ECOLOGY CURRICULA ACTIVITIES
FOR THE HIGH SCHOOL INTEGRATED SCIENCE 1 COURSE

Jane Lucy Derderian Nosal
B.S., California State University, Sacramento, 1993

PROJECT

Submitted in partial satisfaction of
the requirements for the degree of

MASTER OF ARTS

in

EDUCATION
(Curriculum and Instruction)

at

CALIFORNIA STATE UNIVERSITY, SACRAMENTO

SPRING
2009
ECOLOGY CURRICULA ACTIVITIES
FOR THE HIGH SCHOOL INTEGRATED SCIENCE 1 COURSE

A Project

by

Jane Lucy Derderian Nosal

Approved by:

Dr. Rita Johnson, Committee Chair

April 13, 2005
Date
Student: Jane Lucy Derderian Nosal

I certify that this student has met the requirements for format contained in the University format manual, and that this project is suitable for shelving in the Library and credit is to be awarded for the Project.

Dr. Julita Lambating, Graduate Coordinator  April 13, 2009

Date

Department of Teacher Education
Abstract

of

ECOLOGY CURRICULA ACTIVITIES
FOR THE HIGH SCHOOL INTEGRATED SCIENCE 1 COURSE

by

Jane Lucy Derderian Nosal

The ecology curriculum is part of the California content standards for the ninth grade Integrated Science 1 course. Current textbooks used in this course have detailed descriptions of ecology concepts, but are deficient in hands-on activities. The literature has been reviewed in the following areas: climate change as a big issue in science, science, standards and accountability, educational philosophy, motivation, hands-on and inquiry-based activities, teaching strategies, graphic organizers and technology. Sources of data used were professional journals, books and websites. The lessons found in the Appendix are textbook independent are intended to provide students with inquiry-based, hands-on opportunities to learn the science content of the Integrated Science 1 course.
DEDICATION

I would like to dedicate this project to my husband, Tim, who has always supported me in all of my wild escapades. This crazy life has had many interesting adventures and I am so delighted to share them with you. These past 20 years have been amazing and beyond anything I could have dreamed up. I can't wait to see what we do with the next 20... knowing us it will contain the unexpected and will be lots of fun. For Alex and Nick, my children, who were always asking me how many pages were left until I would be finished with this project. I can now tell you that I have completed it and can come out and play. In large part, I started my project because of the two of you: I wanted you to have both parents who had earned a Master's degree.

For my parents, Bill and Mimi Derderian, you have always encouraged me to go further in my education and believed in me. You are the best and I am so lucky to be a part of our family. But I am saying now for the record, I am not going to get a doctorate. For Carol Nosal, my second mom, thank you for all of the support you have given to our family. Date nights with Tim while you watched Alex and Nick were wonderful, as were the weekly dinners together. For Suzy Vitullo, my sister, thank you for all the times you took Alex and Nick so I could continue to work on my paper. Those early morning phone calls when you listened to my latest experience in higher education meant so much to me. To Erica Olmstead, my best friend who insisted that we start this program together. I’ll always have happy memories of our talks at Brookfield’s over their fantastic tortilla soup. Thank you.
ACKNOWLEDGMENTS

First to Dr. Lambating, because creating the mini-project for your class was so beneficial in getting me started on what would evolve into my final project. That paper was a great beginning to the program because I kept adding pieces to it along the way. Thank you Joyce (Dibble) for teaching those amazing computer classes. I loved learning about all the cool websites out there. Watching those TEDTalks was so eye opening as to what is happening on the cutting edge of technology and education. Roz VanAuker, librarian extraordinaire, was so helpful in teaching me how to use the library search engine. Thank you Roz for finding those articles and books for my chapter two. You rock! Dr. Lilly, thank you so much for reading my work and giving me feedback. I always looked forward to Wednesday evenings with your energy and insight on what was needed for each chapter. Your class was a perfect ending to the program. Dr. Johnson, I will never be able to thank you enough for agreeing to be my advisor on this project. Rita, your positive attitude and prompt feedback helped to make this project a reality. Thank you for helping to keep me sane at the end of this journey. You made me believe that I could do anything.

"Science is Nature explained."

Pat Parelli, Natural Horsemanship (2006)
# TABLE OF CONTENTS

Dedication .................................................................................................................... v

Acknowledgments ....................................................................................................... vi

Chapter

1. INTRODUCTION.................................................................................................. 1
   - Statement of the Problem ................................... 2
   - Purpose ............................................................................................................. 2
   - Theoretical Basis of the Project .................................. 3
   - Limitations and Assumptions ..................... 4
   - Definitions of Relevant Terms ..................... 4
   - Organization of the Project ..................... 5

2. REVIEW OF RELEVANT LITERATURE ................................................................ 7
   - Big Issue in Science – Climate Change ................................................... 7
   - Science ............................................................................................................. 9
   - Standards and Accountability .................................................................... 11
   - Educational Philosophy .............................................................................. 14
   - Motivation ..................................................................................................... 16
   - Hands-On and Inquiry-Based Activities .............................................. 18
   - Teaching Strategies ..................................................................................... 19

vii
Chapter 1

INTRODUCTION

The Integrated Science course at the high school level is an introductory course consisting of several disciplines: physics, earth science, chemistry, evolution and ecology. The purpose of this project is to develop a standards-based curriculum for the ecology segment of the curriculum. This project will develop activities based on the California state standards for ecology. Students will benefit from this project by having access to thought-provoking, hands-on activities.

In today’s world of global climate change, continuing increases in human population numbers and correlating increases in usage of finite resources, it is critical that students are educated on how to be environmentally responsible citizens. John Dewey stated “education is the regulation of the process of coming to share in the social consciousness; and that the adjustment of individual activity on the basis of this social consciousness is the only sure method of social reconstruction” (1897, p. 11). Maxine Greene (1995) agreed with Dewey when she wrote the youth of this country need to be able to participate in society’s “ongoing conversation.” It is the task as teachers to educate the public so they can make responsible choices as adults. Teachers will be at an advantage to teach important ecology concepts by having access to a deliberately planned and researched curriculum. This project will provide that material in an easily accessible manner for educators. Those activities that are detailed or have handouts are located in the appendices, while other activities that are more easily described can be found in the methodology portion of this paper.
Statement of the Problem

The ecology curriculum is part of the California content standards for the ninth grade Integrated Science 1 course. Current textbooks used in this course have detailed descriptions of ecology concepts, but are deficient in hands-on activities. Additionally, support materials that would assist comprehension of the state standards are lacking with the current textbook. This textbook was recently adopted by the district and will be used in the classroom for the next seven years.

Purpose

The purpose of this project is to create a science curriculum; which outlines the concepts, knowledge and skills that every student should learn in the ninth grade and is aligned with the intended learning outcomes for ecology. The curriculum is oriented to the ninth grade standards and is textbook independent. The main topic is based upon the concept that stability in an ecosystem is a balance between competing effects. As a basis for understanding this idea:

6a. Students know that biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

6b. Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species, or changes in population size.

6c. Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
6d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

6e. Students know a vital part of an ecosystem is the stability of its producers and decomposers.

6f. Students know at each link in a food web some energy is stored in newly made structures, but much energy is dissipated into the environment as heat.

The method of assessment for each of the topics is discussed in detail in the methods section of this report.

Theoretical Basis of the Project

Herbert Spencer (1820), Lester Ward (1841), John Dewey (1859) and Ralph Tyler (1902) are educators who would support this project (Tanner & Tanner, 2007). Spencer wanted to see education as relevant to the student; that the pupil would take from school knowledge that would help them survive life. Ward wanted to see the curriculum tying the student to the real world. Dewey viewed schools as a place that supported a community of learners. Tyler’s standpoint was from the view of goals and objectives: what was the purpose of education and whether or not that goal was met. These curriculum educators had theories on teaching students that are important to concentrate on while creating this project. Dewey would have approved of collaborative groupings of students. Tyler’s emphasis on objectives keeps the curriculum writer focused on the goals that the state has created for our classes (today
these goals are known as the state standards). Ward and Spencer both insisted that the curriculum be worthwhile to the student and this focuses the writer on content. People are able to make smarter decisions when they are educated in subjects that can have an impact on their lives. Science, in general, is a subject that is important for people to have a good understanding of in order to survive and thrive.

Limitations and Assumptions

The assumption is that other teachers will use this curriculum when teaching ninth grade students the ecology unit of the Integrated Science 1 course. A secondary limitation would be interest and ability of Integrated Science 1 teachers to incorporate this unit into their curriculum. There are technology lessons in the curriculum that are dependant upon computers with Internet access, schools without these resources will not be able to implement those inquiry-based assignments. Site administrators that are pro-lecture and note-taking methods might not support teachers educating students with a completely different strategy.

Definitions of Relevant Terms

Hewitt, Lyons, Suchocki, and Yeh, in Conceptual Integrated Science (2007), provided the following definitions.

*Community:* A community consists of all the living organisms in a specific area.

*Diversity:* Diversity is the variation of life found in an ecosystem. This refers to the different number of plant or animal species found in a specific place.
Ecology: Ecology is the study of how organisms interact with their environment. These studies can be conducted within the different categories of individual, population, community and ecosystem.

Ecosystem: An ecosystem is comprised of all the organisms within a given area and also the non-living features of that environment, such as the rocks, rivers, and weather.

Invasive species: Invasive species are species that have been introduced from their native habitat into new, nonnative habitat. When they thrive in these new surroundings they are considered invasive and are responsible for the decline of native species.

Organism: Organisms are living things, from the smallest bacteria to the enormous blue whale.

Population: Populations are groups of individuals of the same species.

Organization of the Project

Chapter 1 is an introduction into the project. It contains a statement of the problem, methods, theoretical basis for the project, limitations and assumptions, definitions of relevant terms and organization of the project.

Chapter 2 is a review of the literature. Incorporated into this review are the relevance of teaching science, standards and accountability, educational philosophy, motivation, hands-on and inquiry-based activities, technology, big issues in science – specifically climate change, teaching strategies and graphic organizers.
Chapter 3 is an in-depth study on the methods. A description of the curriculum found in the appendix is included in this section of the project. Chapter 4 contains the summary and recommendations for the project.

The ecology curriculum is in the Appendices. The appendices are organized as follows: lessons that support ecology standards 6a, 6b, 6c, 6d, 6e, 6f, investigation and experimentation standards a, b, c, d, j, and m, and puzzles.

The final section of this project contains the references used when researching the literature review for this project.
Chapter 2

REVIEW OF RELEVANT LITERATURE

The purpose of this project is to develop a ninth grade standards-based curriculum for the ecology segment of the curriculum. This literature review describes California curriculum standards, learning through hands-on activities, and science processes that serve as the foundation on which this instructional unit is based. The aspects of this project that will be researched in this paper are: climate change as a big issue in science, science, standards and accountability, educational philosophy, motivation, hands-on and inquiry-based activities, teaching strategies, graphic organizers and technology. Maxine Greene wrote

we can hope to communicate the recognition that persons become more fully themselves and open to the world if they can be aware of themselves appearing before others, speaking in their own voices, and trying as they do so to bring into being a common world. (1995, p. 68)

Big Issue in Science – Climate Change

One of the big issues in science is climate change. Klock (2005) noted, “Media bias on climate change must be countered with scientific knowledge. Higher education holds a key role and responsibility in educating Americans on climate change and should be instrumental in getting American society on an environmentally sustainable path” (Klock, 2005, abstract). The Intergovernmental Panel on Climate Change (IPCC), a scientific group set up by the World Meteorological Organization and by the United Nations Environment Programme, is attempting to provide that basis of
scientific knowledge. The IPCC collects data provided by hundreds of worldwide scientists and dispenses this information through reports that is accessible to anyone, but most specifically to decision makers.

The IPCC stated in their *Climate Change 2007: Synthesis Report*, that “warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level” (para. 3). They went on to report that average Northern Hemisphere temperatures over the last half of the 20th century were “very likely” greater than any other 50 year period over the last 500 years and “likely” the greatest in at least the last 1,300 years.

The National Oceanic and Atmospheric Administration ([NOAA], n.d.) reported that in 2008 the global land surface temperature and global ocean surface temperature were above the 20th century average. Additionally the NOAA noted that Arctic sea ice had its second lowest melt season. The 2008 Atlantic hurricane season had Category 3 or above hurricanes each month from July to November. It was the third costliest hurricane season after 2005 and 2004. There were 1,700 tornadoes from January to November, second behind the 2004 tornado season. Parts of Texas and Southeast United States continued to experience severe drought.

From a state perspective, California continues to work hard to be environmentally responsible. The governor has signed many bills written by California lawmakers. SB 107 requires investor owned utilities to have 20% of their electricity from renewable sources by 2010. AB 1925 has the California Energy Commission
working to find methods to capture and store industrial carbon dioxide. AB 32
demands that greenhouse gas emissions to be at 1990 levels by the year 2010.

From a worldwide perspective, parts of Australia continue to experience
drought. Vietnam, Ethiopia, parts of Central and South America, and the northern
Philippines were flooded after torrential rains. NOAA continues to report that
Northern Hemisphere snow cover is below average.

Science

In 1860, Herbert Spencer published an essay “What Knowledge is of Most
Worth?” Tanner and Tanner (2007) discuss how this essay was to revolutionize our
schools and the curriculum by asking the hard question of why is this topic important
for our students to learn. Spencer was a proponent of science in the classroom because
he saw science as a means for people to become better prepared for life. Knowledge of
science would ensure that the population would not be taken unaware by natural
forces. According to Spencer, the primary aim of education was for human self-
preservation; therefore science was of most worth.

Students need to be educated in science, particularly environmental science,
because decisions that people make today will have an effect on our future, just as
decisions made in the past affect us today. Dewey (1897) said

it is the business of every one interested in education to insist upon the school
as the primary and most effective interest of social progress and reform in
order that society may be awakened to realize what the school stands for, and
aroused to the necessity of endowing the educator with sufficient equipment properly to perform his task. (p. 17)

What a group of people does on one continent affects people on other continents. This is evidenced by the deforestation of the rain forest in South America and Central Africa and the resulting decrease in rainfall in the lower U.S. Midwest in the spring and summer months and reduced rainfall in the upper U.S. Midwest in the winter and spring months (Avissar & Werth, 2005). The researchers found results that suggest that the decrease in winter rainfall in California is tied to deforestation of the Amazon basin, Central Africa and Southeast Asia. There is a flip side to the deforestation, and that is increased precipitation to the southern tip of the Arabian Peninsula in the summer months. To be responsible and ethical, humans need to make environmentally responsible decisions in everyday life; recycling wherever possible, using fluorescent or light-emitting diodes (LED) light bulbs, using energy efficient appliances, driving cars that get good gas mileage and have reduced emissions, or better yet, when possible using mass transportation. These are some examples of what we can be done to minimize human impact on the Earth.

Shymansky, Kyle, and Alport (1983) noted that students with exposure to science curricula are more successful than students without this exposure and these students also developed a positive attitude toward science. National Academies Press has stressed the importance of science literacy, which supports why this project is worth completing: All students should experience the satisfaction that comes from knowledge about the natural world. The emphasis is on students engaging in the
activities rather than passively learning from lecture. While they stressed hands-on activities, they said it is also critical that students are mentally engaged in their activities.

A Pestalozzian principle is to have a student-centered learning environment. According to Tanner and Tanner (2007), Johann Pestalozzi believed that students learn by experience and observation. Science curriculum is based upon creating a hypothesis then gathering and analyzing the data collected during the experiment. Conclusions are drawn from the information found and evaluation of graphs produced in the report.

Finn, Maxwell, and Calver (2002) discussed different principles used in teaching ecology: Principle one: the need for both treatment and control groups, principle two: experiments in ecology utilizes a scientific approach found in other areas of science, principle three an important tool is the use of experiments, principle four there is a link between environmental issues and ecology and principle five not all ecological issues lend themselves to experiments. The authors explained that an important piece of teaching this subject is student participation; that it ties the student to a feeling of ownership and empowerment. They recommended an inquiry-based approach achieved through simulation software, field investigations and laboratory experimentation.

Standards and Accountability

The Consortium for Policy Research Education (1993) supported content standards to outline what students need to learn in each subject area. Content standards
set at the state level should demonstrate what is critical for all students to know and must relate to all the other information that is in the other units in a course according to Lenz (2003). Individuals who work in curricula and standards development need to stay focused on Herbert Spencer’s question “what makes this knowledge worth knowing”.

Lenz (2003) supported standards-based curriculum and noted that to help focus learning, subjects had to be broken down into topics, which define how information should be organized for our students. Lenz went on to argue that those content areas that are most critical for student learning should receive the most instructional time and those areas that are not essential should be given less classroom time. It is important for educators to remain focused on those critical ideas so that students might gain a deeper understanding of the content.

The question was posed of how standards were developed and stressed the importance of the process used in creating them. At the time of the Consortium (1993) article, the public and the experts created the standards. The place to begin was to understand the core of each subject. Different states incorporated different methods to create their standards. Some states relied upon the public and their teachers while other states looked to the professionals in the field for guidance. There needs to be a balance between standards that are written too broadly compared to standards that are too narrow.

Revision of standards has critical to stay current with increases in knowledge. The Consortium for Policy Research Education (1993) maintained that the process of
change is a lengthy one due to the policy system. Sometimes content standards raise values questions (some examples include teaching evolution and sex education in the classroom). These controversies can be quite heated between teachers and the public. However, in the long-term there must be support for professionals because their primary goal is the education of the student.

Due to federal legislation, all schools are required to make sure that all of their subgroups reach the target score. This legislation is called the No Child Left Behind Act (NCLB). In 2001, the Bush administration created the NCLB, in part, to give families more choice over the schools that they would like to attend. This website provides information on the NCLB (http://www.ed.gov/nclb/landing.jhtml). The NCLB targets low-performing schools. Due to the NCLB, districts, schools and teachers started focusing on students performing far below basic on the state standard tests.

One downfall of the NCLB was that many elementary schools provide minimal or no exposure to science and history curriculum. The emphasis on reading and math has increased the pressure on teachers and schools to perform well on the state standardized tests. If a school does not show improvement and reach an Academic Performance Index (API) of 800 the school is in danger of being taken over by the state.

A positive outcome of the NCLB has been the increase in attention on teaching strategies for low performing students. However, the NCLB act treats all schools as if one size fits all and that is not the case. Some schools have a high population of
English language learners, and these students have typically score lower on standardized tests until their fluency in the English language increases to a level where they can be successful on an exam that provides minimal clues for comprehension. The flip side of that is the affluent school with strong community support where most students are academically successful and college-bound. These schools usually score high on the API.

The California science standards are currently tested at the junior and high school level. All high school science classes require state testing for students in the spring. While passing the test does not affect student graduation, testing below basic hurts high school API score. Testing at the state level has taken precedence on how classes are structured and whether or not they are offered to students. A poorly written standardized state test, where the language level is above the comprehension level of the student, has the power to change the classes offered at high schools. If a majority of students do not test well on the state test then the district will look at substituting another science class where students typically score well on these state tests. This might not be in the best educational interests for the student, but schools need to continue to show improvement on the API to avoid being taken over by the state.

Educational Philosophy

The progressive philosophy with its student-centered emphasis and hands-on projects works well with this curriculum. Students are working on collaborative projects and engage in problem-based learning (PBL), which ties in with this philosophy. John Dewey (1897) strongly believed in school as a social place for
students to create a strong community of learners. One of the goals for his school was to establish cooperative learning. For Dewey, school should represent life and be based upon student interests. Students should be active, not passive, learners. For Dewey, education played an important role in social consciousness and responsibility as evidenced by this quote from *My Pedagogic Creed*, “education is the regulation of the process of coming to share in the social consciousness; and that the adjustment of individual activity on the basis of this social consciousness is the only sure method of social reconstruction” (1897, p. 16).

Lindberg (1990) found that inquiry-related teaching improves scientific literacy and comprehension of science concepts. Lindberg attended a science methods course taught by John Settlage that radically changed the participants’ teaching methods of science. Instead of “read and regurgitate”, student were conducting science experiments in the classroom. At the end of one school year, students researched plants, conducted various individual science experiments and became teacher to the other students in the classroom. Haury (1993) discussed how inquiry learning, also known as active learning, demonstrates the constructivist philosophy. Inquiry-oriented learning depends on engaging student curiosity or a sense of wonder. Haury noted that textbooks can be used in inquiry learning for the science classroom, however, it was important that the materials support inquiry-based learning.

One of the tenets of constructivism according to Tanner and Tanner (2007) is that individual subjects do not stand-alone; there are multidisciplinary subjects involved so that students are able to connect this knowledge to the real world. Sprague
and Dede (1999) stated that a constructivist lesson was arranged around concepts and not "facts in isolation". They went on to explain that students do not need to know everything about a concept before they start utilizing their knowledge on that subject. Student interest is paramount for this teaching philosophy to be effective in student education.

Motivation

Over 50 years ago, Lindberg (1961) wrote

if we help boys and girls to learn the processes of discovering knowledge and ways of working for themselves, we need not give our energies to finding fascinating ways to hold their interest or whip up their enthusiasm. The strong urge to pursue learning comes from within. (p. 60)

Science naturally lends itself to the inquiry process due to experimentation found within this subject.

Ernst and Colthorpe (2007) conducted a study on how interactive lecture affects student attention, engagement and understanding. They worked with two groups of students in their second year of physiology at the University of Queensland. In 2004 they worked with 249 students; they repeated the study in 2005 with 243 students. Students fell into one of two groups: the first group was composed of physiotherapy students while the second group was made of speech pathology and occupational therapy students. Typically, the students in the second group do not have as strong a background in science as the physiotherapy students.
Interactive lectures are 10 to 20 minute-long lectures focusing on one area of the curriculum. Interspersed with the lectures are active learning breaks for small groups. Questions are provided that fall into one of three categories: checking for understanding from the current lecture, checking prior knowledge and introducing the next lecture topic. The groups have two minutes to discuss their questions. Whole class discussion occurs when students discuss their group findings with the class. Each lecture session has a minimum of three active learning activities, which take up about 25% to 35% of the total lecture time.

The study found that student achievement on the final exam improved over 20%. This is especially impressive with the speech pathology and occupational therapy students because their scores prior to the study averaged 43.8% and after the study they scored 68%. The physiotherapy students also showed improvement from 59.2% to 79.2%. Increased levels of student interaction improved both student understanding and enthusiasm. Ernst and Colthorpe (2007) thought that this also led to an improvement in student self-confidence.

Spevak (2008) used cartooning with her ninth grade physical science students. She discussed how cartooning was an alternative teaching strategy that appealed to students. Students used dialogue within the comic strip to demonstrate their understanding of a science concept. Students created a word problem with drawings related to their topic. They then switched papers with another student for an informal peer review and quality control on their understanding and diagramming of the concept.
Hands-On and Inquiry-Based Activities

Johnson, Dasgupta, Zhang, and Evans (2009) conducted a survey with students in an introductory statistics class at Washington State University. Students in the spring 1998 course created a survey with 25 hypotheses on various learning styles and student preferences for different teaching strategies. From 1998 to 2001, 462 students filled out the survey. Surprisingly, the results of the survey showed that 37% of the students preferred the traditional method of learning (e.g., lecture). However, as expected, the majority of the students participating in the survey, or 63%, preferred non-traditional methods of instruction. Non-traditional methods are based on discussions, activities, distance learning and Internet classes. Students felt they gained knowledge more effectively when they were taught in a manner that helped them to understand the material and engaged their attention. Therefore, the authors suggest that teaching with a variety of strategies will be most beneficial to student learning.

Goodman and Berntson (2000) designed a high school ecology course for junior and senior students encompassing five instructional units. The authors set up the class to be structured around inquiry questioning strategies. The types of questions were dependent upon how much knowledge students have on a subject. “Why” questions were used when students already had some baseline information on a topic. “How” questions were utilized when students were unfamiliar with the concept. “Is” questions were helpful in inquiry and debate situations. Students conducted labs relating to the unit and kept data in a lab notebook. At the end of the unit, students
demonstrated understanding of the topic by writing an essay on the topic. They used information from their notebook to back up their observations.

Teaching Strategies

Traditional classes have been typically defined as those classes with “passive student lectures” (Wells, Hestenes, & Swackhamer, 1995). Hestenes (1997) found that lecture instruction usually resulted in small changes in preconceived notions. Greater changes in student belief occurred with methods of instruction different from the traditional approach. Every day, students come to class with a mindset on how things work in our world. Just having the teacher telling them that it is different from their belief is not an effective method to get them to change their minds.

Wells et al. (1995) found that traditionally taught courses had low results in content attainment independent of teacher knowledge. So the teacher could be brilliant, but if they were teaching using traditional methods of instruction, students were unlikely to gain the subject information. Hestenes (1997) concluded that this might be due to students misconstruing what they hear in lecture mode. When students “see” something with their own eyes, it is a powerful way for them to understand how the concept actually works.

Hale, Skinner, Williams, Hawkins, Neddenriep, and Dizer (2007) conducted a study with both primary and secondary students. For the purposes of this literature review, the results from the secondary students will be discussed in this paper. The study involved 42 students in the 10th, 11th and 12th grades. Students read grade level material and were placed in a reading proficiency category based upon the words that
were read correctly per minute. They were also given subtests from the *Woodcock-Johnson Achievement Tests, 3rd edition* to establish their reading level.

Students read passages from Spargo's 1989 *Timed Reading Series 3rd edition* and answered multiple-choice comprehension questions. Part of their reading was aloud while other parts were read silently. Students answered the questions immediately after reading each segment. Students also participated in a timed reading. The number of correctly answered questions for each reading passage were added and the mean was calculated by taking that number and dividing it by the number of passages read for that segment of the study. The conclusion of this study was that student comprehension increased from a mean of 6.62 for silent reading to a mean of 7.17 for oral reading. The researchers utilized the mixed-model ANOVA and Pearson's product-moment to determine if this increase was considered significant. Both statistical measurement tools indicated that reading aloud significantly increased comprehension compared to silent reading.

Delo (2008) wrote on the benefits of reading out loud to students. Dialogic reading creates a triangle between the teacher, the student and the book. Delo stated that students should have the choice to either read out loud to their classmates or to opt out of this exercise, by silently reading along. It is important that the teacher ask questions relating to the reading to engage and check for student comprehension. Open-ended questions are best because these questions give students a chance to expand upon what they learned from the reading. Students should be able to summarize the reading.
Delo (2008) provided a list of science books that students could read organized by reading level. Some of these books are non-fiction, while others are fiction. She recommended the following list of activities to be used with students after completing the reading section: summarizing and predicting, identifying three important topics or subjects, writing and performing a drama to teach others about something important from the reading, creating a collage or drawing pictures, and creating a chart on know, want to know and learned in each column.

Schinske, Clayman, Busch, and Tanner (2008) created some exciting activities to engage students when analyzing journal writing. They started with a figure from a scientific journal. To aid student comprehension, they altered the wording of the caption from technical, scientific jargon, to words that students could better understand and comprehend. Students were then instructed to make at least six notes on their transparency (each student had their own transparency and they worked in groups of four). Students then presented their group findings to the class using an overhead projector.

Another activity that Schinske et al. (2008) assigned to their students involved reading and analyzing science journal abstracts. The authors stressed that the students were to select abstracts from articles that were interesting to the students, such as food, video games, and sports. Students were given a pre-assessment and then after the activity a post-assessment (containing the same questions). The point of this activity was to activate student curiosity about the world. Students were told to focus on the author and to try to figure out the author’s personality, interests and hobbies based
upon the article that was written for the science journal. Students worked in small
groups and then presented the findings of their abstracts and ideas about the author to
the rest of the class.

Kirchhoff (2008) provided stories about scientists to students. A variety of
questions about what might have motivated the individual or the basis for the scientific
method was used to help students identify with the scientist and bring the “human
element” back to the course. Kirchhoff noted an increase in student curiosity about the
different ways people think about science.

Schinske et al. (2008) had students create their own journal article complete
with at least one figure based upon the science project they made for a science fair.
Students then presented their project to the class and received feedback from their
peers. They created a draft of their article and were given written feedback from the
teacher. Final articles were bound and given to the students and the school library.

Graphic Organizers

Another tool useful for creating understanding in science is the use of a graphic
organizer. Graphic organizers were defined by Bromley, Irwin-DeVitis, and Modlo
(1995), as “visual representation(s) of knowledge... a way of structuring information,
or arranging important aspects of a concept or topic into a pattern using labels” (p. 6).
Common graphic organizers that can be helpful in teaching science include: cause-
and-effect diagrams, sequence charts, and compare-and-contrast diagrams. Horton,
Lovitt, and Bergerud (1990) conducted a study to evaluate how effective graphic
organizers are in the classroom. The study involved 180 seventh and 10th grade
students. The students were divided into two groups. One group independently read part of a textbook and took notes on the passage. The other group was given a graphic organizer and read a more challenging text passage. The students in this group filled in the graphic organizer with help from the teacher. At this point the groups flip-flopped activities, the first group did the second group’s activity of filling out the graphic organizer and the second group read the text passage and took notes independent of the teacher. After each 45-minute activity the group took a test for comprehension of the reading. The results of the study were impressive: when students studied on their own, they scored 63% correct, however, after completing the graphic organizer their scores increased to 95% correct. Students with learning challenges were observed in this study. Their scores increased from 30% correct with independent study to 73% correct with teacher assisted graphic organizer.

Baxendell (2003) stressed that graphic organizers needed to be consistent (teachers created a standard set of graphic organizers and also established a routine for using them in the classroom), coherent (students needed clear labels for the relationships between concepts and had to limit the number of ideas and minimize distractions) and creative. Students were shown how to use graphic organizers during all stages of the lesson, homework and test review. Pictures should be used and graphic organizers should be provided to cooperative groups and pairs of students in the classroom.

Cause-and-effect organizers can be used with both younger and older students. They are helpful when trying to get across the idea of cause and effect and can be used
in a couple of ways. One is to show one cause with an arrow pointing to one effect. Another way to use it is to have a single “main event” with several causes pointing to the main event and several arrows going from the main event to several effects. Cause and effect graphic organizers can be an especially effective way to assess student understanding on experiments.

Sequence charts can also be useful in showing students the specific steps needed between relationships and subsequent steps. Baxendell (2003) had a used this type of graphic organizer with the steps out of order and challenged students to put them in the correct sequence. Examples were given in math (how to solve fraction problems), preview and review of field trips, and when describing group work. During group work, each person added the next step to the sequence. Then as a group they checked the chart for accuracy.

Compare-and-contrast diagrams are the most common organizer. A Venn diagram that shows similarities and differences is one such use. Baxendell’s (2003) experience has shown that it is helpful to make the layout and the rules crystal clear for their students. Also, there needs to be enough space for students to write their words, especially in the center section. Some rules included students putting down a minimum of three ideas in each section of the diagram, not allowing them to use the most obvious or general similarities or differences. He noted that it was also useful to provide a word bank to make sure that important information was included in the diagram. This organizer is a powerful tool because it employs the higher thinking levels of Blooms Taxonomy.
Another type of graphic organizer is the concept map. Vanides, Yin, Tomita, and Ruiz-Primo (2005) provided terms to students and then had them join the terms with an arrow and a descriptive phrase. Students then reconvened as a class and discussed their findings from their small group discussions. The authors stated that concept maps challenged students to articulate their knowledge on the subject and that sharing their maps with other students sparked stimulating debates.

Stephen DeMeo (2007) conducted a study with first year premedical and science major students. The topic was creating decision maps to aid solving acid-base equilibria problems. To establish base knowledge, the professor lectured on the topic using board notes, examples, readings and homework from the textbook. Afterwards a questionnaire was given to assess student comfort level with the subject. Sixty-one students filled out the survey and 53% thought that the unit was moderately difficult to understand. Solving the homework problems was very difficult for 23% of those surveyed in the class.

Students were then given one of two homework assignments: (a) compile a list of prerequisite knowledge to solve pH problems, or (b) create the start of a map beginning with the question, "For each compound, do I have an acid, base, or a salt (include water as your major species)?" Groups of four students were created; two with a map and two with a list of prerequisite knowledge needed to solve pH problems. Students met for 30 minutes and then reported out to the class. Whole class discussion occurred and the teacher made corrections or additions to information written on the board by the students. The teacher organized the content with boxes and
arrows – a map was starting to take shape on the board. Students were then given two more questions to work on in their small groups. As before, they put their findings on the board, the teacher made any corrections and additions and they discussed it as a class. At this point an acid-base decision map was finished on the board and the teacher created a replicate model of it on the computer and handed out to the students the next day in class. Students used the map to work out different pH problems in class.

Students spent about 3.5 hours in class working with the pH decision map. A week later they were given the pH test. After they finished the test they were given another questionnaire to complete in class. Questions revolved around whether the map was helpful and would they use it in the future. The majority of students, 66% found the decision map either “helpful” or “extremely helpful” for solving pH problems. Seventy percent found the decision map either “helpful” or “extremely helpful” to understanding acid-base concepts. Organizing information in the chapter, when using the decision map, was either “helpful” or “extremely helpful” for 75% of the students. A minority of the students, 6%, felt that the decision map was either “not helpful” or “hampered” their understanding of acid-base concepts and organization of the material.

DeMeo (2007) concluded that it was critical that students create the map and actively participate in this endeavor in the classroom. This is important because students could be corrected on any erroneous thinking on the subject and the teacher then could aid student comprehension on the topic. DeMeo noted that he has
restructured his chemistry class after conducting this study, and now there are not any lectures prior to creating decision maps.

One of the valuable aspects about graphic organizers and decision maps is that they can be an effective teaching strategy to use with ALL students. Graphic organizers can be started and finished by the students on their own, they can be partially filled out and given to the student or they can be completed with the entire class. This activity translates for teachers as "easily modified for our diverse learners". As DeMeo (2007) found with first year college students, decision maps are an excellent whole class activity to use when introducing complex topics to students.

Technology

WebQuests are inquiry-based activities that utilize technology, specifically the Internet. Students are typically engaged with this teaching method because they are in charge of their own learning. The teacher sets up the WebQuest and then assumes the role of advisor rather than direct instructor. Lacina (2007) explained that students work in collaborative groups and, when structured by the teacher, use the higher thinking levels of Bloom's Taxonomy.

In today's high tech world of cell phones with Internet access, computer programs that allow online banking, the ability to research anything at a moment's notice, it is important that students have as much exposure as possible to available multimedia. The school district currently used in this project recently eliminated the computer course requirement for high school graduation. While most students are competent in accessing various entertainment-related websites, there are many
computer applications where most students are not computer literate. For example, many students do not possess the knowledge on how to create tables and graphs on spreadsheet type program such as Excel.

When WebQuests are incorporated in the science classroom, more students are on-task conducting their research on the Internet. Students appreciate the opportunity to decide which topic they want to research. However, some students occasionally complain about the writing aspect of their report. Comments are made that it is easier to take notes from a lecture then to construct their own report. This project is also challenging to them when they need to electronically create tables and graphs depicting the data they find in the course of their research.

Kimberly Vidoni and Cleborne Maddux (2002) contended that there are many benefits to incorporating WebQuests in the classroom. These included narrowed web searches since the teacher provides links to sites, access to child friendly sites - since the teacher had already previewed the site - and a tool that provides access to various perspectives. Vidoni and Maddux asserted that well written WebQuests encourage students to employ critical thinking skills when working on their tasks.

Conclusion

This project is of value to students because it meets the educational goals of the California state standards for ecology. The activities are mentally engaging and where possible hands-on. Assignments and projects increase motivation by tying in to the real world and issues that are contemporary.
The WebQuests proposed in this project support the constructivist philosophy because students create their knowledge through discovery. WebQuests are inquiry-based projects designed for conducting research on the Internet. Johnson discussed how the constructivist philosophy and cooperative learning are inherent for this teaching methodology (Johnson, 2005, as cited in Lacina, 2007). Students build upon their knowledge base as they work on their projects.

Use of graphic organizers has been shown to assist students in organizing information. This strategy can maximize student learning. Therefore, teachers need to be consistent in their use of this medium and they also need to give time for students to synthesize the information while working on their diagrams. This tool helps students understand how concepts connect to larger issues.

Lastly, ecology activities are valid because they will better prepare students for an understanding of nature and how things work in our world. Students need to be educated on how to make decisions based upon facts. This can help them make positive decisions for both themselves and the environment.
Chapter 3

METHODOLOGY

The ecology curriculum found in the Appendix is part of the California content standards for the ninth grade Integrated Science course. The purpose of this project was to provide engaging material in the ecology unit of the Integrated Science 1 course. Ideas on how to better reach students with existing assignments were developed during this time spent focusing on curriculum development. Having previously taught a few of the lessons was valuable in understanding what aspect of the lesson worked for the students and which areas needed improvement to better serve our students. Information on teaching strategies, gathered through research for the literature review at the library at California State University Sacramento and on the Internet, was used to create curriculum that both students and teachers should find compelling and exciting. Lessons found on the Internet, and in teaching journals, were adapted to fit the standards for this class.

Students will have the opportunity to participate in problem-based learning. They will have access to technology while they work on the various WebQuests. Students will conduct labs and will see the effect humans have had on the environment. They will work individually, in small groups and also participate in discussions as a whole class. The main topic of the ecology standards is based upon the concept that stability in an ecosystem is a balance between competing effects, the lessons continually reinforce this concept.
The Thumb War Lab and Penny Lab are lessons designed to assist students with the technical format of writing lab reports. Students are assigned the Your Choice Experiment, which they conduct at home. This report follows the science method format with specific headings and information that must be included to be considered complete. They attain parent and teacher approval prior to conducting their experiment. Motivation is high for this project because students choose their experiment. They can find an existing lab or create their own experiment. The research for the literature review suggested that inquiry learning is student-centered and improves science literacy and comprehension of science concepts.

Research for the literature review suggested that incorporating technology within the curriculum in the classroom was of value to student learning. The Threatened and Endangered Species WebQuest, Ecology WebQuest and Agents for Change WebQuests are projects that integrate science curriculum, inquiry learning and technology. Not only do students conduct online research, but they also utilize three computer programs to detail their research findings; Word for their typed report, Excel for their spreadsheet and graphs and PowerPoint for their presentation to the class on their report. These projects are important because they bring student attention to current environmental concerns.

There are lessons on the water, nitrogen and carbon cycles. These concepts are important for students to learn so they can understand photosynthesis and respiration. Multiple lessons are presented to reinforce student understanding and retention of the
chemical formulas associated with photosynthesis and respiration. Students will also use graphic organizers to help compartmentalize this information.

While the Experimental Variables worksheet does not technically apply to the ecology standards, it provides base knowledge for students for the Population Ecology Lab. Students learn how to identify the independent variable, dependent variables and control groups in an experiment. Students need to know how to distinguish between these variables because they are used in lab write-ups following the scientific method. The Population Ecology Lab is supported in the literature review by being inquiry-based and hands-on for students. World in the Balance is another population lesson that is based upon the human population. Students learn about the impacts of positive and negative growth rates of countries all over the world. This lesson is both standards-based and constructivist because students use math skills in conducting this activity. They also learn about factors that influence other cultures and societies.

The Wolf, the Moose, and the Fir Tree lesson continues with the concept of how stability of an ecosystem is dependent upon balance between populations of producers and consumers. This activity incorporates the reading out loud strategy that was shown in the literature review to increase student comprehension. The lessons on trophic levels, producer to consumer, lead to the energy pyramid and how there is less energy available the further an organism gets from the producer level. Students create a food web that accurately represents an ecosystem and then they show all of the possible food chains found within that web. They compare and contrast food chains
and food webs using a graphic organizer called the Venn diagram. This was suggested by research to aid student comprehension.

The culminating assignment for this project is the Environmental Impact Report. It requires students to use all of the knowledge that they gained from the activities in this course. All of the ecology standards are represented and students work in cooperative groups, which were supported in the literature review by Dewey and progressive educators. Spencer would have approved of this project because of its "real world" application. It is constructivist-based because it incorporates economics, social and environmental issues. Student motivation will be increased during this project because students are in charge of providing a bid to the city council to develop a parcel lot and they will make their own decisions on how to best develop the property and solve the problems that occur when trying to balance various viewpoints.

Setting, Participants, and Instruments

The setting for this curriculum is the science classroom. While the lessons were written for an Integrated Science class, these lessons can also be utilized in a biology class. The curriculum was designed for ninth grade students, however the lessons can be used with junior high school and college students. Computers are necessary to conduct the three WebQuest projects in the Appendix. Students will need access to the Internet and computer processing programs such as Word, Excel and PowerPoint to complete their assignments.
Curriculum Implementation

This curriculum is textbook independent and intended to supplement the course textbook. The activities were designed to catch student attention and increase motivation by bringing a "real world" aspect to the coursework. The activities can be utilized as needed to strengthen the course curriculum. Teachers can pick and choose which lessons they think will best fit their students and their timeframe.
Chapter 4

SUMMARY

Ecology comes under Herbert Spencer's "what knowledge is of most worth" because ecology is the study of how living organisms interact with their environment. The purpose of this project is to develop a standards-based curriculum for the ecology unit. This project is important because nature can teach the child better than man and students should arrive at the answers themselves. Johann Pestalozzi (Tanner & Tanner, 2007) supported the idea that understanding comes from personal observation and experiences.

Ralph Tyler wrote a book entitled Basic Principles of Curriculum and Instruction in 1949 (Tanner & Tanner, 2007). This book has been useful to curriculum writers because of its scientific approach to writing curriculum. According to Tyler, there are four fundamental questions that educators must address when developing their curriculum. They are as follows:

1. What educational purposes should the school see to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be effectively organized?
4. How can we determine whether these purposes are being attained?

Herbert Spencer's ideology on school in 1860 was to get students ready to be successful in living out all aspects of life. Science is considered most important because when people have a good understanding of how the world functions they are
more likely to survive natural disasters. Continuing scientific research on the natural world is important in order to increase our knowledge to safeguard people.

For example, hurricane research has been very important in saving lives. Scientists are able to detect these violent storms early and give warning to the towns that lie in the storm’s path. Humans are able to prepare for or flee an event that used to have devastating effects upon human life. Still with all the knowledge and technology available, many people die in these storms.

Recommendations

Conducting a study on whether this curriculum made a difference in student learning, achievement and attitude would be a great method to either validate the research supporting these teaching strategies or prove them false. It would be interesting to set up the study: one class taught by teacher lecture and textbook readings and a second class that utilized this curriculum with the standards provided to the students at the start of the lessons. The students would need to be at the same level of learning and ideally the same teacher would conduct the study. It would need to be replicated at different schools in different locales to give veracity to the results.

In providing this curriculum to other professionals in the teaching field, this masters project supports the National Council for Accreditation of Teacher Education ([NCATE], n.d.) “Standard 1: Candidate Knowledge, Skills and Professional Dispositions”. Specifically “the unit designs, implements, and evaluates curriculum and provides experiences for candidates to acquire and demonstrate the knowledge, skills, and professional dispositions necessary to help all students learn.” Providing
this curriculum to other teachers also supports NCATE “Standard 5d: Modeling Best Professional Practices In service”. Which reads as follows: “All professional education faculty are actively engaged in dialogues about the design and delivery of instructional programs in both professional education and P-12 schools. They collaborate regularly and systematically with P-12 practitioners and with faculty in other college or university units. They are actively engaged in a community of learners. They provide leadership in the profession, schools, and professional associations at state, national and international levels.”

Obtaining knowledge is not enough to safeguard our population, it is vitally important to implement the information learned in order to keep people safe. At the same time, humans need to make advances in knowledge on complex interactions. Research indicates that students who actively learn in class and participate in hands-on activities have a greater understanding of the concepts that are being taught to them. People are able make smarter decisions when they are educated in subjects that can have an impact on their lives. In general, science is a subject that is important or people to have a good understanding in order to survive and thrive.
APPENDIX

Ecology Lessons and Projects
<table>
<thead>
<tr>
<th></th>
<th>Integrated Science 1 Ecology Standard 6a</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>........................................</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Integrated Science 1 Ecology Standard 6b</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>Integrated Science 1 Ecology Standard 6c</td>
<td>119</td>
</tr>
<tr>
<td>4</td>
<td>Integrated Science 1 Ecology Standard 6d</td>
<td>133</td>
</tr>
<tr>
<td>5</td>
<td>Integrated Science 1 Ecology Standard 6e</td>
<td>189</td>
</tr>
<tr>
<td>6</td>
<td>Integrated Science 1 Ecology Standard 6f</td>
<td>205</td>
</tr>
<tr>
<td>7</td>
<td>Investigation and Experimentation Standards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a, b, c, d, j, m</td>
<td>215</td>
</tr>
<tr>
<td>8</td>
<td>Answers to Ecology Lessons and Projects</td>
<td>265</td>
</tr>
</tbody>
</table>
# Table Contents

Integrated Science 1 Ecology Standard 6a

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Threatened and Endangered Species WebQuest</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Ecology WebQuest</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Climate Change WebQuest</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>Your Development Project</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>Diamante Poem</td>
<td>55</td>
</tr>
</tbody>
</table>
Lesson 1

Threatened and Endangered Species WebQuest

Students will research a threatened or endangered plant or animal species. They will identify the reasons why the species is federally listed and will propose solutions to reverse low species population numbers.

Objectives
- Students will gain an understanding of what causes a species to become threatened or endangered.
- Students will be able to describe the Endangered Species Act.

California State Integrated Science 1 Ecology Standard 6a
- Students know that biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

Materials
- Threatened and Endangered Species WebQuest
  http://zunal.com/webquest.php?user=24701
- Computers – preferably a class set or one computer for every two students

Timeframe
- Introduction to the WebQuest and saving research: 30 minutes
- On-line computer research: 2 to 3 days
- Presentations: 2 days
Acknowledgements

This project was adapted from Emily Dunnagan’s fantastic endangered species WebQuest. Thank you to all of the websites for the data they provide to us for our on-line research. Most especially thank you to the U. S. Fish and Wildlife Service and all they do to protect our threatened and endangered plant and animal species.
Threatened and Endangered Species WebQuest
These buttons are on the left side of each page of the WebQuest so students can easily navigate from page to page.
Title: Threatened and Endangered Species WebQuest
Description: In this WebQuest, students research a threatened or endangered plant or animal species. They identify the causes for population decline and propose solutions to increase species numbers.
Author: Nosal, Janie
Grade Level: 6-8, 9-12
Curriculum: Science
Co-Author(s):
Keywords: threatened, endangered, plants, animals, endangered species act
It's five o'clock at night and your parents are making you watch the news. After complaining to your parents about having to watch the news, you sit down on the couch in disgust. You hear a story that suddenly captures your attention; dolphins are becoming more endangered and there are groups of people working on increasing the dolphin population. These people are trying to clean up the environment so these animals have an uncontaminated place to live. You turn to your parents and ask, "What is an endangered species?"

It is difficult to estimate how many species go extinct every year. Causes of extinction include: environmental (loss of habitat), human impacts, natural selection, and competition with invasive species. Scientists estimate that the natural extinction rate is about one species lost every 100 years. However, in the last 400 years more than 500 species have disappeared forever from North America. Plants such as the beautiful Sexton Mountain Mariposa Lily and animals like the colorful and once-abundant Carolina parakeet are gone forever and will never be seen by human eyes again.

As of May 2008, 574 species are listed as threatened or endangered in other countries and 1,353 species are listed in the United States. The numbers of plants and animals that get listed is increasing, however human efforts to save species from extinction have been successful. Currently, of the 1,353 plants and animals listed in the United States, 1,165 have active recovery plans.

Last Modified: 02/20/2009 17:39:20
You are a reporter for the local newspaper and your editor has given you your first assignment: research threatened or endangered species and in your article educate people about what causes species to become endangered.

You will use the following computer programs: Word, Excel and PowerPoint and your research will be conducted on the Internet. You will write an article on your species, show your data through a table and two graphs and finally you will present your project to our class using PowerPoint.
1. You need to decide on the species you want to research and have to check with me to see if it is still available.
2. You will conduct research on your subject on the Internet.
3. Find the following information:

**History:**
What is the history of the Endangered Species Act (ESA)? When did Congress pass the ESA? What causes species to get listed and how do they go about listing species? Compare and contrast threatened and endangered species.

**Problem:**
What is the problem with the species that you are researching? Why did a problem develop? Where did the imbalance occur? Discuss some of the data that supports the fact that there is a problem.

**Solutions:**
What solutions, if any, have been attempted? What solutions would you propose and why? Compare and contrast what has been done with what you would do for this situation.

**Ethics:**
What role should humans play with regards to other organisms in our world? Should we have an influence on other species or environments? Why or why not? Should we care? Why or why not?

**Format:** Write an article with the above information on your threatened or endangered species. Your paper must be set up like a newspaper with columns. In addition, you must include pictures of the species and its habitat (where it lives). Describe the habitat where it is found. What does it need to survive? What does it eat? How does it fit into its local food web; does it have predators? What areas of the world can you find this species? Are any organizations currently helping this species? If so who are they and what are they doing?
This information is a continuation of the Process page.

Some links to get you started on your project:
http://www.fws.gov/Endangered/wildlife.html
http://www.fws.gov/southwest/
http://www.kidsplanet.org/factsheets/map.html

Attachment Description: Word Lesson
Attachment File: word_report.doc

Attachment Description: Excel Lesson
Attachment File: excel.doc

Attachment Description: PowerPoint Lesson
Attachment File: powerpoint(1).doc

Last Modified: 02/20/2009 18:03:04
### Evaluation

<table>
<thead>
<tr>
<th>Category &amp; Score</th>
<th>You have a ways to go 1</th>
<th>Come on now, you can do better 2</th>
<th>Good Job! 3</th>
<th>Exceptionally done. You rock! 4</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article (Word Document)</td>
<td>Missing three of the required elements for the article.</td>
<td>Missing two of the required elements for the article.</td>
<td>Missing one of the required elements for the article.</td>
<td>Contains all of the required elements for the article.</td>
<td>30%</td>
</tr>
<tr>
<td>Data Table and Two Graphs (Excel)</td>
<td>Missing three of the required elements for the Excel table and graphs.</td>
<td>Missing two of the required elements for the Excel table and graphs.</td>
<td>Missing one of the required elements for the Excel table and graphs.</td>
<td>Contains all of the required elements for the Excel table and graphs.</td>
<td>30%</td>
</tr>
<tr>
<td>Presentation (PowerPoint)</td>
<td>Constantly looking down and away from the audience, does not show interest in the topic, does not appear to know the information, mumbles, hard to hear.</td>
<td>Missing two of the following: great eye contact, enthusiasm (showing interest in the topic), demonstrates mastery of the subject, thoughts are articulated clearly.</td>
<td>Missing one of the following: great eye contact, enthusiasm (showing interest in the topic), demonstrates mastery of the subject, thoughts are articulated clearly.</td>
<td>Great eye contact, enthusiasm (showing interest in the topic), demonstrates mastery of the subject, thoughts are articulated clearly.</td>
<td>30%</td>
</tr>
<tr>
<td>Behavior during research</td>
<td>Rarely on-task getting work done.</td>
<td>Sometimes on-task getting work done.</td>
<td>Usually on-task getting work done.</td>
<td>Always on-task getting work done. Helpful with other students when needed.</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Total Score:** %100
Great job, you have come a long way! Your research and article helped you achieve a better understanding about threatened and endangered species. Your research should have led you to some of the causes of endangerment for plant and animal species that share our world. Changes, especially extreme change, in the environment can have serious consequences for the organisms that occupy that space. You should have gained an understanding of how your species fits in the food web for its habitat.

Now that you are at the end of your project, you have just one last assignment to finish: create a diamante poem (everyone needs to create their own poem). Your diamante poem must have drawings related to your topic and needs to follow this format:

**Wild Wind and Water**

cyclone
strong, forceful

twisting, roaring, destroying
ocean, rain, wind, storm
raging, demolishing, obliterating
powerful, violent
hurricane
This WebQuest was created for all high school freshman students in an Integrated Science course. The California state standards for ecology were used for this project. Specifically the following:
Students know that biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

This WebQuest takes four to five days to complete, depending upon the tech savvy of the student. They should have two to three days in the computer lab, and presentations usually take two days. At the moment I am looking into having the kids create a book using iPhoto and then presenting that to the class. I am also considering creating a Google Groups and having the PowerPoints stored there and then students can check out the different projects and comment on them. The benefit to that is that way it doesn't take up class time (I'm at a block school so the days go by very quickly).

Credits and References
Thanks to the following:
Emily Dunnagan who created a fantastic endangered species WebQuest. I used many of her great ideas in this WebQuest.

Also, thank you to all of the websites used in this project for the data they provide for us to conduct online research. Most especially, thank you to the Fish and Wildlife Service for all they do to protect out threatened and endangered plant and animals species.

Last Modified: 02/20/2009 17:45:03
Lesson 2
Ecology WebQuest

Students will either research an invasive species, an imbalance between predators and prey, or reintroduction of at risk species or ecosystems.

Objective
- Students will gain an understanding of how change can cause some species or ecosystems to become threatened or endangered.

*California State Integrated Science 1 Ecology Standard 6a and 6b*
- Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Materials
- Ecology WebQuest -
  http://zunal.com/webquest.php?user=19519
- Computers - preferably a class set or one computer for every two students

Timeframe:
- Introduction to the WebQuest and saving research: 30 minutes
- On-line computer research: 2 to 3 days
- Presentations: 2 days
Acknowledgements

Thank you Professor Chung at California State University, Sacramento for teaching us how to create a WebQuest and for assigning a project I could take back to the classroom.

Thank you to all of the websites for the data they provide to us for our on-line research. Most especially thank you to The Nature Conservancy for all of their work to protect and preserve our world.

http://www.nature.org/
Ecology WebQuest
These buttons are on the left side of each page of the WebQuest so students can easily navigate from page to page.
Title: Ecology WebQuest
Description: Students will research information about one of the following: imbalances between predators and prey, invasive species, or ecosystems at risk.
Author: Nosal, Jane
Grade Level: 9-12
Curriculum: Science
Co-Author(s):
Keywords: ecosystem, invasive species, predator and prey
You and your group will choose one of the following:
Research how populations have been affected by the imbalance of predators and/or prey. Do predators and prey have a balance that they depend on for healthy populations? And if so, what are some results that occur when these populations are out of balance. What role should humans play with regards to other organisms in our world? Should we have an influence on other organisms or environments? Why or why not? Should we care? Why or why not?

Research ecosystems that are at risk of degradation or destruction. What are the factors that are affecting the health of the ecosystem? What can be done to reverse any negative effects? What are the solutions for this problem? What role should humans play with regards to other organisms in our world? Should we have an influence on other organisms or environments? Why or why not? Should we care? Why or why not?

Research the effect of invasive species into new environments. What are the short term and long term effects that this species has had on native species and the environment? Are there any viable solutions to solving any problems associated with the introduction of non-native species? What role should humans play with regards to other organisms in our world? Should we have an influence on other organisms or environments? Why or why not? Should we care? Why or why not?
You and your group will come up with a hypothesis on what you expect to find in your research. After you gather your data, you will construct fact-based conclusions and solutions to the problem. Through an in-depth study on your topic, you will take the information that you found during your Internet search on either imbalances of predators and prey, invasive species or ecosystems at risk and this will help you gain an understanding on how change affects organisms and their environment.

You will use the following computer programs: Word, Excel and PowerPoint and your research will be conducted on the Internet. Together, you and your team will present your findings to the class in a PowerPoint presentation. If you choose to do the extra credit, you can read your letter to the governor on what you see as a viable solution(s) to the problem.

Last Modified: 12/14/2008 23:07:32
First you create a team of three students.
As a group you will decide the subject you want to research and will check with me that it is still available.
Together you will conduct research on your subject on the Internet. I recommend that you split it up so that you find your information quickly.
You should find the following information:

**History:**
What is the history of this subject? Where did this occur? Who is involved?

**Problems:**
What is the problem? Why did a problem develop? Where did the imbalance occur? Discuss some of the data that supports the fact that there is a problem.

**Solutions:**
What solutions if any have been attempted? What solution(s) would you propose and why? Compare and contrast what has been done with what you would do for this situation.

**Ethics:**
What role should humans play with regards to other organisms in our world? Should we have an influence on other organisms or environments? Why or why not? Should we care? Why or why not?

After you have collected your data, one person will create a PowerPoint presentation with ten slides, another will create a table and two graphics using Excel and the third person will type up a two-page Word document detailing your findings. All of your documents will be “Saved As” your last name on the Rastro drive in the Nosal folder and in your class periods folder.

If you would like extra credit, you could write a letter to the governor. This letter will describe the situation and your recommendations on how to solve the problem. You will need to back up your opinions with facts.

Even though you will be individually responsible for different sections of this project, it is expected that you will help each other out whenever possible. Part of the rationale for working on this project in groups is that you will be able to do the next project individually.

You need to provide at least five resources for your paper.

Some topics and links to get you started on your project:
Imbalances between predators and prey:
Australia and rabbits
El Segundo Blue Butterfly and the Buckwheat plant
http://www.butterflyrecovery.org/species_profiles/el_segundo_blue/
http://www.fws.gov/ams/new/regmap.cfm?arskey=21925
Easter Island and humans

Invasive species:
Rats on the Aleutian Islands
http://www.nature.org/wherewework/northamerica/states/alaska/preserves/art19514.html?src=search
Green Mussels
http://news.ufl.edu/2005/04/21/green-mussel/
Burmese Python in Florida
http://www.fws.gov/contaminants/ANS/ANSinjurious.cfm#constrictor
Northern Pike
http://www.dfg.ca.gov/lakedavis/
Pigs on Channel Islands
http://www.nps.gov/archive/chis/restoringsci/island.html
Quagga Mussels
http://www.californiagreensolutions.com/cgi-bin/gtl/plh/content=1586

The wolf and the grizzly are not invasive species, but their reintroduction into the lower 48 is interesting.
Yellowstone wolves
http://www.pbs.org/wgbh/nova/wolves/bangs.html
Reintroduction of grizzlies in the lower 48 states
http://www.fws.gov/mountain%2Dprairiel/species/mammals/grizzly/

Ecosystems at risk:
Coral Reefs
http://www.nature.org/joinanddonate/rescureef/explore/facts.html
Rain Forests
http://www.nature.org/rainforests/explore/facts.html
http://www.nature.org/rainforests/explore/facts.html
Yangtze River in China
http://www.nature.org/wherewework/asiapacific/china/work/yangtze.html
http://www.nature.org/wherewework/asiapacific/china/features/yangtzedams.html
Shangri-La Gorge
http://www.nature.org/wherewework/asiapacific/china/work/art13296.html

Attachment Description: Word Lesson
Attachment File: ecologywordreport.doc

Attachment Description: Excel Lesson
Attachment File: ecologyexcel.doc

Attachment Description: PowerPoint Lesson
Attachment File: ecologypowerpoint.doc
<table>
<thead>
<tr>
<th>Category &amp; Score</th>
<th>You have a ways to go... 4</th>
<th>Come on now, you can do better... 6</th>
<th>Good job! 8</th>
<th>Exceptionally well done. You're on it! 10</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Document</td>
<td>Missing three of the required elements for the paper.</td>
<td>Missing two of the required elements for the paper.</td>
<td>Missing one of the required elements for the paper.</td>
<td>Contains all of the required elements for the paper.</td>
<td>%25</td>
</tr>
<tr>
<td>Excel Spreadsheet and Graphs</td>
<td>Missing three of the required elements for the Excel table and graphs.</td>
<td>Missing two of the required elements for the Excel table and graphs.</td>
<td>Missing one of the required elements for the Excel table and graphs.</td>
<td>Contains all of the required elements for the Excel table and graphs.</td>
<td>%25</td>
</tr>
<tr>
<td>PowerPoint</td>
<td>Misses three of the following: on time, complete (has all of the elements for the PowerPoint), students know what they're talking about during the presentation.</td>
<td>Misses two of the following: on time, complete (has all of the elements for the PowerPoint), students know what they're talking about during the presentation.</td>
<td>Misses one of the following: on time, complete (has all of the elements for the PowerPoint), students know what they're talking about during the presentation.</td>
<td>On time, complete (has all of the elements for the PowerPoint), students know what they're talking about during the presentation.</td>
<td>%25</td>
</tr>
<tr>
<td>Effort in the Computer Room</td>
<td>Accomplished very little research in the computer room and was disruptive to other students.</td>
<td>Accomplished some research and was off task occasionally.</td>
<td>Made good use of computer time, and was seldom off task.</td>
<td>Made excellent use of the computer time and was helpful to other students.</td>
<td>%25</td>
</tr>
</tbody>
</table>

Total Score: %100
At the end of this activity, you will have collaborated with two other students in creating a report on how change can affect plant and animal populations, through either imbalances of predators and prey, invasive species or at-risk ecosystems. You will have presented your findings in class through a PowerPoint presentation and will have gathered your data from the Internet.

Great job, you have come a long way! Now that you are at the end of your project, you have just one last assignment to finish: create a diamante poem (everyone needs to create their own poem). Your diamante poem must have drawings related to your topic and needs to follow this format:

**Title**

- Line 1: a one-word noun (person, place or thing)
- Line 2: two adjectives that describe the noun in line 1
- Line 3: three verbs that the noun does in line 1
- Line 4: four nouns that the top and bottom noun have in common
- Line 5: three verbs that the noun does in line 7
- Line 6: two adjectives that describe the noun in line 7
- Line 7: a one-word noun (person, place or thing)

**Wild Wind and Water**

- cyclone
- strong, forceful
- twisting, roaring, destroying
- ocean, rain, wind, storm
- raging, demolishing, obliterating
- powerful, violent
- hurricane

This was a group effort so that you could help each other out this first time. You will be conducting a similar WebQuest, but it will be an individual assignment on endangered or extinct plants or animals.
This WebQuest was created for all freshman students in an Integrated Science course. The California state standards for ecology were used for this project. Specifically the following:
Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species or changes in population size.

This WebQuest takes three to four days to complete, depending upon the tech savvy of the student. This does not include presentation time to the class. At the moment I am looking into having the kids create a book using iPhoto and then presenting that to the class. I am also considering creating a Google Groups and having the PowerPoints stored there and then students can check out the different projects and comment on them. That way it doesn't take up class time.

Credits & References
Thanks to the following:
Professor Chung, California State University, Sacramento. Without you and your class, who knows when I would have gotten around to creating this for my students. Thank you for assigning a project I could take back to the classroom.
Thanks to all of the above websites for the data they provided for us to conduct on-line research. Most especially, thank you to The Nature Conservancy for all of their work to protect and preserve our world.
http://www.nature.org/

Last Modified: 12/14/2008 23:14:52
Lessons 3

Climate Change WebQuest

Students will research the impact of climate change on one of three ecosystems.

Objective
- Students will gain an understanding of how climate change can cause some species or ecosystems to become threatened or endangered.

California State Integrated Science 1 Ecology Standards 6a and 6b
- Students know that biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Materials
- Agents of Change WebQuest
  http://zunal.com/webquest.php?user=19498
- Computers - class set or one computer for every two students.

Timeframe:
- Introduction to the WebQuest and how to save their research: 30 minutes
- On-line computer research: 2 to 3 days
- Presentations: 2 days
Acknowledgements

Thank you KD Farrell for working with me to create a WebQuest on global warming. It was great learning about the Zunal website with you.

Thank you to all of the websites for the data they provide to us for our on-line research.
Agents of Change WebQuest

These buttons are on the left side of each page of the WebQuest so students can easily navigate from page to page.
Title: Agents of Change

Description: In this project students learn about the greenhouse effect and global warming. They will also learn about the effects of global warming on three ecosystems: the arctic, coral reefs and rain forests. Students will reflect on their impact on the environment and their contribution to global warming by calculating their ecological footprint, and design a personal plan of action they can take to reduce their carbon footprint.

Author: Farrell, Kristin
Grade Level: 9-12
Curriculum: Science
Co-Author(s): Jane Nosal and K.D. Farrell
Keywords: Global warming, ecosystems, Arctic habitats, coral reefs, biodiversity, rain forests

Last Modified: 11/14/2008 22:32:56
The year is 2008 and Hurricane Ike has devastated parts of Texas. The Sacramento Bee reports that there are reputable scientists making correlations between global warming and longer hurricane seasons. Rising ocean temperatures and low atmospheric pressure create the right conditions for tropical cyclones. You wonder about this and think, "if this is true the consequences could be devastating world wide."

Your job is to document how global warming has affected three different biomes found on Earth: the rain forest, the Arctic, and the coral reef. You will work in teams of three to complete your project.

Last Modified: 12/05/2008 21:55:11
You have been hired by the Federal Bureau of Change as an ecologist in charge of investigating the impact global warming is having on ecosystems around the world.

Your job is to collect information, record observations and notes, meet with fellow scientists from around the world to discuss your findings, and finally prepare and present a final presentation which will be shown to world leaders.

Begin your research by choosing an ecosystem. After meeting with fellow scientists you will prepare a presentation in which you will:

1. State and defend your position on global warming.
2. Show the effects of global warming on your chosen ecosystem.
3. Present the information/data you have collected.
4. Suggest a mitigation plan.

Last Modified: 12/12/2008 18:50:12
Step 1: Develop your background knowledge of global warming based upon the reputable websites below.
Step 2: Choose an ecosystem (Arctic, rainforest, coral reef).
Step 3: Join an international committee (the committee must have a member representing each ecosystem).
Step 4: Research (use websites listed on this page) your ecosystem. Answer guiding questions in your notebook. Also add more information you find interesting for your final report.
Step 5: Write your report. You will share this report with your international committee.
Step 6: Meet with your international committee and discuss/debate your findings.
Step 7: Create a mitigation plan for your individual ecosystem. Visit mitigation link for positive actions you can take.

Before you begin you should have a solid understanding of global warming. Visit the following links to develop your understanding of global warming. In your journal write 1 - 2 paragraphs summarizing your base knowledge. Your summary should include causes of global warming, temperature data, future predicted consequences, and anything else you found interesting.

Some helpful links to check out:

Global Warming
Dr. Global Change
Blue Man Group
Global Warming on Your Level

Arctic ecosystem links:
As you begin you research here keep these questions in mind.
Why are polar bears endangered and what does it have to do with global warming?
What other arctic animals may be facing problems?
What is causing the arctic to change?
This information is a continuation of the Process page.

Polar Bears
Climate Change in the Arctic
Arctic Sea Ice Melting Faster Than Expected

Rainforest links:
As you begin your research keep these questions in mind:
What makes up a rainforest?
Why are rainforests important?
Why are they being destroyed?
How does the destruction affect global warming?
Rain forest and coral reefs
What makes up a rainforest?
Amazing rain forest

Coral reef links:
As you begin your research keep these questions in mind:
Why are coral reefs important ecosystems?
How is global warming affecting coral reefs?
What is the future of coral reefs if the trends continue?
NCCOS
Coral reefs and rain forest

Mitigation links:
Your mitigation plan should be doable and should have a positive impact on the human impact on global warming. Keep this in mind as you explore the following sites and calculate your footprint and develop ways you can reduce your impact on the world.

Here is a definition of carbon footprint.
Measure your carbon footprint with the carbon calculator.
Find out changes you can make on this site What you can do.
Still curious about Hurricane Ike? Check out the file below for some amazing pictures.

Attachment Description: Carbon Footprint
Attachment File: carbonfootprint.ppt

Attachment Description: mitigation plan
Attachment File: kdgwebquestm.doc

Attachment Description: guided questions work sheet
Attachment File wq_guidedquestions.doc

Last Modified: 12/14/2008 11:02:37
<table>
<thead>
<tr>
<th>Category &amp; Score</th>
<th>Beginning 1</th>
<th>Developing 2</th>
<th>Very Good 3</th>
<th>Exemplary 4</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research/Teamwork</td>
<td>Information was not sufficient. Team members did not work well together.</td>
<td>Students identified, with some adult help, at least 4 reasonable ideas/questions. Team members worked well together with few problems.</td>
<td>Students independently identified at least 4 reasonable ideas/questions. Team members worked well with each other.</td>
<td>Students independently identified at least 4 reasonable, insightful, creative ideas/questions. Team members worked exceptionally well together.</td>
<td>10%</td>
</tr>
<tr>
<td>Report/Poem</td>
<td>The report lacked accurate information and data. Poem did not follow structure of the diamond.</td>
<td>Information clearly relates to the main topic. No details and/or examples are given. Poem followed structure but word choices were wrong or missing.</td>
<td>Information clearly relates to the main topic. It provides 1-2 supporting details and/or examples. Was well organized and well written. Poem followed structure.</td>
<td>Information clearly relates to the main topic. It includes many supporting details and/or examples of key information, visuals and data. Poem followed structure and was creative.</td>
<td>35%</td>
</tr>
<tr>
<td>Performance</td>
<td>Presentation was not organized or well planned. Not all members participated, lacked visuals.</td>
<td>Presentation was not well organized or well planned.</td>
<td>Presentation met all requirements.</td>
<td>Presentation met all requirements. It was unique, energetic and entertaining.</td>
<td>20%</td>
</tr>
<tr>
<td>Personal mitigation plan</td>
<td>Student did not develop a plan.</td>
<td>Plan reflects only one idea which is supported by one fact and it is reported accurately.</td>
<td>Plan reflects several ideas that are doable. All elements of the plan are supported by facts.</td>
<td>Plan reflects multiple ideas that are doable. All elements of the plan are supported by facts and reported accurately. Students are enthusiastic about implementation.</td>
<td>35%</td>
</tr>
</tbody>
</table>

Total Score: 100%
Great job, you've come a long way! Now that you are at the end of your project, you have just one last assignment to finish: create a diamond poem. Your diamond poem must have drawings related to your topic and needs to follow this format:

**Title**

1. a one-word noun (person, place or thing)
2. two adjectives that describe the noun in line 1
3. three verbs that the noun does in line 1
4. four nouns that the top and bottom noun have in common
5. three verbs that the noun does in line 7
6. two adjectives that describe the noun in line 7
7. a one-word noun (person, place or thing)

**Wild Wind and Water**

cyclone
strong, forceful
twisting, roaring, destroying
ocean, rain, wind, storm
raging, demolishing, obliterating
powerful, violent
hurricane

_Last Modified: 11/15/2008 10:11:47_
Many students have a partial understanding of global warming which is shaped from media and opinions. The aim of our project is to clear up misconceptions about global warming while focusing on ecosystems. It is the goal of the project for students to understand that changing behaviors is important in solving this crisis, and students to learn that their actions can make a difference.

Objectives:
Students will learn basic principles about three ecosystems (coral reef, Arctic, and rain forest) and how global warming is causing negative changes.
Students will observe data regarding rising ocean temperatures.
Students will visit various websites on coral reefs and observe the biodiversity of sea life they support.
Students will observe data regarding melting sea ice.
Students will visit various websites where they will observe the ecosystem of the Arctic and negative changes resulting from global warming.
Students will visit various websites where they will observe the biodiversity of the rain forest.
Students will observe deforestation and learn the reasons for it.
Students will be taken to sites showing the global implications of deforestation.

Concepts:
What is global warming?
How has global warming affected coral reefs?
How has global warming affected Arctic ecosystems?
How has global warming affected rain forests?

Time:
This WebQuest will vary in length depending on the ability of your students. Upper level (2-3 class periods) Lower Level (4-5 class periods).
Time can be given in and out of class to complete this assignment.
Problems may present themselves (i.e. student understanding, computer / Internet access, systems crashing, etc.).

Management:
Each international team is made up of representatives from one of the three ecosystems. To give students choice let them choose their ecosystem.
Assigning the students to a team is the choice of the teacher.
Schedule time for teams to meet once after they have begun to read about their ecosystems to discuss (teach about) their ecosystem, discuss questions they might still have, decide what direction they want to go on their final presentation.
Students need to record information as they work so they have facts when they meet with their group. A paper notebook, or electronic note taking system will work but we have included a worksheet on the process page for students that need it.
A guided paper is included on the process page for writing a mitigation plan.
Students work independently on research but need to come together as a group to discuss their ideas and make their final presentation.
The students should have an understanding of what an ecosystem is before beginning this project.
Students should identify steps they can take to lessen their impact on the Earth.
An extension is for students to develop a service-learning project to further their learning on this issue.
Lesson 4
Your Development Project

*This project would be best implemented at the end of the ecology unit since it incorporates all of the ecology standards. Recommend that the teacher complete this project before introducing it to the students.*

Students thoroughly research a local ecosystem and how humans affect that ecosystem. Students form groups and submit competing bids for a development of their choice.

**Objectives**

- Students will be able to use ecology to understand their local environment.
- Students will be able to write a large report, create drawings and maps, and to present the report to an audience.
- Students will be able to collaborate in groups, to innovate, and to use their problem-solving skills collectively and as individuals.

**California State Integrated Science 1 Investigation and Experimentation Standards 1, 2, 3, 4, 5, and 6**

- Students know that biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.
- Students know a vital part of an ecosystem is the stability of its producers and decomposers.
- Students know at each link in a food web some energy is stored in newly made structures, but much energy is dissipated into the environment as heat.

**Materials**
- Environmental Impact Project Handout
- Computers with Internet access for research
- Large posters for presentation
- Color pens or pencils and white paper for drawing
- Photocopy attendance sheet for each period

**Timeframe**
- 2 weeks of class time

**Lesson Procedure**

1st day: Explain the project and give out handouts. Assign students to groups of four. Try not to use groups of three. Students decide what kind of project to develop from the list provided. Students will discuss and agree on responsibilities of the project. The groups then submit the rubrics with their names, development title and assigned parts. All students must participate in the presentation of the project. Have student's exchange phone numbers or emails so they can keep in touch during the project. Being absent does not excuse the student for their portion of their work. Students who will be out of class for an extended period of time need to work on an alternative assignment.
2nd day: Library or computer lab. Have students print out their research on paper. Many groups will come up with the same information, books and websites. It is important that students learn research skills on their own. Groups are to sit together and record where they locate the information: website URL, publisher, and date published. Students should leave all research with you in the classroom so progress is not delayed by absent students.

3rd day to 9th day: Each day all students should work on their portion of the project. At the end of the period, mark plus, check, minus or absent on your attendance sheet to indicate the student’s participation level. Most student work will be writing paragraphs, outlining research, or drawing. Mark on your attendance sheet if another student in the group covered the part of an absent or non-working student. Use two pluses for students who go beyond their assigned work. Students can work on their part of the project at home but must be on task during class time. Additional presentation posters are optional and recommended.

10th day: Presentations. All students in a group present their project to the class. Use the presentation rubric to grade each group presentation. After all presentations are finished, have students fill out the peer evaluation form. Form must be completed individually (no collaboration) and turned over when completed. Teacher collects forms so that the other students don’t get to see the evaluation.
Teacher Setup

1. Decide on an area close to the school that will be developed. It should at least be the size of the school property. It can be already developed but in bad shape, a large parking lot, or undeveloped land.
2. Reserve a day at the computer lab for the second day of the project. Make sure account username and passwords for students are taken care of before hand. All students need to research using the computers. If login will be a problem, reserve the lab for two days and add extra day on to the project.
3. Research websites that have the same ecosystem types as your local environment. Try to find websites that have name of plants, herbivores, carnivores, decomposers, and endangered species. An example would be if you live in a western conifer forest or grasslands.
4. Select a day for the presentation and when the written report will be due. You may need to determine if the students need an extra day or two to finish the report.

Modifications for Alternative Learners

Students who will not be in class should have an alternative assignment. Students with an IEP can join a group of four students to make a total of five students in that group.

Acknowledgements

This lesson was adapted from the Ecosystem Development Project, which was created by Lesson Plans Inc. (www.LessonPlansInc.com).
You are going to work in a group of four people to develop a large parcel of land. The development project will incorporate real world economic, social, and environmental issues. The loan for your team to build this project has already been approved. Your teacher will become both an advisor and the judge who decides who wins the development project. The project will include a minimum of three posters for the class presentation. A detailed typed report will be produced to describe the proposal.

Groups
Each member of the group is expected to complete his or her fair share of the project. All group members are expected to compromise, collaborate and share information and ideas.
All students must present at the end of the project. The project can be broken down into sections and each member can be assigned to a section. If a student does not complete their section, other team members will need to pick up the slack. These students will earn extra credit and the underperforming student will be docked points. The sections are:

- Environmental survey and drawing the food web & energy pyramid poster
- Environmental impact assessment
- Economic and social benefits plus drawing the blueprint poster
- Ecosystem management plan and drawing the carbon, nitrogen and water cycle poster
Background Info

There will be a vote at next city council meeting on the proposed sale of a large area of land that has a creek or canal, wetlands, and a farm. Your project must first go through the planning commission (all requirements below) and then to the city council (presentation to your teacher).

Each group represents a development company with different ideas on how to best develop the land. All bidding interests will be required to present an environmental impact assessment, a blueprint of land development, and a statement of social and economic benefits for the community. Additionally, each project bidder must establish an ecosystem management plan to improve and maintain the land not developed in the project.

The city council will determine which bidding party will develop the land based on the best interest of the community. Your city is interested in a monetary gain from the development of the property. Pollution from external sources is a concern for the city residents and some open space is desired regardless of which plan is accepted.
Your choice of projects includes:

Power Plant – A power plant large enough to provide 50% of the electricity for surrounding area.

Amusement Park – A family-oriented theme park.

Residential District – A mix density residential community.

Zoo – A large zoo.

Mall – A cooperation of locally owned stores in one location.

Amphitheater – A large outdoor arena for music concerts.

Office Park – A large office park for multinational companies.

Oil Refinery – A fossil fuel refining factory focused on fuel for cars.

Farm – A locally owned agricultural company.

University – The state university want to open a campus extension here.

Factory – Create a large factory where something is manufactured.

Sports Stadium – Build a large sports field for a sport(s) of your choice.

Park or Open Space – Used for both wildlife and recreational activities.

Other? – If you have another idea other than what is found on this list, run it by your teacher for approval.
Order of Progression

1st: Research animals and plants for the environmental survey and your type of development. Example – if you are going to build an amusement park, research Six Flags resorts to get an idea of what you are going to need to build your project.

2nd: Discuss and draw a rough copy of the blueprint to generate ideas of everything that you are going to build. Make estimates of proportions of what will be built in relation to the entire plot of land. Create a data table for the environmental survey.

3rd: Finish the environmental survey
   - Ecosystem management plan
   - Environmental impact assessment
   - Economic and social benefits
   - Posters: food web, food pyramid, 3 cycles
   - Final blueprint

4th: Presentation to the class
Report

The report will include four sections:

- Environmental survey
- Environmental impact assessment
- Ecosystem management plan
- Economic and social benefits

*Environmental Survey: Before you develop the land...

The object of this survey is to show the people that you have carefully examined what currently exists at and around the development site. The items that are part of your survey are:

- Make a data table of plants, mammals, birds, reptiles, fish, insects, and endangered species present in this type of ecosystem. Columns include the common name, species name, habitat, food source, and autotroph/heterotroph. Provide 20 different species total.

- Explain the features of the biome of your site. Describe the climate of the area.

- How does the fertilizer from the farm affect the creek/canal's water quality? How do the wetlands affect the creek/canal's water quality?
Ecosystem Management Plan: open space on your land...

Part of the parcel needs to be maintained as open space to help the environment. Your team gets to decide how much land to set aside from development. You also need to create a management plan for this open space. The management plan should incorporate:

- Pest control: Are you going to use pesticides, herbicides, fungicides, or bat houses for insect control?

- Native or non-native plants: Which will you plant? Are you going to try to control non-native plants?

- Animal management: Is the land large enough for big animals? Will you allow hunting to control population size?

- Water usage: Are you going to irrigate the trees and lawn, drill for wells or put the creek into a pipe and cover it? Can you use grey water at your site for irrigation of plants?

- Recreational use: Are you going to have hiking trials, sports park, or parks? Other ideas?
Environmental Impact Assessment: After you develop the land...
The local people will be very interested in what effect your planned
development will have on their environment and quality of life. A
careful, scientific presentation of the facts will help to make the best
decision.

Although you are doing research and presenting the impact of your
fictional development, you must use real facts. The preparation of this
Environmental Impact Assessment goes hand in hand with the drawing
of the blueprint of your planned development. Include the following
items:

- A list of the main things you will be building on the parcel.

- How will the development affect the traffic on neighboring
  highways, freeways and roads?

- List the types of garbage and waste materials produced by your
development and explain how you will dispose of them. How
  are you going to use the 3 Rs concept: reduce, reuse and
  recycle?

- How will your development affect the surrounding ecosystems,
  the creeks or canals, and the quality of air and water in the city?
How much electricity/heating/cooling/water will your development need and how you are going to supply this demand.

- Explain how your development will affect city services like police, fire, schools, sewage, and health care and what you are going to do to lessen the impact.

- Make-up birth rates, death rates, immigration rates, emigration rates, and current population size of one animal species in the ecosystem before you develop. Explain how each rate is changed because of the development.

- A review of the impact of this development on any endangered or threatened species found at the site. If there aren't any threatened or endangered species, use an unlisted species that is found on your property.
Economic and Social Benefits: benefits the community receives after you develop...

The main reason why we develop is to provide either an economic or social benefit to society. In what way will your development provide a benefit? Listed below are some of possible benefits. Make estimates for each economic and social benefit to society and explain why you think it is a benefit and not a detriment to society.

Economic benefits would be things that will bring:

- Increased tax revenue for the city. Estimate how much will your development make in a year.
- Jobs: what kind of jobs, how much will each pay, what kind of benefits will you offer?
- Increased land value: Does this attract people to move here or leave? Explain.
- Lowers the impact on city resources (water, sewage, energy).

Social benefits would include things:

- Entertainment and relaxation
- Education
- Health care
- Provides shelter, day care, clothing, or food for families
- Improves the quality of life for youth or elderly residents
Presentation Posters:

There are three required posters: The posters must be large so the students in the back of the room can see and read it during the presentation. You can create additional posters outlining your impact assessment and management plan.

- The blueprint is a drawing of the entire site and the surrounding area. It should show the location of all buildings, parking lots, roads, landscaping and preserved open space, etc. Make sure to consider, especially with homes, what is next to your plot of land and plan accordingly. The blueprint should be drawn to scale using a ruler/meter stick.

- Create a food web of the plants, animals, insects, and decomposers from the environmental survey. Draw a food web that includes the interconnections of the organisms. Create an energy pyramid of the plants, animals, insects, and decomposers of the local ecosystem. Draw an energy pyramid with labels that show how 90% of energy is lost as heat at each level.

- Draw diagrams to show how your development will affect the carbon cycle (CO₂), the water cycle (water usage and water pollution) and the nitrogen cycle (air or water pollution). All three cycles include arrows with labels going into your development and arrows with labels coming out of the development.
Useful Links:

Example Environmental Impact Assessment

Environmental Survey
http://www.mdia.org/wildlife.htm
http://www.mdia.org/plants.htm
http://www.nativeplants.org/
http://www.baynature.com/home.html
http://en.wikipedia.org/wiki/Mount_Diablo_State_Park
http://www.mbgnet.net/index.html
http://www.bringingbackthenatives.net/

Management Plan
http://www.whatisipm.org/
http://www.doityourself.com/stry/pestmanagefarm
http://ianrpubs.unl.edu/range/ec148.htm
http://www.weedcenter.org/management/mgmt_overview.html

Blueprint Planning
http://www.planning.org

Environmental Assessment
http://www.epa.gov/msw/reduce.htm
http://en.wikipedia.org/wiki/Urban_planning#Transport
http://ntl.bts.gov/DOCS/UTP.html
http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookpopecol.html
Presentation Rubric

Project Title: 
Name ____________________________ Assigned Section __________________
Partner Name ________________ Assigned Section _____________
Partner Name ________________ Assigned Section _____________
Partner Name ________________ Assigned Section _____________

<table>
<thead>
<tr>
<th></th>
<th>Large Negative Impact</th>
<th>Small Impact</th>
<th>Large Positive Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job Creation</td>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Tax Revenue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assist Other Businesses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Family Facility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youth / Elderly Facility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollution/Waste</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>(Air, Water, Soil, Garbage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Space Benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Plan</td>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Category</td>
<td>Points Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation Total</td>
<td>50 points total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Participation</td>
<td>50 points total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written Report</td>
<td>150 points total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Project Points (out of 250 points)</td>
<td>250 points</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Collaboration Rubric

You are to rate each of your partners on a scale of
1 to 5.
1 = not so good 5 = awesome

<table>
<thead>
<tr>
<th>Partner Name</th>
<th>1 to 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much did they work on their own part of the project?</td>
<td></td>
</tr>
<tr>
<td>How much did they help you / partners during class time?</td>
<td></td>
</tr>
<tr>
<td>How useful was their help in the decision making of the project?</td>
<td></td>
</tr>
<tr>
<td>How easy was it to work with the partner?</td>
<td></td>
</tr>
<tr>
<td>How often was he/she on task during class time?</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Partner Name</th>
<th>1 to 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much did they work on their own part of the project?</td>
<td></td>
</tr>
<tr>
<td>How much did they help you / partners during class time?</td>
<td></td>
</tr>
<tr>
<td>How useful was their help in the decision making of the project?</td>
<td></td>
</tr>
<tr>
<td>How easy was it to work with the partner?</td>
<td></td>
</tr>
<tr>
<td>How often was he/she on task during class time?</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 5

Diamante Poem

In this activity, students will construct a poem following the diamante outline. This is a great informal assessment to do at the end of major concepts. It also allows students to be creative.

Objectives

- Students will create diamante poems detailing the information that they learned from their lessons. They will illustrate their poems with drawings that support the content of their poem.

California State Integrated Science 1 Ecology Standards

- This assignment supports all of the standards because it is a poem that can be used with any content. This can be incorporated after the lessons in biodiversity, changes in ecosystems, the water, carbon and nitrogen cycles, photosynthesis, respiration, food webs and population.

Materials

- Handout: Diamante Poem
- Blank paper
- Color pencils, pens or crayons

Timeframe

- 30 to 45 minutes
Lesson Procedure

1. This assignment should be completed in class for at least the first poem so students have teacher support on which words fit each category.

2. Students usually remember what words are nouns, but have trouble with adjectives and verbs. I tell them that in this poem their verbs are in an -ing format.

3. It is fun to show the Schoolhouse Rock videos reminding students on the rules associated with nouns, adjectives and verbs. YouTube has these videos:

Nouns: http://www.youtube.com/watch?v=Tc-ukN1Rvb8
Adjectives: http://www.youtube.com/watch?v=3j347DjSve0
Verbs: http://www.youtube.com/watch?v=u4GomSmWZs4

Acknowledgements
I was introduced to this type of poem at the Effie Yeaw Nature Center.
Diamante Poem

Title

Line 1: a one-word noun (person, place or thing)

Line 2: two adjectives to describe the noun in line one

Line 3: three verbs that the noun in line one does

Line 4: four nouns the top and bottom noun have in common

Line 5: three verbs that the noun in line seven does

Line 6: two adjectives to describe the noun in line seven

Line 7: a one-word noun (person, place or thing)

Wild Wind and Water

cyclone

strong, forceful

twisting, roaring, destroying

ocean, rain, wind, storm

raging, demolishing, obliterating

powerful, violent

hurricane

57
# Table of Contents

Integrated Science 1 Ecology Standard 6b

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The Dirty Experiment ................................</td>
</tr>
<tr>
<td>2.</td>
<td>Ecology WebQuest ...................................</td>
</tr>
<tr>
<td>3.</td>
<td>Climate Change WebQuest .............................</td>
</tr>
<tr>
<td>4.</td>
<td>Your Development Project .............................</td>
</tr>
<tr>
<td>5.</td>
<td>Experimental Variables ...............................</td>
</tr>
<tr>
<td>6.</td>
<td>Population Ecology Lab ................................</td>
</tr>
<tr>
<td>7.</td>
<td>World in the Balance ..................................</td>
</tr>
<tr>
<td>8.</td>
<td>An Inconvenient Truth Movie Worksheet ..............</td>
</tr>
</tbody>
</table>
Lesson 6

The Dirty Experiment

In this activity, students will grow radishes from seed. They will manipulate two variables: soil nutrients and mulch layers.

Objective
- Students will gain an understanding of how change might cause plants to grow healthier.

California State Integrated Science 1 Ecology Standard 6b
- Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Materials
- Handout: The Dirty Experiment
- Garden area
- Fertilizer (Miracle Gro) and leaf mulch
- Radish seeds

Timeframe
- Set up garden area: First time set up might be best on a weekend.
- Planting seeds: 10 to 15 minutes
- Germination of seeds: 4 to 6 days
- Monitoring of plant growth: 22 days
- Harvesting of radishes: 22 days
Lesson Procedure

1. Set up two garden beds in full sun with no weeds. The soil needs to be moist but not saturated with water. Till and rake it smooth. The size of your garden bed will depend on how much space you have available for your use and also how many students are in your class. Each bed will be divided in half. Half of the soil will have a two-inch layer of leaf mulch added to the top. The other half will not have anything on top of the soil.

2. One bed will have the native soil without anything added to it.

3. The second bed will have fertilizer added (recommend Miracle Gro). Apply fertilizer according to the directions on the package.

4. After the garden beds have been prepared, have the students plant the radish seeds according to the directions on the package. Make sure that the seeds in the mulch bed are not covered directly on top.

*Note:* Radish seeds were chosen because they grow very quickly. If you have more time available to grow your crop, consider planting carrots, which typically harvest after 70 days.

*Second Note:* Have students bring in bags of leaves for the mulch.
Independent Variables: fertilizer and mulch
Dependent Variable: measured plant growth
Control Group: The 1st treatment with nothing added to the soil and no added mulch to the top of the soil.

After the data tables are filled in, create your graphs. The independent variable is on the x-axis (the treatments with fertilizer and mulch) and the dependent variable is on the y-axis (the growth of the plants). There will be four graphs: height of plant, width of plant, weight of plant and weight of radish root. Each graph will have the different treatment of the soil on the x-axis. The ideal method to graph this data is with the bar graph.
In this activity, you are going to conduct an experiment and write up a lab report. The following treatments are the parameters of the lab which involve growing radish seeds in four different environments:

- 1st Treatment: Seeds are grown in soil with no added fertilizers and no added mulch to the top of the soil.
- 2nd Treatment: Seeds are grown in soil with no added fertilizers and two inches of leaf mulch added to the top of the soil.
- 3rd Treatment: Seeds are grown in soil with added fertilizers and no added mulch to the top of the soil.
- 4th Treatment: Seeds are grown in soil with added fertilizers and two inches of leaf mulch added to the top of the soil.

*Note:* When you plant the seeds in the soil with the mulch layer on top, make sure that the top of the soil over the seed is exposed to the sun. As the plants germinate, gently push the mulch closer to the plants.

You need to write up the purpose, hypothesis, materials, and procedure before starting the experiment. Use the attached Scientific Method format paper to help you with your writing.

Identify the variables in this experiment:

Independent Variable:

Dependent Variable:

Control Group:

After the data tables are filled in, create your graphs. The independent variable is on the x-axis and the dependent variable is on the y-axis. There will be four bar graphs with the four treatments on the x-axis.
Write the heading at the beginning of each section of the lab report.

1. Purpose: In your own words, state the purpose of the activity.

2. Hypothesis: What do you expect to happen and why? Do not use personal pronouns such as I, me, my, our...

3. Materials: A bulleted list of what is needed for this experiment.

4. Procedure: A numbered list of what needs to be done step by step so someone else could read your procedure and duplicate what you did in this experiment.

5. Variables: (a bulleted list as follows)
   - Independent variable (IV): (this is what you change in your lab)
   - Dependent variable (DV): (this is the data you collect)
   - Control group (CG): (the IV is eliminated or at a standard level)

6. Data Table: Remember to label the columns and rows (as appropriate) with the words and units. For example: Time (seconds)
7. Graph: Remember to label the x and y-axis with the words and the units. For example: Time (seconds). Don’t forget the numbers.

8. Conclusion:
   - 1st Paragraph: Recap this Experiment
     - What were you trying to do or find out in this experiment? What type of data did you collect (mass, length, time)? How did you collect it? Do not repeat the entire procedure.
   - 2nd Paragraph: Analyze your Results
     - What does your data show? What did you discover? Report the data with units and any results that you measured or calculated. Do not repeat all of the data.
     - If there is a graph, describe what your graph shows about the relationship (direct or inverse) between the variables.
     - Explain if your hypothesis was supported or contradicted by the results. Specifically, tell how the results of the experiment helped you to evaluate your hypothesis. Compare your results to your hypothesis.
3rd Paragraph: Causes of Measurement Uncertainty

- This is not the same thing as a mistake. You are not to include descriptions of human error or mistakes here; these things should be corrected during the lab and mistakes in data collection are not included in the lab report.

- Look for places in the procedure where the value of your measurement might not be exact (may show variations between the repeated trials) no matter how careful you were in conducting your experiment. These types of unavoidable conditions are called experimental error or scientific uncertainty. Write about what conditions in the lab may be the source of the small differences in data collection.
<table>
<thead>
<tr>
<th>Record Plant Growth (mm)</th>
<th>Soil - no amendments</th>
<th>Soil with organic fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mulch</td>
<td>Mulch</td>
</tr>
<tr>
<td></td>
<td>No mulch</td>
<td>No mulch</td>
</tr>
<tr>
<td>3 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 Days</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Data Table Results

<table>
<thead>
<tr>
<th>Garden Bed</th>
<th>Height of plant (cm)</th>
<th>Width of plant (cm)</th>
<th>Weight of plant (g)</th>
<th>Weight of radish root (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil - no amendments (no mulch)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil - no amendments (with mulch)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil - organic amendments (no mulch)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil - organic amendments (with mulch)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 8

See Lesson 3

Climate Change WebQuest

on Page 25
Lesson 9

See Lesson 4

Your Development Project
on Page 36
Lesson 10
Experimental Variables Worksheet

Students learn to identify the different variables used in experiments.

Objectives
- Students will be able to determine the independent, dependent and control variables.
- Students will be able to successfully complete the Population Ecology Lab after this lesson.

California State Integrated Science 1 Investigation and Experimentation Standard j
- Recognize the issues of statistical variability and the need for controlled tests.

Materials
- Handout: Experimental Variables Worksheet

Timeframe
- 30 minutes

Lesson Procedure
1. As a class, review independent variables, dependent variables and control groups. Do the first problem together on the handout.
2. Have the students work in pairs to finish the worksheet and discuss their results as a whole class.
3. Answers to this activity can be found in Appendix B.

Modifications for Alternative Learners
English Language Limited (ELL) students should be paired with a student fluent in English.
Acknowledgements

This lesson was adapted from the Experiment Variables Worksheet, which was created by Lesson Plans Inc. (www.LessonPlansInc.com).
For the following experiments, identify the independent variable (IV), dependent variable (DV) and control group (CG).

<table>
<thead>
<tr>
<th>IV</th>
<th>DV</th>
<th>CG</th>
</tr>
</thead>
<tbody>
<tr>
<td>The independent variable is what the experimenter changes during the experiment.</td>
<td>The dependent variable is what the experimenter measures.</td>
<td>The control group is when the independent variable either is eliminated or is set at a standard value.</td>
</tr>
</tbody>
</table>

1. One tank of goldfish is fed the normal amount which is once a day, a second tank of goldfish is fed twice a day, and a third tank of goldfish is fed four times a day during a six week study. The fish’s body fat is recorded daily.

IV
DV
CG
2. You give four sunflower different watering with either pure water or different concentrations of salt solutions. After a two-week period, the height is measured.

IV ____________________________________________

DV ____________________________________________

CG ____________________________________________

3. Three redwood trees are kept at different humidity levels inside a greenhouse for 12 weeks. One tree is left outside in normal conditions. Height of the tree is measured once a week.

IV ____________________________________________

DV ____________________________________________

CG ____________________________________________

4. Pea plant clones are given different amounts of water for a three-week period. The first pea plant receives 400 milliliters. The second pea plant receives 200 milliliters. The third pea plant receives 100 milliliters. The fourth pea plant does not receive any extra water: the plant only receives rainwater. The height of pea plants is recorded daily.

IV ____________________________________________

DV ____________________________________________

CG ____________________________________________
5. The number of flowers on different breeds of bushes in a greenhouse is recorded every week for two months.

IV

DV

CG

6. You decide to clean the bathroom. You notice that the shower is covered in a strange green slime. You decide to try to get rid of this slime by adding lemon juice. You spray half of the shower with lemon juice and spray the other half of the shower with water. After 3 days of "treatment" there is no change in the appearance of the green slime on either side of the shower.

IV

DV

CG
Lesson 11
Population Ecology Lab

Students participate in an activity that models a population of rabbits and how density-dependent factors affect a population size.

Objectives
- Students will be able to explain how exponential and logistic growth rates affect population size.
- Students will be able to predict how density-dependent factors like competition for resources and predators control population growth.

California State Integrated Science 1 Ecology Standards 6b and 6c
- Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.

Materials
- Handout: Population Ecology Lab
- Grass field or blacktop with a distance of at least 30 meters
- Clipboard and data table for recording data

Timeframe
- 90 minutes
Lesson Procedure

1. The class is going to mimic how a population of rabbits grows based upon the resources in the environment and predators. On a grass field outside, *two* students will stand on one side and face at least 10 students about 30 meters away. The side with two students will represent rabbits and the other side will represent resources in the environment. The teacher will stand on the side and will be the decomposing area.
2. The teacher will tell the predator to face away from the environment and the environment to face away from the rabbits. The teacher will then tell the environment group to choose the resource they want to be and the rabbit group which resource they are searching for. Students show their resource kinesthetically by making a triangle with their hands (shelter), hand over their mouth (water) and hand over their stomach (food).

3. Once a student has chosen a resource, they cannot change it. The teacher will then tell the environment group to turn around and face the rabbits. The environment group needs to maintain showing their resource. The teacher will then tell the rabbits to go. The rabbits then turn around and run towards the environment and in particular, the resource they chose. Rabbits must run straight and once they reach the environment, they tag the resource they chose and stop. Rabbits may not run around in the environment area searching for their resource.

4. If a rabbit tags a resource, the rabbit survives and reproduces one offspring. The tagged environmental person will become a rabbit in the next generation. If a rabbit does not tag the resource they were searching for, they die and go to the decomposer section. Decomposers go to the environment after one generation (cycling of students from decomposer to environment will keep the lab functioning indefinitely). If a resource is not tagged, they stay where they are at for the next generation.

5. Students repeat this procedure for 10 generations. Count the number of rabbits, environment before you say, “Go” and record in the data table.
6. On the 11th generation, introduce a coyote. Have one student from the decomposers become a predator of the rabbits. The coyote stands where the teacher stands and goes on the same "go" as the rabbits. The coyote then tries to tag as many rabbits running across the field as possible before they reach the environment. If the coyote tags one rabbit, the coyote lives. Each additional rabbit becomes a coyote in the next generation (round). Record the number of coyotes in the data per generation.

7. Discuss carrying capacity after conducting the lab, but before students start working on the observations and questions. Have the students attempt to come up with a definition of this term based upon their experience with the activity. The definition they should come up with is the following: the carrying capacity is the maximum number of individuals a habitat can support. Hewitt, Lyons, Suchocki and Yeh (2007).

8. Answers to this activity can be found in Appendix B.

Note: Remind students that the graph needs a title, labels for the x and y-axis, and the numbers need to be sequential (i.e., 1, 2, 3, or 2, 4, 6).
**Modifications for Alternative Learners**

Students who are not able to participate can record the data and not participate in running or being a resource. Students with an Individualized Education Plan (IEP) can take the handout home if they need extra time, not graph the data, or not calculate the exponential and logistic growths for the populations.

**Acknowledgements**

This lesson was adapted from the Population Ecology Lab, which was created by Lesson Plans Inc. (www.LessonPlansInc.com).
You are going to create a population growth model for rabbits. The model will let you examine how density-dependent factors will affect the population size of rabbits.

Hypothesis: If a population is affected by density-dependent factors, then its rate of growth will __________________________________________________________________________.

Procedure:

*Rabbits*: Face away from the environment group and choose an environmental resource. Run and tag corresponding resource on the environment side. If you tag the resource, you live and go back to the rabbit’s section for the next generation. If you do not tag a resource, you die and decompose (stand next to the teacher).

*Environmental Resource*: Face away from the environment group and choose which resource you want to be (shelter, food or water). If a rabbit tags you, you will become a rabbit in the next generation. If no rabbit tags you, you stay as a resource for the next generation.

*Decomposers*: Stand next to the teacher for the next generation. Go to the environment side after one turn (generation).
Coyotes: Stand next to the teacher. Tag as many rabbits as possible when the teacher says go. If you tag one rabbit, you survive. If you tag more than one rabbit, they become a coyote in the next generation.
### Data Table:

<table>
<thead>
<tr>
<th>Generation</th>
<th>Rabbit Population</th>
<th>Environment</th>
<th>Coyote Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Graphing:

Using a piece of graph paper, create a line graph with population size against number of generations. Use a legend and colored pencils to graph rabbit, environment and coyote populations.
Population Ecology Lab Observations and Questions

1. Independent variable:

2. Dependent variable:

3. What is a limiting factor?

4. Identify limiting factors in this activity.

5. What happened to a rabbit that did not tag its corresponding resource?

6. Why did a tagged resource become a rabbit in the next round?

7. The largest number of rabbits able to survive in the provided environment is called its ________________.

8. What type of growth happened in generations 1 through 4?

9. Why did the above growth not continue forever?
10. Calculate the rabbit population growth for generation 2.

\[
\text{Rate of growth} = \text{birth rate} + \text{immigration} - \text{emigration} - \text{death rate}
\]

\[
r = \_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_
\]

11. Exponential growth formula

\[
\Delta N = rN
\]

where \( r \) is the rate of growth above and \( N \) is the current rabbit population size. Calculate the rabbit population growth for generation 7.

\[
r = \_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_
\]

\[
\Delta N = \_\_\_\_\_\_\_\_\_ \times \_\_\_\_\_\_\_\_\_
\]

12. Logistic growth formula; where \( K \) is the amount of resources in the environment.

\[
\Delta N = rN \times (K - N)
\]

\[
K
\]

\[
r = \_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_
\]

\[
\Delta N = \_\_\_\_\_\_\_\_\_ \times \_\_\_\_\_\_\_\_\_ \times (\_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_)
\]

85
13. Explain how the environment and the rabbits were related and how the introduction of coyotes affected the growth of the rabbit population.
Lesson 12
World in the Balance

For this assignment, students will gain an understanding on human population growth rates.

Objective

- To calculate how long it takes a country's population to double in size and to investigate factors affecting growth rate.

*California State Integrated Science 1 Ecology Standards 6b and 6c*

- Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species or changes in population size.
- Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration and death.

*Materials (for each team)*

- Handout: World in the Balance
- Handout: Double Up
- Handout: Calculating Population Growth
- Handout: Growth Rates Worldwide by Group Number
- Calculator
- Graph paper
- Access to computers with Internet resources
Timeframe

- 61 to 90 minutes for class work on growth rates
- One and a half days in the computer lab to research and type up their report on factors and impacts on growth rates

Lesson Procedure

1. Since 1800, human population has grown from one billion to six billion people. Over the next half century, that number is projected to rise to nine billion. Tell students that in this activity they will investigate how long it takes the populations of different countries and territories to double.

2. Ten tables for Growth Rates Worldwide have been created... one for each group. The original table can be found on the website http://www.pbs.org/wgbh/nova/teachers/activities/3108_worldbal.html#procedure.

3. Organize the class into teams of four and provide copies of the student handouts and other materials to each team.

4. Go over the World in the Balance handout with the students.

5. Use the steps on the "Calculating Population Growth" student handout to demonstrate how to calculate future population sizes using the growth rate data.
6. After the groups have doubled the populations of all of their assigned countries, have them graph their countries' population growths with the best-fit curve.

7. If necessary, help students see that population growth is not a linear function; i.e., it produces a curved graph rather than a straight-line graph. Have teams answer the questions on their student handouts and hold a class discussion about their conclusions.

8. Create a class histogram on the whiteboard to compare population doubling for each country. The histogram will need to have an upper time value of the country that takes the longest to double and should have an upper population size value of 150. Ask each team to represent each of its countries with a data point and an abbreviation of the country's name. Examine the histogram with students. Discuss the questions on the World in the Balance handout. Remind students that this does not represent all the world's countries.

9. Have students brainstorm a list of factors they think might affect growth rate (e.g., birthrate, death rate, access to medical care, nutrition, immigration, education, and income).

10. To conclude the lesson, split each team in half and have students research some of the factors that contribute to low growth rates and the possible environmental, social, and economic impacts on the people within those populations. The other half of the team will research factors contributing to high growth rates and the
corresponding impacts on people in its populations. Together, they will write a two-page report on their findings. Some factors that need to be discussed in their paper: Do they see any commonalities among low-growth rate countries? Among high-growth rate countries? What are some of the differences between the factors among low-growth rate and high-growth rate countries? Now they choose two countries with a negative growth rate and calculate the time it takes for a population to decrease to half its original size given an initial population size of 100 individuals. They need to research reasons for negative growth rates.

Additional Activities

Find two social studies-based activities—one on global warming and the other on U.S. immigration—in our Educational Role Plays at www.pbs.org/nova/worldbalance/roleplay/

*Modifications for Alternative Learners*

Instead of a group of four students, students with an Individualized Education Plan (IEP) can be in a group of five students.
Acknowledgments

This lesson was adapted from the "World in the Balance" NOVA Classroom Activity written by Margy Kuntz.

The Park Foundation, Sprint, and Microsoft provide funding for NOVA.

Major funding for "World in the Balance" is provided by Marguerite and Gerry Lenfest, The John D. and Catherine T. MacArthur Foundation, The Richard and Rhoda Goldman Fund (sponsor of the Goldman Environmental Prize), and The William and Flora Hewlett Foundation.

The Annenberg Foundation funds "World in the Balance" educational outreach.

NOVA Web Site—World in the Balance
www.pbs.org/nova/worldbalance/
Activity Answer

Countries with high growth rates double more quickly than those with low growth rates. High-growth rate countries have higher birth rates and lower death rates. The greater the difference between birth rate and death rate, the more quickly the population grows.

The following table provides sample results for the amount of time it takes for a population to double. The numbers in parentheses are the calculated values for total population size at that period in time. All numbers are rounded up.
### Sample Population Doubling Rates

<table>
<thead>
<tr>
<th>Country</th>
<th>10-year compounded growth rate</th>
<th>Population doubles after approximately:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.097</td>
<td>80 years (105)</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>0.226</td>
<td>40 years (113)</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.121</td>
<td>70 years (111)</td>
</tr>
<tr>
<td>Cameroon</td>
<td>0.221</td>
<td>40 years (111)</td>
</tr>
<tr>
<td>Canada</td>
<td>0.098</td>
<td>80 years (106)</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>0.317</td>
<td>30 years (114)</td>
</tr>
<tr>
<td>Chad</td>
<td>0.353</td>
<td>30 years (124)</td>
</tr>
<tr>
<td>China*</td>
<td>0.062</td>
<td>120 years (103)</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.168</td>
<td>50 years (109)</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>0.167</td>
<td>50 years (108)</td>
</tr>
<tr>
<td>Egypt</td>
<td>0.204</td>
<td>40 years (105)</td>
</tr>
<tr>
<td>Ghana</td>
<td>0.155</td>
<td>50 years (103)</td>
</tr>
<tr>
<td>Guatemala</td>
<td>0.300</td>
<td>30 years (110)</td>
</tr>
<tr>
<td>Guinea</td>
<td>0.264</td>
<td>30 years (101)</td>
</tr>
<tr>
<td>Haiti</td>
<td>0.180</td>
<td>50 years (114)</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.128</td>
<td>60 years (103)</td>
</tr>
<tr>
<td>India</td>
<td>0.157</td>
<td>50 years (104)</td>
</tr>
<tr>
<td>Kenya</td>
<td>0.134</td>
<td>60 years (106)</td>
</tr>
<tr>
<td>Kuwait</td>
<td>0.389</td>
<td>30 years (134)</td>
</tr>
<tr>
<td>Country</td>
<td>Rate</td>
<td>Time (Years)</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
<td>--------------</td>
</tr>
<tr>
<td>Madagascar</td>
<td>0.348</td>
<td>30</td>
</tr>
<tr>
<td>Malta</td>
<td>0.075</td>
<td>100</td>
</tr>
<tr>
<td>Mayotte</td>
<td>0.516</td>
<td>20</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.126</td>
<td>60</td>
</tr>
<tr>
<td>Nepal</td>
<td>0.251</td>
<td>40</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.114</td>
<td>70</td>
</tr>
<tr>
<td>Norway</td>
<td>0.044</td>
<td>160</td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.220</td>
<td>40</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>0.379</td>
<td>30</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.400</td>
<td>30</td>
</tr>
<tr>
<td>Somalia</td>
<td>0.402</td>
<td>30</td>
</tr>
<tr>
<td>Uganda</td>
<td>0.339</td>
<td>30</td>
</tr>
<tr>
<td>United States</td>
<td>0.096</td>
<td>80</td>
</tr>
<tr>
<td>Uruguay</td>
<td>0.082</td>
<td>90</td>
</tr>
<tr>
<td>Vietnam</td>
<td>0.137</td>
<td>60</td>
</tr>
</tbody>
</table>

*Note: China has a government-controlled birthrate.*
Most student graphs should indicate that growth rate is a curve rather than a straight line; however, for countries with a growth rate close to zero (i.e., Germany, Japan, and France), students may not have enough data points to show a curved line. In these cases, you may wish to have students calculate and plot more data points and/or extrapolate the shape of the line based on other graphs. In this activity, doubling the growth rate results in the population size doubling in approximately half as much time.
Greenland and South Africa have the lowest 10–year compounded growth rate (0.001) and would take 6,890 years to double. Montserrat has the highest growth rate (0.553) and would take 20 years to double. A leader of a low–growth rate country might be concerned with having enough workers to sustain a strong economy and support the nation's seniors; a leader of a high–growth rate country might be concerned with providing adequate services—such as education, health care, and jobs—for a large population. World population would double in about 60 years if the projected 10–year growth rate is 0.123.

There are numerous factors that contribute to low and high growth rates. Tell students that while it is possible to generalize factors affecting population size, these generalizations may not be accurate. Each country has a unique set of circumstances. Countries with negative or low population growth rates tend to have low fertility rates and low female illiteracy rates. In the case of Botswana (growth rate of -0.054), however, a high fertility rate is offset by a high infant mortality rate. Countries with relatively high population growth may have high fertility rates and high female illiteracy rates (as in the case of Chad with a growth rate of 0.353).
Other factors that influence the population growth rate of a country include life expectancy, health care, access to fresh water, sanitation, and level of technology.
Since 1800, human population has grown from one billion to six billion people. Over the next half century, that number is projected to rise to nine billion. In this activity you will investigate how long it takes the populations of different countries and territories to double.

You will work in teams of four and will be assigned a six to eight countries. Each group should have a copy of World in the Balance, Double Up, Calculating Population Growth, Growth Rates Worldwide, graph paper and a calculator.

Growth rate = the increase in a country's population during a period of time expressed as a percentage of the population at the start of that time. For example, if a town had 75 people in 1980 and 100 people in 1981, the growth rate for the year would be 33 percent.
You will be using 10-year compounded growth rates to determine when each country's population will double. The 10-year growth rate is based on annual growth rates from 2003 from the U.S. Bureau of Census International Database. The starting population for each country will be 50 individuals, and for this activity the growth rate will be assumed to be constant.

Use the steps on the "Calculating Population Growth" handout to calculate future population sizes using the growth rate data.

After your team has doubled the populations of all of your assigned countries, you need to graph your countries' population growths. Put the number of years on the x-axis in increments of 10 and the number of individuals on the y-axis in increments of five. Now draw the best-fit curve.

As a team answer the questions on the Doubling Up handout. We will have a class discussion about your conclusions.
Create a class histogram on the whiteboard to compare population doubling for each country. The histogram will need to have an upper time value of the country that takes the longest to double and should have an upper population size value of 150.

Each team needs to represent each of its countries with a data point and an abbreviation of the country's name. Examine the histogram and answer these questions:

- Where do most of the countries in the class data set fall on the histogram?
- What else do you observe about the histogram? (Remember that this does not represent all the world's countries.)
- Brainstorm a list of factors you think might affect growth.
- Choose the four lowest and the four highest growth rate countries among our data table representing all the countries.
Research Project

Half of your team will:

- Research some factors that contribute to low growth rates and the possible environmental, social, and economic impacts on the people within those populations.

While the other half of your team will:

- Research factors contributing to high growth rates and the corresponding impacts on people in its populations.

Together, you will write a two-page report on your findings. Some factors to discuss in your paper: Do you see any commonalities among low-growth rate countries? Among high-growth rate countries? What are some of the differences between the factors among low-growth rate and high-growth rate countries? Now choose two countries with a negative growth rate and calculate the time it takes for a population to decrease to half its original size given an initial population size of 100 individuals. Now research reasons for negative growth rates.
Some helpful websites:

CIA World Factbook
www.cia.gov/cia/publications/factbook/

CountryReports.org
www.countryreports.org/

Earth Day Network
www.earthday.net/goals/issues.stm

Population Growth Rate
www.worldbank.org/depweb/english/modules/social/pgr/

Population Issues Overview
www.unfpa.org/issues/index.htm

Population Reference Bureau
www.prb.org/

Six Billion and Beyond
www.pbs.org/sixbillion/

The World Bank Group: Data by Country

World POPClock Projection
www.census.gov/cgi-bin/ipc/popclockw

World Population Prospects
esa.un.org/unpp/
"At first there is only one lily pad in the pond, but the next day it doubles, and thereafter each of its descendants doubles. The pond completely fills up with lily pads in 30 days. When is the pond exactly half full? Answer: on the 29th day."
—Old French riddle

Unlike the lily pads in the French riddle, the human population does not double in size every day. However, it is increasing more quickly than you might suspect. In this activity, you will have the chance to investigate how quickly the populations in different countries are increasing.

**Procedure**

1. Your team will be assigned six to eight countries. Find each country's 10-year growth rates on the "Growth Rates Worldwide" handout. (The 10-year growth rate tells you the rate at which the population of the country increases every 10 years.)
2. Based on each country's growth rate, make a prediction as to how many decades (10-year periods) it might take for each country's population to double in size. Record your predictions on a separate sheet of paper.
3. Use an initial population of 50 individuals for each country. Follow the steps listed on your "Calculating Population Growth" handout to calculate how large each country's population will be after 10 years. Record the new population size on a separate sheet of paper.
4. Repeat the process until each country's population size doubles.
5. Use your results to make a graph that shows how the population for each country increases over 10-year periods. Graph the number of years on the x-axis and the number of people on the y-axis. Draw the best-fit curve.

**Questions**

Write your answers on a separate sheet of paper.

1. Compare your results with your original predictions. How do they compare?
2. Compare your results with those of other teams. How does increasing or decreasing the growth rate affect how quickly the population size increases or decreases?
3. Use your "Growth Rates Worldwide" handouts to find the country or territory with the lowest growth rate and the country or territory with the highest growth rate. Use your formula to calculate how long it would take each one to double. How do they compare to the countries in your original data set? If you were a leader of either of those countries, what would be your concerns about your country's growth rate?
4. The world population is currently estimated at roughly six billion people. If the projected 10-year growth rate is 0.123, how long will it take for the world population to double?
Use the instructions on this handout to calculate population growth estimates for your assigned countries.

**Procedure**

1. Multiply the initial population by the growth rate. This will give you the number of individuals that are added to the population in a 10-year period. (This number should be rounded up, since partial individuals do not exist in the real world.)

2. Add the result from Step 1 to the initial population to get the new population after 10 years.

3. For the next 10-year period, the new population size becomes the starting population value. Multiply the new population size by the growth rate. As before, add the resulting number of individuals to the starting population to calculate the new population size after 20 years.

4. Repeat the process until each country's population has doubled. Note that because you are looking at 10-year periods, the population may not be exactly double in size at the end of a period. For instance, in the example given, you would stop after 30 years, when the population reaches 124.

**Sample Calculation**

Here is a sample calculation for a country with a 10-year growth rate of .25. The country's population doubles soon after 20 years.

<table>
<thead>
<tr>
<th>Starting Population</th>
<th>10-year Growth Rate</th>
<th>Number of New Individuals</th>
<th>New Population Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>50</td>
<td>.25</td>
<td>12.5 (13)</td>
</tr>
<tr>
<td>After 10 years</td>
<td>63</td>
<td>.25</td>
<td>15.75 (16)</td>
</tr>
<tr>
<td>After 20 years</td>
<td>79</td>
<td>.25</td>
<td>19.75 (20)</td>
</tr>
<tr>
<td>After 30 years</td>
<td>99</td>
<td>.25</td>
<td>24.75 (25)</td>
</tr>
</tbody>
</table>
### Group 1

#### Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-Year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montserrat</td>
<td>0.553</td>
</tr>
<tr>
<td>Belize</td>
<td>0.273</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.068</td>
</tr>
<tr>
<td>Djibouti</td>
<td>0.235</td>
</tr>
<tr>
<td>Guam</td>
<td>0.164</td>
</tr>
<tr>
<td>Uruguay</td>
<td>0.082</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.062</td>
</tr>
</tbody>
</table>
Group 2

Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-Year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.098</td>
</tr>
<tr>
<td>Albania</td>
<td>0.053</td>
</tr>
<tr>
<td>Burundi</td>
<td>0.241</td>
</tr>
<tr>
<td>Comoros</td>
<td>0.339</td>
</tr>
<tr>
<td>Mongolia</td>
<td>0.152</td>
</tr>
<tr>
<td>Peru</td>
<td>0.173</td>
</tr>
<tr>
<td>Anguilla</td>
<td>0.244</td>
</tr>
</tbody>
</table>
Group 3

Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-Year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eritrea</td>
<td>0.136</td>
</tr>
<tr>
<td>Chad</td>
<td>0.353</td>
</tr>
<tr>
<td>Guyana</td>
<td>0.045</td>
</tr>
<tr>
<td>El Salvador</td>
<td>0.196</td>
</tr>
<tr>
<td>Cambodia</td>
<td>0.196</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td>0.255</td>
</tr>
<tr>
<td>Australia</td>
<td>0.097</td>
</tr>
</tbody>
</table>
Group 4

Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-Year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honduras</td>
<td>0.258</td>
</tr>
<tr>
<td>Jamaica</td>
<td>0.063</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.168</td>
</tr>
<tr>
<td>Malta</td>
<td>0.075</td>
</tr>
<tr>
<td>Mali</td>
<td>0.321</td>
</tr>
<tr>
<td>St. Helena</td>
<td>0.069</td>
</tr>
<tr>
<td>Tonga</td>
<td>0.207</td>
</tr>
</tbody>
</table>
Group 5

Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-Year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guatemala</td>
<td>0.300</td>
</tr>
<tr>
<td>Bolivia</td>
<td>0.175</td>
</tr>
<tr>
<td>San Marino</td>
<td>0.146</td>
</tr>
<tr>
<td>Egypt</td>
<td>0.204</td>
</tr>
<tr>
<td>Mauritius</td>
<td>0.087</td>
</tr>
<tr>
<td>Jordan</td>
<td>0.316</td>
</tr>
<tr>
<td>Maldives</td>
<td>0.332</td>
</tr>
</tbody>
</table>
Group 6

Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-Year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanuatu</td>
<td>0.174</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>0.198</td>
</tr>
<tr>
<td>Somalia</td>
<td>0.402</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.062</td>
</tr>
<tr>
<td>Iraq</td>
<td>0.316</td>
</tr>
<tr>
<td>Palau</td>
<td>0.165</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.128</td>
</tr>
</tbody>
</table>
Group 7

Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>0.096</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>0.317</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.121</td>
</tr>
<tr>
<td>Liechtenstein</td>
<td>0.093</td>
</tr>
<tr>
<td>Angola</td>
<td>0.216</td>
</tr>
<tr>
<td>India</td>
<td>0.157</td>
</tr>
<tr>
<td>Macau S.A.R. (China)</td>
<td>0.088</td>
</tr>
</tbody>
</table>
## Group 8

### Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>0.126</td>
</tr>
<tr>
<td>Bermuda</td>
<td>0.075</td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.209</td>
</tr>
<tr>
<td>Faroe Islands</td>
<td>0.072</td>
</tr>
<tr>
<td>Cameroon</td>
<td>0.221</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>0.394</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.114</td>
</tr>
</tbody>
</table>
## Growth Rates Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>10-year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicaragua</td>
<td>0.223</td>
</tr>
<tr>
<td>Aruba</td>
<td>0.056</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0.138</td>
</tr>
<tr>
<td>Benin</td>
<td>0.337</td>
</tr>
<tr>
<td>Bahrain</td>
<td>0.173</td>
</tr>
<tr>
<td>Mayotte</td>
<td>0.516</td>
</tr>
<tr>
<td>Tuvalu</td>
<td>0.152</td>
</tr>
</tbody>
</table>
## Group 10

**Growth Rates Worldwide**

<table>
<thead>
<tr>
<th>Country</th>
<th>10-year Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costa Rica</td>
<td>0.167</td>
</tr>
<tr>
<td>Bahamas</td>
<td>0.079</td>
</tr>
<tr>
<td>Chile</td>
<td>0.110</td>
</tr>
<tr>
<td>Iceland</td>
<td>0.050</td>
</tr>
<tr>
<td>Cote d'Ivoire</td>
<td>0.237</td>
</tr>
<tr>
<td>Gaza Strip</td>
<td>0.464</td>
</tr>
<tr>
<td>Nauru</td>
<td>0.207</td>
</tr>
</tbody>
</table>
Lesson 13
An Inconvenient Truth

Students will watch the movie An Inconvenient Truth.

Objective
- Students will gain an understanding of how climate change is happening all over the world.

California State Integrated Science 1 Ecology Standard 6b
- Students know how to analyze changes in an ecosystem that result from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Materials
- An Inconvenient Truth Movie
- Handout: An Inconvenient Truth

Timeframe:
- 90 minutes

Lesson Procedure
Students fill out the worksheet while they are watching the movie. Have a discussion on the answers after watching the movie.

Acknowledgements
This movie worksheet was found on the One Planet Fundraising site. The address for the worksheet is http://www.NewYorkScienceTeacher.com/movies
An Inconvenient Truth

1. What image started the modern day environmental movement?

2. What is considered the most vulnerable part of the earth system?

3. Relatively speaking, compared to the earth, how thick is the atmosphere?

4. How can trapping infrared radiation by the earth's atmosphere be a GOOD thing?

5. How can trapping infrared radiation by the earth's atmosphere be a BAD thing?

6. Sketch the general trend of the "CO₂ Level" versus time graph below:

   ![CO₂ Level Graph]

   CO₂ Level

   CO₂
   (Concentration)

   1958 2000
   (Time in years)
7. What percentage of people depend on glacial melt for their drinking water?

8. Why is studying ice cores important?

9. What is the relationship between carbon dioxide (CO₂) and atmospheric temperature?

10. Over what time period have the hottest 10 years on earth occurred?

11. As the water temperature under a hurricane increases, what happens to the wind velocity of the storm?

12. What has happened to Lake Chad over the years?

13. How much of the sun's radiation gets reflected by ice?

14. What redistributes energy from the equator to the north and south poles?

15. If the ice sheets of Western Antarctica were to melt, approximately how much would sea level rise?
16. List the three factors causing the collision between civilization and earth.
1. 
2. 
3. 

17. Approximately, what percentages of global carbon dioxide emissions come from forest fires?

18. What country is the largest contributor of greenhouse gases into the atmosphere?

19. Which country has the lowest government standards for gas mileage of automobiles?

20. Which two nations have not signed onto the Kyoto Protocol?
# Table Contents

Integrated Science 1 Ecology Standard 6c

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The Wolf, the Moose and the Fir Tree</td>
<td>120</td>
</tr>
<tr>
<td>2.</td>
<td>Population Ecology Lab</td>
<td>130</td>
</tr>
<tr>
<td>3.</td>
<td>World in the Balance</td>
<td>131</td>
</tr>
<tr>
<td>4.</td>
<td>Your Development Project</td>
<td>132</td>
</tr>
</tbody>
</table>
Lesson 14

The Wolf, the Moose and the Fir Tree

In this lesson students will study the trophic interactions between producers, herbivores and carnivores.

Objective

- Students will understand the relationship between producers and consumers in this case study.

California State Integrated Science 1 Ecology Standards 6c and 6e

- Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration and death.

- Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Materials

- Handout: The Wolf, the Moose and the Fir Tree

Timeframe

- 60 minutes
Lesson Procedure

1. Pre-activity: Review the definition and role of producers, consumers, and decomposers in an ecosystem. Go over the terms herbivore and carnivore.

2. Hand out The Wolf, the Moose and the Fir Tree to the students. Read it out loud to the class. Have students summarize each paragraph as a class. This is important to make sure that they understand this study. At the end of each paragraph ask students to predict what might happen next in this article. Answer any questions students ask on the terminology. One method to use to aid comprehension is to ask them the definitions of the scientific words in the reading.

3. As a class answer the questions at the end of each segment.

Acknowledgements

This lesson was adapted from the article The Wolf, the Moose and the Fir Tree written by Gary Fortier in the Journal of College Science Teaching.
Part I: Introduction

Isle Royale National Park, the largest island in lake Superior, provides biologist with a fairly unique system for studying the interactions between different trophic levels. Isle Royale has a rather simple food chain consisting of producers a single large herbivore, moose (*Alces alces*), which in turn has only a single predator, the gray wolf (*Canis lupus*).

The island had a rather large abundance of balsam fir (*Abies balsamea*) until moose colonized the park. Moose swam to the island in the early 1900s. After the establishment of this large herbivore, the balsam fir declined from 46% of the overstory in the nineteenth century to about 5% today. Nearby islands that are inaccessible to moose continue to have a large fir component in their forests, indicating that the decline of the fir on Isle Royale can be attributed to moose herbivory. Balsam fir is not considered optimal forage for moose, but it can comprise up to 59% of their winter diet.

Over the last several decades, researchers have observed significant temporal fluctuations in the densities of the wolf and moose populations and the growth rates of balsam firs. Two hypotheses have been suggested to account for these fluctuations.
The primary productivity or "bottom up" hypothesis argues that plant growth is limited by the energy available to plants, which in turn is determined by temperature and precipitation. Additional plant growth means more forage is available. Thus, herbivores, and ultimately carnivores, should increase in abundance.

Alternatively, the trophic cascade or "top down" model predicts that changes in one trophic level are caused by opposite changes in the trophic level immediately above it. For example, a decrease in moose abundance should produce increased plant growth if moose herbivory limits plant growth. Changes in primary productivity would only have discernible effect on vegetation if higher-level interactions had been removed.

The Isle Royale ecosystem is a good setting to test the predictions of these alternative hypotheses. Longitudinal data is available for each of the key variables, including annual plant growth, herbivore density, and carnivore density. The historical growth rates of balsam fir have been determined through tree-ring analysis. When herbivores remove large quantities of the foliar biomass, annual wood accrual decreases and ring widths shrink. These tree-ring data allow us to estimate the intensity of herbivory over time.

Researchers have censused moose and wolf populations for decades on Isle Royale, providing us with annual estimates of herbivore and carnivore densities. Using the long-term records for each trophic level in the Isle Royale ecosystem, students can evaluate both hypotheses to determine which is correct.
Answer the questions on a separate piece of paper.

Questions 1–8:

1. What is the Primary Productivity Hypothesis (PPH)?

2. Describe a positive (+) relationship according to the PPH.

3. Describe a negative (−) relationship according to the PPH.

4. How many trophic levels are described in this article? Describe each trophic level.

5. What type of relationship (+/−) would you expect to see between the population densities of each trophic level in this system (fir/moose/wolves) under the primary productivity hypothesis?

6. What is the Trophic Cascade Hypothesis (TCH)?

7. What type of relationship (+ or −) would you predict at each trophic level under the TCH?

8. What would you predict the effect to be of wolf removal on plant growth under PPH? Under the TCH?
Part II: Trophic System Data

The data presented in the graphs in figure 1 include census information on the moose and wolf populations, ring-width data of firs on each end of the island, and actual evapotranspiration rates (AET) from April to October. Climate and flora differ substantially on the east and west ends of the island. The west end consists of hardwood forests with a higher AET rate and warmer, earlier summers relative to the boreal forests in the east. The AET rate varies with temperature and rainfall and serves as an index of the amount of water available for plant growth. This rate is strongly tied to primary productivity.

Question 9:

9. What is the purpose of each graph?

Part III: Ring-Width Data

The local topographies for the two samples shown in figure 2A–B are significantly different. The chronologies in figure 2A are from an east end subsample of trees designated RH (Rock Harbor). This area contained an open-canopy section of previously disturbed boreal forest, and it experienced an increase in growth rates after a period of high wolf predation in the late 1970s. Figure 2B depicts a west end subsample designated SS (Siskiwit Swamp). These firs are in a closed-canopy hardwood forest that has been heavily browsed by moose for some time.
Questions 10–21:

10. Are there unclear terms or confusing aspects to either figure?

11. How do the maximum and minimum of the ring-width data correspond to changes in moose density? Does this support the primary productivity hypothesis, the trophic cascade hypothesis, or neither?

12. How do the maximum and minimum numbers of the wolf population correspond to changes in moose density? How might you account for this relationship?

13. How should annual AET look under PPH?

14. How should annual AET look under TCH?

15. Which hypothesis (if any) is supported by the data on annual AET?

16. Do you find any aspect of the figures or captions confusing?

17. The moose population peaked in the mid-1970s and then declined over the next decade. With fewer moose present, how would you predict the trees would respond?
18. How did the trees at each site actually respond?

19. Why did the sites respond differently?

20. What final conclusions can you draw between each trophic level on Isle Royale?

21. Based upon the data collected at Isle Royale, which hypothesis is more strongly supported? Control exerted from the top down as described in TCH or control exerted from the bottom up as described in PPH?
Gary M. Fortier is an assistant professor at Delaware Valley College.

Journal of College Science Teaching

Figure 1. The trophic system on Isle Royale, reconstructed for 1958 to 1994.

(A) The number of wolves on the island from winter aerial counts. (B) Moose population size reconstructed from collected skeletal remains (1959-1981) and from winter aerial counts (1982-1994). (C) Mean ring-width index (26) for eight balsam fir trees sampled in 1992 from the west end of Isle Royale. Vertical bars are ±1 SEM from the arithmetic mean. Dashed line is the best-fit harmonic function (14). (D) Mean ring-width index for eight trees from the east end of the island, as in (C). (E) Actual evapotranspiration from April to October calculated for a weather station about 20 km from Isle Royale. The AET is the amount of water available to plants during the growing season as a function of both rainfall and temperature and has a close relation to primary productivity (24). The shaded areas highlight intervals of forage suppression that we believe are closely tied to periods of elevated moose density, which in turn follow periods of low wolf density (note the lags between trophic levels). These intervals have no correspondence to AET.
Figure 2. Individual ring-width chronologies (26) for balsam fir trees collected from Isle Royale in 1992.

(A) Ten trees, 26 to 48 years of age from location RH, in which fir height exceeded the reach of moose (3 m) in the late 1970s. (B) Nine trees, 48 to 60 years of age from location SS, for which total height at the time of sampling ranged from 1.08 to 1.57 m.
Lesson 15

See Lesson 11

Population Ecology Lab

on Page 76
Lesson 16

See Lesson 12

World in the Balance

on Page 87
Lesson 17
See Lesson 4
Your Development Project
on Page 36
Table Contents

Integrated Science 1 Ecology Standard 6d

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>What is the Carbon cycle?</td>
<td>134</td>
</tr>
<tr>
<td>2.</td>
<td>What is the Nitrogen cycle?</td>
<td>145</td>
</tr>
<tr>
<td>3.</td>
<td>What is the Water cycle?</td>
<td>151</td>
</tr>
<tr>
<td>4.</td>
<td>Transpiration Lab</td>
<td>161</td>
</tr>
<tr>
<td>5.</td>
<td>The Chemistry of Photosynthesis and Respiration</td>
<td>168</td>
</tr>
<tr>
<td>6.</td>
<td>Photosynthesis and Respiration Matching</td>
<td>174</td>
</tr>
<tr>
<td>7.</td>
<td>Photosynthesis and Respiration Chart</td>
<td>176</td>
</tr>
<tr>
<td>8.</td>
<td>Photosynthesis and Respiration Graphic Organizer</td>
<td>178</td>
</tr>
<tr>
<td>9.</td>
<td>Bottle Ecosystems</td>
<td>180</td>
</tr>
<tr>
<td>10.</td>
<td>Your Development Project</td>
<td>188</td>
</tr>
</tbody>
</table>
Lesson 18
What is the Carbon Cycle?

In this activity, students will construct the essential elements of the carbon cycle and will identify carbon sources, sinks, and release agents. The goal is to develop the important elements of the cycle.

Objectives

- Students will understand that carbon is critical to the biosphere and must continue cycling to support life on earth.
- Students will understand and be able to identify carbon sources, sinks, and release agents in the carbon cycle.

*California State Integrated Science 1 Ecology Standard 6d*

- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials

- Handout: What is the Carbon Cycle?
- Blank paper
- Glue sticks or tape
- Magazines and newspapers
- Cardboard or poster board for collages

Timeframe

- Class brainstorming: 5 to 10 minutes
- Class discussion on handout: 15 to 20 minutes
- Small group time with worksheet: 10 to 15 minutes
- Small group time creating collages: 20 to 30 minutes
Lesson Procedure

1. Using class discussion and brainstorming have students try to trace the movement of a carbon atom. Record their ideas on the board. The result should be a version of a simplified carbon cycle, including at least eating and respiration in animals and photosynthesis in plants. It is common for the students to get stuck on the animal-to-plant-to-animal cycle because most have been exposed to the concept several times. You may need to move the cycle development along by encouraging them to think about oceans and whether CO₂ plays a role in them. The ocean is an important carbon sink. Have them consider rocks and minerals – do they contain carbon?

2. Next, pass out the handout on the carbon cycle and have students compare their cycle with the one on the worksheet. Have them discuss the differences and modify the cycle on the board if they think it necessary. Through class discussion, students can share what they have discovered.

3. Introduce the concepts of sink, source, and release agents. Challenge students to label these factors on their modified cycles. Why might these be important factors to identify?
4. Have the students work in small groups completing the worksheet. Then meet as a whole class to discuss their findings. Answers to this activity can be found in Appendix B.

5. Distribute blank paper to the groups. Ask each group to develop a collage using magazines and newspapers that illustrates the carbon cycle. They should label the sinks, sources, and release agents. Each group should present its collage to the class.
**Assessment Ideas**

Consider using the last two discussion questions as a short quiz. Thoughtful answers to these should indicate that the students met the learning goals.

**Modifications for Alternative Learners**

English Language Limited (ELL) students should be able to grasp the concepts in this activity since this activity is set up with students working together so they can help each other understand the readings.

**Acknowledgements**

This lesson was adapted from the carbon cycle, which was created by the University Corporation for Atmospheric Research, Atmospheric Science Explorers (LEARN) (http://www.ucar.edu/learn/index.htm).

All living organisms are based on the carbon atom. Carbon compounds can be solid, liquid, or gas under conditions commonly found on the earth's surface. Because of this, carbon can help form solid minerals (such as limestone), 'squishy' organisms (such as plants and animals), and can be dissolved in water or carried around the world through the atmosphere as carbon dioxide gas. The attributes of the remarkable carbon atom make possible the existence of all organic compounds essential to life on earth.

Carbon atoms continually move through living organisms, the oceans, the atmosphere, and the crust of the planet. This movement is known as the carbon cycle. The paths taken by carbon atoms through this cycle are extremely complex, and may take millions of years to come full circle.
Consider, for example, the journey of a "typical" carbon atom that existed in the atmosphere as part of a carbon dioxide (CO₂) molecule 360 million years ago, during the Carboniferous Period. That CO₂ molecule drifted into the leaf of a large fern growing in the swamp forests of that time.
Through photosynthesis, the oxygen from the CO₂ molecule was released back into the air and the carbon atom was removed from the CO₂ molecule and used to build a molecule of sugar.

The plant could have broken down the sugar at a later time to release the energy stored inside, but this particular sugar molecule was transformed instead into a long-lived structural part of one of the plant cells. Soon after, the fern died and the remains sank into the muck at the bottom of the swamp. Over thousands of years, more plants grew in the swamp and their remains also sank into the swamp, forming a layer of dead plant material many meters thick. Gradually, the climate changed, becoming drier and less tropical. Sand, dust, and other materials slowly covered the ancient swamp and sealed the decaying vegetation under a thick layer of sediment.
The sediment hardened, turning to sedimentary rock. The carbon atom stayed trapped in the remains of the long-vanished swamp while the pressure of the layers above slowly turned the material into coal.

The coal bed was mined by humans 360 million years later, in the 1900s, and burned to fuel industrial civilization.
The process of burning released the energy stored in the carbon compounds in the coal and reunited the carbon atom with oxygen to form $\text{CO}_2$ again.

The $\text{CO}_2$ was released to the atmosphere through the smokestack and the journey continues. Many other paths are possible, some taking only hours or days to trace, others, like the one above, many millions of years.

There are many paths for carbon atoms to take; where they may be stored for extended periods (the "sinks"), where they are likely to be released to the atmosphere (the "sources"), and what triggers those sources (the "release agents"), these all define the carbon cycle.
Carbon sinks include long-lived trees, limestone (formed from the carbon-containing shells of small sea creatures that settle to the ocean bottoms and build up into thick deposits), plastic (a modern invention, but very long-lived), and the burial of organic matter (such as those that formed the fossil fuels we use today). Carbon sources include the burning of fossil fuels and other organic matter, the weathering of limestone rocks (which releases CO$_2$), and the respiration of living organisms. Release agents include volcanic activity, forest fires, and many human activities.
Questions and Observations for the Carbon Cycle

1. What gas do humans and animals exhale? Write the formula for this exhaled gas.

2. Can humans be considered carbon sinks? If so, for how long? What living organisms are better long-term sinks than humans?

3. List two important sinks (things that store carbon), two important sources (things that release carbon), and one important release agent (things that trigger sources) for carbon.

4. We are currently worried that CO$_2$ sources are out of balance with CO$_2$ sinks. If sources produce more CO$_2$ than sinks can remove, CO$_2$ in the atmosphere increases, possibly leading to global warming. What might happen if the reverse were true and sinks took up more CO$_2$ than sources?

5. Explain how understanding the carbon cycle helps atmospheric scientists understand and prepare for global climate changes.
Lesson 19
What is the Nitrogen Cycle?

In this activity, students will construct the essential elements of the nitrogen cycle. Students will work as a whole class and in small groups. The goal is to develop the important elements of the nitrogen cycle.

Objectives

- Students will understand that nitrogen is critical to the biosphere and must continue cycling to support life on earth.
- Students will understand and be able to identify nitrogen sources.

*California State Integrated Science 1 Ecology Standard 6d*

- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials

- Handout: What is the Nitrogen Cycle?
- Blank paper
- Magazines and newspapers
- Cardboard or poster board for collages
- Tape or glue sticks

Timeframe

- Class brainstorming: 5 to 10 minutes
- Class discussion on handout: 15 to 20 minutes
- Small group time with worksheet: 10 to 15 minutes
- Small group time creating collages: 20 to 30 minutes
Lesson Procedure

1. Using class discussion and brainstorming have students try to trace the movement of nitrogen. Record their ideas on the board. The result should be a version of a simplified nitrogen cycle.

2. Pass out the handout on the nitrogen cycle and have students compare their cycle with the one on the worksheet. Have them discuss the differences and modify the cycle on the board if necessary. Use class discussion so students can share what they discovered.

3. Have the students work in small groups completing the worksheet. Then meet as a whole class to discuss their findings. Answers to this activity can be found in Appendix B.

4. Distribute blank paper to the groups. Ask each group to develop a collage using magazines and newspapers that illustrates the nitrogen cycle. Each group should present its collage to the class.

Modifications for Alternative Learners

English Language Limited (ELL) students should be able to grasp the concepts in this activity since this activity is set up with students working together so they can help each other understand the readings.
Acknowledgements

This lesson used information provided by two sources:

- The University Corporation for Atmospheric Research, Atmospheric Science Explorers (LEARN)
  (http://www.ucar.edu/learn/index.htm)

- The Windows to the Universe
  http://www.windows.ucar.edu/tour/link=/earth/Life/nitrogen_cycle.html

The format for this lesson was adapted from the Carbon Cycle, which was created by the University Corporation for Atmospheric Research, Atmospheric Science Explorers http://www.ucar.edu/learn/index.htm

The diagram of the Nitrogen Cycle originated from the Environmental Literacy Council site
http://www.enviroliteracy.org/article.php/479.html
Nitrogen comprises the bulk of the atmosphere (approximately 78%). Nitrogen cycles slowly through the earth’s system. To most of the biosphere, nitrogen in the atmosphere is like the ocean to a thirsty person—amazingly abundant but not quite in the right chemical form. A molecule of nitrogen gas is made up of 2 atoms very tightly bound together. It takes tremendous amounts of energy, such as produced by lightning or fires, to break the bond. Amazingly, an assortment of bacterial species that specialize in taking nitrogen from the air can also convert nitrogen into different usable forms. These bacteria also release nitrogen from organic material back into the atmosphere. Nitrogen is the one element found almost entirely in the atmosphere—there’s very little on land or in the sea. Nitrogen is essential to life, a key element in proteins and DNA.

Most plants get the nitrogen they need to grow from the soils or water in which they live. Animals get the nitrogen they need by eating plants or other animals that contain nitrogen. When organisms die, their bodies decompose bringing the nitrogen into soil on land or into ocean water. Bacteria alter the nitrogen into a form that plants are able to use. Other types of bacteria are able to change nitrogen dissolved in waterways into a form that allows it to return to the atmosphere.
Certain actions of humans are causing changes to the nitrogen cycle and the amount of nitrogen that is stored in the land, water, air, and organisms. The use of nitrogen-rich fertilizers can add too much nitrogen in nearby waterways as the fertilizer washes into streams and ponds. The waste associated with livestock farming also adds large amounts of nitrogen into soil and water. The increased nitrate levels cause plants to grow rapidly until they use up the supply and die. The number of plant-eating animals will increase when the plant supply increases and then the animals are left without any food when the plants die.
Questions and Observations of the Nitrogen Cycle

1. What gas do volcanoes release to the atmosphere? Write the formula for this gas.

2. List three sources of nitrogen.

3. Explain why nitrogen is so important to life.

4. What are three ways to break the nitrogen bond?

5. Explain the role bacteria plays in the nitrogen cycle.

6. Describe the negative effects of excess nitrogen in streams and ponds. What is the source of this extra nitrogen?
Lesson 20
What is the Water Cycle?
In this activity, students will build a model to simulate parts of the water cycle. They will be able to recognize and explain the essential elements of the water cycle.

Objectives
- Students will appreciate that scale models can be an important tool to use to help understand global processes.
- Students will be able to recognize and explain the essential elements of the water cycle.

California State Integrated Science 1 Ecology Standard 6d
- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials
- Handout: The Water Cycle
- Artist’s clay or plastic mountain model
- Clear plastic shoe box with a clear cover
- Petri dish
- Lamp with an incandescent bulb
- Water
- Crushed ice

Timeframe
- Introduction to the water cycle: 30 minutes
- Activity as demonstration: 30 minutes
- Activity as group project: 45 minutes
- Discussion: 20 minutes
Lesson Procedure
If you have a large aquarium, you can do this activity as a demonstration, allowing the students to study and observe the phenomena and develop their own ideas and conclusions for class discussion. With sufficient materials, you can also do it as a group project, with teams of three to four students responsible for setting up the model and drawing conclusions from their own work. As always, it's important not to overly explain what is "supposed" to happen, but rather let them discover the model cycle for themselves.

1. Discuss the water cycle with students. Show the graphic of the water cycle and explain the various parts.
2. Follow the procedure in the student handout.
3. At the last step in the procedure, have students observe the container carefully and note any changes that they see. It might help to add a little smoke to the aquarium to help them see the circulation (A few matches lit, then blown out and quickly dropped onto the clay mountain will work).
4. Answers to this activity can be found in Appendix B.

Modifications for Alternative Learners
Students with language difficulties should be encouraged to rely on labeled diagrams to help answer the questions.

Acknowledgements
This lesson was adapted from the Water Cycle, which was created by the University Corporation for Atmospheric Research, Atmospheric Science Explorers (LEARN) (http://www.ucar.edu/learn/index.htm).
The water (or hydrologic) cycle is vital to life on Earth. In this activity you will be investigating the essential parts of the cycle by building and operating a model. Because big, global-scale systems like the water cycle are difficult to study directly, scientists often use small-scale models to study them. Sometimes these models are physical models like you are using here, and sometimes they are computer simulation models.

Background

Water, in its different forms, cycles continuously through the lithosphere, hydrosphere, atmosphere, and biosphere. Water evaporates into the atmosphere from the land and the sea. Plants and animals use and reuse water and release water vapor into the air. Once in the air, water vapor circulates and can condense to form clouds and precipitation, which fall back to earth. At one time or another, all of the water molecules on earth have been in an ocean, a river, a plant, an animal, a cloud, a raindrop, a snowflake, or a glacier!
As far as we know, earth is the only planet with water in three phases: solid, liquid, and gas. The phase of water is determined by its temperature and pressure.

Water is essential for life on earth. It is recycled through the water or hydrologic cycle, which involves the following processes:

- Evaporation – the changing of water from a liquid to a gas.
- Condensation – the changing of water from a gas to a liquid.
- Sublimation – the changing of water from a solid to a gas.
Precipitation – the process by which water molecules condense to form drops heavy enough to fall to the earth's surface.

Transpiration – the process by which moisture is carried through plants from roots to leaves, where it changes to vapor and is released to the atmosphere.

Surface runoff – the flowing of water over the land from higher to lower ground.

Infiltration – the process of water filling the porous spaces of soil.

Percolation – groundwater moving in the saturated zone below the earth's surface.
Through these processes, the amount of water on earth remains nearly constant and is continually recycled through time. Water molecules may remain in one form for a very long period of time (for example, water molecules can be locked in Antarctic ice for thousands of years) and in other forms for very short times (such as water molecules in desert rainstorms which spend mere minutes as surface water before evaporating into vapor again).

Materials

- Handout: The Water Cycle
- Artist’s clay or plastic mountain model
- Clear plastic shoe box with a clear cover
- Petri dish
- Lamp with an incandescent bulb
- Water
- Crushed ice
Procedure

1. According to your teacher's instructions, form teams of three to four students. Each team will be given the materials listed above.

2. Using the clay, shape a mountain. Place the mountain inside the box against one side with the sloped side facing the interior of the box.

3. Pour water into the box until about one-fourth of the mountain slope is covered. The water forms your model ocean.

4. Replace the lid of the shoebox.

5. Place a petri dish on top of the shoebox over the mountain (as shown in the picture).
6. Place crushed ice into the petri dish.

7. Position the lamp over the ocean. Turn on the lamp. CAUTION: THE LAMP WILL GET HOT. DO NOT TOUCH THE BULB OR SHADE.

8. Observe the container carefully and note any changes that you see. If instructed by your teacher, you may want to see if you can detect any air circulation in the box, by lighting 2 to 3 matches, blowing them out and quickly dropping them onto the model mountain. The smoke they give off should move with the air movement.
Observations and Questions on the Water Cycle Lab

1. Which part of the activity simulated evaporation?

2. Which part simulated condensation?

3. Which part simulated precipitation?

4. What is the energy source and what does it represent?

5. What elements of the water cycle are not represented?
6. How could we demonstrate transpiration in this activity?

7. Would condensation occur in the box without the ice? Why or why not?

8. After observing this activity, explain why water is considered a renewable resource.

9. The system you observed or constructed is a model of the way the actual water cycle works. Why might scientists use a model like this in their research into the water cycle in the real world? Can you think of any reason that using such models might be a problem?
Lesson 21
Transpiration Lab

In this activity, students will make a small terrarium that will allow them to observe and measure the water given off through transpiration.

Objectives
- Students will be able to recognize transpiration and explain its value to the plant.
- Students will be able to explain how transpiration affects climate.

California State Integrated Science 1 Ecology Standard 6d
- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials
- Handout: Transpiration: How Much Water Does a Tree Transpire in One Day?
- Transparent plastic cup to be used as the top of the terrarium
- Second plastic cup for the bottom of the terrarium
- Square piece of cardboard
- Plastic wrap
- Small cutting of a houseplant
- Petroleum jelly (Vaseline)
- Lamp or source of sunlight
- Water
- Scissors
Timeframe
  o Teacher introduction: 20 minutes
  o Activity set-up: 15 minutes
  o Student observation: 30 minutes
  o Discussion/assessment: 15 minutes

Lesson Procedure
1. Follow the procedure in the student handout.
2. Have students calculate the water loss per square centimeter of leaf area.
3. Answers to this activity can be found in Appendix B.

Consider setting up a control where there is no hole in the cardboard and no plant in the container.

Acknowledgements
This lesson was adapted from the photosynthesis–transpiration cycle, which was created by the University Corporation for Atmospheric Research, Atmospheric Science Explorers (LEARN) (http://www.ucar.edu/learn/index.htm).
Teacher Background

Trees absorb water primarily through their roots. They evaporate water through openings in their leaves in a process called transpiration. As with human respiration, trees tend to transpire more with increased temperatures, sunlight intensity, water supply, and size. When it gets too hot, though, transpiration will shut down.

Many factors influence transpiration rates, including leaf shape, size, pores (stomata), and waxiness of the leaf surfaces. Where a particular tree species grows often depends upon how it has adapted its transpiration rate to a particular climate. Conifer needles are more efficient at retaining moisture than broadleaf trees because they have stiff, waxy leaves (needles) with small stomata that are recessed in the leaf surface. Because they are efficient in retaining water, conifers are found in drier and colder climates where water supplies are limited.

Plants transpire vast quantities of water – only one percent of all water a plant absorbs is used in photosynthesis; the rest is lost through transpiration. In one season, one corn plant transpires over 200 liters.

Transpiration, along with evaporation of moisture on land, provides almost two-thirds of the atmospheric moisture that falls as precipitation on land surfaces. The remaining one-third comes from the evaporation of the vast oceans.
Plants absorb water primarily through their roots. They evaporate water through openings in their leaves in a process called transpiration. Plants transpire vast quantities of water – only one percent of all water a plant absorbs is used in photosynthesis; the rest is lost through transpiration. In one growing season for example, one corn plant transpires over 200 liters of water.

Transpiration, along with evaporation of moisture on land, provides almost two-thirds of the atmospheric moisture that falls as precipitation on land surfaces, powerfully affecting global and local climate. Surprisingly, evaporation from the vast ocean surfaces only accounts for one-third of atmospheric moisture.

In this activity, you will make a small terrarium that will allow you to observe and measure the water given off through transpiration.

Materials (per team):

- Transpiration: How Much Water Does a Tree Transpire in One Day?
- Transparent plastic cup to be used as the top of the terrarium
- Second plastic cup for the bottom of the terrarium
- Square piece of cardboard
- Plastic wrap
- Small cutting of a houseplant
Proced u re

1. Line both sides of the cardboard with plastic wrap. Using the scissors, make a small hole (just big enough for the plant stem) in the center of the piece of cardboard.

2. Pull the plant stem through the hole and seal around the hole with petroleum jelly (Vaseline).

3. Record how much water fills the bottom of the cup, and place the stem with the cardboard collar into the cup. Cover with the clear plastic cup as shown.

4. Put the small terrarium in the sun or under a lamp.
5. In fifteen minutes, you should begin to see droplets of water on the sides of the clear inverted cup. More moisture will accumulate with time.

6. If possible, leave the terrarium cups set up in the classroom for several days and measure the total amount of water transpired.

7. Calculate the water loss per square centimeter of leaf area (you can estimate the surface area of a leaf by tracing it onto a piece of graph paper that you have marked into square centimeters and then counting the number of squares the leaf covers).

8. Measure and record the amount of water in the bottom of the cup.
Transpiration Observations and Questions

1. Where does the moisture come from that accumulate along the sides of the top cup?

2. How do you know the water is coming from the plant and not just evaporating from the water in the cup?

3. Imagine that your small plant was a large tree with a thousand times as many leaves. Assume that this tree transpires just like your plant. Calculate how much water it would transpire over the time you ran your experiment.

4. Now imagine a small forest with 1000 such trees. How much water would it transpire?

5. Do you think that the amount of water coming from the forest would affect local climate in any way? If so, how?
Lesson 22
The Chemistry of Photosynthesis and Respiration

This lesson is made up of several worksheets that reinforce photosynthesis and respiration. These activities are intended for use over the course of several days to help students remember the equations. In the first lesson, photosynthesis and respiration is introduced to the students.

Objectives
- Students will understand photosynthesis and respiration.
- Students will be able to write the equation for photosynthesis and respiration.

*California State Integrated Science 1 Ecology Standard 6d*
- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials
- Handout: The Chemistry of Photosynthesis and Respiration

Timeframe
- 10 to 20 minutes Lesson Procedure

1. Remind students that reactants are the starting compounds in a reaction and are on the left side of the equation and that products are the ending compounds in a reaction and are on the right side of the equation.
2. Explain to students that plants use chlorophyll as the site for photosynthesis in the plant cell. Chlorophyll has green pigments which give leaves a green color. Plants absorb the energy from the sun and through a chemical reaction produce energy (sugar) they can use to grow.

Note: If you have access to BrainPOP (an online website that teaches different concepts through animation – http://www.brainpop.com/), play the Photosynthesis and Respiration clip to reinforce the knowledge learned in the lesson. You can use the BrainPOP quiz after the students see the movie.

Acknowledgements

The cool graphic of the sun and the flower came from this site:

http://www.geographyalltheway.com/ib_geography/ib_ecosystems/ecosystems_energy_flows.html

The graphic for respiration came from this site:

The Chemistry of Photosynthesis and Respiration (teacher page)

CO₂ = carbon dioxide
H₂O = water

O₂ = oxygen
C₆H₁₂O₆ = glucose (sugar)

ATP = adenosine triphosphate – a fancy name for energy, which is a product of respiration

Identify the reactants for photosynthesis: 6CO₂ + 6H₂O + sunlight
Identify the reactants for respiration: C₆H₁₂O₆ + 6O₂
Identify the products for photosynthesis: C₆H₁₂O₆ + 6O₂
Identify the products for respiration: 6CO₂ + 6H₂O + ATP

Photosynthesis:

6CO₂ + 6H₂O + sunlight ----> C₆H₁₂O₆ + 6O₂

Respiration:

C₆H₁₂O₆ + 6O₂ ----> 6CO₂ + 6H₂O + ATP
The Chemistry of Photosynthesis and Respiration

These are the players in the photosynthesis and respiration cycles:

\[ \text{CO}_2 = \text{carbon dioxide} \quad \text{O}_2 = \text{oxygen} \]

\[ \text{H}_2\text{O} = \text{water} \quad \text{C}_6\text{H}_{12}\text{O}_6 = \text{glucose (sugar)} \]

\[ \text{ATP} = \text{adenosine triphosphate} \] – a fancy name for energy, which is a product of respiration (not used in photosynthesis)
Fact 1: Plants absorb CO\(_2\) and emit O\(_2\) ... this is muy importante!

Fact 2: All chemical equations are balanced (meaning that if you have 4 carbon atoms on the reactant side of the equation then you will have 4 carbon atoms on the product side of the equation).

Identify the reactants for photosynthesis:

Identify the reactants for respiration:

Identify the products for photosynthesis:

Identify the products for respiration:

Now that you are armed with this knowledge, put together the chemical equation for photosynthesis and then create the one for respiration.
Photosynthesis:

\[ \text{reactant} \rightarrow \text{product} \]

Respiration:

\[ \text{reactant} \rightarrow \text{product} \]
Lesson 23

Photosynthesis and Respiration Matching

This second lesson involves students to match photosynthesis and respiration processes.

Objectives

- Students will understand photosynthesis and respiration.
- Students will be able to match up either photosynthesis or respiration to the process that belongs to it.

*California State Integrated Science 1 Ecology Standard 6d*

- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials

- Handout: Photosynthesis and Respiration Matching

Timeframe

- 10 to 15 minutes

Answers to this activity can be found in Appendix B.
Photosynthesis and Respiration Matching

Put a P for photosynthesis and an R for respiration.

1. ____ Occurs only in plants.
2. ____ Occurs in cells all the time.
3. ____ Oxygen is on the reactant side of the chemical formula.
4. ____ Oxygen is on the product side of the chemical formula.
5. ____ Glucose (sugar) is needed for this reaction to take place.
6. ____ Glucose (sugar) is created from this reaction.
7. ____ This reaction reduces carbon dioxide in the atmosphere.
8. ____ Increases the amount of carbon dioxide in the atmosphere.
9. ____ For this reaction to occur, sunlight must be present.
10. ____ Sunlight is not needed in this reaction.
Lesson 24

Photosynthesis and Respiration Chart

This chart is a strategy to allow students to put the correct process with either photosynthesis or respiration.

Objectives
  o Students will understand photosynthesis and respiration.

California State Integrated Science 1 Ecology Standard 6d
  o Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials
  o Handout: Photosynthesis and Respiration Chart

Timeframe
  o 10 to 20 minutes

Answers to this activity can be found in Appendix B.
Water is needed for this reaction to work.

Oxygen is produced in this reaction.

Glucose (aka sugar) is a reactant in this reaction.

Water is produced in this reaction.

Carbon dioxide is used as a reactant.

ATP is created in this reaction.

Glucose (aka sugar) is produced in this reaction.

Oxygen is needed to make this reaction work.

Sunlight is necessary or there will not be a reaction.

Carbon dioxide is a product of this reaction.
Lesson 25
Photosynthesis and Respiration Graphic Organizer

Students will create a graphic organizer around the concept of photosynthesis and respiration.

Objectives
- Students will understand photosynthesis and respiration.

*California State Integrated Science 1 Ecology Standard 6d*
- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

Materials
- Handout: Photosynthesis and Respiration Graphic Organizer

Timeframe
- 10 to 20 minutes

Answers to this activity can be found in Appendix B.
Photosynthesis and Respiration Graphic Organizers

Directions: Create two graphic organizers with photosynthesis and respiration as the central ideas. Use color pencils or pens. Add pictures.
Lesson 26
Bottle Ecosystems

Students will construct a small-scale model of an aquatic ecosystem. The goal is to keep the goldfish or ghost shrimp alive in a closed system.

Objectives
- Students will create a mini aquatic ecosystem. The closed system will include: several aquatic plants, a goldfish and an aquatic snail.
- Students will understand how the trophic levels interact such that nothing needs to be added to the system for it to function.

*California State Integrated Science 1 Ecology Standard 6d and 6e*
- Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.
- Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Materials
- Handout: Bottle Ecosystem
- One 3-liter clear plastic bottle or large jar with a lid
- Gravel
- Aquatic plants (producer)
- Smallest sized goldfish or ghost shrimp (consumer)
- Snail (decomposer)
- Freshwater from 3 sources: tap, pond, creek or river
- Duct tape
Timeframe
- Creation of the bottle ecosystem: 45 to 60 minutes
- 2 week observation of ecosystem: about 10 minutes each day

Lesson Procedure
1. Use the procedure on the student handout to set up the ecosystem.
2. Help students with predictions by brainstorming about what might be in each water sample and how chlorine, algae, insect larvae, etc may affect the system. Check out the water under a microscope.
3. Using class discussion and brainstorming have students try to trace the movement of nitrogen. Record their ideas on the board.
   - The ammonium from the fish (waste) is used as a plant fertilizer.
4. Using class discussion and brainstorming have students try to trace the movement of carbon. Record their ideas on the board.
   - The plant takes in carbon dioxide from the fish and produces oxygen that the fish uses in respiration.
5. Answers to this activity can be found in Appendix B.
6. Students use the data table to record their detailed observations on the ecosystem and its inhabitants.
7. Remind students daily to monitor the health of their ecosystem. If the goldfish is gasping at the top for air then rescue it because there isn’t enough oxygen in the water for it to survive. If the goldfish is acting lethargic then consider that it is not getting enough calories to survive. Provide fish food so it does not die. At the end of the experiment, either set up a fish tank in the classroom or give the fish to the students.

8. The ecosystems can be set up slightly different from each other and students can analyze the differences. Consider setting up half the class with ghost shrimp and half the class with tiny goldfish.

*Strongly recommend conducting this experiment before doing this with the class.*
Your number one goal is to keep the goldfish, or ghost shrimp, and the snail alive. To do this you need to create a habitat for them to live in – a mini aquatic ecosystem.

Materials
- Bottle Ecosystem
- One 3-liter clear plastic bottle or large jar with a lid
- Gravel
- Aquatic plants (producer)
- Goldfish or ghost shrimp (consumer)
- Snail (decomposer)
- Freshwater from 3 sources: tap, pond, creek or river
- Duct tape

Procedure:
1. Cut the bottle as close to the top of the bottle (so it doesn’t leak later) so you can add the gravel and plants. Press the bottom of the plants into the gravel. Slowly add water to your system (don’t forget to label the bottle with your name and the type of water used for that ecosystem).
2. Make sure that there is a source of algae in your ecosystem. It could be found on the plant leaves or on a rock from the pond (the goldfish will use the algae as a food source).
3. After you set up your ecosystem, put it in a sunny spot and wait two days before adding the goldfish, or ghost shrimp, and snail to your system. Reattach the cut top of the bottle using duct tape. Seal tight so system is airtight. Your ecosystem is now a closed system. Make sure it is not in direct sunlight, otherwise the water could get too hot and kill your living organisms.

4. Make predictions on what you think will happen in each ecosystem with the different sources of freshwater.

Water from the faucet:

Pond water:

Creek or river water:
5. Trace the movement of nitrogen. Record your ideas here:


7. Use the data table to record your detailed observations on the ecosystem.
Bottle Ecosystem Questions and Observations

1. What gas does the plant release into the water? Write the formula for this gas. Is this gas important to your ecosystem? Why or why not?

2. What gas does the plant take from the water? Is this important for the health of your mini ecosystem? Why?

3. Describe the trophic levels contained in your ecosystem. Which organism represents each level?

4. Explain what might happen to your ecosystem if the snail died. What do you think you might observe after a few days to a few weeks?

5. Everyday write your detailed observations of the plant, the fish, the snail, the appearance of the water, and anything else of interest in your system. Make sure you write the date and the time for each journal entry.
<table>
<thead>
<tr>
<th></th>
<th>Plant</th>
<th>Goldfish</th>
<th>Snail</th>
<th>Water</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Table Contents

Integrated Science 1 Ecology Standard 6e

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Producers, Consumers, Decomposers</td>
<td>190</td>
</tr>
<tr>
<td>2</td>
<td>Energy Pyramids and Food Webs</td>
<td>196</td>
</tr>
<tr>
<td>3</td>
<td>Bottle Ecosystems</td>
<td>202</td>
</tr>
<tr>
<td>4</td>
<td>The Wolf, the Moose and the Fir Tree</td>
<td>203</td>
</tr>
<tr>
<td>5</td>
<td>Your Development Project</td>
<td>204</td>
</tr>
</tbody>
</table>


Lesson 28

Producers - Consumers - Decomposers

In this lesson students will trace the flow of energy through the energy pyramid, food chain, and food web.

Objective
  o Students will define and identify producers, consumers, and decomposers.

California State Integrated Science 1 Ecology Standard 6e
  o Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Materials
  o Handout: Producers – Consumers – Decomposers
  o Pictures with producers, consumers, and decomposers combined into a scene
  o Red, blue, and green markers
  o Butcher block paper or white 8 ½ “ x 11” paper

Timeframe
  o 61 to 90 minutes

Lesson Procedure
1. Pre-activity: Discuss the definition and role of producers, consumers, and decomposers in an ecosystem. Tell students that the word autotroph means "self-feeder" in Latin and that the word heterotroph means "other feeder" in Latin. Collect magazine pictures of different ecosystems or have students bring them from home.
2. Put students in cooperative groups. Give students the pictures of the ecosystems and discuss the roles of the producers, consumers, and decomposers in the ecosystem. Have the students identify the producers with the green marker, the consumers with the blue marker, and the decomposers with the red marker. Check the pictures to make sure the students understand what to do.

3. Have students draw a picture of one of the following: a forest scene, a desert scene, an ocean scene, or a scene from their own community. Tell them to include the producers, consumers, and decomposers that would be found in that ecosystem. Display the drawings in the classroom.

4. Answers to this activity can be found in Appendix B.

Extension (highly recommended): Have students write a one-page report discussing the role that each trophic level plays in the ecosystem and telling what would happen if either the producers, or consumers, or decomposers were greatly reduced in the ecosystem. The teacher may want to assign particular ecosystems and trophic levels to each student or have him/her draw the ecosystem for the group.

Acknowledgements

This lesson adapted from the Alabama Department of Education (ALEX), Pathways for Learning Science 7–12 at the following website http://alex.state.al.us/lesson_view.php?id=187.
All ecosystems have organisms that can be classified as producers, consumers, and decomposers. Producers, also known as autotrophs, are organisms that produce their own food using the sun as a source of energy. Consumers, also known as heterotrophs, are organisms that get energy by eating other organisms. Decomposers, also known as heterotrophs, are organisms that break down dead organisms in an ecosystem and return the nutrients to the soil or water.

In this activity, you will define and identify producers, consumers, and decomposers.

Materials:

- Pictures with producers, consumers, and decomposers combined into a scene
- Red, blue, and green markers
- Butcher block paper
Procedure:

1. Define:
   - Producer =
   - Consumer =
   - Decomposer =

2. Discuss, in groups, the importance of producers, consumers, and decomposers within an ecosystem.

3. Identify the producers, consumers, and decomposers in the picture.
   a. Circle the producers with the green marker.
   b. Circle the consumers with the blue marker.
   c. Circle the decomposers with the red marker.

4. As a group, draw a picture of one of the following: a forest scene, a desert scene, an ocean scene, or a scene from the community. Be sure to include the producers, consumers, and decomposers found in that ecosystem.
Producers – Consumers – Decomposers

Observations and Questions

1. Give three examples of organisms that are be producers.

2. Why are producers important in an ecosystem?

3. What are three different organisms that are considered to be consumers?

4. What purpose(s) do consumers serve in an ecosystem?
5. What are three different organisms that are considered to be decomposers?

6. List two things that would happen to an ecosystem if no decomposers were present.

7. What does the word autotroph mean in Latin?

8. What does the word heterotroph mean in Latin?
Lesson 29

Energy Pyramid and Food Web Activity

*Students will better comprehend this activity if they complete Pass the Energy activity on page 203 prior to this activity.*

In this lesson students will create a food web and will trace the flow of energy through the food chains and energy pyramid.

**Objective**
- Students will illustrate the flow of energy through the food web, food chain, and energy pyramid.

**California State Integrated Science 1 Ecology Standards 6e and 6f**
- Students know a vital part of an ecosystem is the stability of its producers and decomposers.
- Students know at each link in a food web some energy is stored in newly made structures, but much energy is dissipated into the environment as heat.

**Materials**
- Handout: Energy Pyramid and Food Web Activity
- Handout: The Players in My Food Web Table
- Color pencils, pens or crayons
- Blank paper

**Timeframe**
- 45 to 60 minutes
*Modifications for Alternative Learners*

Students can create a food web with three examples of producers, primary consumers, secondary consumers, tertiary consumers and decomposers instead of the required four in the activity.
Materials: Blank paper, color pencils, pens or crayons

1. Use the blank paper to create a food web with four different examples of: producers, primary consumers, secondary consumers, tertiary consumers and decomposers. Use organisms that are found in the same ecosystem. Fill in the table, The Players in My Food Web, with the producers, primary consumers, secondary consumers, tertiary consumers and decomposers found in the food web.

2. Next draw at least five (or six) food chains from the food web.

3. Draw an energy pyramid with one of the food chain examples in your food web. Draw it in such a way that there is a visual understanding of how many calories are available at each level.

4. With color pencils, illustrate your food web with drawings of the organisms that are found there.
5. Compare and contrast a food chain and a food web. Use the Venn diagram provided on the next page. Describe energy pyramids and explain how they work, include a description of the type of organisms found at the base of the pyramid and the type organisms are found at the top.
The Players in My Food Web

<table>
<thead>
<tr>
<th>Producer</th>
<th>$1^\text{st}$ Consumer</th>
<th>$2^\text{nd}$ Consumer</th>
<th>$3^\text{rd}$ Consumer</th>
<th>Decomposer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 30

See Lesson 26

Bottle Ecosystems

on Page 180
Lesson 31
See Lesson 14
The Wolf, the Moose and the Fir Tree
on Page 120
# Table Contents

Integrated Science 1 Ecology Standard 6f

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Energy Pyramids and Food Webs</td>
<td>206</td>
</tr>
<tr>
<td>2</td>
<td>Pass the Energy Please</td>
<td>207</td>
</tr>
<tr>
<td>3</td>
<td>Your Development Project</td>
<td>214</td>
</tr>
</tbody>
</table>
Lesson 33
See Lesson 29
Energy Pyramids and Food Webs
on Page 196
Lesson 34
Pass the Energy Please

In this lesson students will trace the flow of energy through the energy pyramid, food chain, and food web.

Objective
- Students will discuss the flow of energy through the energy pyramid, food chain, and food web.

*California State Integrated Science 1 Ecology Standard 6f*
- Students know at each link in a food web some energy is stored in newly made structures, but much energy is dissipated into the environment as heat.

Materials
- Handout: Pass the Energy Please

Timeframe
- 31 to 60 minutes

Lesson Procedure
1. Pre-Activity: Demonstrate the concept of energy efficiency by leading a class discussion that illustrates an energy transfer process. For example, ask students to determine the number of kilowatt-hours of electricity they would receive if the efficiency of transfer in the following flow were only 10%; 10,000 kWh from a power plant---transformer---home---student's room---student's computer. The resulting 1 kWh available for the student's use will introduce the concept of energy flow through a system.
2. Circulate among groups as the students trace the flow of energy through the aquatic ecosystem provided. Determine their understanding of trophic assignments and energy efficiency.

3. Answers to this activity can be found in Appendix B.

Acknowledgements
This lesson was adapted from the Alabama Department of Education (ALEX), Pathways for Learning Science 7–12 at the following website http://alex.state.al.us/lesson_view.php?id=189.

Extension: List organisms in a familiar ecosystem (i.e., a meadow, vacant lot, park, lake, stream, or river). Place them in their proper trophic levels and describe the energy changes between levels.
Pass the Energy Please

The sun is the ultimate source of energy for any ecosystem. Producers capture some of the light energy from the sun and transfer it into chemical energy as organic molecules (food). Energy is transferred through the ecosystem along trophic (feeding) levels. However, some energy is lost making less energy available at the next feeding level.

Organisms use much of their energy to carry out life functions. This energy is converted to heat and lost to the atmosphere so that only 10% of the energy is passed to the next level when one organism consumes another. Usually, the consumer does not eat all parts of an organism; so some energy is lost, although this energy loss is minimal.

A food chain is a simple sequence in which energy is transferred from one organism to another in an ecosystem. Ecosystems, however, are more complex and contain many more species. The food web is a more accurate illustration of energy transfer. Because of the energy lost, there are fewer organisms in each feeding level within the ecosystem.
In this activity, you will trace the flow of energy through the energy pyramid, food chain, and food web of an aquatic ecosystem.

Materials/Equipment:
- Handout: Picture of energy pyramid
- Handout: Food chain and food web

Procedure:
1. Examine sample food chain and food web.

2. Identify the trophic (feeding) levels by filling in the names of organisms in the blank energy pyramid, choosing any food chain from the food web. Be sure to start with the algae (water plants) as the producers at the lowest trophic level.

3. Determine the actual amount of energy transferred to the final consumer. Remember that the energy efficiency is about 10% from one trophic level to the next. Begin with the algae's trapping 1000 calories in organic molecules at the base of the food pyramid and figure the number of calories that would be available to each consumer. Remember: not all food chains will have organisms at all five trophic levels.
Energy Pyramid Observations and Questions

1. Why are there fewer consumers at the top of the energy pyramid?

2. What role does the sun play in the ecosystem?
3. Why is there energy lost between feeding levels?

4. Why are producers essential to the ecosystem?

5. Compare the trophic level of the killer whale when it feeds on the penguin to the elephant seal.

6. What level of consumer would have the greatest population in the ecosystem? Explain why.
Lesson 35

See Lesson 4

Your Development Project
on Page 36
Table Contents

Investigation and Experimentation Standards

\[ a, b, c, d, j, m \]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Your Choice Science Experiment                                                          216</td>
</tr>
<tr>
<td>2</td>
<td>Penny Lab                                                                                 224</td>
</tr>
<tr>
<td>3</td>
<td>Thumb War Lab                                                                            232</td>
</tr>
<tr>
<td>4</td>
<td>Experimental Variables                                                                    240</td>
</tr>
<tr>
<td>5</td>
<td>Worm Composting                                                                          241</td>
</tr>
<tr>
<td>6</td>
<td>Landfill Graphs                                                                          252</td>
</tr>
<tr>
<td>7</td>
<td>Making Smaller Footprints                                                                 256</td>
</tr>
</tbody>
</table>
Lesson 36

Your Choice Science Experiment

In this activity, students will choose and conduct an experiment at home.

Objectives

- Students will create an experiment at home and will write up a lab report following the scientific method.

*California State Integrated Science 1 Investigation and Experimentation Standards a, b, c and d*

- Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- Identify and communicate sources of unavoidable error.
- Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- Formulate explanations by using logic and evidence.

Materials

- Handout: Your Choice Science Experiment
- Handout: Scientific Method Format
Timeframe (suggested)

- Day 1: Discuss project: 30 minutes
- Day 5: Check Parent/Teacher Form: 30 minutes
  - Students can work on another assignment while you check their forms.
- Day 7 or 8: Help students with the write up: 30 to 45 minutes
- Day 14: Check Data: 5 to 10 minutes
  - Students can work on another assignment while you check their data.
- Day 21: Peer Review: 15 to 20 minutes
- Day 24: Turn in lab write up

Lesson Procedure

1. Look at the calendar and fill in the deadlines on their handout.

2. Pass out Your Choice Science Experiment. Read over this paper with students and answer any questions. Stress the importance of the deadlines to keep on track so they are not throwing something together the night before the due date. Each deadline could be worth 20 points with no late work accepted, unless they are absent that day. Allow a few days after passing out the handout until the parent/teacher consent form is filled out with a description of an experiment. Check their papers (parent/teacher consent form) and make sure that their experiments are projects where the students will get numerical data. Information that is described with words work well for tables, but not with graphs. So keep to projects where they will get numbers for their data.
3. After they choose an experiment they can do the bulk of the write up. It is helpful to the students to do this in class, where they are walked through it step by step. They can write the following sections: purpose, hypothesis (it’s critical that they come up with a hypothesis before doing the experiment), materials, procedure, data table and paragraph one of the conclusion.

4. Tell students that all that is left are to do the experiment, write the data in their table, create their graph and write up paragraphs two and three.

5. Give them about a week to two weeks to conduct their experiment. At this point they need to show a data table (it can be on a scrap of paper and they keep it, just check off that they did their experiment).

6. The peer review happens a week after they show me their data. This is important because fellow students may find mistakes that can be corrected before the report is turned in. Their report should be typed to facilitate correcting misspelled words and other errors.

7. The lab report due date should be three to five days after the peer review.

8. Consider creating a sample experiment description and write-up for students to model their project.

Acknowledgements

This is a project that I have modified over the years from one that was utilized by a fellow science teacher, Eric Weber.
Your Choice Science Experiment

Project due date: ________________

This is assignment is worth ______ points and must be completed by the due date assigned. Students have the freedom to choose their experiment. This assignment should reflect your very BEST effort.

You need to get both parental and teacher approval before you start your project. Parent signature needs to come before teacher signature. You need to have an experiment picked out by ________________ (you can get it signed earlier by parent and teacher). Once both parent and teacher sign the approval form, you can start your experiment.

FORMAT: THIS IS AN EXPERIMENT THAT NEEDS TO FOLLOW THE SCIENTIFIC METHOD FORMAT PAPER. This is a formal project and must be typed (hand written projects will lose 5 points). Spelling and grammar errors will result in deductions. At least five multiple trials MUST be conducted and the results put in a table and graph. The conclusion is a critical part of the report and must be at least a page in length.

There will be at least one day where students will work on the writing aspect of this project in class (plan on working on the write-up on ________________). All experimental trials must be completed by ________________. The peer review of the lab report will be on ________________. Students need to have the completed lab report so other students can help critique their work. This report needs to be typed to facilitate fixing errors. It cannot be stressed enough how important it is to have the completed report at school on this day. Students should look on this due date as if they were turning it in to me.

I have read and understand the assignment requirements.

_________________________________  __________________________________
Student name (printed)               Parent signature
Parent-Teacher Consent Form

Date Due: ___________________________

Description of experiment (include how you will get numerical data to fill in your data table and graph):

I will support my child in completing this project.

__________________________
Parent signature

This experiment meets the requirements of our project.

__________________________
Teacher Signature
Scientific Method Format Paper

Write the heading at the beginning of each section of the lab report.

1. Purpose: In your own words, state the purpose of the activity.

2. Hypothesis: What do you expect to happen and why? Do not use personal pronouns such as I, me, my, our...

3. Materials: A bulleted list of what is needed for this experiment.

4. Procedure: A numbered list of what needs to be done step by step so someone else could read your procedure and duplicate what you did in this experiment.

5. Variables: (a bulleted list as follows)
   - Independent variable (IV): (this is what you change in your lab)
   - Dependent variable (DV): (this is the data you collect)
   - Control group (CG): (the IV is eliminated or at a standard level)

6. Data Table: Remember to label the columns and rows (as appropriate) with the words and units. For example: Time (seconds)

7. Graph: Remember to label the x and y-axis with the words and the units. For example: Time (seconds). Don’t forget the numbers.
8. Conclusion:

- 1st Paragraph: Recap this Experiment
  - What were you trying to do or find out in this experiment?
    What type of data did you collect (mass, length, time)?
    How did you collect it? Do not repeat the entire procedure.

- 2nd Paragraph: Analyze your Results
  - What does your data show? What did you discover? Report
    the data with units and any results that you measured or
    calculated. Do not repeat all of the data.
  - If there is a graph, describe what your graph shows about
    the relationship (direct or inverse) between the variables.
  - Explain if your hypothesis was supported or contradicted
    by the results. Specifically, tell how the results of the
    experiment helped you to evaluate your hypothesis.
    Compare your results to your hypothesis.
3rd Paragraph: Causes of Measurement Uncertainty

- This is not the same thing as a mistake. You are not to include descriptions of human error or mistakes here; these things should be corrected during the lab and mistakes in data collection are not included in the lab report.

- Look for places in the procedure where the value of your measurement might not be exact (may show variations between the repeated trials) no matter how careful you were in conducting your experiment. These types of unavoidable conditions are called experimental error or scientific uncertainty. Write about what conditions in the lab may be the source of the small differences in data collection.
Lesson 37
Penny Lab

Students will demonstrate the cohesive forces of water. Students will also create a lab report following the scientific method.

Objectives
- Students will use the scientific method.
- Students will create an if/then hypothesis.
- Students will determine the independent and dependent variables.
- Students will create a bar graph of their results.

California State Integrated Science 1 Investigation and Experimentation Standard b and c
- Standard b: Identify and communicate sources of unavoidable experimental error.
- Standard c: Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

Materials
- Handout: Penny Lab Worksheet
- Pipettes - one for every two students
- Pennies - one for every two students
- Paper towels - one for every two students
- Small (50 mL) beakers with water - one for every two students
- Graph paper

Timeframe
- 60 minutes
**Lesson Procedure**

1. Students get the supplies. Students place the paper towel on top of their desk with the penny on top of the towel. They use their pipettes to collect water from the beaker and then slowly place a series of individual drops, each the same size, onto the surface of the penny. It is important that the students do this slowly so that water can easily bead up onto the penny. Students will add water to the penny until the water spills off. Students record their data (the number of drops of water on the penny until it spilled over) in the data table provided in the handout. The same student dries the penny with the paper towel and conducts two more trials.

2. Once three trials have been complete by one student; their partner conducts the experiment three times, recording their data each time in the data table. Students calculate the average of water drops from their trials and their partner’s trials. They share their averages with you, which are then displayed on the white board or overhead projector. Students fill in their data table with each student’s average for the number of drops. Students are to bar graph their data before finishing the analysis and conclusion questions.

3. Answers to this activity can be found in Appendix B.

Note: Remind students that the graph needs a title, correct labels for the x and y-axis (correct IV and DV values), and the numbers need to be sequential (i.e., 1, 2, 3, or 2, 4, 6).
Modifications for Alternative Learners
Students can graph only their data and the class average data.

Acknowledgements
This lesson was adapted from the Water Cohesion Lab, which was created by Lesson Plans Inc. (www.LessonPlansInc.com).
Purpose: Water molecules have polar bonds due to an uneven sharing of the electrons between the oxygen and hydrogen atoms. This unequal sharing of electrons causes a positive charge at the hydrogen atoms and a negative charge at the oxygen atom. The hydrogen atom of one water molecule attracts the oxygen of another water molecule.

Hypothesis: A maximum of ________ drops of water will fit on top of a penny, then the cohesive forces of water will break and the water will spill onto the towel.

Materials:
- Paper towel
- Pipette
- Penny
- Beaker
- Water
- Graph paper

Procedures:
1. Place your penny on top of the towel.
2. Use your pipette to collect water from the beaker.
3. Slowly place the same size of water drops onto your penny.
4. Continue adding water until the water spills over the side.
5. Record your results in the data table below.
6. Dry off your penny and repeat for trails two and three.
7. Share your average with your teacher. Record other student’s data on your class averages table.
Experimental Data:

<table>
<thead>
<tr>
<th></th>
<th>Me</th>
<th>Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average of 3 Trials</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Class Averages (drops of water)

<table>
<thead>
<tr>
<th></th>
<th>Partner 1</th>
<th>Partner 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entire Class Average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Graphing:
Create a bar graph with your average, your partner’s average and the class average on the x-axis by the number of drops on the y-axis.

Analysis:
1. Independent variable:

   ____________________________

   Dependent variable:

   ____________________________

   Control variables:

   ____________________________

2. When the hydrogen atom of one water molecule attracts the oxygen atom of another water molecule it forms a __________________ bond.
3. What is the difference between cohesion and adhesion?

4. Explain how hydrogen bonding relates to cohesion of water.
5. ____________ causes plants to draw water of its roots to its leaves.

6. ____________ allows water to stay connected as it rises up the tree.

7. How did your hypothesis compare with your average?

8. Why did the water form a bead on the penny and not flow immediately off the edge?
Lesson 38
Thumb War Lab

Students use a game of thumb war to learn the scientific method and the required elements in a lab report.

Objectives
- Students will use the scientific method.
- Students will create an if/then hypothesis.
- Students will determine the independent and dependent variables.
- Students will create a bar graph of their results.

California State Integrated Science 1 Investigation and Experimentation Standards b and c
- Standard b: Identify and communicate sources of unavoidable experimental error.
- Standard c: Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

Materials
- Handout: Thumb War Worksheet
- 30 cm string – for every two students (to measure circumference)
- Ruler – for every two students
- Graph paper and color pencils
- Photocopy of your attendance sheet to record the student's measurements and to track the winners of each round.

Timeframe
- 60 minutes
Lesson Procedure

1. Students fill out their problem statement described in the handout directions. Next student create an If/Then hypothesis. Students will need assistance with this part of the activity. Guide students to a hypothesis of, "If a student has a larger wrist and thumb, then they will be the thumb war champion". It would be best if students use this statement because this lab is set up for this hypothesis.

2. Each student measures their wrist circumference, thumb knuckle circumference, and thumb length and records the information in centimeters in their handout. Students then tell you their measurements and you record it on your attendance sheet next to their names. After recording all the data, select two students to instruct the class of procedures 4 and 5.

3. While the students are reviewing procedures 4 and 5, calculate the averages for thumb length, circumference and wrist circumference.

4. The two student volunteers demonstrate and explain the procedures of how to conduct a thumb war. Volunteers say, "To play the game, a player hooks the four fingers of their right (or left) hand to the four fingers of the other players right (or left) hand and clasps firmly. To start the game both student say, "One, two, three, four, I declare a thumb war."
Both students try to *trap, pin, or capture* the opponent’s thumb for three seconds to win.

- Females play females and males play males. Students can conduct only one thumb war per round.

5. The two volunteers explain the rules to help prevent cheating. Volunteers say, “Use of the index finger to sweep over the opponent’s thumb is not allowed. Twisting the opponent’s arm or wrist to gain leverage is not allowed. Use of the opposite hand is not allowed. When the thumb is pinned, the counting should be at the same speed. Students should not apply too much pressure or force that might hurt the other student.”

6. When students determine the winner, they come to you and tell you who won. You indicate the results on the attendance sheet and select two winning students to play in the next round. The students who lose may socialize and watch the next round.

7. At the end of the tournament, you will have two champions, one male and one female. Write the two winners names on the board. Write the average totals for the class on the board or overhead. Students independently now fill out the analysis and the conclusion.

8. Students will create a bar graph with the wrist, thumb length, and thumb circumference of the male winner, female winner and the class average as the independent variable (IV), and 0–30 centimeters as the dependent variable (DV). The legend should have male winner, female winner and the class average as the categories.

*Note:* Remind students the graph needs a title, correct labels for the x and y-axis, the numbers need to be sequential (i.e., 1, 2, 3, or 2, 4, 6).
Modifications for Alternative Learners

Students with physical limitations can perform your duties: recording measurements onto the attendance sheet, calculating the averages, or selecting students to compete in each of the rounds. Students with an Individualized Education Plan (IEP) can take the handout home if they need extra time. They can also graph one winner instead of the both the winners and the class average.

Acknowledgements

This lesson was adapted from the Scientific Method Activity, which was created by Lesson Plans Inc. (www.LessonPlansInc.com).
**Thumb War Lab**

**Purpose:** Background information about what you are testing.

Hypothesis: If ____________________________,

then ____________________________.

**Materials:**
- 
- 
- 
- 
- 
- 
- 

Your measurements in centimeters:

Wrist: _______ Thumb circumference: _______

Thumb length: _______

**Procedures:**

1. To play the game, a player hooks the four fingers of their right (or left) hand to the four fingers of the other player’s right (or left) hand and clasps firmly.
2. To start the game both students say, "One, two, three, four, I declare a thumb war."

3. Both students try to trap, pin, or capture the opponent's thumb for three seconds to win.

4. Females play females and males play males.

5. Students can conduct only one thumb war per round.

6. No cheating! Use of the index finger to sweep over the opponent's thumb is not allowed. Twisting the opponent's arm or wrist to gain leverage is not allowed. Use of the opposite hand is not allowed.

7. When the thumb is pinned, the counting at the end should be at the same speed when you counted at the start of the game.

8. Students should not apply too much pressure or force that might hurt the other student.

Experiment & Analysis:
Independent variable: ______________________
Dependent variable: ______________________

Male winner:
Wrist: _______ Thumb circumference: _______
Thumb length: ______

Female winner:
Wrist: _______ Thumb circumference: _______
Thumb length: ________

Class average:
Wrist: _______ Thumb circumference: _______
Thumb length: ________

Create a table and a bar graph with the wrist, thumb length, and thumb circumference of the male winner, female winner and the class average as the independent variable (x-axis), and 0-30 centimeters as the dependent variable (y-axis). The legend should have male winner, female winner and the class average as the categories.

Conclusion:

On a separate piece of paper answer the following:

- Why would this activity not be considered a controlled experiment?
- What does your data show? What did you discover? Report the data with units and any results that you measured or calculated. Do not repeat all of the data.
- Describe what the graph shows about the relationship (direct or inverse) between the variables.
○ Explain if your hypothesis was supported or contradicted by the results. Specifically, tell how the results of the experiment helped you to evaluate your hypothesis. Compare your results to your hypothesis.
Lesson 39

See Lesson 10

Experimental Variables

on Page 71
Lesson 40

Worm Composting

In this activity, students will create a worm compost bin.

Objectives

- Students will be able to reduce their impact on the local landfill by composting at home.
- Students will learn how to be more environmentally responsible.

*California State Integrated Science 1 Standard m*

- Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

Materials

- Handout: Red Worm Compost Bin
- Red worms
- Plastic one-gallon milk container
- Handful of soil
- Items from the Composting Do’s and Don’ts
  - Newspaper, etc.
Timeframe

- One day to set up in classroom OR 15 minutes to pass out worms.
- Weeks or months to monitor at home composting bins.

Lesson Procedure

1. To create the worm bin you can choose to either have the students make them at home or at school. Either way, make sure that the containers are at school and ready for worm habitation before you purchase the worms for your students. Inform students that they are not to cut their worms in half.

*Note:* You could create a fun contest among your students for best worm hotel or wackiest worm home. Your students can use their imagination and creativity to illustrate the outside of the worm bin. They could also come up with names for their worms, which they could add to the outside of their container. The kids could decide on the categories and as a class picks the one that best characterizes that category.

Acknowledgements

This lesson was adapted from information provided by Bethany Sanders who wrote an article on DiY Life entitled: Start your own worm-composting bin. http://www.diylife.com/2008/05/07/start-your-own-worm-composting-bin/
The tables on Composting Do's and Don'ts and Worm-Bin Troubleshooting came from a brochure published by Placer and Nevada Counties' Compost Education Program entitled Worm Composting and Other Methods for Recycling Fruit and Vegetable Trimmings.
Worm Composting

Worms? Really? When you provide worms with an appropriate home, they'll work their way through your food scraps and create a dark, rich, moist material that your garden will love. Plus, if you like to fish, you will have a nice supply of fish bait.

There are two kinds of worms you can use to compost your food scraps, red wigglers or red earthworms. Note that earthworms typically found in soil are not appropriate for worm composting, and will likely die in your bin. Look for red worms sold for fish bait.

Bin Sweet Bin... We're going to create our worm habitat using gallon sized milk containers, which we will call bins. Worms need air like you and me, so make sure your bin is well ventilated. Poke holes into the sides and bottom of your container. You can do this with a drill or an ice pick.

You are going to create a hinged-opening near the top of your bin so you can add material, but are still able to close it to keep in the moisture (approximately 5" long by 3" high). Instead of cutting out a “window”, leave one side attached so you can push the plastic closed after you set up your worm bin.

Elevate your bin on blocks so that any water can drain out (otherwise, your worms could drown). Use a tray (a pie tin works great!) to catch this nutrient-rich liquid and feed it to your garden or house plants.
Happy worms are busy worms... Fill your bin 3/4 full with bedding. Shredded newspaper is probably the most popular bedding option, though others include dry and shredded fall leaves, dead plants, and cardboard.

Wet the bedding (this is important) and then wring out the excess water so that the material is about as wet as a wrung out sponge. Then lift it to create air spaces. Toss in a small handful of soil or sand, which worms will use as grit to aid in digestion. Some leaf litter is a fine addition as well.

Add your wigglers to their bedding. You can also place a piece of damp cardboard cut to fit your bin on top of the bedding and worms. Worms love to chomp on cardboard!

Finally, your bin needs to be covered so that it is dark inside for your worms. You can tape dark colored construction paper around the outside (remember to put holes in the paper where the holes are in your bin so that they are open to the air!). Coloring the outside with a dark marker also works well (this is where students can use their creativity to make the outside of the bin interesting. They can draw pictures that will help to darken the interior of the bin. The cover serves to keep your bin dark and moist. You can keep the lid off of your milk container to increase airflow.

Dinnertime!... You'll want a worm to food ratio of 2:1. Feed your worms slowly in the beginning. Too much food will lead to your bin filling up, odor, and possibly, pests. Bury your food scraps under at least one inch of bedding, in different areas of your bin. Start out with the corners. Check each day to make sure that the bedding is moist and add small amounts of water as necessary (a spray bottle works great).
Harvesting your compost... After about two and a half months, you'll notice that the bedding is almost gone and in its place is a dark, rich material. These are called worm castings, or less poetically, worm manure. This means it's time to harvest the compost and provide the worms with new bedding so that they have a place to live and don't go hungry. Worms can't eat their castings, because they are poisonous to them.
Carefully dump the contents of the bin onto a large piece of plastic outside. Pick the worms gently out of the pile while you prepare new bedding for the bin. Look for the tiny worm cocoons, which contain baby worms. Make sure they make their way back into your compost bin too! Return the worms to their happy home and use the compost on your garden, houseplants or flowerbeds.

Worms, worm cocoons and composted material.
These are the worm cocoons.

As always when dealing with live creatures, keep in mind that you've taken them out of their natural habitat and into your care. Though composting with worms isn't difficult, it does require a degree of responsibility and commitment.
### Composting Do's and Don'ts

<table>
<thead>
<tr>
<th>Do Compost</th>
<th>Don't Compost</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Tea bags</td>
<td>o Fruit and vegetable trimmings (in open piles, simple bins)</td>
</tr>
<tr>
<td>o Egg shells</td>
<td>o Sawdust from plywood/treated wood</td>
</tr>
<tr>
<td>o Fallen leaves</td>
<td>o Diseased plants (in cold piles)</td>
</tr>
<tr>
<td>o Most sawdust</td>
<td>o Dairy products or grease</td>
</tr>
<tr>
<td>o Herbivore manure</td>
<td>o Dog, cat or bird feces</td>
</tr>
<tr>
<td>o Coffee grounds and filters</td>
<td>o Meat, bones or fish</td>
</tr>
<tr>
<td>o Chopped, woody pruning's</td>
<td>o Citrus</td>
</tr>
<tr>
<td>o Fruit and vegetable trimmings</td>
<td></td>
</tr>
<tr>
<td>o Lawn clippings and young weeds (without seed heads)</td>
<td></td>
</tr>
</tbody>
</table>

**Remember...**

- Be careful not to drown your worms with too much water.
- To avoid flies and bad odors, no more than 1/3 of your pile should have fruit and vegetable trimmings.
<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Worm-Bin Troubleshooting

<table>
<thead>
<tr>
<th>Problems</th>
<th>Cause</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worms are dying</td>
<td>Food and bedding eaten</td>
<td>Harvest compost, add fresh bedding and food.</td>
</tr>
<tr>
<td></td>
<td>Too dry</td>
<td>Add water until slightly damp.</td>
</tr>
<tr>
<td></td>
<td>Extreme temperatures</td>
<td>Move bin so temperature is between 40 to 80°F.</td>
</tr>
<tr>
<td>Bin attracts flies and/or smells bad</td>
<td>Food exposed/overfeeding</td>
<td>Add a 4 to 6 inch layer of bedding and stop feeding for 2 to 3 weeks.</td>
</tr>
<tr>
<td></td>
<td>Non-compostables present</td>
<td>Remove meat, pet feces, etc.</td>
</tr>
<tr>
<td>Sowbugs, beetles in bin</td>
<td>These are GOOD for your worm compost!!!!</td>
<td></td>
</tr>
</tbody>
</table>
Lesson 41
Landfill Graphs

In this activity, students will graph information about recycling and the amount of different categories of trash.

Objectives
- Students will learn how to be more environmentally responsible by reducing their impact on landfills when they compost at home.

California State Integrated Science 1 Standard m
- Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

Materials
- Handout: Landfill Graphs
- Graph paper
- Color pencils, pens, or crayons

Timeframe
- 45 to 60 minutes

Acknowledgements
The information in the tables came from the US EPA site. www.epa.gov/epawaste/nonhaz/municipal/pubs/msw07-fs.pdf
You will create two bar graphs with the information provided in the two tables. Table 1 contains information on how much material is created in each category and also how much material was recycled in 2006. Table 2 contains information on how much material within each category ends up in the landfill. For example, 85.3 million tons of paper was created in 2006. Of that 85.3 million tons, 44.0 million tons or 51.6% of paper is recycled to be used again. However, 33.9% of the weight found in the landfill in 2006 was composed of paper.

The first graph will have the y-axis labeled Weight Generated (Millions of Tons). The x-axis will be labeled Material. Each bar will be color-coded with a key identifying each corresponding material.

The second graph will have the y-axis labeled Weight Generated (%). The x-axis will be labeled Material. Each bar will be color-coded with a key identifying each corresponding material.

Don’t forget descriptive titles on the graphs.
Table 1. Generation and Recovery of Materials in MSW, 2006
(In millions of tons and percent of generation of each material)

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight Generated</th>
<th>Weight Recovered</th>
<th>Recovery as a % of Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper and Paperboard</td>
<td>85.3</td>
<td>44.0</td>
<td>51.6%</td>
</tr>
<tr>
<td>Glass</td>
<td>13.2</td>
<td>2.88</td>
<td>21.8%</td>
</tr>
<tr>
<td>Steel</td>
<td>14.2</td>
<td>5.08</td>
<td>35.7%</td>
</tr>
<tr>
<td>Plastic</td>
<td>29.5</td>
<td>2.04</td>
<td>6.9%</td>
</tr>
<tr>
<td>Food, other*</td>
<td>31.3</td>
<td>0.68</td>
<td>2.2%</td>
</tr>
<tr>
<td>Yard Trimmings</td>
<td>32.4</td>
<td>20.1</td>
<td>62.0%</td>
</tr>
<tr>
<td>Wood</td>
<td>13.9</td>
<td>1.31</td>
<td>9.4%</td>
</tr>
<tr>
<td>Textiles</td>
<td>11.8</td>
<td>1.81</td>
<td>15.3%</td>
</tr>
<tr>
<td>Total other wastes</td>
<td>19.7</td>
<td>3.9</td>
<td>-</td>
</tr>
<tr>
<td>Total MSW</td>
<td>251.3</td>
<td>81.8</td>
<td>32.5%</td>
</tr>
</tbody>
</table>

* Includes recovery of other MSW organics for composting.
Table 2. Materials Generated in Municipal Solid Waste by Weight

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight Generated (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>33.9</td>
</tr>
<tr>
<td>Glass</td>
<td>5.3</td>
</tr>
<tr>
<td>Metal</td>
<td>7.6</td>
</tr>
<tr>
<td>Plastic</td>
<td>11.7</td>
</tr>
<tr>
<td>Food</td>
<td>12.4</td>
</tr>
<tr>
<td>Yard Trimmings</td>
<td>12.9</td>
</tr>
<tr>
<td>Wood</td>
<td>5.5</td>
</tr>
<tr>
<td>Rubber, Leather,</td>
<td>7.3</td>
</tr>
<tr>
<td>Textiles</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Total MSW</strong></td>
<td><strong>251</strong></td>
</tr>
</tbody>
</table>

Total weight = 251 million tons
Lesson 42
Making Smaller Footprints

Students will read an article and will brainstorm ideas on how to reduce, reuse and recycle at school and at home.

Objectives
- Students will be able to reduce their impact on the local landfill by composting at home.
- Students will learn how to be more environmentally responsible.

California State Integrated Science 1 Standard m
- Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

Materials
- Handout: Waste Not - Want Not Article
- Handout: Environmental Anagrams
- Handout: Making Smaller Footprints

Timeframe
- 45 to 60 minutes
Lesson Procedure

1. Read out loud and discuss the article. Complete the anagram (could be assigned as homework).

2. Next, brainstorm the strategies we can use at school to minimize our impact on the landfill. Here are some strategies we use at our school:

   o Recycle cans/bottles
     o At our school the custodian collects and recycles the cans/bottles (I have a special box in the room for students to put their cans/bottles).

   o Reuse/Recycle paper
     o At our school, we recycle paper.
     o Any extra copies that have a blank side are used as scratch paper (students who forget to bring their binder to school get to use this paper).

3. Brainstorm as a class the strategies we can use to minimize our impact on the environment from home. Here are some ideas on how to minimize your trash:

   o Recycle (glass/plastic/paper)
   o Create compost from scraps from the table and food preparation/also paper towels for the garden.
   o Create a red worm compost bin.
Some ideas on how to minimize our impact on the environment:

- Use fluorescent light bulbs or light-emitting diodes (LED), which use less energy than incandescent light bulbs.
- Choose cars that have better gas mileage and combine trips to decrease the miles driven every week. This will decrease the emissions from cars, which will improve air quality.

The following ideas were found on the Forest Foundation website:

- Use water wisely in the house and outside in the yard - water conservation measures are affected by the types of plants used in the landscape (drought tolerant versus lawn) and the type of irrigation used (drip irrigation versus overhead spray).
- Turn off lights when not in a room.
- Plant trees that lose their leaves in the fall to warm your home and provide shade in the summer to cool your home.
- Insulate your home and have dual or triple pane windows.
- Lower the thermostat in the winter and raise it in the summer.

4. Can we do better? What would that look like? Why is this topic important for us to talk about at school? Here are some ideas:

- This is important for us to talk about at school because as an individual, our impact is small, but as a nation and as a world population, our impact on the environment is large.
It is important to take care of the environment so that it is a healthy place to live.

5. There are signs that say “Reduce, Reuse, Recycle”. There is significance in the order that they give the “3R’s”. The primary importance is on “reduce”. Explain why it is more important to reduce first and to recycle last. Here are some ideas:

- Reduce is of primary importance because then we have less of an impact on the environment because we are using fewer resources.
- Reuse is also important because some items can be used over and over, thus helping to minimize our impact on the environment since we are using fewer resources.
- Recycle is important because we can reuse the materials in the item, which will minimize our impact on the environment since we are using fewer resources. Recycling keeps it out of the landfill.

Answers to the Environmental Anagram can be found in Appendix B.

Extension: http://www.epa.gov/osw/education/teens/act.htm. Great ideas teenagers can use to be environmentally responsible.

Acknowledgements

The information from the Waste Not–Want Not article and the Environmental Anagram came from The Forest Foundation at http://calforestfoundation.org/online_materials.html.
America has many natural resources. These are things that nature provides for our use and enjoyment. The forest is one of our major natural resources. We are lucky to have a great many forests and trees, but we need to be careful how we use them.

In America, we use more paper than anywhere else in the world. Each of us uses almost 700 pounds of paper a year. Where does it all go? You guessed it—landfills. About four out of every ten solid things put into landfills are made of paper, and most of that are newspapers.

Luckily, Americans know they must show responsibility by making wise choices to protect our natural resources. One way is by recycling. We have learned that many products can be recycled to make other items. About a quarter of all the paper that is made in the U.S. today is made from re-used paper.

Americans have also learned that if we make things from a resource that is renewable, like trees, that resource will grow back. It will be available to use again and again. Things made out of ores, such as steel or aluminum, or out of petroleum products, like plastics, are not renewable. Once the ores or petroleum sources are used up, they are gone forever. Most of these products are also not biodegradable.

Even Mother Nature recycles. Pine needles, cones, leaves, dead trees and plants may seem like useless forest waste, but they are really important to the forest. These bits of organic matter fall to the ground. With the help of sunlight, air, water, bacteria, worms, and insects forest waste begins to decay and decompose. As it breaks down, the waste acts as a fertilizer to help trees and other plants grow. Forest waste holds the soil together to prevent erosion.
People now imitate Mother Nature. Many farmers and gardeners stack organic matter together to form a compost pile. In this pile, food and garden scraps will decay and produce fertilizer just like forest litter does in the woods. Each of us should try to be responsible in our use of natural resources so they are available today, tomorrow, and forever.
Environmental Anagram

1. CCYELRD

2. UREESD

3. NWBERELAE

4. IODBBEGARLDAE

5. DLLSALNIF

6. MCTOOPS

7. YDEAC

8. GORACIN

9. CEDOPMSOE

10. SITRESBILIPONY
1. What strategies are we currently using at our school to minimize our impact on the landfill? Could we do more? What would that look like?

- 
- 
- 
- 
- 

2. What can we do at home to minimize our impact on the environment? Could we do more? What would that look like?

- 
- 
- 
- 
- 
- 
- 
- 
- 

3. Why is this topic important for us to talk about at school?
4. There are signs that say "Reduce, Reuse, Recycle". There is significance in the order that they give the "3R's". The primary importance is on reduce. Explain why it is more important to reduce first and to recycle last.

5. Fill in the Venn diagram with examples of the 3 R's (reduce, reuse and recycle).
Appendix B

TABLE OF CONTENTS

ANSWERS TO ECOLOGY LESSONS AND PROJECTS

Page

1. Experimental Variables Handout ............................................ 266
2. Population Ecology Lab Handout ............................................ 268
3. The Wolf, the Moose and the Fir Tree Handout ................. 269
4. Carbon Cycle Handout ............................................ 273
5. Nitrogen Cycle Handout ............................................ 275
6. Water Cycle Handout ............................................ 276
7. Transpiration Lab Handout ............................................ 277
8. Photosynthesis and Respiration Matching Handout ........... 278
9. Photosynthesis and Respiration Chart Handout ............... 279
10. Producers – Consumers – Decomposers Handout ............ 280
11. Bottle Ecosystems Handout ........................................ 281
12. Energy Pyramid Handout ........................................ 282
13. Penny Lab Handout ........................................ 283
14. Environmental Anagram Handout ................................ 284

265
For the following experiments, identify the independent variable (IV), dependent variable (DV) and control group (CG).

1. One tank of goldfish is fed the normal amount which is once a day, a second tank is fed twice a day, and a third tank is fed four times a day during a six week study. The fish's body fat is recorded daily.
   IV: A tank of goldfish is fed twice a day and another tank of goldfish are fed four times a day.
   DV: The fish’s body fat is recorded daily.
   CG: The goldfish that are fed the normal amount of once a day.

2. You give four sunflowers different watering with either pure water or different concentrations of salt solutions. After a two-week period, the height is measured.
   IV: The different concentrations of salt solutions.
   DV: The height of the sunflower plants.
   CG: The plants that received pure water.

3. Three redwood trees are kept at different humidity levels inside a greenhouse for 12 weeks. One tree is left outside in normal conditions. Height of the tree is measured once a week.
   IV: The different humidity levels inside a greenhouse.
   DV: The height of the three redwood trees.
   CG: The redwood tree that is kept outside in normal conditions.

4. Pea plant clones are given different amounts of water for a three-week period. The first pea plant receives 400 milliliters. The second pea plant receives 200 milliliters. The third pea plant receives 100 milliliters. The fourth pea plant does not receive any extra water: the plant only receives rainwater. The height of pea plants is recorded daily.
   IV: The different amounts of water: 400 mL, 200 mL and 100 mL.
   DV: The height of the pea plants.
   CG: The pea plant that does not receive any extra water.
5. The number of flowers on different breeds of bushes in a greenhouse is recorded every week for two months.
IV: The different breeds of bushes.
DV: The number of flowers.
CG: There is no control in this experiment. A control would have been counting the number of flowers on the same type of bushes that are growing outside of the greenhouse.

6. You decide to clean the bathroom. You notice that the shower is covered in a strange green slime. You decide to try to get rid of this slime by adding lemon juice. You spray half of the shower with lemon juice and spray the other half of the shower with water. After 3 days of “treatment” there is no change in the appearance of the green slime on either side of the shower.
IV: Spraying the shower with lemonade juice.
DV: Looking at the appearance of the shower to see if the slime is still there or if it has disappeared.
CG: Spraying the shower with water.
Answers for Population Ecology Lab Handout

1. Independent variable:
   - The existing number of rabbits, environment and coyotes.

2. Dependent variable:
   - The change in number of rabbits, environment and coyotes.

3. What is a "limiting factor"?
   - Anything that restricts population growth.

4. Identify limiting factors in this activity.
   - Food, water, shelter and predation from coyotes.

5. What happened to a rabbit that did not tag its corresponding resource?
   - It died and became a decomposer.

6. Why did a tagged resource become a rabbit in the next round?
   - The rabbit survived and reproduced one offspring due to acquisition of resources and avoidance of predators.

7. The largest number of rabbits able to survive in the provided environment is called its _________________.
   - Carrying capacity.

8. What type of growth happened in generations 1 through 4?
   - Look at student graph in 10 and 11 (expect exponential growth).

9. Why did the above growth not continue forever?
   - The rabbits ran out of environmental resources.

Answers to questions 10 to 12 will vary depending upon the outcome of the activity in each class. Go to student handout for questions 10 to 12.

13. Explain how the environment and the rabbits were related and how the introduction of coyotes affected the growth of the rabbit population.
   - The environment provides the resources that the rabbits need to survive and reproduce, however, when the carrying capacity of the environmental resources are exceeded (too many rabbits for the amount of resources) then the rabbit population crashes when the animals starve due to lack of resources. The coyotes keep the rabbit population from getting too large, which helps the environmental resources such as food as water.
Answers to The Wolf, the Moose and the Fir Tree Handout

1. What is the Primary Productivity Hypothesis (PPH)?
   o Plant growth is limited by the energy available to plants, which is determined by temperature and rainfall.

2. Describe a positive (+) relationship according to the PPH.
   o The rainforest has a warm climate with massive amounts of rainfall. Plants grow rapidly in these conditions.

3. Describe a negative (-) relationship according to the PPH.
   o The desert is extremely hot in the summer with very little rainfall for the entire year. Plants do not grow very rapidly in these conditions.

4. How many trophic levels are described in this article? Describe each trophic level.
   o There are three trophic levels. The fir tree is at the bottom of this food chain and is the producer. The moose is the primary consumer and is the herbivore. The wolf is the secondary consumer and is the carnivore.

5. What type of relationship (+/−) would you expect to see between the population densities of each trophic level in this system (fir/moose/wolves) under the primary productivity hypothesis?
   o When there are more fir for the moose to eat then the moose population will increase. As the moose population goes up, the wolf population will also rise.

6. What is the Trophic Cascade Hypothesis (TCH)?
   o Changes in one trophic level are caused by opposite changes in the trophic level above it.

7. What type of relationship (+ or −) would you predict at each trophic level under the TCH?
   o As the wolf population increases, the moose population decreases due to increased predation by the wolves. The reverse is also true that when the wolf population goes down, the moose population goes up.
   o As the moose population decreases, the fir tree population increases due to decrease foraging by the moose. The reverse is also true that as the moose population goes up, the fir tree population goes down due to increase foraging by the moose.
   o These relationships are called inverse correlations.
8. What would you predict the effect to be of wolf removal on plant growth under PPH? Under the TCH?
   - If plant growth is limited by primary productivity, wolf removal will have no effect on the growth of the firs. Under PPH, plant growth is determined by temperature and rainfall.
   - For the TCH, the removal of the wolf would lead to an increase in the moose population and therefore a decrease in plant growth due to foraging by the moose.

9. What is the purpose of each graph?
   - Population numbers of the wolves (graph A) and the moose (graph B). Graph C measures the average ring-width for eight fir trees on the west side of the island. Graph D measures the average ring-width for eight fir trees on the east side of the island. Graph E measures the actual evapotranspiration (AET) from April to October. The AET is tied to weather temperature and rainfall.

10. Are there unclear terms or confusing aspects to either figure?
   - The banded areas on these graphs may be confusing to some students. Different areas of each graph are shaded to show a possible relationship between minima and maxima at different trophic levels. However, the banded areas of the two ring-width plots (graphs C and D) are lined up; these bands represent minima on graph C (west) but are neither minima nor maxima on graph D (east).

11. How do the maximum and minimum of the ring-width data correspond to changes in moose density? Does this support the primary productivity hypothesis, the trophic cascade hypothesis, or neither?
   - The figures suggest that periods of fir suppression are tied to increases in the moose population, though there is a one to two year lag in the west end of the island and a five year lag on the east end. This discrepancy may be due to the climate differences across the island. If more favorable conditions exist on the west end, then firs on that end of the island should have a higher growth rate and should recover more quickly once the moose population declines. This interpretation would support the trophic cascade hypothesis that moose populations limit fir growth.
12. How do the maximum and minimum numbers of the wolf population correspond to changes in moose density? How might you account for this relationship?
   o When wolf population is down, then moose population goes up.
   o When wolf population is up, then moose population goes down.
   o The above two relationships are "inverse" relationships.
   o Lower predation = more survivors and more offspring.

13. How should annual AET look under PPH?
   o If the PPH were correct then the AET would be affected by changes in temperature and rainfall.

14. How should annual AET look under TCH?
   o If the TCH were correct then the AET would not be affected by foraging from the moose.

15. Which hypothesis (if any) is supported by the data on annual AET?
   o No apparent relationship exits between AET and ring widths, undermining one of the central predictions of the primary productivity hypothesis. This information could be interpreted as indirect support for the trophic cascade model if we assume that these hypotheses are mutually exclusive.

16. Do you find any aspect of the figures or captions confusing?
   o Figure 2A-B captures several differences between the RH band SS sample sites; the mere number of parameters involved may create confusion for some students.

17. The moose population peaked in the mid-1970s and then declined over the next decade. With fewer moose present, how would you predict the trees would respond?
   o One prediction would be that with fewer moose present to forage on the fir trees, the trees would show more growth.

18. How did the trees at each site actually respond?
   o The trees at the Rock Harbor (RH) site showed dramatic increases in growth compared to the trees at the Siskiwit Swamp (SS) site.
19. Why did the sites respond differently?
  o The two sites have different amounts of rainfall available to the trees. The amount of canopy present affects the amount of sunlight available to the trees for optimal photosynthesis. Plants growing in shaded areas will have less growth than plants in areas of full sun.

20. What final conclusions can you draw between each trophic level on Isle Royale?
  o Wolf to moose: As the wolf population increased, the moose population decreased. The inverse was also true that when the wolf population decreased, the moose population increased.
  o Moose to fir: As the moose population increased, the average ring-width of the fir trees sampled decreased which could be due to increased forage of the moose on the fir tree. This increase in forage would have decreased the number of fir tree needles, which could have had an impact on the growth of the fir trees.

21. Based upon the data collected at Isle Royale, which hypothesis is more strongly supported? Control exerted from the top down as described in TCH or control exerted from the bottom up as described in PPH?
  o While it is not a perfect fit, the data best fits the TCH compared to the PPH.
Answers for Carbon Cycle Handout

1. What gas do humans and animals exhale? Write the formula for this exhaled gas.
   - Carbon dioxide: CO₂

2. Can humans be considered carbon sinks? If so, for how long? What living organisms are better long-term sinks than humans?
   - Humans can be considered carbon sinks for as long as they are living. When they die they become carbon sources.
   - Living organisms that are better long-term sinks are organisms that are longer-lived than humans. One example would be the redwood tree that lives for hundreds of years.

3. List two important sinks (things that store carbon), two important sources (things that release carbon), and one important release agent (things that trigger sources) for carbon.
   - Sinks:
     - Limestone
     - Long-lived trees
     - Burial of organic matter
     - Plastic
     - Ocean
   - Carbon sources:
     - Burning of fossil fuels and other organic matter
     - Weathering of limestone rocks (which releases CO₂)
     - Respiration of living organisms
   - Carbon release agent:
     - Volcanic activity
     - Forest fires
     - Other human activities
4. We are currently worried that CO\textsubscript{2} sources are out of balance with CO\textsubscript{2} sinks. If sources produce more CO\textsubscript{2} than sinks can remove, CO\textsubscript{2} in the atmosphere increases, possibly leading to global warming. What might happen if the reverse were true and sinks took up more CO\textsubscript{2} than sources?
   
   - Answers will vary but students may note that less would be available for plant growth or that less atmospheric might result in a slightly cooler atmosphere.

5. Explain how understanding the carbon cycle helps atmospheric scientists understand and prepare for global climate changes.
   
   - Answers will vary, but students should note that understanding the carbon cycle is important because scientists can work on trying to find methods that will reduce CO\textsubscript{2} in the atmosphere. They can also work to find strategies to create carbon sinks.
Answers for Nitrogen Cycle Handout

1. What gas do volcanoes release to the atmosphere? Write the formula for this gas.
   o NH₃

2. List three sources of nitrogen.
   o Decaying organisms
   o Volcanic gases
   o Fertilizers

3. Explain why nitrogen is so important to life.
   o Nitrogen is a key element in proteins and DNA.

4. What are three ways to break the nitrogen bond?
   o Bacteria
   o Lightening
   o Fire

5. Explain the role bacteria plays in the nitrogen cycle.
   o Changes nitrogen from an unusable form (N₂) to useable forms (NH₃, NH₄⁺, NO₃⁻, NO₂⁻).

6. Describe the negative effects of excess nitrogen in streams and ponds. What is the source of this extra nitrogen?
   o Rapid plant growth until the supply is used up, then they die. Increased numbers of herbivores when the plant supply increases, then animals are left without food when the plants die. Nitrogen-rich fertilizer and livestock waste are sources of extra nitrogen.
Answers for Water Cycle Handout

1. Which part of the activity simulated evaporation?
   - Evaporation was simulated as the lamp heated the ‘ocean’.

2. Which part simulated condensation?
   - Condensation occurred as the water vapor from the ocean cooled on the lid of the shoebox near the petri dish of ice.

3. Which part simulated precipitation?
   - The drops of water falling from the lid of the shoebox simulated precipitation.

4. What is the energy source and what does it represent?
   - The energy source was the lamp, which represented the sun.

5. What elements of the water cycle are not represented?
   - Transpiration, infiltration, sublimation, and percolation were not represented.

6. How could we demonstrate transpiration in this activity?
   - We could demonstrate transpiration by adding live plants to the shoebox.

7. Would condensation occur in the box without the ice? Why or why not?
   - Condensation might occur over the mountains but not as quickly. The ice provided a greater temperature difference, forcing the vapor to condense.

8. After observing this activity, explain why water is considered a renewable resource.
   - Water is continually recycled through the various parts of the water cycle.

9. The system you observed/constructed is a model of the way the actual water cycle works. Why might scientists use a model like this in their research into the water cycle in the real world? Can you think of any reason that using such models might be a problem?
   - Student answers will vary, but they should discuss how large-scale systems are difficult to study. One problem could be that large systems can be complex and not all of the variables might be known, or understood, which might result in a skewed understanding of the system.
Answers for Transpiration Lab Handout

1. Where does the moisture come from that accumulate along the sides of the top cup?
   - Water vapor from the plant (transpiration).

2. How do you know the water is coming from the plant and not just evaporating from the water in the cup?
   - The water in the bottom of the cup is sealed from the top of the cup with the cardboard lined in plastic, which forms an impermeable layer to the water.

3. Challenge students to imagine that their small plant was a large tree with a thousand times as many leaves. Ask them to assume that this tree transpires just like their plant and calculate how much water it would transpire.
   - Answers will vary.

4. Now ask them to imagine a small forest with 1000 such trees. How much water would transpire?
   - Answers will vary.

5. Ask if they think this much water going into the air in that area might affect the climate at all. Why or why not?
   - Answers should indicate that there would be a change in the climate because of all the water vapor released into the atmosphere that would then condense and fall back to Earth as rain.
Answers for Photosynthesis and Respiration Matching Handout

Put a P for photosynthesis and a R for respiration.

1. _P_ Occurs only in plants.
2. _R_ Occurs in cells all the time.
3. _R_ Oxygen is on the reactant side of the chemical formula.
4. _P_ Oxygen is on the product side of the chemical formula.
5. _R_ Glucose (sugar) is needed for this reaction to take place.
6. _P_ Glucose (sugar) is created from this reaction.
7. _P_ This reaction reduces carbon dioxide in the atmosphere.
8. _R_ Increases the amount of carbon dioxide in the atmosphere.
9. _P_ For this reaction to occur, sunlight must be present.
10. _R_ Sunlight is not needed in this reaction.
**Answers for Photosynthesis and Respiration Chart Handout**

Directions: Put the description in the correct category.

<table>
<thead>
<tr>
<th>Photosynthesis</th>
<th>Respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide is used as a reactant.</td>
<td>Glucose (aka sugar) is a reactant in this reaction.</td>
</tr>
<tr>
<td>Water is needed for this reaction to work.</td>
<td>Oxygen is needed to make this reaction work.</td>
</tr>
<tr>
<td>Sunlight is necessary or there will not be a reaction.</td>
<td>Water is produced in this reaction.</td>
</tr>
<tr>
<td>Oxygen is produced in this reaction.</td>
<td>Carbon dioxide is a product of this reaction.</td>
</tr>
<tr>
<td>Glucose (aka sugar) is produced in this reaction.</td>
<td>ATP is created in this reaction.</td>
</tr>
</tbody>
</table>
Answers for Producers – Consumers – Decomposers Handout

1. Give three examples of organisms that are producers.
   - Pine tree, fruit trees, grasses, vegetable plants, rose bushes, etc.

2. Why are producers important in an ecosystem?
   - Producers use energy from the sun to produce food and oxygen for all other organisms.

3. What are three different organisms that are considered to be consumers?
   - Horses, dogs, cats, cows, humans, birds, fish, snakes, insects

4. What purpose(s) do consumers serve in an ecosystem?
   - Control populations of other organisms; return carbon dioxide and nutrients to the environment that producers need to produce food.

5. What are three different organisms that are considered to be decomposers?
   - Bacteria, fungi, some insect larva, and insects.

6. List two things that would happen to an ecosystem if no decomposers were present.
   - Very few nutrients would be returned to the environment. Dead organisms would not be broken down and would continue to pile up in the ecosystem.

7. What does the word autotroph mean in Latin?
   - Self-feeder

8. What does the word heterotroph mean in Latin?
   - Other feeder
Answers for the Bottle Ecosystems Handout

1. What gas does the plant release into the water? Write the formula for this gas. Is this gas important to your ecosystem? Why or why not?
   - Oxygen (O₂). This gas is important to oxygenate the water and it keeps the fish and snail alive.

2. What gas does the plant take from the water? Is this important for the health of your mini ecosystem? Why?
   - Carbon dioxide (CO₂). Yes because too much CO₂ will harm the fish and the snail.

3. Describe the trophic levels contained in your ecosystem. Which organism represents each level?
   - Producer = aquatic plant
   - Consumer = fish
   - Decomposer = snail

4. Explain what might happen to your ecosystem if the snail died. What do you think you might observe after a few days to a few weeks?
   - The materials that the snail eats would start to accumulate and the aquatic ecosystem would start to show a build-up of materials.

5. Everyday write your detailed observations of the plant, the fish, the snail, the appearance of the water, and anything else of interest in your system. Make sure you write the date and the time for each journal entry.
Answers for Energy Pyramid Handout

1. Why are there fewer consumers at the top of the energy pyramid?
   - There are fewer consumers at the top of the pyramid due to the loss of energy from one trophic level to another.

2. What role does the sun play in the ecosystem?
   - The sun is the essential source of energy for producers.

3. Why is energy lost between feeding levels?
   - Ninety percent of potential energy is lost in moving from one trophic level to another. This loss is due to the heat expended in obtaining and digesting food, excreting waste, and maintaining body temperature for some organisms. This heat energy is dissipated to the environment and is considered lost because it is no longer useful to do work.

4. Why are producers essential to the ecosystem?
   - Producers are essential to the ecosystem because they convert the sun's energy into a form that can be used by other organisms (i.e. food in the form of sugars and carbohydrates).

5. Compare the trophic level of the killer whale when it feeds on the penguin to the elephant seal.
   - The killer whale is either secondary or tertiary when feeding on the penguin but always quaternary when feeding on the elephant seal.

6. What level of consumer would have the greatest population in the ecosystem? Explain why.
   - Primary consumers. They feed directly upon the producers where the greatest amount of energy is available.
Answers for Penny Lab Handout

1. Independent variable: the different students conducting the lab
   Dependent variable: the number of drops on the penny
   Control variables: there is no control in this experiment

2. When the hydrogen atom of one water molecule attracts the oxygen atom of another water molecule it forms a polar bond.

   - If you held a paper towel vertically from the top and you wet the bottom of the towel, the water will climb up the towel against the force of gravity. This is caused by adhesion.
   - Adhesion is an attraction between molecules of different substances.
   - Cohesion is the attraction between molecules of the same substance.

3. What is the difference between cohesion and adhesion?
   - Cohesion works with molecules of the same substance while adhesion works with molecules of different substances.

4. Explain how hydrogen bonding relates to cohesion of water.
   - Water molecules are attracted to other water molecules.

5. Adhesion causes plants to draw water of its roots to its leaves.

6. Cohesion allows water to stay connected as it rises up the tree.

7. How did your hypothesis compare with your average?
   - Answers will vary with students depending upon their predictions.

8. Why did the water form a bead on the penny and not flow immediately off the edge?
   - Students should discuss how water molecules have polar bonds because there is an uneven sharing of the electrons between the oxygen and hydrogen atoms. This unequal sharing of electrons causes a positive charge at the hydrogen atoms and a negative charge at the oxygen atom. The hydrogen atom of one water molecule attracts the oxygen of another water molecule.
Answers to the Environmental Anagram Handout

1. C C Y E E L R D - RECYCLED
2. U R E E S D - RE-USED
3. N W B E R E L A E - RENEWABLE
4. I O D B B E G A R L D A E - BIODEGRADABLE
5. D L L S A L N I F - LANDFILLS
6. M C T O O P S - COMPOST
7. Y D E A C - DECAY
8. G O R A C I N - ORGANIC
9. C E D O P M S O E - DECOMPOSE
10. S I T R E S B I L I P O N Y - RESPONSIBILITY
REFERENCES


Retrieved October 23, 2007, from