Learning the Water, Carbon and Nitrogen Cycles through the Effects of Intensive Farming Techniques

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Overview

Elements of natural substances are constantly cycling through Earth. Water, carbon, and nitrogen move through Earth's many ecosystems in closed paths called the biogeochemical cycles.

In this unit, students will learn about these cycles by understanding modern farming techniques used to produce enough food to feed a world population of 7.8 billion. Students will plan and carry out experiments, analyze and interpret data, and communicate the information learned.

This curriculum unit is intended for Biology students in Grades 9 and 10. The lessons are meant to be incorporated into "Unit 10: Ecology" of the School District of Philadelphia's Core Curriculum for Biology, which is typically taught at the end of the year (May/June).

Rationale

The biogeochemical cycles operate on a fixed amount of matter on Earth. While the total amounts of water, carbon and nitrogen do not change, these substances exist in many different forms. Water is found on Earth as solid ice, liquid water or gaseous vapor. Carbon and nitrogen both exist as in the atmosphere as carbon dioxide gas and nitrogen gas, respectively, or as an integrated part of living and non-living substances.

The hydrologic or water cycle describes the constant movement of water through Earth and its atmosphere. Major processes of the cycle include:

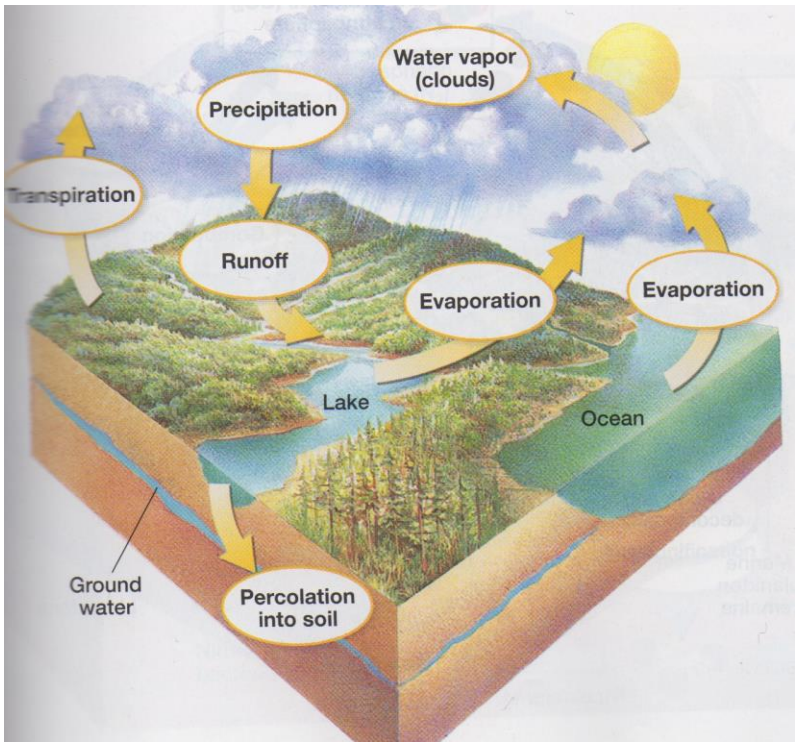
i) Precipitation (when water moves from the atmosphere back to the land; includes rain, snow, sleet and hail)

ii) Percolation (process by which water through the soil into groundwater)

iii) Evaporation (when liquid water changes into gaseous water; occurs directly from surfaces of oceans, rivers and lakes)

iv) Transpiration (water evaporation from the leaves of trees and other plants)

v) Condensation (when gaseous water condenses back into liquid form, mostly because of the cooling of air; results in the formation of clouds) (Raven 1210)



Source: Biology, "The Water Cycle", Holt, Rinehart and Winston, 2004, Print, pg 35

The carbon cycle is a straightforward process that describes the movement of carbon through Earth's ecosystems (see Figure 1 below). Carbon is a major component of all living organisms. In fact, almost 20% of the human body weight is carbon (Raven 1208).

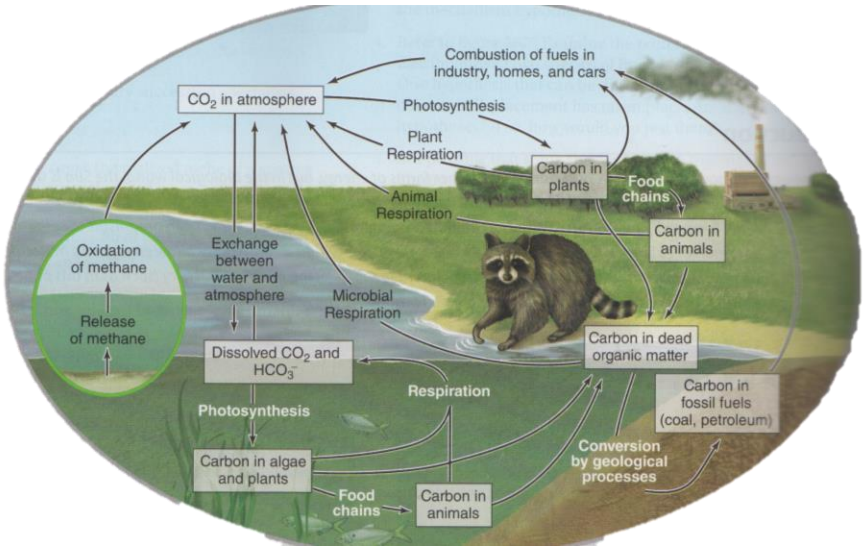


Figure 1: The Carbon Cycle.
Source: Biology, "The Carbon Cycle", McGraw Hill, 2014, Print, pg 1208

Nitrogen is an essential element of all living organisms. Heterotrophs (like humans and rabbits) get the nitrogen needed to build protein and nucleic acids by eating food. Autotrophs (like plants) get the necessary nitrogen by absorbing nitrates (NO_3^-) and ammonia (NH_3) in the soil through their roots. In many ecosystems, nitrogen is the chemical element shortest in supply. Even though nitrogen gas (N_2) makes up 78% of the atmosphere, most living organisms are unable to use the nitrogen in this form (Raven 1210). Prokaryotes convert the nitrogen gas into useable forms of nitrogen (see Figure 2).

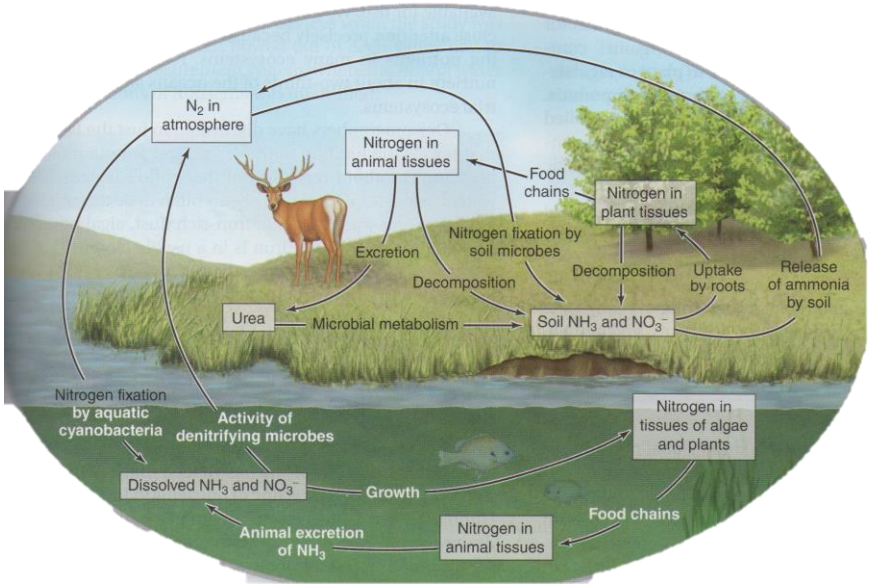


Figure 2: The Nitrogen Cycle
Source: Biology, "The Nitrogen Cycle", McGraw Hill, 2014, Print, pg 12011

Human activities have changed Earth's environment in many ways. These impacts are multifaceted and are complex cause and effect relationships. In this unit, we will explore only one of these activities (intensive farming) and its impact on the water, carbon and nitrogen cycles.

Intensive farming is a type of modern farming that refers to the industrialized production of livestock, poultry, fish and crops. It results in a large amount of food produced per acre, as compared to other subsistence farming patterns. This unit will focus on five intensive farming techniques farmers practice to produce large quantities of vegetables and livestock: irrigation, deforestation, pesticide use, fertilizer use and agricultural machinery use.

Irrigation is the process of artificially applying water to soil to allow for plant growth. Irrigation transports water to crops to increase yield, keep crops cool under excessive heat conditions, and prevent freezing. Often times, this process makes agriculture possible in arid or dry regions, areas that may have initially been unsuitable for growing crops.

Deforestation is the clearing of forests on a large scale, to provide more room for planting crops or raising livestock. Removing trees at such a massive scale can result in negative effects on the environment. It can lead to a loss of habitat for millions of species, promote desertification in certain areas (by eliminating transpiration), as well as drive climate change (National Geographic 2013). With fewer trees to absorb greenhouse gases, more will enter the atmosphere, fueling global warming.

Pesticides are any substances that are intended to prevent, destroy repel or mitigate any pest, in order to increase productivity of crops. They include insecticides, herbicides and fungicides. These chemicals are the most widespread method for pest control; farmers spend approximately $4.1 billion on pesticides every year. However, because pesticides are poisons, they pose a potential risk to humans as well as to the environment. Certain pesticides can enter and "pollute the tissues of virtually every life form on earth, the air, and the lakes and the oceans, the fishes that live in them and the birds that eat the fishes" (Aktar 2009). The insecticide DDT, for example, was found to interfere with the bald eagle's ability to make strong eggshells. The shells became so thin that they cracked when the eagle attempted to incubate them, thus severely decreasing the population of the bald eagle (and other birds of prey).

In addition to pesticides, many farmers also plant their crops with nitrogen, phosphorous and/or potassium based fertilizers in order to foster rapid plant growth. These additional nutrients in the soil typically result in more bountiful harvests and higher yields, but like pesticides, can lead to harmful effects on human health and the environment. Runaway nitrogen can result in "suffocating wildlife in lakes and estuaries, contaminating groundwater, and even warming the globe's climate" (National Geographic 2013). The effects of nitrogen overuse and runoff can be clearly seen in China's lakes. More than

half of their lakes regularly experience blooms of algae and toxic cyanobacteria. These algal blooms in fact threatened the sailing events before the start of the 2008 Beijing Olympic games! See Figure 3 below.

Figure 3. Algae bloom in China's water threatened the 2008 Beijing Olympic Games. Source: NYSun.com

Technological inventions like tractors, ploughs and trucks during the mid 1900s made farming faster and more efficient than in previous years when the primary source of horsepower on farms came from mules or horses. These agricultural machines, however, use fossil fuels to power their engines, which adds CO_2 to the atmosphere when burned.

With the development of these various farming techniques, came the change in food production in America. Corn is an example of a major crop that has dramatically changed over time, in both the way that it is consumed and grown. Sweet corn is the type that Americans purchase for consumption at the supermarket. Dent corn is the type of corn used to make processed foods and to feed livestock, cattle and poultry; it accounts of 95% of all the corn that is grown in the United States.

The United States is now the largest producer of corn in the world. 84 million acres of corn were harvested in the United States in 2011, on over 400,000 farms mostly concentrated in the Midwest. Corn is overproduced primarily because it is a heavily subsidized crop. In the last 15 years, taxpayers paid corn farmers more than $77 billion (Cheney and Ellis, *King Corn*). Farmers are paid per bushel, so the more corn they grow, the more money they make. As a result, corn can be found in almost all foods that we eat, disguised as high-fructose corn syrup, maltodextrin and other processed ingredients.

By analyzing intensive farming techniques, students will learn about the biogeochemical cycles and the impact modern farming has had on these cycles. Pushing students to

understand this concept in detail will add significant depth to a concept that is often oversimplified.

Students often have difficulty retaining the information found in this portion of the biology curriculum because the content is dense and they often struggle to relate the information to their own background knowledge. Explicit teaching of the biogeochemical cycles can be very dry and boring. Students tend to simply memorize the facts, which are quickly forgotten moments after an assessment. Student learning must be an active process that connects to problems relevant to students' lives in order for the information to be retained (Chaplin and Manske, 2005).

Objectives
The objectives of this unit will include the following:

- Explain the stages of the water cycle, the carbon cycle, and the nitrogen cycle
- Analyze how natural and man-made factors affect the water cycle, carbon cycle, and nitrogen cycle
- Evaluate the environmental impact of current trends in the water cycle, carbon cycle, and nitrogen cycle
- Interpret data and draw conclusions
- Obtain, evaluate and communicate information in writing

Strategies

Explicit teaching
Drill and practice
Real world applications
Designing experiments
Practice expository writing
Group Activity/Think pair share

Classroom Activities

At Horace Furness High School, classes meet for 55 minutes every day. Science classes have access to a lab room one day a week.

Class activities include planting seeds with and without fertilizer to compare growth rates; analyzing food labels; making a "Corn Map" of the United States; visiting stations around the room; modeling the water cycle and calculating a person's carbon footprint.

Going into this unit, students should have sufficient background information on the states of matter, water properties (particularly on acids and bases), characteristics of the biomes,

and how energy passes through an ecosystem (trophic levels). They should also have some experience designing and conducting experiments.

Lesson One:

- Objective: Design and conduct an experiment with plants in order to determine the effects of nitrogen on plant growth
- Activities:
    - Students should be given a handout for the lab that includes background information about what fertilizers are and why farmers use them. Students will read through the information and answer pre-lab questions.
    - Students will then be given 20 minutes to work in pairs or groups of 4 to design an experiment to test the effects of Osmocote (a pelleted, slow-release fertilizer) on plant growth. After the teacher checks over the experimental design, students will plant the seeds in cups.
    - Materials needed for this lab activity include: potting soil, Osmocote fertilizer, seeds (ex: dried lima or pinto beans soaked overnight), Styrofoam or plastic cups and water.
    - During the first 7 minutes of class for the next 10 days, students will check on the status of their plant, use a ruler to measure plant growth and add water as necessary. They will record their measurements and observations on the handout provided at the beginning of class.

Lesson Two:

- Objective: Explain why corn is the most common ingredient in popular snack foods
- Activities:
    - On this day, students will bring in two or three food packages from something they've eaten (ex: bag of chips or bottle of soda). Students will work in groups of 2-3 to analyze the ingredient lists and write the top five ingredients on the whiteboard. The teacher will then circle the ones made from corn (see the Appendix for a link to corn-derived ingredients).
    - Students will take notes about the origin plant of these common ingredients (corn): its' evolution from teosinte and why it is found in so many foods
    - Students work in groups to complete an assignment that will further inform students about where and how much corn is produced in the United States. Students will need a blank map of the United States, dry unsalted/unbuttered corn kernels and glue. See the Appendix for Handout 1: Corn Production in the United States.
    - Homework: Students bring in 1 plastic bottle. Due by the beginning of Lesson Six.
        - Additional homework suggestions during this unit include: assigning reading comprehension questions from newspaper articles about environmental science issues (from NYTimes.com) or excerpts from

"Chew on This!" by Eric Schlosser and Charles Wilson or "The Omnivore's Dilemma" by Michael Pollan (for more advanced readers).

Lesson Three:

- Objectives: Describe the different types of corn and its various uses
- Activities:
    - The teacher begins the lesson by showing a video clip from Food, Inc (17:00-21:30) that shows the many products that can be made from corn. The teacher then reviews why corn is overproduced in the United States.
    - Students will take notes on the types of corn and the many uses of dent corn. The teacher will show a video clip from King Corn where the producers attempt to eat dent corn (37:18-38:40).
    - Students work in groups to finish the class work assignment from Lesson Two. Those who finish early can complete additional corn activities that can be found at the end of Handout 1.
    - Homework: Students bring in 1 plastic bottle. Due by the beginning of Lesson Six.

Lesson Four:

- Objectives: (1) Describe the importance of nitrogen in plants and humans (2) Explain the stages of the nitrogen cycle
- Activities:
    - Warm-up activity: Students brainstorm ways farmers can increase their crop productivity.
    - The teacher begins the lesson by reviewing the main ideas from Lesson Two (why corn is overproduced and why/how it is found in so many of our food products)
    - The teacher shows a video clip from the documentary "King Corn" (insert time clip) about fertilizing cornfields with ammonia.
    - The teacher leads a brief discussion about what ammonia is and why it is used as fertilizer (because it contains the element nitrogen).
    - Students will take notes on the importance of nitrogen in the ecosystem and the nitrogen cycle
    - For the rest of the period, students should answer a worksheet about the nitrogen cycle to demonstrate that they understood the lesson. Nitrogen cycle worksheets can be found at these links:
        - http://www.biologyjunction.com/Cycles_worksheet.pdf
        - http://www.biologyjunction.com/Biogeochemical_Cycles.pdf
    - Homework: Students bring in 1 plastic bottle. Due by the beginning of Lesson Six.

Lesson Five:

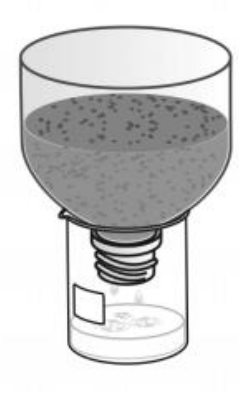
- Objectives: (1) Describe why and how food is produced in mass quantities (2) Define "intensive farming"
- Activities:
    - Students will watch a video: "7 Billion, National Geographic" (https://www.youtube.com/watch?v=sc4HxPxNrZ0), followed by a brief discussion about human population size and growth.
    - Students will have 30 minutes to visit five stations around the room. Each station will describe one of the following techniques in detail with words and pictures: irrigation, deforestation, pesticide use, fertilizer use or agricultural machinery use. Students will fill in the chart based on the information found at each station.
    - Students will then brainstorm the positive AND negative impacts of these farm techniques for 5 minutes (think/pair/share). They will write one of the impacts on the back whiteboard.
    - If time allows, the teacher will review each of the techniques and their possible impact on an ecosystem.
    - Homework: Students bring in 1 plastic bottle. Due by the beginning of Lesson Six.

Lesson Six:

- Objectives: (1) Explain the stages of the water cycle (2) Analyze how man-made factors (ex: agriculture) can effect the water cycle
- Note: At the beginning of class, collect all the water bottles. These plastic bottles can be used for the water cycle demonstration in this lesson, or for the soil activity in Lesson Seven.
- Activities:
    - The teacher will do a quick demonstration that shows how much of the world's total water is available for human consumption. Students will record the percentages in their notebooks.
        - This demonstration can be found on the California Academy of Sciences Website: http://www.calacademy.org/teachers/resources/lessons/earths-water-a-drop-in-your-cup/
    - In groups of 3 or 4, students will then complete an activity to demonstrate some of the steps of the water cycle. Based on this activity, students will draw out a water cycle. Students will then use their chart from yesterday and write one paragraph about how they think irrigation and deforestation can affect this cycle. Each student will be expected to write at least 2 sentences in order to receive credit. Examples of water cycle demonstrations can be found at these links:
        - https://www.ucar.edu/learn/1_1_2_4t.htm
        - http://www.haverford.edu/educ/knight-booklet/watercycle.htm
    - If there is extra time at the end of class, the teacher can review the water cycle activity and connect it to an actual water cycle in an ecosystem.

Lesson Seven:

- Objectives: (1) Explain the stages of the water cycle and the carbon cycle (2) Analyze how man-made factors (ex: agriculture) can affect the water cycle and the carbon cycle
- Activities:
  - The lesson will begin with a review of the water cycle and the effects irrigation and deforestation have on the water cycle. To review the water cycle, students will watch CoCoRa HS's video: "The Water Cycle" (https://www.youtube.com/watch?v=ZzY5-NZSzVw). The teacher will then lead a brief discussion about (a) how irrigation and deforestation can affect the cycle (b) what pesticides and fertilizers are and why farmers use them.
  - With the guidance of the teacher, students will draw a complete water cycle into their notebook.
  - Students will then complete an activity where they work in groups of four to drip water through different types of soil. Students will analyze the drip rate (using stop watches) and the pH of the dripped water (using pH paper).
    - Materials needed per group: four empty 20 oz soda bottles (inverted and cut about 4 inches from the opening), potting soil, sand, soil rich in humus, soil found outside the school, 4 beakers, water, pH paper, cotton ball, stop watch.
    - Fill each of the cut plastic bottles with the different types of soil and stuff a small piece of cotton at the bottle opening. Slowly drip water into the soil (see the picture below).



    - Students will analyze how much water moves through the soil in 1 minute and record it on their handout. Students will test the pH paper of the dripped water and record it.
    - When the students finish dripping water through the different soil types, they should answer post-activity questions on their handout. These post-activity questions should have them analyze their data and connect their results to the water cycle.
  - If time permits, the teacher will lead a discussion on the results of the soil activity and its implications.

Lesson Eight:

- Objectives: (1) Explain the stages of the carbon cycle (2) Analyze how man-made factors affect the carbon cycle
- Activities:
    - The teacher will review the results of the soil activity from Lesson Seven.
    - The teacher will then complete an activity where they calculate the carbon footprint of common food products.
        - The teacher will distribute a worksheet that contains a world map. Students will be given about 6 minutes to first predict where the most common fruits, vegetables and meat products purchased in grocery stores are produced. After 6 minutes, the teacher will tell students where these products are produced. Students will write the food name on the country and then determine its distance to Philadelphia using Google Maps.
        - Next, students will calculate total food emissions for the production and transportation of these foods using this website: http://www.foodemissions.com/foodemissions/Calculator.aspx.
    - During the last 15 minutes of class, the teacher will review the activity with the students and relate it to the carbon cycle.

Lesson Nine:

- Objective: Relate sustainable agriculture techniques to the carbon cycle
- Activities:
    - The class will begin with a review of lesson eight's activity.
    - The teacher will draw a detailed picture of the carbon cycle that students will draw into their notebooks. The teacher will then lead a discussion relating this cycle to Lesson Eight's activity. The teacher will continue the discussion by relating sustainable agriculture techniques (such as low-till agriculture) to the carbon cycle.
    - Students complete an online activity where they choose between two plates of food the one that took less carbon to make (www.eatlowcarbon.org).
    - The last assignment for this lesson will ask students to pick one of the sustainable agriculture techniques discussed in class today and explain how they affect the carbon cycle. Students will have the choice to write their answer in paragraph form, or draw a picture.

Lesson Ten:

- Objective: Evaluate the environmental impact of agriculture on the carbon cycle (climate change)
- Activities:
    - This is the final day that students will collect data on their plant experiment that they began on Day 1. After the students measure their plants for the final time, the

teacher should briefly review the results of the experiment, as well review how a lab report should be written.

- To officially start Lesson 10, the teacher will review the carbon cycle using pictures and a video (https://www.youtube.com/watch?v=4vJ_1ojjlxw).
- Students will then work on a case study about climate change (http://sciencecases.lib.buffalo.edu/cs/files/paleoclimatology.pdf). Note: This is an in depth and clear case study, but it is long in length. For lower level biology classes, a modified version of this case study should be distributed.
- For the last 15-20 minutes of class, the teacher will review the main points from the case study and lead a discussion about how agriculture has affected climate change.
- Homework – Lab Report. Due in 7 days.

[The cumulative unit assessment will be the lab report assigned in Lesson Ten, the guidelines of which can be found in the Appendix (see Handout 2: Lab Report Grade Sheet). The Ecology Unit will culminate in a written exam in which students demonstrate their knowledge by answering multiple choice and free response questions. Many of these questions will be pulled directly from a sample high-stakes exam (i.e. Biology Keystone, Biology SAT, ACT Science and/or Science PSSA).]

Annotated Bibliography/Resources

Student Resources

Johnson, George B. *Holt Biology*. Orlando, Fl.: Holt, Rinehart and Winston, 2004. Print.

[This biology textbook provides a good reference and pictures for students.]

Schlosser, Eric, and Charles Wilson. *Chew on This: Everything You Don't Want to Know about Fast Food*. Boston: Houghton Mifflin, 2006.

[This book is a modified version of the book “Fast Food Nation”. It can be used as an extension of the topics covered in this unit. Reading excerpts from the book would be appropriate homework assignments for this unit.]

Teacher Resources

"7 Billion, National Geographic Magazine." *YouTube*. YouTube, n.d. Web. 04 June 2014. <https://www.youtube.com/watch?v=sc4HxPxNrZ0>.

[This is a well-made video describing the increasing world human population.]

"Activity 4: The Water Cycle." *Learn: Atmospheric Science Explorers*. University Corporation for Atmospheric Research, n.d. Web. <https://www.ucar.edu/learn/1_1_2_4t.htm>.

[This is one potential water cycle activity.]

Aktar, Wasim, Dwaipayan Sengupta, and Ashim Chowdhury. "Impact of Pesticides Use in Agriculture: Their Benefits and Hazards."*Interdisciplinary Toxicology* 2.1 (2009): n. pag. Web.

[This journal article provides extensive information about the benefits and harms of pesticide use in agriculture.]

Associated Press. "China's Olympic Sailing Venue Beset by Algae Bloom."*New York Sun* 26 June 2008: n. pag. Web.

[This news article discusses the algae bloom that threatened the sailing event in the 2008 Beijing Olympic games.]

Bernhard, Anne. "The Nitrogen Cycle: Processes, Players, and Human Impact."*Nature.com*. Nature Publishing Group, 2012. Web. 25 Mar. 2014.

[This website provides a reference about the nitrogen cycle.]

"Carbon Nitrogen Phosphorous Cycle Worksheet." N.p., n.d. Web. <http://www.biologyjunction.com/Cycles_worksheet.pdf>.

[This worksheet reviews the carbon and nitrogen cycle.]

Carnell, Ronald L., and Rebecca M. Price. *Global Climate Change: What Does It Look Like?* (n.d.): n. pag. National Center for Case Study Teaching in Science, 6 Jan. 2012. Web.

[This is a good case study about climate change and its implications.]

Chaplin, Susan B. “A Theme-Based Approach to Teaching Non-Majors Biology.” NSTA.org. N.p., Sept. 2005. Web.

[This journal article describes another approach to making science learning more relevant to students.]

"Corn Derived Ingredients." N.p., n.d. Web. <http://pov-tc.pbs.org/pov/pdf/foodinc/foodinc_corn_derived_handout.pdf>.

[This PDF lists some of the ingredients derived from corn.]

D'Alessandro, Liane. "The Water Cycle." Haverford College, n.d. Web. <http://www.haverford.edu/educ/knight-booklet/watercycle.htm>.

[This is a water cycle activity.]

Deforestation. National Geographic, n.d. Web. <http://environment.nationalgeographic.com/environment/global-warming/deforestation-overview/#>.

[This website provides good background information about deforestation.]

"Earth's Water: A Drop in Your Cup." *California Academy of Sciences*. N.p., n.d. Web. <http://www.calacademy.org/teachers/resources/lessons/earths-water-a-drop-in-your-cup/>.

[This activity demonstrates how much water on Earth is available for human use.]

Eat Low Carbon. Bon Appetit Management Company, n.d. Web. <www.eatlowcarbon.org>.

[This is an interactive quiz that has participants compare foods based on the carbon content in them.]

"Food Carbon Emissions Calculator by CleanMetrics." CleanMetrics, 2011. Web. 05 June 2014. <http://www.foodemissions.com/foodemissions/Calculator.aspx>.

[This website allows viewers to calculate the total amount of carbon dioxide certain foods emit during production and transportation.]

Food, Inc. Dir. Robert Kenner. 2008.

[This documentary film examines corporate farming of animals in the United States.]

Hydrologic Cycle. West University University, n.d. Web. <http://online.wvu.edu/Faculty/demo/Module_2/hydrologic.html>.

[This website clearly describes the components of the water cycle.]

Instructional Strategies Online. Saskatoon Public Schools, n.d. Web. <http://olc.spsd.sk.ca/De/PD/instr/strats/explicitteaching/index.html>.

[This website is a good resource about different instructional strategies.]

Intensive Agriculture. Dennis O'Neil, 2006. Web. <http://anthro.palomar.edu/subsistence/sub_5.htm>.

[This website provides good background information about intensive agriculture.]

King Corn. Dir. Ian Cheney and Curtis Ellis. 2007.

[A humorous and informational documentary that follows two friends out to Iowa to grow an acre of corn. In the process, they learn about how corn is grown in America, how it is processed and the effects of its overproduction. This video can be viewed for free on www.hulu.com]

Landeen, Melissa. "The Carbon Cycle or The Circle of Life." *YouTube*. YouTube, 29 May 2012. Web. 05 June 2014. <https://www.youtube.com/watch?v=4vJ_1ojjlxw>.

[This video describes the carbon cycle.]

Pollan, Michael. *The Omnivore's Dilemma: A Natural History of Four Meals*. New York: Penguin, 2006.

[This book provides great background knowledge about modern food production, especially that of corn and meat.]

Raven, Peter H., and George B. Johnson. *Biology*. 10th ed. New York: McGraw Hill, 2014. Print.

[This AP biology textbook is a great resource on all biology topics.]

"The Water Cycle." Community Collaborative Rain, Hail and Snow Network, n.d. Web. 05 June 2014. <https://www.youtube.com/watch?v=ZzY5-NZSzVw>.

[This video describes the water cycle.]

"Water, Carbon and Nitrogen Cycle Worksheet/Color Sheet." N.p., n.d. Web. <http://www.biologyjunction.com/Biogeochemical_Cycles.pdf>.

[This link leads to a worksheet about the water, carbon and nitrogen cycles.]

Appendices

Handout 1: Corn Production in the United States
This handout is adapted from " http://www.educationworld.com/a_lesson/03/lp324-01.shtml"

Each of the 21 U.S. states listed on the chart below produced at least 50,000,000 bushels of corn in 2001.

1. Round off each number on the chart to the nearest hundred million.

2. On a U.S. outline map, glue next to each state one kernel of corn for each 100,000,000 (100 million) bushels of corn grown in that state.

State name	Corn Production (in bushels)	Production (rounded to nearest 100,000,000)	Number of Corn Kernels
Colorado	149,000,000	100,000,000	1 kernel
Illinois	1,629,200,000		
Indiana	884,500,000		
Iowa	1,664,400,000		
Kansas	387,400,000		
Michigan	200,000,000		
Minnesota	806,000,000		
Nebraska	1,139,300,000		
Pennsylvania	97,000,000		
Ohio	437,500,000		
Wisconsin	330,200,000		
Texas	167,600000		
South Dakota	370,600,000		

3. Name the top 3 corn-producing states.

4. Why does the United States overproduce corn?

5. Humans can only eat so much corn before we don't want to eat it anymore. Think of three things Americans might do with all the extra corn that is produced each year.

Additional Corn Activity #1:
Seed Dissection. 5 pts.
1. Draw a picture of your dried corn seed. Put in details of what you see.

2. Label the four main parts of the corn seed (endosperm, pericarp, tip cap, germ) on your picture above.

3. Return the dried corn seed. Take a soaked seed and break it apart. Look inside the seed answer the following questions:

i) how does the inside of the seed look?

ii) how does the inside of the seed feel?

iii) what do you think the inside of the seed is?

Additional Corn Activity #2:
Making Oobleck with a Partner. 5 pts.
Procedure:
1. Grab your supplies (about ½ cup corn starch in a ziploc bag, a small plastic cup with water, a plate).
2. Fill a small plastic cup with water.
3. Slowly mix the water into the corn starch a little at a time until you get a gooey mixture. Don't add too much water. If the mixture is too runny add more cornstarch to thicken. If it is too thick or crumbly, add a few drops of water to thin.

Questions:
1. What happens if you push an object (such as your finger) slowly into the Oobleck? What happens when you push an object quickly and with more pressure?

2. Can you roll the Oobleck into a ball? _____ If so, roll it into a ball and then leave it on the plate. What happens?

3. Will the ball bounce on the table like a tennis ball? _____

4. What happens to the Oobleck when you hold it above the plate and let it hang?

5. You just make a polymer! A polymer is a chemical compound made by polymerization (combining smaller molecules to a bigger one); it consists of repeating structural units. Polymers are important for life. They range from familiar synthetic plastics (ex: Styrofoam) to natural biopolymers such as DNA and proteins. Cornstarch is a natural polymer made from corn. Draw a picture of how you THINK the molecular structure of cornstarch looks.

Handout 2: Lab Report Grade Sheet

Style:
Neat, legible handwriting _____/1
Each section of lab report titled _____/2

Title:
Present _____/1

Group Members:
Present with first and last names _____/1

Introduction:
5 Background facts present_____/3
Background facts are relevant to the experiment and accurate _____/3
Hypothesis present, well-stated and testable _____/2
Purpose _____/2
Independent/Dependent/controlled variables defined _____/3

Materials:
Listed and complete_____/2

Procedure:
Complete and easy to follow _____/2

Data:
Organized _____/2
Complete _____/1

Results:
X-Y graph is plotted correctly, according to data table _____/2
All axes are labeled, key is provided if necessary _____/2
One sentence description present and clear _____/1
Title of graph present _____/1

Conclusion:
Identifies support for or against hypothesis _____/2
Uses information from lab to support answer _____/1
Discussion of results (what do your results mean? why did you get the results you did?) _____/3
Identifies at least two sources of possible error _____/1
Proposes a follow-up experiment _____/2
Additional info (+2) _____

Grammar and Spelling:
More than 5 misspelled words (-2)
More than 5 grammatical errors (-2)

Total: _____/40 = _____% = _____

Content Standards

This unit aligns to the Pennsylvania Academic standards for Science and Technology and Engineering Education, as well as the Pennsylvania Common Core Standards in Reading and Writing for Science and Technical Subjects.

4.2.10.B.1: Explain how human practice affect the quality of the water and soil.
4.6.10.B.1: Describe an element cycle and its role in an ecosystem.
4.6.10.B.2: Explain the consequences of interrupting natural cycles.
4.6.10.C.3: Analyze consequences of interrupting natural cycles.