next trophic level. Describe the biogeochemical cycles of carbon, nitrogen, phosphorus, and sulfur, and ways in which humans disrupt these cycles. Compare the flow of matter and energy through an ecosystem.

UNIT 2 ACTIVITIES

Step 1. Read Chapter 2 in your textbook (*Principles of Environmental Science*, 4th ed. by Cunningham and Cunningham) and answer the questions in these worksheets. For hints, or to double-check your answers, go to the Biology 105 website.

Step 2. Your textbook covers some of the material in Chapter 2 in a very brief manner! If this is your first exposure to these concepts, you may need additional help. I have provided seven online tutorials to help you with the main concepts for this unit. These tutorials are accessible from the Unit 2 webpage (on the Biology 105 website) and correspond to the textbook and worksheets according to the following table:

Concept / Tutorial Title on Biology 105 Website	Textbook Headings	Textbook Pages	Worksheet Questions
1. Energy and Thermodynamics	Matter is made up of atoms, molecules, and compounds	27	5-6
	Energy occurs in different types and qualities	31-32	15-19
	Thermodynamics regulates energy transfers	32	20
2. Chemistry	Matter is made up of atoms, molecules, and compounds	27-28	7-9
	Chemical bonds hold molecules together	28	9-10
	Electrical charge is an important chemical characteristic	28-29	9-11
	Organic compounds have a carbon backbone	29-30	12
	Cells are the fundamental units of life	31	13-14
3. Water	--	--	21
4. Photosynthesis and Cellular Respiration	Extremophiles live in severe conditions	32-33	23
	Green plants get energy from the sun	33-34	22, 24
	How does photosynthesis capture energy?	34-35	24-27
5. Food Chains and Trophic Levels	From Species to Ecosystems (& all subheadings below it)	35-39	28-35
6. Biogeochemical Cycles	Biogeochemical Cycles and Life Processes (& all subheadings below it)	40-45	36
7. Flow of Matter and Energy	--	--	37

Step 3. For lab points, do the lab activity entitled "Acids and Bases in Your Daily Life." This lab can be done at home, but you must first obtain a packet of materials in the Biology Learning Center to take home. The instructions for the lab activity are on the Biology 105 website. There are worksheets for this activity later in this packet. When you have completed the activity, take your worksheets to the front desk in the Biology Learning Center for lab points.

Step 4. For lab points, do the lab activity entitled "Biodiversity Under the Microscope." Go to the Biology 105 website to find the instructions for this activity. There are worksheets for this activity later in this packet. When you have completed the activity, take the results to the front desk in the Biology Learning Center for lab points.

Step 5. Prepare for the Unit 2 Exam. Study your completed worksheets, view the tutorials, and take the online multiple-choice self test (on the Biology 105 website).

Step 6. Come in to the Biology Learning Center to take your Unit 2 Exam. The exam will consist of 40 multiple-choice questions.



6. Describe the law of conservation of matter.

7. Define element and atom. Name and describe the three components of an atom.

8. Distinguish between atomic number and atomic mass.

***ELEMENTS OF LIFE: CHEMICAL BONDS HOLD MOLECULES TOGETHER & ELECTRICAL CHARGE IS AN IMPORTANT CHEMICAL CHARACTERISTIC***

9. Define the following terms.

a. ion

b. isotope

c. molecule

d. compound

10. Chemical Reactions: In this unit, you will only be required to write out and balance two chemical reactions. One is the reaction for photosynthesis, and it is covered in more detail in the Photosynthesis and Cellular Respiration section. The other is the reverse of this reaction: cellular respiration. It is also covered in more detail in this section.

11. Define acids and bases. Describe the pH scale, and where acids and bases are located on the pH scale. See Fig. 2.5.

***ELEMENTS OF LIFE: ORGANIC COMPOUNDS HAVE A CARBON BACKBONE***

12. Organic chemistry and biochemistry: **Organic chemistry** is the study of compounds that contain carbon. One area of study within organic chemistry is biochemistry, which is the study of organic compounds in living things. Name the four major classes of organic biochemical compounds, and list examples of each class.

***ELEMENTS OF LIFE: CELLS ARE THE FUNDAMENTAL UNITS OF LIFE***

13. Describe why cells are the fundamental units of life.

14. Define enzymes and metabolism.

***ENERGY: ENERGY OCCURS IN DIFFERENT TYPES AND QUALITIES***

15. Define energy.

16. Distinguish between kinetic energy and potential energy and give examples of each.

17. Describe the relationship between heat and temperature as described in the text.

18. Define heat and temperature as defined in the glossary in the back of the textbook. (See the online tutorial for an explanation.)

19. Distinguish between high-quality and low-quality energy, and give examples of each.

***ENERGY: THERMODYNAMICS REGULATES ENERGY TRANSFERS***

20. Distinguish between the first and second laws of thermodynamics, and define entropy.

21. Your textbook (in previous editions) had a section in Chapter 2 that discussed the seven unique qualities of water. I've summarized this information for you here:
- Water makes up 60–70% (on average) of the weight of living organisms. It is the medium in which all of life's chemical reactions occur. Water is a solvent that dissolves the nutrients that cells need, as well as the wastes that cells produce.
  - Water dissolves salts and other compounds, producing electrolytes, which conduct electricity and are important in metabolism.
  - Water molecules are cohesive, tending to stick together. This gives water a high surface tension.
  - Water exists as a liquid over a wide range of temperatures.
  - Water expands with it crystallizes. This makes ice (a solid) less dense than liquid water.
  - Water has a high heat of vaporization, meaning that it absorbs a great deal of heat before being converted to water vapor. This makes water useful for evaporative cooling.
  - Water has a high specific heat, meaning that water absorbs a great deal of heat before the temperature of the water increases. This is why day and night temperatures do not fluctuate as much along the coast (like San Diego) as they do inland (like Tucson).

***ENERGY FOR LIFE***

22. Name the source of energy used (directly or indirectly) by all living organisms except extremophiles.

***ENERGY FOR LIFE: EXTREMOPHILES LIVE IN SEVERE CONDITIONS***

23. Describe chemosynthesis and give examples of the extreme environments in which extremophiles live.

***ENERGY FOR LIFE: GREEN PLANTS GET ENERGY FROM THE SUN***

24. You should be able to describe the **electromagnetic spectrum** (Fig. 2.11) in the following detail: The sun emits radiant energy in a variety of wavelengths. The most abundant wavelengths are those we see as **visible light**. Radiant energy with wavelengths shorter than visible light includes **ultraviolet**, **x-rays**, and **gamma rays**. Radiant energy with wavelengths longer than visible light includes **infrared waves** (= heat), **microwaves**, and **radio waves**. More than half of the incoming sunlight may be reflected or absorbed by atmospheric clouds, dust, and gases. In particular, harmful, short wavelengths are filtered out by gases (especially ozone) in the upper atmosphere.

25. Briefly describe the process of photosynthesis. Name the organelle in plant cells that carries out photosynthesis. Name the molecule (pigment) that captures light energy in photosynthesis.

***ENERGY FOR LIFE: HOW DOES PHOTOSYNTHESIS CAPTURE ENERGY?***

26. Write the balanced chemical equation that summarizes the process of photosynthesis. Remember, you need to know this one!

27. Define cellular respiration, and write the balanced chemical equation that summarizes cellular respiration.

***FROM SPECIES TO ECOSYSTEMS: ORGANISMS OCCUR IN POPULATIONS, COMMUNITIES, AND ECOSYSTEMS***

28. Define the following terms.

a. species

b. population

c. community

d. ecosystem

29. This edition of your textbook left out the explanation of the terms biotic and abiotic, but you still need to learn them! Here are the definitions:

a. **abiotic components** of an ecosystem: non-living factors, such as climate, water, minerals, pH, and sunlight

b. **biotic components** of an ecosystem: living components, including organisms and their products (secretions, wastes, and remains)

*FROM SPECIES TO ECOSYSTEMS: FOOD CHAINS, FOOD WEBS, AND TROPHIC LEVELS LINK SPECIES*

30. Define the following terms.

- a. biomass
- b. productivity
- c. producers
- d. consumers
- e. food chain
- f. food web
- g. trophic level
- h. herbivores
- i. carnivores
- j. omnivores

31. There are two additional terms you need to know:

- a. **autotrophs**: same as producers. Autotroph means "self-feeder."
- b. **heterotrophs**: same as consumers. Heterotroph means "other feeder."

32. You need to be able to look at a food chain or food web, and identify the organisms using the terms in questions 30 and 31 above. SEE THE ONLINE TUTORIAL #5 ON THE BIOLOGY 105 WEBSITE FOR MORE DETAILS.

33. Distinguish between the following, and provide examples.

- a. scavengers

b. detritivores

c. decomposers

**FROM SPECIES TO ECOSYSTEMS: ECOLOGICAL PYRAMIDS DESCRIBE TROPHIC LEVELS**

34. Describe three reasons why the trophic structure in most ecosystems is shaped like a pyramid, with most of the energy stored in producers.

35. According to “the popular rule of thumb,” what is the average amount of energy at one trophic level that is carried up to the next trophic level?

**BIOGEOCHEMICAL CYCLES AND LIFE PROCESSES**

36. There are five major biogeochemical cycles to learn in this course: water, carbon, nitrogen, phosphorus, and sulfur. The water cycle will be covered in Unit 10. The following is what you need to know for Unit 2.

**a. THE CARBON CYCLE**

Summary of the cycle: Carbon exists in the atmosphere in the form of carbon dioxide. Plants take up carbon dioxide and convert it into carbohydrates through the process of photosynthesis. Plants, animals, and decomposers convert carbohydrates into energy through the process of cellular respiration, and release carbon dioxide back into the atmosphere. Some dead plant material is buried before being broken down by decomposers, and, with time and pressure, is converted into peat, coal, oil, and gas. When either fresh wood or fossil fuels are burned, CO<sub>2</sub> is released back into the atmosphere. CO<sub>2</sub> can also become dissolved in ocean water, where it may be incorporated into the shells and skeletons of marine organisms. These shells eventually become calcareous sediments on the ocean floor, and through geologic processes may be converted into limestone and dolomite. If these rocks are subjected to volcanic activity, carbon dioxide is released back into the atmosphere by volcanoes.

Ways in which humans can disrupt the carbon cycle:

- 1. Destruction of forests causes less carbon dioxide to be taken up by plants.
- 2. Burning of wood and fossil fuels increases the amount of atmospheric carbon dioxide. A possible consequence of an increase in atmospheric carbon dioxide is global warming.

## b. THE NITROGEN CYCLE

Summary of the cycle: Nitrogen-fixing bacteria in the soil convert  $N_2$  into ammonia, then nitrite, and finally nitrate. (Legumes are a group of plants that are particularly important in nitrogen fixation, as they have roots with nodules containing nitrogen-fixing bacteria.) Plants take up the nitrate through their roots, and incorporate nitrogen into their proteins and their DNA. Animals take up nitrogen by eating plants or other animals. When plants and animals die, or when animals release nitrogenous wastes, decomposers convert the nitrogen back into ammonia. Denitrifying bacteria can convert nitrate back into  $N_2$ , which goes back into the atmosphere.

Ways in which humans can disrupt the nitrogen cycle:

- 1. The burning of fossil fuels creates nitric oxide, which leads to the formation of acid rain.
- 2. The bacteria that break down livestock wastes and agricultural fertilizers produce nitrous oxide, which contributes to the greenhouse effect.
- 3. Harvesting nitrogen-rich crops without crop rotation depletes the soil of ammonia and nitrate.
- 4. Overgrazing by livestock and use of pesticides destroy nitrogen-fixing bacteria.
- 5. Runoff of fertilizers and improperly treated wastewater excess nitrate to aquatic ecosystems, leading to excessive growth of algae. The subsequent breakdown of dead algae leads to the depletion of dissolved oxygen in the water.

## c. THE PHOSPHORUS CYCLE

Summary of the cycle: As rock is broken down by erosion and weathering, phosphate ions are added to the soil. Through erosion, run-off and leaching, phosphate ions are carried to the oceans and drift down into ocean sediments. Through geologic processes, these ocean sediments become rock, and are eventually exposed on land once again by geologic uplift. Plants take up phosphate ions from the soil through their roots, and animals take up phosphorus by eating the plants. When animal wastes and dead plants and animals are broken down by decomposers, phosphate ions are returned to the soil. Human activities speed up the cycle when phosphorus-rich rock is mined in order to make fertilizer and detergents.

Ways in which humans can disrupt the phosphorus cycle:

- 1. Phosphorus in rocks is being depleted by mining, erosion, and runoff faster than the phosphorus can be replaced by geologic processes.
- 2. Agricultural runoff and improper wastewater discharge add excess phosphate to aquatic ecosystems, leading to excessive growth of algae. The subsequent breakdown of dead algae leads to the depletion of dissolved oxygen in the water.

## d. THE SULFUR CYCLE

The only things you need to know for this course about the sulfur cycle are:

- 1. Sulfur is important for all living things, since sulfur is an important component of protein molecules, and therefore found in the tissues of all living things.
- 2. Some fossil fuels, particularly coal, can contain high amounts of sulfur. When the coal is burned, sulfur oxides are released into the atmosphere, leading to acid rain.

37. Compare the flow of matter and energy through an ecosystem. (Tutorial 7)

End of textbook questions for Unit 2