Middle School Curriculum Revision and Environmental Science Activity Guide for the Appleton Area School District

A Project Report Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science In Natural Resources/Environmental Science

University of Wisconsin-Stevens Point

By

Eric A. Toshner

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Abstract

My goal for this project and paper was to become involved in the middle school curriculum of the Appleton Area School District and develop and find environmental science lesson that would correspond with the new units that were developed. As I found out, the process of revising curriculum was much more difficult and time consuming than I had thought. The problems that occurred were not as much in the curriculum itself, as it was in getting teachers involved in the process of the revision. Many teachers were upset with the idea of having to change what they are comfortable with even though it is what is best for the students of the Appleton Area School District.

What you will read in this paper is the process that the revision committee went through to accomplish their goals of curriculum revision along with some of the problems that occurred throughout the process. There is also some environmental science lessons that will fit into each of the newly developed units.
Acknowledgements

Thanks to my parents for being so supportive and encouraging during the three years that this masters took. I would also like to thank my grandparents for being so enthusiastic about continuing my education. Last but not least, I would like to thank my wife for her love, understanding, and continuing support as I complete this portion of my education.
# Table of Contents

Abstract iii  
Acknowledgements iv  
List of Appendices vi  
Chapter One Page 1  
Chapter Two Page 7  
Chapter Three Page 18  
Chapter Four Page 24  
Chapter Five Page 40  
Bibliography Page 45  
Appendices Page 47  
Activities Page 54
List of Appendices

State Environmental Science Standards: Page 48
Revised 7th Grade Science Units-Detail: Page 49
Revised 8th Grade Science Units-Detail: Page 50
Revised 7th Grade Science Standards: Page 51
Revised 8th Grade Science Standards: Page 52
Old Appleton Area School District Science Standards: Page 53
Chapter One

Introduction

This chapter will look at the research problem along with all subproblems that are associated with it. The significance of the problem will be discussed along with any limitations associated with these problems. Specific terms that will be used throughout the paper will also be defined.

The Research Problem Statement

The purpose of this project is to work with Appleton Area School District middle school teachers and administrators to realign the seventh and eighth grade science curriculum to meet state and federal standards and benchmarks and to develop an environmental education activity guide to follow the newly developed units.

The Subproblems

1. To be part of the middle school science revision committee.

2. Determine the needs of the middle school science program based on committee input.
3. Develop units that will meet present state and federal benchmarks for 7\textsuperscript{th} and 8\textsuperscript{th} grade science.

4. Create an environmental education activity guide for grades 7-8 that will include activities based on the newly developed units set forth by the revision committee.

5. Plan and implement an in-service that will examine the environmental education activity guide and allow Appleton Area School District Middle School Science teachers a hands on opportunity to work with the activity guide.

**The Hypotheses**

The creation of a middle school environmental education activity guide for the newly revised 7\textsuperscript{th} and 8\textsuperscript{th} grade science program for the Appleton Area School District will increase the teacher awareness of environmental education at the middle school level and encourage the teaching of environmental education throughout the middle school level.

**Significance of the Problem**

The importance of this problem can be viewed from two perspectives. One approach is to look at how the teachers and students at the middle school
level are benefited from an environmental education activity guide. The second approach is to look at how the Appleton Area School District will be benefited by meeting the Wisconsin Department of Public Instructions state environmental standards.

Currently, in the Appleton Area School District, there is little to no support for the teaching of environmental education at the middle school level. In fact, little has been done in terms of environmental education in the district since a handbook was set up in the early 1990’s. With the move to spiral the teaching of middle school science, an activity guide in environmental education can become a valuable resource. The guide will permit teachers to have something at hand that can supplement the newly developed units and foster an environmentally conscious attitude in the students. The in-service will also help the teachers become acquainted with environmental education standards and understand the material that is available in the guide before they use it.

This guide and the inservice that is provided will also move the Appleton Area School District into compliance with the state statutes and administrative rules which require districts to develop and implement environmental education curriculum plans at the Middle School level. The Wisconsin Environmental Education Act of 1990 required that “EE
objectives and activities shall be integrated into the kindergarten through grade 12 sequential curriculum plans, with the greatest emphasis in art, health, science and social studies education.” (section 121.02 (1), Wis. Stats. 1990) As stated earlier, at the present time the Appleton Area School District is not meeting this requirement. It is important for the Appleton Area School District to meet the Wisconsin Environmental Education Act goals so that the students can understand that they are part of this world and their actions will affect for better or worse their community and the world around them. These students will also become well-rounded citizens with the knowledge that they acquire.

Limitations

This study will only provide the Appleton Area School District Middle School teachers with a source of activities in environmental education that they will be able to use in their classrooms. Teachers will be encouraged to use this guide and to attend the inservice that will be offered. Because of lack of time for in-services offered by the district, having an inservice for each middle school will be extremely difficult. A voluntary in-service will be offered that will allow teachers from all Middle Schools to attend.
Definition of Terms

1. Appleton Area School District (AASD)

The Appleton Area School District is a district of 15,000 students and is located in the city Appleton, Wisconsin on the northern shore of Lake Winnebago.

2. Middle School Level

Middle school level includes students in grades 7 through 8 and approximately 200 teachers in four schools.

3. Environmental Education

Environmental education is a process that leads to responsible individual and group actions that should enhance critical thinking, problem solving, and effective decision-making skills.

4. Utilized

Utilized refers to the use of a curriculum guide by the middle school teachers of the Appleton Area School District.

5. Curriculum Guide

A curriculum guide is a resource of materials and activities to help teachers plan curriculum.
Assumptions

1. Teachers will be willing to teach Environmental Education in the classroom when given easy access to Environmental Education materials.

2. Teachers will be willing to participate in inservices that show how to use the curriculum guide.

3. The Appleton Area School District will be willing to offer an in-service that will allow teachers to use the activity guide before it is used in the classroom.
Chapter Two

Literature Review

Introduction

To gain a better understanding of any subject that is being researched, literature must be looked at through a number of different sources. These sources include print sources and the Internet. This section will look at the four main areas that are important for this paper.

Goals of Environmental Education

The ultimate goal of environmental education is to develop citizens who are willing to work both individually and collectively to protect, improve, and sustain the quality of the environment not only for their generation, but also for generations to come (Engleson and Yockers, 1985). They must also be willing to solve the environmental problems and be motivated to work toward their solution (Stapp, 1969). The key component that many people see in this goal is scientific knowledge (Shin, 1999), but Hungerford and Volk (1990) have shown through research that knowledge alone is not enough to make students take any kind of citizen action on their own. They
need to have skills that will aid them in this venture. These skills can be
developed through the subgoals or foundations of EE.

Hungerford, Peyton and Wilke (1980) developed four subgoals or levels of
curriculum development that will give students the background needed to
get to the final level of action. The first level deals with ecological
knowledge. At this level students should be given the ecological
foundations that will permit them to make sensible ecological decisions in
the future (Hungerford, Peyton and Wilke, 1980). This includes looking at
populations, energy flow, succession and the implications of human
activities on the environment to name a few (Hungerford, Peyton and Wilke,
1980).

The second level looks at conceptual awareness. This goal is designed to
show the students how individual and group actions can impact the quality
of life that we have and the quality of the environment that we enjoy
(Hungerford, Peyton and Wilke, 1980). With this goal we look at how our
activities affect the environment and what these activities will do to the
environment, as we know it in the future. Students will also look at the
values that we have developed for the environment and the issues associated
with our actions.
The third level looks at the investigation and evaluation of environmental issues. Here the students will gain the knowledge and skills that are required for investigation of environmental issues and the evaluation of the solutions for these issues (Hungerford, Peyton and Wilke, 1980). There are two basic components to this level, one deals with the knowledge and skills of investigation and evaluation and the other with providing opportunities for participation in environmental issue investigation and evaluation (Hungerford, Peyton and Wilke, 1980).

The last level is the environmental action skills level. Here students are given the skills necessary to take action on the environmental issues. These skills include persuasion, political action, legal action and ecomanagement among others (Hungerford, Peyton and Wilke, 1980). The two components of this level include giving the students the skills to take action and also providing the students with opportunities to take action (Hungerford, Peyton and Wilke, 1980).

These levels were then used as a basis for the five subgoals for environmental education in Wisconsin that were developed by Engleson and Yockers in 1985. The first subgoal is perceptual awareness, which deals with developing ways in which an individual becomes conscious of the world around them and begins to feel compassion of what is around them.
With this subgoal, the two lowest levels, receiving and responding, of the Taxonomy of Educational Objectives: Affective Domain are met (Engleson and Yockers, 1985). At this level the students need to become aware or conscious of something in the environment but do not have to know what the characteristics of it are (Engleson and Yockers, 1985).

The second subgoal is knowledge. Here the students gain a basic understanding of how the environment works and how humans interact with the environment around them. This level satisfies the lowest levels of the Taxonomy of Educational Objectives: Cognitive Domain: Knowledge (Engleson and Yockers, 1985).

The third subgoal is environmental ethic. In this subgoal, students develop a sense of what is fundamentally right and wrong with the world around us (Engleson and Yockers, 1985). With this goal we want students to develop beliefs, attitudes and values about the environment. This subgoal satisfies the upper levels of the Taxonomy of Educational Objectives: Affective Domain (Engleson and Yockers, 1985).

The fourth subgoal is citizen action skills. This subgoal helps students to develop the skills that are needed to take action on environmental issues that affect their community, and more importantly their own well being (Engleson and Yockers, 1985). These skills include identifying
environmental issues, identifying and evaluating alternative solutions, and planning individual and group actions among other skills (Engleson and Yockers, 1985). Students need to learn these skills so that the actions that they take will not go unnoticed. The Taxonomy of Educational Objectives: Cognitive Domain: Intellectual Abilities and Skills are met with this subgoal (Engleson and Yockers, 1985).

The last subgoal is citizen action experience. The main purpose of this subgoal is to give the students real world experience in the solving of environmental problems. These experiences include using various methods of citizen action, determining if the action is wise and necessary, and seeing if the action is effective (Engleson and Yockers, 1985).

All these subgoals will help to achieve the main goal of environmental education, which is to develop citizens who are willing to work both individually and collectively to protect, improve, and sustain the quality of the environment not only for their generation, but also for generations to come (Engleson and Yockers, 1985). We must remember that all of these goals can be taught across the range of subjects and have a great potential to make cross-curricular links that will help to reinforce that material to the students (Chapman, 1999).
Developing Curriculum

"Education programs and curricula should be developed in response to three concerns: the physical, intellectual, moral and ethical development needs of human beings; the need to fulfill social responsibilities; and the need to understand the content of the various disciplines" (Engleson and Yockers, 1985). This definition by Engleson and Yockers completely covers the areas that Hungerford, Peyton and Wilke, (1980) developed following the four levels of cognitive knowledge and skills within the expansive range of environmental literacy (Ramsey, Hungerford and Volk, 1992). Even though these goals have been set, designing an effective and comprehensive curriculum guide can be a rather large task (Volk, 1993). According to Volk (1993), there are several steps in curriculum design. The first step in curriculum design is to identify the goals. Next, is to develop the scope and sequence of the curriculum. Then you must evaluate what the district already has. The last step is to prepare the curriculum and provide inservice and implementation plans (Volk, 1993).

Another aspect to look at is the perceptions of professional environmental educators. Many of these educators believe that environmental education goals are not being met and see a need to develop knowledge across the four
levels discussed by Hungerford, Peyton and Wilke, (1980) (Volk,
Hungerford, and Tomera, 1984).

I believe that the best way to develop curriculum in Wisconsin is by looking
at the main publications of “Wisconsin’s Model Academic Standards for
Environmental Education” by Fortier, Grady, Lee and Marinac (1998) and
also “A Guide to Curriculum Planning in Environmental Education” by
Environmental Education” by Fortier, Grady, Lee and Marinac (1998) offers
a break down of performance standards that students should know about
environmental education by the time they reach 4th grade, 8th grade and 12th
grade. These standards are also broken into five categories: question and
analysis, knowledge of environmental processes and systems, environmental
issues investigation skills, decision and action skills, and personal and civic
responsibility (Fortier, Grady, Lee and Marinac, 1998).

“A Guide to Curriculum Planning in Environmental Education” by
Engleson and Yockers (1985) provides the reader provides with a direction
for planning a comprehensive environmental education program that is
based on perceptual awareness, knowledge, environmental ethics, citizen
action skills, and citizen action experience.
These two publications offer the reader an extremely well designed
guideline for the development of a curriculum that addresses all of the
environmental education standards while allowing individual district needs
to be addressed.

**Spiral Curriculum**

As we look at the K-12 experience of our students, we must realize that the
"... understanding and abilities associated with major conceptual and
procedural schemes need to be developed over an entire education, and the
unifying concepts and processes transcend disciplinary boundaries.
(http://www.nap.edu/readingroom/books/nses/html/)." We know that
learning is enhanced when concepts are encountered more than one time.
This is true not only in everyday life, but also in the education of our
students. For our students to truly learn a concept and not forget it once they
leave the classroom, we must build on the concepts throughout their
educational experience.

This idea of spiral curriculum or the constructivist theory was developed
base on the thought that learners construct new ideas or concepts based upon
their current or past knowledge. One of the leaders in this area of thought
was Jerome Bruner. Bruner thought that the task of the instructor was to
translate information to be learned into a format that was appropriate to the
learner’s current state of understanding, and that curriculum should be
organized in a spiral manner so that the student continually builds upon what
they have already learned (Bruner, 1966). Spiral curriculum can therefore
be defined as certain concepts and skills that are taught every year, but in an
upward spiral of difficulty

(https://www.nap.edu/readingroom/books/nses/html/).

Research done by the National Science Teachers Association on spiraling or
spacing of a science topic over several years shows that students can learn
and retain new material better if they study it in spaced intervals rather than
all at once. In this way, students can revisit a concept at successively higher
levels as they progress through their education (http://www.nsta.org/). To
fully implement this kind of curriculum, the entire K-12 program of a district
may have to be looked at and revised.

**Developing Activity Guide**

Developing an activity guide that will be more than a book put on a shelf to
collect dust has turned out to be one of the toughest parts of this project. I
want to make this activity guide something that all Appleton Area School
District Middle School science teachers will be able to use with ease and that will have activities for all of the new units at the middle school level. With these units that have been developed and the activities that I design for the units, I hope to change learner behavior by giving students the opportunity to develop ownership in environmental issues so that they are prompted to become responsible citizens (Hungerford and Volk, 1990). To supplement the activities that I develop, I hope to use activities from the many resources that are available to me from the Internet, WCEE and any local resource that may help.

**Summary**

Designing an environmental education activity handbook for middle school use will help to infuse the goals of environmental education into the curriculum. By designing the activity guide in a way so that all disciplines can use it in a simple manner is very important. One way to make sure of this is by using guidelines from the North American Association For Environmental Education, whose workbook can be found online at [http://www.naeee.org/npeee/workbook.pdf](http://www.naeee.org/npeee/workbook.pdf). This publication allows the user to look at six key characteristics to critically analyze the activity that you are looking at. This will be helpful when looking through the numerous
materials that are available for environmental education. Another way to make sure that activities are not only simple to use, but also well developed is to use the many activity books that can be found at the WCEE. This will simplify finding activities tremendously because these activity guides and resources have already be looked at, reviewed, and found to be extremely useful in teaching environmental education.

The end goal of this activity guide is to help prepare the students to become citizens who are willing to work both individually and collectively to protect, improve, and sustain the quality of the environment not only for their generation, but also for generations to come (Engleson and Yockers, 1985). Getting teachers involved and willing to use environmental education in their disciplines can accomplish this goal.
Chapter Three

Introduction

The main problem of the paper can be broken down into several subproblems. As you look at these subproblems, a detailed explanation of the subproblem and how it will be resolved must be included along with any important information that will help to explain why the subproblem is important.

Methodology

Subproblem One

To become part of the Appleton Area School District Middle School Revision Committee.

This is one of the simpler parts of this project to accomplish. The main part of this subproblem involved the time that was needed to accomplish the goal of revising the middle school science curriculum in the Appleton Area School District. Meetings were set at one per week after school and lasted for two to three hours per meeting. Although the committee started out with many participants, the main group that continued to come to meetings was Pat Marinac (Science Program Leader), Nancy AufderHeide (Science
Teacher, Einstein Middle School), Denise Steiner (Science Teacher, Madison Middle School), Karen Sinclair (Science Teacher, Wilson Middle School), Tanya Genke (Science Teacher, Roosevelt Middle School) and myself.

Subproblem Two

To help with the development of units for the new middle school science curriculum in the Appleton Area School District.

The first step in the development of a new middle school science curriculum in the Appleton Area School District was to critically look at the Appleton Area School District’s science program and decide what needed to be done to make it better for the needs of the students. As part of the Appleton Area School District Middle School Revision Committee, we were responsible for looking at all of the topics that are taught in the middle school and determining what topics need to stay at the middle school level and what topics needed to be move to a different level. The purpose of this was to allow time for students to concentrate on, learn, and retain the most important concepts. It also allows the committee to assure that the benchmarks that are developed address both the content and process skills for the middle school level.
Subproblem Three

To create a middle school activity guide that will include activities in environmental education that will coincide with the newly developed science units.

My first order of business in the development of an activity guide was to examine the needs of Appleton Area School District science curriculum. Considering nothing has been done since the creation of an environmental education handbook in the early 1990's, the needs of this district were extensive. At the present time there are little to no environmental education resources available to the middle school teachers in the Appleton Area School District, so the activity guide that is developed, would be the major resource in the district and will coincide with the newly developed units.

My next step was to go out and find the materials that I would use to compile the activities that would be used in the activity guide. There were several areas that I chose to use in the search including the Wisconsin Center for Environmental Education (WCEE) at the University of Wisconsin-Stevens Point, the Internet, and teacher's and administrators within the district. The best source of information turned out to be the WCEE. The center has a vast amount of resources organized for every grade level.
After finding the materials to develop new activities and materials that contained existing activities, I needed to evaluate what I had. Part of the evaluation process was to use different activities in my class and also use the North American Association for Environmental Education guidelines. I was also able to convince teachers on my team to try activities in their classes. This gave me more than one perspective on the effectiveness of the activity.

Once activities were selected, it was time to assemble the activity guide. This first step of assembly was to organize materials according to what unit they fit into and the grade level that the unit is in. This would allow easy utilization for all teachers.

After all of the activities were organized by unit, I placed them into a binder that was given to each of the four middle schools in the Appleton Area School District. Included with the binders were the goals of environmental education and explanations of these goals, an instruction guide and examples of classroom use. These binders were given to the teachers of the middle schools in the spring of 2004.
Subproblem Four

To construct and implement an inservice for the middle school teachers of the Appleton Area School District that will explain the use and purpose of the activity guide.

My goal of the inservice that was developed for the teachers was to make it as interesting and hands on as possible. To make sure that this happens, I will included several lessons that I think are fun and exciting to experience along with information on the purpose of the activity guide.

The inservice included a short amount of time to explain the activity guide and how I developed it. It also included time to go through the activities that were selected for each unit and also several activities that will be done by the teachers so that they understand the activities better.

The inservice will be held for the middle school science teachers in the Appleton Area School District. I hope to discuss with Pat Marinic, the 7-12 science district program head, when this inservice will be and the best times to accomplish this. The best days for this inservice would be during a staff development day or during the summer. I hope that the teachers who attend the inservice will take more of a leadership role in their school and be a source for any questions on any part of the activity guide.
If this inservice goes well, and there is interest shown, I hope to have another inservice that will be used for any new teachers in the Appleton Area School District in the coming years.

If I fail to get enough volunteers to attend the inservice, I will meet with teachers at each of the four middle schools individually to discuss the activities that are in the guide.

**Subproblem Five**

To continue to find new lessons that will coincide with the new middle school science curriculum of the Appleton Area School District.

I do not want this activity guide to become something that is only used a few years and then put on a shelf to gather dust. To insure that this will not happen, I plan to continue to find new lessons that will coincide with the curriculum units. I also would like to find Appleton Area School District middle school science teachers willing to be in charge of the activity guide for their school and help to keep the activity guide updated.
Chapter Four

Introduction

The following results will describe what happened when the subproblems were addressed. Each subproblem will include a detailed look at the work done to answer the problems that were addressed and if the work done was successful or not.

Results

Subproblem One

To become part of the Appleton Area School District Middle School Revision Committee.

Becoming part of the middle school revision committee was as easy as going to meetings that were set once a week and lasted two to three hours. The meetings rotated between Einstein Middle School, Wilson Middle School, Roosevelt Middle School and Madison Middle School, so that travel time to the meetings would be the same for all involved. Although the size of the group started out with around ten members, it quickly dwindled to a core group of five teachers. The largest problem with this committee was dealing with teachers who were not willing to make a change in the curriculum even
though it was in the best interests of the students. The science program in Appleton has seen no real change since 1981 and a change of this magnitude can be a very daunting matter for those who are involved. Many of the teachers who complained about the change were not willing to come to the meetings and therefore did not voice their concerns as these changes were taking place. For many of the teachers, comfort in teaching subjects that they were used to, took precedent over what was the best for the students of the Appleton Area School District. In the end, the committee decided to move forward with a plan that would better prepare the students of the Appleton Area School District for their continuing education.

Subproblem Two

To help with the development of units for the new middle school science curriculum in the Appleton Area School District. The development of new units for the middle school science curriculum became a task that was much larger than I had imagined it would be. I thought that it was as simple as taking the old Appleton Area School District curriculum and getting rid of the subjects that did not fit the needs of middle school science and replacing those subjects with ones that did. This turned
out not to be the case and was much more involved than simply looking at the old curriculum.

The first step in the revision of the middle school science curriculum was to break into several small groups and review the previous work that was done in the alignment committee. The main focus of this group was to:

- Critically review the AASD K-12 science program
- Develop a mechanism for articulating between grade level studies
- Establish grade level benchmarks
- Provide a framework for curriculum development and material selection

By doing this, the committee was able to break down the curriculum and put general topics in each grade level. After much debate and many meetings, the committee came up with these recommendations and comments:

- At the elementary level, delineation and clarification of the ‘process standards needs to be made. The curriculum must incorporate a clear emphasis on these standards.

- More focus on ‘science inquiry’ at the elementary level must be made – and supported with hands-on materials and resources.

- Adequate support of resources throughout the implementation years (as opposed to just at the beginning) is needed to make elementary science successful. ‘Quantity buying’ and a central distribution/support program should be investigated.
• Sites need funds designated for science supplies (esp. elementary)

• Middle level science program should consist of three (3) ‘mods’ per year, one (1) each of: life, earth & physical – with process standards (A, B, C, G, H) being strongly woven through.

• One (1) more credit of science should be required for graduation.

• More semester courses need to be offered at the high school level (ex: biotech, anatomy & physiology, astronomy, meteorology). This must happen sooner than later. Waiting until the high school program is scheduled for program revision is too late.

• Staff development will be crucial to program success. It needs to be increased – and ongoing.

• Staff development should include teacher-coaches in the classroom.

After reviewing these suggestions and discussing how science is taught not only at the middle school level, but also at all levels through out the Appleton Area School District the revision committee broke into several small groups and discussed and answered the following question:

1. How do standards guide the development of the program?
   • the process standards should guide science in the classroom
   • start with the process standards and work backwards to the ‘program’
   • content standards should provide the outline for what to teach
   • they should delineate the end result with a timeline (benchmarks)
   • they should help us develop a ‘concept’ oriented program (big rocks)
2. How should middle school students learn science?
   - through guided inquiry with appropriate assessment
   - to develop mastery of core concepts
   - pare down the curriculum (depth vs. breadth)
   - do interwoven 'general science' rather than 'mods'
   - constructivism
   - address student misconceptions
   - expect students to do high level thinking (explain, justify)
   - take time
   - exploration / hands-on

3. What must AASD do to provide an outstanding, standards-led science program?
   - Staff development
   - Establish clearly defined expectations for students (and teachers) (that will eliminate lots of re-teaching)
   - Value science as much as reading and math
   - Provide opportunities for HS and MS teachers to mentor elementary teachers.
   - Provide resources that will allow this to happen.
   - Provide classroom coaching

After looking at all the recommendations and suggestions, it was time to move forward and develop units for the new middle school curriculum. The first step was to look at the topics that are taught at the middle school level and break theses into seventh and eighth grade topics. The idea here is that what is taught at the seventh grade level would be built upon at the eighth grade level. One of the major tasks at this point was to decide what the students should know by the time they attend middle school. The committee looked at the Appleton Area School District science standards and the
Wisconsin State Science Standards and used these documents to guide them through the unit development of the curriculum revision. By breaking the benchmarks and standards into logical sequences, the following units were decided upon by the committee. These units are listed with the Appleton Area School District performance standards that are addressed with each unit:

**Instructional units for 7th grade science (with performance standards)**

**Building Blocks:**

- Identifies methods to separate mixtures into their component parts
- Explains that substances react chemically in characteristic ways with other substances to form new substances
- Demonstrates factors that influence reaction rates
- Explains that oxidation involves the combining of oxygen with other substances
- Explains that many elements can be grouped according to similar properties
- Identifies substances that contain only one kind of atom as pure elements, and explain that 100+ different kinds of elements exist
- Explains that elements do not break down by normal laboratory reactions
- Describes the levels of organization in living system, including cells, tissues, organs, organ systems, organisms, and ecosystems; and the complementary nature of structure and function at each level
Energy, A Hot Topic:

- Explains how heat can be transferred through conduction, convection, and radiation
- Describes the sun as the principle energy source for phenomena on Earth's surface
- Illustrates that energy is a property of many substances
- Illustrates that heat flows from warmer objects to cooler ones until both objects reach the same temperature
- Explains that just as electric currents can produce magnetic forces, magnets can cause electric currents

The Changing Earth:

- Illustrates how land forms are created through constructive forces
- Understands general concepts related to gravitational force
- Explains that Earth's crust is divided into plates that move at extremely slow rates in response to movements in the mantle
- Illustrates processes involved in the rock cycle
- Differentiates between sedimentary, igneous, and metamorphic rocks and the evidence of minerals, temperatures and forces that created them
- Explains that vibrations move at different speeds in different materials, have different wavelengths, and set up wave-like disturbances that spread away from the source
- Identifies layers of the Earth, including a core, mantle, and lithosphere

Why I Should Care:

- Explains the processes involved in the water cycle
• Analyzes the influence living organisms have on Earth’s water (hydrosphere) and atmospheric systems
• Identifies factors that impact the number and types of organisms an ecosystem can support
• Investigates human impact on Earth’s resources over the past 100 years
• Explains that the basis for efforts to conserve/recycle renewable and non-renewable resources are a result of past use
• Explains how multicellular organisms have specialized cells, tissues, organs, and organ systems that perform specialized functions (adaptations)

Instructional Units for 8th grade (with performance standards)

Lost in Space:
• Explains how heat can be transferred through conduction, convection, and radiation
• Identifies the sun as the principle energy source for phenomena on Earth’s surface
• Compares different wavelengths within the range of visible light as perceived as different colors
• Examines the electromagnetic spectrum and compare and contrast the difference in wavelength recognizing that only a small portion is visible and perceived by the human eye
• Understands general concepts related to gravitational force
• Explains gravitational force keeps planets in orbit around the sun, and moons in orbit around the planets
• Explains that many billions of galaxies exist in the universe
• Investigates the history and contributions of the space program
• Describes the composition and structure of Earth’s atmosphere
• Illustrates how the tilt of Earth’s axis and Earth’s revolution around the sun affect seasons and weather patterns
• Distinguishes characteristics of our sun and its position in the universe
• Illustrates characteristics and movement patterns of asteroids, comets and meteors

Weather . . . or not:

• Explains how heat can be transferred through conduction, convection, and radiation
• Compares different wavelengths within the range of visible light as perceived as different colors
• Examines the electromagnetic spectrum and compare and contrast the difference in wavelength recognizing that only a small portion is visible and perceived by the human eye
• Identifies the sun as the principle energy source for phenomena on Earth’s surface
• Describes how land forms are created through destructive forces
• Illustrates how the tilt of Earth’s axis and Earth’s revolution around the sun affect seasons and weather patterns
Uses meteorological tools and interpret a weather map or station model

Land Use:

- Identifies the sun as a principle energy source for phenomena on Earth’s surface
- Investigates components of soil texture, fertility, and resistance to erosion
- Describes how land forms are created through destructive forces
- Describes how disease in organisms can be caused by intrinsic failures of the system or infection by other organisms
- Investigates the human uses of Earth’s resources over the past 100 years
- Describes how organisms react to internal and environmental stimuli through behavior response

Changes Over Time:

- Describes factors that can impact Earth’s climate
- Explains how fossils provide important evidence of how life and environmental conditions have changed on Earth over time
- Describes how the fossil record, through geologic evidence, documents the appearance, diversification and extinction of many life forms
- Describes how successive layers of sedimentary rock and the fossils contained within them can be used to confirm the age, history, and changing life forms of Earth, and how this evidence is affected by the folding, breaking and splitting of layers
- Summarizes the evidence of common ancestry, chemical processes, and internal structures that demonstrate unity among organisms
• Examines the concept of extinction and its importance in biological evolution
• Investigates basic ideas related to biological evolution

Genetics:

• Differentiates between asexual and sexual reproduction
• Compares the variety of animal and plant body plans and internal structures that serve specific functions for survival
• Explains that the characteristics of an organism can be described in terms of a combination of traits
• Explains how dominant and recessive traits contribute to genetic variation within a species
• Investigates, evidence that supports the idea that there is a unity among organisms despite the fact that some species look very different
• Explains that evidence for common ancestry, chemical processes, and internal structures demonstrates unity among organisms
• Explains that hereditary information is contained in genes, each of which carries a single unit of information; inherited traits of an individual can be determined by either one or many genes; and a single gene can influence more than one trait

* To see the activities that are associated with these units, please reference the activities section in the appendices

After the committee compiled the units, the next big step in the process of revision of the curriculum was the selection of books for each grade.
Subproblem Three

To create a middle school activity guide that will include activities in environmental education that will coincide with the newly developed science units.

Due to what I saw was a lack of environmental education in the middle school curriculum of the Appleton Area School District, I set out to develop an activity guide that would encourage middle school teachers to add environmental education into their classroom. I believed that if there were activities readily available to the teachers, they would feel more comfortable to use environmental education. So I set out to find environmental education activities that would fit into the newly developed middle school science units.

The first thing that I did was to decide what type of activity would fit with each task in each of the newly developed units. This was made easier by the work that committee did while developing the units. Each unit was laid out showing specifically what would be taught in each unit. By looking at the specifics of the units, I was able to look for precise activities that would become a perfect fit with all of the units. I found that there was an abundance of materials available that would fit into many units and less activities in others. I also wanted to make sure that the activities would be
straightforward enough for the teachers to become comfortable teaching environmental education in their classroom. I did not want to find lessons that make the teachers uncomfortable and reluctant to teach environmental education. This guide will hopefully give the teachers confidence teaching environmental education so that they will infuse more into their lessons in the future.

The activity guide turned out to be a huge, but worthwhile undertaking.

While some of the units were much easier to find activities for, I was able to find several for every unit. I feel that this is an excellent start to this guide that I will be able to add to in the future.

Subproblem Four

To construct and implement an inservice for the middle school teachers of the Appleton Area School District that will explain the use and purpose of the activity guide.

The main goal of the meeting was to explain the purpose of the activity guide to the middle school teachers of the Appleton Area School District and make the teachers more at ease using the activity guide in their classrooms.

As I found out working on the revision committee, moving away from a person's comfort zone can be problematic for many individuals, so I wanted
to make sure that in the course of the inservice, the teachers who are involved will be as comfortable as possible with the lessons that are included in the activity guide.

Because of the climate of the middle school science curriculum at this time, an inservice was out of the question. I was able to meet with several representatives from the middle schools. These teachers included Scott Stepanski (Science Teacher, Einstein Middle School), Nancy AufderHeide (Science Teacher, Einstein Middle School), Denise Steiner (Science Teacher, Madison Middle School), and Karen Sinclair (Science Teacher, Wilson Middle School). Unfortunately, no one from Roosevelt Middle School was able to meet.

My first goal of the meeting was to discuss the goals of environmental education and why they are important for the Appleton Area School District. Included in this discussion were the four goals of environmental education and a look at the Wisconsin state environmental education standards. The idea of looking at the standards was to show the teachers of the middle school teachers of the Appleton Area School District the importance of environmental education in the classroom.

After looking at the standards, I assured the teachers that adding environmental education would not add time to their lessons and would still
allow them to teach what is needed at both the seventh and eighth grade levels. One of the barriers that teachers have said prevented them from teaching environmental education is time. I explained that having lessons that are specifically picked for each unit would allow the teachers to integrate environmental education into each unit as they see appropriate. Another barrier that is often stated that prevents teachers from teaching environmental education in the classroom is lack of knowledge. By going through several of the lesson with teachers, I will have reduced some of the fear associated with teaching something new and allow the teachers to gain confidence in the new material that I presented them.

**Subproblem Five**

To continue to find new lessons that will coincide with the new middle school science curriculum of the Appleton Area School District.

Anyone who is in the field of education can tell you that it is an ever-changing line of work. For teachers to be truly effective, they must stay up to date in the subject area that they are teaching. Staying up to date can come from taking classes, or by reading current publications that are available not only in the print form, but also more increasingly through the Internet.
I plan to continue to update the activity guide so that it stays as current as possible and also so that it continues to offer the middle school teachers of the Appleton Area School District many opportunities to infuse environmental education in their classrooms. By continuing to use the Wisconsin Center of Environmental Education and the many professors that I have encountered during my studies at the University of Wisconsin - Stevens Point as two of the many resources that are available to me, I feel that updating the activity guide will be a rewarding and worthwhile task because it will not only keep the activity guide current, it will also help me stay current in the field of environmental education.
Chapter Five

Introduction

Any concluding thoughts and recommendations will be talked about in this last chapter. I will discuss what I feel are some things to remember when looking at curriculum revision and teaching in general.

Conclusions and Recommendations

Subproblem One

To become part of the Appleton Area School District Middle School Revision Committee.

Becoming a member of the Appleton Area School District revision committee was a great experience for me as an educator. Although it was extremely frustrating at times, it makes you take a critical look at your teaching and forces you to make changes for the better. It does not matter what kind of teaching experience that you have, all opinions are appreciated by all who are involved. Also remember that as teachers, we must do what is the best for the students of our classes and give them the best opportunity to succeed in the future, whether it is in a college situation or in the professional setting. Therefore our curriculum must change to not only meet
the standards that are placed on our profession, but also our students’ needs. This is not always the popular choice, but it is definitely the right choice. When revising curriculum, the most important thing to do is to involve as many people as possible in the process. This will hopefully cut down on some of the negativity that can be involved with a major change in what people are expected to teach. Also keep all teachers updated and allow them to voice their opinions and concerns as much as possible so that everyone feels that they are part of the process of change.

Subproblem Two

To help with the development of units for the new middle school science curriculum in the Appleton Area School District.

When past curriculum is looked at and revised, you can bring new life to what is being taught. This is very important in today’s education climate. Everyone is critically looking at standards and what is being taught. It is important for teachers to stay current in their field and to continue to update their lessons to reflect what is happening in the world around them. By updating what we teach, we can get rid of the lessons that do not work and bring in new activities that will not only add excitement to the classroom, but will also help teachers keep from burning out and becoming bored with
what they are teaching. We also will better prepare our students for a successful future by making sure that they are receiving the best information for that subject. There are many sources that are available to help with curriculum revision and they will make the revision a rewarding experience.

Subproblem Three

To create a middle school activity guide that will include activities in environmental education that will coincide with the newly developed science units.

If you look hard enough, you will be amazed at the number of resources that are out there for teachers. It is almost overwhelming when you first start your search for a particular topic. But the more you search, the more energized you become because you can see the students learning and enjoying the hands on activities that you are bring to your class. Even if you are not revising your curriculum, it doesn’t hurt to look for new ways to teach your subject. You can find new and exciting activities to replace the ones that do not work the way you hoped they would. You will also help other teachers by sharing the exciting activities that you are finding.
Subproblem Four

To construct and implement an inservice for the middle school teachers of the Appleton Area School District that will explain the use and purpose of the activity guide.

Getting some teachers to commit to any type of program or inservice during non-school hours is a tough thing to do. The best thing to do is to get backing from administration to show that this is an important program to attend. But no matter what happens, do not get discouraged by the outcome. If you need to meet with the teachers, go to their school so they do not have to travel. If you make the sacrifice, they will see that you are committed and will at least listen to you. If you are excited about what you are talking about, that may be enough to pull teachers in the right direction.

Subproblem Five

To continue to find new lessons that will coincide with the new middle school science curriculum of the Appleton Area School District.

Finding new and improved lessons for what you teach is something that all teachers should do. We need to stay current in our fields and get rid of the old activities that do not work. Everyday there is something new in the world that will grab the attention of your students and make it interesting
and fun for them to learn. If we can all just find one new lesson a unit each year, we will help our students to become excited about learning and help ourselves become more excited about teaching.
Bibliography


Web Sites

http://www.statpac.com/surveys

http://writing.colostate.edu/references/research/survey/pop4

http://www.naaee.org/npeeeworkbook.pdf

http://www.nap.edu/readingroom/books/nses/html/

http://www.nsta.org/
Appendices
State Environmental Science Standards
FOURTH GRADE

Performance Standards

By the end of grade four, students will:

THE CHARACTERISTICS OF ORGANISMS

F.4.1 Discover how each organism meets its basic needs for water, nutrients, protection, and energy in order to survive

F.4.2 Investigate how organisms, especially plants, respond to both internal cues (the need for water) and external cues (changes in the environment)

LIFE CYCLES OF ORGANISMS

F.4.3 Illustrate the different ways that organisms grow through life stages and survive to produce new members of their type

ORGANISMS AND THEIR ENVIRONMENT

F.4.4 Using the science themes, develop explanations for the connections among living and non-living things in various environments
POPULATIONS AND ECOSYSTEMS

F.8.8 Show* through investigations* how organisms both depend on and contribute to the balance or imbalance of populations and/or ecosystems, which in turn contribute to the total system* of life on the planet.

DIVERSITY AND ADAPTATIONS OF ORGANISMS

F.8.9 Explain* how some of the changes* on the earth are contributing to changes in the balance of life and affecting the survival or population growth of certain species.

F.8.10 Project how current trends in human resource use and population growth will influence the natural environment, and show how current policies affect those trends.
EIGHTH GRADE

Performance Standards

By the end of grade eight, students will:

STRUCTURE AND FUNCTION IN LIVING THINGS

F.8.1 Understand* the structure and function* of cells, organs, tissues, organ systems, and whole organisms

F.8.2 Show* how organisms have adapted structures to match their functions*, providing means of encouraging individual and group survival within specific environments

F.8.3 Differentiate between single-celled and multiple-celled organisms (humans) through investigation, comparing the cell functions of specialized cells for each type of organism

REPRODUCTION AND HEREDITY

F.8.4 Investigate* and explain* that heredity is comprised of the characteristic traits found in genes within the cell of an organism

F.8.5 Show* how different structures both reproduce and pass on characteristics of their group

REGULATION AND BEHAVIOR

F.8.6 Understand* that an organism is regulated both internally and externally

F.8.7 Understand* that an organism's behavior evolves through adaptation to its environment

http://www.dpi.state.wi.us/standards/scif8.html

6/15/2004
F.12.8 Using the science themes*, infer* changes in ecosystems prompted by the introduction of new species, environmental conditions, chemicals, and air, water, or earth pollution

MATTER, ENERGY AND ORGANIZATION IN LIVING SYSTEMS

F.12.9 Using the science themes*, investigate* energy* systems* (related to food chains) to show* how energy is stored in food (plants and animals) and how energy is released by digestion and metabolism

F.12.10 Understand* the impact of energy* on organisms in living systems*

F.12.11 Investigate* how the complexity and organization* of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy* used to sustain an organism

THE BEHAVIOR OF ORGANISMS

F.12.12 Trace how the sensory and nervous systems* of various organisms react to the internal and external environment and transmit survival or learning stimuli to cause changes in behavior or responses

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Submit questions or comments regarding this website to: Edy Paske, Webmaster, Academic Excellence Division

TWELFTH GRADE

Performance Standards

By the end of grade twelve, students will:

THE CELL

F.12.1 Evaluate* the normal structures and the general and special functions* of cells in single-celled and multiple-celled organisms

F.12.2 Understand* how cells differentiate and how cells are regulated

THE MOLECULAR BASIS OF HEREDITY

F.12.3 Explain* current scientific ideas and information about the molecular and genetic basis of heredity

F.12.4 State the relationships between functions* of the cell and functions of the organism as related to genetics and heredity

BIOLOGICAL EVOLUTION*

F.12.5 Understand* the theory of evolution*, natural selection, and biological classification

F.12.6 Using concepts of evolution* and heredity, account for changes* in species and the diversity of species, include the influence of these changes on science, e.g. breeding of plants or animals

THE INTERDEPENDENCE OF ORGANISMS

F.12.7 Investigate* how organisms both cooperate and compete in ecosystems

http://www.dpi.state.wi.us/standards/scif12.html  
6/15/2004
Revised 7th Grade Science Units-Details
This document designates themes for instruction at 7th and 8th grade and identifies AASD performance standards that will be addressed within each of the themes.

Instructional units for 7th grade science (w/ performance standards)

Building Blocks:

- Identifies methods to separate mixtures into their component parts
- Explains that substances react chemically in characteristic ways with other substances to form new substances
- Demonstrates factors that influence reaction rates
- Explains that oxidation involves the combining of oxygen with other substances
- Explains that many elements can be grouped according to similar properties
- Identifies substances that contain only one kind of atom as pure elements, and explain that 100+ different kinds of elements exist
- Explains that elements do not break down by normal laboratory reactions
- Describes the levels of organization in living system, including cells, tissues, organs, organ systems, organisms, and ecosystems; and the complementary nature of structure and function at each level

Energy, A Hot Topic

- Explains how heat can be transferred through conduction, convection, and radiation
- Describes the sun as the principle energy source for phenomena on Earth’s surface
- Illustrates that energy is a property of many substances
- Illustrates that heat flows from warmer objects to cooler ones until both objects reach the same temperature
- Explains that just as electric currents can produce magnetic forces, magnets can cause electric currents

The Changing Earth:

REVISED: 6 May 2003
• Illustrates how land forms are created through constructive forces
• Understands general concepts related to gravitational force
• Explains that Earth's crust is divided into plates that move at extremely slow rates in response to movements in the mantle
• Illustrates processes involved in the rock cycle
• Differentiates between sedimentary, igneous, and metamorphic rocks and the evidence of minerals, temperatures and forces that created them
• Explains that vibrations move at different speeds in different materials, have different wavelengths, and set up wave-like disturbances that spread away from the source
• Identifies layers of the Earth, including a core, mantle, and lithosphere

Why I Should Care:

• Explains the processes involved in the water cycle
• Analyzes the influence living organisms have on Earth's water (hydrosphere) and atmospheric systems
• Identifies factors that impact the number and types of organisms an ecosystem can support
• Investigates human impact on Earth's resources over the past 100 years
• Explains that the basis for efforts to conserve/recycle renewable and non-renewable resources are a result of past use
• Explains how multicellular organisms have specialized cells, tissues, organs, and organ systems that perform specialized functions (adaptations)

Instructional Units for 8th grade (w/ performance standards)
This document takes identified themes for instruction at 7th and 8th grade and identifies instructional units that incorporate AASD performance standards. Primary topics for the unit are shown in the boxes immediately following the titles.

**Instructional Units for 7th grade science**

**Building Blocks**

- Elements and the periodic table
- Solids/liquids/gases
- Properties of matter (reinforce measurement)
- Mixtures/solutions/compounds
- Bonding (ionic & covalent)
- Mixture separation (physical & chemical)
- Levels of organization (subatomic – biosphere+)

- Cells & other levels of organization (will need to be developed)
- Elements (K: cpt3, cpt4)
- Periodic table (F:  
- Chromatography – mixture separation
- Mixtures, changes, bonding (K: cpt1)
- Solids, liquids, gases (K: cpt2)
- Periodic table bingo; alien periodic table;
- Element reports/models
- Element scavenger hunt
- Dilutions (factors of 10)
- Measurement

14 May 03
DRAFT
Energy

- What is Energy
- Forms of Energy
- Potential/kinetic
- Energy conversions

- Define E (work) run up the stairs stuff
- Distinguish forms of E (H: cpt3, cpt1, cpt4) (E: cpt6)
- Mousetrap cars
- Roller Coasters
- Energy conversions – Rube Goldberg
- KEEP activity binder & opportunity for course
- Life: Energy pyramids (E: cpt2)
  The Bucket Brigade
- Nutrition – calories (K: cpt4)
- Renewable / non-renewable E (Kaukauna site, Wrightstown, wind E)
- HEAT: insulation, evaporative cooling. Keep the Heat (S.O.)
  Adaptations of certain animals. Food coloring demo of convection
  (Janelle) (K: p94-95; F: cpt1)

14 May 03
DRAFT
The Changing Earth

- Rock cycle
- Density, convection, and gravity
- Plate tectonics

- Rock cycle (crayon lab for processes in the rock cycle)
- Mineral testing (for important rock forming minerals only)
- Density & convection
- Gravity (settling, movement to center)
- Plate tectonics (NO vinegar volcanoes!!)
- Video: Born of Fire
- Viscosity races 😊
- Earthquakes: wavelengths, ‘slinkies’, earthquake generators, resistance building activity
- Layers of the Earth
- Weis Earth Science Museum
Why I Should Care!

- Water cycle & processes
- Ecosystems
- Carbon cycle, other cycles
- Environmental issues

- Water cycle & processes (H:cpt1; E: cpt1) (Project WET)
- Bottle bio to demonstrate processes
- Ecosystems: adaptation (E:p.31), symbiotic relationships, 'create a critter,' carrying capacity (E). [possibly do a few dissections here]
- Lots of Project Wild activities
- Atmospheric issues around build up of CO2; photosynthesis & respiration cycle
- Pollution (E: cpt 4 & 5)
- Issues to investigate: global warming, greenhouse effect, rainforest cutting, fossil fuels, DDT, Fox River (pcb), non-point source pollution and L. Winnebago (fertilizers & algae growth); landfills, CWD, etc.
Revised 8th Grade Science Units-Details
Lost in Space:

- Explains how heat can be transferred through conduction, convection, and radiation
- Identifies the sun as the principle energy source for phenomena on Earth’s surface
- Compares different wavelengths within the range of visible light as perceived as different colors
- Examines the electromagnetic spectrum and compare and contrast the difference in wavelength recognizing that only a small portion is visible and perceived by the human eye
- Understands general concepts related to gravitational force
- Explains gravitational force keeps planets in orbit around the sun, and moons in orbit around the planets
- Explains that many billions of galaxies exist in the universe
- Investigates the history and contributions of the space program
- Describes the composition and structure of Earth’s atmosphere
- Illustrates how the tilt of Earth’s axis and Earth’s revolution around the sun affect seasons and weather patterns
- Distinguishes characteristics of our sun and its position in the universe
- Illustrates characteristics and movement patterns of asteroids, comets and meteors

Weather . . . or not:

- Explains how heat can be transferred through conduction, convection, and radiation
- Compares different wavelengths within the range of visible light as perceived as different colors
- Examines the electromagnetic spectrum and compare and contrast the difference in wavelength recognizing that only a small portion is visible and perceived by the human eye
- Identifies the sun as the principle energy source for phenomena on Earth’s surface
- Describes how land forms are created through destructive forces
- Illustrates how the tilt of Earth’s axis and Earth’s revolution around the sun affect seasons and weather patterns
- Uses meteorological tools and interpret a weather map or station model

**Changes Over Time**

- Describes factors that can impact Earth’s climate
- Explains how fossils provide important evidence of how life and environmental conditions have changed on Earth over time
- Describes how the fossil record, through geologic evidence, documents the appearance, diversification and extinction of many life forms
- Describes how successive layers of sedimentary rock and the fossils contained within them can be used to confirm the age, history, and changing life forms of Earth, and how this evidence is affected by the folding, breaking and splitting of layers
- Summarizes the evidence of common ancestry, chemical processes, and internal structures that demonstrate unity among organisms

**Land Use**

- Identifies the sun as a principle energy source for phenomena on Earth’s surface
- Investigates components of soil texture, fertility, and resistance to erosion
- Describes how land forms are created through destructive forces
- Describes how disease in organisms can be caused by intrinsic failures of the system or infection by other organisms
- Investigates the human uses of Earth’s resources over the past 100 years
- Describes how organisms react to internal and environmental stimuli through behavior response
Genetics:

- Examines the concept of extinction and its importance in biological evolution
- Investigates basic ideas related to biological evolution

- Differentiates between asexual and sexual reproduction
- Compares the variety of animal and plant body plans and internal structures that serve specific functions for survival
- Explains that the characteristics of an organism can be described in terms of a combination of traits
- Explains how dominant and recessive traits contribute to genetic variation within a species
- Investigates, evidence that supports the idea that there is a unity among organisms despite the fact that some species look very different
- Explains that evidence for common ancestry, chemical processes, and internal structures demonstrates unity among organisms
- Explains that hereditary information is contained in genes, each of which carries a single unit of information; inherited traits of an individual can be determined by either one or many genes; and a single gene can influence more than one trait
Instructional Units for 8th grade science

Rings Around the Sun (formerly, Lost in Space)

- Convection/conduction/radiation
- Electromagnetic spectrum
- Properties of the sun and its relationship to other celestial bodies (esp. Earth)

- Take an approach from the universe in (Powers of 10 video)
- Light: make a telescope
- Solar energy – solar cookers
- Electromagnetic spectrum: guest speakers (who use various types of technology)
- Match the wave length to the technology
- The view on the way in: planets.
- The space station challenge: to live on another planet
- International Space Station Discovery (Einstein ms)
- Hubble
- Video: Moon Shot
- Seasons (dome activity) – sun/earth relationships
- Pendulums – gravitational tilt

14 May 03
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Weather... or Not

- Weather/meteorology
- Weathering/erosion

- Weather patterns in the atmosphere
- Tools: make thermometers, anemometers, weather stations, determine dew point,
- Simple weather mapping (fronts, highs & lows,
- Revisit conduction, convection, radiation (the science behind tornadoes, hurricanes, etc)
- NOVA: lightning Energy transfer
- High Cliff activities (see Kristie)
Earth: Our Primary Resource (formerly 'Land Use')

- Soils
- Watersheds
- Land use
- Natural resources: use & abuse

- Landforms topo maps
- Soil maps: texture, porosity, composition
- Design a community: watershed in a box (Kristie)
- Dams
- Barriers to migration
- Agriculture today: IPM, chemicals & fertilizers, mega-farms (leading to a discussion of disease & organisms), parasite stories (from Nate)
- Field trips: UW Farms, Hillshire (?)
- City planning: run-off, green space, diseases & problems in towns
- Resource use: forestry, water, mining (issues: CWD, Dutch elm & more current tree diseases, gypsy moths, etc.), wildlife (deer, sturgeon, frogs, sea turtles, etc)

14 May 03
DRAFT
Changes Over Time

- Geologic time
- Fossil life parallel
- Biological change

Geologic timeline
Changes in life forms through geologic time
Fossils (book C)
Fossil casts
Natural selection
Genetics

- Genetic traits: dom/reces; sex-linked
- Chromosomes & alleles
- Ancestry

Book C

- Reebop activity adding an element of natural selection and its effect on future generations
- Timeline of genetic knowledge and important scientists
- Simple Mendelian genetics: punnet squares 'kid lab', reebops, wheel of traits, tasting lab (PTC), pedigrees, 'I am my own grandpa!
- Issues: cloning, human genome
- Forensic science with genetics
- Fast plants – using seeds from 7th grade!
- Pedigrees
- Nancy A's video on common ancestry

14 May 03
DRAFT
Revised 7th Grade Science Standards
Seventh Grade Science

Description
This class is an inquiry-based science course that focuses on six major themes in science: energy, forces, changes over time, cycles, interactions, and patterns. These themes are explored through the study of integrated topics: the building blocks of life (elements, matter, cells); the energy of life (forms of energy, energy conversions, food chains); the changing Earth (rock cycle, Earth forces); and Earth systems and cycles (water cycle, ecosystems, environmental issues). Students gain an understanding of the processes of science as well as content knowledge. Laboratory work reinforces course content and encourages the development of observation and critical thinking skills.

Credits

Prerequisites

Textbooks/Resources

Required Assessments
Performance-based inquiry design.

Board Approved

Revised

AASD Science Goals for K-12 Students

➢ Students will know about science themes and connect and integrate them into what they know about themselves and the world around them.
➢ Students will realize that scientific knowledge is public, replicable, and continually undergoing revision and refinement based on new experiments and data.
➢ Students will realize that science includes questioning, forming hypotheses, collecting and analyzing data, reaching conclusions, evaluating results, and communicating procedures and findings to others.
➢ Students will use science to explain and predict changes that occur around them.
➢ Students will use science to evaluate consequences in order to make responsible choices.
➢ Students will use their knowledge of science concepts and processes in making informed choices regarding their lifestyles and the impact they have on their environment, and enhance their natural curiosity about their environment.
➢ Students will understand that science and technology affect Earth's systems and provide solutions to human problems.
➢ Students will use science to analyze topics related to personal health, environment, and management of resources; they will help evaluate the merits of alternative courses of action.
### AASD Science Standards

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Science Connections</td>
<td>Students in the AASD will understand that there are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations; constancy, change, and measurement; evolution, equilibrium, and energy; and form and function among scientific disciplines.</td>
</tr>
<tr>
<td>B. Nature of Science</td>
<td>Students in the AASD will understand that science is ongoing and inventive, and that scientific understandings have changed over time as new evidence is found.</td>
</tr>
<tr>
<td>C. Science Inquiry</td>
<td>Students in the AASD will investigate questions using scientific methods and tools, revise their personal understanding to accommodate knowledge, and communicate these understandings to others.</td>
</tr>
<tr>
<td>D. Physical Science</td>
<td>Students in the AASD will demonstrate an understanding of the physical and chemical properties of matter, the forms and properties of energy, and the ways in which matter and energy interact.</td>
</tr>
<tr>
<td>E. Earth &amp; Space Science</td>
<td>Students in the AASD will demonstrate an understanding of the structure and systems of Earth and other bodies in the universe and their interactions.</td>
</tr>
<tr>
<td>F. Life &amp; Environmental Science</td>
<td>Students in the AASD will demonstrate an understanding of the characteristics and structures of living things, the processes of life, and how living things interact with one another and their environment.</td>
</tr>
<tr>
<td>G. Science Applications</td>
<td>Students in the AASD will demonstrate an understanding of the relationship between science and technology and the ways in which that relationship influences human activities.</td>
</tr>
<tr>
<td>H. Science in Social &amp; Personal Perspectives</td>
<td>Students in the AASD will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.</td>
</tr>
<tr>
<td>Course Objectives</td>
<td>Performance Indicators</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1. Connect and integrate energy concepts into an understanding of the natural world</td>
<td>Performance will be satisfactory when the student:</td>
</tr>
<tr>
<td></td>
<td>a. Explains how heat can be transferred through conduction, convection, and radiation.</td>
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<td></td>
<td>b. Describes the sun as the principle energy source for phenomena on Earth's surface.</td>
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<td></td>
<td>c. Illustrates that energy is a property of many substances.</td>
</tr>
<tr>
<td></td>
<td>d. Illustrates that heat flows from warmer objects to cooler ones until both objects reach the same temperature.</td>
</tr>
<tr>
<td></td>
<td>e. Designs investigations to test the usefulness and limitations of a model.</td>
</tr>
<tr>
<td></td>
<td>f. Explains how the general rules of science apply to the development and use of evidence in models and applications.</td>
</tr>
<tr>
<td></td>
<td>g. Shows evidence of how science and technology are interdependent using examples from personally conducted investigations.</td>
</tr>
</tbody>
</table>

Above objective aligned with AASD science standards: science connections, the nature of science, science inquiry, physical science, earth and space science, life and environmental science, science applications, and science in social and personal perspectives.
<table>
<thead>
<tr>
<th>Course Objectives</th>
<th>Performance Indicators</th>
<th>Classroom Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Use scientific reasoning to investigate the forces that shape the Earth</td>
<td>Performance will be satisfactory when the student:</td>
<td>• Quizzes and tests</td>
</tr>
<tr>
<td></td>
<td>a. Illustrates how land forms are created through constructive forces</td>
<td>• Projects</td>
</tr>
<tr>
<td></td>
<td>b. Explains general concepts related to gravitational force.</td>
<td>• Laboratory experiences &amp; reports</td>
</tr>
<tr>
<td></td>
<td>c. Explains how models and their interpretation changes as new evidence arise.</td>
<td>• Research and class presentations</td>
</tr>
<tr>
<td></td>
<td>d. Identifies and investigates careers in science or technology and the skills and academic courses needed for the career.</td>
<td>• Performance assessment (inquiry focused)</td>
</tr>
<tr>
<td>Above objective aligned with AASSD science standards: science connections, the nature of science, science inquiry, physical science, earth and space science, life and environmental science, science applications, and science in social and personal perspectives.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Objectives</th>
<th>Performance Indicators</th>
<th>Classroom Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Examine changes that occur to Earth over time</td>
<td>Performance will be satisfactory when the student:</td>
<td>• Quizzes and tests</td>
</tr>
<tr>
<td></td>
<td>a. Explains that Earth’s crust is divided into plates that move. at extremely slow rates in response to movements in the mantle.</td>
<td>• Projects</td>
</tr>
<tr>
<td></td>
<td>b. Evaluates the scientific evidence used in various media.</td>
<td>• Laboratory experiences &amp; reports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Research and class presentations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Performance assessment (inquiry focused)</td>
</tr>
<tr>
<td>Above objective aligned with AASSD science standards: science connections, the nature of science, science inquiry, physical science, earth and space science, life and environmental science, science applications, and science in social and personal perspectives.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Course Objectives

#### 4. Examine cycles in the natural world

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Classroom Assessments</th>
</tr>
</thead>
</table>
| Performance will be satisfactory when the student:  
a. Illustrates the processes involved in the rock cycle.  
b. Explains the processes involved in the water cycle.  
c. Differentiates between sedimentary, igneous, metamorphic rocks and the evidence of minerals, temperatures and forces that created them.  
d. Identifies data and locates sources of information to answer questions. |  
- Quizzes and tests  
- Projects  
- Laboratory experiences & reports  
- Research and class presentations  
- Performance assessment (inquiry focused) |

Above objective aligned with AASD science standards: science connections, the nature of science, science inquiry, physical science, earth and space science, life and environmental science, science applications, and science in social and personal perspectives.

### Course Objectives

#### 5. Recognize interactions that occur in the natural world

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Classroom Assessments</th>
</tr>
</thead>
</table>
| Performance will be satisfactory when the student:  
a. Identifies methods to separate mixtures into their component parts.  
b. Explains that substances react chemically in characteristics ways with other substances to form new substances.  
c. Analyzes the influence living organisms have on Earth’s water and atmospheric systems.  
d. Identifies factors that impact the number and types of organisms an ecosystem can support. Investigates human impact on Earth’s resources over the past 100 years.  
e. Explains that the basis for efforts to conserve/ recycle renewable and non-renewable resources is a result of past use.  
f. Designs and conducts investigations that provide quantitative or qualitative data to answer questions.  
g. Predicts results of investigations through observation. |  
- Quizzes and tests  
- Projects  
- Laboratory experiences & reports  
- Research and class presentations  
- Performance assessment (inquiry focused) |

Above objective aligned with AASD science standards: science connections, the nature of science, science inquiry, physical science, earth and space science, life and environmental science, science applications, and science in social and personal perspectives.
<table>
<thead>
<tr>
<th>Course Objectives</th>
<th>Performance Indicators</th>
<th>Classroom Assessments</th>
</tr>
</thead>
</table>
| 6. Recognize the variety of patterns that occur in the natural world. | Performance will be satisfactory when the student:  
a. Explains that many elements can be grouped according to similar properties.  
b. Identifies substances that contain only one kind of atom as pure elements, and explain that 100 different kinds of elements exist  
c. Explains that elements do not break down by normal laboratory reactions.  
d. Explains ways in which light interacts with matter.  
e. Explains that vibrations move at different speeds in different materials, have different wavelengths, and set up wave-like disturbances that spread away from the source.  
f. Identify layers of Earth, including a core, mantle, and lithosphere.  
g. Describe the levels of organization in living systems, including cells, tissues, organs, organ systems, organisms, and ecosystems; and the complementary nature of structure and function at each level.  
h. Explain how multicellular organisms have specialized cells, tissues, organs, and organ systems that perform specialized functions.  
i. Evaluates, explains, and validates questions, hypotheses, and conclusions of investigations. | • Quizzes and tests  
• Projects  
• Laboratory experiences & reports  
• Research and class presentations  
• Performance assessment (inquiry focused) |

Above objective aligned with AASD science standards: science connections, the nature of science, science inquiry, physical science, earth and space science, life and environmental science, science applications, and science in social and personal perspectives.
Revised 8th Grade Science Standards
Students will use science to analyze topics related to personal health, environment, and management of resources. They will help evaluate the

Students will understand that science and technology are related and provide solutions to human problems.

Students will use their knowledge of science concepts and processes in making informed choices regarding their lifestyles and the impact they

Students will use science to evaluate consequences in order to make responsible choices.

Students will use science to explain and predict changes that occur around them.

Students will realize that science includes questioning, forming hypotheses, collecting and analyzing data, reaching conclusions, evaluating results, and communicating procedures and findings to others.

Students will realize that scientific knowledge is public, replicable, and continually undergoing revision and refinement based on new evidence.

Students will know about science themes and concepts and integrate them into what they know about themselves and the world around them.

AASD Science Goals for K-11 Students

Revised

Board Approved

Required Assessments

Textbooks/Resources

Prerequisites

Credits

Eighth Grade Science

Eighth Grade Science

This class is an inquiry-based science course that focuses on six major themes in science: energy, forces, change over time, space, interactions, and patterns. These themes are explored through the study of Earth's changing surface, weather and climate, astronomy, chemistry, interactions, and energy systems. Students will learn how to use the Earth's resources (agriculture, aquaculture, and renewable energy) and use planning, decision-making, and technological processes in making informed choices regarding their lifestyles and the impact they have on their environment, and evaluate the consequences of these choices in order to make responsible choices.

Performance-based inquiry design

Performance-based inquiry design
<table>
<thead>
<tr>
<th>Personal Perspectives</th>
<th>H. Science in Social &amp; Science Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students in the ASASD will use scientific information and skills to make decisions about themselves. Wisconsin.</td>
<td>Students in the ASASD will demonstrate an understanding of the relationship between science and technology.</td>
</tr>
<tr>
<td>and the ways in which that relationships influences human activities.</td>
<td>and the ways in which that relationships influences human activities.</td>
</tr>
<tr>
<td>The processes of life, and how living things interact with one another and their environment.</td>
<td>The processes of life, and how living things interact with one another and their environment.</td>
</tr>
<tr>
<td>Bodies in the universe and their interactions.</td>
<td>Bodies in the universe and their interactions.</td>
</tr>
<tr>
<td>Students in the ASASD will demoststrate an understanding of the structure and systems of Earth and other</td>
<td>Students in the ASASD will demoststrate an understanding of the structure and systems of Earth and other</td>
</tr>
<tr>
<td>Forms and properties of energy, and the ways in which matter and energy interact.</td>
<td>Forms and properties of energy, and the ways in which matter and energy interact.</td>
</tr>
<tr>
<td>Students in the ASASD will demonstrate an understanding of the physical and chemical properties of matter, the</td>
<td>Students in the ASASD will demonstrate an understanding of the physical and chemical properties of matter, the</td>
</tr>
<tr>
<td>understanding to accommodate knowledge, and communicate these understandings to others.</td>
<td>understanding to accommodate knowledge, and communicate these understandings to others.</td>
</tr>
<tr>
<td>Students in the ASASD will investigate questions using scientific methods and tools, resolve their personal</td>
<td>Students in the ASASD will investigate questions using scientific methods and tools, resolve their personal</td>
</tr>
<tr>
<td>have changed over time as new evidence is found.</td>
<td>have changed over time as new evidence is found.</td>
</tr>
<tr>
<td>Students in the ASASD will understand that science is ongoing and inventive, and that scientific understandings</td>
<td>Students in the ASASD will understand that science is ongoing and inventive, and that scientific understandings</td>
</tr>
<tr>
<td>and empirical and norm and function among scientific disciplines.</td>
<td>and empirical and norm and function among scientific disciplines.</td>
</tr>
<tr>
<td>Interactions: evidence, models, and explanations. Consistency, change, and measurement. Elevation, equilibrium,</td>
<td>Interactions: evidence, models, and explanations. Consistency, change, and measurement. Elevation, equilibrium,</td>
</tr>
<tr>
<td>Students in the ASASD will understand that there are underlying themes: systems, order, organization, and</td>
<td>Students in the ASASD will understand that there are underlying themes: systems, order, organization, and</td>
</tr>
</tbody>
</table>

Eighth Grade Science

AASD Science Standards

AASD Science Curriculum
<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Connect and integrate energy concepts into an everyday context</td>
</tr>
<tr>
<td></td>
<td>2. Examine how heat can be transferred through conduction, convection, and radiation</td>
</tr>
<tr>
<td></td>
<td>3. Understand that small portion is visible and perceived by the human eye</td>
</tr>
<tr>
<td></td>
<td>4. Designs investigations to test the usefulness and limitations of phenomena on Earth's surface</td>
</tr>
<tr>
<td></td>
<td>5. Experiments how the general rules of science apply to the model</td>
</tr>
<tr>
<td></td>
<td>6. Designs investigations to test the usefulness and limitations of paradigms in wave length recognizing that only a few light as perceived as different colors</td>
</tr>
<tr>
<td></td>
<td>7. Examines the electromagnetic spectrum and compares and contrasts differences in wave length within the range of visible light as perceived</td>
</tr>
<tr>
<td></td>
<td>8. Quizzes and tests</td>
</tr>
<tr>
<td></td>
<td>Laboratory experiences &amp; reports</td>
</tr>
<tr>
<td></td>
<td>Research and class presentations</td>
</tr>
<tr>
<td></td>
<td>Performance assessment (inquiry focused)</td>
</tr>
</tbody>
</table>

- Uses language to predict future events or changes in the natural world.
<table>
<thead>
<tr>
<th>Perspectives</th>
<th>Performance Indicators</th>
<th>Classroom Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science, earth and space science, life and environmental science, science applications, and science in social and personal</td>
<td>- Identifies leaders in science or technology careers. - Identifies examples of themes that are included or excluded. - Describes how models and their interpretation change as new evidence arises. - Explores how forces and their interpretation change through discussion. - Describes how interactions are created through destructive</td>
<td>- Focuses on performance assessment (rigor). - Research and class presentations. - Laboratory experiences &amp; reports. - Projects. - Quizzes and tests.</td>
</tr>
<tr>
<td>AASD Science Curriculum</td>
<td>- Investigates components of soil texture, fertility, and around the sun, moon, and orbit around the planets. - Explains that gravitational force keeps planets in orbit. - Forces, magnets, and electricity can cause electrical currents. - Explains that electrical currents can produce magnetic fields. - Understands general concepts related to gravitational force.</td>
<td>Eighth Grade Science</td>
</tr>
</tbody>
</table>
above objective aligned with asd science standards: science connections, the nature of science, science inquiry, physical science, earth and space science, life and environmental science, science applications, and science in social and personal perspectives.

<table>
<thead>
<tr>
<th>Course Objectives</th>
<th>Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Evaluate the scientific evidence used in various media.</td>
<td></td>
</tr>
<tr>
<td>2. Explain how scientific knowledge applies to social issues.</td>
<td></td>
</tr>
<tr>
<td>3. Recognize the many billions of galaxies exist in the universe.</td>
<td></td>
</tr>
<tr>
<td>4. Investigate basic ideas related to biological evolution.</td>
<td></td>
</tr>
<tr>
<td>5. Examine the concept of extinction and its importance in understanding organisms.</td>
<td></td>
</tr>
<tr>
<td>6. Summarize the evidence of common ancestry, chemical evolutionary layers.</td>
<td></td>
</tr>
</tbody>
</table>

Performance Indicators:

- Fossil records are used to construct an evolutionary tree of life.
- Many life forms. and environmental conditions have changed on Earth over time.
- Time is documented by the appearance, displacement, and extinction of fossil records.
- Examine how the fossil record, through geologic evidence, demonstrates how successful layers of sedimentary rock can occur on Earth over time.
- The evidence is affected by the folding, breaking and spilling of age, history, and changing the forms of Earth, and how this evidence is used to confirm the fossil records with within them can be used to construct the evolution of life over time.
### Course Objectives

- Examine cycles in the natural world
- Differentiate between asexual and sexual reproduction
- Identify data and locate sources of information to answer questions

### Classroom Assessments

- Performance indicators

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Classroom Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Research and class presentations</td>
</tr>
<tr>
<td>Rubric</td>
<td>Laboratory experiences &amp; reports</td>
</tr>
<tr>
<td>Quizzes and tests</td>
<td>Focuses on performance assessment (Inquiry)</td>
</tr>
<tr>
<td>Classroom Assessments</td>
<td>Performance Indicators</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Research and class presentations</td>
<td>- Investigates a specific local problem to which there has been a scientific or technological solution.</td>
</tr>
<tr>
<td>Laboratory experiences &amp; reports</td>
<td>- Proposes a design (or re-design) of an applied science model or an innovation that will have an impact in the community.</td>
</tr>
<tr>
<td>Projects</td>
<td>- Shows evidence of how science and technology are independently used to solve problems.</td>
</tr>
<tr>
<td>Quizzes and tests</td>
<td>- Raises further questions that still need to be answered.</td>
</tr>
</tbody>
</table>

**Focused (required):**
- Performance assessment (rubric)
- Research and class presentations
- Lab options/experiences & reports
- Projects
- Quizzes and tests

**Earth and space science, life and environmental science, science applications, and science in social and personal perspectives.**

Above objectives aligned with AASLD science standards: Science connections, the nature of science, science inquiry, physical science,
Earth and space science, life and environmental science, science applications, and science in society, ethics, and personal perspectives

Above objective aligned with ASID science standards: science connections, the nature of science, science inquiry, physical science

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Performance Indicators</th>
<th>Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group decision</td>
<td>Presses a scientific solution to a problem involving earth and space science, life and environmental science, or physical science and different organisms despite the fact that some species look very similar.</td>
<td>Investigates evidence that supports the idea that there is a natural world. Patterns that occur in the natural world.</td>
</tr>
<tr>
<td>Research and class presentations</td>
<td>Explains how dominant and recessive traits combine to generate new organisms in terms of a combination of traits.</td>
<td>Recognizes the variety of life on Earth, the atmosphere, and the universe.</td>
</tr>
<tr>
<td>Laboratory experiences &amp; reports</td>
<td>Explains how the characteristics of an organism can be inherited. Selection model.</td>
<td></td>
</tr>
<tr>
<td>Projects</td>
<td>Compares the various types of animal and plant body plans and characteristics with those of other species.</td>
<td></td>
</tr>
<tr>
<td>Quizzes and tests</td>
<td>Differentiates characteristics between similar species.</td>
<td></td>
</tr>
</tbody>
</table>

Classroom Assessments

- Eighth grade science
- Performance Indicators
- Course Objectives

ASID Science Curriculum
Old Appleton Area School District

Science Standards
The AASD K-12 Science Standards are organized into primary, intermediate, middle, and high school levels and aligned with the Wisconsin State Standards. These standards will provide the framework for developing Appleton Area School District grade level/course curricula.

Introduction
May, 1999
K-12 Science Standards Committee

apply scientific thinking, reasoning, and knowledge throughout their lives.

Students will become scientifically literate and will become informed and informed individuals. They will use scientific process and principles to make informed decisions. The study of science encourages students to examine the world around them.

MISSION
Students will use science to analyze topics related to personal health, environment, and solutions to human problems.

Students will understand that science and technology affect the Earth’s systems and provide enhanced their natural curiosity about their environment.

Students will use their knowledge of science concepts and processes in making informed choices regarding their lifestyles and the impact they have on their environment, and choices to make responsible choices.

Students will use science to evaluate consequences in order to make responsible choices.

Students will use science to explain and predict changes that occur around them.

Students will realize that science includes questioning, forming hypotheses, collecting and communicating procedures and findings to others.

Students will realize that scientific knowledge is public, replicable, and continually undergoing revision and refinement based on new experiments and data.

Students will know about themselves and the world around them.

Students will know about science themes and connect and integrate them into what they

ASD GOALS FOR K-12 SCIENCE
<table>
<thead>
<tr>
<th>Evidence</th>
<th>Specific science-related problem.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show how the ideas and Themes of life and work are related to the scientific method.</td>
<td></td>
</tr>
<tr>
<td>Use models and explanations to predict actions and events.</td>
<td></td>
</tr>
<tr>
<td>Use evidence to show that the natural world changes.</td>
<td></td>
</tr>
<tr>
<td>Specifically, evidence from systems, Models, and Explanations.</td>
<td></td>
</tr>
<tr>
<td>Collect evidence to show that &quot;8&quot; is changed.</td>
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</tr>
<tr>
<td>By collecting and organizing evidence, the problem is identified.</td>
<td></td>
</tr>
<tr>
<td>By collecting and organizing evidence, the problem is identified.</td>
<td></td>
</tr>
<tr>
<td>By collecting and organizing evidence, the problem is identified.</td>
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</tr>
<tr>
<td>By collecting and organizing evidence, the problem is identified.</td>
<td></td>
</tr>
<tr>
<td>By collecting and organizing evidence, the problem is identified.</td>
<td></td>
</tr>
</tbody>
</table>

Students in Wisconsin will understand that these are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations. Connections, change, and measurement; evolution, equilibrium, and energy; form and function among scientific disciplines.
| Application | Evidence at issue | Explanation of how models are developed and use of scientific evidence to support | Evidence needed in planning and the development of major ideas | describe the people and their culture who have contributed to the development of major ideas and their influence.  
Develop an understanding of how discoveries and evidence lead to major scientific developments.
Identify and describe the conditions that have contributed to the development of major scientific ideas.
Acquire information about how evidence was used to develop major ideas.
Plan investigations to help answer science-related questions and use references to help answer.
Acquire information about science.

<table>
<thead>
<tr>
<th>Students will</th>
<th>By the end of grade twelve, ASID</th>
<th>By the end of grade eight, ASID</th>
<th>By the end of grade six, ASID</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evidence is found.

Students in Wisconsin will understand that science is one of our ongoing and inventive, and that scientific understandings have changed over time as new evidence is found.

**STRAND B: NATURE OF SCIENCE**
<table>
<thead>
<tr>
<th><strong>STRAND C: SCIENCE INQUIRY</strong></th>
<th><strong>ASK ADDITIONAL QUESTIONS TO HELP ANSWER QUESTIONS OF INTEREST TO SCIENTISTS, TEACHERS, AND OTHER AUDIENCES</strong></th>
<th><strong>COMMUNICATE RESULTS OF INVESTIGATIONS IN WAYS THAT SUPPORT CONCLUSIONS WITH LOGICAL ARGUMENTS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROBLEM SOLVING</strong></td>
<td><strong>Ask additional questions that might help focus on further inquiries</strong></td>
<td><strong>Arrange results of investigations in ways that support conclusions with logical arguments</strong></td>
</tr>
<tr>
<td><strong>COLLECTION</strong></td>
<td><strong>Formulate the degree of precision of conclusions of investigations</strong></td>
<td><strong>Provide evidence to explain results and raise further questions.</strong></td>
</tr>
<tr>
<td><strong>DESIGN AND CONDUCT RESPONSIBLY AND EFFECTIVELY</strong></td>
<td><strong>Develop means to design and conduct responsible and effective investigations.</strong></td>
<td><strong>Design and present data, explanations, interpretations, and observations of procedures and materials available.</strong></td>
</tr>
<tr>
<td><strong>DATA COLLECTION</strong></td>
<td><strong>Develop record systems to organize and record information.</strong></td>
<td><strong>Explain data, explanations, interpretations, and observations of procedures and materials available.</strong></td>
</tr>
<tr>
<td><strong>DATA ANALYSIS AND INTERPRETATION</strong></td>
<td><strong>Design and conduct investigations that provide evidence to answer questions of interest to scientists, teachers, and other audiences.</strong></td>
<td><strong>Design and conduct investigations that provide evidence to answer questions of interest to scientists, teachers, and other audiences.</strong></td>
</tr>
<tr>
<td><strong>COMMUNICATION</strong></td>
<td><strong>Design and conduct investigations that provide evidence to answer questions of interest to scientists, teachers, and other audiences.</strong></td>
<td><strong>Design and conduct investigations that provide evidence to answer questions of interest to scientists, teachers, and other audiences.</strong></td>
</tr>
<tr>
<td><strong>SCIENTIFIC THINKING</strong></td>
<td><strong>Ask additional questions that might help focus on further inquiries.</strong></td>
<td><strong>Arrange results of investigations in ways that support conclusions with logical arguments.</strong></td>
</tr>
<tr>
<td><strong>ASD Board Approved June 1999</strong></td>
<td><strong>By the end of Grade Eight, ASD Students will investigate questions using scientific methods and tools.</strong></td>
<td><strong>By the end of Grade Eight, ASD Students will investigate questions using scientific methods and tools.</strong></td>
</tr>
<tr>
<td>Motion and Forces</td>
<td>Motion and Forces</td>
<td>Motion and Forces</td>
</tr>
<tr>
<td>-------------------</td>
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<td>-------------------</td>
</tr>
<tr>
<td>Differentiate the fundamental forces</td>
<td>Explain the situations in relation to real life</td>
<td>Explain how models of the universe impact their explanatory frameworks</td>
</tr>
<tr>
<td>Interactions:</td>
<td>Interactions:</td>
<td>Interactions:</td>
</tr>
<tr>
<td>Identify the forces in chemical and physical systems</td>
<td>Describe the forces acting on objects in motion</td>
<td>Observe and describe objects at rest in motion</td>
</tr>
<tr>
<td>Experiment:</td>
<td>Experiment:</td>
<td>Experiment:</td>
</tr>
<tr>
<td>Change the system with mass and energy in motion</td>
<td>Change the system with mass and energy in motion</td>
<td>Change the system with mass and energy in motion</td>
</tr>
<tr>
<td>Explanations of energy and exchange</td>
<td>Explanations of energy and exchange</td>
<td>Explanations of energy and exchange</td>
</tr>
<tr>
<td>Matrix:</td>
<td>Matrix:</td>
<td>Matrix:</td>
</tr>
<tr>
<td>Students will</td>
<td>Students will</td>
<td>Students will</td>
</tr>
<tr>
<td>By the end of Grade 3, AASD</td>
<td>By the end of Grade 6, AASD</td>
<td>By the end of Grade 9-12</td>
</tr>
</tbody>
</table>

*STRAND D: PHYSICAL SCIENCE*
**STANDARDS: PHYSICAL SCIENCE (continued)**

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
<th>Grade Level</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examine nuclear interactions.</td>
<td>They interact with material radiation, gravity, and sound as properties of electromagnetic science themes and knowledge of science.</td>
<td>6-8</td>
<td>Use models to explain the laws of conservation of energy.</td>
</tr>
<tr>
<td>Examine nuclear interactions.</td>
<td>They interact with material radiation, gravity, and sound as properties of electromagnetic science themes and knowledge of science.</td>
<td>6-8</td>
<td>Use models to explain the laws of conservation of energy.</td>
</tr>
<tr>
<td>Observe substances.</td>
<td>Explain how substances interact with one another to produce new substances.</td>
<td>4-6</td>
<td>Students will be able to explain changes in matter using the concept of chemical and physical reactions.</td>
</tr>
<tr>
<td>Investigate the behaviors of light.</td>
<td>Investigate the chemical and physical reactions of basic substances.</td>
<td>K-3</td>
<td>By the end of grade five, students will be able to describe the characteristics of energy.</td>
</tr>
<tr>
<td>Observe chemical reactions.</td>
<td>Identify the types of chemical reactions using acid/base reactions, oxidation and reduction, and interactions involving endothermic and exothermic reactions.</td>
<td>4-6</td>
<td>By the end of grade six, students will be able to describe the characteristics of energy.</td>
</tr>
<tr>
<td>Observe chemical reactions.</td>
<td>Investigate the behaviors of light.</td>
<td>K-3</td>
<td>Students will be able to describe the characteristics of energy.</td>
</tr>
<tr>
<td>Observe chemical reactions.</td>
<td>Investigate the behaviors of light.</td>
<td>K-3</td>
<td>By the end of grade five, students will be able to describe the characteristics of energy.</td>
</tr>
</tbody>
</table>

**Grades:**
- K-3
- 4-6
- 7-8
- 9-12
<table>
<thead>
<tr>
<th>Earth Science Standards</th>
<th>Grade Level 1</th>
<th>Grade Level 2</th>
<th>Grade Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map of station model, create and interpret a weather</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Use meteorological tools</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Investigate how weather, water and atmospheric systems interact</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Analyze the influence of Earth's surface features on climate</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Describe the distribution and characteristics of major rocks, minerals, and soils</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Identify the seasons and their relationship to changes in Earth's orbit</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Part of the chemical cycle: atmospheres, and living things as an interactive system</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Understand how minor cycle components exist, and nonrenewable resources are a result of past use, and renewable resources are used in fixed amounts and more efficiently</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Year's resources over the past 100 years</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Investigate human use of the Earth's resources over the past 100 years</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Investigate how weather conditions affect people and communities, and renewable resources in the environment</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Investigate nonrenewable resources and sustainable practices</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Describe renewable and nonrenewable resources</td>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
</tbody>
</table>

**Interactions:**
Students in Wisconsin will demonstrate an understanding of the structure and systems of the earth and other bodies in the universe and their interactions.
<table>
<thead>
<tr>
<th>Program</th>
<th>Solar System</th>
<th>Heat and Light</th>
<th>Earth and Beyond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain prominent scientific contributions of the space age.</td>
<td>Investigate the history and evolution of the solar system.</td>
<td>Describe the relationships among the various bodies in the solar system.</td>
<td>Describe the sun as a source of heat and light.</td>
</tr>
<tr>
<td>Earth on Earth. Their implications to geologic and relative ages of the universe and the solar system.</td>
<td>Galaxies, and universe. Their implications to the origin and relative ages of the universe and the solar system.</td>
<td>Compete in the various bodies that the solar system and concepts.</td>
<td>Identify celestial objects and note changes in their patterns.</td>
</tr>
<tr>
<td>Investigate and understand the planets and other members of the solar system.</td>
<td>Investigate and understand the organization of the solar system.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Space**

| Rocks and Fossils can be inferred by studying evolution of the Earth and life. Many aspects of the history and life. | Investigate and understand that. |

**Earth (continued)**

<p>| 9-12 | 7-8 | 4-6 | K-3 |</p>
<table>
<thead>
<tr>
<th>Models the sporangiospore process</th>
<th>Explain how heredity is a characteristic of all living systems.</th>
<th>Give examples of plant and animal life cycles.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate how the instructions within the cells of an organism are carried in the DNA in all organisms.</td>
<td>Explain how cell differentiation and reproduction is regulated through the expression of different genes.</td>
<td>Explain how cells carry out the many functions needed to sustain life.</td>
</tr>
<tr>
<td>Genotypes for variation between cell characteristics of the organism that allow classmates to work with one another and their environment.</td>
<td>Explain how diseases is a breakdown in instructions or functions of an organism.</td>
<td>Explain the basic needs of organisms.</td>
</tr>
<tr>
<td>Explain how the interactions between cell structures and their underlying functions will students will complete the interactive systems by the end of grade six, AASD.</td>
<td>Explain how the interactions between cell structures and their underlying functions will students will complete the interactive systems by the end of grade six, AASD.</td>
<td>Explain how the interactions between cell structures and their underlying functions will students will complete the interactive systems by the end of grade six, AASD.</td>
</tr>
<tr>
<td>By the end of grade nine, AASD.</td>
<td>By the end of grade nine, AASD.</td>
<td>By the end of grade nine, AASD.</td>
</tr>
</tbody>
</table>

**Strand F: Life and Environmental Science**
<table>
<thead>
<tr>
<th>Environment and Behavior</th>
<th>Environment and Behavior</th>
<th>Environment and Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain the evidence of</td>
<td>Investigate how organisms</td>
<td>Investigate how organisms</td>
</tr>
<tr>
<td>competition among species</td>
<td>are composed of individuals</td>
<td>are composed of individuals</td>
</tr>
<tr>
<td>and environmental factors</td>
<td>species</td>
<td>species</td>
</tr>
<tr>
<td>that may be beneficial or detrimental to the</td>
<td>Dynamic environment</td>
<td>Dynamic environment</td>
</tr>
<tr>
<td>nature of that organism's</td>
<td>Explain the evidence that</td>
<td>Explain the evidence that</td>
</tr>
<tr>
<td>behavior and survival to the</td>
<td>organisms</td>
<td>organisms</td>
</tr>
<tr>
<td>organisms</td>
<td>regulate both internally and</td>
<td>regulate both internally and</td>
</tr>
<tr>
<td></td>
<td>explain how organisms depend on</td>
<td>explain how organisms depend on</td>
</tr>
<tr>
<td></td>
<td>explain the pattern of</td>
<td>explain the pattern of</td>
</tr>
<tr>
<td></td>
<td>behavior</td>
<td>behavior</td>
</tr>
<tr>
<td></td>
<td>Environment</td>
<td>Environment</td>
</tr>
<tr>
<td></td>
<td>(continued)</td>
<td>(continued)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Life Cycles (continued)</th>
<th>Life Cycles (continued)</th>
<th>Life Cycles (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>
| cause changes in behavior or survival of learning stimuli to environment and transmit internal and external organizations react to changes in various systems of various tree how the sensory and

<table>
<thead>
<tr>
<th>Claire</th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| name organizations stimuli demonstrate unity organisms and processes, and internal common ancestry, chemical summarize the evidence of

<table>
<thead>
<tr>
<th>Diversity of a species.</th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| evolution accounts for the explain how biological

<table>
<thead>
<tr>
<th>Apparent</th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| environment becomes more increase human impact on the population and abuse conditions predict that as human

<table>
<thead>
<tr>
<th>Ecologies</th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| of imbalance of populations and on and contribute to the balance explain how organisms depend

<table>
<thead>
<tr>
<th>Strand E: Life and Environmental Science (continued)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9-12</td>
<td>7-8</td>
<td>4-6</td>
</tr>
<tr>
<td>Science: Science Applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Identify the benefits of the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>use of technology in jobs in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wisconsin.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relationship Influences Human Activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students in Wisconsin will demonstrate an understanding of the relationships between science and technology and the ways in which that technology influences human activities.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Strand H: Science in Social and Personal Perspectives

<table>
<thead>
<tr>
<th>Technology</th>
<th>Reasoning and Scientific Inquiry</th>
<th>State and Local Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem in science or combination of solutions to a problem</td>
<td>Advocate a solution or retrieve at a group decision</td>
<td>Sometimes hindered progress in technology have helped and hindered science and technology.</td>
</tr>
<tr>
<td>Science and technology, frames, and considerations of value; ethics, beliefs, time</td>
<td>A consensus-building discussion to participate in physical science and participating in research, including societal science depend on many factors involving the Earth and development of a scientific solution to a decision about issues.</td>
<td></td>
</tr>
<tr>
<td>Show how policy decisions are informed by science and information about the issue.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Students in Wisconsin will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.
The influence of objects, materials, or events on one another.

Illustrate. The skill of giving examples to describe something on a premise.

Inference. The skill of using the results of an investigation based on new evidence.

Identity. The skill of recognizing patterns, facts, or details among objects according to characteristics.

Evaluate. The skill of collecting and examining data to make judgments and appraisals.

Explain. The work that a physical system is capable of completing.

Discover. The skill of learning through study or investigation.

Describe. The skill of developing a detailed picture of image.

Construct. The skill of developing a creative situation of problems.

Apply. The skill of selecting and using information in other tasks or patterns that are not always readily visible.

Analyze. The skill of recognizing the underlying details of important science skills and knowledge found in the standards.

The following terms are used uniquely in science. They are used consistently throughout the standards. They represent the range of rigorous

Understanding. The skill of having and applying well-organized bodies of knowledge.

Show. The skill of illustration.

Relate. The skill of association.

Predict. The skill of explaining new events based on observations of events.

Observe. The skill of describing scientific evidence.

many inquiry skills.

Investigate. Scientific methodology that systematically employs
Glossary of Terms
Activities
Building Blocks

Activities:

What am I Eating

Food Webs and Trophic Levels

Measuring the Temperature of Three Liquids

Change and Cycles Lesson: Where Land, Air, and Water Meet

Where Does Water Run Off After School

Adventures in Density
I'm Eating What?

Subject/Content Area
Biology/Photosynthesis/Plant Pigments/Nutrition

Activity Structure(s)
Telementoring, Information Exchanges, Question-and-Answer Activities, Information Searches, Pooled Data Analysis

Goals/Outcome Statements
AT&T ENRICH: IC,D,F; IIIB,C,E
SG,CAS,CFS: 11A1-3; 11B5; 12A4; 12B1-5
Upon completion of this activity, students will be able to:
- explain the roles pigments play in photosynthesis;
- describe the similarities and differences among plant species in terms of photosynthesis;
- create a poster identifying the various plant samples based on collected data; and
- evaluate the nutritional content of edible plants compared to their pigment content.

Tools and Resources
Aluminum foil
Beaker
Chromatography solvent
Poster boards
Assorted arts and crafts items
Mr. Sketch pens (or any water-based felt-tip pens; permanent ink will not work)

Student instructions to plant pigment chromatography
(The College Board and Educational Testing Service)

Poster Information Sheet: I'm Eating What?

Scoring Rubric: Poster
Websites:
http://www.chem.csustan.edu/chem1002/mrsketch.htm
http://www.askjeeves.com/
http://www.sc2000.net/~czaremba/aplabs/plantpig.html
http://www.naturalland.com/
http://www.vg.com/
http://www.scientificamerican.com/askexpert/index.html
http://www.leafy-greens.org/
http://www.produceoasis.com/
http://onhealth.webmd.com/conditions/condctr/diabetes/index.asp
http://askanexpert.com
http://www.desertusa.com/magdec97/eating/nopales.html
http://www.collegeboard.org/ap/biology/html/lab004.html
http://www.collegeboard.org/verity/bin/list.cgi

Search Engines
http://www.yahoo.com
http://www.google.com
http://www.altavista.com

Detailed Description of Project

Based on a 45-minute class period, this project takes six to eight days to complete. This project is a self-contained activity that can be inserted into any unit on photosynthesis, plant classification, and/or basic nutrition. Students should be placed into groups of two to four. In their groups, students will be responsible for determining the pigment content of a variety of dark green leafy vegetables (spinach, collards, etc.) using paper chromatography. After selecting a plant species, students will conduct an Internet search to find more information about their chosen plant species in order to produce an informational poster.

Days 1-2:
Introduce students to chromatography. Have students access the website http://www.chem.csustan.edu/chem1002/mrsketch.htm. (Mr. Sketch Chromatography) Use Mr. Sketch pens (or any water-based felt-tip pen) to demonstrate chromatography and prepare the lab for the chromatography experiment to be conducted on Day 3.

Days 3-4:
Have students access the instructions for the pigment lab at http://www.sc2000.net/~czaremba/aplabs/plantpig.html. When students are finished with the lab, have them record their results on a spreadsheet and email the data they have collected to the lab coordinator.
Days 5-6:
Have students analyze the data they have collected on a computer spreadsheet. Direct students to also research their chosen plants and begin creating their posters. Have students email their collected data to participating classes (optional).

Days 7-8:
Encourage students to complete all activities they have worked on during the past few days. Assign an essay entitled *How does the pigment content of a dark green leafy vegetable compare with its nutritional content?*

**Assessment of Students**
Assessment of students' understanding and performance includes the following two components:

*Poster Project: I'm Eating What?* (See attached scoring rubric.)

Students' reflections on the project as emailed to the project coordinator.

**Teacher Notes**
Procedure for participation in this project if more than one class or school is involved:

- a project coordinator must be chosen,
- a maximum number of classes or schools that will be accepted for this project must be determined;
- participants in this project must agree to conduct this activity within the same time frame;
- all participants must agree to email the data collected by their students by 3:00 p.m. on Day 4 of the project;
- the project coordinator must email the collected data to all participants on Day 5 of the project;

Students will evaluate each group's poster using the poster scoring rubric. Each participating teacher will develop a scoring rubric to evaluate each individual student's response to the question: How does the pigment content of a dark green, leafy vegetable compare with its nutritional content?

To extend the project, have students:

- compare and contrast the prices of all the plant species used in the project and present the findings in a chart using a computer program;
- determine which of the plant species are used in baby foods and find their nutritional value. (Based on the nutritional values found, have students pretend they work for a baby food manufacturer and write an editorial explaining reasons for using certain plants in their foods and not others. They should include a chart or graph that shows the compared nutritional values of the plant species that are used); and
- follow the recipe created for the chosen plant species and prepare it for the class to enjoy.
Credits

Author(s):
Aileen Boué
John Loehr
Rey Petravich
Carl C.Prieto
Elaine Rohrbacher

Editor(s):
Jack Callum
Lori L. Cason
Jean Hart
Antoinette Rubalcaba
Sister Fran Wohn, B.V.M
I’m Eating What?
Poster Information Sheet

Objective:
Create and explain a resourceful poster with material relevant to the particular plant species used in your chromatography experiment.

Information on the poster should include:
Common name of plant species
Scientific name of plant species
Graphics of the species
Nutritional information about the species
A recipe using the species (cannot be a salad)
Plants that are related to the species
A table of \( R_t \) values of pigments for the species examined
Summary of the most helpful website
A bibliography card

Guidelines:
1. Use one or two poster boards that can be displayed.
2. This project must reflect contributions from each member of the group.
3. Each student is responsible for at least one part of the project. His/her name must be listed on the back of the poster board with his/her contribution identified.
4. The poster board(s) will be evaluated based on appearance, creativity, accuracy, level of content, required elements, and teamwork.
5. Creativity is encouraged.
I’m Eating What? | Poster | Scoring Rubric

4

Shows a complete mastery of concepts and activities. At this level the poster is free of all errors. Material used is well beyond material presented by the instructor and demonstrates effort on the group’s part.

3

Shows mastery of the concepts and activities beyond the average group. At this level, errors are limited to mistakes in format, appearance, or minor concepts. Material used is beyond material that is presented by the instructor and demonstrates some effort on the group’s part.

2

Shows mastery of the concepts and activities of an average level. At this level, errors are present in terms of format, appearance, and concepts. Material used is limited to that presented by the instructor and demonstrates little extra effort on the part of the group.

1

Shows limited mastery of the concepts and activities. At this level, errors in format, appearance, and concepts are common. Use of outside material is minimal. The group demonstrates limited effort and understanding.

Criteria Evaluated:
Appearance/Creativity
Accuracy
Level of content
Required elements
Teamwork
Creating A Visual Relationship of Organisms: Food Webs and Trophic Levels

Type of Entry: Class Activity (to be done in one class period).
Type of Activity:
- Cooperative Group Activity
- Student-centered

Target Audience:
- Life Science (grades 6-8)
- Biology
- Ecology

Abstract:
The inter-connection of organisms in the environment is extremely complex. There are multitudes of plants and animals in our world. Many of these organisms need to relate and react to each other in order to survive and maintain homeostasis. This natural balance of organisms is due in part to their feeding habits. Due to the extreme importance of feeding behaviors in the scientific world, most life science and biology courses require students to be able to analyze food webs and be able to assign the various trophic levels (producer, primary consumer, secondary consumers, tertiary consumer) to them. In this activity, students will become introduced to the creation and interpretation of food webs. Students are also responsible for the assignment of the organisms in the food web to the various trophic levels they belong to (in some cases, organisms can belong to more than one trophic level). The activity works well for all types of learners, as it includes visual, kinesthetic, and auditory components. It also works well in providing a lesson which is student-centered and keeps students active for a 45-minute period.

Preparation:
There is a considerable amount of preparation that the teacher needs to do before the activity can be done in class. However, the preparation is a one-time event. That is, once the preparation is done, the same activity can be repeated each year without any preparation. The following is a list of materials which will be needed to prepare the lesson board used:

1. A 36" x 48" cardboard presentation board (usually is folded in 3 sections, and can be found in any craft store).
2. Velcro tape (also available at any craft store).
3. Glue and Scissors
4. 3 X 5 index cards: 4 green cards, 8 blue cards, 8 red cards, 2 purple cards, 8 white cards.
Preparing index cards:

- Obtain 4 green index cards, and glue to each, one of the following pictures: grass, hay, shrubs, trees.
- Obtain 8 blue index cards, and leave 4 blank. On the other 4 cards, glue to each, one of the following pictures: rabbit, mouse, giraffe, cows.
- On the back of the cow card write "Cow-tipping is a load of fun, but let's hope they land on the hay" (or anything that indicates to students what is eaten by cows). On the back of the mouse card, write "The teeth of a mouse are not sharp enough for meat, so they eat small shrubs." On the back of the rabbit card, write "Bugs tends to eat carrots, but many of his relatives simply like grass." On the back of the giraffe card, write "The giraffe's long neck allows it to eat leaves from trees."
- Obtain 8 red index cards, and leave 4 blank. On the other 4 cards, glue to each one of the following pictures: lion, humans, snakes, hawks.
- On the back of the human card, write "many humans still love a good steak!" On the back of the lion card, write "the lion loves to munch on meaty giraffe necks." On the back of the haw card, write "the haw is a fierce creature whose teeth, beak and claws can tear apart a rabbit." On the back of the snake card, write "snakes can swallow a mouse whole."
- Obtain the 2 purple cards. Leave one blank. On the other card, glue the picture of the owl. On the back of the card, write "the superb night vision of the owl allows it to see hidden snakes crawling in the brush."
- Obtain the 8 white index cards. Label four of them with the word "sign". To the following four cards, write one of each of the following words: producers, primary consumers (herbivores), secondary consumers (omnivore or carnivore), tertiary consumers (carnivore).
- On the back of each and every card, you will need to put a small piece of velcro, since these cards will be fixed onto the presentation board.

Preparing Presentation Board

- You will only need to use the middle (main) section of the presentation board. You will want to arrange it as shown. Use the glue (rubber cement glue works well) to attach the cards to the board.
- There will be 4 rows. The bottom row will contain the four green index cards for the producers. The next row above will have the 4 BLANK blue cards, spaced directly above the green row. The third row will contain the 4 BLANK red cards, spaced directly above the blue cards. The last row is really only the one BLANK purple card which is to be placed as the top card of the third row.
- Beside each row place the white index cards which had the words "sign" on them. Again, see example.
- Put a piece of velcro on each card on the board so that students will be able to affix index cards onto the board (I have placed small boxes onto the chart to guide you).

Preparing Packets for Student Cooperative Groups
Obtain 4 office envelopes. Into each, place one of each of the following:

1. One of the blue animal index cards
2. One of the red animal index cards
3. a 10-inch long paper arrow which has a piece of velcro on the back.
4. One of the white index cards indicating feeding levels.
5. One group will also have in their packet the purple "owl" card.

Conducting The Lesson
I have included the actual two-page packet I give to the students. It describes the implementation of the lesson.

Method of Assessment/Evaluation
When students have completed the presentation board, they receive credit for answering the questions given at the end of the assignment. You can decide what kind of credit that will be. There is then a 10 minute discussion where all terms and concepts are reinforced vocally for the auditory learner, and all questions are answered by students to check for comprehension.

Extension/Reinforcement/Additional Ideas
I find it valuable to have index cards for other animals and spaces for students to place them their position in the food web given the trophic level of the organism. Students can also vocally be given descriptions of animals and be tested on their ability to classify them into the proper trophic level. One last follow-up activity would be to give groups one more "arrow:" and have them make more connections between organisms. This activity is meant to be a basic one-day introduction to the study of the relationships between organisms. It should be followed up by more activities/sponge activities that develop more higher-order thinking skills.
CREATING A VISUAL RELATIONSHIP OF ORGANISMS
Food Webs and Trophic Levels

As we have discussed, there are multitudes of plants and animals in our world. All of these organisms need to relate and react to each other in order to survive and maintain a natural balance. In this activity, you will examine the inter-relationship of organisms. You will be in charge of creating a graphic representation of this inter-relationship.

Procedure:

1. You will be put into groups of five or six and assigned Role A, Role B, Role C, Role D, Role E and possibly Role F. Send one member up to get a packet from the teacher.
2. In your packet, you will find:
   a. 2-3 pictures of living animals on blue, red. or purple index cards.
   b. A sign stating one of the following: "producers", "primary consumers (herbivores)", "secondary consumers (may be carnivores)", "tertiary consumers".
   c. An "arrow".
3. The roles are as follows:

   **Role A**: Is the secretary who will be responsible for writing the answers to the questions at the end of the activity.

   **Role B**: Will fill in the chart that accompanies the activity.

   **Role C**: Needs to properly use the BLUE index card.

   **Role D**: Needs to properly use the RED index card.

   **Role E**: Needs to properly use the ARROW and the card which says "producers", "primary consumers (herbivores)", "secondary consumers (may be carnivores)", "tertiary consumers".

   **Role F (if needed)**: Needs to properly use the PURPLE index card.

4. Read the back of each animal card which describes the way your organisms interact.
5. Have ROLES C, D and F bring your animal cards to the front poster and place them where they belong. Return to seats.
6. Wait until all groups have put on their cards. Then have ROLE A answer question #1 on your worksheet.
7. Using your knowledge of science, decide where your sign (see 2b above) belongs on the chart and send ROLE E to bring it up and place it correctly on our chart. When each group has finished, proceed to next step.

8. Examine the chart, and think of one other connection that could be made BETWEEN columns #1, #2, #3, #4. Send ROLE E to bring your arrow up to the front and add it into our chart.

9. When each group has finished with the above steps, work within your group and have ROLE A and ROLE B to answer the remaining questions and fill in the chart. See your teacher to receive a stamp for the questions and for filling in the chart found on your worksheet.

10. Wait until all groups are finished, and then be prepared to discuss your findings and understandings of food webs and trophic levels.

QUESTIONS:

1. What is the name for the columns individually numbered #1, #2, #3, and #4?

2. What is the name of many of these (answer from #1) when interconnected as they are in a true ecosystem?

3. Discuss the relationship between producer, primary consumer, secondary consumer and tertiary consumer.

4. (a) Define herbivore. (b) Define carnivore.
Measuring the Temperature of Three Liquids

How does heat compare to temperature?

Overview

A variety of liquids and varying volumes are used to examine heat and temperature. One word of caution, the oil is messy. Some caution should be used when heating the oil. It might be wise to let only a few groups heat the oil or do that portion as a demonstration.

Materials

Per lab group:

- 250-mL beakers, 4
- Celsius thermometer
- hot plate
- water, 250 mL
- Karo Syrup, 100 mL
- cooking oil, 100 mL
- hot pad (hot hands or beaker tongs)
- ring stand with ring, clamp
- safety goggles

Procedure

Have students place 150 mL of water in a 250-mL beaker. They should then place the beaker on the hot plate and turn the hot plate to high. Have them heat the beaker of water for 5 minutes. While this beaker of water is heating, they should place 100 mL of water in another 250-mL beaker. Using a thermometer they then take the starting temperature of this water.

100 mL Water  100mL Karo  100 mL Oil  150 mL Water
After the five minutes of heating, students remove the beaker (containing 150 mL of water) and determine its temperature. They then place the second beaker (100 mL of water) on the hot plate and insert the thermometer, holding it in place by a clamp on a ring stand. Have them record the temperature every 30 seconds for 5 minutes. In the two remaining beakers, students place 100 mL of Karo syrup and cooking oil respectively and repeat the procedure, recording temperatures every 30 seconds for five minutes. These beakers could be set up and heated all at the same time. Multiple ring stands could be used to hold the thermometers in place. Have students graph the time versus temperature for each liquid.

**Background**

Although in everyday language we sometimes confuse heat and temperature, they have very distinct meanings in science. The heat content of a substance depends on its quantity, temperature, and the material of which the substance is made. Temperature does not indicate the heat contained by that body. It is more a measure of the hotness of that body.

Water will heat up slower than the oil and Karo syrup. On the graph, the oil and Karo syrup lines will be steeper, indicating that they heat faster than water. The beaker containing the greater amount of water will not have as high a temperature as the beaker containing the smaller volume of water.
Change and Cycles Lesson
"Where Land, Air, and Water Meet"

Activity (Allow 30-45 minutes)

To develop an understanding of parts per million as a concept, teams of students will create successive dilutions of a solution to reach a parts-per-million concentration. The atmosphere is a mixture of gases. Similarly, the world's oceans and fresh waters contain dissolved chemicals. Many substances dispersed in air or water are measured in parts per million. Some of these substances are colorless, odorless, and tasteless, yet even in small quantities they can be toxic.

Materials

For each group of three students:

- One eyedropper
- Supply of water
- A cylinder with 10-milliliter graduations
- Three 12-ounce clear plastic cups
- Masking tape
- Marking pen
- One bottle of food coloring (darker colors will work best)
- A calculator (optional)
- One box of crayons, pastels, or colored chalk
- A notebook for recording results.

The procedure can be copied and handed out to students.

Procedure

Before beginning the activity, put a piece of masking tape on each cup and label them "Sample 1," "Sample 2," and "Sample 3."

Sample 1

1. Put 99 drops of water in the graduated cylinder. Record the volume of this amount of water in the notebook. (You will need this measurement later to avoid having to measure another 99 drops.) Pour the water from the 99 drops into the cup marked "Sample 1."
2. Add one drop of food coloring to sample 1. Stir the water. Record the color in your notebook using crayons, pastels, or chalk.
3. Answer the questions in the question section. You can use a calculator. Write the answers on the sheet or copy the information into your notebook.

Sample 2

1. Pour an amount of water equal to 99 drops into the graduated cylinder. Pour this into the cup marked "Sample 2."
2. Add one drop of sample 1 to sample 2.
3. Stir and record the resulting color.
4. Answer the questions in the question section.

Sample 3

1. Pour an amount of water equal to 99 drops into the graduated cylinder. Pour this into the cup marked "Sample 3."
2. Add one drop of sample 2 to sample 3. Stir and record the color of the solution.
3. Answer the questions in the question section.

Questions

- What is the concentration of food coloring in sample 1?
- Can you see the food coloring in sample 1?
- Suppose the food coloring was a harmful substance, how would you "clean" the water?
- What happened to the color of the water in sample 2? Describe and explain.
- What is the concentration of food coloring in sample 2?
- What is the concentration of food coloring in sample 3?
- Can you see the food coloring in sample 3?
- Explain why or why not.
- How could a parts-per-billion solution be made?

Extensions

Once the students are familiar with the procedure required to create a parts-per-million solution of a pollutant, have a selection of substances available for them to dilute and observe. Encourage the students to create experimental tests for determining if other substances are observable in the part-per-million concentration. Some suggested substances to experiment with are detergent and acid (vinegar). You can ask:

1. Are the new substances observable in any way? (Do they form a film, or foam, or is there discoloration?)
2. Has there been a change in a Ph test for the acid or base? (Use litmus paper to test the solutions.)

Answers will vary.
Discussion note: is a diluted substance "gone" just because it is no longer visible? How can these ideas be transferred from a liquid to a gas like CO2?

For the Teacher

Answers to the Questions in the Lesson
Sample 1: Because you have added one drop of food coloring to 99 drops of water, the concentration is one part per hundred, which can also be expressed as 1/100 or 1 percent. A calculator can be used to visualize the answer. Divide 1 by 100. The answer is 0.01. The color should be visible.
Students might answer that filtering the water through a substance like sand or through paper might "clean" it, but filtering will not remove a chemical solution. The teacher might use this question as an opportunity to discuss the removal of CO2 from the atmosphere. Just as no such simple process as filtering the water will remove food coloring, no simple process will remove
excess CO2 from the atmosphere. Reducing the amount of CO2 emitted by human activity reduces the need to remove it later.

**Sample 2:** To 99 drops of new water, you add a drop of the solution from sample 1, which consists of .99 parts water and .01 part food coloring. Because you have now diluted the .01 drop of food coloring in a total of 100 drops of solution, divide .01 by 100 on the calculator. Your answer is .0001. This means you now have 1 part food coloring in ten thousand, or 1/10,000. Depending on the color used, the food coloring in sample 2 should be faintly visible.

**Sample 3:** Again you have 99 drops of new water and one drop from the solution in sample 2. The one drop is .9999 parts water and .0001 parts food coloring. To calculate the concentration of food coloring in sample 3 divide .0001 by 100 (the total number of drops in the solution). The answer is 0.000001 or one part food coloring in one million (1/1,000,000). The food coloring will not be visible at this concentration.

**Making a parts-per-billion sample:** Continue the procedures described above. Begin with 99 new drops of water. Use one drop of the parts-per-million solution. You will get 0.00000001 parts food coloring or one part food coloring in one-hundred million (1/100,000,000). For the final step, take nine new drops of water and add to it one drop of the previous solution. This yields 0.000000001 or one part per billion.
WHERE DOES WATER RUN OFF AFTER SCHOOL?

OBJECTIVE
Students will describe relationships between precipitation, runoff and aquatic habitats.

METHOD
Students measure and calculate the area of the schoolground; calculate the volume and weight of water falling on the schoolground; determine specific and annual rainfall and runoff; and trace the course of that water to aquatic habitats.

BACKGROUND
Rainfall is obvious—but runoff from rainfall is a relatively abstract concept. Although we may notice and in fact get drenched in a rainstorm, we don’t typically stop to wonder how much rain is falling. The volume and mass of the water in a rainstorm is astounding to those who calculate the values. NOTE: See “Puddle Wonders” for an interesting related activity.

Developing an understanding of precipitation and runoff is an important part of understanding the water cycle. Rainfall is one form of precipitation. Rainfall is one way water re-enters aquatic habitats. Once rain falls upon a surface, water begins to move both laterally outward and vertically downward. Lateral movement is runoff and finds its way into streams, rivers and lakes. Vertical movement seeps into the soil and porous rock and re-charges groundwater supplies.

Paving and soil compaction can reduce an area’s water absorbing ability and therefore increase runoff. Reduced absorption rates can negatively impact vegetation and groundwater recharge.

Runoff is the dominant way that water flows from one location to another. It is in runoff that many pollutants find their way into moving waters. These are kinds of pollutants called “nonpoint source.” What this means is that widespread sources of pollution such as garden insecticides, automobile emissions caked on parking lots, lead from paints and exhaust, etc., are washed by runoff into streams, rivers, lakes and oceans. Eventually the water becomes part of an aquatic habitat and the toxins begin their damage.

Runoff is also responsible for erosion, transportation and deposition of sediments scoured from the land’s surface. Substandard agricultural and other land practices often prepare fields and their topsoil to be washed away.

On the positive side, the contamination levels in much of runoff are negligible. Runoff waters are necessary to renew many aquatic habitats that are dependent upon inflow for continuity. The inflow prevents lakes from shrinking due to evaporation and it prevents streams from going below minimum flow levels. Inflow thus helps support aquatic life. Without some runoff, aquatic habitats would suffer. In this activity,
the students calculate both the volume and the weight of rainfall. They consider relationships between rainfall and runoff, including effects on wildlife and the environment.

The major purpose of this activity is for students to increase their awareness and appreciation of some things they may take for granted—rainfall, runoff and the connections between surface waters and aquatic habitat.

**MATERIALS**
writing materials; meter or yardsticks; long piece of twine with marks every yard or meter; rain gauge; local rainfall data
OPTIONAL: calculator; trundle wheel.

**PROCEDURE**
1. In this activity, students will find out how much rain falls on their schoolground—and how much it weighs! First, the students must determine the total area of the schoolground. For the purposes of this activity, the outer dimensions of the property will satisfy. There is no need to subtract the area of the buildings since it is assumed that rain falls upon them as well.

The formula for calculating area is:
Area = Length x Width (or A = LW)

NOTE: See the extensions to this activity for metric approximations.

The length and width of the schoolground must be measured. The students can use a length of twine (approximately 100 feet in length). Mark the twine every three feet. The marking can be done with an ink marker, short pieces of string tied every yard, or a knot each three feet. If a trundle wheel is available, it is convenient to use for measuring.

NOTE: A trundle wheel is a device that makes the measurement of linear distance simple. It is a wheel that operates a counter or clicks as it is rolled over the surface attached to a handle. Each revolution of the wheel represents one yard or meter. Check to see if the school has one. City road crews often have them and may loan one to you for a few days.

The main difficulty with calculating the area in this activity comes from irregularly-shaped schoolgrounds. Try not to get bogged down in detailed exactness. A healthy approximation will do. Here are a few examples:
2. Once the area of the schoolgrounds has been established, the next step is to determine the amount of rain that falls in the area. Three options are possible:
   - Calculate the annual rainfall on the schoolgrounds using information from resource agencies, e.g., weather bureau, soil conservation service, local TV weatherpersons, local newspapers.
   - Using a rain gauge, measure the amount of rain over a period of time.
   - Calculate the amount of rain that falls in a given storm.

When the students have decided on a way to measure the amount of rain that falls on their schoolground during a specified period of time, ask them to calculate the amount. This provides the students with a value for the depth of rainfall on the surface of the land.

3. With the depth of rainfall determined, and the area of the schoolground measured, the next step is to calculate the volume of rainfall. For example, suppose the area of the schoolground is 50,000 square feet and the annual rainfall is six inches or .5 feet. Then the volume of rain would be:

\[
50,000 \text{ square feet} \times .5 \text{ ft of rain} = 25,000 \text{ cubic feet of rain}
\]

The volume of rain is 25,000 cubic feet of rain.

4. Knowing the volume, the students can now calculate the weight of the rain. Water weighs 62.5 pounds per cubic foot, thus the weight of six inches of rain (25,000 cubic feet) is:

\[
25,000 \times 62.5 = 1,562,500 \text{ pounds or 781.25 tons of rain.}
\]

5. All of the measurements and calculations done in this activity are intended to impress upon students that there are remarkable volumes and weights of water moving through the water cycle. Even short periods of rainfall produce amazing amounts of water. All the water that the students measure eventually finds its way to a wildlife habitat. A major issue of concern is how humans affect the quality and quantity of water that eventually reaches aquatic habitats. Consider and discuss the following questions:
   - Where does the water from rainfall go when it leaves the school site?
   - How much water is absorbed by the different surfaces on the school site?
   - With what kinds of potential pollutants does the water come in contact?
   - Where is the location of the nearest wildlife habitat that receives the school's runoff?
   - How do people use the water between the time it leaves the school and arrives in the wildlife habitat?
   - What are some of the positive and negative effects that the water may have on the environment at various points on its journey?
EXTENSIONS

1. Obtain a map of the school and check it against the accuracy of the one you made. Make a copy of the school district map, or use your own map, and plot runoff routes on it. Check periodically during rainstorms to identify the drainage patterns. Try to find a way to estimate how much water is draining in specific places.

   NOTE: Most school districts have maps in the administrative department concerned with buildings and grounds.

2. If you did not already, place a rain gauge on the schoolground and measure actual amounts of rain. Repeat your calculations.

3. Do this activity in metric:
   - 100 feet = 30.48 meters
   - 3 feet = 1 yard = .9114 meter
   - Square feet x .0929 = square meters
   - Inches x 2.54 = centimeters
   - Feet x .3048 = meters
   - Pounds x .4536 = kilograms

4. A serious modern concern is the contamination of groundwater. How might water in the groundwater table or aquifer become contaminated with chemicals potentially harmful to human health? To the health of other animals, including wildlife? Identify as many sources of contamination to groundwater and runoff in your area as possible. What can, or is, being done to reduce or eliminate these sources and their effects?

EVALUATION

1. Describe at least two relationships between aquatic habitats, precipitation, runoff and surface water.
2. Name two human activities that have affected the quality of runoff.
3. Name two human activities that have affected the quantity of runoff.
4. Name two ways that runoff can affect humans.
5. Name and describe two ways that runoff can affect aquatic wildlife.
6. Write an advertising campaign slogan to convey the importance of runoff to wildlife. Include the need for clean water without toxins.
7. Write a short list of steps to take for wildlife to protect the quality of runoff water.
Adventures in Density

Floating on a raft on the Mississippi... shipwrecked on an iceberg... being towed to sea by a great fish... How are these accounts (penned by authors Mark Twain, Arthur Roth, and Ernest Hemingway) adventures in density?

▼ Summary
Students conduct investigations to discover how the density of water is affected by heat and salinity, and relate their "discoveries" to literary adventures.

Objectives
Students will:
• demonstrate how heat and salinity affect the density of water.
• relate the compactness of water molecules to the density of water in different states.
• recognize that concepts of density can be found in literature and daily life.

Making Connections
Through reading or personal experiences, most students have enjoyed adventures about icebergs, fishing, rafting, etc. All these adventures involve density. Investigating how heat and salinity affect the density of water helps increase students' understanding of the basic properties of water.

Background
Water is one of the few substances on Earth that can be naturally found in all three states: solid, liquid, and gas. One difference between each of these states is density: how close water molecules are to each other. The amount of particles (mass) within a certain space (volume) determines the density of a substance. Water vapor is the least dense of water states because the molecules are furthest apart from each other. The molecules of warm water are less dense (less compact) than cold water. However, ice is less dense than liquid water. The density of water can be influenced by a variety of factors, and many aspects of water density play important roles for life on Earth.

Heating and cooling water affect the density of water. Heating water speeds up the movement of water molecules. When their movement is increased, water molecules are less able to stay near each other. As they move faster, the molecules bounce off each other more frequently and move farther apart, decreasing the density of water molecules. Therefore, warm water is less dense than cold water.

As water cools, water molecules lose heat energy and move more slowly. This allows water molecules to move closer together, becoming more dense. Therefore, cold water will sink and warm water will rise. Since the molecules of cold water are closer together, they can
support the less dense warm water above it. Warm water will sit on top of cooler water; where these two layers meet is called a thermocline.

But what happens when water gets very cold and turns to ice? Since ice is extremely cold water, one might expect the molecules to move very little and be very close together (very dense). However, one only needs to put ice cubes in a soft drink or go ice-skating to know that ice does not sink; therefore, it cannot be denser than liquid water. The molecules in ice do move very slowly; however, they are farther apart from each other in ice than when in liquid form. This is because when water freezes, the molecules spread out and are arranged in a lattice-like pattern. This formation increases the distance between water molecules, making ice less dense than liquid water. (See "Hangin’ Together.")

Adding certain materials to water, such as salt, increases its density. If salt is added to fresh water, the amount of material within the space water occupies increases. Whereas only water molecules previously consumed space, now salt molecules are crowded into the same space. This makes salt water more dense than fresh water.

Pressure also increases the density of water. Deep water has greater pressure than surface water because the weight of the water molecules above pushes down on the deeper molecules, forcing them closer together and making them more dense. Temperature also decreases with depth, and cooler water has greater density than warmer water. As the depth of water increases, the density of water increases. A large body of water contains many density levels. Each level provides a different habitat in which certain plants and animals may live. Many factors determine where organisms live—sunlight, water temperature, pressure, food supply, etc. People who harvest food from lakes and oceans know this and will drop their nets or fishing lines to the depth (density level) at which they will most likely find the food they are seeking.

Lakes in temperate climates benefit from the formation and melting of ice. As water cools in the fall, water molecules slow down and move closer together (becoming more dense). The density of water continues to increase until the temperature reaches 39 degrees F (4°C); this is when the density of water is at its greatest. When the temperature of water falls to 39 degrees F, the water begins to sink. As the temperature of water drops below 39 degrees F, it begins to freeze and molecules become arranged in the lattice-like pattern. As it freezes, ice rises and

A density difference causes icebergs to float; these provide refuge for many animals. ARCHIE SÄTTERFIELD
flEffi

Part II
Distribute Heavy and Light Reading. Have students determine the role of density in each selection. In the first selection, wildlife finds refuge on floating ice. (Ice is less dense than liquid water.) In the second story, the density of water increases as the depth of water increases. In the last selection, the raft would more easily float on the denser salt water.

Wrap Up
Have students summarize the results of their activities. Have students cite situations in their lives that have involved different densities of water (e.g., ice-skating, feeling cool water at the bottom of a pool or lake). Ask students to identify density concepts in daily events and further readings.

Assessment
Have students:
• demonstrate the relationship of water temperature and salinity to density (Part I).
• cite examples of different densities of water in excerpts from literature (Part II).
• interpret a diagram representing closeness of water molecules to the density of ice and to liquid water (Warm Up and Wrap Up).

Upon completing the activity, for further assessment have students:
• identify which of each of the following pairs represents a denser material: cool water or warm water; fresh water or salt water; ice or liquid water.
• set up a demonstration to show why fish don't freeze in winter.

Extensions
Have students construct miniature rafts that can float and write imaginative stories about their adventures on them. Students may also create science-fiction stories about life on a planet where air is denser than water or ice is denser than liquid water.

Resources

Advantages in Density
Project WET Curriculum and Activity Guide
Adventures in Density

**Temperature**

a. Get a beaker (or cup) of cold water and a beaker of hot water (wear protective gloves). Put a drop of red food coloring in one and a drop of blue in the other (it doesn’t matter which). Gently tilt both beakers so that the liquids almost touch and allow hot water to flow over cold.

Look at the containers from the side; draw a picture of what you see.

Which is more dense, cool water or warm water? Answering the next two questions should support your response.

How does heat energy affect the movement of water molecules? (Hint: Compare boiling water to cool water.)

b. Add food coloring to cold water. Put a straw in the cold water; position your finger over the opening. When you lift the straw above the surface, water should stay in the straw. Put the straw on the inside edge of the cup of hot water and slowly release the cold water. Where does it go?

c. Float a blue-colored ice cube in a glass of warm water. Look from the side: what happens to the blue coloring as the ice melts?

Even though ice is colder than liquid water, ice floats. Considering this, how would the density of molecules in ice compare to molecules in liquid water?

**Salinity**

a. Fill two glasses with water. While stirring, add salt to one of the glasses until no more salt dissolves. Place a hard-boiled egg in each glass. The egg should float in the salt water; if not, try adding more salt.

How does salt affect the density of water? (Hint: Which has more particles within the same amount of space, fresh water or water with salt added to it?)

b. Try to float fresh water (dyed with food coloring) on top of salt water. Be careful when pouring; try to flow the fresh water gently over the salt water.

**Temperature and Salinity**

a. See how you can alter the above experiments by adding salt and heating or cooling water.

For example, when floating fresh water on salt water, how would heating the fresh water affect the result? Is warm salt water less dense than cold salt water?

Describe how you altered the experiment and record your observations.
Energy

Activities:

Testing a Pinwheel Turbine

Three Part Energy Lesson:

- Reading Energy Bill
- Home Energy Use
- CO₂ Contribution

Waterwheels, Windmills, and Turbines

Don’t Throw Energy Away

The Cost of Using Energy

Energy Divide

People Power

Diminishing Returns
Testing a Pinwheel Turbine

FOR USE WITH FACT SHEET NO. 14: ROPING THE TEXAS BREEZES

OVERVIEW

Students will learn that wind power in Texas is a fast growing energy source with great potential. By constructing a wind-powered pinwheel, which creates the energy to perform work, students will gain insight into the concept of generating electricity from wind power. Students will see value in renewable energy sources for Texas and be able to locate the most viable geographic regions of Texas for wind energy. Students will understand that the sun is the ultimate source for the wind.

TIME FRAME

Two 45-minute periods

TEACHER GUIDE

Background Information

Wind is formed by the sun’s uneven heating of air, which results in the air’s movement. The potential for using wind is excellent in West Texas and along ridges in the Panhandle. There is a continuous supply of wind in coastal areas as well, where the land is heated, causing hot air to rise, and cold air rushes in from ocean areas to fill the spaces. The rising hot air causes convection currents. Global convection currents in combination with the rotation of the earth create constant predictable wind patterns.

Early sailing ships used the predictable wind patterns, called the “trade winds,” to establish sailing routes.

Windmills can be used by themselves to do work, such as pumping water for cattle, or larger, multiple wind turbines can be built in a group called a “wind farm,” which can generate electricity which can be transported to for homes and businesses via the power grid. Wind turbines change the wind’s kinetic energy into mechanical power, and then changes the mechanical power to electric power.

Teaching Instructions

Teacher should read the student activity first. In preparation for this lab, students can make a checklist of the materials to collect the day before the experiment. Either cover stock paper or a manila folder can be used, as long as a square, 20 to 24 cm on each edge, is formed. A round smooth pencil is needed, so that there is less friction. Students should read Fact Sheet #14, Roping the Texas Breezes, before preparing for this activity. Appropriate safety guidelines should be reviewed. Students may research more information regarding a generator, which takes the mechanical energy of a turbine and converts...

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

TEKS utilized: SCL. (b) 6.1(B) make wise choices in...conservation of resources; 6.2(C) construct reasonable explanation; 6.9(C) describe energy types...and determine if the type is renewable, non-renewable or inexhaustible; 6.9(A) identify energy transformations occurring during the production of energy for human use; 6.9(B) compare methods used for transforming energy in devices...such as wind power plants; MATH: (b) 6.1(C) use integers to represent real life situations; SOC.S. (b) 6.5 (A) explain...distribution of natural resources that influence...economic development; 6.3 (A) create thematic maps; 6.7 (A) identify and analyze ways people have adapted to the physical environment in selected places and regions; 6.7(C) describe ways in which technology influences human capacity to modify the physical environment; L.A. 6.13 (E) summarize...making charts; 6.10 (H) draw inferences.
it to electrical energy. Students can keep a folder on energy and place their drawings, charts, lab activities, pictures, etc. in it.

Students should be able to measure in centimeters for this activity. The 10 gm mass used should be taped securely. Students should create a data table to record their results. Directions for using the fan should be clear. When the windmill is in motion, it will perform work by pulling up the 10 gm mass a one-meter distance.

When students perform 5 trials and record the seconds, they can create their own data table. For example:

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>3.1</td>
</tr>
<tr>
<td>4</td>
<td>2.7</td>
</tr>
<tr>
<td>5</td>
<td>2.9</td>
</tr>
</tbody>
</table>

**Total** = 14.2 seconds

**AVG (average)** =

<table>
<thead>
<tr>
<th>Total Time</th>
<th># of Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.2</td>
<td>5</td>
</tr>
</tbody>
</table>

2.8 seconds

Since in this example the measurements are only to one decimal place, the rounded average is 2.8 seconds.

**GLOSSARY**

atmosphere – composed of air, which is composed of tiny particles of gases like oxygen, hydrogen and nitrogen

bushing – a lining for a circular piece like a sleeve (the bottle top sipper acts as a bushing in this experiment)

convection current – the movement of parts of a fluid (like air) differing in density and temperature; transfer of heat by the movement of air

generator – machine for converting mechanical energy into electric energy

kinetic energy — energy resulting from motion

wind – air in motion (when air is heated and rises and cold air rushes in to replace the warm air); wind energy is kinetic energy related to the motion of air in the atmosphere

work – distance an object is moved by a known force against some resisting force (friction)

**ASSESSMENT ANSWERS**

**Short Answer Questions**

1. The sun causes the heat responsible for convection currents.

2. Refer to the map in Fact Sheet #14

3. Cities with the greatest wind potential in Texas are Lubbock, Amarillo, El Paso, and Corpus Christi. Reasons for settlement include access to water and water transportation; cattle centers grew into cities as well.

4. The sun is the ultimate energy for wind movements.

5. Wind, solar and biomass are renewable; oil and gas are not renewable. The sun creates wind through convection; the sun creates biomass through photosynthesis.

**Multiple Choice Questions**


**STUDENT ACTIVITY #14:**

**TESTING A PINWHEEL TURBINE**

**Key Vocabulary**

define the following terms:

- atmosphere, bushing, convection current, generator, kinetic energy, wind, work

**Materials** (for each group of 4 students)

- 1 liter plastic water bottle (empty) with sipper top
- 1 piece of cover stock or a manila folder
- 1 thumbtack
- 1 smooth, round painted pencil with eraser (pencil should slide through opening of sipper top)
- 1.1 meters of sewing thread
- 1 10 gram mass; (or 1 hole stopper weighing approximately 10 gm) or other suitable 10 gm object
• 1 meter stick
• 2 small pieces of masking tape
• 1 rubber band
• 1 stopwatch or timer
• 1 floor fan or a breezy day (fan can be shared)
• goggles

Constructing a pinwheel “Elevator” (wear goggles)
1. Cut a square from cover stock paper 21.5 x 21.5 cm; or a square from a manila folder (can be 20 x 20 cm to 24 x 24 cm).
2. Draw 2 lines diagonally on your square from corner to corner.
3. Mark a point 2 cm from the center on each diagonal line (you will have 4 such marks).
4. Using scissors, cut the cover stock square (or manila folder square) from each corner to the 2 cm mark. Do this 4 times, once for each corner of your square.
5. Your square now has 4 triangles drawn on it, connected in the middle. Hold your square and draw a dot in the right hand corner of each triangle, as you turn your square all the way around. Now you have a dot on alternate sides of each of the 2 diagonals.
6. Pin all of the dotted corners together in the center to make a pinwheel.
7. Tack the pinwheel to the end of the eraser on the pencil.
8. Cut a 1 cm square hole into direct opposite sides of the water bottle, 10 cm from the bottom of the bottle on each of the 2 sides.
9. Remove the cap from the empty water bottle and fill the bottle 9 cm from the bottom with sand (water could also be used as the weight). Sand should not reach the height of the 2 holes.
10. Remove the sipper tip from the top of the water bottle cap and place the cap back on the bottle.
11. Wrap a rubber band several times around the pencil; almost 3 cm from the eraser end on the pencil.
12. Slide the free end of the pencil through the sipper tip. The rubber band on the pencil will stop the sipper tip from coming close to the pinwheel. The sipper tip acts as a bushing.
13. Tie or tape the 10 gm mass to the end of the thread.
14. Tape the free end of the thread to the eraser so the length of the thread between the mass and the pencil is 1 meter.
15. Slide the pencil through the plastic bottle, using both square holes.

Performing the Activity (wear goggles)
1. Holding the pinwheel so it is still and covering the holes with your fingers to keep the sand inside, place the plastic bottle on its side on a table. (The sand will flow to a level below the holes when the bottle is on its side.) Allow the thread to hang down loosely, with the 10 gm mass at the end. (If outside in the wind, hold the bottle.)
2. Holding the pinwheel still, place the bottle in a position that causes the fan to spin the pinwheel.
3. Release the pinwheel and start the stopwatch or timer at the same time. Measure the amount of time it takes for the pinwheel to reel up the 10 gm mass exactly 1 meter. This is work being done by the pinwheel.
4. Repeat five times and record the seconds for all five trials.
5. Sum the 5 readings and divide by 5 to find the average time. Make a data table and enter the readings. Choose your headings.
**ASSESSMENT**

**Short Answer Questions**

1. Explain how the wind is really caused by the sun.
2. Practice drawing a map of Texas a few times from memory. Place an X where you live and label the name of your town. Place a dot and label each of these cities on your map: Houston, Dallas, San Antonio, Austin, Lubbock, Amarillo, El Paso, and Corpus Christi. Shade in the areas on your map, where wind power potential is the greatest.
3. Which of the cities in #2 have the greatest potential for using wind energy? Why did people settle in the places these cities are located?
4. Name the original source for the following energy conversions:
   - wind turbine → generator
   - air convection current → wind turbine
5. Make a list of the renewable and non-renewable sources of energy you know.

**Multiple Choice Questions**

1. Do you think wind power will benefit homeowners?
   - a) yes
   - b) no
   - c) depends
   - d) never

2. If many of us used wind power, how would this help society?
   - a) use less imported energy
   - b) reduce pollution
   - c) stabilize energy prices
   - d) all answers, a, b, & c

3. Modern wind turbines:
   - a) have short, flat blades
   - b) are built close to the ground
   - c) have long thin blades
   - d) are not used in Texas

4. Cities you might expect to use wind power are:
   - a) Corpus Christi
   - b) Amarillo
   - c) Lubbock
   - d) All answers a, b, and c

5. Convection currents
   - a) are caused by rising hot air
   - b) allow cold air from the ocean to rush in over land
   - c) have the sun as their real source
   - d) all answers a, b, and c

6. Driving through Texas you might see:
   - a) a few remaining windmills in West Texas
   - b) the last windmill used in Texas in a Houston museum
   - c) both answers a & b
   - d) some of the 80,000 active windmills in Texas

7. Windmills and wind turbines are:
   - a) cheap to operate
   - b) non-polluting
   - c) using a free source of energy
   - d) all answers a, b, and c

8. If using energy from wind turbines was suggested for your city:
   - a) you would want to use only oil for energy
   - b) you would support and encourage using wind energy for electricity
   - c) you would oppose wind energy
   - d) you would never use electricity that was wind generated

9. A convection current:
   - a) radiates energy
   - b) conducts heat
   - c) is caused by differing air temperature
   - d) is a measure of electricity

10. Wind power is:
    - a) a fossil based energy
    - b) non-renewable energy
    - c) a renewable energy
    - d) a limited resource

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InfinitePower.org

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Unit Goal:
Students will expand on the basic knowledge that they have gained through previous activities on the subject of energy. They will do this by examining their personal energy use and looking at ways to improve energy conservation.

Summary:
This unit is designed to extend on the basic topic of energy by having students examine their own personal energy use through a series of engaging activities. These activities will look at how to read energy bills, why energy costs fluctuate, ways that energy can be saved in buildings, how much pollution an individual produces and an investigation into the various viewpoints surrounding global climate change. These lessons are designed force students to follow the natural progression of where energy comes from and how much we use, to what does this consumption mean to the future of the planet earth.

Rational:
Energy is the central theme to all of life on earth. Whether you are talking about atoms or cells, energy is essential to everything. When looking at the subject of Biology, energy is intertwined throughout the field of study. One theme in the study of Biology is Ecology. At some point in the discussion of Ecology the topic of the use of our natural resources if brought up. This is the area that this unit will fit exceptionally well in.
Unit Lessons:
Title:
Reading Energy Bills (from KEEP Activity Guide)

Objectives:
Students will be able to:
- Read and interpret information from electric and natural gas bills.
- Analyze a year’s worth of utility bills to determine an occupant’s energy use patterns.

Description of Procedure: (See Activity Guide for more details)
Recognizing and interpreting electricity and natural gas use patterns by reading utility bills makes students aware of how people use energy at home and can lead students to develop sound strategies for managing their own energy use.

Steps:
1. Review the definitions of a kilowatt-hour, cubic foot, and therm with the students.
2. Hand out copies of the Example Utility Bill. Have the students find out as much information as possible that they can find on the bill. Use a guide to reading utility bills to help students find all of the information on the bill.
3. Hand out copies of Reading a Set of Utility Bills and Utility Bills for One Year. Have students complete the chart in part I. Also have students complete the graph.
4. Ask students to generate a list of observations about the graph and infer reasons for the shape of the lines. Refer to Analyzing Energy Use Patterns Using Energy Bills for suggestions.
5. Have students complete Part II and answer the questions on Reading a Set of Utility Bills.
6. Have students read their own energy bills and come up with observations of their own energy use.

Title:
Energy Prices: Laws of Supply and Demand (from KEEP Activity Guide)

Objectives:
Students will be able to:
- Define demand, supply, and equilibrium price and quantity.
- Read, interpret, and draw graphs depicting demand and supply curves, and determine energy prices from these curves.
- Identify the conditions that cause a shortage or surplus of an energy resource.

**Description of Procedure: (See Activity Guide for more details)**

Investigating the relationship between the supply, demand, and price of energy resources helps students understand how energy prices are set, how different conditions cause prices to change, and how changes in energy prices affect the household budgets of citizens.

Steps:

1. Recreate the table below so the students can see it.

<table>
<thead>
<tr>
<th>Price of Gasoline ($/gallon)</th>
<th>Quantity of Gasoline Purchased per Week (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4.00</td>
<td></td>
</tr>
<tr>
<td>$3.00</td>
<td></td>
</tr>
<tr>
<td>$2.00</td>
<td></td>
</tr>
<tr>
<td>Current Price (Example: $1.67)</td>
<td></td>
</tr>
<tr>
<td>$1.00</td>
<td></td>
</tr>
<tr>
<td>$0.50</td>
<td></td>
</tr>
</tbody>
</table>

2. Using the current price and quantity of gasoline as a reference point, ask students how much gasoline they would purchase per week at each price.
3. Explain that this table is a demand table and show the relationship between price and quantity purchased per week. Have students graph the information. Show students a demand curve for gasoline.
4. Discuss demand curves and see if they work for other energy sources.
5. Discuss the law of demand with students.
6. Have students predict factors that could change the demand for gasoline.
7. Show students a supply curve for gasoline.
8. Define and discuss the law of supply.
9. Have students predict factors that could change the supply of gasoline.
Title:
Home Energy Use

Objectives:
At the completion of this activity, you should be able to
- Identify the major construction, maintenance and design features that make a building energy efficient.
- Define and use each of the vocabulary terms discussed in this unit.
- Explain energy saving steps to a homeowner.

Description of Procedure: (Full Lessons Included)
Energy Lesson Plan

Summary: Discuss home/school energy use and do an energy audit of school and home. Home audit adapted for the Alliance to Save Energy web site at http://www.ase.org/
The dates on the CO2 sheet can changed to reflect the time of the unit. This is a great activity to get parents involved in their child's schoolwork.

Grade Level: 6-8

Subject Areas: Earth Science

Setting: Classroom, Home

Time
Preparation: One hour

Activity: Three days with one weekend allowed for homework

Vocabulary: See Vocabulary Sheets

Materials: Vocabulary Sheets, Home Energy Audit Data, and Materials to make a draft detector: pencil, tape, and tissue paper or thin plastic

Objectives
At the completion of this activity, you should be able to
- Identify the major construction, maintenance and design features that make a building energy efficient.
- Define and use each of the vocabulary terms discussed in this unit.
- Explain energy saving steps to a homeowner.

Skill Objectives
- Recognizing energy conservation design features in buildings
- Using energy conservation vocabulary
Making and recording observations
Conducting a simple energy audit

Major Understandings
Many buildings are poorly designed from an energy standpoint and can be made more energy efficient.
Heat loss takes several forms; conduction, convection, radiation, and air infiltration all contribute to heat loss.
There are many useful steps that can be taken to reduce building heat loss, increase comfort and save energy and money.

Rationale
Learn the importance of saving energy and ways that it can be done

Background
We spend most of our time in buildings -- homes, schools, offices, and stores. But most people hardly notice details about the buildings, such as how they are designed, how they are built, and how well they are maintained. These details have a strong effect on how much we enjoy a building and how much it costs.
An "energy-efficient" building is more comfortable than a wasteful building. It needs less fuel for heat and less electricity for cooling. A building that is badly designed and poorly kept up wastes money because it is trying to heat and air-condition the outdoors as well as the indoors.
This activity turns you into an instant BUILDING INSPECTOR. Your assignment is to identify whatever helps or hurts energy conservation in a specific building. You can become a kind of detective looking for "bad guys" that waste energy and money.

Teacher Background
For a nation with a small population (around 6% of the world's), the United States uses an enormous amount of energy, about a third of the energy produced each year on the planet. As Wilson Clark stated in his book Energy for Survival: the Alternative to Extinction, "it's as if every American citizen had 300 laborers working 24 hours a day for him alone."
Such a situation cannot continue to exist. There are many alternatives, but not all are very attractive. To give ourselves the best chance of maintaining a comfortable standard of living without monopolizing the world's resources, we must develop awareness and habits of conservation. That is what this activity seeks to develop.
The biggest energy consumers in the home are space and water heating. Conservation measures that affect those two factors can make a marked difference in the energy consumption and comfort level of buildings. The owner of an older home or building can save as much as 50% on heating bills by adding insulation and storm windows. Although there is an initial cost, most energy conservation improvements pay for themselves in five years or less. Add to that the energy conservation tax credits that begin to be available when energy supplies are scarce, and you begin to realize that heating a poorly insulated house is like burning money.
Procedure
1. Go over the two vocabulary sheets and discuss them with the rest of the class to be sure you understand each of them.
2. Make a draft detector to use during your energy audit.
3. Go through the Interior and Exterior Data Sheets and complete the observation for your school.
4. Using the Interior and Exterior Data Sheets, complete the observations on your house, apartment, or a building suggested by the teacher. Use the draft detector to help locate air infiltrations.
5. Develop a set of recommendations for improving energy conservation in the house, apartment, or building that was studied. List alternative whenever possible, so that the owner has choices in making conservation improvements.
6. Compare observations with other students in order to improve your study. Revise your improvements sheet based on these discussions.

Assessment
Questions:
1. How many of the items on the Energy Savers list are inexpensive and easy to install?
2. Why are most building lots landscaped the way they are? Do good energy conservation principles generally seem to be used?
3. The locations of most windows in a dwelling are related to the need for light inside and the desire of those designing the home for balance and appeal. What effect would conservation practices have on window locations?
4. For what purposes is hot water really needed in a home? What are the reasons for many people using more hot water than they really need?
5. If a homeowner had only a limited amount of money, what energy savers do you think would help most for the least money?

Extension:
Have the students see how much CO2 that their family produces. See CO2 production sheet

Resources
• Obtain class sets of brochures on home energy conservation from your local utility.
• Collect samples of insulation, caulk, and weather-stripping, and pictures of these items being installed. Many hardware and building supply stores have free "how-to" pamphlets and samples for prospective customers.
• Ask a builder, energy manager, building superintendent, or other person familiar with building materials to talk with the class about the problems of energy conservation in buildings.
Vocabulary Sheet

Heat Bandits

Radiation: passage of energy through open space, like sunlight. During the daytime a building absorbs solar radiation, but after the sun goes down, it starts to reradiate heat to the cold outside air unless something is done to block the radiation.

Conduction: passage of heat through a material. Some materials, like glass and metal, conduct heat (and lose it) easily. Insulation helps to block conduction of heat. If ceilings and walls are poorly insulated, they conduct heat from the house to outside.

Convection: transfer of heat by movement of air. As heated air contacts cold surfaces such as windows, it loses heat. The cooled air is denser than warm air, so it tends to settle, pushing warm air toward the ceiling. These temperature changes and air movements form a pattern. Warm, light air from the ceiling area is chilled along the window, becomes heavier and drops to the floor. It moves across the floor, is reheated, moves up the opposite wall, (away from the window), across the ceiling and down past the window again. Each cycle the air loses heat. Heat must be supplied from a sunny window, a furnace, stove, or other heater to maintain a comfortable temperature.

Condensation: beads of moisture that form on surfaces as warm, moist air is cooled. Moisture condensing from room air (showers, breathing, cooking, etc. provide the moisture) shows up most on the cooled areas. Wet or frozen windows are reminders of wasted heat. The cures are double or even triple glazing of windows, heavy drapes, insulating shades, or sliding panels.

Air infiltration: air seepage due to wind. Air pressure pushes cold air in through tiny openings on the windy side and draws heated air out of the opposite side of the house. Drafts occur through wallboard cracks, gaps around paneling (top, bottom, and sides), cutouts for pipes and wiring, poor seals for window sashes, badly weather-stripped doors, and loose molding at bottoms of walls.

Energy Savers

Insulation: material with high resistance (R-value) to heat flow. Some commonly used materials for home insulation are fiberglass, cellulose, rock wool, and Styrofoam. The resistance to heat flow is provided by the many small dead air spaces between the fibers or particles. Insulation comes in as variety of forms: blankets, or batts, foam, boards, or small loose pieces.

R-value: the factor that tells how much resistance to heat flow a material has. The higher the R-value, the greater the insulating efficiency of the material. R-values are commonly stated per inch of building material. R-values are additive - thicker material or a combination of materials means increased resistance to heat flow. Approximate R-value per inch of thickness for common insulation materials:

Material “R” per inch thickness

Flexible

Cellulose fiber with vapor barrier 3.20-4.00**
Glass fiber or mineral wool 3.00-3.40**

Loose Fill

Glass fiber and mineral wool 2.80-3.40
Cellulose 3.50-3.70
Vermiculite, expanded 2.13

**Rigid Board**
Polystyrene, extruded 5.26
Expanded urethane, preformed 5.80-6.25
Glass fiberboard 4.00
Polystyrene, molded beads 3.57

**Foamed-in-Place**
Expanded urethane, sprayed 6.25

- Determined from ASHRAE Handbook, 1972
**Varies according to density and fiber diameter**

R-value standards for an efficient house:
Ceiling: R-33; Exterior Wall: R-19; Floor: R-22;

**Vapor barrier:** a waterproof liner used to prevent passage of moisture through the building structure. Vapor barriers in walls and ceilings should be located on the heated (indoor) surface of the building. Some insulation comes with a vapor barrier attached.

**Window treatments:** applications to the interior side of windows (blinds, shades, shutters, draperies), used to save energy by keeping heat in or out.

**Damper:** a trapdoor or other device, which controls the passage of air through a duct, chimney, or stovepipe.

**Flow restrictor:** a device attached to a water nozzle or showerhead to reduce the flow of water while maintaining the pressure of the spray. This saves energy by cutting down on the amount of hot water being used.

**Clock thermostat:** a thermostat equipped with a timer to change temperature levels automatically at certain times of day. It helps to save energy by turning down the heat at night and during the hours when people are usually out of the house.

**Roof overhang:** a solid horizontal or angled projection on the exterior of a building placed (ideally) so that it shades southern windows in summer only, when the sun is high in the sky. This saves on air-conditioning. (To determine the approximate size overhang needed, add the height of the window to the distance from the top of the window to the overhang, and divide by 2.)

**Windbreak:** a dense row of trees, or a fence or other barrier that interrupts and changes the local path of the wind. Windbreaks located on the north and west sides of a building can save heat by reducing wind chill and air filtration.

**Air lock entry:** a porch, vestibule, or entry hall with an inner door and an outer door at the entrance of a house or building. The two doors save energy by cutting down on air exchange when people go in or out.

**Caulk:** a soft, semi-solid material that can be squeezed into nonmovable joints and cracks of a building, thereby reducing the flow of air into and out of the building.

**Weather-stripping:** material, which reduces the rate of air infiltration around doors and windows. It is applied to the frames to form a seal with the moving parts when they are closed.
Home Energy Audit Data

Name or location of building inspected: ____________________________

Interior = Yes No Does Not Apply

1. Are the ceilings insulated? (In apartments, ask the superintendent or building owner for details.)

2. How thick is the insulation? (Check with ruler in attic or crawl space. Tell in inches - last column.)

3. Is there a vapor barrier (plastic, aluminum, or heavy brown paper) on the indoor side of the insulation?

4. If the building is on a slab or has an unheated basement, does the first floor have insulation under the floors?

5. If the basement is heated, are the basement walls insulated?

6. About how much of the floor is covered with rugs, padding, and carpeting? (per cent of fraction)

7. Are heating and cooling equipment (ducts, grilles, radiators) blocked by furniture, rugs, drapes, etc.?

8. Are walls and ceilings light enough in color to reflect light well?

9. Are insulating drapes or other tight window treatments such as framed shades in place?

10. Are these insulating drapes or other tight window treatments such as framed shades in place?

11. If there is a fireplace, does it have a damper and glass doors?

12. Is the damper closed when the fireplace is not in use?

13. Are the glass doors kept closed during fireplace use to keep warm room air from escaping up the chimney?

14. Does the draft detector move when placed along edges of doors and windows on calm and windy days?
15. On windy days does the draft detector show air currents through electrical outlets placed on outside walls?

16. Check other openings for drafts, and make a list of drafty openings. EXAMPLES: plumbing pipes entering walls, exhaust fans in kitchen or bathroom while OFF, chimney pipes exiting through walls or ceilings.

17. Are hot water faucets free from drips?

18. Have flow-restrictors been placed in pipes connected to showerheads?

19. Is there a clock thermostat adjusted to "set-back" (lower) temperatures automatically at bedtime?

20. Check the cellar for exposed hot water or steam pipes. Are they all insulated?

21. Check cellar or attic for ducts carrying heated air. Are they wrapped with insulation?

22. Check baseboard-type radiators. Are openings or metal fins inside blocked or filled with dust?

23. Is the exhaust hose from the clothes dryer detached from its vent and run through a filter to keep warm, damp air inside the house?

24. Has the furnace been cleaned and serviced in the last year?

**Exterior ================**

1. Are there fewer windows on the north side of the building?

2. Are the north windows smaller than those on the other sides?

3. Does the roof on the south side extend out from the house far enough to block summer sun from walls and windows?

4. Will the roof overhang the lower winter sun to warm south walls and windows?
5. Are there storm windows in place and tightly sealed? (If large amounts of moisture condense on the inside of windows and freeze on coldest days storm windows are not working properly.)

6. If there are no storm windows, are there temporary (plastic) barriers installed? (They should create an air space about 3/4 of an inch thick between inner and outer glazings.)

7. Are evergreen shrubs and trees planted as windbreaks around the north and west sides of the building?

8. Are deciduous (leaf shedding) trees planted on the south side for summer shade and winter sun?

9. Does snow melt more quickly on your roof than it does on similar houses nearby? (Indicates need for more ceiling insulation).

10. Can you see spaces for air leaks between the house and its foundation, broken windows, rotted boards or other sources of cold air leaks into the cellar or crawl space?

11. Are cellar doors insulated and tight-sealing?

12. Are attic vents open summer and winter? (Unless the attic is paneled and occupied, vents should be open. Ceiling insulation should keep your house warm, not a sealed attic. Vents from ceilings of rooms below into the attic should be open in summer, but closed and insulated in winter.)

13. Are cracks and joints around windows, doors, stairways, pipes, and electrical wires caulked?

14. Is there weather-stripping around the inner and outer doors? Around the windows?

15. Are cracks in walls and foundations sealed and holes plugged in?

16. Is there an air lock entry hall, double door, or insulated storm door at each outside entrance?
Carbon Dioxide (CO₂) Contribution

Goal: Calculate your monthly contribution of CO₂. December 18th – January 18th.

Due January 20th

Instructions

1. Using an electrical bill, find out how much electricity in kilowatt-hours your family used in a month. Divide by the number of people in your house to determine your personal portion of electrical use.

b. Determine how much carbon dioxide that represents in Kg or lbs by multiplying the following.

   i. 1 kilowatt-hour of electricity form a coal plant generates 1 Kg of CO₂ or 2 lbs of CO₂.
   ii. If you use natural gas, use the same steps as above, but use the following information: Burning 100 cubic feet of natural gas produces 5.5kg (11.5 lbs) of CO₂.

2. Use your family’s car or truck odometer (if there is more than one car or truck, pick one of them to use), to determine how far the car is driven in a month.
   a. You must calculate the miles per gallon of the car or truck. To do this, determine how many gallons and miles it takes to drive between one fill-up.
   b. Burning 1 gallon of gas produces 9 Kg or about 19 lbs of CO₂.

3. Double your figures from 1 and 2 above to account for all the products you buy. This is a good estimate of your monthly contribution of CO₂.
   a. Convert this answer to tons.
   b. 2000 lbs = 1 ton.

Please answer the following questions. Please use tons as your answers.

1. How much CO₂ (in tons) do you add to the atmosphere in a year?

2. The population of Einstein is around 450 students.
   a. How much would Einstein contribute monthly if each student use the same amount of energy as you?
   b. How much in a year?

3. The population of Appleton is about 70,000 residents.
   a. How much would Appleton contribute monthly if each resident used the same amount of energy as you?
   b. How much in a year?

*Please see the sample problem on the back of this sheet.
***You must show all of you work to receive full credit! ***
Sample:

1) **Electric Bill:**
   430kwh = 430 kg of CO₂ = 860 lbs of CO₂
   Personal Contribution: 430/3 = 143.3kg = 286.6 lbs of CO₂

2) **Driving:**
   35 miles to the gallon
   Approximately 375 miles driven
   Personal Contribution: 375/35 = 10.7 gallons = 94.4kg = 203.3 lbs of CO₂

3) **Doubling for Products:**
   143.3 + 94.4 = 237.7kg
   286.6 + 203.3 = 489.9lbs
   237.7 x 2 = 475.4kg of CO₂ per month
   489.9 x 2 = 979.8lbs of CO₂ per month

4) **Per Year:**
   475.4 x 12 = 5704.8kg of CO₂ per year
   979.8 x 12 = 11,757.6lbs of CO₂ per year or 5.88 tons of CO₂ per year

5) **Einstein Middle School Population**
   450 x 475.4 = 21,390kg of CO₂ per month
   450 x 5,704.8 = 2,567,160 of CO₂ per year
   450 x 979.8 = 440,910lbs of CO₂ per month = 220.5 tons
   450 x 11,757.6 = 5290920lbs of CO₂ per year = 2,645.46 tons

6) **Appleton Population**
   70,000 x 475.4 = 33,278,000kg of CO₂ per month
   70,000 x 5,704.8 = 399,336,000kg of CO₂ per year
   70,000 x 979.8 = 98,586,000lbs of CO₂ per month = 49,293 tons
   70,000 x 11,757.6 = 823,032,000lbs of CO₂ per year = 411,516 tons

**Title:**
Viewpoints (from KEEP Activity Guide)

**Objectives:**
Students will be able to:

- Provide an overview of the theories behind global climate change.
- Identify at least two different viewpoints about global climate change.
- Write an objective paper about the opinions of different people involved in the global climate change debate.

**Description of Procedure: (See Activity Guide for more details)**

Differing opinions about an environmental problem make the problem an issue. The issues concerning global climate changes are frequently in the news. Encouraging students to investigate all sides of this issue or any other issue that results from our energy use helps them to make objective and thoughtful decisions.

**Steps:**

1. Students will investigate different people's opinions about how we should respond to the possible results of an enhanced greenhouse effect.
2. Discuss sources where students can find information about global climate change.
3. Have students work in pairs or groups of three to investigate the various viewpoints involved in this issue. Each student will have a role or responsibility in the group.
   - i. Students will find six sources of information on global climate change.
   - ii. Have groups further investigate two sources.
   - iii. Have students use **Global Climate Change Viewpoint** form to summarize their findings.
   - iv. Everyone in the group should read all sources, but each group member is only responsible for drafting the **Viewpoint** form for one source.
4. After the groups have investigated at least two different sources of viewpoints about global climate change, have them present their findings to the class.
5. When students have finished their presentations, have them post the **Global Climate Change Viewpoint** form on the wall. Have them group similar or related viewpoint together.

**Unit Assessment Strategy:**

Throughout the unit there are build in assessment opportunities. With the utility bill, students should be able to find the information on their own. The Energy Prices: Laws of Supply and Demand lesson has a final activity called...
Mr. Sene's Dilemma, which allows students to use the knowledge that they have collected to complete the activity. The personal energy use lesson has questions that the students will answer. The viewpoint lesson allows students to form opinions based on the research that they have done and present them in class.

Another possible assessment is to have the students assess the school's energy use to determine possible ways to save money.
Objectives

Students will be able to
• demonstrate how wind and water can move a simple turbine; and
• recount the role of turbines in electricity generation.

Rationale

Understanding how turbines operate helps students explain how humans have developed technology to further their ability to use energy resources.

Background

See also “Facts about Hydropower” and “Facts about Wind” in Appendix.

The wind gently blows across the surface of a lake. This is a calming sight, but who would think that wind and water are both sources of energy that can power all the electrical appliances in our home?

Wind is a form of energy created in part by the sun. The heating and cooling of Earth’s surface and Earth’s rotation help form wind. The sun heats Earth’s surfaces. This heat is then radiated, warming the surrounding air. About two percent of the sun’s energy that reaches Earth is converted to wind energy.

Wind energy has been used for hundreds of years. Farmers and ranchers have used windmills to pump water to fields and livestock in remote locations.

Today wind machines provide electricity for operating lights and appliances, and mechanical power for pumping water. There are three kinds of wind systems: small systems that yield up to 100 kilowatts (kW) used by farms, rural residences, and remote communities; intermediate-sized machines that yield between 100 kW and one megawatt (MW) used for irrigation and small utilities; and large-scale systems with a capacity of at least one MW that can be used for large-scale utility or industrial needs.

Only a small amount of electricity in Wisconsin is generated through wind power (about 0.6 MW). The Public Service Commission of Wisconsin has prescribed that utilities build a 10 MW wind research facility by the year 1999. According to the Wisconsin Energy Bureau, it is economically achievable to harness 100 MW of wind-generated electricity by the year 2010.

Similar to wind energy, water power has been used for many years to do work. Many people have seen grist mills located by streams. The flowing stream causes a
Getting Ready:
Construct a turbine prior to the class and use this as a model. This turbine can also serve as the pinwheel used in the Orientation.

To prepare for Part C in the Waterwheels, Windmills, and Turbines Activity Sheet, cover the spout of an electric kettle with a piece of aluminum foil and secure with tape. Poke a pencil hole in the foil near the tip of the spout.

Resources:
For Teachers


Complementary Activities


(Continued on next page)

Waterwheel to rotate that turns gears within the grist mill to grind flour. Waterwheels also lift objects (including water) and power machinery.

Hydroelectric power is produced from the flowing, falling water of rivers and streams. Although large dams provide most of our hydroelectric power, small systems (producing less than 100 kW) can also be used to provide power for individual homes. To extract power from the flow of water, the water must be channeled under pressure to a turbine or waterwheel. The greater the water pressure, the greater the power. To harness and control the power of flowing water, people build dams. Water collects behind the dam, creating a reservoir. The stored water behind the dam contains a large amount of potential energy. When water is released from the reservoir, it flows through the dam in pipes (called penstocks) to the powerhouse. In the powerhouse the water pressure is applied to a turbine, and the turbine converts kinetic energy to mechanical energy. A shaft spins a generator to produce electricity. After the water has moved through the turbine, it is released into the river below the dam (see *Electricity from Falling Water* on page D 57).

Hydroelectric power is cost-effective, but there are drawbacks. The damming of a river or stream has a critical and sometimes irreversible impact on its long-term ecological balance. The formation of the reservoir floods the surrounding land area, destroying some habitats and creating others. Impoundment of water results in an accumulation of silt above the dam site, clogging mechanisms of the dam and affecting the natural sedimentation process further downstream. However, dams provide new recreational areas and can reduce the occurrence of natural disasters such as floods and erosion.

Currently, Wisconsin receives about 2,000 kilowatt hours (kWh) of the electricity it generates (4.1 percent) from hydroelectric power. Of the existing dam sites, 74 are owned by utilities and 57 are owned by private developers (see *Electric Utility Hydroelectric Sites in Wisconsin* in “Facts about Hydropower”).

When people talk about hydroelectric power, they are talking about using the power in flowing liquid water to generate electricity. But steam can also be used. Heat produced by the combustion of fossil fuels (coal, oil, or natural gas) or the fission of uranium is used to convert water to steam. The steam is then piped to a turbine where it strikes the turbine blades, causing the turbine shaft to rotate.
The rotating turbine shaft is connected to a generator’s wire coil. The generator converts this mechanical energy to electrical energy. As the turbine shaft rotates, it causes the generator’s wire coil to spin. The spinning wire coil is surrounded by magnets that induce an electric current. Large generators can produce electric voltages of about 22,000 volts. The electric current produced by the generator in the power plant is then transmitted through power lines to homes and businesses in the surrounding community (see Electric Power from Fossil Fuels and Electricity from Uranium on pages D 58-59).

So, the next time you dip your toes in a babbling brook or feel a cool breeze on your face, remember: these resources also have the energy to generate electricity for appliances we use every day.

**Procedure**

**Orientation**

Show students a pinwheel and ask if they think it can do work. Remind them of the definition of work (applying a force—a push or a pull—that moves something a distance). Blow on the pinwheel to show students that it moves. Ask students to think of situations where a wheel similar to this can do work. Show students photographs or describe windmills and waterwheels.

Discuss what sources of energy make the windmills and waterwheels turn. Explain that the wheels are tools or simple machines that convert the kinetic energy in the wind or water to mechanical energy. Tell them that another word for this working wheel is a turbine, a wheel with blades joined to a shaft. Inform them they will make their own model turbine and experiment with different ways to make it turn.

**Steps**

1. Divide the class into small groups and provide each group with a copy of Waterwheels, Windmills, and Turbines Activity Sheet. One student in the group can be responsible for getting materials, another student for reading directions and providing guidance, and another for constructing the turbine.

2. Have students read the Introduction and Making a Turbine sections of the activity sheet. Go over each step with students to make sure they understand the procedure.

3. Tell students to make their model turbines. It is important to check to see that the shaft fits snugly in the hole in the pie plate. You may need to glue the shaft to the pie plate. The turbine should not rotate around the shaft. **CAUTION: Warn students to be careful when using scissors and that the edges of the cut pie plate may be sharp.**

4. When the students have finished their turbines, tell them to follow the instructions for conducting the experiments described in Using the Turbine, Parts A, B, and C on the Waterwheels, Windmills, and Turbines Activity Sheet and record answers to the questions on the activity sheet. **CAUTION: Supervise the kettle at all times to make sure no one gets burned.**

Students will be able to answer most of the questions based on their observations.

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**For Students**


**Credits:**


Portion of background adapted from National Energy Foundation. Understanding Electricity Kit. Salt Lake City: © 1989, National Energy Foundation. All rights reserved. Used with permission.


Related Activities:

This activity could be preceded with investigations found in K-5 Sparks for Theme II: Suninvestigations, Windy Wonders, and Water Fun. Help students appreciate their dependence on electricity through K-5 Energy Sparks for Theme II: Electricity in Our Lives. Students identify energy sources used to generate electricity in “Fueling Around.” Have students learn more about electricity with the activity “Circuit Circus.”

Answers to Activity Sheet Questions:

Part A: The Windmill
1. The windmill spins gently when you blow on it lightly.
2. The windmill spins more quickly when you blow harder. You supply more energy when you blow harder.

Part B: The Waterwheel
1. The water has stored energy.
2. When the water strikes the blades of the turbine, the turbine spins.
3. To make the turbine turn the fastest, you should hold it as far from the cup as possible because the farther the water falls, the more kinetic energy it has and the more work it can do on the turbine.

Part C: The Steam Engine
1. Yes. The turbine turned as the steam hit it.
2. The steam was produced by boiling water in a kettle.

For Part B, question 1: the water is the cup has potential or stored energy (see “Potentially Kinetic”). For Part B, question 3: students should find that holding the cup of water higher makes the turbine spin faster.

Closure

When everyone has finished, discuss their answers to the questions posed in the Waterwheels, Windmills, and Turbines Activity Sheet. Stress to students that the turbine caused a change in the direction of the energy of motion. The wind, water, and steam moved in a straight line until they hit the blades of the turbine. Then the turbine moved in a circle. Point out that because the turbine caused a change, we can call it an energy converter. Tell students that turbines are an important part of the machinery we use to make electricity. Discuss information about windmills, dams, and generators in power plants (see the Background).

Assessment

Formative
- Did students follow directions and successfully build model turbines?
- To what extent did students make careful observations and respond thoughtfully to the questions?
- Were students able to make the turbines spin using wind and water?

Summative

Have students build or sketch a simple power plant, including a turbine, and trace the flow of energy from the turbine to their homes.

Water mill photograph from Portage County Historical Society, 1910.
Introduction
Have you ever seen a windmill whirling in a breeze? Or a waterwheel slowly turning in a stream? Our ancestors joined the shafts of these bladed wheels to gears, levers, and different types of machines. They used these simple machines to mill grain, lift heavy materials, and pump water. In the early nineteenth century, many factories used waterwheels to run machines that spun cotton and sawed lumber.

Today, modern turbine engines are used instead of waterwheels and windmills. Modern turbines are also bladed wheels with shafts that are joined to other machines. Modern turbines spin much faster and deliver more power than waterwheels or windmills. These turbines are mainly used to produce electricity.

Making a Turbine
Each group will need:
- 1 pair of scissors
- 1 large paper clip (not the non-skid type)
- 1 pencil
- 1 plastic drinking straw
- 1 aluminum pie plate (at least 4 inches [10 cm] in diameter)
- 1 metal nail
- 1 foam cup
- Masking tape
- Glue

1. Cut out the turbine pattern. Use four pieces of tape to secure the paper to the pie plate.
2. Remove the edge of the pie plate by cutting a circle on the pie plate. You may want to leave some space around the turbine pattern for now and cut more carefully around the edge later. Make sure that the turbine pattern stays taped to the pie plate.

3. Cut along each of the dotted lines. Cut from the edge toward the center of the circle.

4. Cut along the small solid lines (the dashes) on the turbine pattern.

5. Use the nail to make a hole in the center of the turbine.

6. Trim the pie plate by cutting along the outer edge of the turbine pattern. Remove the turbine pattern from the pie plate.

7. Twist each blade of the turbine slightly in the same direction.

8. To make the shaft, cut a piece of drinking straw so that it is the same length as the one shown below.

9. Carefully widen the hole in the turbine with a pencil point. Be sure you do not make the hole bigger than the straw. Put the piece of drinking straw through the hole. Make sure that the straw (shaft) fits snugly in the hole. Use glue if necessary. (Allow the glue to dry.)
10. Shape a paper clip into a long "L." Fit the shaft on the long end.

11. Bend the long end of the paper clip down as shown in the picture. Tape the pencil to the long end of the paper clip. Your turbine should now look like the drawing.
Part A: The Windmill

1. Blow lightly on the turbine from the side.

**Question:** What happens?
**Our Answer:**

2. Blow harder on the turbine.

**Question:** What happens? Why?
**Our Answer:**

Part B: The Waterwheel

1. Make a hole in the bottom of your foam cup with a nail. Widen the hole with your pencil. Then cover the hole with your finger and fill the cup with water. Hold the cup about six inches (15 cm) above the aluminum tray.

**Question:** What kind of energy does the water in the cup have?
**Our Answer:**

2. Let one group member hold the turbine just below the cup. Remove your finger from the cup.

**Question:** What happens to the turbine?
**Our Answer:**
Using the Turbine (Continued)

3. Refill the cup with water and hold it in the same position as you did before. Repeat Step 2, but let another group member hold the turbine at different heights and positions under the cup.

Question: Where should you hold the turbine to make it spin the fastest?
Why?

Our Answer:

Part C: The Steam Turbine

Hold your turbine just over the hole in the spout of the kettle. CAUTION: Make sure your fingers are not close to the spout.

Question: Does your turbine spin?

Our Answer:

Question: How was the steam made?

Our Answer:
Don't Throw Energy Away

Objectives

Students will be able to

- explain that energy consumption includes products and materials they use (Part I); and
- develop a plan that outlines how they can save energy by reducing, reusing, or recycling items they normally throw away (Part II).

Rationale

The energy used to develop, transport, and market a product is often overlooked as a component of consumers' energy consumption. Having students learn about these "hidden" energy uses, and analyze ways to reduce the amount of waste these uses generate, introduces them to another aspect of energy conservation.

Background

As consumers and citizens, we should be aware of the flow of energy throughout the environment and within our industrial society. Just as a tree or human cannot grow without energy, human-created materials such as pencils, airplanes, school lunch bags, and television sets cannot be created or used without expending energy.

The total amount of energy needed to make and transport a product is called embodied energy. For example, the engine powering a steam shovel used to mine a metal consumes energy in the form of gasoline. The equipment used to fell a tree, whether powered by hand or by engine, consumes energy. The process of transporting the metal-bearing ore to a refining plant or milling the tree requires energy to power the machinery. Combining the processed metal and wood with other raw material to make a finished product draws on even more energy. All the energy used in these processes is used once and is unavailable for future use.

Even after the product is created, energy is used. Energy is needed to produce the packaging and to ship the product to the retailer. Selling the product involves energy use. Depending on the purpose of the product, the consumer may expend energy when using it. Finally, the product is thrown away, which also requires energy.

People in Wisconsin throw out everything from toothpaste tubes to old television sets, food scraps to plastic milk jugs, jelly jars to paper. If you add up all the waste from your house, from the store where you shopped, and from the restaurant where you ate, it would amount to five pounds (2.25 kg) per person of municipal
Getting Ready:

This activity is divided into two parts. The second part includes three activities related to energy and waste management (reduce, reuse, recycling). Based on your classroom needs, you may have students participate in just one part, all parts, or any combination.

If time allows, have students keep a tally of what they throw away for a day or a week and bring the information to class (see Orientation).

Resources:

For Teachers


Wisconsin Paper Council. 111 East Wisconsin Avenue, P.O. Box 718, Neenah, Wisconsin 54957-0718. Phone: (414) 722-1500.

 solid waste thrown into the trash every day. Fortunately, Wisconsin residents recycle about 1.25 pounds (0.56 kg) of waste per day. If you multiply the remaining 3.75 pounds (1.69 kg) by 365 days per year, then by five million Wisconsin citizens, your results will show that Wisconsin citizens still throw away more than 3.4 million tons (3.06 million metric tons) of stuff each year!

When a product is thrown away, it is the end of the line for the energy flow history of the product. The embodied energy used to create the product is lost as waste heat and never available for use again. Clearly, we need to develop ways to reduce the amount of embodied energy used during production, to allow the saved energy to be used for alternative purposes. In addition, we should consider the energy that is stored within the product. Wood, plastics (made from petroleum), and glass all have energy stored within their chemical bonds. Wisconsin’s trash contains enough energy to heat more than 300,000 homes a year.

So, what else can we do with waste besides send it to a landfill? The approaches most often recommended to decrease the amount of waste we generate are labeled the Three Rs (Reduce, Reuse, Recycle). See student pages for more information about these options. While people reduce, reuse, and recycle many products, some items should be used only once and then put into a landfill or incinerated. These items include hospital waste such as syringes.

Some communities in Wisconsin have built waste-to-energy plants to deal with solid waste materials. This approach involves using solid waste, specifically the chemical energy stored in the waste, as a fuel source. Waste is burned and the heat produced is used to generate electricity. Each ton of solid waste has the energy equivalent of 70 gallons (265 l) of gasoline—enough energy to drive a small car from coast to coast. However, toxic substances are often released into the air when waste products are burned, and burning also results in the production of a toxic ash. Another drawback to burning waste is that some of the materials that burn the best or contain the most stored energy (paper, plastic) are also the best candidates for recycling and reuse, resulting in greater embodied energy savings compared to the stored energy received from burning.

None of these approaches is the sole solution to our waste disposal problem. In 1990, Wisconsin passed Act 335, the Waste Reduction and Recycling Law, which banned certain items from Wisconsin’s landfills and required communities to establish effective recycling programs. Wisconsin currently reuses, recycles, or composts more than 25% (by weight) of its municipal solid waste each year. These actions reduce the need for landfill space and help save energy, sending a message to manufacturers and waste disposal managers that we, as consumers, are serious about conserving energy resources for future generations.

Procedure

Orientation
Open a can of soda and take a sip of it. Ask students to identify ways you just used energy. If students do not mention the aluminum can and its contents, introduce the term embodied energy (the total energy required to produce and transport a product). Explain that large amounts of energy are needed to produce aluminum (about 98,000 BrU/lb.). (See Aluminum Production.)
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Smelters
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bauxite
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Processing bauxite produces high
volumes of red mud, for which there is
currently no use. Additionally, the mud
must be contained to keep it from
contaminating water and other
environmental
resources.

Smelters or reduction plants transform
white alumina powder into molten
aluminum. First, the powder is dissolved in
a hot, liquid salt solution in a
large pot. Then an electrical current
flows into the pot, causing aluminum to
settle to the bottom, where it is removed.

This process makes producing aluminum
very energy intensive.

Molten aluminum is almost always alloyed
(mixed with other metals and
elements) to make it stronger. Then it is
poured into molds to form ingots.
Ingots may be long rods, huge slabs weighing
20 tons (18,144 kg), or small
bricks weighing only 4 pounds (1.8 kg).

Ingots are melted and turned into products. Huge slabs of aluminum are
usually rolled into sheets of varying thickness for products such as
aluminum foil, airplanes, and beverage cans. Smaller ingots of aluminum
may be melted and poured into molds, creating tea kettles, automobile parts,
and other products.

See also Aluminum from Raw Materials vs. Recycled Materials.
Inventory of Things Typically Thrown Away

<table>
<thead>
<tr>
<th>Type of material</th>
<th>Composition of material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>Plastic</td>
</tr>
<tr>
<td>Durable goods (products used three years or more; e.g., furniture, tires, appliances)</td>
<td></td>
</tr>
<tr>
<td>Nondurable goods (products used three years or less; e.g., disposable items, paper, some clothing, food)</td>
<td></td>
</tr>
<tr>
<td>Packaging</td>
<td></td>
</tr>
</tbody>
</table>

Steps

Part I—Embodied Energy
1. Share some of the Wisconsin trash statistics with students (see Background). Discuss the connection between energy and solid waste. Emphasize the following:
   - Each time something is produced, energy is required (embodied energy).
   - When products are bought and used inefficiently or tossed away prematurely, the energy that was used to produce the product is essentially wasted.
   - Many products contain stored energy (chemical energy) that is unavailable when the product enters a landfill.

2. Divide the class into small groups. Have the group select one product (and/or its packaging) from Inventory of Things Typically Thrown Away charts to analyze (see Orientation). If possible, students should choose a locally produced item. For example, bicycles are made in Waterloo; batteries and bologna in Madison; pens in Janesville; soy sauce in Walworth; shoes in La Crosse; beer in Milwaukee; glass in Burlington; and paper, cheese, and plastics in many Wisconsin towns.

3. Have students compile a report on the product that includes the following:
   - Raw materials used during production (optional)
   - Production steps and energy resources required to make the product (embodied energy)
   - Information about potential energy that is stored in the chemical bonds of the product
   - Energy-related problems associated with throwing away the product (should relate to embodied energy and/or stored energy)
   - How creating the product may affect the environment (optional)

This report can be based on practical knowledge, background reading, or contacts with or visits to the manufacturer to obtain more information about the process.

Part II—Save Energy through Waste Management
1. Involve students in one or more of the following activities to introduce them to alternatives to throwing things away, often called the Three Rs (Reduce, Reuse, Recycle):
   - Generating Less Household Waste: Reduce
   - Once Is Never Enough: Reuse
   - Something New from Something Old: Recycle
2. Have students identify which approach(es) might work as alternatives to disposing of their product (they may also want to include other options such as choosing not to purchase, incinerating, landfilling, etc.). Instruct students to evaluate each alternative they identified and use the evaluation to select one approach. Students can use a decision-making grid like the sample on this page to help decide (for more information see “A Decision-Making Model—A Tool for Analysis” on page A 38 in the Appendix).

Closure

Have each group conduct a presentation about their product (how it is made and used), focusing on the energy involved. The group should discuss how development and disposal of their product relates to energy use. Next, the group should present disposal alternatives they evaluated and chose (or did not choose, if landfilling was the only viable option). The summary of the presentation should emphasize how their chosen action helps conserve energy.

Sample Decision-Making Grid

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Convenient</td>
</tr>
<tr>
<td>Reduce:</td>
<td></td>
</tr>
<tr>
<td>Buy ball point pens that are not packaged.</td>
<td></td>
</tr>
<tr>
<td>Reduce/Reuse:</td>
<td></td>
</tr>
<tr>
<td>Purchase fountain or cartridge pen.</td>
<td></td>
</tr>
<tr>
<td>Reduce:</td>
<td></td>
</tr>
<tr>
<td>Contact manufacturer to ask for less packaging.</td>
<td></td>
</tr>
<tr>
<td>Incinerate</td>
<td></td>
</tr>
<tr>
<td>Landfill</td>
<td></td>
</tr>
</tbody>
</table>

Assessment

Formative

- Can students explain the connection among energy use, prudent shopping, and waste disposal practices? (Part I)
- Are students able to provide examples of how to reduce, reuse, and recycle household waste? (Part II)

Summative

Challenge students to develop a classroom plan to address a waste generation problem. Most likely this plan will involve limiting the amount of paper that is used and thrown away. Their plan should report how much energy is used to make paper (from both virgin resources and recycled). Each of their proposed solutions should highlight the energy that could be saved by the action.
“Reduce” is one of the three Rs when it comes to addressing the solid waste problem. Reducing essentially means less waste in the first place. There are a variety of things consumers can do to reduce the amount of material they contribute to the waste stream; many of these focus on selective and prudent purchasing practices (see also Once Is Never Enough: Reuse).

One way a consumer can reduce waste generation is to avoid buying products that are excessively packaged. A large portion (around 35 percent) of the waste we generate is packaging. There are many benefits of packaging: fewer damaged goods, product preservation, and organizing and presenting contents. However, items can sometimes be overpackaged (such as wrapped in many layers of plastic and paper, large containers for small products, single-sized serving containers packaged together). Because energy is needed to produce packaging as well as to produce the product, many companies are making efforts to conserve energy by improving their packaging practices.

The following are other ways consumers can help reduce the amount of waste generated:
- Ask yourself, “Do I really need this item?”
- Buy long-lasting products rather than items that have a shorter life span and end up as waste sooner
- Buy goods in returnable or recyclable containers
- Invent new uses for old materials

Individuals can also contact the manufacturers of products they buy and persuade them to use less energy during the production process. Decreasing the number of steps or the materials needed to create a product or its packaging means less energy is needed to produce and transport materials. In other words, the product’s embodied energy is reduced.

Saving time and money are among the many reasons industries strive to improve the efficiency of their production processes. The less energy they use, the less energy they have to pay for. Such practices are especially important as the price of energy increases. Paper production is one example of an industry that has reduced its energy use. The paper industry has decreased the amount of energy it needs to produce a ton of paper by 27 percent since 1972.

Illustrating the Waste Alternative
1. Ask students to bring to class various containers used to package food. Have students classify the predominant type of material (glass, aluminum, steel, paper, etc.) used in the packaging. If a package is made out of different types of materials (like cardboard and plastic), have students separate the package into different materials.

   **CAUTION:** Students may need to wear protective gloves and to use scissors.

2. For each package, instruct students to weigh each type of material.
3. Have students use the data from the chart below to calculate how many kilocalories or kcal (1 kcal = 1,000 calories = 1 food Calorie) were used to produce the packaging. If more than one material was used in the packaging, they should determine the energy needed for each material and total the results.

<table>
<thead>
<tr>
<th>Material</th>
<th>kcal/lb</th>
<th>kcal/oz</th>
<th>kcal/gm</th>
<th>BtUs/lb</th>
<th>BtUs/gm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>5,131</td>
<td>321</td>
<td>11.4</td>
<td>20,373</td>
<td>44.9</td>
</tr>
<tr>
<td>Glass</td>
<td>1,918</td>
<td>120</td>
<td>4.2</td>
<td>7,611</td>
<td>16.6</td>
</tr>
<tr>
<td>Steel</td>
<td>3,724</td>
<td>233</td>
<td>8.3</td>
<td>14,778</td>
<td>32.6</td>
</tr>
<tr>
<td>Aluminum</td>
<td>24,837</td>
<td>1,552</td>
<td>54.7</td>
<td>98,560</td>
<td>217.1</td>
</tr>
<tr>
<td>Plastic</td>
<td>4,670</td>
<td>292</td>
<td>10.3</td>
<td>18,532</td>
<td>40.8</td>
</tr>
</tbody>
</table>


Example: Calculate how much energy was used to make a steel can that weighs 2 ounces.

\[
\frac{2 \text{ ounces}}{} \times \frac{233 \text{ kcal}}{\text{ ounce}} = \frac{466 \text{ kcal}}{\text{ steel can}} \quad \text{[466 kcal to produce a 2-oz. steel can]}
\]

4. Compare the amount of energy used to make the containers from the different packaging materials with the amount of energy in the packaged food. Ask students what they think about the energy values for the packaging and for the food.

5. Students can find similar food items packaged in different ways and compare the energy costs to package each type. For example, have students compare a six-pack of applesauce snack desserts to a glass jar of applesauce. How might these findings affect their purchasing decisions?
Another approach to generating less household waste is to throw less away. But what do you do with something after you use it? Use it again! This component of waste reduction, called Reuse, is often overlooked, but is perhaps the best alternative for saving energy and protecting resources. When you reuse something, that means energy is not needed to create a new product to replace the one that was thrown away. Here is a list of ideas to try:

- Buy products in returnable containers
- Reuse plastic or paper grocery bags (or buy a canvas bag and reuse it)
- Give old furniture, clothes, and household items to charities
- Buy furniture, clothes, and household items from thrift shops, charities, and yard sales
- Fix something instead of throwing it away
- Make creative crafts (bird feeders out of milk cartons, magazine storage containers out of cereal boxes)
- Carefully remove gift wrapping and reuse (or use the Sunday comics from the newspaper to wrap gifts)
- Use both sides of a sheet of paper

**Illustrating the Waste Alternative**

1. Share The Throwaway Bottle with students. Discuss energy sources needed to complete each step (petroleum for digging machines and trucks, natural gas or electricity from coal in the glass factory).

2. Have students identify the energy-consuming steps required at each stage of producing and throwing away the bottle. Help students identify the steps that probably use nonrenewable resources such as coal or oil. Students may also identify other energy uses not included in the diagram (such as the consumer driving to and from the store).

3. Propose to students that this bottle can be reused instead of thrown away. Some stores sell liquids in bulk, so the bottle can be taken to the store and refilled. What percentage of the energy use indicated in the diagram could be saved if the bottle were reused? If the consumer refills the bottle, 97 percent of the energy could be saved. If the consumer returns the bottle to the factory and they refill it, 88 percent of the energy would be saved.

4. Have students discuss advantages and disadvantages of throwaway containers. Record their suggestions in a two-column chart on the chalkboard. The chart might look like the one below:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not need to remember to bring container with you when you go to the store. Do not have to keep items clean for reuse.</td>
<td>Extra energy is needed to produce new containers. Extra resources are consumed and environment polluted during production process. Adds more material to the waste stream.</td>
</tr>
</tbody>
</table>
Figures show energy costs at each step.

1. Mining sand and other materials: 7%
2. Transporting raw materials: 17%
3. Manufacturing glass bottle: 60%
4. Transporting bottle: 4%
5. Filling bottle at the bottling plant: 9%
6. Transporting filled bottle to the store: 2%
7. Buying bottle at the store: <0.1%
8. Taking bottle home and drinking contents: <0.1%
9. Putting empty bottle in garbage can: <0.1%
10. Taking empty bottle to garbage dump: 1%
Something New from Something Old: Recycle

There is a way for people to throw away things without adding materials to the landfill. This is to throw things into a different stream: the recycling stream. Recycling is another one of the Three Rs listed as a solution for dealing with solid waste. Recycling involves taking discarded items and transforming or remanufacturing them into similar or different products.

Items that are commonly recycled include paper, steel, glass, aluminum, and plastic containers. Recycling saves energy because energy is not needed to locate, obtain, and process raw materials. However, there are alternative energy costs. The basic steps of recycling are separation of recyclable from non-recyclable materials, collection of materials, processing (breaking or melting materials into their basic material, such as paper into pulp), and remanufacturing. These steps, along with transportation to retailers, all use energy. Although recycling has its own energy costs and there are some pollution issues with recycling, there is evidence that recycling paper can save energy.

<table>
<thead>
<tr>
<th>Recycling 1 ton of</th>
<th>Saves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>10 gallons of oil</td>
</tr>
<tr>
<td>Plastic</td>
<td>1,000 to 2,000 gallons of gasoline</td>
</tr>
<tr>
<td>Newspaper</td>
<td>100 gallons of gasoline</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2,350 gallons of gasoline. This is equivalent to the amount of electricity used by the typical Wisconsin home over a period of ten years.</td>
</tr>
<tr>
<td>Iron</td>
<td>1 ton of coal</td>
</tr>
</tbody>
</table>

From Wisconsin Department of Natural Resources, Recycling Facts and Figures. Madison, Wis.: Wisconsin Department of Natural Resources, n.d.

Many states, including Wisconsin, are concerned about finding space to store solid waste and want to promote better use of our resources. Below is data on proportions of solid waste the United States generates and recovers through recycling and composting.

**Products Generated and Recovered in 1994**
*(in thousands of tons)*

<table>
<thead>
<tr>
<th>Product</th>
<th>Generated</th>
<th>Recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper and Paperboard</td>
<td>81,300</td>
<td>28,730</td>
</tr>
<tr>
<td>Steel cans</td>
<td>2,920</td>
<td>1,550</td>
</tr>
<tr>
<td>Aluminum cans</td>
<td>1,710</td>
<td>1,120</td>
</tr>
<tr>
<td>Plastic packaging</td>
<td>9,490</td>
<td>710</td>
</tr>
<tr>
<td>Glass bottles and jars</td>
<td>12,070</td>
<td>3,110</td>
</tr>
<tr>
<td>Disposable diapers</td>
<td>2,980</td>
<td>negligible</td>
</tr>
<tr>
<td>Tires</td>
<td>3,690</td>
<td>560</td>
</tr>
</tbody>
</table>

Illustrating the Waste Alternative

Provide students with a copy of Recycling Paper. Help students understand that recycling paper avoids many of the energy-consuming steps needed to make paper from wood (cutting down trees, transporting to the mill, debarking the tree, turning the wood into pulp). Recycling paper also has energy costs because the paper needs to be separated and turned into pulp. Removing ink and other foreign materials and disposing of these materials requires energy as well and also affects the environment. Involve students in a debate in which they discuss the pros and cons of recycling paper. Invite speakers from a lumber company, a paper manufacturer, and a paper recycling plant to speak to the class or take students on a tour of such facilities. Have students look for the recycling symbol on recycled paper products and packaging. What could the prevalence of this symbol mean for energy and natural resource savings?

An alternative is to show students overhead transparencies of Steps in Making Aluminum Products from Raw Materials and Steps in Making Recycled Aluminum Products and to compare energy uses between aluminum manufacturing and recycling.
Make new paper from old paper.

**Here Is What You Will Need**
- Paper to be recycled (Newspaper, scraps of construction paper, facial tissue, and paper towels will work. Avoid glossy paper. Notebook paper may also be difficult to use.)
- Water
- Blender, egg beater, or mixer
- Piece of window screen (slightly larger than the size you want the paper to be)
- Tub, basin, or cake pan (larger than the window screen)
- Liquid starch (optional—this helps strengthen the paper)
- Materials to decorate paper, such as dried flowers, pine needles, pieces of construction paper (optional)
- 3 or 4 pieces of blotting paper or towels
- Rolling pin
- Iron (optional)

**Here Is How**
1. Tear the paper into tiny pieces. Decide if you want to mix colors or keep paper mainly white (a small piece of construction paper adds a lot of color).

2. Soak the torn paper in hot water for at least an hour (the longer the better). If you used newspaper, you may want to rinse it to remove some of the ink.

3. Fill the blender about half full of water and add the soaked paper; blend until it's a smooth pulp mixture, adding more water as necessary (the finer the mixture, the smoother your paper will be). You may add a few tablespoons of liquid starch (optional).

4. Put the window screen on the bottom of the tub, basin, or pan.

5. Pour the pulp mixture over the screen and carefully lift the screen and allow excess water to drain. Place the screen on a blotter or towel. You can add decorations at this time.

6. Cover the screen and paper with another piece of blotting paper or towel and use a rolling pin to squeeze out the water.

7. Carefully remove the recycled paper from the screen and lay it flat on another piece of blotting paper or towel to dry (or leave the paper on the screen until it is nearly dry). Make sure the new paper remains flat. You can also sandwich the paper between two sheets of blotting paper or towel and iron it until it is dry.

Use the paper to send a letter to a friend!
STEMS IN MAKING ALUMINUM PRODUCTS FROM RAW MATERIALS

1. Open Pit Mining. Bauxite ore is loaded into trucks.
2. Processing Plant. Bauxite is crushed and washed.
3. Refinery. Chemicals are used to refine bauxite into alumina.
4. Smelter. Alumina is melted. Other metals are added to molten aluminum to strengthen it.
5. Mold. Molten aluminum is poured into molds of cylinders, sheets or squares.
6. Products. The castings are remelted, hammered, or rolled into various items.

STEMS IN MAKING RECYCLED ALUMINUM PRODUCTS

1. Recycling Center. Aluminum is collected and crunched into bales.
2. Melting Furnace. The baled aluminum is melted.
3. Molds. Molten aluminum is poured into molds to form sheets, blocks and cylinders.
4. Products. The castings are reshaped into useful items.

RECYCLED ALUMINUM REDUCES:
* Water Consumption by 95%
* Energy Use by 95%
* Air Pollutants by 95%

Illustrations adapted from Florida State University, Energy & Environmental Alliance, Institute of Science and Public Affairs. Connections: Energy, Environment, Economics, and Education Working Together 5, no. 1 (1996): 5. Used by permission. All rights reserved.
The Cost of Using Energy

Objectives

Students will be able to
- calculate the cost of energy used by various products; and
- compare the costs of buying and operating lights and appliances.

Rationale

Calculating energy costs and comparing the costs of buying and operating standard and energy-efficient products enables students to make informed choices when purchasing products that use energy.

Background

(Also see the Background in “At Watt Rate?,” “Reading Utility Bills,” and “So You Want to Heat Your Home?”)

Mr. Jones buys a 60-watt incandescent light bulb for 42 cents. Ms. Smith buys a 17-watt compact fluorescent bulb that puts out nearly the same amount of light for $9.99. The incandescent bulb Mr. Jones bought is obviously the better buy. Or is it?

Do we know how much it costs to operate the lights and appliances we have or to fuel the cars we drive? Will buying efficient lighting, appliances, and cars save money in the long run even though they may cost more than their less efficient counterparts? By answering questions like these, we can find ways to save money and use energy more efficiently.

Determining the cost of the energy we use begins with finding information on energy prices. Gasoline prices are available from a nearby service station. Electric and natural gas rates are printed on utility bills. If energy prices are not easily available, average Wisconsin energy prices for 1995 are included on the Energy Cost Analysis Sheets that accompany this activity.

The next step is to calculate the total cost of energy that products use. A general formula that does this is

\[ \text{Amount of energy used} \times \text{energy price per unit of energy} = \text{total cost of energy} \]

For example, suppose a car used 10 gallons of gasoline last week. If gasoline cost $1.16 per gallon, then the total cost for the gasoline used is

\[ 10 \text{ gallons} \times 1.16 = 11.60 \text{ per gallon} \]
Comparing the Cost of Buying and Operating Refrigerators
- The Cost of Operating Small- and Medium-Sized Electrical Appliances and Equipment

(NOTE: This cost analysis sheet also uses the Appliance Survey sheet [from the activity “At Watt Rate?” page N 75] and Cost Calculation Table for Appliance Survey.)

Getting Ready:

You may want to gather specific energy cost information from a local utility or a service station.

Resources:

See Resources in the activity “At Watt Rate?”

Credits:


(Continued on next page)

This formula can also be used to calculate the total cost of energy used by lights, home appliances, or any other products that use energy. See the Energy Cost Analysis Sheets that accompany this activity for more examples of calculations.

This method of calculating total energy costs can also be used to compare the total energy costs of similar models of products. Comparing items in terms of total energy costs can reveal the model with the lowest total energy costs over time. Choosing this model over others with higher total energy costs would save the buyer money. For example, suppose we compare the cost of fuel per year for two new cars. The purchase cost of the cars is the same, but the first car has an overall fuel efficiency of 25 miles per gallon (mpg) and the second car has an overall fuel efficiency of 30 miles per gallon. Assume that both cars will be driven an average of 13,000 miles during the year, and the average price of gasoline will be $1.16 per gallon. The fuel costs per year for each car can be calculated using the following formula.

13,000 miles per year x $1.16 per gallon = fuel cost per year
X mpg

The fuel cost per year for the first car is

13,000 miles per year x $1.16 per gallon = $603.20 per year
25 mpg

The fuel cost per year for the second car is

13,000 miles per year x $1.16 per gallon = $502.67 per year
30 mpg

The second car, with an overall fuel efficiency of 30 miles per gallon, has lower fuel costs per year than the first car. Buying the second car would save its owner $100.53 in fuel costs each year. Therefore, based on this comparison, the second car is the better buy in terms of fuel costs.

Although choosing products that have low energy costs is important, it is not the kind of cost information consumers usually look for when deciding which product to buy. Consumers are more likely to compare retail prices between product types and will often choose the cheapest one. However, buying a product based only on the lowest retail price may not save money in the long run, because products with the lowest retail price often use more energy and have higher energy costs than similar, more energy-efficient products with higher retail prices. Cheaper, less efficient products may also have shorter useful lives than their more efficient counterparts, so they may need to be replaced more often. For example, an incandescent light bulb may last only 1,000 hours while a compact fluorescent (CFL) bulb may last 10,000 hours. Therefore, ten incandescent light bulbs would be needed to equal the useful life of one CFL.

Accounting for the retail price of a product and the total cost of energy it uses during its useful life is known as calculating the life cycle cost of the product. A simplified formula for calculating life cycle cost is

Retail price of product + ([energy cost / year] x [useful life in years]) = life cycle cost
Life cycle cost calculations can show consumers the total amount of money they will have to spend on the product over its useful life. When life cycle costs between products are compared, the one with the lowest life cycle cost turns out to be the better buy in the long run. These products are often the most energy efficient. (See Energy Cost Analysis Sheets for sample calculations.)

A sound understanding of the relationship between energy costs and energy use has many benefits. Knowing how much money we spend on energy to run the products we use can lead to ways of using these products more wisely, thereby saving money as well as energy. Knowing how to compare energy costs of similar products can help us choose products that save energy costs over time. Fortunately, many products that save on energy costs are also energy efficient and yield environmental benefits as well.

**Procedure**

**Orientation**
Discuss the following scenario with students:

Mr. Jones buys a 60-watt incandescent light bulb for 42 cents. Ms. Smith buys a 17-watt compact fluorescent bulb that puts out nearly the same amount of light for $9.99. Which light bulb is the better buy?

Ask students if they think the cost of electricity used by the bulbs is important, and then ask which consumer will save money in the long run. Record answers on the chalkboard or elsewhere so that they can be reviewed later. Have students explain the reasons for their answers.

Tell students that they will be learning how to answer questions like these by conducting energy cost analyses for different products.

**Steps**

1. On the following pages are several Energy Cost Analysis Sheets. Depending on which Energy Cost Analysis Sheets students complete, you may want to review the definition of life cycle costs and sample calculations (see Background; see also examples of calculations found on the sheets).

2. Assign students to complete their cost analysis survey at home. Encourage students to have adult family members assist with the project. NOTE: It is advisable to secure parental permission prior to conducting surveys. A Parental Permission Form for Home Energy End Use Surveys is found on page N 83.

NOTE: To calculate energy costs for a year, the survey has students multiply monthly costs by 12 months. This approach has limitations because energy use varies during each of the seasons (for example, longer nights in winter and extended use of lights). You might want to discuss these shortcomings with students but explain that for simplicity the year's costs are being based on one month. Some students may be interested in actually measuring their energy use each month and plotting the totals on a bar graph to compare quantities.
Closure
Have students discuss the answers to the questions on the Energy Cost Analysis Sheets. You may also want to review the scenario discussed during the Orientation and have students revise their answers based on the sheets they completed.

Discuss with students the connection between using energy-efficient products and the cost of using energy. Do students think that energy efficiency is cost-effective overall? What existing barriers might prevent people from buying more energy-efficient products?

Use the results from the Energy Cost Analysis Sheets and the Action Ideas: Energy Efficiency Measures to create an energy management plan.

Assessment

Formative
- How well did students complete the different Energy Cost Analysis Sheets?
- Were students able to give reasons why they would buy a particular product based on its energy and life cycle costs?

Summative
Students could perform life cycle cost analyses for products not covered in the Energy Cost Analysis Sheets, such as water heaters and home heating systems (see Background for life cycle cost information).
Introduction
How much does it cost to provide electricity for lighting? Are some types of lighting more cost-effective than others? To answer these questions, you will calculate electricity costs for some of the lights you use in your home and school. Then you will compare the cost of using incandescent and compact fluorescent bulbs to see which is the better buy.

Instructions:
Use the table below to calculate the cost of lighting for a light bulb (or a fixture with more than one light bulb) in your home or school. An example of the calculations needed has been provided in the first column.

Before you do the calculations, find out how much a kilowatt-hour of electricity costs in your area. This information can be found on your family’s utility bill or by calling your local electric utility, or it may be provided by your teacher. Write your answer below.

If you cannot find the cost of electricity in your area, use these 1995 Wisconsin average electricity costs for a home or school:
Home (residential rate): $0.07 per kilowatt-hour (kWh)  
School (commercial rate): $0.06 per kilowatt-hour (kWh)

| 1. Light bulb or fixture (and watts per bulb) | EXAMPLE: Lights in kitchen  
4, 60-watt bulbs | Your light bulb: |
| 2. Watts | = 240 watts  
(4 bulbs x 60 watts) |
| 3. Hours / day | 2 hours/day |
| Average # of hours/day that light bulb is on |
| 4. Is it left on when no one is using it? | Yes |
| 5. Amount of time item is on in a month | 60 hrs  
(2 hrs/day x 30 days) |
| Hours/day (Row 3) x 30 days |
| 6. Watt-hours used when on | 14,400 watt-hrs  
(240 watts x 60 hrs) |
| Watts (Row 2) x time item is on (Row 5) |
| 7. Total kilowatt-hours for month | 14.4 kWh/month  
(14,400 watt-hrs / 1,000 watts) |
| Watt-hours (Row 6) divided by 1,000 watts |
| 8. Cost of using light fixture for one month | $1.00  
(14.4 kWh x $0.07 per kWh) |
| Total kilowatt hours for month x cost of electricity |
| 9. Cost for lighting bulb for one year | $12.00  
($1/month x 12 months) |
| Cost per month x 12 months |
In this section, you will compare the cost of using incandescent bulbs with the cost of using compact fluorescent lamp (CFL) bulbs to find out which is the better buy.

**Answer this question before you complete the rest of this section:**
Suppose you need a new bulb for a fixture that is lit for at least four hours per day. A 60-watt incandescent light bulb costs $0.42. A 17-watt CFL bulb that provides nearly the same amount of light costs $9.99. Which bulb would you buy and why?

Use the information provided in the **Lighting Information** table to complete the following steps in order to compare the cost of buying and using incandescent and CFL bulbs.

**Lighting Information**

<table>
<thead>
<tr>
<th>Information Listed on Packaging</th>
<th>Incandescent Bulb</th>
<th>CFL Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Output</td>
<td>840 lumens</td>
<td>750 lumens</td>
</tr>
<tr>
<td>Bulb wattage</td>
<td>60 watts</td>
<td>17 watts</td>
</tr>
<tr>
<td>Bulb life</td>
<td>1,000 hours</td>
<td>10,000 hours</td>
</tr>
<tr>
<td>Cost of each bulb (including tax)</td>
<td>$0.42</td>
<td>$9.99</td>
</tr>
</tbody>
</table>

NOTE: You can also get this information in the lighting section of a hardware or discount store. Read the packaging the bulbs come in. Make sure you compare incandescent and CFL bulbs with an identical or nearly identical number of lumens so you are comparing different types of bulbs that put out the same amount of light.

**Steps**
1. Divide the bulb life of a CFL by the bulb life of an incandescent bulb. Round your answer to the nearest whole number. The answer you get is equal to the number of incandescent bulbs that will need to be replaced to equal the bulb life of one CFL bulb. Write your answer in the space below.
2. Determine the total energy used by both bulbs over the bulb life of one CFL in kilowatt-hours.

   Formula: Wattage of bulb  \( \times \) \( \frac{1 \text{ kilowatt}}{1,000 \text{ watts}} \) \( \times \) bulb life of a CFL in hours

   Incandescent  \( \text{______________} \)  CFL  \( \text{______________} \)

3. Write down the electric rate in your area in dollars per kilowatt-hour ($/kWh). If you cannot find out what your family pays for electricity, use the 1995 Wisconsin average residential rate of $0.07 per kilowatt-hour (kWh).

4. Find the total cost of the electricity used by the bulbs over the bulb life of one CFL in dollars ($). Multiply your answer to Step 2 by your answer to Step 3 for each type of bulb.

   Incandescent  \( \text{______________} \)  CFL  \( \text{______________} \)

5. Calculate the total cost of the bulbs. For incandescent bulbs, multiply the bulb cost from the Lighting Information table by the number of incandescent bulbs needed to equal the life of one CFL (see your answer to Step 1).

   Incandescent  \( \text{______________} \)  CFL  \( \text{______________} \)

6. Find the total cost of buying and using incandescent and CFL bulbs. Add your answers from Step 4 to your answers from Step 5.

   Incandescent  \( \text{______________} \)  CFL  \( \text{______________} \)

7. Based on the calculations you completed, which light bulb (the incandescent or the CFL) would you buy and why?
Introduction
Is the refrigerator with the lowest sticker price always the best buy? Answer this question by performing the following analysis comparing the costs of purchasing and operating different refrigerators.

1. Find out what your family pays for electricity. This information can be found on your family's utility bill or by calling your local electric utility, or it may be provided by your teacher. Write your answer below.

If you cannot find out what your family pays for electricity, use the 1995 Wisconsin average residential rate of $0.07 per kilowatt-hour (kWh).

2. Answer this question before you complete the rest of this sheet:
The retail price for five refrigerators is shown in the Refrigerator Data table that follows. Which refrigerator would you buy and why?

   Refrigerator Data

<table>
<thead>
<tr>
<th>Refrigerator</th>
<th>Average Retail Price</th>
<th>Average Energy Use Per Year (kWh / Year)</th>
<th>Energy Cost Per Year ($ / Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$870</td>
<td>660</td>
<td>$46.20</td>
</tr>
<tr>
<td>B</td>
<td>$850</td>
<td>665</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>$750</td>
<td>830</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>$860</td>
<td>818</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>$900</td>
<td>915</td>
<td></td>
</tr>
</tbody>
</table>

3. Calculate how much it would cost to operate each of the refrigerators for a year by using the average energy use per year information and the cost of electricity from Step 1. Record your answers in the “Energy Cost Per Year” column of the Refrigerator Data table. Use the formula below to do this calculation. The energy cost per year for Refrigerator A has already been calculated.

   \[
   \text{Average energy use (kWh) per year} \times \text{electricity cost per kWh (from Step 1)} = \text{energy cost per year}
   \]

4. Circle the refrigerator listed in the Refrigerator Data table that has the lowest energy cost per year.

5. Is the refrigerator with the lowest energy cost per year the most efficient refrigerator?
6. Assume that the refrigerators will last 15 years. Calculate the life cycle cost for each refrigerator using the formula below. The life cycle cost per year for Refrigerator A has already been calculated.

\[
\text{Average retail price} + (\text{energy cost per year} \times 15 \text{ years}) = \text{life cycle cost}
\]

Record your answers in the “Life Cycle Cost over 15 Years” column of the Refrigerator Life Cycle Costs table.

### Refrigerator Life Cycle Costs

<table>
<thead>
<tr>
<th>Refrigerator</th>
<th>Average Retail Price</th>
<th>Energy Cost Per Year (from previous table) ($ / Year)</th>
<th>Life Cycle Cost over 15 Years ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$870</td>
<td>$46.20</td>
<td>$1563.00</td>
</tr>
<tr>
<td>B</td>
<td>$850</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>$750</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>$860</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>$900</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Circle the refrigerator listed in the Refrigerator Life Cycle Costs table that has the lowest life cycle cost.

8. Is the refrigerator with the lowest life cycle cost the most efficient refrigerator?

9. Based on the answers you calculated for each of the tables and your answers to the above questions, choose the refrigerator you think would be the best buy overall and discuss the reasons for your choice. Indicate whether the efficiency of the refrigerator influenced your decision.
Introduction
How much does it cost to provide electricity for small- and medium-sized electrical appliances and equipment? Are some types of appliances and equipment cheaper to run than others? To answer these questions, you will calculate electricity costs for some of the small- and medium-sized electrical appliances and equipment you use in your home and school.

What You Will Need:
- Appliance Survey Sheet (Ask your teacher for this table.)
- Cost Calculation for Appliance Survey
- Kilowatt-hour of electricity costs in your area. This information can be found on your family’s utility bill or by calling your local electric utility, or it may be provided by your teacher. If you cannot find the cost of electricity in your area, use the 1995 Wisconsin average electricity costs of $0.07 per kilowatt-hour (kWh) for home (residential rate).

Instructions:
You need to complete the Appliance Survey Sheet. Ask your teacher for directions. Transfer the results (Total Kilowatt Hours for Month) for each appliance you looked at to the Cost Calculation Table.

Questions
1. Compare the electrical home appliance or school equipment rankings for wattage and for kilowatt-hours (kWh) per day. Do appliances or equipment with the highest wattages use the most energy per day? Explain your answer below by comparing two or more of the appliances or pieces of equipment listed.

2. Suppose you wish to conserve energy and save money by reducing the use of electrical appliances or equipment, or by reducing waste (for example, turning off the television when no one is watching). Pick two appliances or pieces of equipment that you could use less. Then estimate how much less time you would use the appliance or equipment each day (for example, you might reduce the time the television is on from four hours per day to three hours per day).

3. Calculate how much energy and money you would save by reducing the use of the electrical appliances or equipment you chose in Question 3. Do you think reducing the use of these appliances or pieces of equipment every day is a good idea? Explain.
<table>
<thead>
<tr>
<th>Item Name</th>
<th>Description of appliance</th>
<th>Total kilowatt hours for Month (32,580 watt-hours + 1,000 watts)</th>
<th>Rank of Item's Electricity Use (Rank: the item using the most electricity #1, the second #2, etc.)</th>
<th>Cost of Using Item for One Month (Total kilowatt hours for month x cost of electricity)</th>
<th>Cost for Using Item for One Year (Cost per month x 12 months)</th>
<th>Grand Total: The cost for using all these items for one year. Add all the columns together.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color television with remote</td>
<td>From Appliance Survey Sheet</td>
<td>32.6 kwh/month</td>
<td></td>
<td>$2.28 (32.6 kwh/month x $0.07)</td>
<td>$27.36 (2.28/month x 12 months)</td>
<td>$</td>
</tr>
</tbody>
</table>

**Note:** The table is a cost calculation table for an appliance survey, detailing the cost of different appliances based on their electricity usage and the cost of electricity per kilowatt hour.
Students will be able to
- explain why they might concern themselves with the needs of future energy users;
- demonstrate how conservation practices can promote the long-term availability of a resource;
- appreciate how increased population places a strain on energy resources; and
- distinguish between renewable and nonrenewable resources.

Rationale
By analyzing their response as energy consumers, students learn how consumption patterns and choice of resource affect the availability of future resources.

Background
"It's mine!"
"No! It's mine!"
"Now, kids, what have I told you about sharing?"

How many times have we heard or even participated in similar conversations? There are many things we share in life, including energy resources. When something in common is shared without consideration of other people, problems or tragedies may arise. This "Tragedy of the Commons" idea—expressed in a writing by William Forster Lloyd in 1833—was expanded by Garrett Hardin to illustrate challenges to sustaining our natural resources.

In terms of modern energy use, the "Commons" is energy resources, primarily fossil fuels such as coal, natural gas, and petroleum. The "Tragedy" is that although energy resources are developed and used for the good of society, these practices often involve inefficient use and overconsumption. These practices can lead to environmental problems and depletion of the resource. Over the past hundred years, our use of fossil fuels has increased significantly. Projections of when these fuels will run out vary from 50 to 200 years. Regardless of the depletion date used, the fact is, there is a limited amount of fossil fuels and eventually there will not be enough to meet our growing demands.

In the early 1970s, in response to increasing concern about environmental quality, government agencies such as the Department of Energy and the Department of Natural Resources launched many energy efficiency programs. There are indications that these programs have been effective. Overall, the amount of energy...
use per capita (residential) in 1995 was 8.2 percent less that it was in 1970. In 1994, commercial energy use per employee had fallen 15 percent since 1975. In 1993, Wisconsin ranked 13th lowest in the nation in per capita energy consumption. This ranking was 10.8 percent below the United State's average. Each individual using less energy now makes more energy available for future users.

Despite these conservation efforts, there are threats to their continued success. Wisconsin's per capita energy consumption increased 3.1 percent in 1995, after a 1.4 percent increase in 1994. Since its low point in 1982, per capita energy use in Wisconsin has risen nearly 16 percent. The increases are due to larger use of coal to generate electricity, a growing economy, increased use of air conditioning, and continued increased use of petroleum for transportation. The number of miles Wisconsin citizens drove was 34 percent higher in 1994 than in 1982.

Another threat to achieving sustainable or reduced energy consumption is increasing population. In 1970, Wisconsin's population was 4,418,000. In 1995 it was 5,101,581. In the year 2020 the population is projected to be around 5,677,000. Wisconsin's population growth will increase overall energy consumption and may outweigh attempts to save energy through conservation.

Since most of the energy we use in Wisconsin comes from finite resources and, despite our best efforts, the demand for these resources will continue to grow as our population increases, the need to find alternative resources is becoming more and more apparent.

Wisconsin Resource Energy Consumption by Type of Fuel
(Trillions of Btu and Percent of Total)

1995

- Nuclear 119 (8%)
- Renewable 67 (4%)
- Petroleum 479 (32%)
- Coal 470 (31%)
- Natural Gas 386 (25%)

Resources:

For Teachers


Complementary Activities


For Students


Suess, Dr. *The Lorax*. Produced by Columbia Broadcasting System (CBS) and FOX Co., Distributed by Playhouse Video, 30 min., 1990. Videocassette.

Many residents and companies in Wisconsin have already begun to locate and use renewable resources as alternatives to fossil and nuclear fuels. Renewable resources are those that can be replaced relatively quickly by natural processes. Some of these resources, such as wood, can be replenished. Replenishable resources can be depleted if their rate of use exceeds their rate of replacement. Other resources, such as wind and solar, are essentially inexhaustible and will be available as long as the sun continues to shine (which it is expected to do for a few billion more years). NOTE: There are environmental impacts from using renewables as well that affect sustainability; see Energy Resources Fact Sheets.

Currently about four percent of the energy we use in Wisconsin comes from renewable resources. The primary renewable resource used in Wisconsin is wood. It is burned for space heating in homes and to provide energy to run industrial machinery. Hydroelectric power currently ranks second. Hydroelectric power production comes from approximately 130 sites, and production is closely tied to annual rainfall. Other renewable resources used in Wisconsin include biogas energy from landfills and wastewater treatment plants that have installed collection and conversion equipment, fuel derived from municipal solid waste, and active solar and wind systems. In the absence of government support (for example, tax incentives, subsidies) and because conventional energy prices have remained low, installation of active solar and wind systems in Wisconsin has remained slow.

The amount of energy we obtain from renewables is projected to increase, but by how much varies. The following table compares the current and potential use of renewable energy resources.

Both conservation practices and investments in renewable resources can help Wisconsin promote sustainable energy generation and use, and thereby avoid the tragedies of overconsuming and wasting our common energy. Modern technologies and advances have afforded most Wisconsin citizens with lifestyles our grandparents would only have dreamed of. We, in turn, need to consider how our consumptive practices will affect future energy users. Each of us should consider using energy today with the needs of tomorrow’s energy users in mind.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Potential</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>200</td>
<td>44.7</td>
</tr>
<tr>
<td>Solar</td>
<td>125</td>
<td>3.8</td>
</tr>
<tr>
<td>Ethanol</td>
<td>63</td>
<td>0.0</td>
</tr>
<tr>
<td>Hydropower</td>
<td>30</td>
<td>26.7</td>
</tr>
<tr>
<td>Wind</td>
<td>18</td>
<td>0.01</td>
</tr>
<tr>
<td>Combustible waste</td>
<td>20</td>
<td>3.4</td>
</tr>
<tr>
<td>Biogas</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>Total</td>
<td>467</td>
<td>81</td>
</tr>
</tbody>
</table>
Procedure

Orientation

Have students list ways they use energy during a typical day. Remind them that products they use also require energy during the manufacturing process. Ask students if they have ever had problems getting enough energy to meet their needs (like running out of gasoline in a car or boat, needing wood for a fire). If any of them have experienced a power outage, have them share their feelings. Point out that, although there have been shortages, most power outages are caused by storms or technical problems.

Have students list different sources of energy. Write their responses on the board or post copies of the Energy Source Illustrations. If necessary, review the different resources and what is involved in developing them for various end uses (for example, coal is mined and transported to a power plant where it is burned to generate electricity).

Steps

1. Divide the class into groups of five or six students each. Tell them they are going to be participating in an activity called “Energy Divide.” Scatter a bag of candy on a table or a designated spot on the floor in front of each group.

NOTE: An alternative is to have one group come to the front of the class and demonstrate the game to the rest of the class.

Ground Rules for the Energy Divide

• The candies represent Energy Units.
• Each of you in this group represents a different energy consumer (this can be a large consumer, such as a country, or small one, such as an individual or a household).
• You are not allowed to talk to each other.
• The object of the game is to obtain enough energy resource units to support your basic life or operational functions. The minimum number of Energy Units needed by each consumer is five units for every 20 years. Anything above this minimum goes toward additional energy uses; anything below means the consumer does not have enough energy.
• You will have four 5-second rounds in which to collect energy. Each round represents 20 years of energy use. You will be notified when to start and stop each round.
• When the game begins, and during each round, you may try to collect the Energy Units you need (five per round), as many as you want, or none. If you do not get any or enough Energy Units during one round, you may participate in the next round if Energy Units are still available. If not, you cannot sustain your current living standards and must step out of the game. NOTE: An optional rule is that energy consumers must take equal or more Energy Units with each successive round (e.g., if they take 15 Energy Units in one round they must try to take at least 15 in the next).
• At the end of the rounds, each group member can keep one piece of candy (optional).

Credits:


Related KEEP Activities:

Have students use the survey “At Watt Rate?” to analyze the ways they use energy. Follow this activity by showing them ways they can conserve energy (see Action Ideas: Energy Efficiency Measures). Students can learn more about each of these resources through teaching ideas in K-5 Energy Sparks for Theme II: Introducing Energy Resources, Introducing Renewable and Nonrenewable Energy Resources, Fossil Fuel Products, Suninvestigations, Windy Wonders, and Water Fun and activities such as “Digging for Coal,” “Get That Gasoline!” and “Harnessing Nuclear Energy.” Enrich this activity with concepts found in 6-12 Energy Sparks for Theme II: Human Population Growth and Energy Use. Use activities such as “Energy Futures” to have students envision how scenarios developed during this activity could be applied to future societies.

2. Tell the class the basic rules (see Ground Rules for the Energy Divide). Begin the first round, and call time after 5 seconds. Wait a few seconds and begin the second round, and so forth. Continue with all four rounds even if they run out of candy. When the last round is over, instruct the groups to return the candy.

3. Discuss the results of the game. For example, what does it mean if they ran out of candy? Request explanations for why Energy Units were used up or left over. If some Energy Units were left over, are there enough units for 20 or 40 more years of energy use?
   - Have students identify the problems caused by not having enough energy. Refer students to the discussion during the Orientation. Point out that for the most part, people in Wisconsin have the energy they need for anything they want to do. Tell students that “Energy Divide” simulated that future users may not have enough energy if current energy use practices continue. Elicit students’ opinions about why they think they should or should not be concerned about future energy users.
   - Ask students about things they share with other people (a bathroom, television, pizza). Have students describe arguments or problems that may arise over sharing a common item and discuss how they resolve such issues.
   - Challenge students to compare their sharing experiences to “Energy Divide.” Briefly provide students with information about the “Tragedy of the Commons,” helping them to identify the tragedy and the commons. Discuss why it is better to share than to hoard resources. Explain that sharing in this simulation is even more difficult because the resource—the Energy Units—represent nonrenewable energy resources. These are resources that are no longer available after one use.

4. Ask students to provide suggestions on what they would do if they were to participate in the “Energy Divide” again. Have the class develop a set of recommendations that would ensure that each member of the group had enough energy to last through the four rounds. For example, they might recommend that consumers take no more than ten Energy Units in each round.

5. Have the groups play “Energy Divide” again, incorporating their suggestions to ensure that the energy will last. If the groups worked cooperatively, at the end of each round each group member should have enough energy and there should be some Energy Units left over. Although at the end of the fourth round there may not be enough Energy Units for many more rounds, at least this cooperative strategy is more promising. NOTE: If any students do not work cooperatively, you can insist that they do (playing the role of a law enforcement agency) or stop the game to further explore reasons people behave the way they do. You can also discuss how our society tries to promote or force cooperation (laws, regulations, incentives).

Inform the students that the more cooperative version of “Energy Divide” simulated energy conservation practices. Conservation involves wise use and careful management of resources (reducing waste, using only what is needed), so that current users will have enough to meet their needs while ensuring that resources will be available for future users. Ask students to share ways they avoid wasting energy. NOTE: See Extensions for ways to use the “Energy Divide” to illustrate challenges with population growth and to simulate renewable energy resources.
Closure
Have students review the results of the two different ways “Energy Divide” was demonstrated. They may want to devise a chart or table to record the number of Energy Units collected by all the students during the different versions. Ask them to compare the outcome of the game when they worked cooperatively to when they were unaware of each other’s intentions. Review reasons why current users of energy should care about future consumers.

If students could design the parameters for a new set of rounds, what would they suggest as the best case scenario for the game? How would they adjust the number of players, the amount of energy used, and the proportion of renewable energy to make energy supplies last longer? List each suggestion students make. If time allows, have them implement the strategies in a new version of “Energy Divide.”

Have students analyze whether their proposed adjustments to the activity could be applied realistically to real-life energy use policies. Challenge students to develop a plan of how energy resources should be developed and used (see Assessment).

Assessment

Formative
• Were students able to relate this simulation to a “Tragedy of the Commons” (problems with sharing a common resource)?
• What are the reasons students think they should or should not be concerned about future energy consumers?
• How effective were the conservation strategies suggested by the students to help conserve the amount of Energy Units each member of the group consumed?
• Can students explain why increased population challenges even the best conservation plans?
• Are students able to provide a definition for renewable and nonrenewable resources?

Summative
Have students develop a personal energy use plan for today and for 20 years from now (an alternative is to create a plan for their own or a fictional community). Both the current and 20-year plan can include ways students will conserve energy. For the 20-year plan they should envision what energy resources (renewable and nonrenewable) they would like to see used. They can also investigate ways they can begin using renewable resources more today (lighting with sunlight vs. electricity, biking or walking vs. driving a car). Have students evaluate each other’s plans, identifying things they do and do not like, providing justifications for their comments.

Extensions

Energy Use and Population Growth
To use “Energy Divide” to illustrate population growth, have one group begin the game, but pause at the end of the second round. Ask several students to come up and join the group. Explain that these additional students also need to get enough Energy Units. When the last two rounds are completed, ask the class what adding students to the demonstration represents. Do students think the number of people in Wisconsin 40 years from now will be the same as it is today? Inform students of Wisconsin’s projected population in 2020 (5,677,000) and point out that this projection is just over 20 years away.

Have students suggest how the “Energy Divide” activity could be further adjusted to allow more people to use the same amount of energy resources. For example, appliances are becoming more efficient so they need less energy; therefore, the game could be adjusted so that each member only needs three Energy Units instead of five.
Energy Use and Renewable Energy
Add about eight pieces of red candy to each bag of candy. Have the groups play “Energy Divide” and tell them that any time a group member collects a red piece of candy he or she “uses” it and returns it to the pile at the end of the round. The red Energy Units can be used again in the next round. After the rounds are complete, discuss the color of the Energy Units that are left over. There may be some yellow candies left, along with all the red candies that were present when the rounds began.

What do students think the red candies, which are resources that can be used over and over again, represent? Explain that the red candies represent resources that are renewable. Tell or have students identify examples of renewable energy resources (solar, wind, hydropower, wood) or post appropriate Energy Source Illustrations. Explain that some of these resources (solar, wind, hydropower) are always available; can be replenished and are available as long as they are not used up faster than they are replaced (e.g., trees for wood). Inform students that the number of red candies (about four percent of the total) represents the proportion of renewable resources currently used in Wisconsin.

Variations to “Energy Divide”

Global Energy Use
A variation of this simulation is to involve the whole class in comparing world populations and consumption. Assign students to stand in different parts of the room representing different areas of the globe; the number of students in each group will roughly symbolize the population of that continent. North America has two students, South America has three, Western Europe has three, Africa has five, Australia, Russia, and Eastern Europe have two, and the rest of the class is in Asia (ideally 23 students). Have one student from each group be responsible for obtaining the resources for his or her group. Provide these students with “energy grabbers.” North America’s energy grabber is a large cup. Europe, Australia, and Russia each get a medium cup. South America gets a small cup, and Africa and Asia each get a spoon. The students have 30 seconds to walk back and forth to the pile of Energy Units. Discuss the results and allotments of resources, and reasons for the differences.

Energy Reserves
The “commons” also refers to where the energy resources are located. Although Wisconsin has no fossil fuels, it gets its share as part of the United States. What would happen if this were not the case? In other words, suppose Texas suddenly decided to keep all its remaining oil and natural gas reserves for itself, or suppose Wyoming, Montana, and some of the Eastern states did the same with coal. How would Wisconsin deal with this? How would we as Wisconsinites feel about that? Have students produce a play that illustrates how they would deal with this problem.
People Power

Objectives

Students will be able to
- explain the difference between work and power; and
- convert from one unit of power to another.

Rationale

This activity allows students to use their own experience to explain the difference between work and power.

Background

When people say the words energy, work, or power in everyday conversations, listeners usually have little trouble understanding what these words mean. For example, one teacher might say to another, “I put a lot of work into my lesson plan last night and it paid off. Today’s class went really well.” The other teacher would understand immediately what the first is talking about.

But what are the scientific definitions of energy, work, and power? Energy is often defined as the ability to do work. In turn, work has a specific definition in physics—it is equal to the force needed to move an object multiplied by the distance it is moved. Although the teacher planning the next day’s lesson during the evening may say that he is doing work, by definition, work is done only when the teacher actually moves something, such as moving his pen to write his lesson plan.

To determine how much work a person does to move himself or herself, we need to measure the force exerted and the distance traveled. An easy way to do this is to have a student climb a flight of stairs. To climb the stairs, the student must do work to overcome gravity. The work done is equal to her weight, which is the force she must exert to overcome gravity, multiplied by the height of the staircase. For example, the work done by a student weighing 550 Newtons (N) and climbing a 3-meter-high staircase is:

Work = Force x Distance

= student's weight x height of staircase
= 550 Newtons x 3 meters
= 1,650 joules
NOTE: The Newton is the metric unit for weight, the gravitational force (9.8 m/s²) of an object's mass (kg). 550 Newtons is equal to about 125 pounds (1 lb. = .45 kg). To figure out your weight in Newtons using a bathroom scale, multiply the weight in pounds by .45 kg and then by the force of gravity (9.8 m/s²).

Joules (j) is the unit used to measure work (how much an object is moved). Using the force of one Newton to push an object one meter results in one joule of work (work = force x distance; 1 joule = 1 Newton x 1 meter)

The horizontal distance she traveled when going up the stairs is not counted since this distance is not in a direction that overcomes gravity.

Would the work done by a student slowly walking up the staircase be different than if she ran up the same staircase? No, because the definition of work does not take into account the time needed to climb the stairs (work equals force multiplied by distance). Yet the two situations are different. When the student runs up the stairs, she does the same amount of work in less time than when she walks up the stairs. In other words, she works faster. The term that expresses this difference is power, which is defined as the work done per unit of time, or the rate of doing work. In terms of a formula

\[
\text{Power} = \frac{\text{work done}}{\text{time}}
\]

for stair climbing

\[
\text{Power} = \frac{\text{weight (Newtons)} \times \text{height of stairs (meters)}}{\text{time (seconds)}}
\]

The power output of the student walking up the stairs in 10 seconds is

\[
\text{Power} = \frac{\text{work done}}{\text{time}} = \frac{550 \text{ N} \times 3 \text{ m}}{10 \text{ seconds}} = 165 \text{ watts}
\]

The power output of the same student running up the stairs in two seconds is

\[
\text{Power} = \frac{550 \text{ N} \times 3 \text{ m}}{2 \text{ seconds}} = 825 \text{ watts}
\]

One watt is equal to one joule of work done per second. Watts are a unit of power often associated with electrical equipment like light bulbs, hair dryers, and stereo amplifiers. Watts also describes the power output of engines and students running up stairs. The watt is a small unit of power. Therefore, multiples of the watt, such as the kilowatt (1,000 watts) or the megawatt (one million watts), are often used.

NOTE: In the United States, power for large motors such as in lawn mowers and automobiles is measured in an English unit called horsepower. One horsepower equals about three-quarters of a kilowatt. (See Watt's a Horsepower? for the origin of the unit of horsepower.)

Remember, power is the rate at which work is done. See the Power Data Table for sample power outputs.
In the stair climbing exercise, the student running up the stairs does 825 joules of work every second. At the end of two seconds, the time it takes the student to reach the top of the stairs, she will have done 1,650 joules of work.

Saying that a student expended four-fifths of a kilowatt of power running up the stairs sounds impressive. This is the same amount of power produced by more than eight 100-watt light bulbs. However, if the student's power output from running up the stairs could somehow be converted into electrical power, the bulbs would only stay on for two seconds. Furthermore, a student cannot maintain a power output of four-fifths of a kilowatt by running up a staircase higher than 3 meters for more than a few seconds without growing tired and slowing down.

Running up stairs is not a practical way to produce electricity. Is there another way to convert a student’s mechanical power into electrical power for light bulbs? The student could ride a stationary bicycle whose rear wheel is connected to a small electrical generator wired in a circuit to a light bulb. When the student pedals the bicycle, she generates electricity and lights the bulb.

In fact, generating electricity using a power plant is similar to generating electricity by riding a stationary bicycle. The boiler in a power plant converts the chemical energy in fossil fuels into the kinetic energy of steam by burning fossil fuels to boil water. This process is like a student's body converting the chemical energy from food into the mechanical energy of moving muscles. Like the rear wheel of the stationary bicycle, the turbine in a power plant is connected to an electrical generator. Heated steam pushing on the turbine blades spins the turbine, much like a student pushing on bicycle pedals spins the rear bicycle wheel. The mechanical energy of the spinning turbine or the spinning bicycle wheel is then converted into electrical energy by the generator. The electricity produced by the power plant generator travels through transmission lines to the lights in our homes. Similarly, the electricity produced by the generator connected to the bicycle wheel travels through the wires of a circuit to light a light bulb.

Finally, what about the teacher mentioned earlier who put a lot of work into his lesson plan? Does his brain's actual power output increase with extra mental effort? Studies that have measured the brain's power output showed that the difference between thinking hard and not doing so was about four watts—little more than the power output of a small candle burning to the end.

Conversions:
1 pound (lb) = 0.45 kilograms (kg)
1 Newton (N) = 1 kg x 9.8 m/s²
1 horsepower = 746 watts
1 kilowatt (kW) = 1,000 watts
1 megawatt (MW) = 1,000,000 watts, or 1,000 kilowatts (kW)
Procedure

Orientation
Ask students if a person does more work walking up a flight of stairs or running up the same flight of stairs.

Steps
1. Have students find a staircase, measure its height, and time how long it takes to walk up and run up the staircase. Students may try one of the following four approaches.
   NOTE: These approaches should be considered with respect to students who may be self-conscious about their weight or physical abilities.
   • Have students locate, measure, and climb a flight of stairs on their own time and bring their results to class.
   • Have one or two students walk up and run up the stairs while the rest of the class waits.
   • Provide students with a set amount of time with which to find a staircase in the school and conduct the measurements.
   • Walk up and run up a staircase yourself and provide students with the data.
   NOTE: The reason students are climbing stairs to measure the work they do is because their weight, which is equal to the force they need to overcome gravity, can easily be measured. Measuring the force they exert with their feet while walking across a floor is much more difficult (see Background).
2. Hand out and have students complete the Calculating Work and Power by Climbing Stairs.
3. Have students complete Part III of the activity sheet.
4. Discuss how students felt after climbing the stairs slowly compared to climbing them rapidly. If they did the same amount of work, why did they feel differently? They should note that the amount of time they used to climb the stairs was different. Explain to students that because it took less time to do work when running up the stairs, they expended more power.
5. Have students complete Part IV of the activity sheet. Discuss the different units of measurement for power. Relate them to different units of measuring length, such as meters and yards. Of the three units used to measure power, which have they heard of before?
6. Show students a 100-watt bulb. What do they think “100-watts” listed on the top of the bulb means? Explain that it refers to the power output of the bulb. A light bulb with a power output of 100 watts converts 100 joules of electrical energy into light and heat energy every second.
7. Ask where the energy to light the bulb comes from. Students may mention putting the bulb into a socket, flipping a switch, providing it with electricity, etc. Challenge students to explain how we get electricity. Briefly explain that one way to get electricity is to generate it in a power plant using fossil fuels (see Background).
8. Ask students if the power they expended by climbing the stairs could somehow be converted into electrical power. If so, could they produce enough electricity to light a light bulb?
9. Have students complete Part V of the activity sheet to determine how their power output from climbing the stairs relates to the power output of a 100-watt light bulb.
10. Ask students if it is possible to convert the power produced by a person into electrical power. Describe how this conversion can be done with a person riding a stationary bicycle with its rear wheel connected to an electrical generator. You may also compare generating electricity using a bicycle with the way a power plant generates electricity (see Background).

Closure
Have students summarize their stair-climbing activity using the words work and power. Discuss what happened to the energy they used to climb the stairs.
**Assessment**

**Formative**
- Are students’ worksheets completed thoroughly and accurately?
- Are students able to explain the difference between work and power?
- Are students able to convert from one unit of power to another?
- Can students relate the power output of climbing stairs to other examples like engines and light bulbs?

**Summative**
- Have students give other personal examples that illustrate the difference between work and power.
- Have students calculate how much time it would take a person to climb stairs, if they know the height of the stairs, the weight of the person, and the amount of power produced.

Example: The power output of a 240-pound (109 kg) football player running up a 25-foot (7.6 meters) high set of stairs in a stadium is equal to 1.5 horsepower (1,119 watts). How long did it take him to run up the stairs? (Answer: 7.2 seconds)

**Extensions**

Have the class do this activity using metric units for height, weight, work, and power. The class could also convert the units of energy used in this activity to other units such as Btus and calories.

Discuss the origin of the horsepower unit by having students read *Watt’s a Horsepower?* After reading this, have students define a unit of their own such as the “studentpower,” “humanpower,” or “childpower,” and then convert the horsepower figures from their *Calculating Work and Power by Climbing Stairs* activity sheets into the unit they have defined.

Challenge students to come up with ways to convert the mechanical energy of a person to other forms of energy.
Watt’s a Horsepower?

The origin of the term horsepower seems obvious: it is the power output of a horse doing work of some kind. But what exactly does this mean? How did the power of a horse come to be defined as precisely 550 foot-pounds per second?

When steam engines first appeared in England at the turn of the eighteenth century, they were used to pump water from mines, a task that horse-driven pumps had previously done. Soon, steam engines were rated in terms of the number of horses they could replace, or their “horsepower.” For example, a steam engine might be rated at four horsepower, meaning that it could replace four horses. Rating steam engines this way gave people a general idea of a steam engine’s power, but it was not a precise definition. How much power could horses actually produce? Were they big horses or small ones? What if the horses got tired after a while?

Attempting to answer these questions, a number of steam engine inventors and developers defined horsepower on their own. Some of these definitions even had specific values. For a time, however, no one could agree on a single definition for this unit, so few people took the horsepower rating of steam engines seriously.

By the late eighteenth century, James Watt (1736-1819) had made major improvements to the steam engine (he did not invent it). Because of his work, steam engines became more efficient and economical to use. Watt eventually became a successful businessman and by 1800, he and his partners had produced over 500 steam engines and his improvements were readily adapted by other manufacturers.

Watt understood that having different definitions of horsepower was confusing. How could customers compare steam engines made by different manufacturers, if different horsepower definitions were used? To end the confusion, Watt sought a definition of horsepower that everyone could agree with. He made a series of measurements to see how much weight an average horse could lift steadily. From this, Watt arrived at a figure of 550 foot-pounds per second. This value was eventually adopted and is now the accepted definition of one horsepower.

However, there is nothing special about this particular definition. A horsepower could easily have been defined as 500 foot-pounds per second. What must be remembered is that definitions of units are often chosen for convenience and are not necessarily related to the laws of science. People agree to use certain units because the definitions are sensible and because those who define the units are often in a position of influence in society. In the case of Watt, the success of his steam engines and his prominence as a scientist and businessman played as much a role in the adoption of his horsepower definition as did his measurements of a horse’s ability to lift weights.

Not only did Watt define horsepower, his fame eventually led the scientific community to name a metric unit of power after him. Today, one watt is defined as one joule of energy per second, and one horsepower equals 746 watts.
<table>
<thead>
<tr>
<th></th>
<th>Horse power</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>A hummingbird in flight</td>
<td>0.00094</td>
<td>0.7</td>
</tr>
<tr>
<td>A small candle burning</td>
<td>0.004</td>
<td>3</td>
</tr>
<tr>
<td>to the end</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical light bulbs used</td>
<td>0.05 to 0.4</td>
<td>25 to 300</td>
</tr>
<tr>
<td>by homeowners</td>
<td>0.012 to 0.044</td>
<td>9 to 33</td>
</tr>
<tr>
<td>Incandescent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compact fluorescent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A gasoline-powered lawn</td>
<td>0.25 to 2</td>
<td>187 to 1,500</td>
</tr>
<tr>
<td>mower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An adult human running</td>
<td>1.74</td>
<td>1,300</td>
</tr>
<tr>
<td>a 100-meter dash in 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A hair dryer</td>
<td>1.34 to 2</td>
<td>900 to 1,500</td>
</tr>
<tr>
<td>A horse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average (doing field</td>
<td>0.94</td>
<td>700</td>
</tr>
<tr>
<td>work)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum (pulling a weight</td>
<td>3</td>
<td>2,240 (2.24 kW)</td>
</tr>
<tr>
<td>equal to 35 percent of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>horse's body weight)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watt's steam engines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical range</td>
<td>10.7 to 21.4</td>
<td>8 to 16 kW</td>
</tr>
<tr>
<td>Largest engines</td>
<td>134</td>
<td>100 kW</td>
</tr>
<tr>
<td>Automobiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical 1980s models</td>
<td>67 to 161</td>
<td>50 to 120 kW</td>
</tr>
<tr>
<td>Honda Civic GL</td>
<td>84</td>
<td>63 kW</td>
</tr>
<tr>
<td>Lincoln Town Car</td>
<td>150</td>
<td>112 kW</td>
</tr>
<tr>
<td>The Columbia power plant</td>
<td>1.3 million</td>
<td>1,000 MW</td>
</tr>
<tr>
<td>in Portage, Wisc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A moon rocket (Apollo 11</td>
<td>3.5 million</td>
<td>2,600 MW</td>
</tr>
<tr>
<td>on a Saturn C 5 rocket)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>during launch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The sun</td>
<td>$5.1 \times 10^{23}$</td>
<td>$3.8 \times 10^{26}$</td>
</tr>
</tbody>
</table>

Calculating Work & Power by Climbing Stairs

Introduction
In this activity, you will find out if a person does more work walking up a flight of stairs or running up the same flight of stairs by having you or someone else actually try this. You will also learn what scientists mean by the words work and power.

Part I
1. Find a staircase that is not used by a lot of people. Using a ruler, record the height of one step in centimeters in Table I.

2. Count the number of steps that you or your classmate will be climbing and record your answer in Table I.

3. Calculate the total height of the staircase in centimeters.

4. Calculate the total height of the staircase in meters.

<table>
<thead>
<tr>
<th>Table I</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Height of one step (cm)</td>
</tr>
<tr>
<td>2. Number of steps climbed</td>
</tr>
<tr>
<td>3. Total height of staircase (cm)</td>
</tr>
<tr>
<td>= height of one step multiplied by number of steps climbed</td>
</tr>
<tr>
<td>4. Total height of staircase (m)</td>
</tr>
<tr>
<td>= total height of staircase (cm) divided by 100</td>
</tr>
</tbody>
</table>
Part II

5. Next, decide who will be climbing the stairs and who will be recording the time of the stair climber. Write the name and the weight of the stair climber in the blank spaces below. If the stair climber does not know his or her weight, either use a scale and measure it, estimate the stair climber’s weight, or use a standard weight of 100 pounds.

Name of stair climber __________________________

Weight of stair climber __________________________ pounds

6. To figure out weight in Newtons, multiply pounds by \(0.45\) kg and then by the force of gravity \((9.8\text{ m/s}^2)\)

7. Have the stair climber climb the stairs slowly and steadily. Record the time it takes in seconds in Table II under the column labeled “Slowly.” You may want to practice this a few times to get an accurate time.

8. Now have the same stair climber climb the stairs rapidly. This does not mean that the stair climber has to risk getting hurt by climbing the stairs as fast as possible. Record the time it takes in seconds in Table II under the column labeled “Rapidly.” You may want to practice this a few times to get an accurate time.

NOTE: it is important that the same stair climber climb the stairs slowly and rapidly because the same weight must be used to compare the work done while climbing the stairs for both cases.

<table>
<thead>
<tr>
<th>Climbing Stairs</th>
<th>Slowly</th>
<th>Rapidly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required (seconds)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part III

9. Calculate the work done by the stair climber in climbing the stairs slowly and rapidly using units of joules. Record your answers in Table III below.

Formula: Work done (joules) = height of staircase (m) x weight of stair climber (N)

<table>
<thead>
<tr>
<th>Climbing Stairs</th>
<th>Slowly</th>
<th>Rapidly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work done (joules)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Was the work done by climbing the stairs slowly the same as or different from climbing the stairs rapidly? Does your answer surprise you? Record your responses in the blank space below.

Part IV
11. Calculate the power output of climbing the stairs slowly and rapidly in watts. Record your answers in the appropriate spaces below.

Formula: \[ \text{Power} = \frac{\text{Work done climbing stairs (foot-pounds)}}{\text{Time required to climb stairs (seconds)}} \]

Power output of person climbing stairs slowly \[ \quad \text{watts} \]

Power output of person climbing stairs rapidly \[ \quad \text{watts} \]

Part V
12. Suppose the power output of a person climbing stairs could somehow be directly converted into electrical power. How many 100-watt light bulbs could a person light by climbing the stairs slowly and rapidly? Record your answers in Table IV below.

Formula: \[ \text{Watts from Step 11} \div 100 \]

<table>
<thead>
<tr>
<th></th>
<th>Slowly</th>
<th>Rapidly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of 100 watt light bulbs a person could light by climbing stairs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Diminishing Returns

Objectives

Students will be able to
- identify evidence of the second law of thermodynamics during the conversion of chemical energy to light energy;
- calculate the system efficiency for a variety of conversion processes; and
- compare the system efficiency of certain conversion devices and systems.

Rationale

Students gain a better appreciation of how energy is used by investigating the second law of thermodynamics and how this law relates to system efficiencies. In addition, students learn how individual actions contribute to using energy more efficiently.

Background

NOTE: For a brief overview of relevant background for this activity, see Generating Electricity from Coal and the illustration The Efficiency of Electric Power Delivery Systems.

Suppose you paid $100 a year to light your home. What if you found out that only five dollars of this payment went toward paying for light? Would you feel shortchanged? What about the other $95 of energy you paid for? Where did it go?

If you light your home with incandescent light bulbs, most of your $100 paid for the heat the light bulb generated rather than the light. A light bulb is one of many types of conversion devices. Its purpose is to convert electrical energy to light energy. NOTE: The efficiency of incandescent light bulbs can range from five to ten percent.

During the conversion process, all the energy that enters a conversion device is turned into other forms of energy. That is, you end up with an equal quantity of energy before and after conversion. This is another way of stating the first law of thermodynamics (energy can be neither created nor destroyed; see 6-12 Energy Sparks for Theme I: The Laws of Thermodynamics on page N 174 for more information).

However, not all the energy is converted into the desired form of energy (such as light). Although the quantity of energy is the same before and after conversion, the quality is different. An incandescent light bulb has a thin wire filament mounted inside it. When the bulb is turned on, an electrical current passes through the filament, heating it up so much that it emits light. The heat energy that is produced by the light bulb is often called waste heat, because it is difficult to use this form of energy to do work.
The energy that is wasted when a light bulb shines exemplifies the second law of thermodynamics, which states that with each energy conversion from one form to another, some of the energy becomes unavailable for further use (see 6-12 Energy Sparks for Theme I: The Laws of Thermodynamics on page N 174 for more information). Applied to the light bulb, the second law says that 100 units of electrical energy cannot be converted to 100 units of light energy. Instead, of the 100 units that are used to generate light, 95 are needed to heat the filament.

The word efficiency describes how much of a given amount of energy can be converted from one form to another useful form. Due to unavoidable compliance with the second law of thermodynamics and the capabilities of current technologies, most of the modern conversion devices—such as light bulbs and engines—are inefficient (see Efficiency of Energy Converters). The amount of usable energy that results from the conversion process (electricity generation, lighting, heating, movement, etc.) is significantly less than the initial amount of energy. In fact, of all the energy that is incorporated into technologies such as power plants, furnaces, and motors, only about 16 percent is converted into practical energy forms or used to create products. Where did the other 84 percent go? Most of this energy is lost as heat to the surrounding atmosphere.

If there is so much room for increasing efficiency, why have these improvements not occurred? When light bulbs and other conversion devices were first invented, energy supplies seemed abundant and there was not much concern for the waste heat they generated as long as their primary purpose (light, movement, and electricity) was accomplished. However, as it is becoming apparent that the energy supplies—primarily fossil fuels—that we use are indeed limited, one goal of technology has been to make conversion devices more efficient.

The light bulb is one example of a conversion device for which a more efficient alternative has been developed. This alternative, the compact fluorescent light bulb (CFL), was commercially introduced in the 1980s. Instead of using an electric current to heat thin filaments, the CFLs use tubes coated with fluorescent materials (called phosphors) that emit light when electrically stimulated. Even though they emit the same amount of light, a 20-watt compact fluorescent light bulb feels cooler than a 75-watt incandescent light bulb. The CFL converts more electrical energy into light, and less into waste heat. CFLs have efficiencies between 15 and 20 percent, making them three to four times more efficient than incandescent light bulbs. NOTE: There are other considerations with developing and using efficient conversion devices, such as costs and government subsidies.

A single 20-watt compact fluorescent bulb, compared to a 75-watt incandescent light bulb, saves about 550 kWh of electricity over its lifetime. If the electricity is produced from a coal-fired power plant, that savings represents about 500 pounds of coal.

Many power plants in Wisconsin use coal to generate electricity. It is not possible to take a chunk of coal and use it directly to light a bulb. The chemical energy in coal first needs to be converted to electricity (this is true for other resources such as wood, oil, and natural gas). Therefore, which energy resource used also affects the efficiency of modern electrical appliances (or conversion devices).


**Complementary Activities**


(Continued on next page)
This conversion process requires several steps. The coal is mined, crushed, and transported to the power plant. Then it is burned to generate electricity. Finally, the electricity is delivered to our homes through transmission wires and is then put to some end use, such as lighting a bulb (see Generating Electricity from Coal). Each of these steps in the coal-fired electrical system uses energy from other sources (e.g., gasoline for transportation) or involves an energy conversion. Therefore, the efficiency of converting electricity to light depends on the efficiency of each step. The total efficiency of the whole process is called the system efficiency. It is equal to the product of the efficiencies of the individual steps. The system efficiency for an incandescent bulb is only 1.3 percent (see The Efficiency of Electric Power Delivery Systems).

Even though the process of coal-to-electricity-to-light has a low efficiency, it is an improvement over earlier electrical systems. The efficiency of power plants has risen from 3.6 percent in 1900 to about 33 percent today. Scientists and engineers are developing new technologies to make power plants even more efficient and to improve electrical transmission. Another approach to generating electricity more efficiently is to use alternative energy sources and conversion systems. Hydroelectric plants are 90 percent efficient at converting falling water to electricity and the best efficiency of a wind turbine is 47 percent (see Comparison of Efficiencies).

The efficiency of any system is affected by the efficiency of every conversion within the system. Therefore, individuals—although at the “end” of an energy conversion system—can make noteworthy contributions to the efficiency of the whole system. An example of this is replacing incandescent light bulbs with compact fluorescents. This simple change raises the overall efficiency of a coal-fired electrical system from 1.3 percent to five percent. This may not seem like much of an improvement, but the cumulative results of many people doing this are massive. For example, if every household in Wisconsin replaced one 75-watt incandescent light bulb with a 20-watt compact fluorescent bulb, enough electricity would be saved that a 500-megawatt coal-fired power plant could be retired.

Installing efficient light bulbs is just one action people can take to improve system efficiency. Other efficient electrical appliances, such as water heaters, air conditioners, and refrigerators, are available and becoming more affordable. Turning off lights and other devices when not in use also creates less demand on the system. Therefore, individuals—whether they are engineers improving an energy conversion device or they are children turning off lights around the home—can make significant contributions to energy conservation.
Generating Electricity from Coal

Let's examine a system for lighting an incandescent light bulb, using energy that originally comes from coal.

The coal that is mined contains a certain amount of energy. But energy was used to mine the coal, which must be counted as part of the input. After being washed and sorted, the coal must next be transported to the power plant. It takes energy to transport coal. This energy use must be added to the input side of the ledger.

Coal (1) (the numbers refer to the related sections of the figure below) is burned in the furnace (2) at the electric power plant. The steam (3) turns a turbine that turns the generator (4). Each of these conversion steps has its own efficiency. In the end, only about one-third of the energy of the coal entering the plant is converted to electrical energy (6). The other two-thirds is wasted as heat. It goes up the stack (5) with the hot exhaust gases or into the cooling tower (7).

The electrical energy must now be transported over high-voltage transmission lines and a lower-voltage distribution system. As the energy flows through transformers (to step the voltage up or down), it heats up the conductors and disappears into the surroundings. Therefore, energy is lost during transmission.

The remaining energy now arrives at the lamp. At this point, most of the energy is lost in the process of heating the filament in the incandescent light bulb. Only five percent of the energy entering the light bulb is actually converted to visible light. This illuminating energy is finally absorbed by some object within the room and converted into heat.

**Orientation**

Draw students' attention to the incandescent and compact fluorescent lights. Have students describe the main energy conversion they see. They should note that electrical energy is being converted to light energy. They may also know that heat energy is being generated. Ask students which bulb they think is more efficient; that is, which is better at converting electrical energy to the desired light energy rather than to heat. Note their answers.

**Steps**

1. Ask students to describe where the energy to light a light bulb comes from. If they say electricity, ask them where their electricity comes from. Tell students that most of the energy for electricity generation in Wisconsin comes from burning coal (about 70 percent). Mention that energy is stored in the chemical bonds of coal.

2. Show students an overhead transparency or sketch on the chalkboard the basic steps in the conversion of the chemical energy in coal into electrical energy (see The Efficiency of Electric Power Delivery Systems). Have students interpret what is happening at each step and identify reasons why 100 percent of the energy is not transformed from one stage of the process to another (second law of thermodynamics).

3. Demonstrate how to calculate the system efficiency (see Calculating System Efficiencies) and work with students to figure out the system efficiency for converting chemical energy within coal to light energy.

4. Tell students they are going to simulate what happens to the chemical energy in coal as it is converted from one form to another during the electrical generation process. Review the Steps of the Relay Simulating Energy Conversion Process and what each step represents. Emphasize that throughout the simulation, the water represents the energy within coal (and electricity and light) and not the coal itself. Therefore, when water is spilled or not completely transferred from one stage of the relay to the other, it means that energy was either lost as waste heat during the process or used to complete an energy conversion.

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**The Efficiency of Electric Power Delivery Systems**

![Diagram of energy conversion process from coal to light energy](image_url)

5. Divide the class into teams of eight students. Extra students can serve as time keepers or as “Law Enforcement” (see Step 7), or they can be added to the “transmission line” step of the relay. If there are too few students, reduce the number of students in the transmission line or have the relay be a demonstration where one group of students illustrates the process and the rest of the class provides comment.

6. Take the class to the large playing area and have the teams line up in different places. Make sure the distance between each of the team members is correct and that the containers and cups are distributed to the appropriate team members.

7. Share the following information with students before starting the game:
   - The teams are racing each other.
   - There are two ways to win: To be the first to finish and to be the team that ends up with the most water in their cup. The water in the cup represents light energy.
   - The time keepers record how long it takes for the teams to complete the relay and which was fastest. An alternative is to allot time limits to each part of the relay and the time keeper can make sure team players do not stay too long on each task.
   - While students should not try to spill water unnecessarily, they should also avoid being too careful (for example, blocking the holes in the containers is not allowed). Students representing “Law Enforcement” can make sure the second law of thermodynamics is obeyed. For example, they can interrupt the careful team and pour out some of their water. (The poured water represents either the energy used to mine and transport coal or a kind of “heat tax” that must be “paid” in order for an energy conversion to occur.)

8. Begin the relay. Note when the first team has completed passing all the “energy” (water) through the relay. After all the teams are finished, note which of the teams had the most water in their cup.

**Closure**
Discuss the results of the relay and what spilling water represents. Review how energy is used in each conversion process or transfer and mention that many energy transfers and conversions are inefficient. Discuss how the system could realistically be made more efficient and how the game could be adjusted to illustrate these efforts.

Emphasize realism, because students could try to transport water carefully, but even in this process they are using energy, which could be represented as a mandatory loss of water.

Point out that the last stage of the relay represents an incandescent light bulb, which converts only five percent of the electrical energy to light. Provide students with information about the compact fluorescent light bulb and how it is designed to be more efficient. How could they adjust the relay to simulate a compact fluorescent light bulb that can convert 20 percent of the electrical energy it receives into light?

**Assessment**

**Formative**
- Can students describe the steps needed to convert the chemical energy in coal to light energy?
- Are students able to provide examples that explain why each step is not 100 percent efficient?
- Ask students to identify how individuals can help improve system efficiency (students should mention actions such as using energy-efficient appliances).

**Summative**
Provide students with efficiencies for other conversion systems and have them calculate and compare system efficiencies (see Comparison of Efficiencies). Students can also create relay races or tag games to simulate these conversion processes.
Note: Efficiencies between steps are shown in parentheses, and cumulative net efficiencies for the system are shown inside the squares. Each step that has efficiency less than 100% loses low-quality heat energy to the environment.
RESIDENTIAL
Wind
Turbine
Wind
100%

WIND TURBINE (47%)

PV CELL (15%)

RESIDENTIAL
Solar Electric
Sunlight
100%

PV CELL (15%)

CENTRALIZED
(UTILITY) PV
System
Sunlight
100%

PV CELL (15%)

Transmission (91%)

CFL (20%)

47%

20%

47%

18.2%

3.6%

42.8%

8.6%

2.1%


Note: Efficiencies between steps are shown in parentheses, and cumulative net efficiencies for the system are shown inside the squares. Each step that has efficiency less than 100% loses low-quality heat energy to the environment.
Imagine a system that has only two components. Component A has an efficiency of 50 percent and component B has an efficiency of 20 percent. Make a drawing like this on the chalkboard.

![Diagram of system with components A and B]

Suppose we put in 100 units of energy. How many units of useful energy will we get out of A? (Answer: 50 percent of 100 units = 50 units)

100 units → 50% → 50 units

So, we have 50 units we can put into B. How many units of useful energy will we get out of B? (Answer: 20 percent of 50 energy units = 10 energy units)

100 units → 50% → 50 units → 20% → 10 energy units

What is the efficiency of the whole system?

Answer: \[
\frac{\text{energy out}}{\text{energy in}} = \frac{10 \text{ units}}{100 \text{ units}} = 10 \text{ percent}
\]

Is there a way of calculating the system efficiency without calculating what’s left after each step? Some students may perceive that there is. If not, point out that multiplying the efficiencies of all components gives the system efficiency:

\[50\% \times 20\% = 10\%\]

Therefore, for the system efficiency for converting chemical energy in coal to light energy is as follows:

<table>
<thead>
<tr>
<th>Process</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>96%</td>
</tr>
<tr>
<td>Transporting</td>
<td>97%</td>
</tr>
<tr>
<td>Electrical Generation</td>
<td>33%</td>
</tr>
<tr>
<td>Transmission</td>
<td>85%</td>
</tr>
<tr>
<td>Lighting</td>
<td>5%</td>
</tr>
</tbody>
</table>

\[96\% \times 97\% \times 33\% \times 85\% \times 5\% = 1.3\%\]
Steps of the Relay Simulating Energy Conversion Process

The chart Converting Chemical Energy to Light Energy explains how students can simulate the chemical energy to light energy conversion process. The last three columns focus on the conversion process and the efficiency of each step. An explanation of what contributes to the inefficiency is found in the parentheses. The location of the students during the relay is diagrammed below (distances between students will depend on size of playing area; start with about six feet between all students except the ones in the transmission line who should be about an arm’s length apart). To accurately represent the energy used or lost as heat during the steps, encourage students to be hasty during the relay so that they do spill water.

A student representing the miner takes one cup of water (the cup has a hole in the bottom) at a time from the gallon of water to the yogurt container with one hole in the bottom.

A second student (representing transportation) carries the yogurt container to the power plant and pours the water into the yogurt container with holes covering a third of its bottom, which represents a power plant.

To represent electricity generation, a third student holds the yogurt container and spins around in a circle.

Four students stand in a row to represent a power line. Each student has a cup with a hole in the bottom. Transmission is shown by the first student receiving a cup of water and pouring the water into the next student’s cup who passes it down the line. The first student refills his or her cup when it is emptied and continues the process until water runs out or the relay is complete. Each student can only use one hand.

A final student, who represents a light bulb, cups his or her hands to receive water and pours it into a paper cup (one without a hole in the bottom). The relay is done when the cup is filled or when water runs out.
<table>
<thead>
<tr>
<th>Energy conversion process</th>
<th>Efficiency</th>
<th>Steps of the relay simulating energy conversion process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal is mined out of the ground. (Energy is needed for mining process.)</td>
<td>90%</td>
<td>A miner takes water one cupful at a time to the yogurt container with one hole in the bottom, which represents a train car.</td>
</tr>
<tr>
<td>Coal is transported to the power plant. (Energy is needed to carry the coal.)</td>
<td>97%</td>
<td>A second student carries the yogurt container and pours water into the yogurt container that has holes covering one-third of its bottom. (Large amount of excess heat energy from steam, friction, etc. is released.)</td>
</tr>
<tr>
<td>Coal is processed and burned at the power plant. Burning is used to boil water that creates steam which turns a turbine and generates electricity.</td>
<td>33%</td>
<td>A third student holds the yogurt container and spins around in a circle. (Energy is used to overcome resistance and is lost as heat.)</td>
</tr>
<tr>
<td>Electricity is transmitted to homes through power lines. (Energy is used to power the light bulb.)</td>
<td>85%</td>
<td>A row of students pass cups of water to each other one at a time in the cup topped with a small hole in the bottom. The last student pours water into the cup and puts hands into the cup (with no hole in the bottom).</td>
</tr>
<tr>
<td>Electricity passes through the strands of an incandescent light bulb. (Most of the energy is used to heat the filament that generates light.)</td>
<td>5%</td>
<td>A final student transfers the water from his or her cupped hands into a cup that has holes in the bottom.</td>
</tr>
</tbody>
</table>

**Represented by**

- **Energy content of coal:**
  - 100% of original energy in coal

- **Location of energy:**
  - 96% of original energy in coal
  - 99% of original energy in coal
  - 31% of original energy in coal
  - 26% of original energy in coal
  - 13% of original energy in coal

- **Conversion Efficiency:**
  - 90%
  - 97%
  - 33%
  - 85%
  - 5%

- **Representation:**
  - In the chemical bonds of coal in the ground
  - In the chemical bonds of coal in trains
  - In the chemical bonds of coal that arrives at the power plant
  - In the electricity generated by power plant
  - In the light energy being emitted from the light bulb

- **Water in the final cup:**
  - Water in student's cupped hands

**Related Topic:**

- Diminishing Returns

**Theme:**

- WE NEED ENERGY

**Activity Guide:**

- KEEP Activity Guide
The Changing Earth

Activities:

What Creates Natural Oil Seeps?

What Role Does Oil Play In Our Lives?

How Much Gasoline Do We Use?

What is Phase Separation?

How Does Oil Become Plastic?

Mining Simulation Lab (That's The Way The Cookie Crumbles)

Oil and Water in the Middle East Region
What creates natural oil seeps?

In this activity, students learn about the processes that create natural oil seeps by experimenting with oil, water, sand, and pressure. Because of its physical characteristics, oil flows toward the Earth's surface until its progress is blocked and it becomes trapped. If oil is trapped close to the surface, and the ground is saturated with water, the oil can seep out. Pressure from the water and wet soil push the oil to the surface, where it forms a pool. Before people dug wells, natural oil seeps were the only source of petroleum.

Materials For each group:

1. Glass jar of at least 350 mL capacity with a tight-fitting lid (such as a spaghetti-sauce jar)
2. 90 mL vegetable or mineral oil
3. 100 mL water with enough food coloring added to differentiate it from the oil
4. 120 mL sand
5. Spoon or wooden stirrer
6. For each student:
   Goggles
   Gloves

What to do

1. Fill the jar with 120 mL sand.

2. Add 90 mL oil.

3. Observe where the oil goes. Does it seep into the sand, or rest on top? (More oil seeps into coarse sand than fine sand.)
4. Poke a spoon down the inside of the jar. What happens? (The oil on top of the sand sinks.)
5. Stir the oil into the sand, or mix by covering the jar tightly and shaking it.
6. Add about 90 mL colored water. (You may need to stir to mix in the water.)
7. Observe what happens. (As the water seeps into the sand, the oil rises.)
8. Add more water, if necessary, to saturate the sand. Where is the oil now? (On top of the water.)
9. Cover the jar tightly and turn it upside down. Shake, if necessary, to make the sand fall to the bottom.
10. Observe how the oil and water move up through the sand to the surface.

**Discussion**
Because oil flows to areas of lesser pressure- and is less dense than water- it sometimes raises to the Earth's surface naturally. When oil gets trapped below hard rocks underground, it usually rests on top of water.
What role does oil play in our lives?

This activity explores the many uses of oil and what it would be like to live without petroleum products. It's easy to think of ways we use oil as fuel—gasoline for our cars, diesel fuel for trucks, jet fuel for airplanes, and heating oil, for example. But oil is also used to make petrochemicals, with which we manufacture plastic toys and food packaging, synthetic fabrics and rubber, skin balms, detergents, fertilizers, medicines, and glue. How many different products made from oil can you find in your everyday life? What could you substitute for them?

What to do

Together as a class, make a list of products made from oil. (Guide students by using the background information provided in the article that accompanies this foldout.) Focus on things important in students' everyday lives—for example, sneakers, lunchboxes, and clothing of nylon, rayon, or polyester.

Talk about what life would be like without these products. Discuss the ways in which cultures that had no access to petrochemicals—such as the ancient Egyptians or American colonists—managed without the petroleum products we use today.

Think of substitutes for petroleum products. For example, students might wear leather shoes and woolen clothing, play soccer with a leather ball, and use cotton bandages that would stick to their skin with tree sap.

Discussion

Because oil flows to areas of lesser pressure—and is less dense than water—it sometimes raises to the Earth's surface naturally. When oil gets trapped below hard rocks underground, it usually rests on top of water.
How much gasoline do we use?

To help students understand the role gasoline plays in their daily activities, have them predict the distance a particular driver will travel in a week—how much gasoline it will take. Children can also do this activity on an individual basis, choosing as the driver a parent, grandparent, aunt, brother, or other significant adult; later, students can compare their findings. For children living in an urban area, where cars are used less frequently, the activity may be adapted to focus on the gasoline used by mass transit buses.

Materials

This activity requires a volunteer driver and car. Students also need pencil and paper, and a calculator.

What to do

Predict how far the car will go:
Record the odometer reading. Convert the figure from miles to kilometers by multiplying it by 1.6 (for example, 1,000 miles equals 1,600 km).

1. Find out where the driver plans to go during the week. A typical schedule might include:
2. Bringing Suzie to school five mornings, 2 km per trip (times 5)
3. Driving to work and home, 5 km each way (times 10)
4. Going to the grocery store, 1.5 km each way
5. Taking Suzie to soccer practice, 2 km each way
6. Family outing on Sunday, 25 km each way

Calculate the number of kilometers the driver plans to travel. Add an estimated amount for unplanned travel. The sum of the two is your estimate of the total distance the car will travel during the week.

Predict how much gasoline the car will use:
Have the driver bring the car to school with a full tank. Observe the fuel gauge and ask the driver how much gasoline is needed to fill the tank. (The owner's manual should have this information.) Convert the figure from gallons to liters by multiplying it by 3.8 (for example, 10 gallons equals 38 liters).
Find out the car's average mileage. (The driver may look up the car's official mileage, calculated by the U.S. Environmental Protection Agency, or provide an estimate based on experience.) Determine the metric equivalent (kilometers per liter) by converting miles to kilometers (multiplying by 1.6) and dividing the result by 3.8 (the number of liters in a gallon).
Based on the number of kilometers calculated above, estimate how many liters of gasoline the driver will use during the week.

**Determine the accuracy of your predictions:**
When the driver brings the car back a week later, observe the fuel gauge and the odometer, and record what they show. Find out whether the gas tank has been refilled during the week and, if so, how much gasoline was added. Using your initial and current odometer readings, compute the actual distance traveled. Use the fuel gauge to compute the approximate amount of gasoline used. Compare your estimates of how far the car would travel and how much gasoline it would use with the observed data. Also, compare the actual kilometers per liter figure with the manufacturer’s estimate.

Guess how much the driver spent on gasoline for the week. Then find out the current price of gasoline and compute how much the driver actually spent.

**Discussion**
Did the car use more gasoline than you predicted it would? Can we change our driving habits to use less gasoline? In 1950, the average car traveled only about 14 miles per gallon (6 kilometers per liter) of gasoline. Today, the average is about 20 miles per gallon (8.5 kilometers per liter), and some cars are twice that efficient. Can you think of ways cars could be made even more efficient? (They could be smaller or built without conveniences such as air conditioning, for example.)
What is phase separation?

Oil and water don't mix. Alcohol and water do mix. When water gets into an oil-and-alcohol mixture, the water and alcohol blend, and the oil separates. In the experiment that follows, children observe this process, known as phase separation, and discuss how it affects the way we transport fuels.

Materials For each group:

1. Three glass jars of at least 150 mL capacity, one with a tight-fitting lid (such as a mustard jar)
2. 20 mL rubbing (isopropyl) alcohol
3. 20 mL vegetable or mineral oil
4. 80 mL water with enough food coloring added to differentiate it from the oil and the alcohol
5. Spoon or wooden stirrer
6. For each student:
7. Goggles
8. Gloves
9. Rubber aprons or other protective body-coverings

What to do

1. Fill one jar with 20 mL alcohol, and a second jar with 20 mL oil.
2. Add 40 mL colored water to each of the two jars.
3. Stir each jar.
4. Observe what happens. (The oil and water separate. The alcohol and water stay mixed.)
5. Mix the contents of the two jars in a third jar. Cover very tightly and shake well.
6. Observe what happens as the contents settle. (The liquids will separate, but the alcohol will stay in the water, not mix with the oil.)

Discussion

Gasoline that contains up to 10 percent ethanol, a type of alcohol usually made from corn, helps reduce air pollution because it burns more completely. It emits less carbon monoxide—a pollution problem most common in high-altitude cities with cold climates, such as Denver, Colorado.

But gasoline containing ethanol is not well-suited for transportation by pipeline, the main means of moving gasoline around the United States. Pipelines often contain small amounts of water—not a problem with conventional gasoline, since oil and water don't mix. But when gasoline contains ethanol, water present in the pipeline will blend with the
ethanol, diluting and ruining the fuel. Because of phase separation, gasoline containing ethanol must be transported by other means, such as trucks.
How does oil become plastic?

Petroleum extracted from the Earth is refined and then processed to produce monomers—liquid substances composed of single molecules of low molecular weight. Monomers are combined to create polymers—the complex molecules of high molecular weight that are used to make plastics and other synthetic materials. Students can learn about this type of chemical change by working with aqueous solutions of white glue and sodium tetraborate (borax) to make a type of polymer called putty.

Materials For each group:

1. Package of food coloring (four bottles)
2. 120 mL (four-ounce) bottle of white school glue
3. At least 100 mL water
4. For each student:
   5. 10 mL sodium tetraborate (borax) solution (see instructions below)
   6. 10 mL water
   7. Medicine cup marked in mL
   8. Wooden stirrer
   9. Paper cup
   10. Paper towels
   11. Wax paper
   12. Empty, open, sealable plastic bag
   13. Strip of masking tape about 8 cm long
   14. Goggles

What to do
The teacher should prepare the borax solution ahead of time by putting 30 mL borax in 500 mL hot water and stirring to dissolve. For each child, fill a plastic bag with 10 mL solution and seal. (Always test the putty recipe before the class activity begins just to check that the solution is the right strength.)

After the materials are distributed, have each student write his or her name on a strip of masking tape and place it on the empty plastic bag. (Before going on to the next step, have children cover their work areas with paper towels.)

Use the medicine cup to measure 15 mL water and then pour it into a paper cup. Measure 15 mL white glue and add it to the paper cup. (It may be necessary to scrape the glue out with the stirrer.) Stir the glue-water solution. Add two drops food coloring and continue stirring.

Add the glue-water mixture in the paper cup to the plastic bag containing the borax solution. Seal the plastic bag. Squish the mixture and mix the contents for about 20 seconds to form a gelatinous substance: putty.
Scoop the putty from the bag, knead it a few minutes to get rid of most of the stickiness, then place it in the clean plastic bag and seal. Wash and dry hands thoroughly and clean up materials before handling the putty again. (Excess borax solution can be flushed down the drain with plenty of water. All other liquids and materials should be placed in a plastic bag and discarded in the trash.)

Cover work area with wax paper and investigate the putty's properties: pull it slowly and quickly, cut it, roll it into a ball and drop it, flatten it, make impressions in it, and so on. Discuss the differences between the original ingredients and the product that resulted.

Describe the physical characteristics of putty in as many ways as possible.

After these explorations, the putty can be taken home in plastic bags. Do not encourage students to make putty at home, because if they pour leftover borax-glue mixture into the sink, it will plug the drain. Also, make sure that students know to keep putty away from younger children, who might eat it.

**Discussion**

Through this activity, students observe first hand the effects of polymerization. Compare the physical properties of the borax and glue solutions to those of the putty. What other processes have similar effects? (The chemical change that takes place during baking is one example.) Scientists use the processes of chemical change to refine petroleum into many different kinds of polymers, from which plastics, nylon, vinyl, and a wide variety of other synthetic materials are manufactured.
INTRODUCTION:

Many energy resources are unevenly distributed and have limits to their usefulness. In fact, in most processes, energy is not uniformly distributed. Thus, processes that require greater quantities of energy are often less economical and therefore abandoned for "cheaper" and "easier" techniques. Consider this idea as you complete the exercise.

In this lab, you will demonstrate mining of the earth's surface and underground, and will observe the limits of several energy sources.

APPARATUS/MATERIALS:

- 1 chocolate chip cookie (NOT for consumption)
- ruler
- forceps
- dissecting probe
- dissecting mount
- 3 sheets of white paper (preferably recycled)
- digital balance/massing pan
- plastic pipette (for use with water)

PROCEDURE:

1) Mass your cookie and record this value on the wipeboard at the front of the classroom. Mass a sheet of paper and jot this value down.
2) Measure the diameter of your cookie and estimate the area using the standard formula. Record this value on the class data table.
3) Set your cookie in the center of one of your sheets of paper. Count the number of visible chunks of chocolate embedded in the surface of the cookie. Record this number and put it in the class data table on the wipeboard.
4) Predict, based on your cookie size and you and your lab partner's "cookie mining experience" how many chocolate deposits you will find total in your cookie. Record this value in the class data table.
5) Utilize the instruments as hand to begin mining your cookie. As you mine, separate your chocolate from your crumbled cookie, by carefully placing your chocolate on one sheet of paper and the crumbled cookie on the other.
6) Consider the process complete when you have excavated as much chocolate as possible for the quantity of time and energy invested.
7) Mass your cookie crumbles, your mined chocolate, and your remaining cookie. Record these values on the class data table. Count your "large" chocolate pieces and record this on the class data table.
8) Clean up your stations, wash your hands, and get a cookie for you and your lab partner to snack on it while you complete your analysis.
Mining Simulation Lab
That's the Way the Cookie Crumbles

DATA/OBSERVATIONS:

Mass of Cookie (undisturbed): ______________________ g
Mass of Sheet of Paper: ______________________ g
Diameter of Cookie: ______________________ cm
Area of Cookie: ______________________ cm²
Visible Chocolate Chunks:
Estimate Total Chocolate Chunks:
Mass of Cookie Crumbles: ______________________ g
Mass of Removed Chocolate: ______________________ g
Total "Large" Chocolate Chunks:

ANALYSIS:
1) This is a mining simulation activity. What does the chocolate represent? What does the cookie represent?

2) Compare and contrast the number of chocolate deposits visibly observed and actually in existence. How does the actual number of deposits compare to the predictions?
3) Was there a correlation between chocolate harvested and surface area or mass?

<table>
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<th>Class Data</th>
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<td>Group</td>
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4) Where was the most time and energy invested in the mining process? What are other sources of time and energy not measured by the activity?

5) What role (if any) did the pipette and water serve for you? How does its use model real mining techniques?

6) Strip mining is often employed by mining groups. Given your chapter reading and current mining experience, offer an explanation for why.

7) Describe at least three environmental impacts of surface mining.
8) Use the internet to research 3 minerals mined in Wisconsin and/or the midwest. For each mineral,
   a) briefly describe the mining process
   b) identify where and in what industry the mineral is used
OIL AND WATER IN THE MIDDLE EAST REGION

Overview:
In this lesson, students will explore the roles of oil and water in the Middle East, especially in Iraq. Students will use maps to look at the distribution of oil in the Middle East and discuss what it means for the different countries in the region. They will also examine how water has influenced the region historically (in the "fertile crescent" region between the Tigris and Euphrates rivers) and politically (for example, how Iraq's access to water is limited to one small part of its border). Finally, they will study specific aspects of Iraq's struggles with water, using satellite imagery to understand and illustrate the problem.

Connections to the Curriculum:
Geography, geology

Connections to the National Geography Standards:
Standard 1: "How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective"
Standard 11: "The patterns and networks of economic interdependence on Earth's surface"

Time:
Two to three hours

Materials Required:
- Computer with Internet access
- Blank Xpeditions outline maps of the Middle East region, one for each student
- Writing and drawing materials

Objectives:
Students will
- study maps of Iraq and the Middle East to learn the basic geography of the region;
- analyze the role played by the distribution of oil and water in the Middle East, and how this sometimes contributes to conflicts in the region;
- create maps showing all the major sources of water in the Middle East and including other geographic names and features;
- read about conflicts in the Middle East region caused by water and answer questions; and
- study satellite imagery of Iraq and study specific aspects of the conflicts it faces relating to water.

Geographic Skills:
- Asking Geographic Questions
- Acquiring Geographic Information
- Organizing Geographic Information
- Answering Geographic Questions
- Analyzing Geographic Information

Suggested Procedure

Opening:
Most people think of oil as the central resource that shapes the Middle East. Why is this so? Ask students to look at National Geographic's Middle East: Natural Resources map and
consider the variable crude oil reserves of the different countries. Which countries appear to have the most oil? The least? Might this explain why we hear more in the media about some countries in this region than others?

Development:

Now ask students to look at the same map and to think about water while they consider the following quotes, taken from National Geographic News articles they will be reading later in the lesson:

"Many of the wars of this [20th] century were about oil, but the wars of the next century will be about water." -Former World Bank Vice President Ismail Serageldin

"The next war in the Near East will not be about politics, but over water." -Former UN Secretary General Boutros Boutros-Ghali

Using the Iraq map and the Middle East: Natural Resources map, point out to students that two of the most important ancient civilizations, Egypt and Mesopotamia, developed in areas where water was plentiful. Why do students think this is the case?

Why do students think water is so important? Have them form small groups and brainstorm about this question, writing down their ideas.

Give each student a copy of the basic Xpeditions outline map of the Middle East, with the borders on. In their small groups, ask them to use the maps on the Iraq Web site to fill in the names of countries and major cities on their individual maps, and to do the same for the following bodies of water in the region:

- Persian Gulf
- Red Sea
- Gulf of Aden
- Mediterranean Sea
- Caspian Sea
- Dead Sea
- Gulf of Aqaba
- Tigris (Dijlah) River
- Euphrates (Al Furat) River
- Jordan River
- Nile River
- Sea of Galilee
- Gulf of Suez

Ask students to read the following articles about water in the Middle East, and answer the questions that follow (they can work alone, in pairs, or in small groups):

National Geographic News: Water and Peace in the Middle East
National Geographic News: Protests Grow Over Plan for More Turkish Dams

[Note: Be sure to point out to students that these articles were written in 2000, but that while some of the region's leaders have changed, the issues remain the same.]

- Briefly describe why water is a source of conflict, according to these articles.
- Which countries are making plans to somehow change the natural flow or distribution of water? Which countries object to these plans, and why?
- How does one country's control of a water source impact another country?
- Why is the Southeast Anatolia Project (GAP) particularly controversial? Why is Turkey so determined to continue despite so much opposition?
• How have these issues developed since these articles were written in 2000? (Further research required.)

Closing:
Bring the class back together and ask students if what they learned about the importance of water bore out the ideas they brainstormed earlier in the lesson. Were there any surprises? What else would students like to explore based on what they have learned in this lesson?

Suggested Student Assessment:
Ask students to form four groups and explore the USGS: Earthshots page about Iraq. Then, ask each group to take one of the following sections from the page and study it in detail, creating their own maps based on USGS satellite imagery:

• Irrigating in Mesopotamia
• Draining marshes in Iraq
• Trenching along the border; the use of water for military purposes [Note: There is less information about this particular topic, so it will require more research; you may want to assign it to more ambitious students or eliminate it altogether if time is limited.]
• [Oil] spilling and burning in Kuwait

Have students explore other resources to learn more about their topic, such as these:
UN Food and Agriculture Office: AQUASTAT—Iraq
WaterNet: Water and Conflict
Students should, at minimum, consider geography, politics, and the consequences (real or potential) to the people living in the region. Have each group present what they have learned to the class.

Extending the Lesson:

• Have students explore the Web or the library to find out what has happened to Turkey's plans to build dams. Which other countries have become involved in the controversy?

• Have students use the USGS: Earthshots site to find other parts of the world that are dealing with issues of drought and flooding. Try to find regions where water has also become a political issue.
Why I Should Care

Activities:

“...But Not In My Backyard!”
A Growing Human Population
Recycling Paper
To Spray or Not to Spray
Project AAR: Appleton Acid Rain Project
Owl Pellets
Habitat Lap Sit
How Many Bears Can Live In This Forest?
The Price is Right
Water Actions
A Drop in the Bucket
What if Water Cost as Much as Gasoline?
"...But Not in My Backyard!"

**Subject/Content Area**
Environmental Science/Physical Science

**Activity Structure(s)**
Information Searches, Question-and-Answer Activities

**Goals/Outcome Statements**
AT&T ENRICH: IIA-C; IIIF
SG,CAS,CFS: 11A3; 11B9; 11C1,2; 13B1,3

Upon completion of this activity, students will be able to:
- explain how nuclear energy, hydroelectric energy, wind energy, solar energy, biomass fuels, and synthetic fuels can be used to generate electricity;
- compare the advantages and disadvantages of producing electrical energy through the use of nuclear energy, hydroelectric power, wind energy, solar energy, biomass fuels, and synthetic fuels;
- discuss the problems and dangers involved in the storage and disposal of radioactive waste;
- give an oral presentation explaining the benefits and problems of a particular alternative energy source used to generate electricity; and
- design a news article, poster, or PowerPoint slide presentation on an alternative energy source.

**Tools and Resources**
Science textbook
Library books
Newspapers
Magazines
Activity Sheet: "...But Not in My Backyard!" (Background Information)
Activity Sheet: Pros and Cons of an Alternative Energy Source
Scoring Rubric: "...But Not in My Backyard!"
Scoring Rubric: "...But Not in My Backyard!" Teacher-generated (optional)

Computers with Internet access
Netscape Navigator or Microsoft Explorer
Microsoft Word
Microsoft PowerPoint
Websites:
The Quick Virtual Nuclear Power Plant Tour:
http://www.cannon.net/~gonyeau/nuclear/

David Rezachek's Home Page (links to alternative energy sources)
http://home.hawaii.rr.com/rezachek/

http://www.eren.doe.gov

BioEnergy Homepage (a resource for bioenergy, bioconversion, and bioprocess technology)
http://www.biotech.wisc.edu/jeffries/debate.html

Ask an Expert:
http://www.askanexpert.com

Mad Scientist Network:
http://madsci.wustl.edu

Nuclear Information and Resource Service:
http://www.nirs.org/

Union of Concerned Scientists:
http://www.ucsusa.org/index.shtml

National Renewable Energy Laboratory:
http://www.nrel.gov/clean_energy/

**Detailed Description of Project**

This one-week activity on alternate energy sources can be used to supplement a unit on energy resources and recycling. In this project, students will explain the pros and cons of an assigned alternative energy source. The project timeline is as follows:

Allow one period to introduce the activity and assign students into groups of three or four. Have groups determine which alternative resource they want to research: nuclear energy, wind energy, synthetic fuels (coal gasification and coal liquefaction), solar energy, hydroelectric energy, or biomass fuels.

Allow two or three days for Internet research, library research, and small group work. (More time may be required depending on the ability of students.) Posters may be done at home.

Allow two days in class for presentations.
Project Procedures:

**Day 1:**

Distribute "... But Not in My Backyard!" background information activity sheet to each student.

Divide students into groups of three or four. Explain to the students that they need to read the scenario and determine which alternative energy source can be used in place of nuclear energy, such as: wind power, synthetic fuels (coal gasification and coal liquefaction), solar energy, hydroelectric power, or biomass fuels.

Before the students are dismissed from class, make sure that they have selected and submitted the name of a particular alternative energy source.

**Days 2–4:**

Allow the students to research their alternative energy source. Have the students work in their small groups to answer the following questions on the activity sheet, *Pros and Cons of an Alternate Energy Source*, about their alternative energy source: how it is mined and refined; how it is used to generate electricity; and the advantages, disadvantages, and feasibility of using this alternative energy source. Instruct students to contact an expert and ask him or her the following question: What would it be like to live close to an electric generating plant that uses either nuclear energy or fossil fuel?

Explain to the students that they will be required to present to the class the data they have collected and defend their alternative source of energy as the most beneficial for the area. Direct students to complete the chart so they have a record of the events that take place at the meeting.

**Day 5:**

Allow the student groups to present the pros and cons of their alternative energy source.

In a well-monitored discussion, instruct students to individually develop a list of components that are representative of an excellent project. Guide students to discover that a mix of alternatives may be the answer, depending on a number of climatic, ecologic, and economic factors. Then, using consensus to create a class scoring rubric, have the students determine the parameters and descriptors from their selected components. If the students are having difficulty creating the rubric, show the students the suggested rubric template.

**Assessment of Students**

Students will be assessed according to a class-generated rubric using the attached template or the teacher-generated scoring rubric (attached).
Credits

Author(s):
Clare Kaelin

Editor(s):
Brian Agustin
Christine Fedorenko
Alice B. Schmeelk
Christopher Stiglic
"...But Not in My Backyard!"
Activity Sheet (Background Information)

The Lakefront Electrical Company has decided to construct a nuclear power plant on Lake Euphrates, eight kilometers (five miles) from your home. Lakefront says that electrical use in your part of the state is growing at the rate of 3.2% per year. Current generating capacity will be adequate for only five more years. Given the delays in building and licensing a new nuclear plant, the Euphrates installation probably will not be in operation for another eight years.

In order to speed up this process and avoid possible objections from the public, Lakefront has initiated a vigorous public relations and educational campaign to win the support of residents in the immediate area. The company has asked you and five of your neighbors to serve on an advisory committee that will inform the public about this project at several public meetings.

You will be required to explain to the public the parts of a nuclear reactor, how it works, and the advantages of using nuclear energy to produce electricity (playing down the disadvantages). You may prepare news releases, a poster, a PowerPoint presentation, or some other summary of this information. Be prepared to present your information at a joint meeting of the Lakefront Electrical Company and the Citizens' Advisory Council on Government Energy Policy.

As a member of the Citizens' Advisory Council on Government Energy Policy, you are appalled at the above decision. You have reviewed the proposal and believe that an alternate form of energy could be used to generate the proposed new power plant. These alternative sources include hydroelectric power, wind power, biomass fuels, synthetic fuels, and solar power.

You and a partner will select any one of the alternative sources to study in greater detail. How does it work? Where is it used today? What are its advantages and what are its disadvantages? Prepare a news article, a poster, a PowerPoint presentation, or some other summary of the information you learn about this energy source. Be prepared to present your information at a joint meeting of the Lakefront Electrical Company and the Citizens' Advisory Council on Government Energy Policy.
"... But Not in My Backyard!"
Pros and Cons of an Alternative Energy Source

Activity Sheet
Name(s) ___________________ Team Members _______________________

Alternative Energy Source ____________________________

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<thead>
<tr>
<th>Alternative Energy Source</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Nuclear Energy</td>
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<tr>
<td>Synthetic Fuels:</td>
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<td>Coal Gasification</td>
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<td>Coal Liquefaction</td>
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<td>Solar Power</td>
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<td>Hydroelectric Power</td>
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<td>Biomass Fuels</td>
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<td>Wind Power</td>
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<td>Content</td>
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<td>Includes all of the content.</td>
<td>Well organized, all components present.</td>
<td>To be determined by student discussion.</td>
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<td>3</td>
<td>Missing one area of content.</td>
<td>Some confusion due to organization.</td>
<td>To be determined by student discussion.</td>
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<td>2</td>
<td>Missing two areas of content.</td>
<td>Much confusion due to poor organization.</td>
<td>To be determined by student discussion.</td>
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<td>Missing more than two areas of content.</td>
<td>No apparent organization.</td>
<td>To be determined by student discussion.</td>
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Note: Students may determine the parameters of the content, organization, and creativity criteria.
"...But Not in My Backyard!" | Scoring Rubric (Teacher-Generated)

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<td>Student's response is thorough, accurate, and creative; shows an in-depth understanding of science skills, procedures, and concepts.</td>
<td>Student's response is complete, mostly accurate, and original; shows a satisfactory understanding of science skills, procedures, and concepts.</td>
<td>Student's response is mostly complete but includes some inaccuracies; shows an adequate understanding of science skills, procedures, and concepts.</td>
<td>Student's response is only partially complete and has many inaccuracies; shows an incomplete understanding of science skills, procedures, and concepts.</td>
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A Growing Human Population

Subject/Content Area
Environmental Science/Populations/Carrying Capacity/Biotic and Abiotic Factors

Activity Structure(s)
Information Searches, Question-and-Answer Activities

Goals/Outcome Statements
AT&T ENRICH: IIC; IIIC
SG,CAS,CFS: 11A3; 11B9
Upon completion of this activity, students will be able to:
- describe how overpopulation has affected our resources;
- illustrate data and results in a graph; and
- use a concept map to illustrate the problems stemming from overpopulation.

Tools and Resources
Scoring Rubric: A Growing Human Population Presentation
Computers with Internet access
Excel or ClarisWorks
Inspiration software or drawing tools from Microsoft Word or ClarisWorks
PC projector
Websites:
http://cpl.lib.uic.edu/004chicago/timeline/population.html
http://www.census.gov/
http://lycoskids.infoplease.com/ipka/A0774780.html
http://www.zpg.org

Detailed Description of Project
During the 10-day time period of this project, students will conduct an Internet search to gather population data about several cities (national and international). They will also search for information about the resources available to the population of each of the cities. The students will use the data and information they have collected to predict population changes in the future and explain in a concept map and PowerPoint presentation how the population will affect the available resources in the city areas.
Day 1:
Introduce students to the concepts related to human population and how human population affects resource availability. Pair students. Explain to the students that their assignment is to search the Internet to gather population figures and information about resources for eight to 15 cities, both national and international. (Some suggested cities to research are Chicago, New York, Los Angeles, Charlotte, Detroit, Phoenix, Venice, Mexico City, etc.) Tell students that they will also be required to predict how the population figures of the cities will change over the next 10, 20, and 50 years.

Days 2-4:
Discuss with the students the importance of the availability of natural and man-made resources for each of the cities they are researching. Discuss also the many formats that students can use to convey the data, information, and predictions to their classmates. Explain that student pairs will be required to construct graphs, concept maps, PowerPoint presentations, and written reports; additional formats they choose are encouraged, but not required. Answer any questions students may have. Suggest that students address the problems that result from overpopulation (i.e., shortages of food, fuel, wood, etc., and contamination of water, environment, etc.).

Allow students to begin or continue their Internet searches.

Days 5-7:
Inform students that they should be completing their information and data collection. Encourage students to begin work on their graphs, concept maps, PowerPoint presentations, and written reports if they have not already done so.

On Day 7, tell students that the next three class periods will be devoted to students' presentations.

Days 8-10:
Have students present their findings to their classmates (PowerPoint presentations). When all student pairs have had a chance to present to the class, allow them to discuss possible solutions for the problems specific to the cities for which information was shared.

Assessment of Students
Assess students' presentations using the attached presentation scoring rubric.

Teacher Notes
This project is more meaningful and challenging if cities with growing and shrinking populations are included.

It is recommended that students have previous knowledge about how to construct graphs and concepts maps, as well as a working knowledge of the software being used (Excel, PowerPoint, etc.).
Credits

Author(s):
Yositara C. Almeida

Editor(s):
Vincenza Giusti
Joan Kowalczyk
John Loehr
Maria Elena Robles
Claudette Terry
<table>
<thead>
<tr>
<th>Criteria Evaluated</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Elements</strong></td>
<td>All required elements are present on the slides: - Research - Graph - Concept map</td>
<td>All but one required element are present on the slides: - Research - Graph - Concept map</td>
<td>All but two required elements are present on the slides: - Research - Graph - Concept map</td>
<td>Three required elements are missing from the slides: - Research - Graph - Concept map</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td>The slides are very attractive. Text is legible. No grammatical errors. Animation and effects are used throughout to enhance the presentation.</td>
<td>The slides are attractive. Text is legible. No grammatical errors. More than half of the slides have animation and effects that enhance the presentation.</td>
<td>The slides are legible. The amount of text is too great for the space within which it is presented. There may be some grammatical errors. Less than half of the slides have animation or effects.</td>
<td>The slides are not legible. The amount of text is too great for the space provided throughout the page(s). There are several grammatical errors. There is no use of animation or effects in the presentation.</td>
</tr>
<tr>
<td><strong>Problem solving</strong></td>
<td>Addresses a real issue directly related to research findings.</td>
<td>Addresses an issue somewhat related to research.</td>
<td>Addresses an issue which is unrelated to research.</td>
<td>Does not address an issue related to the assignment.</td>
</tr>
<tr>
<td><strong>Research</strong></td>
<td>Answers most questions and includes many other interesting facts.</td>
<td>Answers some questions and includes a few interesting facts.</td>
<td>Answers some questions.</td>
<td>Does not answer any questions.</td>
</tr>
<tr>
<td><strong>Creativity</strong></td>
<td>Creativity is highly advanced. Information is presented in a unique format. Unique information and visuals are evident throughout.</td>
<td>Creativity is more advanced. Information is presented in a unique format. Some unique information and visuals are evident.</td>
<td>A basic level of creativity is evident. Information is presented in a unique format. No unique information is evident.</td>
<td>There is no evidence of creativity. All information is presented in its original format.</td>
</tr>
<tr>
<td><strong>Data and Results</strong></td>
<td>Data table and graph are neatly completed and totally accurate.</td>
<td>Data table and graph are neatly completed and somewhat accurate.</td>
<td>Data table and graph are complete with minor inaccuracies and/or are illegible.</td>
<td>Data table and/or graph missing.</td>
</tr>
<tr>
<td><strong>Presentation Graph</strong></td>
<td>The group interacts with their audience and moves about during the presentation. All material is presented using language that is unique; it does not appear in written format. Individual students have defined roles in the presentation.</td>
<td>The group makes eye contact with their audience. Most material is presented in a new form, not as it is written on the screen or page. Individual students have well-defined roles in the presentation.</td>
<td>The group makes minimal eye contact with their audience. Everything is read directly from the screen or page. Individual students have defined roles in the presentation.</td>
<td>The group makes no eye contact with their audience. Everything is read directly from the screen or page. Individual students do not have defined roles in the presentation.</td>
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</tbody>
</table>
TITLE: RECYCLING PAPER

AUTHOR: Christy Hornung, Dodge City Public Schools, Dodge City, Kansas

OVERVIEW: Fifty percent of the solid waste produced in North America is paper. Producing enough paper uses vast numbers of trees and immense amounts of energy. Waste products from the production of energy and from the manufacturing often produce pollution, and live trees help preserve the global ecology. It makes sense to cut down on our high use of packaging in products. In addition, it makes sense to recycle.

RESOURCES/MATERIALS:
- old newspaper
- electric blender
- large pan
- wire screening
- water
- cornstarch
- stirrer
- wax paper
- rolling pin

ACTIVITIES AND PROCEDURES:

DIRECTIONS FOR RECYCLING
1. Tear a page of used paper into small pieces. Place it in a large pan. Add enough water to cover the paper and soak for 10 minutes.
2. While the paper is soaking, mix one-fourth of a cup of water with about one-eighth of a cup of cornstarch. Stir until the cornstarch dissolves.
3. Pour off the water in the pan that was not absorbed by the paper. Put the paper in a blender. Add the cornstarch and water mixture. Cover the blender. Run the blender on high for two minutes.
4. Put the screen over the pan. Pour the material onto the screen. With your hands, spread it out so that it is flat and thin. Cover the material with wax paper. Use a rolling pin to squeeze out the excess water. CAREFULLY remove the wax paper.
5. Allow the new paper to dry completely. This may take a day or two. GENTLY peel it from the screen. Try writing on it. Write down what happens.

DESCRIPTION:
1. What was the texture, color, odor, and so on of the paper?
2. Was the paper easy to write on? If so, in what ways, if any, does it need to be improved?

EVALUATION:
1. Do you feel that the effort to recycle paper is worth the trouble? Why or why not?
2. How many times can paper be recycled?
To Spray or Not to Spray:
A Debate Over Malaria and DDT

by
Frank J. Dinan and Joseph F. Bieron
Department of Chemistry and
Biochemistry
Canisius College

As they settled into the office of Mr. Mali Sahriti, the United Nations Secretary for Public Health, all the participants of the impending discussion were nervous. Each was determined to press the points that would persuade Mr. Sahriti in his or her favor. Here, at last, was their chance to influence the United Nations decision on whether or not to ban the global use of DDT or to allow its use for the control of malaria.

Each of the three visitors to Secretary Sahriti's office, Dr. Nicole Lund, a tropical disease specialist with the World Health Organization, Chiba Ilogu, the ambassador from the central African country of Malawi, and Dr. Patricia Canavan, a DDT expert and representative of the Sierra Club, were well prepared for the meeting. They had studied the issues carefully and were anxious to present their views to the secretary, hoping that they could influence his recommendation on DDT's future use.

Secretary Sahriti began the meeting. "Welcome, and thank you for coming. I know that you all have strongly held, expert views on the proposed global ban on the use of DDT that the United Nations Organization is considering, and I am most anxious to hear them. As you know, I must make a recommendation to the Secretary General in the near future on whether the United Nations should invoke a worldwide ban on the use of DDT by 2004. Since I am not as informed as each of you on aspects of this issue, you will have to provide me with some of the background that underlies your positions. Perhaps we could begin with you, Dr. Lund."

Nicole Lund, a physician specializing in tropical diseases, had been with the World Health Organization (WHO) for six years. Her work at WHO as well as her prior training was focused on malaria and its control.

"Thank you, Mr. Secretary, I'd be happy to start. As you are aware, even though WHO is a part of the United Nations, we are strongly opposed to the proposed ban on the use of DDT. Our reasons for this are quite straightforward. The number of malaria infections throughout the world has grown dramatically as the use of DDT for mosquito control has declined. Our studies show that between 350 and 500 million people in 101 countries..."
throughout the world are currently infected with malaria, and between two and three million deaths result from these infections each year. Malaria also causes damage to the economies of developing nations, estimated at a half billion dollars annually.

"As I am sure you are aware, malaria infections are caused by mosquito bites, and nothing else is as effective as DDT for the control of mosquito populations. I should also mention that as of today, there is no effective vaccine against malaria, and we cannot say with any certainty when and if one will be developed."

"May I add to Dr. Lund’s comments, Mr. Secretary?" asked Chiba Iogu.

"Certainly, Minister Iogu, please do."

"It is important to realize that malaria poses a threat to 40 percent of the world's population, and that most of those affected live in poor, underdeveloped parts of the world. Sub-Saharan Africa, Central and South America, and South East Asia are among the areas at the highest risk. I am particularly concerned because 90 percent of those dying from malaria are African children.

"In 1973, after DDT had been used for malaria control for over a decade, there were less than 400 cases of malaria in all of South Africa, and in 1977 only a single malaria death occurred. Now, not only is the number of malaria cases increasing, but the rate of increase is also accelerating.

"Since South Africa yielded to political and economic pressure from the developed nations and stopped the use of DDT in 1995, its rate of malaria infections has quadrupled, and hundreds of additional deaths have occurred."

Secretary Sahriti leaned forward in his chair and said, "Why do you say that South Africa's decision to ban DDT use was the result of political and economic pressures from the developed countries?"

"Because, Mr. Secretary, the developed countries are major contributors to the economies of the underdeveloped nations, and they often insist on a ban of DDT use as a condition for their aid. This is a clear case of the developed world imposing its values on poor nations regardless of the consequences for those nations. I am sure you realize that malaria is not a problem in most of the developed world, although that may be changing now."

The Sierra Club representative, Patricia Canavan, was visibly agitated. She said, "May I make some observations that would add a bit of balance to our discussion, Mr. Secretary?"

"Of course, Dr. Canavan."

"The reason that the developed countries want DDT banned from use worldwide is that
its use presents an unacceptable risk to our environment and to our health. It is a risk that we simply cannot afford to take.

"DDT is so stable in the environment that it takes many years for it to decompose after it is exposed to air and water. Ten years after DDT began to be used studies found it in even the most remote areas of the world, places where it had never been applied. Wind and water transport DDT all over the globe.

"And then it began to show up in birds, fish, domestic animals, and humans. DDT accumulates in fatty tissues, and is passed from mothers to their infants during breast-feeding. Nursing infants all over the world were ingesting DDT from their moment of birth."

Nicole Lund shifted uneasily in her chair as she responded, "What you say is true, Dr. Canavan, but would you please tell us how many human deaths DDT has caused among the billions of human beings that have been exposed to it?"

"I think you know very well that DDT has not been proven to be the direct cause of any human deaths, Dr. Lund. I also think that you know that the 'precautionary principle' demands that we not take risks whose consequences we cannot predict."

"I am afraid that I am not aware of the details of the precautionary principle, Ms. Canavan," Secretary Sahriti interjected. "Could you enlighten me about it?"

"Certainly, Mr. Secretary. The precautionary principle requires that when an activity raises potential threats of harm to humans or the environment, it should not be undertaken even if some cause and effect relationships are not fully established scientifically. So we must assume that the potential risks posed by future use of DDT are such that we cannot take a chance and allow it to be used."

"Let me see if I understand this concept," said the secretary. "The precautionary principle maintains that some technological activities pose such grave potential threats to our well-being that they should not be undertaken, even if definitive scientific evidence is not available to establish that the activity will cause the harm. Is that correct, Dr. Canavan?"

"That's right. The principle might seem a bit unreasonable at first glance," Patricia Canavan replied, "but if you consider the totally unanticipated problems caused by the use of asbestos and PCBs as well as the harm done to the ozone layer by chlorofluorocarbons you can understand why use of the precautionary principle is necessary."

"One more question, if I may, Dr. Canavan. Is it true that the precautionary principle focuses only on the risks associated with a technology and not the benefits that may result from its use?"

"Yes. because the potential risks associated with some technological activities are so
grave that regardless of the benefits that may be derived from them, they must not be undertaken. Besides, we have seen that the risks associated with a new technology are often not apparent until it is in use, and then it is too late to undo the harm that has been done."

Chiba Iogu interjected, "Mr. Secretary, the question that you have raised about the benefits is exactly why the precautionary principle, so beloved by environmentalists, is not a reasonable guideline in many areas, and especially so in the case we are considering here. I believe that the developed world is far more concerned with the theoretical long-term risks of DDT use than it is with the needless and very real deaths of millions of people, mostly children, in the poor nations of the world.

"And we have only touched on the great economic benefits that could result in those nations if the threat of malaria were significantly reduced. It is estimated that new badly needed development programs would bring in a half billion dollars per year to those poor nations, and their health care costs would be reduced by about two billion dollars per year if malaria were controlled. Think of the good this could do."

Patricia Canavan replied, "How can we know, though, that long-term chronic exposure to DDT won't do irreparable harm to us all, and to our children? There is no doubt that DDT does bioaccumulate in humans and throughout the environment. If its use is allowed to continue we may pass a point of no return, one where irreversible harm has been done."

Nicole Lund countered, "Despite the great public outcry caused by Rachel Carson's book Silent Spring, claims of the risk to human health and the environment caused by DDT have never been confirmed or replicated by any scientific inquiry, even after the passage of almost 40 years. And there is no evidence that DDT has ever caused harm to a single human being. We simply cannot afford to close our eyes to DDT's benefits and focus only on its potential risks.

"And there is a way to keep any risks that may be involved in DDT's use much lower than they have been in the past. A recent study conducted in Belize has demonstrated that DDT protects people against malaria not only by killing mosquitoes, but mainly by repelling them. It showed that only three percent as many mosquitoes entered huts sprayed with DDT on their interior walls as entered unprotected huts. If DDT is used in this way, in small amounts and only in enclosed spaces, it presents a greatly reduced environmental and health risk."

"That may be true," answered Patricia Canavan, "but how can we be sure that DDT intended for use in this way will not be used in agriculture, and in other ways that will spread it widely into the environment?"

Ambassador Iogu responded, "DDT would only be provided in small amounts, and it would be used only by trained indoor spraying technicians. These would be the
conditions for its use."

"I don't think anyone would believe," replied Patricia, "that if DDT is provided to all sorts of people in all sorts of places it wouldn't be misused. Sooner or later, it would once again become a major threat to both our health and the environment."

"I agree that we cannot reduce the risk to zero, Dr. Canavan," said the ambassador, "but certain risks must be accepted to provide health benefits in the least developed parts of the world. We have to balance these potential risks against some certainties. The certainties are that as many as 500 million people will suffer and more than a million people will die from malaria each year if we deny them the public health benefits that come from using DDT."

Patricia responded, "I understand your point, Ambassador Iogu, but once the DDT genie is out of the bottle again, we may find it impossible to control. Not even the most farsighted among us could begin to imagine the damage to the environment and to human health that could result from its use. Technological dangers sneak up on us, and by the time that we realize that we are in danger, it is often too late to prevent the damage. May I remind you of the ozone, PCB, and asbestos examples once again."

Secretary Sahriri leaned back in his chair, folded his hands before him, and said, "I am afraid that our time is up and I must bring our discussion to a close. I thank you all for coming to this meeting. Your arguments have been most enlightening and have raised many important issues. I assure you that I will consider all of the points that you have raised very carefully before making my recommendation to the Secretary General."

Questions

1. At one point in the discussion, Ambassador Iogu comments, "Malaria is not a problem in most of the developing world, although that may be changing." This comment is not followed up in the case study. What changes could the ambassador be referring to? How can this comment be related to the West Nile virus problem troubling parts of the northeastern United States?

2. What are the strengths, weaknesses, and implications of the precautionary principle as a method for deciding whether a technology should be used?

3. What are the strengths, weaknesses, and implications of risk/benefit analysis as a method for deciding whether a technology should be employed?

4. Compare risk/benefit analysis to the precautionary principle. Which of these methods do you feel would generally lead to better decisions on questions involving potential applications of technologies in society? On what reasoning is your conclusion based?

5. How do you think that the question of using DDT for malaria control vs. banning
its use worldwide will be resolved? Is your answer to this question the same as your view on how this matter should be resolved? Explain.
PROJECT AAR: Appleton Acid Rain Project

Students from our classes can participate in project AAR. Acid rain will be collected during a month according to a specific protocol. The methodology utilized includes collecting rain water in a glass jar lined with a ziploc bag and held in place by a rubber band. The jar must be at least three feet off the ground to avoid any splash back. The jar must also be kept out of the rain shadow of the home and of the trees in the area. This means that the jar must be kept at least as far away as the object is high. The jar must also be kept out of low lying areas and away from streams. The time for collection is 6:30 to 7:00 AM each day and brought to school in an effort to maintain the same temperature at which it was collected. On weekends the acid rain collected is placed in a glass jar in the refrigerator and brought to school the following Monday. The data collected for the sample month of October is shown in the following table.

<table>
<thead>
<tr>
<th>DATE/OCTOBER</th>
<th>pH</th>
<th># SITES REPORTING</th>
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<tbody>
<tr>
<td>03</td>
<td>5.0</td>
<td>09</td>
</tr>
<tr>
<td>08</td>
<td>4.4</td>
<td>33</td>
</tr>
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<td>4.7</td>
<td>51</td>
</tr>
<tr>
<td>11</td>
<td>4.5</td>
<td>42</td>
</tr>
<tr>
<td>18</td>
<td>4.4</td>
<td>21</td>
</tr>
<tr>
<td>19</td>
<td>4.9</td>
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<tr>
<td>26</td>
<td>4.5</td>
<td>39</td>
</tr>
<tr>
<td>29</td>
<td>4.5</td>
<td>01</td>
</tr>
<tr>
<td>10</td>
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<td>28 average</td>
</tr>
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</table>

The average amount of rain during this time period .41 inches per day with 10 days of rain at pH 4.5 with 28 sites reporting on the average. The normal rainfall has a pH of 5.6.
The acid rain is a little over ten times stronger than normal rainfall. Collections of this nature provide a good deal of information about the watershed in the area and also provide some information about stream pH. Acid snow was collected in February. The project reported the protocol and procedure as it is collected.
Owl Pellets

Subject: Science
Grade Level: 5-8
Topic: Skeletal System
Duration: 45-60 minutes
Skills: Analysis, comparing similarities and differences, generalizations
Objective: When asked the students will be able to:
1. Dissect an owl pellet to remove bones and remains.
2. Reconstruct a skeletal system
3. Identify possible prey of the owl

Materials
owl pellets
dissecting tools (toothpicks, tweezers)
construction paper
glue
skull guide
skeleton diagram

Procedure
1. Divide the students into groups of two. Review safety procedures including the need to wash hands before and after doing the activity. Give each group an owl pellet.
2. Have students separate bones from fur and other materials.
3. Students should use skull guide to help identify the type of animal that was eaten by the owl by comparing the various skulls found.
4. Determine if there are bones from more than one animal in the pellet. If there are, determine how many different animals are represented in one pellet.
5. Lay out the bones to form as many complete skeletons as possible. Skeletons may be glued on to construction paper for display or labeling.

Assessment
1. Completion of owl pellet dissection, and identification of various bones found.
2. Oral questions before/after activity

Extensions
1. Draw a picture of a simple food chain that includes the owl, its prey, and other animal or plant life that may be in the chain.
HABITAT LAP SIT

OBJECTIVES
Students will: 1) identify the components of habitat; 2) recognize how humans and other animals depend upon habitat; and 3) interpret the significance of loss or change in habitat in terms of people and wildlife.

METHOD
Students physically form an interconnected circle to demonstrate components of habitat.

BACKGROUND
NOTE: This activity was inspired by a "New Game," and adapted to teach concepts related to wildlife.

See "The Beautiful Basics," "Everybody Needs A Home," "What's That, Habitat?" "Habitacks" and "Habitat Rummy" for activities with similar purposes. People and other animals share some basic needs. Every animal needs a place in which to live. The environment in which an animal lives is called "habitat." An animal's habitat includes food, water, shelter and space in an arrangement appropriate to the animal's needs.

If any of these components of habitat is missing or is affected significantly so that the arrangement for the individual animal or population of animals is no longer suitable, there will be an impact. The impact will not necessarily be catastrophic, but can be. There are a great many additional limiting factors beyond those of suitable food, water, shelter and space. For example; disease, predation, pollution, accidents and climatic conditions are among other factors which can have impact.

All things are interrelated. When we look at a biological community, we find interrelationships and interdependencies between plants and plants, plants and animals, as well as animals and animals. These interrelationships and interdependencies are important.

The major purpose of this activity is for students to become familiar with the components of habitat, and to recognize that it is not sufficient for there to be food, water, shelter and space in order for animals to survive—those components of habitat must be in a suitable arrangement.

MATERIALS
none needed

PROCEDURE
1. This activity takes very little time—but has a lot of impact! Ask the students to number off from "one" to "four." All the "ones" go to one corner of the room, the "twos" to another, etc.
2. As the students move to their corners, clear a space in the center of the room. Better still, go outside to a clear, grassy area. The "ones" should sit or stand together, "twos" together, etc.
3. Assign each group a concept as follows: "ones"=food, "twos"=water, "threes"=shelter, "fours"=space.
4. Now, it's time to form a circle! This is done by building the circle in chains of food, water, shelter and space. A student from each of the four groups walks toward the cleared area. The four students stand next to each other, facing in toward what will be the center of the circle. Four more students—one from each group—join the circle. Keep adding to the circle in sets of four until all the students are in the circle.
5. All students should now be standing shoulder to shoulder, facing the center of the circle.
6. Ask the students to turn toward their right, at the same time taking one step toward the center of the circle. They should be standing close together, with each student looking at the back of the head of the student in front of him or her.
7. Don't panic—this will work! Ask everyone to listen carefully. Students should place their hands on the shoulders of the person in front of them. Students slowly sit down as you count to three. At the point of three, you want the students to sit down—on the
knees of the person behind them, keeping their own knees together to support the person in front of them. You then say, "Food, water, shelter and space—in the proper arrangement (represented by the students’ intact, “lap-sit” circle)—are what is needed to have a suitable (good) habitat."

8. The students at this point may either fall or sit down. When their laughter has subsided, talk with them about the necessary components of suitable habitat for people and wildlife.

9. After the students understand the major point—that food, water, shelter and space are necessary for any animal’s survival, and in their appropriate arrangement comprise a suitable habitat—let the students try the circle activity again! This time ask them to hold their lap sit posture. As the students lap-sit—still representing food, water, shelter and space in their appropriate arrangement—identify a student who represents “water.” Then say, “It is a drought year. The water supply is reduced by the drought conditions.” At this point, have the student who was identified as representing “water” remove himself or herself from the lap-sit circle—and watch the circle collapse, or at least suffer some disruption in arrangement. You could try this in several ways—removing one or more students from the circle. Conditions could vary: pollution of water supply, urban sprawl limiting availability of all components, soil erosion impacting food and water supplies, etc. Since animals’ habitat needs depend upon food, water, shelter and space, in their appropriate arrangement, “removal” of any will have an impact.

10. Ask the students to talk about what this activity means to them. Ask the students to summarize the main ideas they have learned. They could include: a) food, water, shelter and space, in their appropriate arrangement, can be called habitat; b) humans and other animals depend upon habitat; c) loss of any of these elements of habitat will have impact on the animals living there; and d) the components of habitat must be in an arrangement suitable to the needs of the individual animals or populations of animals in order for the animals to survive.

VARIATION
Have the students form a circle, holding hands. Walk around the circle, first naming one student as an animal of a particular ecosystem. Name the next four students in the circle as food, water, shelter and space for that animal. Repeat the process until all the students are involved. Any “extras” can be identified as elements of habitat, e.g., resulting from a particularly good year for habitat needs for the last animal named. When all of the students have been designated as an animal or as components of an animal’s habitat, comment on the fact that they are holding hands. This represents the idea that all things in an ecosystem are interrelated. Briefly discuss the idea of interrelationships. Then move the students into position to the “lap sit” described in the Procedure above.

EVALUATION
1. What are the five essential components of habitat?
2. Explain how the arrangement of food, water, shelter and space is important to humans and other animals.
3. What would probably have the greater long-term impact on the wildlife living on a farm in Iowa? A severe winter which killed many animals or the development of part of the farm into a commercial shopping center?
WHAT DID YOUR LUNCH COST WILDLIFE?

OBJECTIVES
Students will: 1) trace some foods from their source to the consumer; 2) identify the impact those foods and their processing have on wildlife and the environment in general; and 3) recommend, with explanations, some food habits that could benefit wildlife and the rest of the environment.

METHOD
Students trace food sources, diagram environmental impacts, and apply the knowledge they gain by making changes in some of their consumer choices.

BACKGROUND
NOTE: Especially for younger students, this activity makes a nice summary companion to “What’s For Dinner?”

Most of us make lifestyle choices each day that have some impact on wildlife and the environment. Many of those impacts are indirect, and therefore we are not as aware of them as we might be. The choice of foods we eat, for example, is an area with many implications for wildlife and the environment.

The places and ways in which foods are grown has impact. For example, we know that loss of habitat is one of the most critical problems facing wildlife.

Habitat may be lost to agricultural use or development as well as to industrial, commercial, and residential uses. Given that people need food, the ways in which we grow that food—and the ways we care for the land in the process—are very important. Farmers can take measures to maintain and improve wildlife habitat as they grow and harvest their crops. They can pay attention to the impact of their growing practices. Both inorganic and organic fertilizers are commonly used in industrial agriculture. These compounds may run off or leach into water supplies. In lakes, for example, this run-off may contribute to a huge increase in the growth of plant nutrients such as algae. This excess growth can act as a pollutant, poisonous to aquatic animal life such as fish, amphibians, arthropods, and insects.

Use of insecticides and herbicides also affects the environment, including wildlife. Obviously, if pesticides kill and eliminate the food source for wildlife, the wildlife either leaves or dies. Indirect effects can include accumulation of pesticides in the bodies of animals such as predatory birds, fish and mammals, including people.

Not all of the impact is due to some farmers’ practices, however. Certainly the transportation, processing, packaging and marketing industries are involved as well. Questions about the natural resources involved in getting the food from its source of origin to the consumer are critically important. One example is increased exploration for and development of fossil fuels used to transport the food from growing site to consumer, used often to fuel the processing, and frequently used in the packaging, as in the case of fossil fuel-derived plastics.

Ethical considerations can also be raised concerning the impact upon individual animals and plants by the methods used to produce food for people, as well as choices of which foods to eat. If the students have concern about adopting lifestyle habits that can be healthful to themselves at the same time they have less impact on wildlife and the environment, they can look at the food they eat as one place to begin.
The major purpose of this activity is to provide a means for students to begin that process.

**MATERIALS**
writing and drawing materials

**PROCEDURE**
1. Select a processed food item. Identify the item's ingredients. In a discussion with students, trace the item's ingredients all the way back to their origins. Include where and how they grew, processed, transported, packaged and made available to the consumer. Ask the students to generate a list of foods they either brought or bought for lunch. Be sure to include any packaging materials the foods came in.
2. Ask the students to trace the path the food takes. (The students may want to do some research at this point to get some additional information.)
3. Ask each student to pick one food to trace all the way back to its origins, including where and how it grew, was harvested, processed (if it was!), was transported, was packaged and was made available to the consumer—the student. Ask the students to make simple flow diagrams of the path the food takes. (The students may want to do some research at this point to get some additional information.)
4. Next ask the students to add drawings of possible and likely impacts to wildlife and the environment along the path their food took to get to them.
5. Ask the students to report back to their classmates—using their diagrams as a visual aid as they describe the path taken by their food and its impact to wildlife and the environment along the way.
6. Ask the students to discuss and summarize their findings.
7. Ask each student to think of one change he or she could make in his or her own lunch-time eating habits that would be likely to have a beneficial—or at least less harmful—effect on wildlife and the environment. Describe the reasoning for this change and evaluate its consequences. If, after examination, each change seems in fact to be helpful, suggest that the students try making their changes for a week. At the end of the week, ask the students to report back. Were they able to stick with the change? What happened? If they didn't make the change, why not? Did they forget? If they did make the change, did they find themselves making or thinking about any other possible changes? If yes, what were they?

**EXTENSIONS**
1. Map the energy used to grow and get the food to you.
2. Include impact on other specified natural resources along the way.
3. Distinguish between renewable and nonrenewable resources.

**AQUATIC EXTENSION**
If it is not already obvious, do this activity again asking the question, "What Did Your Lunch Cost Aquatic Wildlife?" Think of whole populations of species of aquatic animals and aquatic habitats.

**EVALUATION**
1. Trace the possible course of a container of milk served in your school back to its probable source. What impact does this journey have on wildlife?
2. Name three food habits that could reduce negative impacts to wildlife and the environment. Explain the reasoning behind your suggestions.
HOW MANY BEARS CAN LIVE IN THIS FOREST?

OBJECTIVES
Students will: 1) define a major component of habitat; and 2) identify a limiting factor.

METHOD
Students become "bears" to look for one or more components of habitat during this physically-involving activity.

BACKGROUND
It is recommended that this activity be preceded by one or more activities on adaptation; basic survival needs; components of habitat; crowding; carrying capacity; habitat loss; habitat improvement; herbivores, carnivores, and omnivores; and limiting factors. See the cross references for suggestions. For additional information about black bears, see "Bearly Born."

In this activity, the black bears are the focus in order to illustrate the importance of suitable habitat for wildlife. One or more components of habitat—food, water, shelter and space in a suitable arrangement—are emphasized as one way to convey the concept of "limiting factors."

Black bear habitat limits black bear populations, especially through the influences of shelter, food supply and the social tolerances or territoriality of the animal. Shelter or cover is a prime factor. Black bears need cover—for feeding, hiding, bedding, traveling, raising cubs and for denning. With limits of space, adult bears will kill young bears or run them out of the area. These young bears must keep moving around either until they die or find an area vacated by the death of an adult.

When food supplies are reduced by factors such as climatic fluctuations, competition becomes more intense. Some adult bears might temporarily move to seldom-used areas of their home range, sometimes many miles away. They must live on what food is available in the area. These individuals may become thin and in poor condition for winter hibernation or, in the case of young bears, be forced from the area by more aggressive adults.

All components of habitat are important. Food, water, shelter and space must not only be available—but must be available in an arrangement suitable to meet the animals' needs. For black bears, shelter is especially important.

All possible conditions are not covered by the design of the activity. However, by this simple illustration, it is possible for students quickly to grasp the essential nature of the concept of limiting factors.

The major purpose of this activity is for students to recognize the importance of suitable habitat. Inadequate food and/or shelter are two examples of what is called a limiting factor—something which affects the survival of an animal or a population of animals.

MATERIALS
five colors of construction paper (a couple of sheets each of red, yellow, green, blue, and orange) or an equal amount of light poster board; one black felt pen; envelopes (one per student); pencils; one blindfold; five sheets green construction paper (for extension).
The components of an actual bear’s diet will vary between areas, seasons and years. For example, a bear in the state of Alaska would likely eat more meat (fish) and fewer nuts than a bear in Arizona. One similarity among black bears everywhere is that the majority of their diet is normally made up of vegetative material.

If you follow the table when making the food cards, there should be less than 80 pounds of food per student, so that there is not actually enough food in the area for all the “bears” to survive.

3. If you want, you can also include “water” as a habitat component by making additional squares from light blue paper. To calculate how many water cards to make, multiply the number of students by 1.25 (round to the nearest whole number). For example, for a group of 20 students you would make $20 \times 1.25 = 25$ water cards. Divide the water squares into five equal piles (or roughly equal) and mark each group with the one of following letters: R, L, ST, SP, and M. These letters represent all the places where a bear could find water: rivers, lakes, streams, springs and marshes.

4. In a fairly large open area (e.g., 50’ x 50’), scatter the colored pieces of paper.

5. Do not tell the students what the colors, initials, and numbers on the pieces of paper represent. Tell them only that the pieces of paper represent various kinds of bear food. Since bears are omnivores, they like a wide assortment of food, so they should gather different colored squares to represent a variety of food.
6. Have each student write his or her name on an envelope. This will represent the student’s “den site” and should be left on the ground (perhaps anchored with a rock) at the starting line on the perimeter of the field area.

7. Have the students line up on the starting line, leaving their envelopes between their feet on the ground. Give them the following instructions: “You are now all black bears. All bears are not alike, just as you and I are not exactly alike. Among you is a young male bear who has not yet found his own territory. Last week he met up with a larger male bear in the big bear’s territory, and before he could get away, he was hurt. He has a broken leg. (Assign one student as the injured bear. He must hunt by hopping on one leg.) Another bear is a young female who investigated a porcupine too closely and was blinded by the quills. (Assign one student as the blind bear. She must hunt blindfolded.) The third special bear is a mother bear with two fairly small cubs. She must gather twice as much food as the other bears. (Assign one student as the mother bear.)"

8. Students must walk into the “forest.” Bears do not run down their food; they gather it. When students find a colored square, they should pick it up (one at a time) and return it to their “den” before picking up another colored square. (Bears would not actually return to their den to eat; they would eat food as they find it.)

9. When all the colored squares have been picked up, the food gathering is over. Have students pick up their den envelopes containing the food they gathered and return to class.

10. Explain what the colors and numbers represent. Each color is a kind of food and the numbers represent pounds of food eaten. Ask each student to add up the total number of pounds of food he or she gathered—whether it is nuts, meat, insects, berries or plant materials. Each should write the total weight on the outside of his or her envelope.

11. Using a chalkboard, list “blind,” “injured,” and “mother.” Ask the blind bear how much food she got. Write the amount after the word “blind.” Ask the injured bear and the mother bear how much they got and record the information. Ask each of the other students to tell how much food they found; record each response on the chalkboard. Tell the students each bear needs 80 pounds to survive. Which bears survived? Is there enough to feed all the bears? How many pounds did the blind bear collect? Will she survive? What about the mother bear? Did she get twice the amount needed to survive? What will happen to her cubs? Will she feed her cubs first or herself? Why? What would happen to her if she fed the cubs? What if she ate first? If the cubs die, can she have more cubs in the future, and perhaps richer, years? (The mother bear will eat first and the cubs will get whatever, if any, is left. The mother must survive; she is the hope for a continued bear population. She can have more cubs in her life; only one needs to survive in order for the population to remain static.)

12. If you included the water squares, each student should have picked up at least one square representing a water source, or he or she does not survive. Water can be a limiting factor and is an essential component of habitat.

13. Ask each student to record how many pounds of each of the five categories of food he or she gathered. Ask each student next to convert these numbers into percentages of the total poundage of food each gathered. Provide the students with the background information about black bears so that they can compare their percentages with what are typical percentages eaten by black bears in Arizona. Ask each student to attempt to guess how healthy their bear would be. How do the bears’ requirements for a diet seem to compare with the needs of humans for a balanced and nutritious diet?

14. Ask the students to arrive at a class total for all the pounds of food they gathered as bears. Divide the total by the 80 pounds needed by an individual bear (approximately) in order to survive in a ten-day period. How many bears could the habitat support? Why then did only ____ bears survive when your class did this activity? Is that realistic? What percentage of the bears survived? What percentage would have survived had the food been evenly divided? In each case, what percentage would not survive? What limiting factors, cultural and natural, would be likely to actually influence the survival of individual bears and populations of bears in an area?

**EXTENSIONS**

1. Cut paper or poster board into 2” x 2” squares. Make 5 squares per student. For example, with a class of 30 students, you would make 150 squares. Divide all the squares into 5 equal piles and mark the cards in each pile with one of these letters: B, T, D, H and F. These represent B = bedding sites, T = travelways, D = dens, H = hiding cover and F = feeding sites. For purposes of this activity, these are defined as follows:
**Bedding Sites**  Black bears are usually active in early morning and late evening, and bedded most of the rest of the day and night. Bedding sites are usually in areas of dense vegetation, steep topography, and/or large trees where the bears feel secure.

**Travelways**  Bears require corridors of cover (made up of thick vegetation and/or steep topography) to enable them to travel between areas of food, water and shelter within their home range.

**Dens**  Black bears use dens as shelter for hibernation from November to April in each year. Bears have been found denning in hollow logs, caves, holes dug into hillsides, under buildings and even in culvert pipes. Bears often prepare and may use more than one den, and may change dens during the winter because of disturbance or if the den leaks. Bears seldom re-use dens from one year to the next.

**Hiding Cover**  Black bears evolved as animals that escape danger from predators and other bears by hiding in thick cover.

**Feeding Sites**  Bears will often use areas with less cover than hiding areas or bedding sites for feeding. Feeding sites are, however, often found close to thick hiding cover to allow the bear to quickly escape danger if necessary.

NOTE: This information is based on actual research data from a study in Arizona. These components of shelter may vary slightly in different parts of North America.

2. In a fairly large open area (e.g., 50' x 50'), scatter the colored pieces of paper.
3. Have the students line up along one side of the area. Tell them that they are to become "bears" for the purposes of this activity. Review the concept of habitat—that a bear would need shelter, food, water and space in a suitable arrangement in order to survive. Do not tell the students what the letters on the squares of paper represent. Tell them only that they represent one element or component of bear habitat.
4. Direct the students to move as individual "bears" into the area. Each bear must pick up as many of the components of habitat as possible. Some competitive activity is acceptable as long as it is under control. Bears are territorial. Remember that if bears fight, which they seldom do, they can become injured and unable to successfully meet their needs for survival.
5. When the students have picked up all of the squares of paper in the area, have them return to the classroom or be seated in any comfortable area. Ask the students to separate their squares of paper into piles according to the letter on each. Using a chalkboard or large pad for a visual reference, ask the students to guess what the letters on the green cards represent—giving them the clue that each is an element of cover or shelter for a black bear. What kinds of shelter would a bear need? What do these initials represent? Record how many bears got at least one of each kind of shelter. How many got only four kinds? Three? Two? How many got only one kind of shelter? For the purposes of this activity, only those bears with at least one of each kind of necessary shelter can survive through one year. Ask students what would happen if a bear has all types of shelter except a den? (The bear could live from April through October, but would not have a secure place to hibernate and might not survive the winter.) Ask the students what would happen if a bear did not have travelways? (Without travelways, home ranges become fragmented and bears are not able to reach needed food, water or other shelter.) Suggesting that the students need one of each kind of shelter represents the importance of appropriate shelter as a necessary component of an animal's habitat. Shelter is a very important part of a bear's habitat. A bear needs shelter in which to search for food and water. Bears also need shelter for traveling through their home range; and shelter for bedding, hiding, and denning. In this activity, how many bears survived? What was a "limiting factor" for this population of bears? (Shelter.) What other things possibly could become limiting factors? (Water and space, or territory, are two examples.) Would food be a limiting factor for bears? (Yes, however bears are omnivores and can utilize many sources of food.)
6. Ask the students to summarize what they have learned about the importance of suitable habitat for bears' survival. How is this similar and different to the needs of other animals?

**EVALUATION**

1. Define "limiting factor." Describe some of the factors which may limit the survival of an animal that lives in your area.
2. Invent a board game to demonstrate some of the limiting factors associated with wildlife.
The Price Is Right

When you pay your water bill, what exactly are you paying for?

**Summary**
Students learn about economics and environmental planning as they calculate the cost of building a water development project.

**Objectives**
Students will:
- calculate the costs involved in supplying clean water to consumers and removing wastewater.
- recognize that cost and environmental considerations influence the planning and construction of water projects.

**Materials**
- Sample water bill (optional)
- Copies of Student Data and Instruction Sheet
- Copies of Water Development System Map
- Calculators
- Ruler

**Making Connections**
Students who earn their own spending money likely understand the value of certain things, such as compact disks, snack foods, or gas for their cars. They have probably heard adults complain about paying bills, such as the water bill. They may wonder why we pay for water. Learning the real and sometimes hidden costs and processes involved in supplying clean water to and removing wastewater from homes helps students appreciate the value of water resources.

**Background**
Individuals, businesses, communities, states, and countries are all involved in water resource economics on a daily basis. The cost of water influences individual and community decisions, such as whether to take long showers, whether to purchase a new water-efficient irrigation system, and whether to upgrade a wastewater plant.

When current water supplies no longer meet the needs of a growing community or when the waste generated by this growing population becomes too much for a treatment plant to process, water management decisions must be made. Options include reducing water consumption through conservation, installing more efficient water technologies, and building new treatment facilities. People may be asked to approve an increase in taxes or an increase in water or wastewater treatment bills to cover additional costs. Whatever option is chosen, chances are public funds will be needed; therefore, citizens will have opportunities to voice their opinions and to raise concerns. Most levels of government conduct public planning forums.

There is far more to constructing a water project than meets the eye. Aside from the construction of the physical plant, surveying potential sites, engineering water lines, establishing operation systems, and maintaining production also contribute to the cost. The list in the side bar on page 335 highlights costs associated with various water projects. (Costs vary among different regions of the country.)

**Procedure**
**Warm Up**
Show or describe a water bill to students. What do they think is involved in establishing the cost of water? Why does water need to be paid for? To help students appreciate the costs involved in securing water resources, have students play a price guessing game. Using the list of sample costs on page 335, ask them to guess the cost of a particular...
Components of Municipal Water and Wastewater Treatment Systems

1. WATER SOURCE (GROUND WATER WELL FIELD)
2. UNTREATED WATER LINE
3. WATER TREATMENT PLANT
4. WATER TANK
5. WATER MAIN
6. HOUSEHOLD WATER LINE
7. COMMUNITY SEWER LINE
8. COMMUNITY WATER LINE
9. HOUSEHOLD SEWER LINE
10. SLUDGE DIGESTER
11. SETTLING TANK
12. AERATION BASIN
13. WATER TREATMENT PLANT
14. WATER MAIN
15. WATER TREATMENT OUTLET

The Activity
1. Explain to students that their task is to help a community redesign their municipal water and wastewater treatment systems. A new water treatment plant has already been built, but they need to construct water lines through which untreated water can flow from the source (a ground water well field) to the new plant. In addition, a new wastewater treatment plant must be built and sewer lines run from the community to the plant. Both construction projects need to use Best Management Practices; "best" can be defined as the route and location that require the least costs and have fewer environmental effects. NOTE: Real-life situations would involve many other considerations for choosing the best location, including health concerns, substrate conditions, aesthetics, political matters, and so forth.

2. Divide the class into small groups; supply each group with a copy of the Water Development System Map and review its contents and environmental features. Give each group a copy of the Student Data and Instruction Sheet and discuss.

3. Allow time for groups to identify what they think is the best location for each project.

Wrap Up
Have each group present its proposed plan and calculated costs for class review. Group members should summarize considerations and factors they used to help them make the decision. Encourage students to provide constructive criticism for the proposed plans. Can the class reach consensus regarding where to locate the projects?

Present students with the Answer Key. Do students agree with the solutions given in the key? Tell students that if this was a real-life situation, other factors and conditions would come into play, and the actual locations might be different. In other words, students may have justifiable reasons why their proposals are better.

Inform students that in some situations, citizens must pay additional taxes to fund the construction of water management projects. How do students think of the costs reflected in a water bill now?
they feel about citizens incurring the cost of the project through increased taxes? Do students think they would willingly pay the price for new water supplies? Which would they rather do: change their habits and use less water, or pay more money for increased supplies? Discuss how the cost of water management projects is often a prohibiting factor to building new systems.

Have students learn about water projects in local communities. How much did they cost? Who paid for them?

**Assessment**

Have students:

- analyze what factors affect water use charges (*Warm Up* and *Wrap Up*).
- calculate the cost to build an untreated water line, a wastewater treatment plant, and sewer lines (step 3).
- determine the route for an untreated water line to a treatment plant, select a site for the construction of a wastewater treatment plant, and justify their choices (step 3 and *Wrap Up*).
- evaluate other students' selected locations for water projects (*Wrap Up*).

**Extension**

Have students role-play bankers and project designers. The project designers request a loan for their water development system. Because the bank will only loan funds to one group of project designers, students should be well prepared to answer the banker's questions, such as "How much money do you need?" "What is your economic justification for the loan?" and "How do you intend to repay this loan?" The banker will consider the best designed project plans, proposed budget, and responses to questions when determining the loan recipient.

**Resources**


**Student Data and Instruction Sheet**

**Instructions**
Read the following information and refer to the map and data to find the best locations for the untreated water line and the wastewater management plant.

**Untreated Water Line**
- sketch possible routes for the water line
- calculate costs for each route
- assess environmental impacts of each route
- use the above information to determine the most cost-effective and environmentally sensitive route

**Wastewater Treatment Plant**
- consider placing the wastewater treatment plant at each of the six designated sites on the map
- assess the best location based on the following:
  - costs (of running a single major sewer line from town to the plant)
  - environmental concerns (specifically, proximity to discharge site [the river], direction of streamflow, quality of ground water being drawn into pumping wells, quality of river water that could become part of the ground water)
  - legal placement of wastewater lines (it may be unlawful to cross wetlands, public property, state parks, or wildlife refuges)
  - aesthetics and health issues (including odor, down-stream flows, and landscape considerations)
- use the above information to determine the most cost-effective and environmentally sensitive location

Prepare a presentation for your classmates, including reasons why you think your routes and sites are the best.

**Data**

NOTE: The following are hypothetical costs; they include materials and labor. Contact local engineers, treatment plants, and construction companies to obtain costs more relevant to your community.

- untreated water line (runs from well field to plant) = $12/foot ($40/meter)
- main sewer line (runs from sewer collection point to wastewater treatment plant) = $9/foot ($30/meter)
- wastewater treatment plant = $45,000,000
- easement on farmland = $1,000 per linear mile
- construction of lines under existing two-lane highway = $100,000
- construction of line to cross river (this complicated process involves permits and completing environmental impact statements) = $500,000
- construction of line to cross existing bridge = $50,000
- construction of line to cross wetland = illegal
Water Actions

Acid rain, ground water contamination, water shortages—how can we resolve these seemingly overwhelming issues?

**Summary**

Investigating, analyzing, and participating in projects that address water resource issues give students a sense of accomplishment and provide motivation to help manage and protect water.

**Objectives**

Students will:
- explain the importance of considering the feelings and values of others involved in water-related issues.
- analyze the appropriateness of proposed action strategies.
- plan and evaluate the steps needed to investigate and conduct an action project.
- conduct water action projects.

**Materials**

- Depends on the project selected

**Making Connections**

Ground water contamination, water shortages, acid rain, nonpoint source pollution—these are just a few of the water-related issues people hear about every day in the news. Several Project WET activities provide students opportunities to gain a better understanding of water-related issues. Students can acquire first-hand experience in water issue resolution by educating and involving others in learning about these issues as well.

**Background**

After students become aware of a water resource issue, they may be interested in learning how they can help resolve the problem. Many Project WET activities have an action component that encourages students to share their knowledge about water or water issues with their families and community and to explore options for resolving these issues.

Active participation in local, state, and national decision-making processes is important. However, people should consider all sides of an issue during the process. This is especially critical when formal and nonformal educators and young people consider issues.

To learn about all aspects of an issue, people should conduct an investigation and analysis. This consists of researching the problem and learning how others perceive it. Research includes finding out who is (or was) involved in creating the issue and who will be needed to help remedy it. Who are the key players? Who has been affected by the issue, and are they involved in the solution?

People can become involved in protecting water resources in a variety of ways. One of the most powerful methods is education. Helping other people better understand the background and implications of an issue promotes appreciation of and concern for it. Through class-sponsored water festivals, letter writing to the editors of newspapers, public debates, presentations to community groups, and informational posters about water-related issues, people become more familiar with issues.

Some problems can be corrected by people taking direct action, such as community service projects (trail work, litter patrol, and designating and protecting sensitive areas). Implementing water conservation practices helps with water quantity problems. Cleaning up a river or refraining from pouring toxic chemicals down storm drains reduces the burden placed on wastewater treatment plants.
People can use economic strategies to bring about change. For example, fund-raising activities can help provide monetary support for a group or organization. If people believe laws and regulations are needed to correct a situation, they can contact their representatives to voice their opinions. Voting for a person who supports your views helps ensure that your voice will be heard. While most students in grades K-12 are too young to vote, they can encourage adults to exercise this right.

When contemplating a project, establish a goal and determine objectives. The goal is the purpose or intent of the project. Objectives are specific and achievable tasks related to accomplishing the goal. The specific steps to accomplishing the objectives are the methods.

An example of a goal is: “To improve stream habitat.” One objective is to inventory the macroinvertebrates to assess the quality of the stream. This method involves collecting and analyzing macroinvertebrate populations. Setting time lines and laying out a budget are intrinsic components of a project.

The saying “Look before you leap” relates directly to student-led service projects and is critical to their success. **Only projects that comply with policies of the school system or of nonformal organizations should be considered.** Planning is important. Select realistic projects that have clear goals, obtainable objectives, and appropriate tasks. Safety must always be a primary concern.

After thoroughly researching the issue and deciding upon an action strategy you will still need to consider several factors before beginning a project. An action analysis criterion developed by Hungerford et al. (1992) can be organized into a checklist to determine if action is warranted and appropriate.

- Is there sufficient evidence to warrant this action?
- Is the chosen action the most effective one available?
- Are there legal (social, economic, ecological) consequences of this action? If so, what are they?
- Do my personal values support this action?
- Do I understand the beliefs and values of others who are involved in this issue?
- Do I understand the procedures necessary to take this action?
- Do I have the skills, time, courage,
and resources to complete this action? (Hungerford et al. 1992, 145-47).

Educators should be aware of considerations and needs unique to their school and community, and include these in the checklist. Relevant to the needs of the school setting, Lane and Rossw (1993) have added an additional set of considerations for the teacher. These include the following:

- Is the project relevant to the objectives of the class?
- How does the project fit into the curriculum?
- What are the interdisciplinary connections?
- Will student motivation and ownership be generated?
- Will the project include a diversity of learning techniques? (Lane and Rossw 1993, 241).

When action projects are conducted in a school setting, purposeful learning must occur. The decision to become involved should come from the students. They may need guidance to determine if the project is within their capabilities.

**Procedure**

**Warm Up**

Share with students one or both of the case studies at the end of this activity. Have students identify specific projects described within the case studies and discuss what they think was involved in completing them.

**The Activity**

1. Have students identify a water-related issue that interests them. Students can obtain information by reading newspapers or magazines, and watching news programs and documentaries; guest speakers, field trips, and videos can also provide students with ideas. If possible, involve students in Project WET activities that will help them learn about this issue (e.g., “Whose Problem Is It?”). (If students decide to work in groups, the activity “Idea Pools” suggests a technique for organizing individuals according to common interests and issues.)

2. If students decide they want to become active in helping resolve this issue, have them generate research questions. These research questions should include: What caused the problem? What are the environmental implications of the problem? How do other people perceive the problem? How are their values related to their viewpoints? What efforts have been taken to resolve it? These questions are answered by reading textbooks and news articles, interviewing experts, and conducting surveys. Once the information has been collected, it should be organized in a report or chart for easy reference. This information can be used to determine if action should be taken regarding this issue.

Regardless of the goal and objectives of the action, students should anticipate and assess potential responses/reactions that their action could elicit from classmates, school officials, and community members. The action should be weighed against the response.

3. Involve students in a discussion of what can be done to correct this problem. Students can participate in the activity “Perspectives” to consider the pros and cons of various solutions. Can the action be initiated by individual students (e.g., water conservation) or will they need to involve other people? Ask students to create a list of potential action strategies.

4. After students have developed a list of potential action strategies, help them evaluate the strengths and weaknesses of the strategies. Lead them through an analysis criteria checklist similar to the one in the Background. Make sure local considerations and concerns are added to the list.

5. Provide students with the student activity sheet, Project Action Planning Form for Teachers and Students. Discuss the information on this form. Review the research procedures required for students to complete this form. Conduct group meetings and discussions to help students execute the forms, initiate action, and complete their projects. For long-term projects, arrange for students to submit progress reports on a regular basis.
Students use storm drain stencils to inform residents in their watershed. COURTESY: CITY OF BELLEVUE, WASHINGTON

▼ Wrap Up and Action
When students have completed their projects or taken some kind of action, have them discuss their feelings and experiences. Do they think they were effective? What evidence supports their opinion? What problems did they encounter? What were the rewards? What would they change if they were to repeat the project? Are they interested in becoming involved in a similar project in the future? What advice would they give to other students who would like to conduct a similar project?

Discuss ways that students can inform others about what they have accomplished. They may want to write a feature article for a local newspaper. Would the local television news program be interested? Perhaps they could present a summary of their efforts to another class or at a town or school meeting.

Assessment
Have students:
• investigate and research a water-related issue (steps 1 and 2).
• recognize the feelings and values of individuals representing diverse viewpoints regarding the issue (step 2).
• identify potential strategies to resolve the issue (step 3).
• assess the strengths and weaknesses of the proposed action strategies (step 4).
• plan and conduct a project designed to address a water-related issue (step 5).
• evaluate the outcomes of the project (Wrap Up).
• publicize and publish the results of the project (Wrap Up).

Resources


For Information
On storm drain monitoring and stenciling programs, contact:
Step Coordinator, Oregon Department of Fish and Wildlife, P.O. Box 59 2501 S.W. First Avenue Portland OR 97207
Earthwater Stencils 4425 140th S W , Dept. WT Rochester WA 98579
Center for Marine Conservation 306A Buckroe Avenue Hampton VA 23664

Water Actions
Project WET Curriculum and Activity Guide
Objectives
Students will:
• calculate the percentage of fresh water available for human use.
• explain why water is a limited resource.

Materials
• 2 colors of construction paper
• Sheets of white paper
• Markers
• Water
• Globe or world map
• 1000-ml beaker
• 100-ml graduated cylinders
• Small dish
• Salt
• Freezer or an ice bucket
• Eyedropper or glass stirring rod
• Small metal bucket
• Copies of Water Availability Table

Making Connections
Students may know Earth is covered mainly by water, but they may not realize that only a small amount is available for human consumption. Learning that water is a limited resource helps students appreciate the need to use water resources wisely.

Background
Ironically, on a planet extensively (71 percent) covered with water, this resource is one of the main limiting factors for life on Earth. The Water Availability Table summarizes the major factors affecting the amount of available water on Earth. If all the clean, fresh water were distributed equally among people, there would be about 1.82 million gallons (7 million liters) per person. This is only about .003 percent of the total water on Earth.

On a global scale, only a small percentage of water is available, but this percentage represents a large amount per individual. The paradox is that, for some, water may appear plentiful, but for others it is a scarce commodity. Why are some people in need of more water? Geography, climate, and weather affect water distribution. Agriculture, industry, and domestic use also affect availability.

Procedure
▼ Warm Up
Tell students they are going to estimate the proportion of potable water on Earth and compare it to the rest of the water on the planet. Have students work in small groups. Instruct them to draw a large circle with a marker on a white sheet of paper. Offer them two sheets of different-colored construction paper. One color represents available fresh water; the other represents the rest of the water on the planet.

Tell students that they will be tearing the two sheets of paper into a total of 100 small pieces. Ask them to estimate how many pieces will represent potable water and how many pieces will indicate the rest of the water on the planet. Instruct each group to tear up their paper and arrange the 100 pieces within the circle so that these pieces reflect their estimates. Have groups record the number of pieces representing “potable” and “remaining” water.
NOTE: For simplicity, measurements have been retained in metric. To convert to standard measurements, refer to the Metric Conversion Table in the Appendix.

1. Show the class a liter (1000 ml) of water and tell them it represents all the water on Earth.

2. Ask where most of the water on Earth is located. (Refer to a globe or map.) Pour 30 ml of the water into a 100-ml graduated cylinder. This represents Earth’s fresh water, about 3 percent of the total. Put salt into the remaining 970 ml to simulate water found in oceans, unsuitable for human consumption.

3. Ask students what is at the Earth’s poles. Almost 80 percent of Earth’s fresh water is frozen in ice caps and glaciers. Pour 6 ml of fresh water into a small dish or cylinder and place the rest (24 ml) in a nearby freezer or ice bucket. The water in the dish (around 0.6 percent of the total) represents non-frozen fresh water. Only about 1.5 ml of this water is surface water; the rest is underground.

4. Use an eyedropper or a glass stirring rod to remove a single drop of water (0.003 ml). Release this one drop into a small metal bucket. Make sure the students are very quiet so they can hear the sound of the drop hitting the bottom of the bucket. This represents clean, fresh water that is not polluted or otherwise unavailable for use, about .003 percent of the total! This precious drop must be managed properly.

5. Discuss the results of the demonstration. At this point many students will conclude that a very small amount of water is available to humans. However, this single drop is actually a large volume of water on a global scale. Have students use the Water Availability Table to calculate the actual amounts.

**Wrap Up**

Referring to the Warm Up, remind students of their earlier guesses at how much water on Earth is available to humans and compare the actual percent of Earth’s water available. Have students explain their reasoning for their initial estimates. How would they adjust their proportions? (One-half of one of the pieces of paper represents potentially available water [0.5 percent]. Only one small corner of this half [0.003 percent] is actually potable water.)

Ask students again if enough water is currently available for people. If the amount of usable water on the planet is divided by the current population of approximately 6 billion, 7 million liters of water is available per person. Theoretically, this exceeds the amount of water a person would require in a lifetime.

---

**ANSWER KEY: Water Availability Table**

| Total water (100%) on Earth divided among all people (based on a world population of 6 billion people) | = 233.3 billion liters/person |
| Minus the 97% of each share (226.3 billion liters) that contains salt (oceans, seas, some lakes and rivers) | = 7 billion liters/person |
| Minus the 80% of this 7 billion that is frozen at the poles (5.6 billion) | = 1.4 billion liters/person |
| Minus the 99.5% of the 1.4 billion that is unavailable (too far underground, polluted, trapped in soil, etc.) (1.395 billion) | = 7 million liters/person |

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**A Drop in the Bucket**

*Project WET Curriculum and Activity Guide*
So, why does more than one-third of the world's population not have access to clean water? Discuss with the class the main factors affecting water distribution on Earth (e.g., land forms, vegetation, proximity to large bodies of water). Other environmental influences affect availability of water (drought, contamination, flooding). Students can also consider that other organisms use water, not just humans.

**Assessment**

Have students:
- determine the proportion of Earth's available fresh water (Warm Up and Wrap Up).
- calculate the volume of water available for human use (step 5).

Upon completing the activity, for further assessment have students:
- develop a television commercial outlining reasons why water is a limited resource.

**Extensions**

Students can calculate how much water they might use in a lifetime. Provide them with the following instructions: Keep track of how much water they use in one day. (The average person in the United States uses about 50 gallons [190 l] per day.) Multiply daily use by 365 days and then by 70 years (estimated lifespan). How does this compare to the 1.82 million gallons (7 million liters) available to them? (This applies to direct water use only.)

Students can identify areas of the globe where water is limited, plentiful, or in excess and discuss the geographical and climatic qualities contributing to these conditions. For example, large variations in precipitation occur within states. (Death Valley receives as little as 2 to 5 inches [5 to 12.5 cm] per year; only 100 miles [160 km] away, mountain ranges receive more than 30 inches [76 cm] per year.) These variations dramatically impact plants, people, and other animals.

**K-2 Option**

Conduct the first four steps of the activity. (If beakers are not available, use approximate volumes with one gallon [4 liters] of water representing all water on Earth. Of this, 1 fluid ounce [30 milliliters] is fresh water, and all but one small drop of the fresh water is frozen at the poles.) To help students appreciate these proportions, have them participate in the following activity. Construct, or have students make, spinners. (Make the disk, pointer, and washers out of sturdy cardboard.) Give each child a copy of the Water Chart. Children spin the pointer and color a box of the chart in the appropriate row to indicate where the pointer landed. Which row of the chart do students think will fill up first?

**Resources**


# Water Availability Table

<table>
<thead>
<tr>
<th>Quantity to be divided among people on Earth</th>
<th>Amount Available liters/person</th>
<th>% of total water</th>
</tr>
</thead>
<tbody>
<tr>
<td>All the water on Earth</td>
<td>233.3 billion</td>
<td>100%</td>
</tr>
<tr>
<td>Only the fresh water</td>
<td></td>
<td>3%</td>
</tr>
<tr>
<td>(calculate 3% of the amount available)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only the non-frozen fresh water</td>
<td></td>
<td>0.6%</td>
</tr>
<tr>
<td>(calculate 20% of the remaining amount available)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available fresh water that is not polluted, trapped in soil, too far below ground, etc.</td>
<td></td>
<td>.003%</td>
</tr>
<tr>
<td>(calculate 0.5% of the remaining amount available)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Water Chart

![Water Chart](image)

**K-2 Option**
What if Water Cost as Much as Gasoline?
activity sheet

Sale on water! Only ______ per gallon!

A) Multiply the number of gallons of water listed after each use below by the price per gallon. Put this answer in the space provided. An example has been done for you using the price of $1.00 per gallon of water.

example: Bath 30 gallons x $1.00 = $30.00 per bath

B) Each time you use water:

1. Put a mark (x) after the type of water use. Keep a tally of each use.

2. The price listed under "cost" will tell you how much to pay for that water use. Now put that amount of money in your envelope.

<table>
<thead>
<tr>
<th>Use</th>
<th>Price Per Gallon</th>
<th>Cost Per Use</th>
<th>Check here each time you use water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing dishes by hand</td>
<td>10 gallons</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>Automatic dishwasher</td>
<td>11 gallons</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>Flushing toilet</td>
<td>4 gallons</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>Cooking &amp; drinking</td>
<td>3 gal/day</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>Washing hands</td>
<td>1 gallon</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>Brushing teeth</td>
<td>2 gallons</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>(water running)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shower</td>
<td>18 gallons</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>Bath</td>
<td>30 gallons</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
<tr>
<td>Washing clothes</td>
<td>30 gallons</td>
<td>X___________</td>
<td>$_________ each use</td>
</tr>
</tbody>
</table>
Rings Around The Sun

Activities:

Measuring the Number of Calories In Sunlight

Solar Energy Experiment

Hot Sources (Solar Heating)

Radiometer Experiment (How Does Solar Heat Reach the Earth)

Shoebox Solar Cooker
Measuring the Number Of Calories In Sunlight

Objectives

The student will do the following
1. Define calorie.
2. Determine the amount of heat available from the sun in his/her area.
3. Compare the absorption of solar energy by three different collectors
4. Define the solar constant
5. Offer several explanations for discrepancies between the data collected and the solar constant.

Background Information

Unimaginably vast amounts of solar energy reach the earth each day. Some is reflected or refracted back into space, some is absorbed by the earth’s atmosphere, and some reaches the surface of the earth. Although the amount reaching the earth’s surface is huge, not all of it is useful to human beings. The energy is diffuse and must be captured and concentrated before we can use it for most of the purposes for which we require energy. Secondly, energy conversion (from one form to another) cannot be carried out at 100 percent efficiencies.

Solar scientists have determined that the amount of solar energy reaching the earth’s atmosphere is 1.94 calories per square centimeter per minute. This value is known as the solar constant. Obviously solar collectors will not receive this amount of energy because of the atmosphere’s absorption and reflection of some of the energy. Other factors also affect the collection of solar energy: latitude, altitude, weather conditions, seasons of the year, orientation of the collector, and other factors all come into play.

Procedure

I. Review with the class the definitions of the terms calorie, centimeter, and milliliter. Introduce the solar constant to the students. The solar constant is a computed average for the amount of heat energy reaching the earth’s atmosphere in a unit of time. It is defined as being 1.94 calories per square centimeter per minute (1.94 cal/cm²/min).

II. Divide the students into groups of three. Give each group the listed materials and review the steps in the instructions for the experiment (see the student sheet, included).

III. Have the students complete the experiment, filling out the data table on the student sheet as they go.

IV. Continue with the follow-up below.

Follow-Up

I. How did the solar heat absorptions determined in this experiment compare to the solar constant? (You may want to have the groups average their three trials for each test tube and record the figures on the chalkboard or a chart.)
II. What are some possible explanations for why the collected data differs from the solar constant? Can your students formulate hypotheses and design experiments to test some of these explanations?

The solar constant is a value that does not apply directly to solar collectors located on the earth’s surface. It does not take into consideration the absorption of energy by the atmosphere. Because of this absorption, it is not possible to actually receive 1.94 cal/cm²/min in a collector on the earth’s surface. It may be possible, on the other hand, to attain values greater than this in the experiment. Errors in calculations, rounding of figures, errors in measurement, and other faults in carrying out the procedure, as well as faults in the procedure itself, all may affect the experiments outcome.

III. How do the three test tubes differ in their abilities to trap heat from sunlight? (Look again at the averages of the trials.)

IV. Have the students determine, using their figures, the amount of heat absorbed by a typical black and glass solar collector with dimensions of 2 x 1.5 m.

The area of the collector is 3m². This is 30,000 cm². Determine which test tube most closely approximates a solar collector and use the calorie absorption average for that test tube. Multiply the figure by 30,000. (Remember that this figure represents energy absorption for one minute What about for an hour? a day?)

V. How does the time of day affect the availability of solar heat?

At noon, the sun’s rays are most nearly perpendicular to our area on the earth. This means that they must pass through less atmosphere than at any other time of the day. The less atmosphere the rays pass through, the more energy is available. In the morning and afternoon, however, the rays strike the earth’s surface more obliquely and must pass through more atmosphere than at noon. Less energy is available.

VI. Why doesn’t the earth itself overheat?

Some of the heat absorbed by the earth’s atmosphere and surface is radiated into space during the night. Earth’s 24-hour rotation period helps maintain a temperature suitable for the great variety of life forms on this planet.

**Measuring The Calories In Sunlight**

**Instructions**

1. Prepare the test tubes. Use black tape, a grease pencil, or another provided material to cover the entire bottom portion of one test tube and one half of the bottom of a second test tube. (See the illustration below) Leave the third test tube clear.
2. Determine the area of the hand lens (magnifying glass). Measure the diameter of the lens. Find the radius by dividing the measurement in half. Record the radius across the data table. Compute the area of the lens using the formula \( A = \pi r^2 \), where \( A \) is the area, \( \pi = 3.14 \), and \( r^2 \) is the square of the radius. Record the area across the data table.
3. Choose one of the test tubes. Using the graduated cylinder, measure 10 ml of distilled water and pour it into the test tube. Measure and record the temperature of the water. Place the test tube in the test tube rack and hold the hand lens to focus the sun’s rays directly into the water. (See the illustration.) Do this for five minutes. Measure and record the final temperature of the water. Compute and record the change in temperature. Repeat this procedure twice more (for a total of three trials).
4. Repeat the entire procedure in III for each of the other two test tubes.
5. Compute the calories of heat energy from sunlight absorbed by the water in each trial. Multiply the mass of the water by the number of degrees the temperature changed (Remember that one milliliter of water has a mass of one gram) Record these figures in the data table.
6. Compute the number of calories of energy received per square centimeter (of lens surface) per minute in each trial. Record these figures in the data table.
7. Compute the percent efficiency of your collection of solar energy as compared to the solar constant. Divide
each of your figures by 1.94 cal/cm²/min and multiply by 100 to get a percentage. Record these figures in the data table.

**DATA TABLE**

<table>
<thead>
<tr>
<th>Data Category</th>
<th>CLEAR TRIAL#</th>
<th>CLEAR TRIAL#</th>
<th>CLEAR TRIAL#</th>
<th>HALF-BLACK TRIAL#</th>
<th>HALF-BLACK TRIAL#</th>
<th>HALF-BLACK TRIAL#</th>
<th>BLACK TRIAL#</th>
<th>BLACK TRIAL#</th>
<th>BLACK TRIAL#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius of lens (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area of lens (cm², compute A = πr²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water (ml)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial temperature (°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Final temperature (°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in temperature (°C; computed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Time (minutes)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calories absorbed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Calories/cm²/minute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar constant (cal/cm²/min)</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
</tr>
<tr>
<td>Percent efficiency compared to solar constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PURPOSE: The purpose of the following experiment is to demonstrate that energy from the sun can be collected and stored in many ways.

RESOURCES/MATERIALS: one plastic bottle painted white, one plastic bottle painted black, several small balloons

ACTIVITIES AND PROCEDURES: General information -

Our sun is an average sized star and it has been burning for about 4.5 billion years. Few people think of the sun as a nuclear furnace and fewer realize this is a source of nuclear energy that does not pollute. About four million tons of the sun's matter turns into energy every second and only one-billionth of the sun's light ever strikes the Earth.

At the equator the Earth receives about one kilowatt per square meter of solar energy. A kilowatt is 1000 watts of or the amount of energy needed to light 10 one-hundred watt bulbs. If man could make full use of solar energy, almost every house in the world could be energy independent. Only a few households would have to be dependent on the electric company and this would reduce the pollution problem greatly. The consumption of gas, oil, or coal would be reduced and this would also help reduce the level of pollution. The automobile could be powered by the sunlight during the day and use battery power at night. This would also reduce pollution and help prevent global warming.

Turning solar energy directly into electricity today is not very efficient; however, solar energy can be best collected as heat. The following experiment will teach young people how to collect and store the sun's energy in the form of heat.

The teacher will notice the experiment demonstrates a method to collect and store solar energy and has been designed for grade one through six. It is possible for young students to expand the concepts of these experiments into local science fair projects.
The Black and White Bottle Experiment

The experiment is performed with the two plastic bottles. The teacher will note one bottle is painted black and the other is painted white. Place the open end of one small balloon on the mouth of the white bottle and do the same for the black bottle. Make sure the balloon forms an air tight seal. Now place both bottles in bright sunlight. Within a few minutes, the students will notice the balloon on the black bottle will start to expand. The balloon of the white bottle will remain limp. Have a student touch the black bottle to notice that it is warm. Then have the same student touch the white bottle to notice that it is much cooler than the black bottle.

Questions -
1. Why do you think the balloon on the black bottle expanded?
2. Does heat make air expand?
3. Does a black object get warmer in the sunlight than a white object?
4. What would be a good color to paint your car if you wanted to stay cool in the summer?

Explanation -
The black bottle will absorb the sun's energy much better. The white bottle reflects away most of the sun's energy. As the bottle absorbs energy, the air inside the bottle warms up and expands making the balloon full with air.
Hot Sources

Solar Heating

Demonstration

Overview

This simulation demonstrates the transfer of heat through a vacuum.

Materials

Per class:

- bottle (pint size, clear and flat)
- 1-hole stopper (fits bottle)
- thermometer
- bell jar
- vacuum pump
- electric heater
- water

Procedure

This demonstration requires a little time to set up but very little time to execute. Fill the bottle with water and stopper it. Insert the thermometer and measure the initial temperature of the water. This can all be done before the class begins. With students present, place the bottle (filled with water and stoppered) inside a bell jar on the vacuum stand. Make sure there is a good seal. Using the pump evacuate the bell jar. On the outside of the bell jar, place an electric heater so that it faces the jar. Turn it on and have students note the changes in temperature.

Background

The focus here is to demonstrate that heat can be transferred through a vacuum. After the heater has been turned on, an increase in temperature should be noted. This demonstration attempts to simulate what is occurring when the sun produces solar energy and moves through space (a vacuum) to Earth. This is an example of the radiation of heat.

Variations

A light bulb is composed of a glass bulb that has been at least partially evacuated. A hand held close to this bulb will begin to warm.
Radiometer Experiment

How does solar heat reach the Earth?

Overview

A common radiometer is used to demonstrate radiation.

Materials

Per class:

- radiometer
- light source (overhead projector turned on its side, sunlight, lamp)
- black cloth (12-in square)

Procedure

Have students place the radiometer in a bright light and observe what happens under different conditions of light. Ask them to explain in terms of heat, particles (or molecules), and pressure what they observe.

Background

The vanes of a radiometer have a shiny mirrored side and a black side. The glass chamber that surrounds these vanes has been evacuated so that there are very few molecules remaining and very little pressure inside the chamber. This low pressure allows for a greater difference between energy transferred between the shiny side and the darker side of the vane. The effect of an increase in energy of the gas molecules compared to the number of molecules present is enhanced.

As the radiometer is exposed to bright light, gas particles on the black side of the vane gain energy upon collision with the vane. Thus they are made hotter. Since the gas particles bounce off at a greater velocity than before, this change in momentum imparts a reaction force to the vane, causing it to move away. The pressure, therefore, increases on the black side. The vanes begin to rotate with the black sides moving away from the bright light source. Note that this is opposite to the directions one would expect if it were radiation pressure. Radiation bouncing off the shiny side would impart twice the force to the shiny side than to the black side that absorbs radiation.

Variations
Students could vary the experiment by moving the light source to see what effect this varying distance and position has on the outcome.
**Summary:**
Students build and use a simple solar cooker and experiment using the sun to heat food.

**Grade Level:** (K-2) 3

**Subject Areas:** Family Living and Consumer Education, Science, Social Studies, Technology Education

**Setting:** Outdoors on a sunny day and classroom

**Time:** Preparation: one week
Activity: three 50-minute periods

**Vocabulary:** Greenhouse effect, Insulation, Solar cooker, Solar oven

**Major Concept Areas:**
- Natural laws that govern energy
- Development of energy resources
- Management of energy resource use

**Materials:**
- Each group of students will need a copy of the following student pages:
  - Building a Shoebox Cooker (Materials and Procedure) and materials listed on this student page
  - Using a Shoebox Cooker
  - Solar Cooking Record (optional)
- Photographs of commercial solar ovens (optional)

---

**Objectives**

Students will be able to
- construct an effective solar oven;
- explain how a solar oven works; and
- discuss the benefits and challenges of using a solar oven.

**Rationale**

Operating a solar oven helps students learn about solar energy and heat-related principles and appreciate the importance of energy-related technologies.

**Background**

Did you ever hear the expression, “It’s hot enough to fry an egg on the sidewalk?” Sidewalks don’t really get quite hot enough to cook on, but you could build a solar box cooker, place it on a sidewalk, and allow it to collect the sun’s heat energy and cook many different kinds of food. Commercial solar cookers are also available (see Resources). To work properly, a solar box cooker (also called a solar oven) must hold heat energy long enough for the food to absorb the heat and cook.

Making a solar oven can be both simple and difficult. Collecting energy from the sun is easy. When sunlight strikes a surface and is absorbed, it gets converted to heat energy (or infrared radiation). A glass or Plexiglas cover works like a greenhouse window to let sunlight in but not let the infrared radiation out. Solar cookers usually include some kind of reflector that increases the amount of energy the cooker receives by reflecting light inside the box onto the cooking container.

Keeping the heat energy in the oven is more difficult. Solar box cookers must be carefully insulated and tightly sealed so the captured heat cannot escape.

The key to a successful solar oven is making sure it faces the sun. To keep the solar cooker hot all day, it must be continually turned to follow the path of the sun. For a gradual heating process, place food in an oven and direct it toward the sun’s midday position. The food cooks slowly, reaching its peak heat by mid-afternoon. The food is ready to eat by early evening.

Solar box cookers reach between 140 degrees F (60 °C) and 266 degrees F (130 °C) depending on their construction and intensity of the sunlight. Clear, sunny days provide the best results. However, as long as the cooker faces the sun and is well-insulated, the temperature outside the cooker should have little effect on the cooking rate. So solar cookers can be used in December as well as in July.
The choice of ovenware can affect the cooking time in a solar cooker. Ovenware can be made from glass, ceramic, earthenware, or metal. Each material conducts and retains heat differently. Often dark-colored ovenware is best for solar cookers because it absorbs light energy better than light-colored materials.

What can be cooked in a solar oven depends on the quality of the cooker. A conventional recipe suitable for a slow cooker works well, because the solar cooker will get hotter than a slow cooker. Baking should be done on clear, sunny days as it requires higher temperatures. Cutting the ingredients into small pieces will help the food cook faster. The foods, especially liquids and moist meals such as stews, need to be sealed in the solar box cooker so water does not condense on the glass cover.

Simple solar cookers, such as those made from a shoebox, should be able to do the following:
- Heat water for hot chocolate, tea, or instant soup
- Warm canned soups, vegetables, and stews
- Prepare hot dogs
- Melt cheese, chocolate, or marshmallows
- Make simple pizzas (cheese and tomato sauce sprinkled on prepared crust)
- Bake chocolate chip cookies

Better built solar cookers can cook regular meals. With a well-constructed or commercial oven you can prepare foods, such as vegetables and grains, that need to be cooked more thoroughly. For example, summer squash, fresh peas, green beans, spaghetti, noodles, instant potatoes and rice cook relatively quickly. White rice, rolled oats, pearl barley, and squash should cook in two hours. Lentils, black-eyed peas, black beans, and potatoes will need about three hours.

Frying eggs may not be the best use for a solar oven, but you can cook eggs in breads, casseroles, and cakes. Whether you decide to make a warm drink on a cold day in December or a complete meal, solar box cooking is fun and delicious.

### Procedure

#### Orientation
Ask if any students have ever been in a car that has been parked in the sun. Have a student describe what it feels like inside the car. Students may have also heard warnings about not leaving pets and children in parked cars because of the risk of heat exhaustion or stroke.

Discuss how sunlight passes through the glass windshield and windows in a car. When the light strikes the interior surfaces of the car, it is absorbed and converted to heat energy. The heat can not escape through the glass and causes the interior temperature of the car to increase.

#### Steps
1. Ask students if they think heat from the sun can be used to melt things such as chocolate or cheese. Tell students that by applying what they know about heat collecting in a parked car, they can design an oven that uses the sun's energy to cook food.

### Getting Ready:
Use an unshaded outdoor setting where the solar ovens can remain undisturbed for at least an hour. You may want to provide students with the materials list the week before the activity is scheduled and have them bring the items from home. An alternative is to build one solar oven and have groups use a single oven to conduct experiments. If possible, invite aides or parents to help with the construction. Have students decide what food they'd like to cook and create a shopping list. You may request that students bring in these ingredients as well. See Steps 2 and 3 for variations for younger students.

### Resources:
#### For Teachers
Burns Milwaukee, Inc., 4010 West Douglas Avenue, Milwaukee, WI 53209.
Phone: (414) 438-1234.
Vendor for solar ovens.

Solar Cookers International, 1724 11th Street, Sacramento, CA 95814.
Phone: (916) 444-6616.

Sun Light Works, P.O. Box 3386, Sedona, AZ 86334.
Phone: (602) 282-1344.

(Continued on next page)
Complementary Activities


For Students


2. Divide the class into working groups. Hand out and discuss **Building a Shoebox Cooker**, Materials and Procedure for Variation #1, #2, or #3. NOTE: Variation #1 involves cutting and placing foam trays in the box for insulation. Younger students may have a difficult time handling the pieces of foam and will get frustrated when they try to line the shifting trays with foil. Shifting can be minimized by cutting the trays to fit tightly against each other. Small hands may find Variation #2, the two-shoebox method, easier. Variation #3 is the easiest but may not be as effective.

3. Provide students with copies of *Using a Shoebox Cooker* and have them prepare the food they want to cook. Have students test and use their cookers. The **Solar Cooking Record** can be used to document observations, and this data can also be used to make graphs. NOTE: For younger students, it may be enough to observe that the sun heats food and to note temperature changes.

**Closure**
Have students share the results of their cooking experiments. Do they think they would regularly use solar ovens? Remind students that the ovens they constructed are simple, and that there are more technical and efficient models available. Inform students that there are companies that sell commercial solar cookers that are very effective at heating food. If available, show pictures or overhead transparencies of some of these cookers. Students can compare qualities of these cookers to their own.

Discuss ways students can test or improve the cookers. Questions to explore include:
- How well does the cooker work on cloudy days?
- What effect does outside temperature have on the cooking rate?
- Is there any difference when the cooker is used in December than when it is used in June?
- Would a bigger box, more reflectors, or different types of insulation improve the effectiveness of the cooker?
Assessment

Formative
- How well did students construct the ovens?
- Can students explain how a solar oven works?
- How effectively do the solar ovens heat food?

Summative
- Have students plan a party for another class or their parents in which food is cooked in the solar ovens. The event can begin with students explaining how they made the solar ovens and how they work. During the presentation, students can discuss the potential and practicality of solar oven use in their own future.
- Students can research the many different designs for solar cookers and experiment with different properties and adaptations. For example, try placing a thicker piece of metal, such as a piece of a cookie sheet or baking pan, in the bottom of the solar oven to increase heat transfer and storage.

Related KEEP Activities:

Use this activity as part of a unit on solar energy or heat. See K-5 Energy Sparks for Theme II: Sunvestigations or K-5 Energy Sparks for Theme I: Exploring Heat. A solar cooker can also be used to enrich investigations in “Taking Temperatures.” Older students can apply concepts from solar cooking to activities such as “So You Want to Heat Your Home?” and “Siting for Solar and Wind Energy.” Other uses of solar energy such as those found in “The Miracle of Solar Cells” could be done with younger students.

Credits:
Activity adapted from “Now You’re Cooking—With the Sun” pp. 68-81 in Florida Middle School Energy Education Project: Energy Bridges to Science, Technology and Society. Tallahassee, Fla.: State of Florida for the Florida Energy Office, 1994. Used with permission. All rights reserved.

Activity adapted from Hawai’i Extension Service. Making Shoe Box Cookers

Related KEEP Activities:

Use this activity as part of a unit on solar energy or heat. See K-5 Energy Sparks for Theme II: Sunvestigations or K-5 Energy Sparks for Theme I: Exploring Heat. A solar cooker can also be used to enrich investigations in “Taking Temperatures.” Older students can apply concepts from solar cooking to activities such as “So You Want to Heat Your Home?” and “Siting for Solar and Wind Energy.” Other uses of solar energy such as those found in “The Miracle of Solar Cells” could be done with younger students.

Extensions

Students may be interested in exploring how solar cookers are currently being used worldwide, especially in places where electricity is unavailable and traditional fuel sources, such as wood, are being depleted (see Resources).

Purchase a commercial solar oven or invite a guest speaker (such as a vendor) who regularly uses a solar oven to show and discuss more sophisticated models and methods of solar cooking (see Resources). Students can also see solar ovens in use at the Midwest Renewable Energy Fair (see Appendix).
Building a Shoebox Cooker

Materials for Variation 1 and 2

- Shoeboxes with lids (one per student or one per group) Variation 2: two boxes per student or team, one being roughly one inch (2.5 cm) larger than the other in all dimensions
- Foam produce trays, well washed (approximately four per shoebox) Variation 2: insulating material such as Styrofoam packing material, crumpled newspaper, cardboard, etc.
- Overhead transparencies (one per shoebox)
- White glue (optional)
- Duct tape (Masking tape is an alternative, but it won't last as long.)
- Heavy-duty aluminum foil (approximately two feet (60 cm) per shoebox)
- Chopsticks or twigs (one stick per shoebox)
- Rulers
- Pencils
- Single-hole punch
- Scissors, knife, or razor cutters
- Oven thermometers (one per group)
- Small food containers made of heat-conducting material such as glass or metal (Make sure food containers will fit inside the cookers! Examples include baby food jars, pot pie pans, petri dishes and Pyrex custard cups, or containers made from aluminum foil.)
- Food that is easy to heat (Try melting cheese on chips, chocolate on graham crackers, etc.)
- Plastic wrap
- Pot holders
- Sunglasses
- Decorating materials and paint (optional)
  NOTE: High-temperature spray paint works best as it won't crack when heated.

NOTE: For a larger solar cooker, use bankers' boxes instead of shoeboxes and acrylic plastic sheets instead of overhead transparencies. Using bankers' boxes will work best with Variation 2 (see Procedure).

You may decorate or paint your solar ovens. Take care not to paint the overhead transparency or the reflector flap. Painting the exterior of the box is a matter of aesthetics; it doesn't affect the box's ability to absorb heat. Experts vary in their opinions of whether the interior of solar ovens should be reflective (to direct more sunlight onto the cooking food) or black (to absorb more heat to help cook the food). If you paint the foil-covered interior, use high-temperature black paint. CAUTION: Painting the interior can expose the food to volatile gases. Set the oven outside in the open with the lid open for a day to allow the gases to escape. An alternative is to line the interior with black construction paper. You may want to conduct an experiment where half the class has a black interior and the other half has foil to discover which method is more effective.
Procedure: Variation 1

1. Remove and save the lid from the shoebox. Line the inside of the shoebox with foam produce trays. The trays should be placed so that their raised edges are touching the shoebox floor and walls, forming an insulating air space. You may be able to fit trays in the shoebox with minimal cutting. If you have lots of trays, make two layers. If necessary, use white glue to hold the trays in place.

2. Line the interior of the insulated shoebox with aluminum foil, bringing the edges of the foil up and over the rim of the box. Use only one piece of foil (if possible) to help seal the interior of the cooker. If more than one piece of foil is necessary, overlap the edges to reduce heat loss. It may be easier to use two pieces of foil, one sized to the length of the box and one sized to the width. The two pieces of foil can then be laid in the box across each other (crisscrossed).

3. Using duct tape, tape the loose edges of the foil to the outside of the shoebox. This step completes the body of the cooker.

4. Using a ruler and pencil, draw a rectangle on the inside of the shoebox lid 3/4-inch (1.88 cm) from the edges of the lid. Mark one of the long sides "fold."
5. Using the scissors, knife, or razor cutter, cut carefully along the other three sides of the marked rectangle, so that the shoebox lid has a flap in it. Fold the flap up along the last edge of the rectangle. This flap will be your cooker's reflector.

6. Carefully smooth a piece of foil over the underside of the flap. The smoother, the better! Secure the foil with glue or tape; if tape is used, fold the foil onto the top of the flap and tape it on that side, so as not to cover the shiny bottom of the flap with any tape.

7. Cut a piece of overhead transparency to fit inside the shoebox lid. If at all possible, use a single piece to reduce heat loss. If you have to fit two pieces together, overlap them by at least one inch (2.5 cm).

8. Tape the overhead transparency to the inside of the shoebox lid, completely covering the cut opening. Make sure that the tape is securely fastened to the 3/4-inch (1.88 cm) border around the opening. The overhead transparency lets sunlight into the cooker.

9. Securely place the lid onto the shoebox. Raise the reflector flap. Near one of the top corners, punch a hole in the lid with the single-hole punch. Insert the narrow end of a chopstick in this hole, so that the thick end is resting on the shoebox lid, but not on the overhead transparency. You may need to make a “nest” for the thick end of the chopstick with a bit of tape. The chopstick is your reflector support.

10. Your shoebox cooker is complete!
**Procedure: Variation 2**

1. Remove the lid from the smaller of the two shoeboxes. Line the smaller shoebox neatly with aluminum foil.

2. Remove and save the lid from the large shoebox. Insulate the bottom of the large shoebox by putting in a layer of insulating material. Pieces of foam trays, crumpled paper, corrugated cardboard, sand, or soil can be used. (You may want to set up an experiment: Which type of insulation works best?) Make the layer no deeper than the difference in height between the two boxes, so that when the small box is set on the insulation inside the big box, the boxes’ rims are even.

3. With the small box inside the large box, carefully fill in the air spaces between their four walls with more insulation. The insulation should come up to the rims of the boxes.

4. Cover the top of the insulation with a strip of aluminum foil, securing it on the outside of the large box and inside of the small box with tape. The aluminum foil will keep the insulating material isolated from the cooking chamber within the small box. Try to minimize the amount of tape used on the inside of the small box, to avoid covering large areas of the reflective foil.

5. Using a ruler and pencil, draw a rectangle on the inside of the shoebox lid 3/4 inch (1.88 cm) from the edges of the lid. Mark one of the long sides “fold.”

6. Using the scissors, knife, or razor cutter, cut carefully along the other three sides of the marked rectangle, so that the shoebox lid has a flap in it. Fold the flap up along the last edge of the rectangle. This flap will be your cooker’s reflector.
Procedure: Variation 2 (Continued)

7. Carefully smooth a piece of foil over the underside of the flap. The smoother, the better! Secure the foil with glue or tape. If tape is used, fold the foil onto the top of the flap and tape it on that side, so as not to cover the shiny bottom of the flap with any tape.

8. Cut a piece of overhead transparency to fit inside the shoebox lid. If at all possible, use a single piece to reduce heat loss. If you have to fit two pieces together, overlap them by at least one inch (2.5 cm).

9. Tape the transparency to the inside of the shoebox lid, completely covering the cut opening. Make sure that the tape is securely fastened to the 3/4-inch border around the opening. The overhead transparency lets sunlight into the cooker.

10. Securely place the lid onto the shoebox. Raise the reflector flap. Near one of the top corners, punch a hole in the lid with the single-hole punch. Insert the narrow end of a chopstick in this hole, so that the thick end is resting on the shoebox lid, but not on the overhead transparency. You may need to make a “nest” for the thick end of the chopstick with a bit of tape. The chopstick is your reflector support.

11. Your shoebox cooker is complete!

NOTE: Use larger boxes, such as bankers’ boxes, to make a bigger solar cooker. Follow Steps 1-4 of the procedure. Use the lid of the larger box as the reflector (see Step 7 and 10). You may want to tape one long end of the lid to the box. It may also help to cut the corners so the lid lifts up and down like a door. Use an acrylic plastic sheet instead of overhead transparencies, cutting it so that it rests on the insulation layer. Make handles to put in and remove the glass by using rolls of tape or by drilling holes into the acrylic sheet and inserting knobs. You will need sticks that are at least two feet long to support the reflective lid.

Variation 3

Materials:
• Shoebox
• Aluminum foil
• Tape
• Clear plastic wrap
• Food that is easy to heat (Try melting cheese on chips, chocolate on graham crackers, etc.)
• Pot holders
• Sunglasses

Procedure:
1. Line the shoebox with aluminum foil and tape in place if necessary.
2. Place food on aluminum foil.
3. Cover shoebox with plastic wrap and tape in place.
4. Set box in the sun.
CAUTION: The solar oven can get very hot, so use pot holders. Do not stare at the sun or the sun’s reflection in the aluminum; it can damage your eyes. Sunglasses are recommended.

1. Make sure that your food container will fit inside the cooker. Prepare the food you want to cook. For example, sprinkle cheese on nacho chips, make a simple cookie recipe, place pieces of chocolate and marshmallows on graham crackers, etc.

2. Locate a sunny area for the cookers. Watch out for trees, buildings, and other structures that may cast shadows on your cookers. Your cookers will be outside at least an hour, and they must not be shaded. Remember that as the Earth rotates, shadows move and change lengths throughout the day.

3. Put a thermometer in each cooker (or in selected cookers if you don’t have enough thermometers). Make sure that the lids are set securely on each cooker and that the reflective flaps are raised. Aim the cookers toward the sun. You can tell when the cookers are aimed correctly by adjusting their orientation until the cookers’ shadows are as small as possible.

4. Adjust the reflective flap by moving it up and down and observing the reflected light within the cooking chamber. At the point when the interior is brightest, insert the chopstick support into the hole on the flap, to secure the flap at that angle. NOTE: Because Earth rotates, the cookers’ orientation and reflective flap angle may need to be adjusted during the cooking period.

5. Preheat your cooker by letting it sit in the sun. On a sunny day, shoebox cookers can easily reach 200 degrees F (93 °C) in 30 or 40 minutes. Check the thermometers periodically.

6. When the cookers are hot enough (at least 150 degrees F [66 °C]), place your foods in the cooking containers, cover the containers with plastic wrap (optional) and as quickly as possible put the containers in the cookers. The less time the lids are off, the less heat you’ll lose. It may help to have one student lift a lid while the other quickly puts the food in.

7. Let it cook! You may wish to keep recording temperatures and weather observations at set intervals.
Solar Cooking Record

Name(s): ________________________________

Date: ________________________________

What is the weather like today?
   Temperature: _____ Cloud cover: ____________ Wind speed: ____________
   Other:

Draw or describe where you are placing your solar cooker and why you think this is a good location.

What are you cooking?

Shake down the thermometer to its lowest reading and note this below (the lowest reading of many oven thermometers is 100 degrees F). Put the thermometer in the box, marking the time next to the first temperature reading. Record the temperature every 15 minutes (continue recording on back if you need more space). Put a box around the time when the food was placed in your cooker. Describe any changes you see in the food.

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature</th>
<th>Changes in food after placed in solar cooker</th>
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What does your food look like after cooking for at least one hour? Describe if you think it cooked thoroughly or not.

What does it taste like? Does it taste like it's cooked thoroughly?
Weather ... or not

Activities:

The Effects of Weather Patterns on Food Crops

Weather Experiments:
Sugar Cubes, Steel Wool and Gravel

Climate and CO2: Analyzing Their Relationship

Weather and Agriculture
The Effects of Weather Patterns on Food Crops

Subject/Content Area
Earth Science/Biology/Chemistry/Environmental Science/Math/Food Service/Computer Technology

Activity Structure(s)
Information Searches, Peer Feedback Activities, Social Action Projects, Information Exchanges, Pooled Data Analysis

Goals/Outcome Statements
AT&T ENRICH: IIIB-F
SG,CAS,CFS: 11A2,3; 11B4,5,7-9,12,13; 12B6; 13A1
Upon completion of this activity, students will be able to:
- use the computer to obtain global weather information, both current and historical;
- use weather maps, charts, and graphs to organize and interpret climatological data obtained from the Internet;
- predict climatological conditions in assigned locations;
- describe the usual crops grown in those assigned locations;
- suggest modifications in crop selection to maximize the availability of food in those assigned locations, given the predicted short-term climatic changes, such as El Niño, La Niña, etc.; and
- prepare a variety of foods native to those assigned locations.

Tools and Resources
Lab notebooks
Graph paper
Library access with geography resources (i.e., world atlas, world and US maps, weather maps)
Video about weather patterns
Teacher Information Sheet: The Effects of Weather Patterns on Food Crops Sample Lesson Plan
DESCA Scale for Rating a Class
DESCA Questionnaire
Scoring Rubric: The Effects of Weather Patterns on Food Crops
Computers with Internet access
Websites about global weather patterns:
http://www.wsu.edu/DrUniverse/
http://www.pmel.noaa.gov/toga-tao/el-nino/nino-home.html
http://www.elnino.noaa.gov/
http://www.ncdc.noaa.gov/ol/climate/severeweather/extremes.html
http://freespace.virgin.net/mike-ryding/global.htm

Websites with recipes for food fair:
http://www.cbyc.com/
http://www.globalgourmet.com/
http://recipes.alasra.com/
http://www.globalgourmet.com/

**Detailed Description of Project**

This project lends itself to an interdisciplinary collaboration among the science teacher, the food services teacher, the math teacher, and the language arts teacher. If this collaboration is not feasible, this project is still appropriate for the biology classroom as a part of the ecology unit. The students will analyze the effects that weather patterns in different parts of the world have produced on food crops. The students' analyses should include ecological, political, social, and economic effects of global weather patterns. This project challenges students to determine why predictions are necessary to prevent famine. The project takes approximately two weeks to complete.

**Week 1:**

Review map-reading skills. (The attached lesson plan is a suggested approach to this review.) Show a video about weather patterns. (Select a current video from the local library.) Review details of weather prediction. Explain the project and divide the students into groups of four. Explain that each student is expected to keep a journal in the lab notebook and, for every day of participation in this project, each student should also write an outcome sentence completing one of the following statements: I learned..., I discovered..., I remembered..., etc. In addition, each group is expected to:

- email experts and use the Internet to gather information;
- prepare a report on the effects of global weather on food crops (This can be supervised by the language arts teacher.);
- collect current local weather information;
- tabulate and graph the current weather information (This could be supervised by the math teacher.); and
- construct a weather prediction/climate indicator chart for our local conditions that could be used by the farmers in Illinois regarding their crops.
Assign world and US locations for each group to investigate. Select these locations, including areas where famine has occurred in the past and where it is threatened, based on current weather conditions.

Students should be expected to investigate the foods usually prepared in their assigned location, and find some other foods using alternative crops that might appeal to the natives. Students are also expected to prepare predictions about the likelihood of famine in their assigned location, and suggest alternative crops to prevent this.

**Week 2:**

Allow additional preparation time, then have students present their findings to the class. Designate a date for the International Food Taste Exhibit. For this exhibit, students prepare foods from their assigned locations and bring them to school for everyone to sample. (This could be supervised by the food services teacher.)

**Assessment of Students**

At the end of the activity, collect the students' papers and assess the students' work using the rubric attached. Assess the quality of the lesson using the DESCA questionnaire. When the project is completed, have the students turn in their daily journals and a summary outcome statement. (It is not necessary to assign point values for this part of the activity, but it will help the students to process the information.) Consider awarding extra credit points to those students who actually prepare food for the International Food Taste Exhibit.

**Credits**

**Author(s):**
Minnie Robinson

**Editor(s):**
Brian Agustin
Christine Fedorenko
Minnie Robinson
Alice B. Schmeelk
Christopher Stiglic
The Effects of Weather Patterns on Food Crops
Teacher Information Sheet

Day 1:
Cushioning: Whole Class; one to three minutes
Ask students to talk about their favorite foods. Use the KWL strategy to discuss what they already know about how we get our food for survival and relate this to other countries and states.

Attentive lecture/discussion; five to 10 minutes
Present and discuss the following topics:
  • food supply emergency this year;
  • how El Niño spreads food crises to 37 countries;
  • decline of cereal production in developing countries;
  • crisis of food supplies in Africa, Asia, Latin America, and parts of the former Soviet Union;
  • food shortages in Liberia and Sierra Leone;
  • rains in Somalia and foods in Kenya;
  • crop losses in Uganda, Tanzania, and Ethiopia;
  • droughts in China, Philippines, Thailand, Papua New Guinea, and Indonesia;
  • cereal crops in El Salvador, Guatemala, Honduras, Nicaragua, and Panama; and
  • food shortages in Haiti, Dominican Republic, and former Soviet States.

Questions: whole class writing activity; three to five minutes
Ask students to list five possible causes of food shortages; describe what would happen if people could not get cereal grains; and explain what they think should be done to prepare for food shortages around the world.

Sharing pairs; 15 to 20 minutes
Ask students to form pairs and use the computer and the Internet to construct a graph that compares food crises in 10 different countries.

Whip-around, pass option strategy; five to 10 minutes
Ask each group to share their results.

Review-test strategy; four to five minutes
Ask students to respond to or summarize identifying statements presented in the attentive lecture/discussion session. Give the correct identification for each concept.
### DESCA Scale for Rating a Class

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>DIGNITY</strong></td>
<td></td>
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<tr>
<td>1</td>
<td>No personal dignity  Students slouch or mope, as if feeling unimportant, weak or hopeless. Or act as if they will be worthless without success or others’ approval. Little evidence of self-confidence, self-respect, faith in oneself.</td>
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<td>3</td>
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<td>4</td>
<td>Clear dignity in all  Talented or not, students sit and walk tall, speak up, self-assured. Students seem confident they can succeed or, when they don’t succeed, can handle the failure. Students seem secure in themselves.</td>
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<td>5</td>
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<tr>
<th>ENERGY</th>
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<tbody>
<tr>
<td>1</td>
<td>Energy too low or high  Mood too boring, slow, lifeless; much inactivity, waiting, apathy, time wasting. Or mood too frantic, stressful, exhausting, anxious.</td>
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<td>2</td>
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<tr>
<td>3</td>
<td>Comfortable flow of energy  The mood is comfortably alive. All students keep busy, engaged, active. No evidence of clockwatching. Time tends to fly.</td>
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<td>4</td>
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<thead>
<tr>
<th>SELF-MANAGEMENT</th>
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<tbody>
<tr>
<td>1</td>
<td>Students only follow orders  No evidence of self-responsibility, initiative, self-direction, personal choice. Work is passive, without personal commitment.</td>
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<tr>
<td>2</td>
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<td>3</td>
<td>All students self-directing  Students make appropriate choices, guide and discipline themselves, work willfully, persistently. Students not bossed.</td>
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<tr>
<th>COMMUNITY</th>
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<tr>
<td>1</td>
<td>Students self-centered  Students act only for personal advantage, unconcerned with others’ welfare. No evidence of teamwork, loyalty, belonging, kindness among peers or toward teacher.</td>
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<td>2</td>
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<tr>
<td>3</td>
<td>Strong mood of togetherness  Much sharing, cooperation, interdependence, mutuality. Students support one another and the teacher. No antagonism, rejection.</td>
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<td>4</td>
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<td>5</td>
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<tr>
<th>AWARENESS</th>
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<tbody>
<tr>
<td>1</td>
<td>Dull, mindless busywork  Work is mechanical. Students seem unaware, or unresponsive, or narrow-minded, shallow. No thinking, concentrating or searching. Student talk is impulsive or uncreative, thoughtless. Much inattentiveness.</td>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
<td>All students aware and alert  Much concentration, observing, listening, thinking, noticing, evaluating. Students appear to be mindful, aware of what is going on. High level of attentiveness</td>
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Dear Student:

How was class for you today? Please check one item in each category:

Dignity
___ I had strong, good feelings about myself.
___ I felt OK about myself.
___ Unsure.
___ I didn't feel very good about myself.
___ I thought I was bad, hopeless, or stupid.

Energy
___ I was always comfortably active.
___ I was sometimes active.
___ Unsure.
___ I was rarely comfortably active.
___ My energy was very low or too high and stressful.

Self-management
___ I made many choices, managed myself, felt self-responsible.
___ I was usually self-managing.
___ Unsure.
___ I rather drifted along.
___ I always felt controlled or bossed, not self-responsible.

Community
___ I felt I belonged in the group and was fully accepted.
___ I felt pretty good about being in the group.
___ Unsure.
___ I did not feel good about being in the group.
___ I felt only selfishness and rejection from others.

Awareness
___ I was aware and alert all the time. I did a lot of thinking.
___ I was aware and alert most of the time.
___ Unsure.
___ The class was dull.
___ I felt very dull, very bored.
## The Effects of Weather Patterns on Food Crops | Scoring Rubric

<table>
<thead>
<tr>
<th></th>
<th>4 Points</th>
<th>3 Points</th>
<th>2 Points</th>
<th>1 Point</th>
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</thead>
<tbody>
<tr>
<td>Follows Directions</td>
<td>Includes emailing experts, written report, graphs of local weather, predictions for assigned location, and suggestions for alternate crops.</td>
<td>Only four of the five activities accomplished.</td>
<td>Only three of the five activities accomplished.</td>
<td>Two or fewer of the five activities accomplished.</td>
</tr>
<tr>
<td>Presentation</td>
<td>Good eye contact. Interesting, easy to understand.</td>
<td>Students are reading from notes; information is difficult to understand.</td>
<td>Students are reading from notes, confused during process; present information inaccurately, then correct themselves.</td>
<td>Students present information inaccurately.</td>
</tr>
<tr>
<td>Facts</td>
<td>Accurate and topic completely explained.</td>
<td>Accurate, but some portions missing.</td>
<td>Accurate, but opinion included and stated as fact.</td>
<td>Primarily opinion; topic not covered well.</td>
</tr>
<tr>
<td>Graphs</td>
<td>Includes title, axes labeled with units; clearly indicates information being presented; neatly constructed.</td>
<td>Three of the four parameters acceptable.</td>
<td>Two of the four parameters acceptable.</td>
<td>Only one of the parameters is present, or graphs are missing.</td>
</tr>
<tr>
<td>Paper</td>
<td>Complete coverage of topic; grammar and spelling accurate.</td>
<td>Topic almost completely covered; well written.</td>
<td>Topic incompletely covered or poorly written.</td>
<td>Topic incompletely covered and poorly written.</td>
</tr>
<tr>
<td>Sources</td>
<td>Uses and cites sources from library, Internet, and maps.</td>
<td>Uses and cites only two of the three types of resources suggested.</td>
<td>Uses and cites only one of the types of resources suggested.</td>
<td>Cites no references.</td>
</tr>
<tr>
<td>Group Dynamics</td>
<td>All members participate equally.</td>
<td>One member participates noticeably less than the others.</td>
<td>Two members participate noticeably less than the others.</td>
<td>Group is clearly dominated by one person.</td>
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TITLE: Weathering Experiments: Sugar Cubes, Steel Wool and Gravel !!!

AUTHOR: Kate Hayne, Soroco Junior High School; Oak Creek, CO

GRADE LEVEL: 6-8

RESOURCES/MATERIALS: For each group of students:
10 sugar cubes
jar with a lid
10 pieces of gravel
2 small pieces of steel wool
2 small plastic bags

OBJECTIVE: To allow the students to see both chemical and physical weathering of "rocks"

ACTIVITIES AND PROCEDURES:

Steel Wool Experiment

Procedure:
1. Students should label one bag "dry" and put one small piece of steel wool in that bag.
2. Students should label the other bag "wet", wet the other piece of steel wool, and put it in the bag.
3. Both bags should be sealed and stored for 3-4 days.

Observations:
1. In what ways are the bags the same?
2. In what way(s) do the bags differ?
3. Examine the wool from the "dry" bag. Please describe its appearance.
4. Try to pull the steel wool apart. Is it easy or hard to pull apart?
5. Work over a piece of white paper. Carefully roll the piece of steel wool between your fingers. Describe what has fallen on the white paper.
6. Examine the steel wool from the "wet" bag and repeat the steps in 3-5 above.
7. How were the wet and dry steel wool different?
8. What caused the changes in the wet steel wool?
9. What kind of weathering is this?
10. Please explain how this kind of weathering could happen to a rock.

Sugar Cubes and Gravel

1. Describe the appearance of the sugar cubes.
2. Place the sugar cubes in the jar and shake 20 times.
3. Pour the contents of the jar onto a piece of paper separating the sugar cubes and the crumbs. (don't eat any of it !!!)
   a. Describe any changes you notice in the sugar cubes.
b. Were these changes due to chemical or physical weathering? Why?

4. Return the sugar cubes to the jar and shake another 20 times.

5. Again pour the contents onto a piece of paper separating the crumbs and the cubes.
   a. Did the second shaking cause the cubes to look more worn?
   b. Is the amount of crumbs greater than, the same as or less than the first shaking?

**REPEAT the above using pieces of gravel instead of sugar cubes.**
CLIMATE AND CO2: ANALYZING THEIR RELATIONSHIP

Overview:
In this lesson, students will speculate on various scenarios of future world climates if the greenhouse effect increases.

Connections to the Curriculum:
Geography, environmental studies, science

Connections to the National Geography Standards:
Standard 7: "The physical processes that shape the patterns of Earth's surface"

Time:
Ten to twelve hours

Materials Required:
- Computer with Internet access
- Wall map of the world
- Pencils, pens, or markers
- Climate map of the United States
- Graph paper

Objectives:
Students will
- be familiar with carbon dioxide (CO2) and theories about its role in the greenhouse effect;
- read about the global conference that was held in Kyoto, Japan, in 1997 to set international limits on CO2 emissions;
- know the leading producers of CO2 emissions;
- understand the reasons for patterns of CO2 production;
- understand the implications of the greenhouse effect; and
- understand the processes of possible change in world climates.

Geographic Skills:
- Acquiring Geographic Information
- Organizing Geographic Information
- Analyzing Geographic Information

Suggested Procedure
Opening:
Review the following information about the greenhouse effect with your students. [Note: You can find additional data at New Scientist: Climate Change.]

Causes of the greenhouse effect
Carbon dioxide, methane, nitrous oxide, and other gases are transparent to incoming sunlight, allowing the heat from the sun to enter Earth's atmosphere. These gases trap the heat close to the Earth's surface, warming the atmosphere. Fuel combustion is the largest
human-made source of carbon dioxide. Deforestation is the second largest human-made source.

Possible outcomes related to the greenhouse effect
From 1860 to 1994 carbon dioxide in the atmosphere rose from 280 to more than 350 parts per million. A network of scientists organized by the United Nations predicts that by 2100 continued emissions of carbon dioxide at current rates might raise global temperatures and sea levels. Islands and shorelines could be inundated, climate zones could shift, and weather could grow more turbulent.

Uncertainties
Due to the climate system's complexity, computer simulations of warming and its impacts are, by nature, imprecise. Skeptics say that conclusions drawn from such simulations form a weak basis for international action. Major uncertainties include the role of clouds in warming or cooling the atmosphere and the role of oceans in absorbing atmospheric heat and carbon dioxide.

Development:
Ask students to draw a diagram of the role carbon dioxide plays in the global greenhouse. Discussion should ensure that students understand that an increase in CO₂ means a "thicker" (more efficient) blanket over the Earth's atmosphere, which might cause the temperature of the atmosphere to increase (global warming).

Student groups should tackle these topics and answer the questions that follow:

- What is the present level of atmospheric CO₂?
- Why has carbon dioxide concentration risen since 1860?
- What was the carbon dioxide level when you were born?
- What was the carbon dioxide level when your parents were born?

Give students data on approximate CO₂ emissions by nation. Data can be found at the Trends in Fossil Fuels site, linked in the list below.

- Is the rate of carbon dioxide emission a factor of population concentration? Why?
- Are there any global patterns of emissions?
- How do these patterns compare to what you know about the development of countries around the world?

Ask students to research the 1997 Kyoto conference on climate change. A summary of the conference can be found at the site linked in the list below.

- Why was a conference held on global warming?
- What countries participated?
- What are some terms of the international treaty produced at the conference?
- Has your country adopted the treaty? Why might it wish to do so? Why might it reject the treaty?

Closing:
Have groups speculate on the consequences of global warming, such as melting ice caps and shifting climate zones.

Suggested Student Assessment:
Have each student write a fact-based story illustrating a possible greenhouse-effect scenario. The story should be set in the future and begin, "If we knew in 1998 what we know now...."

Aaron Doering of Century High School in Rochester, Minnesota, contributed classroom ideas for Standard 7.

Related Links:
BBC: 1997 Kyoto Conference on Climate Change
Environmental Literacy Council
NOAA: Climatic Extremes and Weather Events
Trends in Fossil Fuel Carbon Dioxide Emissions
CLIMATE CONTROLS

Overview:
This lesson has students consider how various parts of the world and the United States are affected by climate controls such as world air currents. They will read about climate controls and will create maps showing how these controls affect the climate in various places around the country.

Connections to the Curriculum:
Geography, science

Connections to the National Geography Standards:
Standard 8: "The characteristics and spatial distribution of ecosystems on Earth's surface"

Time:
Two to three hours

Materials Required:
- Computer with Internet access
- Wall map of the world
- Blank Xpeditions outline map of the world (one per student)

Objectives:
Students will
- read and discuss the Climate Controls section of the Creative Climates activity;
- use outline maps to label areas that might be affected by climate controls; and
- create maps of specific places in the United States and write captions to show how each of these places might be affected by climate controls.

Geographic Skills:
- Asking Geographic Questions
- Organizing Geographic Information
- Analyzing Geographic Information

Suggested Procedure

Opening:
Have students read the Climate Controls section of the Creative Climates activity, and hold a brief class discussion on the different types of climate controls that are mentioned, using a world wall map as a reference.

Development:
Give each student a blank world outline map. Have them refer to the video clip of world air currents in the Family Xpeditions Xtras section of Creative Climates, and a physical world map (available at MapMachine). Ask them to mark areas on the outline map that they think might be affected by the climate controls they have read about (except for latitude, which is the obvious one).

After students have had a chance to label some places on their own, discuss what they've done and ask them to label the following places in the United States that are definitely
affected by climate controls: coastal California, California and Nevada deserts, the Rocky Mountains (and other mountain ranges).

Closing:
Have students look carefully at their maps, and discuss the ways in which they think each of the regions they have mapped is affected by climate controls.

Suggested Student Assessment:
Ask students to write captions to go with their maps describing the factors that control the climate in each place they have labeled. As an option, have students research one or two of these places to find out about the effects of the climate controls on vegetation, animals species, and human life in these areas.

Extending the Lesson:
Have students look at the world climate map and predict what the weather might be like in the following cities: Juneau, Alaska; Riyadh, Saudi Arabia; St. Petersburg, Russia; and Jakarta, Indonesia. Then have them research these places on the Internet and/or in print materials to see if their predictions were accurate. Ask them to find out about each city's weather, including its temperature, precipitation, wind patterns, and seasonal variations.

Related Links:
Envirolink
National Geographic: Expeditions Activity—Creative Climates
Earth Our Primary Resource

Activities:

Watershed in a Box

Planning a New Town

Journey North Web Site @
http://www.learner.org/jnorth/index.html

To Dam or Not To Dam

Dichotomous Key Activity

How Wet is Our Planet?

Color Me a Watershed
UNIT 1: WATERSHED MODEL EXPLORATION

In this Unit, natural processes that create landforms and support habitat types are discussed. Model watersheds are used to introduce the concept of the interdependency of physical and ecological features of the watershed system.

In Activity 1, students become familiar with their models as a way to explore how watersheds evolve and how these systems are connected to the coasts.

In Activity 2, students will increase their knowledge of watershed features by discussing the features created in their models, and comparing their models with local landscape features.

Time Frame:

Teacher Preparation ............................................................ 120 minutes
(See ‘Getting Ready’ Section in Watershed Works Users Guide)
Unit 1: Watershed Model Exploration
Activity 1: Introducing Watershed Models................................. 25 minutes
Activity 2: Watershed Features Discussion................................. 20 minutes

What You Need

For the class:

☐ 2 pitchers of blue-colored water
☐ 1 bottle of blue food coloring
☐ paper towels
☐ bucket
☐ Watershed Features display board

For each team of 4-6 students:

☐ 1 watershed-cutting tub set-up (see instructions on pages __)
☐ 1 sponge
☐ 1 piece of wood, 2" x 4" x 8"
☐ 1 aluminum pie pan
☐ 1 sturdy spoon
☐ at least 4 blank 3" x 5" index cards
☐ 1 pair of scissors
☐ collection of photographs and/or textbooks with photos of watershed and watershed features and landscapes, such as snow-covered mountains, canyons, eroded gullies, lagoons, coastlines, and fossils in sedimentary layers.

For each student:

☐ 1 piece of white paper
☐ pencil

If you have slides or a video showing aerial views of local geological features you could start off the activity with a brief showing.
Activity 1: Introducing Watershed Models

1. Spend a few minutes discussing how local landforms were created. Reflect and paraphrase the students’ ideas, encouraging discussion to reveal concepts about forces that shape the land, particularly the role of water in shaping the land.

2. Explain that scientists often use models to investigate processes in nature that are difficult to observe directly because they happen over extended periods of time or in response to phenomena that are difficult to predict. Let students know that in this unit/exercise they will be using models to investigate the formation of drainage systems, and the relationship between upper watersheds and the ocean. In particular, they will investigate answers to questions, such as:

- How was our local landscape shaped by water?
- How do these processes affect the landscape now, and how does it change over time? Are there seasonal differences?
- What are the different features of watershed systems?
- What happens if a river is dammed up?
- How can a dam affect the beach?
- How does groundwater pollution affect the ocean?

3. Emphasize that models make it possible to speed up time and see how watershed systems change over time, and how human activities can affect both watersheds and ocean environments.

4. Explain the model: the tub contains a mixture of water and diatomaceous earth. This ‘earth’ is made up of the shell-like skeletons of tiny plants called diatoms that accumulated on the bottoms of seas millions of years ago. Explain that in the model, the diatomaceous earth represents the land.

5. Point out the dripper system and show the students how it works. Ask the students what they think it may represent in their model. Encourage them to describe a variety of possibilities, such as a rainstorm, waterfall, or flood. Tell the students that they will use their models to find out more about what happens when drainage systems are cut naturally into the earth. They will be working in teams to carefully observe what happens to all parts of the watershed as it is formed. In Activity 1, they will explore the equipment and materials and make their first watersheds.
Demonstrating How to Make a Watershed

1. Use one tub as a demonstration tub, then go around to each group and make sure they are set up correctly. The 'earth' inside each tub should be sloped, the tub should be level, with no piece of wood under it.

2. Demonstrate how to use the dripper system. Show the students how to adjust the drip rate to about 2 drips per second.

3. Orient them to the scale of the model. Invite students to imagine that the tub is a miniature landscape, and that they themselves are tiny.

4. If the drippers are not already full, appoint a volunteer who will help you circulate among the teams, pouring blue water from a pitcher into the drippers.

5. Tell teams that when they receive their materials, one half of each team should prepare the tubs by sloping the earth, while the other half of each team tests the dripper system and sets the drip rate by letting the system drip into a pie pan.

Students Create Watershed Models:

1. Organize teams of students (ideally 4-6 per group) and arrange the desks and tables in the classroom so that each model rests on a level surface.

2. Encourage students to pick up a pinch of the diatomaceous earth and examine it to satisfy their curiosity; tell them not to touch the earth after starting their watershed-making process.

3. Circulate among the groups, helping them to set up the models, answering questions, and making sure that all of the team members are getting a chance to interact with the materials and equipment.

4. Refocus the attention of the entire class, providing any additional pointers you think may be needed. Instruct the teams to begin the watershed-making process by starting the drippers, adjusting the rate to about 2 drips per second and letting the water drip for 5 minutes. Explain that this 5-minute period represents many, many years (5000) in the life of the watershed.
5. Caution students not to try to alter the watercourses during the experiment. The whole idea of using this model is to find out what happens as a drainage system is cut naturally into the earth. While the water is running, they should not touch the tub or the dripper system -- but they should watch closely to see what is happening.

6. Encourage students to circulate and watch as each model watershed evolves in a different way. Encourage them to describe and talk with each other about what they see happening during the five-minute period.

7. Circulate around the class again, answering questions that may arise, checking the drip rates, and making a mental note of the ideas students are expressing. Encourage them to describe what is happening to the water and the earth.

8. When teams complete the five-minute watersheds, tell them to stop the drippers.

9. Hand out a piece of white paper to each student and have him or her draw the watersheds they have created. Ask them to label features and write notes about anything special that they observed (optional, depending on time frame for presentation).

10. Ask students to share their experiences and watershed systems with the group, discussing the events and features they observed. Ask them to share what they learned about how water shapes the land from this activity.

11. If the discussion (Session 2) is to immediately follow the 'lab' period, tell students to keep their practice watersheds intact.

12. If the discussion period will not follow immediately after Session 1, demonstrate cleanup procedures. Show the students how to remove the "ocean" that has formed at one end of the tub by using the sponge to soak up the water and squeeze it into the pie pan.

13. The tubs can be left in place if they will be used again, or they can be stacked at the side of the room, with plastic garbage bags between each tray so they don't stick.
Activity 2: Discussing Watershed Features

In this session, students increase their knowledge of watershed features by discussing the drainage systems they created in the last session, and comparing their model watersheds with local landscape features. They then compare their models with photos and diagrams showing a variety of watershed features. The discussion should be appropriate for the age level of your students and their prior experiences with earth science (if any). Concentrate on what your students actually observed in their models and solicit their prior knowledge of watershed systems.

After discussing the features of the model watersheds students created in Activity 1, you can build on students' observations by introducing the processes of erosion and weathering that tear down landforms, and processes that build up landforms, such as deposition, volcanism, and uplift. Lastly the students make marker flags, for use in Unit 2.

The Day of the Activity

Assemble the materials for making the watershed feature flags. Be prepared to demonstrate how to cut a 3" x 5" index card into four equal rectangles, then to cut the rectangles into eight equal triangles. Or, instead of index cards, you could also use cut up pieces of overhead transparency material for the watershed feature flags. Students can write on these with indelible pens. This is an excellent way to reuse scratched or used transparencies.

Discussing Watershed Features

1. Tell the students that in this activity, they will discuss the results of their first watershed modeling session, starting with identification of watershed features. Later they will discuss how the water created the features they observed.

2. Ask them to Imagine that they are tiny travelers along the watercourses created in the models -- what features did they see along the model watersheds? Where did their journey ultimately take them? Encourage students to tell you about different formations or watershed features they observed in their watershed models, and list their responses on the chalkboard or butcher paper, as the start of an ongoing list of water-related features that will remain in the classroom throughout the unit.
WATERSHED WORKS UNIT 1: Discussing Watershed Features

3. The models enable the students to view entire watersheds and gain a sense of the factors that influence the direction of flow. Ask questions to stimulate their thinking, such as: "If you couldn’t see where the water was dripping from, how would you know which way the water was flowing?" "What seems to influence the courses that the watersheds take?" "Where does the water eventually flow to?"

4. Ask the students if any of the features they observed in their tubs reminded them of any real features in their community, or that they have seen before elsewhere. Allow time for students to discuss their observations.

5. Add any information you may have learned about how local landforms were shaped by water over thousands of years (or invite an expert to give a short presentation). Share any photos, maps, or information from which you may have gained insights.

6. During the discussion, if the terms have not already surfaced, you may want to add that the place where a stream starts is called the headwaters or source, and that smaller streams that flow into a larger river are called tributaries. An area of land that drains to the same location, through a river with all of its connecting tributaries and streams is called a watershed system.

7. Put up the Watershed Features display board you created in a location accessible/visible to all of the students. Distribute any additional pictures and textbooks that you have collected containing photographs or illustrations of watershed systems. Have students work in pairs or small groups to review the materials with the goal of identifying as many features as they can that might appear in their model watersheds.

8. Reconvene the class and ask them to add to the list any new features that they saw in the resource materials that they also observed in their models.

9. Ask the students, "Did you ever see any of these features along a real river or creek?" "Are there any features of a real river that you have not yet seen in the models?" (Encourage any comments that suggest the students are making connections between their models and the real world. Erosion gullies or places where streams flow across the beach on their way to the ocean are good examples.)
Processes that Tear Down Land Forms

1. Ask the students, "What happens to the diatomaceous earth that is pushed out of the way when the water cuts a river system in your models?" [They will probably notice that the material is moved downstream by the water.]

2. Define the word 'erosion' -- the wearing away of land by water, waves, wind or glaciers. In the case of rivers, streams and oceans, erosion is the moving of material by water. Explain that wherever water flows over soil or rock or sand, erosion is taking place.

3. Ask the students, "Can anyone give me an example of erosion near our school or near your home?" Take several responses. If students do not mention it, point out that erosion can often be seen after a series of rainstorms, when the soil has been saturated and can't soak up any more water. They will see tiny streams of water ("rills") running through the soil. As these rills run, they grow in size, and become muddy because they pick up small particles of dirt and rock. Over thousands of years, entire hillsides can eventually wind up as sediment on the bottom of a lake or wetland, along a beach or in the ocean.

4. Point out that the model contains a soft, powdery material, while in the real world, mountains are composed of hard rock as well as soil. Over thousands of years, rock is broken down into gravel, sand and soil, as it is warmed and cooled in daily and seasonal cycles, and slowly broken down by chemical and physical processes. This breaking down of bedrock into soil is called weathering.

You may want to ask students for their ideas on how much sediment a slow-moving river carries, as opposed to one that moves quickly. They may want to observe their models for ideas on this question, and/or design an experiment to test their ideas in Unit 6.

5. Point out that erosion can be a very serious problem, washing topsoil away from land much faster than it can be replaced. Erosion can also undermine homes and roads. Erosion problems are made worse when trees and plants are removed, or through road building or other development, so water that once soaked into the soil now runs off, carrying soil with it.
Processes that Build Up Land Forms

1. Explain that the eroded material carried by water is called sediment. Ask the students, "What happens to the sediment carried by your model rivers?" [They will probably see that it is deposited further downstream.] Some of it winds up in the form of a delta, where their rivers enter a lake or the ocean. (Sediment is also deposited on floodplains and alluvial fans.) Explain that this process, which also occurs in the real world, is called deposition. The processes of weathering and erosion wear away high landforms, while deposition builds up new landforms in low areas.

2. Ask the students, "What would happen to all of the mountains and hills in the world if weathering, erosion, and deposition were the only forces shaping the land?" [They will probably infer that after a few million years, all mountains and hills would eventually be flattened by erosion, and the sedimentary material would be deposited in lakes and oceans.] Ask, "Is there any evidence in your model that supports your prediction?" [Material is washed down the slope into the "ocean."] "Why does that NOT happen?" Ask, "Why is the Earth not leveled?" "Why do we still have mountains and hills?" Invite several responses, asking the students to describe some of the processes that build up the land, such as volcanoes, uplift of continents, and mountain building. If students do not know about these processes you can describe them briefly.

(Note: If older students have been introduced to the theory of plate tectonics, you may allude to it here. Otherwise it is sufficient to explain that the earth’s crust is in constant motion. The Oceans in Motion video -- see ‘Resources’ -- is a good resource to explain these concepts to students, and could be shown ahead of this exercise as background.)

3. Finally ask the students if anyone can guess where the sand on the local beaches comes from. [Keep in mind that there is almost always a multiplicity of sand sources, including shells, and just about everything that can be found on the beach. See the BEACHOLOGY units for more activities about the sources of sand]

"What kind of feature is a beach?" [depositional].

4. Point out that if we could speed up time -- so that one thousand years passed in just one minute -- we could see how "constructive" forces (such as volcanism, uplift, and deposition) built up the land, and how "destructive forces" (such as erosion and weathering) wore it down. That's what our models do for us -- allow us to see what would happen to the watershed system if we could speed up time.
What Do Models Tell Us?

1. Remind the students about some of the ideas they expressed at the beginning of the first session concerning how landforms are created. Ask them: "Do you now believe that your earlier ideas were correct?" "If you do, how did the models support your theories?" "If you have changed your minds, how did the models help you see things in a different way?"

2. Ask the students to explain some of the ways that their watershed models are like the real world, and ways that they are different.

3. Ask students to reflect on the advantages and disadvantages of using models in science to explore questions such as:

   - Keeping in mind that models are somewhat like the real world -- but not exactly like it -- how can models help us understand processes like the formation of landforms? [They enable us to explore in the laboratory processes that would take thousands of years to observe in nature. They also show us the entire watershed system, from source to the ocean, and everything in between.]
   - Why should we be careful using models to understand natural processes? [Because models are not exactly like the real world, we could reach the wrong conclusions if we depended on models alone.]

Making Watershed Features Flags

1. Explain to the students that later in the unit they will keep more careful track of changes in the model rivers and watersheds over time. To do this, they will make small flags with names of watershed features that they can plant in the earth whenever one of these features appears. They will also keep track of the order in which watershed features develop over time.

2. Demonstrate how to cut a 3" x 5" index card into four equal rectangles, then cut the rectangles into eight equal triangles. Label one end of a triangle with a watershed feature such as "lagoon," or "delta" (or make similar sized flags out of used or scratched transparencies).

3. Have the students organize themselves into the same teams as in Activity 1 and provide each team with about four index cards, a pencil, (or transparencies and indelible marking pens) and a pair of scissors. Direct them to cut the cards into triangles, then prepare a set of watershed labels they think will occur during model runs. You may want to place the watershed feature flags from each team in plastic bags or envelopes for safe-keeping until they are used in the next activity.
GETTING UP TO SPEED

This section is not meant to be read aloud to or distributed directly to students (although that is at your discretion). It is primarily intended to provide the necessary, concise background for you — the Surfrider chapter representative or teacher — in presenting Unit 1 activities and responding to students' questions. Please see the 'Resources' section in the Users Guide for books and other reference materials that will help you and the students to delve deeper into the subject matter addressed in this unit.

Presenters' Overview

In this Unit, students are introduced to the natural processes that create landforms and support habitat types. Model watersheds are used to introduce the concept of the interdependency of physical and ecological features of watershed systems.

The goal of Activity 1 is for students to become familiar with their models as a way to explore how watersheds evolve and how these systems are connected to the coasts. Begin by asking students two or three questions about how they think local landforms were created. Listen to their initial ideas and discuss some of the questions that the models may help them investigate.

The students will be organized into teams and given the opportunity to acquaint themselves with the materials and model watershed systems. They will have fun while developing useful techniques for future activities and exploring the potential of their models.

While students are creating their first trial watersheds, you will have time to circulate among the teams encouraging them to describe and talk about what they see happening to the evolving watersheds. This is a good time to learn more about the students' prior knowledge related to watershed functions and features. Encourage students to observe the watersheds evolving in the models of other teams, thereby sharing and comparing observations and ideas among the larger group.

In Activity 2, students will increase their knowledge of watershed features by discussing the features created in their models, and comparing their models with local landscape features.
About Watersheds

Watershed, in its simplest, scientific meaning, is a drainage basin -- the area through which all waters flow from their highest source before draining naturally to a receiving sea or lake. Within the watersheds of the great rivers, such as the Salween or the Mekong of the Himalayas or the Mississippi on the American Continent for example, are the watersheds of thousands of smaller rivers, streams and lakes, each with their own particular character and history.

All land is part of a watershed, and is shaped by the water that flows over it and through it. A river is much more than water flowing to the sea. Its ever-shifting bed and banks and the groundwater below are all integral parts of the river. A watershed includes not only the land and water draining to an ocean or lake, but the mountains and forest, flood plains and valleys, marshes and beaches -- as well as the communities of plants, animals and people who live there. A river carries downhill not just water, but just as importantly sediments, dissolved minerals, the nutrient-rich detritus of plants and animals, and substances introduced by humans, both living and dead. In doing so, a river shapes the land and the living communities that evolve along its banks and within the watershed of which it is a vital part.
About Watersheds continued

A watershed starts at mountain peaks and hilltops. Snowmelt and rainfall wash over and through the high ground into rills, which drain into fast flowing mountain streams. As the streams descend, tributaries and groundwater add to their volume and they become greater streams, and then rivers. As they leave the mountains, rivers slow and start to meander and braid, seeking the path of least resistance across widening valleys, whose alluvial floors were laid down by millennia of sediment-laden floods. Eventually the rivers will flow into a lake or ocean. Where the river is muddy and the land flat, the sediments laid down by the river may form a delta, splitting the river into a 'bird-foot' of distributary channels that discharge into the sea. The river's estuary, the place where its fresh waters mix with the ocean's salt water, is one of the most biologically productive parts of a watershed -- and of the ocean. Most of the world's fish catch comes from species that are dependent for at least part of their life cycle on a nutrient-rich estuarine habitat.

As the ridges, forests, meadows, marshes and even the beaches within a watershed are all inter-related, when a change is introduced to one of these elements, it can have repercussions on the others. If a river or stream flows through an agricultural area, it can pick up fertilizer, manure, and pesticides from farming operations. As it passes urban and suburban areas, a stream might gather fertilizers that wash off lawns, untreated sewage from failing septic tanks, wastewater discharges from industrial facilities, sediment from construction sites, and polluted runoff from impervious surfaces like parking lots. These substances may be deposited on river flood plains, or concentrate in coastal estuaries or receiving marine waters. All of these land uses -- agricultural, suburban, urban, and coastal -- can have an impact on our fresh and marine waters and watershed systems.
Clockwise from top left: Urban channel with sediment deposit and high rises in the distance (PHOTOGRAPHY: MOZDOZEN)

Tributary at confluence with larger stream (PHOTOGRAPHY: EVE KUSZEWSKI)

Removal of riparian vegetation has resulted in erosion and **failure of stream bank** (PHOTOGRAPHY: EVE KUSZEWSKI)

River erosion undercutting meadow bank (PHOTOGRAPHY: MOZDOZEN)
GLOSSARY OF TERMS

Flood Peak: The highest flow level or discharge in a flood event.

Floodplain: A level area near a river or stream channel, constructed by the river in the present climate, and overflowed during moderate and higher flow events.

Gradient: (of a stream or river) The rate of fall of a stream, typically expressed as a number of feet of elevation change per mile.

Groundwater: Water stored and/or flowing beneath the ground surface, through the pore spaces of subsurface soils and rock.

Gully: A steep sided, V-shaped erosional feature, usually associated with loosely consolidated, fine textured soils. Gullies often form due to runoff over areas where vegetation has been removed and on steep hillsides.

Infiltration Capacity: The rate at which surface soils are able to absorb water from rainfall and runoff.

Lake: A body of water of considerable size, which is surrounded by land. A lake may be formed when a landslide blocks a stream, by volcanic or seismic activity, or by glaciation.

Levee: An embankment constructed along the banks of a river, wetland or irrigation channel to prevent high flows or tides from flowing out onto the adjacent area.

Meander: A rounded or 's'-shaped bend or curve in a stream or river. Meanders are formed by the dynamics of the free-flowing water, and meandering rivers and streams usually occur in alluvial areas with very low gradients.

Non Point Source Pollution: Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants (which are discrete sources), comes from many diffuse sources. NPS pollution is caused by rainfall, snowmelt or other runoff moving over and through the ground.

(continued on next column)
As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;
- Salt from irrigation practices and acid drainage from abandoned mines;
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems;
- Atmospheric deposition and hydromodification are also sources of nonpoint source pollution.

Plunge Pool: A depression in the bed of a river or stream, formed by scouring flows at the base of a waterfall.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current and low depth. The comparable feature in a river would be called Rapids.

Rill: Small channels formed by water running over the surface of the ground. Water collecting in these small channels may then concentrate and join to form larger channels as they move downslope, which in turn meet to form still larger channels. The smallest channels, rills, meet to form creeks, runs or streams; then these features meet and grow until, at some undefined size, they are termed rivers.

Riparian: Of or pertaining to the banks of a natural watercourse. This term is most often used to describe the transition zone between aquatic habitats in streams and upland areas. The particular habitat that is supported in this zone is extremely valuable as wildlife nesting, forage, cover and migration corridors, provides favorable conditions within the adjacent aquatic habitat (shade for cool water temperatures and clear channels, cover, nutrients, woody debris), and stabilizes stream and river banks.
GLOSSARY OF TERMS continued

River: A large, natural stream of water emptying into an ocean, lake or another water body, and usually fed along its course by converging tributaries.

Riverbank: The land bordering a river, sloping up from its bed to meet the adjacent land.

Riverbed: The lower portion of a river channel, between its banks, and ordinarily at least partially covered by water.

River Mouth: The outlet of a river, where it flows into the ocean or another body of water.

Runoff: Water from irrigation, snowmelt or rain that flows from the land surface into streams, creeks, wetlands or the ocean.

Sediment: Solid particles of organic or inorganic material that come from the weathering of rock and are carried and deposited by wind, water or ice.

Sediment Load: Solid particles produced by weathering and transported through a channel by stream flow. The sediment load may be divided into two components: that which is suspended within the water column, suspended sediment, and that which is moved along the bed of a channel, bedload.

Sheetflow: Runoff that flows over the ground surface in a diffuse manner, not concentrated in a channel.

Stream: A feature formed by flowing water, concentrated in a channel or bed, as a brook, rivulet, or small river.

Stream Terrace: Remnant floodplain features adjacent to a stream or river, where the stream has changed in its course and/or elevation, and has created a new active floodplain.

Transpiration: The process by which plants release water that has been taken up through their roots into the atmosphere. Transpiration occurs through the leaf pores of plants. (Also called Evapotranspiration)

Tributary: A stream that flows into a larger stream, river or other body of water.

Valley: An elongated lowland between ranges of mountains, hills or other uplands, often having a river or stream running along its bottom.

Watershed: A geographic area in which all sources of water, including rain fall, snowmelt, streams, rivers, lakes, estuaries, and wetlands, as well as ground water, drain to a common surface water body, usually the sea.

Water Table: The upper limit of the portion of the ground wholly saturated with water. A water table may be within a few inches beneath the ground surface, or many feet below it.

Wetland: Land where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Indeed, wetlands are found from the tundra to the tropics and on every continent except Antarctica.

Plunge pool at base of waterfall
ABOUT THIS PUBLICATION

This workbook was printed with soy based inks on recycled paper. Cover stock: New Leaf paper's Everest cover stock is 100% post-consumer waste recycled paper and is process chlorine free. Interior stock: Simpson's Quest is 100% post-consumer content paper that is non-deinked. The small flecks you see are bits of toner and ink from its past life.

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PLANNING A NEW TOWN

Overview:
In this lesson, students will make decisions about buildings, businesses, services, and housing areas to include in the development of a new town. After discussing essential elements of a self-sustaining community, the students will prepare a map and give oral presentations on different aspects of the new town.

Connections to the Curriculum:
Geography, social studies, economics

Connections to the National Geography Standards:
Standard 12: "The processes, patterns, and functions of human settlement"

Time:
Eight to ten hours

Materials Required:
- Graph paper
- Large sheets of drawing paper
- A letter to your students (the instructor can modify the example below and hand it out at the start of the lesson)

Objectives:
Students will

- learn how to make basic urban plans for fulfilling the goals identified in a class discussion about communities.

Geographic Skills:
Asking Geographic Questions
Answering Geographic Questions
Analyzing Geographic Information

Suggested Procedure

Opening:
Hand out a letter to the students requesting their help in planning a new town. Here is an example:

Dear Students:

The council members of Weebeebuilding Town have recently acquired a large plot of land. The members of the council would like your assistance in creating a new town on this land. The council will provide funding for 20 buildings in the first year, but it is important that you make wise choices about which buildings should be constructed. Once you have settled on specific sorts of buildings, you will need to draw up plans in the form of a large-scale map. Please present your map and supporting documents to the council on (specify a date).

Development:
Survey the students to determine which sorts of buildings (commercial, residential, industrial, municipal) they want to include in their new town. Organize this information into a chart listing type of building and how many.

Discuss with the class why certain buildings are necessary—a school, perhaps, and a fire station, a gas station, a grocery store, a residential building (such as an apartment complex), an office building, and so on. Introduce the concept of growth. Should some buildings go up before others? Which should be built in the first year? These should offer employment for a few people who move to the town as well as for others who commute. What services should support these people? Other threads for the discussion:

- What factors would help determine the buildings needed and how many of each (e.g., population of the town, distance from next town, or physical obstacles such as rocky soil, a large river, or a lake)?
- Where will people be employed? In what industries?
- Are there some sorts of buildings we could really do without?
- Do we need more than one grocery store?
- Are there some options that we could combine (e.g., gas station and video store)?
- Will any critical factors change with time (e.g., population, income level, and/or land availability and value)?

Next discuss locations for the various buildings. Consider such questions as, "Would the following locations be logical?" Explain your answers.

- A grocery store on the outskirts of town?
- An elementary school next to a jail?
- A library near a school?
- Four grocery stores next to each other?
- A video rental store near a busy road?
- A school on the opposite side of town from residential areas?
- A shopping mall in a sparsely populated area?
- A park next to a neighborhood?

Have students form small groups representing construction companies. The companies should determine which buildings they are going to build the first year and provide valid reasons for their choices. Have the students list which businesses they would like to build the second year and into the future. When would something such as a fingernail salon go up? How quickly would the town expand? What factors would influence growth? Would there be any reason not to grow year after year? What happens if a major employer leaves town or goes bankrupt?

Using graph paper, have the student construction teams draw plans for their new town. How would they lay out the community? Would everything in the first-year plan be on a main street or widely dispersed? Once the plans are drawn, they should be presented to the town inspector (the teacher) for approval.

After inspection, have the class vote on their favorite plan from among those submitted. Transfer that plan grid square by grid square to a large display in your classroom.

Closing:

Repeat the process for subsequent years of town growth, using different colors and a different "construction firm" for each year's new development. Discuss the map's evolution with your class, noting the unexpected paths development can take with so many different people shaping the town. Would your students advocate a town council with strong zoning authority if they were to construct the town again?
Suggested Student Assessment:
Hand out a map similar to the one the students made. Have some important features missing from the map. Place the fire department at the far outskirts of town. Place two grocery stores on the map, both in the same neighborhood. Have students analyze the map and answer questions such as the following:

- When planning a new town or city, what are some things you should definitely include?
- Where would be a suitable location for a school in this town? An entertainment complex?
- What is wrong with the location of the fire department?
- Why are there two grocery stores? Is two enough? Too many?

Students should recognize important needs such as a fire department, a hospital, a school, a post office, residences, and grocery stores. They should also understand that in general these types of structures take priority over businesses that serve a smaller segment of a town's population. Can they suggest communities that might be exceptions to such guidelines?

Extending the Lesson:

- Invite guest speakers (e.g., town planners, civil engineers, or town council members) from your community to speak to the class.
- Analyze a real map of your community. How was it settled? Why did early residents stay in this place?
- Describe the types of settlements that existed before cities emerged (for example, stopping places on the routes of hunters and gatherers, isolated farmsteads, villages).
- Discuss the geographic reasons for the location of the world's first cities.

Nicole Sweet of East Valley Middle School in Spokane, Washington, contributed classroom ideas for Standard 12.

Related Links:
About.com Cities and Transportation
National Geographic: Lewis and Clark
National Geographic: Virtual World—The New Suburb?
Population Reference Bureau
Use the Journey North web site found at
http://www.learner.org/jnorth/index.html

A great way to get students involved in hands on migration issues
To Dam or Not To Dam

Correlations

Correlated for grades 5-8; grades 9-12 require more in-depth scientific investigations & research.

Science Standards

Content Standard A: Science As Inquiry
Identify questions that can be answered through scientific investigations.
Think carefully & logically to make the relationships between evidence & explanations.

Content Standard C: Life Science
Understand regulation and behavior among organisms.
Understand populations and ecosystems.

Content Standard E: Science & Technology
Understand the abilities of technological design.
Understand science & technology; limitations, benefits and consequences.

Content Standard F: Science in Personal & Social Perspectives
Understand populations, resources and environments.
Understand risks & benefits of the project.
Understand science & technology in society.

Guidelines

Theme 1: Questioning & Analysis Skills.a. Modify, clarify and focus questions to guide learning and environmental investigations.b. Connect questions with appropriate types of inquiries and define the scope of inquiry.c. Judge the merits or strength of information.d. Locate and collect information about topics from a variety of sources in a variety of ways.
Theme 2: The Earth As a Physical Systema. Predict the consequences of a specific physical phenomenon.
Theme B: The Living Environmenata. Understand that biotic communities are made up of plants and animals uniquely adapted to live in a particular environment.
Understand major kinds of interactions among organisms or populations of organisms.

Theme 2C: Humans & Their Societies.a. Understand that how individuals perceive the environment is influenced by both individual traits and group membership or affiliation.b. Become more familiar with political and economic systems and how these systems take environmental systems into consideration.c. Understand that human systems change over time and conflicts sometimes arise over differing viewpoints and goals.
Theme 2D: Environment & Society Understand that human-caused changes have consequences for the immediate environment as well as for other places and future times.

Theme 3A: Skills for Analyzing Environmental Issues.a. Analyze environmental issues and proposed solutions.b. Apply knowledge of ecological and human processes and systems to identify the implications of specific environmental issues for those systems.c. Identify, justify, and clarify views on environmental issues and alternative ways to address them.
Theme 3B: Skills for Investigating Environmental Issues.a. Apply their growing research and analytical skills to investigate environmental issues.b. Examine and propose action strategies for addressing particular issues.c. Consider the assumptions and interpretations that influence the conclusions that they and others draw about environmental issues.
Theme 4: Personal & Civic Responsibility.a. Understand that societal values can be both a unifying and a diverse force.

Geography Standards

Essential Element I: The World In Spatial Terms2.a. How to use mental maps to organize information about people, places and environments in a spatial context.
Essential Element II: Places and Regions.a. The physical and human characteristics of places.b. How culture and experience influence people's perceptions of places and regions.
Essential Element III: Physical Systems.a. The interaction of living things and the physical environment.
Essential Element IV: Human Systems.a. How the forces of cooperation and conflict among people influence the division and control of the Earth's surface.
14. How human actions modify the physical environment.

15. How physical systems affect human systems.

16. The changes that occur in the meaning, use, distribution, and importance of resources.

18. How to apply geography to interpret the present and plan for the future.

This activity appears in Project WILD Aquatic Education Activity Guide © 1987, 1992 Council for Environmental Education. The complete aquatic guide can be obtained by attending a Project WILD workshop. For more information, contact the Montana Project WILD Office at 406-444-1267.

Subjects: Social Studies, Science

Skills: analysis, classification, communication, description, discussion, evaluation, generalization, inference, interpretation, invention, kinesthetic concept development, listening, listing, observation, public speaking, reading, synthesis, writing

Duration: two or three 45-minute periods, depending on whether time out of class is used to develop position papers & write essays

Group Size: developed for 30 students; can be modified for smaller or larger groups

Setting: Indoors

Key Vocabulary: dam, river, costs, benefits, tradeoffs

Objective

Students will evaluate potential positive and negative effects from constructing a dam on a river.

Method

Students role play individuals representing differing perspectives & concerns related to a complex issue.

Materials

to role playing cards, using descriptions on next page

Background

Copy or read to students

Hypothetical situation: The town of Rocksburg, population 900, is located along the scenic Jones River approximately 60 miles from the closest big city. The mayor and city council of the big city have proposed that a dam be constructed two miles upriver of Rocksburg.

In the Environmental Impact Statement written by the city engineers, the following information was identified:
The dam would meet the area's electrical power demand for ten or more years in the future. It would provide some water for irrigation and would help with flood control problems downriver.

Construction would be of rock-earth fill, 75 feet high and 300 feet across. Seven miles of river would be turned into a lake.

The dam construction would take five years to complete and would employ over 2,000 workers. After the dam was finished, approximately 150 workers would be required to keep the plant running.

Wildlife would be affected in the following ways:
20% loss to the deer herd thatbrowsesthe lands alongside the river due to lost forage
20% loss to small mammals living in the river valley due to loss of habitat
20% loss to the area's songbird population due to lost riverbank nesting sites
blockage of the upstream and downstream movement of fish that live in the river due to the creation of the lake and dam
increase of the area's wintering bald eagle population; the dam and lake will increase access to bald eagle prey species, primarily fish; the eagles could winter in the area but would have to migrate to other areas to nest; the dam would reduce riverbank trees suitable for nesting
reduction and possible elimination of fish species adapted to cooler and/or flowing water including trout, minnows and darters while at the same time increasing warmer, non-flowing water habitat suitable for bass, bluegill and carp
loss of 10,000 acres of prime timber growing land and wildlife habitat

The people of Rocksburg are concerned about the problems and benefits from the number of people that would come to their town during and after the construction of the dam. For example, they project the arrival of 2,000 workers plus their families during construction for five years and that 150 permanent workers plus their families would stay after the dam was finished. They are concerned about effects on schools, sewage disposal, roads, homesites, property values, and the rural atmosphere, as well as police, fire, and hospital emergency capacities. They see some potential benefits from the development, such as new recreation opportunities for the people of Rocksburg and the city which is only about an hour away (water skiing, sailboarding, motorboating, swimming, fishing, camping, picnicking and other lake-related sports).

Other impacts could include:
loss of drinking water quality locally and in the metropolitan area
flooding of Native American Indian archeological sites
cultural changes for local Native American tribal people who have fished the river for generations
water for irrigation at a lower monetary cost
potentially less (monetarily) expensive power when compared to other forms of power production (e.g., nuclear, coal, oil, fossil fuels)
potentially more (monetarily) total power bills that may be necessary to pay for construction of the dam
loss of seven miles of prime whitewater; private and commercial raft, kayak and canoe trips would be gone

Procedure

1. Provide students with the background information. Generate an initial discussion with them about some of the possible costs and benefits from the construction of this dam, considering it from a variety of perspectives.

2. Ask each student to choose the role of an individual to become or represent for the purpose of this activity — or assign roles randomly. See "Roles" below. Establish a balanced variety of roles
with people having conflicting values and concerns relating to the potential impacts of this dam construction. NOTE: Teachers have copied the role descriptions and cut them apart to pass out to students. Create any additional roles which serve to illustrate a variety of major perspectives and interests.

NOTE: Some students have dressed for their roles to heighten the dramatic quality of the experience.

3. Ask students to prepare for their role, developing a short position paper for use as background for the dramatization of their role.

4. Arrange the classroom to represent a meeting room for the county council in the area in which the town of Rocksburg is located. Students will role-play their position and make a presentation to the five-member Rocksburg County Council. This council will ultimately make a recommendation to the F.E.R.C. (Federal Energy Regulatory Commission) on a siting permit for the dam.

5. After all the students have made their presentations, ask the county council to render a decision.

6. Following the council's decision, have a brief class discussion to summarize the "pros" and "cons" that emerged from the students' presentations. Identify and list the benefits, if any, and costs or liabilities, if any, as a result of building the dam. Include effects on people, plants and animals.

7. After the role play and class discussion, ask each of the students to write a brief essay describing his or her own personal recommendation for whether or not to build this dam. The students might expand their position papers, or "start from scratch" in writing their essays.

Extensions

1. Change roles and conduct the council meeting again. Note any differences in the results as well as your perceptions of the process and experience.
2. Find out if there are any proposals to create new dams or any other proposals that will affect wildlife habitat in your region. If so, investigate the "pros and cons" of one or more of these proposals, from your perspective.
3. Is there a dam in your area? Visit it. Find out about its effects on people, plants and animals -- both positive and negative, if any.

Evaluation

1. Name two or more possible benefits to people if a dam were constructed on a river.
2. Name two or more possible negative consequences to people if a dam were constructed on a river.
3. Describe possible positive and negative effects on a variety of different kinds of plants and wildlife under each of the following conditions if these conditions existed as a result of the construction of a dam: water levels in the area below the dam are low for at least part of the year; water going over the dam drops a long way; very cold water is taken from the bottom of the dam and released into the river below.

Roles

A.G. "Rick" Ulture: a representative of the local farmers' coalition interested in the dam's potential for protecting crops from floods as well as its ability to provide water for irrigation.
Lotta Power: a lobbyist for the municipal electrical power company developing the dam.

Rob or Marta Kanu: kayaker concerned with the loss of the whitewater stretch for canoeing and kayaking.

Sam N. Fish: a local sporting goods store owner and avid angler concerned with the loss of migration routes of the fish.

Dan D. Lion: the president of the "Save Our Native Plants and Wild Animals" organization.

Pat "Pottery" Brusher: an archeology professor from the local university who has researched archeological sites of Indian fishing camps along the river.

Lynn Drippen the director of the municipal water quality authority responsible for providing quality drinking water for the city, and attracted to the dam's potential for providing a reservoir of high quality water useable during long hot summers.

H. M. Owner: a representative for all homeowners in the river valley below the dam who would like to see more flood control.

Bobbie Lawkeeper: the local Rocksburg sheriff concerned about maintaining police protection, peace, health and safety with only a one-person staff as the sole legal authority in the region.

T. M. Burr: the owner of a lumber company whose land would be inundated by the reservoir.

I. M. Floaten: an owner of a whitewater rafting company who uses the river for commercial rafting. Concerned about loss of the "best seven miles of the river," I.M. argues that the best rapids would be submerged by the lake.

"Sky" Soarer: the president of the local bird club who has organized eagle-watching trips to the river every winter for the last 15 years.

Sam Slalom: an avid water skier who sees the new lake as a real boon to skiing interests.

Velma or Virgil Vigil: a local representative of the Gray Panthers, a group of elders concerned about any rise in power bills.

"Boater" Cartop: an older fisherperson who enjoys throwing the boat on the top of the car and putting in at the closest float spot -- especially lakes!

Marshal or May Flyfisher: a long-time resident who champions the purity of fly fishing and insists on pristine habitat, noting the necessity of white water riffles.

Col. "Bull" Winkle: the president of "More Moose Now" who believes that with the lake behind the dam, more moose habitat will be created.


Cy or Sy N. Tist: a respected biologist who is prepared to testify about potential effects on wildlife from the building of the dam.

O. L. Slick: a salesperson for motor boats, water skis and other recreational equipment.
Forest or Park Site: a forester who has worked in the local woods for more than 50 years.

Running Waters: a tribal leader who is concerned about loss of native heritage from flooding the region for the dam.

E. Conomy: a local businessperson who is concerned about the long-range business potential of the area.

C. D. Minium: a wealthy land developer who has architects working on designs for lakeside condominiums and resort homes. Engineers are joining forces to build a more comprehensive, interdisciplinary understanding of cities as ecological systems. Previously, ecologists favored study sites as untouched by human influence as possible -- the more remote the better. When urban educators taught ecology and had the opportunity, they would bring their students outside of the cities to find "nature."
Dichotomous Key Activity

In this activity, you will be using a dichotomous key found at the LEAF web site (put together at the University of Wisconsin-Stevens Point) to identify an unknown tree. After identifying the unknown tree, you will follow a link from that site to the Silvics of North America web site (USDA Forest Service Northeastern Area - St. Paul Field Office) to collect some information on your tree and fill in the worksheet included with this exercise.

Instructions:

1. Open your web browser.
2. Type in the address for the LEAF web site (www.uwsp.edu/cnr/leaf)
3. Click on the “Tree Identification” link.
4. Choose “LEAF On-line Tree Key.”
5. Read the sections on the left entitled “What is a Dichotomous Key?” and “How to use this key.” We will be doing exercise #2.
6. After you’ve read the instructions, scroll down in the left hand frame until you see the list of numbers. Click on the number you’ve been given for your “unknown tree.”
7. Using the images shown in the left hand frame, answer the questions in the right hand frame until you get the pictures in the two frames to match. If you have trouble answering any of the questions, ask your instructor for help.
8. Once you get the pictures to match – Congratulations! You’ve identified your tree – scroll down to the bottom of the right hand frame and click on the link for Silvics of North America to learn more about your tree.
9. Fill out the worksheet on your tree using the information you find at this site.

Resources:
University of Wisconsin-Stevens Point
(www.uwsp.edu)
LEAF Website
(www.uwsp.edu/cnr/leaf)
USDA Forest Service Northeastern Area - St. Paul Field Office
(www.na.fs.fed.us/spfo)
Silvics of North America - online book/publication with information on around 200 trees
Dichotomous Key Activity
Tree Information Worksheet

Scientific name: ________________

Common name: ________________

Family name: (scientific)

(also known as:)

Family name: (common)

Range:

Climate (what range of temperatures and rainfall does this tree grow in):

Size/longevity (height, width/diameter, life span):

Damaging agents (major or most damaging - list a maximum of 5):

Used for (this could be uses by humans and/or animals, plants, or other organisms):
Dichotomous Key Activity

_Instructor’s Guide_

**Number of students:** Up to 25 students. Can team students up, but better as individual exercise.

**Time required:** apx. 60 mins.  
**Prep. time required:** 5-10 mins.

**Equipment required:** Computer (with internet connection & web browser) for each student

**Preparations:** Assign each student a number from 1-27 (not including 20 or 21). These will be their unknowns that they have to key out and report on. For students who have a conifer (see below), they should also key out #20 before they do their unknown. For students with a deciduous tree, they should key out #21 before they do their unknown.

Students looking for unknowns # 2, 3, 5, 7, 12, 14, 19, 21, 22, 23 (conifers) should key out unknown #20 first.

Students looking for unknowns # 1, 4, 6, 8, 9, 10, 11, 13, 15, 16, 17, 18, 20, 24, 25, 27 (deciduous trees) should key out unknown #21 first.

**Notes/Comments:** Have the students look at their information worksheet with you before they start. Make sure they understand the information they’re looking for. The site also has a lot of very technical information, and they shouldn’t be intimidated. Remind students to look very carefully at the information on their unknown (in the left frame). There is sometimes text as well as pictures. If students can’t find a question or tree which matches their unknown in the right hand column, they either need to back up to a question they answered incorrectly earlier or possibly scroll down completely within the frame they’re in as there may be additional choices they don’t see.

**Key to trees on LEAF Site:**

1. Black Cherry  
2. White Pine  
3. Tamarack  
4. White Birch  
5. Jack Pine  
6. Black Walnut  
7. Scotch Pine  
8. Sugar Maple  
9. Red Oak  
10. White Ash  
11. Cottonwood  
12. Balsam Fir  
13. Basswood  
14. Eastern Hemlock  
15. American Beech  
16. Trembling Aspen  
17. Red Maple  
18. Big Toothed Aspen  
19. Northern White Cedar  
20. White Oak  
21. Black Spruce  
22. Red Pine  
23. White Spruce  
24. Yellow Birch  
25. Black Ash  
26. Norway Spruce  
27. Shagbark Hickory
HOW WET IS OUR PLANET?

OBJECTIVES
Students will: 1) describe the amount and distribution of water on the earth in oceans, rivers, lakes, groundwater, icecaps and the atmosphere; and 2) make inferences about the importance of responsible use of water.

METHOD
Students calculate water volumes using percentages.

BACKGROUND
The earth has been called the water planet. Between two-thirds and three-fourths of its surface is water. The earth’s water can be seen in flowing rivers, ponds, lakes, oceans, locked in the northern and southern icecaps, and drifting through the air as clouds. Water that has seeped into the earth’s crust (groundwater) is more difficult to see, yet all these forms of water are part of a dynamic interrelated flow that we call the water cycle. It is illustrated below:

![Water Cycle Diagram]

Each of the segments of the water cycle shares a portion of the total amount of water on the planet.

Students tend to think of the water on the planet as being limitless and yet simple calculations demonstrate the fact that the amount of water is limited. Scientists believe that all the water that we will ever have is on the earth right now. Whatever amount is available to humans and wildlife depends largely on how its quality is maintained. Human beings have a responsibility to conserve water, use it wisely and protect its quality.

The major purpose of this activity is for students to acquire an understanding of how fragile a resource water actually is.

MATERIALS
a large display map of the world; a 12-inch diameter globe (one showing the ocean bottom is best); a five or ten-gallon aquarium; bucket, trash can, or other container; writing materials; calculators; measuring cup; one quart container for every three students; one measuring tablespoon for every three students.

PROCEDURE
NOTE: Refer to the table in the Variations to this activity for the metric approximations.

1. Using a map of the earth, begin a discussion of how much water is present. Ask the students to comment on why the earth is called “the water planet.” Call the students’ attention to the statistic that between two-thirds and three-fourths of the surface is covered with water. After general discussion, provide the students with the following statistics:

**Water on Earth**

<table>
<thead>
<tr>
<th>Type of Water</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceans</td>
<td>97.2%</td>
</tr>
<tr>
<td>All icecaps/glaciers</td>
<td>2.0%</td>
</tr>
<tr>
<td>Groundwater</td>
<td>0.62%</td>
</tr>
<tr>
<td>Freshwater lakes</td>
<td>0.009%</td>
</tr>
<tr>
<td>Inland seas/salt lakes</td>
<td>0.008%</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>0.001%</td>
</tr>
<tr>
<td>All rivers</td>
<td>0.0001%</td>
</tr>
<tr>
<td>Total</td>
<td>99.8381%</td>
</tr>
</tbody>
</table>

2. Discuss the relative percentages. Do the calculations for them or ask the students to calculate the estimated amounts of fresh water potentially available for human use:

<table>
<thead>
<tr>
<th>Water Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>0.62%</td>
</tr>
<tr>
<td>Freshwater lakes</td>
<td>0.009%</td>
</tr>
<tr>
<td>Rivers</td>
<td>0.6291%</td>
</tr>
<tr>
<td>Including icecaps/glaciers</td>
<td>2.0%</td>
</tr>
<tr>
<td>Total</td>
<td>2.6291%</td>
</tr>
</tbody>
</table>

3. In discussing these figures, emphasize that the usable percentage of existing fresh water is reduced by pollution and contamination. Also, all the groundwater is not available and icecaps certainly are not readily available. Discuss the needs of humans for usable fresh water. Ask the students to consider what other life forms need both fresh and saline (salt) water.

4. Now show the students five gallons of water in an aquarium. Tell them how much is there. Provide the students with the following quantity: 5 gallons = 1280 tablespoons.

5. Have the students assume that the five gallons represent all the water on earth. Do the calculations for them, or ask the students to calculate the volume of all the other quantities on the water percentage list. This will require the use of decimals. Remind the students that for multiplication, all the decimal places must be shifted two places to the left so that 97.2% becomes 0.972 prior to multiplication; e.g. 0.972 x 1280 tablespoons = 1244.16 tablespoons. The following values result:

<table>
<thead>
<tr>
<th>Source</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oceans</td>
<td>1244.16</td>
</tr>
<tr>
<td>2. Icecaps/glaciers</td>
<td>25.60</td>
</tr>
<tr>
<td>3. Groundwater</td>
<td>7.93</td>
</tr>
<tr>
<td>4. Freshwater lakes</td>
<td>0.11</td>
</tr>
<tr>
<td>5. Inland seas/salt lakes</td>
<td>0.1</td>
</tr>
<tr>
<td>6. Atmosphere</td>
<td>0.0128</td>
</tr>
<tr>
<td>7. Rivers</td>
<td>0.0012</td>
</tr>
<tr>
<td>Total</td>
<td>app. 1280 Tablespoons</td>
</tr>
</tbody>
</table>

6. Once the values are obtained, ask the students to calculate the volume of the water other than ocean water. (It is approximately 34 tablespoons.) Ask them to divide up in teams of three and put 34 tablespoons of water in a container and take it to their workplace.

7. At their workplaces, ask the students to remove the amount of water represented by all freshwater lakes and rivers. (It is 0.111 tablespoons, approximately one-tenth of a tablespoon.) Then ask the students to extract the amount represented by rivers. (It is one-thousandth of a tablespoon.) This is less than a drop. Discuss the relative proportions with the students.

8. Consider the fragile nature of the freshwaters, wetlands and oceans of our planet. Discuss how all species depend upon this minute percentage of water for their survival. Summarize the activity by using an earth globe to illustrate that if the earth were this size (12 inches in diameter,) less than one-half cup (eight tablespoons) of water would fill all the oceans, rivers, lakes and icecaps. Close by emphasizing the importance of keeping the earth’s waters clean and healthy and—when we do use waters—using them wisely and responsibly.

NOTE: For younger students this activity may be modified into a demonstration. It also can be modified into a step-by-step activity with a list of the quantities given the students.
VARIATION
Do this activity using the metric system. This approach is particularly well suited for younger students. (The metric system allows students a chance to relate percentages directly to measurement units.) The table below shows the results of calculating “Water on Earth” percentages based on 1 dekaliter (1 dekaliter = 10 liters).

1 DEKALITER (10,000ml)
1. Oceans 9,720.0 ml
2. Ice Caps/Glaciers 200.0 ml
3. Groundwater 62.0 ml
4. Freshwater Lakes 0.9 ml
5. Inland Seas/Salt Lakes 0.8 ml
6. Atmosphere 0.1 ml
7. All Rivers 0.01 ml
8. Unaccounted for 16.19 ml

This table shows metric approximates for the quantities used in this activity.

EXTENSIONS
1. Create a mural of the water cycle that graphically includes the statistics that represent the relative amount of water in each component of the cycle.
2. Calculate how much pollution is entering our waterways each year. The Information Please Almanac and The Cousteau Almanac are good sources for such information.
3. Calculate the size of a model of the earth that would accommodate all the water in the aquarium used in the demonstration.
4. Which wildlife habitats require the most water?

EVALUATION
1. Estimate the percentage of water that is distributed in each of the following areas of our planet: oceans, rivers, freshwater lakes, inland seas and saltwater lakes, groundwater, icecaps and glaciers, and the atmosphere.
2. Explain why it is important that humans use water responsibly.
What might make a watershed blue...or brown...or green?

**Summary**
Through interpretation of maps, students observe how development can affect a watershed.

**Objectives**
Students will:
- recognize that population growth and settlement cause changes in land use.
- analyze how land use variations in a watershed can affect the runoff of water.

**Materials**
- Maps and photographs of community, past and present (optional)
- Copies of Maps A, B, and C
- For Option 1:
  - Colored pencils
- For Options 2 and 3:
  - Calculator
  - Copies of the chart *Area of Land Coverage*
  - Copies of the chart *Volume of Rain and Volume of Runoff*

**Making Connections**
Learning about the past refines our current perspectives and helps us plan for the future. Historical, sequential maps provide graphic interpretations of watershed history. By comparing past and current land use practices, students can recognize trends in development; this knowledge can help them appreciate the importance of watershed management.

**Background**
Resource managers and policymakers use maps to monitor land use changes that could contribute to increased amounts of runoff flowing into a river. Vast amounts of public and private time, energy, and money have been invested in research projects specifically designed to collect land use data. Land uses that are monitored include, but are not limited to: urban (residential, parks, and businesses); agriculture (pastures and corn, soybean, wheat, sunflower, tomato, pineapple, and lettuce production); industry; transportation systems (roads, railroads, and trails); and public lands (refuges, parks, and monuments).

Land use changes can have significant impact on a region’s water resources. Streams, lakes, and other bodies of water collect water drained from the surrounding land area, called a watershed or drainage basin. After periods of precipitation or during snowmelt, surface water is captured by the soil and vegetation, stored in groundwater and in plants, and slowly released into the collection site (e.g., a stream).

Resource managers are developing and using Geographic Information Systems (GIS) to store data and generate land use maps electronically. Although the process of collecting the data is tedious work, the ease of generating usable maps and map overlays is significant. For example, a water manager could generate a map that shows a river’s watershed and major tributaries, its floodplains, and the locations of urban dwellings (homes and businesses), to display areas likely to be impacted by floods. This information is valuable to local governments, planners, Realtors, bankers, homeowners, and others. This map could also be compared to similar land use maps from 10, 20, or 30 years ago.
One way watershed managers study drainage basins is by measuring streamflow. Determining how much water is discharged by a watershed involves measuring the amount of water (volume) that flows past a certain point over a period of time (velocity). Streamflow is measured in cubic feet per second (cfs) or cubic meters per second (cms).

By measuring the amount of water flowing through a stream channel over a period of years, scientists calculate average streamflow. When streamflow changes significantly from its normal quantities, watershed managers investigate reasons for this anomaly. The amount of water discharged by a watershed is influenced by soil conditions, vegetative coverings, and human settlement patterns. Wetlands, forests, and prairies capture and store more water than paved roads and parking lots. Consequently, urban areas will have more runoff than areas covered with vegetation.

Water managers carefully assess land use changes and set development policy accordingly. For example, in areas that are susceptible to erosion, the incorporation of soil conservation measures (e.g., planting cover crops on farmland and establishing grassed waterways) can significantly reduce erosion and stream sediment load. Managers may designate lands so susceptible to erosion that landowners are required to plant vegetation on them. In urban areas, local governments may set aside natural areas to serve as filters for storm water runoff, based on runoff data and stream water quality problems. In each situation, using maps to understand past and present land use helps water managers better predict future problems.

Sample GIS map.

**Procedure**

▼ **Warm Up**

What did the land and water around cities like Los Angeles, Portland, Minneapolis, Houston, Chicago, New Orleans, Miami, or Washington, D.C., look like 100 or 50 years ago? How has growth changed each region? Ask students to imagine their community 100 years ago. They may want to refer to old photographs or news stories. Was the school in existence? What happened when water fell on the ground then, compared to now? If a body of water is near the school, would its appearance and condition have been altered over the years? Tell students that maps can teach us about the past and possibly answer questions such as these.
\textbf{The Activity}

Provide students with copies of Maps A, B, and C. Explain that they represent aerial views of a watershed taken at different times. To simplify map interpretation, the borders of the watershed coincide with the edges of the grid. In addition, the outlines of various land areas (e.g., wetlands, forests) align with grid lines.

Following are three options for interpreting changes in the watershed presented on the maps. The first option may be more appropriate for younger students, but can help all students complete Options 2 and 3. Students should be able to multiply and calculate percentages to complete the second and third options.

Option 1
1. Tell students to look at Maps A, B, and C. Explain that they represent changes in this land over a 100-year period. Have students look at the key for each map. Instruct them to designate each land area with a different color (e.g., color all forest areas green). They should use the same color scheme for all maps.

2. When students finish coloring, have them compare the sizes of the different areas on each map and among maps. Ask them to compare plant cover and land use practices in each of these periods. They may note changes in croplands, forests, grasslands, wetlands, urban land uses, etc.

3. Discuss one or more of the following questions:
   - What happens to the amount of forested land as you go from Map A to Map C?
   - Which map has the most land devoted to human settlements?
   - Where are most of the human settlements located?
   - What effect might these human settlements have on the watershed?
   - Would you have handled development differently?

Option 2
1. Have students determine the land area of each of the maps. Each unit in the grid represents 1 square kilometer; there are 360 square kilometers (or 360,000,000 m\(^2\)) on each map.

2. For each map, have students determine how much area is occupied by each type of land coverage (e.g., forest, wetland, and farmland). Responses can be guesses or exact calculations. For example, for Map A, 17 of the grid units are occupied by wetlands. By dividing 17 by the total number of units (360), students should calculate that 4.7% of the land area is wetlands. The amount of land allotted to wetlands, forests, etc. will change for each map, but the amount of stream coverage (111 squares or 30.8%) will remain constant. Students should record their answers in the \textit{Area of Land Coverage} chart.

\textbf{NOTE:} Most watershed calculations employ standard measurements: inches and cubic feet per second (cfs). However, to facilitate students' computations, metric measurements are used here.

3. Tell students that the watershed has received 5 cm (0.05 m) of rain. (Although rain does not normally fall evenly over a large area, assume that the 5 cm of rain fell evenly over the entire watershed.) By converting both the rainfall and the land area to meters, students can calculate the amount of water (m\(^3\)) which fell on the land. 18,000,000 m\(^3\) of rain fell on the watershed (0.05 m x 360,000,000 m\(^2\) = 18,000,000 m\(^3\)). Of this 18,000,000 m\(^3\) of rain, 5,550,000 m\(^3\) landed on the stream (111,000,000 m\(^2\) x 0.05 m = 5,550,000 m\(^3\)). This might seem like a large quantity of water, but if 5 cm of rain did fall evenly on a watershed of this size, the stream would receive this volume of water. (\textbf{NOTE:} 100 cm = 1 m; 1,000,000 m\(^2\) = 1 km\(^2\).)

4. Ask students to estimate the amount of water that would be drained from the land into the stream. Tell students that for the watershed represented by Map A, 2,767,500 m\(^3\) of rain was runoff (i.e., the water flowed into the stream and did not soak into the ground, did not evapo-

\textbf{ANSWER KEY: AREA OF LAND COVERAGE3E}

<table>
<thead>
<tr>
<th></th>
<th>MAP A</th>
<th>MAP B</th>
<th>MAP C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 years ago</td>
<td>50 years ago</td>
<td>Present</td>
</tr>
<tr>
<td>Land coverage</td>
<td>(\text{km}^2)</td>
<td>(%)</td>
<td>(\text{km}^2)</td>
</tr>
<tr>
<td>Forest</td>
<td>189</td>
<td>32.7</td>
<td>162</td>
</tr>
<tr>
<td>Grassland</td>
<td>30</td>
<td>5.6</td>
<td>14</td>
</tr>
<tr>
<td>Wetland</td>
<td>17</td>
<td>4.7</td>
<td>13</td>
</tr>
<tr>
<td>Residential</td>
<td>13</td>
<td>3.6</td>
<td>33</td>
</tr>
<tr>
<td>Agriculture</td>
<td>10</td>
<td>2.8</td>
<td>27</td>
</tr>
<tr>
<td>Stream</td>
<td>111</td>
<td>30.8</td>
<td>111</td>
</tr>
</tbody>
</table>
rate, and was not used by plants or animals). (Runoff volumes are provided in the Answer Key below. In Option 3, students can calculate runoff for each land area.)

5. Discuss changes in land coverage represented in Maps A through C. Ask students if they think the amount of runoff would increase or decrease.

6. Tell students that when 12,450,000 m³ of rain fell on the land represented by Map A, 2,767,500 m³ was runoff. For Map B, 3,612,500 m³ was runoff. For the Map C, 4,797,500 m³ was runoff. Discuss the following questions in addition to those listed in Option 1.
   - Which absorbs more water, concrete or forest (or wetlands or grasslands)?
   - Which map represents the watershed that is able to capture and store the most water?
   - What problems could arise if water runs quickly over surface material, rather than moving slowly or soaking in?
   - How might the water quality of the stream be affected by changes in the watershed?

Option 3

Have students determine how the figures in Option 2 were obtained. In the chart Volume of Rain and Volume of Runoff, each land area has been assigned a proportion of the water that is not absorbed or that runs off its surface. Using the information from this chart and from the Area of Land Coverage chart, have students calculate the amount of water each land area does not absorb. For example, for the forested land in Map A, 189 km² x 1,000,000 m²/km² = 189,000,000 m³ of land. Multiply this by the amount of rainfall (189,000,000 m² x 0.05 m = 9,450,000 m³). Since 20% of the rainfall was runoff, 1,890,000 m³ of water drained into the stream from the forested land (9,450,000 m³ x .20).

NOTE: The figures for percent runoff are based on hypothetical data. To determine how much water is absorbed by surface material, one needs to know soil type and texture, slope, vegetation, intensity of rainfall, etc. In addition, many farms and urban areas practice water conservation measures that help retain water.

ANSWER KEY: VOLUME OF RAIN AND VOLUME OF RUNOFF

<table>
<thead>
<tr>
<th>Land coverage and % runoff</th>
<th>MAP A 100 years ago</th>
<th>MAP B 50 years ago</th>
<th>MAP C Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>volume m³</td>
<td>runoff m³</td>
<td>volume m³</td>
</tr>
<tr>
<td>Forest 20% runoff</td>
<td>(9.45 x 10⁶)</td>
<td>(1.89 x 10⁶)</td>
<td>(8.1 x 10⁶)</td>
</tr>
<tr>
<td>Grassland 10% runoff</td>
<td>(1.0 x 10⁶)</td>
<td>(.7 x 10⁶)</td>
<td>(1.0 x 10⁶)</td>
</tr>
<tr>
<td>Wetland 5% runoff</td>
<td>(.85 x 10⁶)</td>
<td>(.65 x 10⁶)</td>
<td>(1.65 x 10⁶)</td>
</tr>
<tr>
<td>Residential 90% runoff</td>
<td>(.65 x 10⁶)</td>
<td>(.585 x 10⁶)</td>
<td>(1.65 x 10⁶)</td>
</tr>
<tr>
<td>Agriculture 30% runoff</td>
<td>(.5 x 10⁶)</td>
<td>(.15 x 10⁶)</td>
<td>(1.35 x 10⁶)</td>
</tr>
<tr>
<td>Total runoff</td>
<td>2,767,500</td>
<td>3,612,500</td>
<td>4,797,500</td>
</tr>
<tr>
<td>Total runoff plus stream discharge (5,550,000 m³)</td>
<td>(8.3175 x 10⁹)</td>
<td>(9.1625 x 10⁹)</td>
<td>(10.347 x 10⁹)</td>
</tr>
</tbody>
</table>
and prevent it from streaming over the surface. The information in the chart is intended only for practice and comparisons.

**Wrap Up and Action**

Have students summarize how changes in the land affect the quantity and quality of runoff in a watershed. Discuss land use practices in the community and how they may affect water discharge in the watershed. Take students on a walking tour around the school and community, and note areas that contribute to or reduce storm runoff. (For example, parking lots, paved roads, and sidewalks promote runoff; parks, wetlands, and trees capture water.)

Students could attend a public meeting in which changes in land use for their community are being discussed.

If students were to draw a fourth map of the same area 100 years in the future, how would it appear? Have students plan a city that contributes positively to a watershed. They should contact city planners or conduct library research to support their projections.

**Assessment**

Have students:
- compare land area occupied by farms, towns, and natural areas in a watershed during different time periods (Options 1 and 2).
- describe how surface runoff is influenced by changes in land use (Option 2).
- calculate quantities of runoff from different land areas in a watershed (Option 3).

Upon completing the activity, for further assessment have students:
- design a city plan that regulates urban runoff.

**Extensions**

Have students explore changes in their own community. Sources of historical and current maps include the Natural Resource Conservation Service, the Bureau of Land Management, the U.S.D.A. Forest Service, the U.S. Geological Survey, or a local public works department. Sometimes libraries contain historical, hand-drawn maps from the 1700s to the 1900s. Resource people in these agencies or the community will also have information and perspectives about past, present, and future water use.

Students may want to conduct a more accurate analysis of the degree to which different surface areas are permeable to water. Contact conservation agencies or extension agents in the community to learn how different soil types affect runoff.

Several books for young people powerfully describe and illustrate the effects of human development on land areas. Students may want to compare the changes indicated by the maps to changes portrayed in *Window*, by Jeannie Baker, or other sources.


Or e-mail cfitzpatrick@esri.com for information about how to order and use ArcView, a computer program that enables learners to investigate GIS files.

**Resources**


**Notes ▼**
**Chart for Option 2**  
**AREA OF LAND COVERAGE**

<table>
<thead>
<tr>
<th>Land coverage</th>
<th>MAP A 100 yrs. ago</th>
<th>MAP B 50 yrs. ago</th>
<th>MAP C Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km(^2)</td>
<td>%</td>
<td>km(^2)</td>
</tr>
<tr>
<td>Forest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grassland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stream</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Chart for Option 3**  
**VOLUME OF RAIN AND VOLUME OF RUNOFF**

<table>
<thead>
<tr>
<th>Land coverage and % runoff</th>
<th>MAP A 100 years ago</th>
<th>MAP B 50 years ago</th>
<th>MAP C Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>volume m(^3)</td>
<td>runoff m(^3)</td>
<td>volume m(^3)</td>
</tr>
<tr>
<td>Forest 20% runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grassland 10% runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland 5% runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential 90% runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture 30% runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total runoff plus stream discharge (5,550,000 m(^3))</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Map A

100 YEARS AGO

KEY

AGRICULTURAL
RESIDENTIAL
WETLANDS
GRASSLANDS
FOREST
STREAM

Color Me a Watershed
Project WET Curriculum and Activity Guide
Map B

50 YEARS AGO

KEY

AGRICULTURAL
RESIDENTIAL
WETLANDS
GRASSLANDS
FOREST
STREAM
Changes Over Time

Activities:

Excavating Your Recycling Bin as a Fossil Record

Designer Animal - Animal Adaptations
TITLE:
Excavating Your Recycling Bin as a Fossil Record

GRADE LEVEL:
Grades 6-12

RESOURCES/MATERIALS:
trash can, students, and work sheet

Your recycling bin and two views of it for labeling

OVERVIEW: We are going to simulate how scientists study the past. Scientists use layers of rock with fossils to understand the past. (These layers of rock are called 'STRATA')

OBJECTIVE(s):
1 Relative of Rock layers (Oldest deposited on bottom)
2 Describe objects in trash as events occurring through time
3 Fossil record is in 3-D
4 Collection of accurate data is critical

ACTIVITIES AND PROCEDURES:
1 Students divided into groups
2 Each group will be allowed to excavate ___ cm of paper from the recycling bin. Each group assigned a different layer of paper. Try to learn as much as they can about their layer.
3 Record data on the outlines given. There is a top view and side view of the recycling bin. Facts that may be useful: subject, dates, teachers names, position of paper, type of paper, Xerox or ditto.

Example of where to record data

<table>
<thead>
<tr>
<th>Mr. Smith's Quiz</th>
<th>Xerox Math</th>
<th>etc.</th>
<th>1cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Students write data collected here as a side view. However, another view from the top of the bin can also be labeled.

TYING IT ALL TOGETHER: Students can see that papers in bin are similar to the fossil record in that deposition of papers in the recycling bin are events through time like the changing fossil record. Fossil record is in 3-D. Accurate data is necessary before destroying sequence.
Title - Designer Animal - Animal Adaptations

Primary Subject - Science
Secondary Subjects - Science
Grade Level - 5 - 8
This is a useful lesson for teaching animal adaptations. It fits well with Science or Social Studies when examining endangered animals etc. This lesson introduces students to, or extends students’ knowledge on, the concept of adaptation in animals – the idea that certain animals have developed features which help them survive in their environment. With older children, this can lead into the concept of ‘survival of the fittest’, which could be integrated with a unit of work in SOSE (Darwinism, Nazism, etc.). From this lesson, students will show their understanding of the concepts discussed in a creative way.

Lesson Format
Begin lesson by talking about animals which have physical features which make them well suited to their environment (with older children: survival of the fittest). This includes animals which are camouflaged to their habitat, features which allow animals to survive in their climate, and features which allow animals to get food and defend themselves. Physical features include:

- Elephant – trunk
- Giraffe – neck
- Echidna – spines
- Gecko – fake tail
- Kangaroo – hind legs
- Goat – surefootedness
- Bright colors indicating poisonous
- Shark – sense of smell
- Hunting dogs - ears
- Lion – color, claws
- Polar bear – coat, color, claws
- Skunk - smell
- Zebra – what happened there?
- Sloth – can be man-made

Animals gain and adapt their physical features over millions of years, but our task today is going to cut down that time just a little - you are going to design an animal which is perfectly suited to its environment.

Background Information: It is the future, the year 3000, and it is now possible for humans to build planets, and genetically engineer or create plants and animals to live on that planet. You are one of the scientists working on the animals, and it is your job to design and create an animal which will be perfectly suited to its environment on this new planet.

Task: You need to pick one of the following environments of already created planets and create an animal which is going to be strong and resilient enough to survive in that environment. You need to consider how this animal is going to stay warm or cool, what it is going to eat, how it is going to get its food and water, and how it is going to care for its young to make sure they survive. Your animal must FIT INTO the existing food chain - it cannot be the ultimate predator (the one which can eat everything else and nothing can eat it).
ENVIROMENTS
Select 1 of the following:

1: This planet is dark and cold most of the time. It is very mountainous. It rains almost all day. Because of the wet, dark conditions, the only plants that grow well are small mosses and funguses. Animals on this planet include a type of mouse, a nocturnal hunting large cat, fish, and a variety of insects.

2: This planet is dry and hot. Most of the planet is flat. Water is found in underground streams but there is little water on the surface of the planet. Most of the planet’s surface is covered in sand, although there are patches of dry grass. When plants can get their roots down into the water table, they grow into tall trees with leaves at the top but not along the trunk. Plants which are not connected to the water table are small and dry, but they are edible. Animals on this planet include insects, a species of birds which roost in the high trees, a sand-colored lizard and a type of rat.

3. This planet is tropical: wet and hot. Most of the planet is covered by rainforest. The planet is very flat. Water collects in large pools and lakes which have water in them all year ‘round. A species of poisonous plant grows thickly on the ground. The spines of this plant are poisonous, and any animal which steps on one is sure to die. The vegetation is plentiful, and includes leaves, fruits and nuts. Animals include carnivorous snakes, varieties of insects, monkeys, fish and birds.

4. This planet has a moderate climate. It never gets very hot or very cold, but stays mild all year ‘round. It rains for part of the year and the water forms pools and lakes which dry up towards the end of the year and then the planet is very dry. The planet is partly mountainous and partly flat. Vegetation includes tall trees with high leaves and fruit, and a smaller plant which bears nuts. However, these nuts are inside hard shells which need to be removed before the nut can be eaten. Animals include rats and mice which live underground, insects, birds that nest in the tall trees, slow moving mammals which also live in the trees and a species of carnivorous nocturnal wolf.

When you are designing your animal consider the following:

- Size
- What does it eat?
- How will it catch/get food and water?
- How will it keep warm/cool
- Where will it shelter?
- How will it protect/defend itself from attackers?

In the rest of the space, which should be almost a page, you need to draw a labeled picture of your creature. If you wish, you may just draw arrows from your list of criteria to your picture rather than write it all out again. Give your animal a name and congratulations! You’ve created a new animal!
Assessment

- Has the student fulfilled all parts of the task?
- Has the student chosen features which allow the animal to survive in this environment?
- Is it neatly presented and labeled?
Genetics

Activities:

Mixed – Plate Biology, Hawaiian Style: Hawaiian Pineapple

Formation of a Biological Company

Feast or Famine? Are Genetically Modified Organisms the Answer?

Saving America’s Endangered Species
MIXED-PLATE BIOLOGY, HAWAIIAN STYLE: HAWAIIAN PINEAPPLE

Submitted by: Randyll Warehime
W. R. Farrington High School
Honolulu, Hawaii.

The pineapple (*Ananas comosus*) is a monocot that belongs to the bromeliad family. It is thought to have originated in Brazil and the first record of its introduction to Hawaii is in 1813. In 1900 James B. Dole, whose father was a cousin of Governor Sanford B. Dole, began growing and canning pineapple in central Oahu. By 1958, pineapple had become America's second most important fruit and Hawaii led the world in both quantity and quality of pineapples. The Hawaiians called pineapple *hala-kahi*ki, meaning *hala* (an indigenous plant used to make woven mats) from a foreign land and though everyone associates pineapple with Hawaii, most production has moved back to foreign lands. Now, only a relatively small acreage is used for the fresh fruit market, all canned pineapple comes from overseas, largely from the Philippines. (Neal, 1965)

The pineapple fruit contains the protein degrading enzyme bromelain, which is extracted and sold in such products as Schilling's Meat Tenderizer. Papaya contains a functionally analogous enzyme.

**TOPIC: Enzymes; Digestive System**

**MATERIALS:**
- Fresh pineapple, 1 (can be frozen and used later)
- Canned pineapple, 1
- Jello, 2 small boxes any flavor
- Bowl, 1
- Boiling & Cold water, 4 cups each
- Spoon, 1
- Paper cups
- Knife, 1

**PROCEDURE:**
If students will eat the gelatin desserts, follow standard sanitary precautions. This is intended to be a demonstration lesson.

1. Cut the fresh pineapple into cubes.
2. Make Jello according to instructions on box.
3. Put one piece of canned pineapple into half of the paper cups and one piece of fresh pineapple into the other half of the cups.
4. Refrigerate until set. It usually takes longer than one period.
5. Assign homework: "Which Jello would you like tomorrow and why?" or some sort of variation on that theme.
7. Follow-up question: "What is meat tenderizer and what does it do?"

**DISCUSSION:**
Jello consists of gelatin (a protein), sugar, and flavoring. Gelatin protein is insoluble. Amino acids, the building blocks of protein, are soluble. The Jello made with canned pineapple gels and that which is made with fresh pineapple doesn't. The bromelain enzyme in the fresh pineapple degrades the gelatin protein; digests it into a bowl of amino acids—still nutritious!! During the canning process, pineapple is heated to a temperature high enough to denature the bromelain enzyme (a protein itself) making it functionless. Thus, the gelatin protein molecules remain intact and insoluble.

**EXTENSIONS:**
What other fruits contain protein-digesting enzymes? Using fresh pineapple, determine the temperature at which the enzyme denatures.
Formation of a Biological Company

Miriam Turner

Rationale:
In forming a functional company, the students will be able to identify biological concepts and facts through investigative procedures as well as:

1. be able to apply biological concepts to environmental issues.
2. recognize the impact of biological concepts on the food chain.
3. understand the financial involvement of biological concepts.
4. improve cooperative learning skills.

Materials:
Heath Biology text Supplemental materials

Procedure:

Day 1

1. Teacher presentation of biological concept (1 session)
2. Handout of chapter/concept outline
3. (homework) Assignment of reading/questions

Day 2

1. Formation of company
   - President
   - Environmental specialist
   - Biological research engineer
   - Financial consultant
   - Government representative
2. Explanation of job responsibilities
3. Presentation of problem
4. Presentation of problem questions
5. (homework) Research of problem

Day 3

1. Development of laboratory experience based on view/responsibilities of company position
2. Company meeting to compare/adjust proposals
3. (homework) Reevaluate laboratory experience and prepare procedure

Day 4

1. Laboratory experiences in specific areas of company assignment
2. (homework) Laboratory write-up per job assignment
Day 5-6

1. Resolution of problem as cooperative group
2. Preparation of group presentation

Day 7

1. Wrap up of unit
2. Evaluation through teacher selected activity

Role Responsibilities

President-director of company

1. Responsible for setting company goals with company
2. Responsible for understanding all aspects of problem
3. Responsible for overall running of company

Environmental specialist

1. Responsible for research on environmental issues of problem
2. Responsible for meeting government regulations
3. Responsible for implementation of solution

Biological research engineer

1. Responsible for understanding biological concepts and facts
2. Responsible for research related to biological functioning
3. Responsible for presenting knowledge of future impact and changes of biological component

Financial consultant

1. Responsible for cost analysis and long range cost planning for problem resolution
2. Responsible for improving company financial status

Government representative

1. Responsible for knowing government regulations regarding problem resolution
2. Responsible for development of guidelines for company plans

Total Group Member Responsibilities

1. Work cooperatively with each group member
2. Thoroughly perform individual responsibilities
3. Present required prepared material on deadline dates
4. Verbally/written input from each group member

**Grading**

1. Each group member will be graded individually for contribution
2. Total group grade will be given for final presentation
3. Individual grades will be given daily for participation/production
4. Group grades will be given daily for cooperative participation/production
5. Individual group member grades will be given for homework assignments

**Grading Components** (Extra Credit for exceptional contributions)

1. Assignments 20%
2. Group contributions by individuals 20%
3. Daily individual grades 10%
4. Daily group activity grades 10%
5. Final presentation by group 25%
6. Individual Evaluation 15%
FEAST OR FAMINE?
Are GMO's (Genetically Modified Organisms) the Answer?

GRADE LEVELS
10-12

TIME ALLOTMENT
Four class periods of 45-minutes each

OVERVIEW
In this lesson students will learn about what genetically modified organisms (GMO's), how they are modified, and the pros and cons to using them. They'll investigate Web resources to answer fundamental questions about and to understand the issues around the development and use of GM foods. Students will share this information as "experts" in a roundtable discussion. The lesson concludes with students writing a position paper to outline their recommendations for the development and use of GMO's backed by the scientific basis for these reasons. These papers will then be presented to a mock congressional committee making decisions on the development and use of GMO's.

SUBJECT MATTER
Science

LEARNING OBJECTIVES
Students will be able to:
• Identify what foods are currently genetically modified.
• Determine how plants are genetically modified using current terminology: vectors, cloned gene, and transfection.
• Identify the advantages and disadvantages of genetically modifying foods.
Analyze the arguments supporting and discouraging the use of GMO's.

STANDARDS
The Maine Learning Results Standards:
http://www.state.me.us/education/lres/lres.htm

Science and Technology
A. Classifying Life Forms, grades 9-12
   Students will understand that there are similarities within the diversity of living things.
   1. Explain the role of DNA in resolving questions of relationship and evolutionary change.
   3. Analyze the basic characteristics of living things including their need for food, water, and gases and the ability to reproduce.

B. Ecology, grades 9-12
   Students will understand how living things depend on one another and on non-living aspects of the environment.
   3. Analyze the factors that affect population size (e.g., reproductive and survival rates).
   4. Analyze the impact of human and other activities on the type and pace of change in ecosystems.

C. Cells, grades 9-12
   Students will understand that cells are the basic units of life.
   2. Illustrate how cells replicate and transmit information, including the roles of DNA and RNA.
   5. Analyze and debate basic principles of genetic engineering: how it is done, its uses and some ethical implications.

D. Continuity and Change
   Students will understand the basis for all life and that all living things change.
   1. Explain how mutations can be caused by gene mutation or chromosomal alteration and describe the possible results of such mutations on individuals or populations.
   4. Describe how genetic manipulation can cause unusually rapid changes in species.
NATIONAL SCIENCE EDUCATION STANDARDS
F. Science in Personal and Social Perspectives
   Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. Pollution is a change in the environment that can influence the health, survival, or activities of organisms, including humans.

MEDIA COMPONENTS
Video
PBS: Frontline: "Harvest of Fear;"
A Frontline/NOVA Special

Web sites
Frontline: Harvest of Fear
http://www.pbs.org/wgbh/harvest
This Web page is designed to answer questions raised by the video. Shockwave and Flash plug-ins are required to access this site.

Colorado State University Transgenic Crops: An Introduction and Resource Guide
http://www.colostate.edu/programs/lifesciences/TransgenicCrops/
The site gives an introduction and resource guide to transgenic crops.

MATERIALS
Per class
• VCR and TV
• Computers and Internet access

Per student
• GUESS WHAT'S COMING FOR DINNER? Worksheet
• HARVEST OF FEAR Worksheet
• ENGINEER A CROP Worksheet
• GUESS WHAT'S COMING FOR DINNER? Worksheet
PREP FOR TEACHERS
- Bookmark all Web sites.
- Load the plug-ins Shockwave and Flash plug-ins onto the computer(s).
- Preview the video and cue it the appropriate starting point.
- Make a copy of each student worksheet for every student.

INTRODUCTORY ACTIVITY
Step 1
Have students explain how traditional plant breeding happens. Write their explanations on the board as they respond.
- Traditional breeding involves all the genetic materials from two related plants. The pollen from one is transported from the anther to the stigma of another. The seeds will have the desired combination of traits (hybrid).

Step 2
Ask students how define Genetically Modified Organisms. Discuss students' answers.
- The terms "GM foods," or "GMO's," are most commonly used to refer to crop plants created for human or animal consumption using the latest molecular biology techniques.

Step 3
Ask if students can explain or predict the process of genetic engineering and how it differs from traditional breeding.
- In genetic engineering, you are transferring one or two desired genes that are new to a plant. The source of the genes does not have to be closely related. Genetically modified foods are plants in which one or two genes have been inserted to give them a specific trait.)

Step 4
Explain that students will be working in teams of two to learn as much as each student can about how plants are genetically modified and the issues surrounding their use. Distribute the HARVEST OF FEAR Worksheet to each student. Ask students to read through the question as you CUE the PBS video, "Harvest of Fear." Provide students with a Focus for Media Interaction: instruct them to write their answers on their Worksheet as they identify the answers while viewing the
video. **START** the video at the beginning of the tape. **STOP** the video after about 40 minutes at the AUDIO CUE of the Minnesota farmer describing what they wear when they spray for pesticides. You will hear the farmer say, "Don't want the grandkids around. Those are the types of things we don't have to have around with BT corn."

Give students enough time to complete the worksheets. Once the worksheets are completed, discuss student answers.

**Step 5**
Provide students with a Focus for Media Interaction and distribute the GENETICALLY MODIFIED FOODS BENEFITS/RISKS Worksheet. Ask students to log on to the Colorado State University Transgenic Crops Web site at http://www.colostate.edu/programs/lifesciences/Transgenic Crops/. Give students an opportunity to read through the home page, then, ask students to click on the "Risks & Concerns" link on the navigational bar to the left. Have teams of students work through the sheet as they investigate this area of the site. They should be sure to cite any health, environmental, and economic risks and benefits they read about. Discuss the answers students recorded on their Worksheet.

**LEARNING ACTIVITY**
Assemble students into teams. Now ask them to log on the Harvest of Fear Web site at http://www.pbs.org/wgbh/harvest. Distribute the GUESS WHAT'S COMING FOR DINNER? Worksheet as a Focus for Media Interaction. Ask students to list any GM foods they find that are currently on the market. On the Web site, direct students to the "Guess What's Coming for Dinner" option. Then, students should click on the animation button to the right. There will be a fly circling a table of food. When students click on the plates of food, they will find a description of the food, the engineered traits, sources of new genes being tested, and the commercial name. Working with a partner, have students complete the GUESS WHAT'S COMING FOR DINNER? Worksheet. Discuss what students have learned about these genetically modified foods.
Provide a Focus for Media Interaction by distributing the ENGINEER A CROP Worksheet. While still on the Harvest of Fear Web site, have students click on the "Engineer a Crop" link from the home page. Ask the teams of students to answer the Worksheet questions about how selective breeding differs from transgenic manipulation.

- A transgenic crop plant contains a gene or genes that have been artificially inserted instead of the plant acquiring them through pollination. The inserted gene sequence (known as the transgene) may come from another unrelated plant, or from a completely different species: transgenic BT corn, for example, which produces its own insecticide, contains a gene from a bacterium. Plants containing transgenes are often called genetically modified or GM crops, although in reality all crops have been genetically modified from their original wild state by domestication, selection and controlled breeding over long periods of time.

Provide students time to complete the Worksheet. Discuss the answers students discovered.

CULMINATING ACTIVITY
Step 1
Ask students to formulate an opinion about GMO’s and provide scientific reasons why we should or shouldn’t use GMO’s. Instruct each individual student to write a position paper, providing information and scientific facts to substantiate their point of view. With their partner, students must prepare a presentation for another class. Students will be paired with another team that has the opposing view to present a debate to the audience.

If possible, have the second partner videotape the presentation while the other student speaks. Explain to students that their audience might know very little about the subject, and may understand none of the scientific facts about GMO’s. Stress that the presentations should be clear and descriptive.
Step 2
Students will read and/or present their position papers to their audience. Alternate proponent and opponent speakers and be sure that students are aware of timing their responses so that the opposing team of students has time to present their point of view. The speakers should leave enough time for questions and answers from the audience.

Back in the assigned class, have students report on their presentations to the other class, and, if possible, show the videotape. How did the audience react to each of the views? Discuss what types of questions the audience asked, making sure to present both the pro and con views of GMO's. Discuss whether the issues about the use of GMO's were presented appropriately.

CROSS-CURRICULAR EXTENSIONS
Social Studies
Take students on a field trip to meet with a state or federal legislator. Ask students to identify how policy is established for the use of new consumable products on the market. Have students identify the relationship between politics, economics, and science and report their findings and discoveries to the class.

Communication/Speech
Ask students to prepare a debate about the issue of labeling genetically modified foods.

COMMUNITY CONNECTIONS
Have students identify where starvation occurs in the world. What are the growing conditions in these areas? How much arable land is available for farming? What measures are currently employed in these areas to reduce starvation? Invite guest speakers from the standard farming community, the organic farming community, and farmers growing GMO's to present their opinions.
TEACHER RESOURCES

Biotechnology Industry Organization
http://www.bio.org/about.asp
This Web site gives the industry position on food and agricultural biotechnology. It includes discussion on food labeling and government regulation information and lists production or coming to market products.

Article by Channapatna S. Prakash
http://www.plantphysiol.org/cgi/content/full/126/1/8/view=full
20&pmid-11351063
An article that explains "The Genetically Modified Crop Debate in the Context of Agricultural Evolution."

Agribiological Foundation
http://www.agbioworld.org
This Agribiological Foundation site provides information on supporting the use of GMO's, including endorsements from famous scientists.

Union of Concerned Scientist
http://www.ucsus.org
This site gives information on biotechnology and genetically engineered crops.

HARVEST OF FEAR
Student Worksheet
**GUESS WHAT’S COMING FOR DINNER?**

Student Worksheet

Name: ____________________________

<table>
<thead>
<tr>
<th>Current GMO Foods on the Market</th>
<th>Engineered Trait(s)</th>
<th>Sources of New Genes</th>
<th>Commercial Name</th>
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## GENETICALLY MODIFIED FOODS

**Benefit / Risk Worksheet**

Names: ______________________ And ______________________

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<th>BENEFITS:</th>
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<th>ECONOMIC</th>
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HARVEST OF FEAR
Student Worksheet

NAME: ____________________________

1. What are "Frankenfoods?"

2. What is the importance of the papaya crop in Hawaii?

3. From what organism is the gene that is used to modify papaya?

4. How are these genes inserted into plants?

5. What is meant by the term "Transgenic?"

6. Where does the gene for BT corn come from?

7. Name two other crops that have been genetically modified:

8. Name one environmental consideration in support of GM foods:
1. What are "Frankenfoods?"
   • Answer: Genetically modified foods.

2. What is the importance of the papaya crop in Hawaii?
   • Answer: It is a major food source and economic crop in Hawaii.

3. From what organism is the gene used to modify papaya?
   • Answer: It came from a harmless gene from the ring spot virus.

4. How are these genes inserted into plants?
   • Answer: "Gene gun." Tiny tungsten balls with the gene of interest attached which are then fired into the leaf of the plant.

5. What is meant by the term "Transgenic?"
   • Answer: Containing genes from two different organisms.

6. Where does the gene for BT corn come from?
   • Answer: From the origin of the gene used: Bacillus theringiensis.

7. Name two other crops that have been genetically modified:
   • Answer: Potatoes, rice, cotton.

8. Name one environmental consideration in support of GM foods?
   • Answer: It reduces the amount of pesticides sprayed into the environment.
1. How would you produce a crop with a specific trait using selective breeding?

2. How many seasons or generations would it take to produce this new crop by selective breeding?

3. How do you make a plant transgenic?

4. How did you make the tomato crop insect resistant?

5. How many steps does it take to produce a transgenic plant?

6. Name two advantages to transgenic manipulation:

7. Name two disadvantages to transgenic manipulation:
ENGINEER A CROP
Teacher Answer Sheet

NAME: __________________________

1. How would you produce a crop with a specific trait using selective breeding?
   • Answer: A Farmer would save the seeds from the "best" plant and grow them next season.

2. How many seasons or generations would it take to produce this new crop by selective breeding?
   • Answer: Four seasons

3. How do you make a plant transgenic?
   • Answer: One or more genes are artificially inserted into the DNA of the plant's chromosomes. The gene can come from the same type of plant, but sometimes it comes from another types of plant or even another type of organism.

4. How did you make the tomato crop insect resistant?
   • Answer: You first add a gene to a vector, and then add the vector to Agrobacterium tumefaciens (a bacterium that causes disease in plants) by transferring a portion of its DNA into plant cells. This bacterium will grow and divide on a media plate. Now add small pieces of tomato plant leaf to the bacteria. The DNA of the bacteria enters the cells of the leaf. Move the plant cells to the growth medium for plants. Spray herbicide on the plant cuttings. Only the ones with the new gene will then survive.

5. How many steps does it take to produce a transgenic plant?
   • Answer: Six

6. Name two advantages to transgenic manipulation:
   • Answer: It is faster to develop and a less random process.

7. Name two disadvantages to transgenic manipulation:
   • Answer: Inserting new genes may lead to problems with resistance, allergenicity or toxicity. Report genes may also cause problems in the environment.
SAVING AMERICA'S ENDANGERED SPECIES

Background: Can you imagine a world without bald eagles, northern spotted owls, Hawaiian monk seals, or red wolves. Each of these species of the phylum Chordata is in danger of extinction. In a recent issue of Life magazine, 100 different endangered plant and animal species were discussed. The reasons for their endangered status includes: habitat destruction, predation, disease, and lack of adequate safeguards from excessive commercial, recreational, and scientific use. Before humans arrived on the planet, one species out of a million died out every year; and these, due to natural causes. Now, with pesticides, pollutants, and sophisticated technology, we are killing tens of thousands of species every year. If we continue at this rate 1/5 of the life forms will be extinct within 30 years.

Purpose: What are the causes and possible solutions to the endangered status of a particular endangered chordate from North America?

Procedures:

This endangered species project will be produced in the form of a newsletter. Each group of students will select one of the many species and do research on it. Each group will have to produce a news letter about the species. The final copy of the newsletter must be word processed on a computer. Student groups may have up to 4 members, but no two groups may use the same species. To give every group a fair chance, the group's species will be selected by drawing from a hat. Neatness is very important as copies of all of the newsletters will be distributed around the country for evaluation and use. Each newsletter MUST include, at least, the following sections:

Science:

- The classification taxons and scientific name of your animal.
- A description of the habitat and region your animal occupies.
- The reasons your animal is endangered and what if anything is being done about it.

History:

- The history of human development and a geographical description of the region in which your species is found.

Humanities: (at least 2 of the following)

- A word game about your species.
- A poem about your species.
- A comic strip about your species.
- An interview with a public official about your species.

Cross- Cultural:
- A Spanish (or other foreign language of your choosing) translation of the description of your species and its habitat and a foreign language advertisement about saving your species.

Art:

- A black and white pencil or ink drawing of your species. An advertisement about saving your species.

List of References:

- A bibliographical list of books, periodicals, professional experts, and scientific organizations you used to gather your information.

How can one help?

- A list of ideas or ways people can donate time and/or money to help save the species from extinction.

Project = _________ points
Project is due -----> __________________

ENDANGERED SPECIES NEWSLETTER

Group Members:
Each newsletter MUST include, at least, the following sections:

Science:

- The classification taxons and scientific name of your animal. 5 POINTS
- A description of the habitat and region your animal occupies. 5 POINTS
- The reasons your animal is endangered and what if anything is being done about it. 10 POINTS

History:

- The history of human development and a geographical description of the region in which your species is found. 10PTS

Humanities: (at least 2 of the following)
5 POINTS EACH = 10 POINTS

- A word game about your species.
- A poem about your species.
- A comic strip about your species.
- An interview with a public official about your species.

Cross-Cultural:

- A Spanish (or other foreign language of your choosing) translation of the description of your species and its habitat and a foreign language advertisement about saving your species. 10 POINTS

Art:

- A black and white pencil or ink drawing of your species. 10 POINTS
- An advertisement about saving your species. 10 POINTS

List of References:

- A bibliographical list of books, periodicals, professional experts, and scientific organizations you used to gather your information. 10 POINTS

How can one help?

- A list of ideas or ways people can donate time and/or money to help save the species from extinction. 10 POINTS
- General appearance - 10 POINTS

Another 2 points **extra credit** will be given per section based on the initialing showing who worked on which sections.

If your newsletter doesn't look like a newsletter, you will get only 50% of the points you earned. Once you reassemble the report into a newsletter format, we will reinstate the full number of your points. This must be done by June 3, 1995.

ENDANGERED SPECIES NEWSLETTER

Group Members:

Each newsletter MUST include, at least, the following sections:

Science:

- The classification taxons and scientific name of your animal. 5 POINTS
- A description of the habitat and region your animal occupies. 5 POINTS
- The reasons your animal is endangered and what if anything is being done about it. 10 POINTS

History:
The history of human development and a geographical description of the region in which your species is found. 10PTS

**Humanities:** (at least 2 of the following)

5 POINTS EACH = 10 POINTS

- A word game about your species.
- A poem about your species.
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Miscellaneous

Activities:

Animal Breathing: What gases do you inhale and exhale?
Air Purity
Keepers of the Gate
Leaf Openings
Microbreweries:
  How do cells get the energy they need to perform their duties?
Plant Air
Plant Breathing
Plant Composition
Plant Energy
Plant Food
Plant Growth and Carbon Dioxide
Plant Pieces
Plants and Animals
Plants in Sunlight
Teacher Materials
Animal Breathing

What gases do you inhale and exhale?

Materials

Per lab group of four:
Part A. Exhaling

- 4 test tubes
- 4 soda straws
- 80 mL of phenolphthalein

Part B. Exhaling and Inhaling

- two 250-mL Erlenmeyer flasks
- 200 mL water with phenolphthalein (pink)
- two 2-hole rubber stoppers (to fit the flasks)
- 2 long glass tubes
- 2 short glass tubes (8–12 cm long)
- 2 pieces of hose (about 30 cm long)
- 1 short piece of hose (5 cm long)
- Y-shaped tube
- 4 soda straws (1 per student)
- magic marker or marking pencil

Part C. The Glowing Splint

- 4 splints
- matches

Procedure

Part A. Exhaling
In this activity students will discover that carbon dioxide is a component of the air that they exhale. They will use phenolphthalein indicator or limewater to detect the presence of carbon dioxide. Instruct the students to do the following:
Pour 20 mL of phenolphthalein or limewater in a test tube. Use a clean drinking straw to exhale into the solution.

Notes. Part A.
To prepare phenolphthalein solution, dissolve 1 gram of phenolphthalein powder in 40 mL of ethyl alcohol and then mix this solution in 120 mL of distilled water.
Use 3–5 drops of phenolphthalein solution for every 100 mL of tap water. To adjust the pH, add a few drops of very dilute NaOH solution till the water turns rose pink and
retains that color. Test the water by blowing into it through a straw. When it changes from pink to colorless in 30–45 seconds, it is ready for use by students. If you supply each student with 5 mL of the water and phenolphthalein mixture, you will need to prepare at least 200 mL for a class of 40 students.

Place some cotton or a few layers of paper towels in the soup can to cushion the bottom of test tubes. Substitute a test tube rack or other container for a soup can.

To make the NaOH (sodium hydroxide) solution, dissolve 400 mg of NaOH in 100 mL of water. This will give you 0.04 percent solution. Caution! NaOH pellets are very caustic, and the reaction generates heat. Use eye protection when preparing the solution. This quantity will be sufficient for Parts A and B.

**Part B. Exhaling and Inhalong**

In this activity students will discover the differences in the carbon dioxide content of inhaled air and exhaled air. As students breathe in through the apparatus, they draw air through the short tube that is above the surface of the pink liquid from flask marked “Inhaled Air.” When they breathe out, air is bubbled through the pink liquid in the flask marked “Exhaled Air,” which will turn colorless as its pH decreases due to formation of carbonic acid. The carbon dioxide, present in exhaled air, reacts with water to form carbonic acid. The liquid in the “Inhaled Air” flask will retain most of its pink color, whereas the liquid in the “Exhaled Air” flask will turn colorless as it reaches pH 8.3.

Instruct students to do the following:

Label one flask “Inhaled Air” and the other flask “Exhaled Air.” Pour one-half of the pink liquid into one flask and the other half into the other flask. Close the mouth of the “Inhaled Air” flask with the rubber stopper that has a hose attached to the short glass tube. Use the other stopper to close the mouth of the “Exhaled Air” flask. Make sure that both stoppers are tightly fitted in the flasks, the long glass tubes are immersed in the pink liquid, and the short tubes are above the level of liquid in the flasks. Attach your mouthpiece to the free end of the Y-shaped tube. Wait for a signal from a member of your group who will be timing and then breath in and out through the mouthpiece. It may help to hold your nose closed. Stop when the liquid becomes colorless or you get tired. Record the amount of time it took for the liquid to change from pink to colorless. Open the stopper of “Exhaled Air” flask and add one drop of sodium hydroxide solution into the flask. Gently swirl the liquid in the flask. If the liquid turns pink and stays pink, stop and reconnect the stopper. If the liquid is still colorless, add a drop at a time of the sodium hydroxide solution and carefully swirl the liquid till a rose pink color appears and remains. Breathe in and out through the apparatus for one full minute. Count and add drops of sodium hydroxide until the pink color reappears and does not change. Record your count.

**Notes. Part B.**

Prepare the phenolphthalein-water in the same way as you did for Part A. Supply it in a closed container or add an additional drop of NaOH in the liquid to prevent color change from occurring due to contact with air before the students use it.

You will have to prepare part of the apparatus used in Activity B for each group in advance. Caution! Unless your students have had experience cutting and inserting glass tubes into rubber stoppers, don’t assign that job to students. To assemble the apparatus, insert a short tube in one hole of each two-hole stopper so that about 2 cm of the upper end of the tube is above the top of the stopper. Insert a long tube in each of the stoppers
so that the lower end remains about 1 cm above the bottom of the flask when the stopper is fitted into it. Use glycerine or cooking oil as lubricant to facilitate the task. You may decide to let your students continue assembling the apparatus from here onwards. Use a piece of flexible tubing to attach one side of the Y tube to the short tube of one flask. Use another piece of flexible tubing to attach the other side of the Y tube to the long tube in the other flask. The students will use the top branch of the Y tube to attach their individual mouthpieces. Check and correct the height of glass tubes so that the apparatus will operate as intended. Test each apparatus before it supplying to students. If you use 125 mL Erlenmeyer flasks, use about 50 mL of liquid in each flask. Prepare limewater (saturated calcium hydroxide) solution. Lime (calcium hydroxide) is used for, among other things, manipulating the pH of soil, making mortar, and making pickles. It is available from chemical supply companies, but can also be found at gardening, hardware and grocery stores. There are several easy and reliable methods for preparing limewater for testing for the presence of carbon dioxide. Here is one method you may choose: 
Put 2 liters of distilled water into a clean plastic soda bottle. Add 3.5 g of calcium hydroxide, cap the bottle and shake well. Allow the bottle to stand undisturbed for about 24 hr to allow excess precipitate to settle. Carefully pour off the liquid solution into an additional soda bottle or other suitable container, disturbing the precipitant at the bottom of the bottle as little as possible (filter if necessary). This prepared limewater solution should be stored in a tightly capped container and used as needed. It should remain clear until it comes into contact with carbon dioxide. This produces a milky precipitate of calcium carbonate, causing the solution to appear cloudy.

Part C. The Glowing Splint
Instruct the students to light one end of the splint and then blow it out. They should have a glowing end left. Have them exhale on this end.

Background

The presence of carbon dioxide in an aqueous solution can be detected by using indicators such as limewater, bromthymol blue, and phenolphthalein. When carbon dioxide is bubbled through limewater (calcium hydroxide) solution, an insoluble product (calcium carbonate) is formed which settles down as white precipitate, thus the expression “limewater turns milky.” When CO$_2$ is passed through blue-colored bromthymol blue solution, carbonic acid is formed, which in turn, lowers the pH of the solution causing a visible color change. Bromthymol blue is blue at pH 7.6 and turns yellow at pH 6.0. Similarly, when CO$_2$ is bubbled through pink-colored phenolphthalein solution, carbonic acid, formed by carbon dioxide dissolving in the water, decreases the pH thereby turning the solution colorless. Conversely, when you add drops of a base (like NaOH) to the colorless phenolphthalein solution, it will increase its pH and the pink color will appear again. Phenolphthalein, which is red at pH 10.0, turns colorless at pH 8.3. Help students infer that the liquid in the “Exhaled air” flask turned colorless because there is a relatively greater concentration of carbon dioxide in exhaled air than inhaled air. Exhaled air may have 100 times the volume of carbon dioxide present in inhaled air (4.00% vs. 0.04%).
Air Purity

Does the gas produced by a green plant restore the purity of air?

Materials

Per lab group: (or one set-up for a demonstration)

- Elodea
- beaker
- water
- sunlight or lamp
- black cloth
- bell jar
- hose
- candle
- converging lens
- clamp lamp
- 200 watt clear bulb

Procedure

Have students set up the apparatus as shown at right.

The Elodea is placed in a beaker of cold water and the funnel is placed on top. A hose will connect the funnel to the bell jar. This bell jar contains only a candle that has burned itself out (no plant in jar). After one day, have the students try to ignite the candle wick using the lens and the lamp.

Background

It was found that the gas found in the bubbles does restore the air. This same gas is being produced by the green parts of the plant.
Keepers of the Gate

Materials

Per lab group:

- Zebrina plant (common name: Wandering Jew)
- scalpel or razor blade
- glass microscopic slides
- coverslips
- microscope
- eyedropper
- forceps
- colored pencils

Procedure

Students take a leaf from the Zebrina plant and wrap it around their finger with the underside facing up. They then use the scalpel (or razor blade) to make a thin cut across the leaf. Students peel back a thin portion of the epidermal layer using the forceps. It should appear transparent.

After making a wet mount of this material, they observe under both low and high power with the microscope. Next, students sketch cells that clearly contain chloroplasts. These cells should be the guard cells.

Background

The opening and closing of the stomates is regulated by the guard cells. One theory states that when the guard cells photosynthesize they produce sugar which draws water into the cell. The guard cells become swollen or turgid, forming the opening known as a stomate. At night, when the photosynthetic activity stops, the guard cells lose the water and become flaccid. The stomates close down. Note: Stress the importance of guard cells needing chloroplasts in order to carry out their function of regulating the stomates.
Leaf Openings

Are there pores in leaves?

Materials

Per lab group:

- 1 leaf of Zebrina* or Rheo (Red spiderwart)
- clear nail polish
- transparent tape
- microscope slide
- microscope
- 1 beaker (large enough to hold the leaf)
- distilled water

Per class

- 1 heat lamp

*Zebrina are used in hanging baskets. The leaves are fleshy, purple underneath and striped.

Procedure

Have students paint a small area on the underside of a single leaf of Zebrina or Rheo with clear nail polish. After it has dried, have them place a piece of transparent tape on this area and gently pull it off. The tape pulls off the nail polish along with the upper epidermis of the leaf. This can be mounted on a microscope slide. Using microscope (100' power), have students draw what they see. Have them repeat the procedure but this time use the top side of the leaf. Next, students soak a leaf in a beaker of distilled water for five minutes and examine the leaf again using the nail polish process. Have them draw both sides of the leaf.

Background

Students should be able to see the stomata which includes the guard cells and opening. This opening allows water vapor to escape. As the guard cells swell with excess water, the opening appears and allows water vapor to escape. Usually more stomata are found on the underside of the leaf than on the top. Since the stomata allow gases to enter and leave the plant, they also allow water vapor to escape. To minimize this loss of water, more of them are found on the underside of the leaf where evaporation is at a minimum.

Variations
The stomata are usually easy to see, but students may need some guidance. They should not only focus on the actual structures, but also on possible functions. After completing this experiment, students read pp. 18–21 in the monograph. The diagram in the monograph is somewhat misleading. Keep in mind that the guard cells of the stomata are green because they contain chlorophyll. Also the leaf depicted has been turned upside-down and the sample is actually being taken from the underside of the leaf.
Microbreweries

How do cells get the energy they need to perform their duties?

Materials

Per lab group:

- 2 wide-mouth bottles
- fruit juice (apple or guava, or a 5% sugar solution)
- yeast culture
- nalgene tubing
- L-shaped glass tube
- #6 rubber stopper with 1 hole
- test tube
- bromthymol-blue solution or lime water
- incubator or water bath heated to 28°C
- masking tape
- crucible
- depression slide with cover slip

Procedure

This activity consists of several different steps, during which students will observe a form of anaerobic respiration (fermentation), capture the waste products produced, perform tests to determine the nature of the waste product, and study the effect of the waste product on other organisms. Before begin-ning the experiment, review with the students how to determine the density of liquids, recognize differences in the boiling points of alcohol and water for distillation, and use a microscope.

Your students will begin by fermenting fruit juice using yeast. They should first calculate the density of the juice by taking mass and volume measurements using the graduated cylinder. When these measurements are complete, the students should pour 100 ml of juice into each of the wide-mouth bottles, and inoculate one bottle with 1 mL of yeast suspension (save the second bottle to use as a control). Have the students make whatever observations seem appropriate and record their findings (smell, color, drawings of yeast as viewed with a microscope, etc.)

The students should then tape a test tube containing 15 ml bromthymol blue or lime water to the outside of the bottle containing the yeast. Have them stopper the bottle with a rubber stopper fitted with glass and nalgene tubing, allowing the end of the tubing to rest
in the indicator solution (see diagram below). The set-up should then be placed in the incubator, and students should observe yeast action throughout the period. After three days, the students will carefully decant 10 mL of the juice into a graduated cylinder (reserving the remaining solution), and calculate the density of the solution.

In the final part of the experiment, the students will distill the fermented juice and calculate its density. To distill the juice, have the students place the wide-mouth bottle into water bath. The bath should not heat the juice above 98°C. The free end of the nalgene tubing should be placed in a graduated cylinder, and the cylinder into a cold water bath (do not let water into the cylinder). Liquid will condense in the cylinder; when all of the juice has burned off, have the students calculate the density of the liquid. Finally, the students will check the purity of the distillate. Have them place the alcohol in a crucible and light it carefully. What color is the flame (pure alcohol will burn clear or blue)?

**Background**

In nature, as in physics, energy must remain constant. Organisms break down larger compounds, such as sugars and starches, into smaller components, releasing the stored energy contained in the bonds. This process, the reverse of photosynthesis, is called **respiration**. Respiration that occurs in the presence of oxygen (aerobic respiration) is an extremely efficient process: animals may be able to form 36 high energy ATP molecules from a single glucose molecule. But oxygen is not always available, and, unfortunately, if an organism is going to survive, it still needs to produce energy. Thus, cells can also carry out anaerobic respiration, a much less efficient form of respiration that generates only two units of ATP. The rest of the energy is stored in waste products—lactic acid in animals, alcohol in plants—which must be expelled from the system.

In this experiment, students will see how yeast employs anaerobic respiration to extract energy from fruit juice. Winemakers exploit this process, lacing anaerobic containers of grapes with yeast. The yeast ferments the juice, and eventually dies, killed by its own waste product, alcohol. Why is alcohol deadly to yeast, and harmful even to humans? Alcohol is a waste product—by definition, all of the energy that could be useful to the consumer has been extracted from the food, leaving this com-pound. There are no energy benefits associated with a waste product, and, in addition, any organism that consumes the waste product will need to find a way to dispose of it, which will require even more energy.
Plant Air

Does a plant restore the air?

Materials

Per lab group: (or one set-up for a demonstration)

- Geranium plant
- candle
- converging lens (magnifying glass)
- bell jar
- flood lamp or clamp lamp
- 200 watt clear bulb

Procedure

Have students place a geranium plant in a bell jar along with a candle that is not burning. Using a flood lamp with a 200 watt clear bulb, the students focus a beam of light with a converging lens on the wick of the candle. After the candle has lighted, have them observe what occurs over a short period of time and then after a longer period of time (1–2 days). Once the candle has been extinguished, have them attempt to relight it using the same procedure.

Background

This experiment is a remake of the famous Priestley experiment. He used a spring of mint and found that the air was restored by the plant. The candle could be relighted after a period of time.

Variations

Be sure that the bell jar has a good seal so it remains air tight. Geranium plants can be obtained from most plant nurseries. This experiment could be done as a demonstration with students making the observations over a period of time. This experiment along with the next one, "Plant Breathing," can be set up at the same time and observed over a period of days.
Plant Breathing

What about light?

Materials:

Per lab group: (or one set-up for a demonstration)

- Geranium plant
- candle
- converging lens (magnifying glass)
- bell jar
- flood lamp or clamp lamp
- 200 watt clear bulb
- dark cloth to cover bell jar

Procedure:

Students place the plant and candle into the bell jar and cover the bell jar with a dark cloth for one night. The next day, have them light the candle using the light and converging lens. Then students observe what happens.

When it goes out, have the students cover the plant bell jar again with the dark cloth and leave it for two days. Have them attempt to relight the candle. If it does relight, have them cover the jar again and leave for another day. Have them try to relight the candle again using the lens and lamp.

Background

The results show that light is essential to the plant process which somehow restores the air. Ingenhousz first did this experiment and concluded that the plant process that restores air diminishes toward the end of the day and completely stops at sunset.

Variations

Be sure that the bell jar has a good seal so it remains air tight. Geranium plants can be obtained from most plant nurseries. This experiment could be done as a demonstration with students making the observations over a period of time. This experiment along with the previous "Plant Air," can be started at the same and observed over a period of time. After completing this experiment, the student reads pp. 21–22 in the monograph.
Plant Composition

Part 1. Does a green plant make glucose?
Part 2. Does a plant contain starch?

Materials

Per lab group:

PART 1. A. Sugar in Green Leaves
- onion bulbs (sprouted with green shoots)
- Benedict's or Fehling's solution
- bunsen burner or hot plate
- test tube

PART 1. B. Test for Cane Sugar
- onion bulbs (sprouted with green shoots)
- Benedict's or Fehling's solution
- bunsen burner or hot plate
- test tube
- 5% cobalt
- distilled water

Part 1. Demonstration
- sucrose (cane sugar)
- hydrochloric acid—concentrated
- bunsen burner or hot plate
- sodium carbonate
- Benedict's or Fehling's solution

PART 2. A.
- specially prepared leaves (see Notes. 2. A.)
- 2 petri dishes
- dilute iodine solution in dropper bottle
- tweezers or clothespin
- paper towels
- 1 test tube
- 2 strips black paper or foil (5 cm x 2 cm)
- 2 small paper clips or pieces of Scotch tape
- water (for washing leaf)

PART 2. B.
- specially prepared water (see Notes. 2. B.).
- 2 wide-mouth jars or beakers
- 2 glass funnels (short-stemmed)
- 2 test tubes
- 5–6 sprigs *Elodea* (6–8 cm long)
- scissors
- 1 tsp baking soda
- stirring rod or spoon
- lamp with 75 or higher wattage bulb
  (optional)

PART 1. A. Have students cut a 3 centimeter long portion of the green shoots of the onion bulbs. Add this strip to a test tube. Then students add 10 mL of Benedict's solution and boil the contents over a bunsen burner. For a control, add 3 mL of molasses (clear) into another test tube, boiling it and adding the Benedict's solution or Fehling's solution. If they see a change of color from blue to shades of green to reddish orange, then a simple sugar is present.

PART 1. B. Have students cut a 3 centimeter long portion of the green shoots of the onion bulbs. Add this strip to a test tube. As a demonstration you may want to show a positive sugar (sucrose) test. Add 4 grams of sucrose (cane sugar or common table sugar) to a test tube with about 15 mL of distilled water. Then add 1–2 mL of a 5% cobalt nitrate solution and add a 50% solution of sodium hydroxide. A violet color is a positive test for cane sugar.

Have students repeat this test using their green shoots.
Shoots from onion bulbs can be obtained by using a common onion and placing one side of it in the water. The side that has the brownish spot is the side that must be placed in water. The bulb can be supported by toothpicks stuck in the side.

**Part 1. Demonstration.** As a demonstration, the teacher can show how cane sugar (sucrose) can be converted to glucose. Add a very drops of concentrated hydrochloric acid to 4 grams of sucrose. Boil gently for a minute and neutralize the acid with sodium carbonate. Add the sodium carbonate until no effervescence occurs. Then test with Benedict's or Fehling's for the presence of glucose.

**Part 2. A.** In this activity the students will discover that chlorophyll is necessary for photosynthesis. Students will perform iodine test on leaves for presence of starch.

Leaves will come from two different sources—plants that have been in the dark—and those that have been in bright light. Remind students of food testing activities they had done in the seventh grade block on human physiology. You may want to prepare a solution of starch in a transparent container and place it on an overhead projector and add a few drops of dilute iodine solution to refresh their memories. *Whether you prepare leaves for iodine test in one central location for the whole class or allow groups to do their own will depend on the facilities available and the laboratory skills of students in your class (see Notes, Part 2. A).*

From the first group of plants, supply prepared chlorophyll-free leaves to students—one leaf per group—in a petri dish or similar wide container. Repeat with leaves from second group of plants. Ask your students to predict what will happen to the two leaves (one kept in the dark for 48 hours and the other in bright light for the same period). Have students carefully add enough drops of iodine solution on the first leaf to cover the entire surface. Have them wait for two to three minutes. Instruct them not to touch the leaf. Then, using tweezers or clothespin, students transfer the leaf to another dish and wait for about 10 minutes. Have them cover the leaf with water and rinse thoroughly. Students remove the leaf and place it on a folded paper towel and examine. Students repeat the procedure with the second leaf.

If using variegated plants, skip the part about covering the leaves with foil or carbon paper or cork sheets. The leaves will have portions that do not naturally contain chlorophyll. It is important that students make a sketch showing parts of the leaf that do and do not contain chlorophyll before removing chlorophyll.

When covering leaves students need to take care not to damage the leaves or the plant. Use light-weight paper clips or pieces of scotch tape.

Provide enough material to students to cover both sides of a part of a leaf. Have students do this without damaging the leaf or the plant. The plant will be placed in bright light for 24 to 48 hours. Students will predict the results of iodine test on the leaf. Have them compare the results with the results from previous iodine tests.

**Notes. Part 2. A.**

**Alternate procedures.** There are at least two ways of doing Part A. In the classic procedure, part of a leaf is covered with opaque material and left in light for 24-48 hours. Chlorophyll is removed and a starch test is performed on the leaf without chlorophyll. Another approach is to start with a plant that has variegated leaves. First step in this procedure is to draw a diagram of a leaf showing parts with and without chlorophyll. If a
Polaroid camera is available you may wish to take pictures. Removal of chlorophyll followed by a starch test will reveal that there is a correspondence between areas that contained chlorophyll and presence of starch.

**Plant preparation.** Start two days prior to class. Select potted plants (all the same kind) that have leaves that are not too thick or too large. Divide your available potted plants into two groups. Place one group in total darkness for about 48 hours and the other group in strong light for the same period. Then have students perform iodine test for starch. Remember to keep the leaves from the two groups of plants separate and do not remove too many leaves from any one plant.

**Heat sources.** If you plan to use a heat source other than a hot plate to heat the alcohol, use a double boiler to prevent the alcohol from coming close to the flame. It is recommended that you turn off the flame before pouring alcohol in the inner container. Boiling water will be hot enough to heat the alcohol. Leaf preparation. Before starch test can be done the leaves have to be prepared by boiling in water to break the cell walls. This makes it easier to remove chlorophyll which has to be removed as it masks the starch in the leaves. Chlorophyll is soluble in alcohol.

Fill a large beaker about one-half with water and place on a hot plate. Wear eye protection. Gently drop leaves from first group of plants into the water and allow to boil. Keep the leaves in boiling water for about five minutes. Carefully remove the beaker of water, turn down the heat setting on the hot plate, and place another beaker which has about 200 mL of isopropyl alcohol (70%) in it. Drop boiled leaves into the alcohol and let it heat for two to three minutes. Don’t boil the alcohol; it needs to be warm. If you have a second hot plate available place isopropyl alcohol in a large beaker and warm it while the water boils. Remove the leaves from alcohol after they have lost their green color. If necessary pour out the used alcohol in another container and add fresh alcohol.

**Dilute iodine preparation.** To prepare dilute iodine solution dissolve 2 g of potassium iodide in 25 mL of water. Add 1 g of ground iodine crystals and stir. Make final volume of solution to 300 mL. Store in dark brown bottle away from heat. Supply to students in dropper bottles.

**PART 2. B.** In this activity the students will discover that gas is one of the products of photosynthesis. Ask your students to do the following:

Label the beakers "A" and "B" and fill each about one-half with specially-prepared water (see Notes. Part 2. B.). Add one-half teaspoon of baking soda in each beaker and stir. Carefully place a funnel upside down in each beaker of water. If the tip of the funnel is above the level of water in the beaker, add more specially-prepared water till the tip is at least 1 cm below the surface of water. Cut off about 1 cm from the bottom part of each shoot of *Elodea* plant. If possible do the cutting while plants are under water. Place 5–6 shoots of *Elodea* in the wide part of funnel in Beaker A in such a way that the cut ends are at the top. Do not place any plants in Beaker B. Fill a test tube completely with the specially-prepared water, cover the mouth of the test tube with your thumb. Turn the tube upside down and place over the stem of the funnel without losing any water from the test tube. Repeat the process for the second beaker. Take both beakers to an area designated by your teacher where there is strong light. Place both beakers at the same distance from the light source. Predict what will happen in the two beakers. Observe every 3 minutes for a total of 15 minutes or longer, if necessary.
Notes. Part 2. B.

Each activity has a control component and an experimental component.

Plant preparation. Make sure that Elodea plants are young and healthy. For best results place Elodea plants in 2.5 percent solution of baking soda about an hour before supplying to students. One good way to supply Elodea to students is to use plastic bags—one per group per activity.

Specially prepared water. To make specially-prepared water, boil tap water to remove dissolved gases, including chlorine and carbon dioxide. Allow water to cool to room temperature before supplying to students. You will need at least 1 liter of this water per group. Estimate about 10 liters per class per activity depending on the size of the beaker/jar and class size. Start preparing water at least a few days before the class will use it. Remember it will have to cool back to room temperature. If you do not have a facility to boil this quantity of water fill large containers, like aquaria, with tap water and leave it uncovered for 24–48 hours to allow time for dissolved chlorine to escape. Baking soda will be added to the "specially-prepared" water as a source of carbon dioxide.

Light sources. If you do not get bright light in your room you will need to supply artificial light. Lamps with 75–100 watt bulbs will serve well. More intense light will speed up the rate of oxygen production. If you use very high wattage lamps (for example, 500-watt) be sure to protect plants from heat by covering the lamp with blue cellophane while leaving vent holes for heated air to escape. Protect eyes from strong light and keep combustible materials away from the lamps.

Background

The first products of photosynthesis are the simple sugars such as glucose. Most dicotyledons continue the conversion in the leaves of the glucose to starch. However, some plants such as marine algae, sugar beets, corn, and onions so not converted the sugar into starch in the leaves. These plants can be used to show the presence of glucose. In corn, the pathway of glucose from the leaves may be traced to the seed.

Photosynthesis occurs in chlorophyll-containing parts of green plants. Carbon dioxide and water react to form a simple six-carbon sugar and oxygen. In many plants (primarily dicotyledons), this sugar is converted to starch in the leaves. In most monocotyledons, for example corn, the leaves do not convert glucose to starch and will test negative for starch. Photosynthesis occurs in certain other organisms such as, photosynthetic sulfur bacteria. Oxygen is not produced as a result of this type of bacterial photosynthesis. Light is required to energize the first part of photosynthesis in which water molecules are split to produce oxygen (Hill reaction). Therefore, water is the source of all oxygen given off as a result of photosynthesis. Light is not required for the fixation of carbon dioxide (dark reaction). Dark reaction, which follows the Hill reaction, cannot occur without the products of the reaction that requires light energy.

Scientists have estimated that nearly 90% of oxygen available on this planet is produced by marine and freshwater plants.

Students will perform a series of activities. The first activity will involve investigating the requirement of chlorophyll for production of starch. Simple sugar (glucose) is a product of a series of complex reactions collectively called photosynthesis. The sugar is then
converted into other substances, like starch. Iodine solution will be used to detect the presence of starch.
In the second activity they find out that a gas is one of the products of photosynthesis. Ideally after collecting the gas the students would perform the standard glowing splint test for oxygen, but it is very seldom successful. It takes a long time to fill a test tube with oxygen. It takes a very long time to fill a test tube with oxygen.
Plant Energy

Where did the energy come from?

Materials

Per lab group:

- dried lawn grass blades
- one 100-mL beaker
- 50 mL water
- thermometer
- ring stand with 2 rings
- wire gauze
- metal container (aluminum can) or evaporating dish
- matches or lighter

Procedure

You may want to first dry the grass in the oven instead of allowing students to perform this portion. Place grass blades in a single layer on a cooking sheet and place in the oven at a low temperature (200°F) for a few minutes. As the grass dries, it becomes a dark green. Be sure not to let it turn too dark or blacken. Set up a the ring stand and with two rings as depicted:

Have students count out a certain number of grass blades to burn (10–20). These blades are piled underneath the top ring into the metal container on the second ring. The beaker with the 50 mL of water is on the wire gauze sitting on the top ring. The temperature of the water is taken and then the grass is ignited using matches. After the grass is burning well and a flame is heating the beaker of water, have students measure the temperature of the water again. Next students assume that one grass seed equals three blades of grass and counts out the number of seeds that are equal to the number of grass blades that they burned. The procedure is repeated, but this time grass seeds are used instead of grass blades. Have them compare their results.
Discuss their results and focus on the blades of grass producing more energy. Have them create explanations of why this difference has occurred.

**Background**

The point of this experiment is to begin to have students focus on the importance of plants as energy sources. At a greater depth, this means that the process of photosynthesis is converting the energy provided by the sun into a more usable form, plant matter. The blades of grass should produce more energy and cause the water to have a higher temperature.

**Variations**

The drying process is more easily done by the teacher. If seeds are particularly oily this made affect the results.
Plant Food

Do nutrients for a plant come from the soil?

Materials:

Per lab group:
- 1 plate of plastic wells
- 1 cup potting soil
- 12 germinated barley seeds
- balance

Per class:
- 1 heat lamp

Procedure:

First have students weigh the plastic wells. Then they fill each plastic well with dried soil and weigh the plastic wells filled with soil. To obtain dry soil, expose the soil to light from a heat lamp. The difference between these two measurements is the initial weight of the soil. Students add a sprouted seed to each soil filled well and allows it to grow for two weeks. Be sure that students add water to the soil and that the wells receive regular sunlight or regular exposure to light from a grow light. After two weeks, students carefully remove the plants, shaking the soil from the roots. Any fragments of the original see should also be removed with the soil. Using a heat, students dry the soil and weigh the dried soil. The soil and other parts that have been removed will be also weighed. Students record these measurements.

Background

This experiment is small version of the van Helmont experiment that lasted five years. The conclusion that plants did not use the soil for food should be shown by these results. After examining the results, van Helmont concluded that the water must be the source of nutrients. As the monograph indicates this conclusion would lead to another experiment. Guide students to these same end points.

Variations

Sprouts are easily obtained by placing barley seeds between two moistened paper towels. In about two days, the barley seeds will be sprouted and ready for use. Fast plants would shorten the growing process.
Plant Growth and Carbon Dioxide

What happens to carbon dioxide when a green plant grows?

Materials—Per lab group:

Part A.
bell jar
50 mL limewater
Geranium plant
sunlight or bright light
one 100-mL beaker

Part B.
bell jar
50 grams solid potassium hydroxide (or sodium hydroxide)
one 100-mL beaker
200 watt clear light bulb
converging lens (or magnifying glass)

Procedure:

Part A.
Have students place 50 mL of limewater in the beaker and place inside a bell jar. Also have them place a geranium plant inside. After 2 days of exposure to light, students make observations and note any changes.

Part B.
Have students place a beaker holding 50 grams of potassium hydroxide or sodium hydroxide in a bell jar. Also have them place a candle. After one day, students try to light candle using the con-verging lens and clamp lamp with the 200 watt clear light bulb. Have them make any observations.

Notes.
Prepare limewater (saturated calcium hydroxide) solution. Lime (calcium hydroxide) is used for, among other things, manipulating the pH of soil, making mortar, and making pickles. It is available from chemical supply companies, but can also be found at gardening, hardware and grocery stores. There are several easy and reliable methods for preparing limewater for testing for the presence of carbon dioxide. Here is one method you may choose:
Put 2 liters of distilled water into a clean, plastic soda bottle.
Add 3.5 g of calcium hydroxide, cap the bottle and shake well.
Allow the bottle to stand undisturbed for about 24 hr to allow excess precipitate to settle.
Carefully pour off the liquid solution into an additional soda bottle or other suitable
container, disturbing the precipitant at the bottom of the bottle as little as possible (filter if necessary). This prepared limewater solution should be stored in a tightly capped container and used as needed. It should remain clear until it comes into contact with carbon dioxide. This produces a milky precipitate of calcium carbonate, causing the solution to appear cloudy.

**Background**

These two experiments focus upon providing proof that plants cannot produce oxygen unless carbon dioxide is present. Have the students focus upon the design differences and how that relates to the outcome of the experiment. The two different designs of these experiments are important to note. Students may need information concerning carbon dioxide absorbers and how they work. This information does not have to be in great detail. Keep in mind it does have a limit and can become totally saturated with carbon dioxide. This may alter the outcome of the experiment.
Plant Pieces

Is the process of plant growth where oxygen is produced, and carbon dioxide and water are used, a process of the entire plant as an organ?

Materials—Per lab group

- Elodea
- one 100-mL beaker
- water
- dark cloth

Procedure

Have students take a leaf from an aquatic plant and tear it into pieces. Then they place these fragments in beaker of water. After exposing this beaker to sunlight or light, each student should make observations. The experiment is repeated but the beaker is covered with a dark cloth instead of exposing it to light.

Background

Students should begin to realize that fragments of leaves are still undergoing photosynthesis. This means that what is needed within the plant for the process of photosynthesis is much smaller than an individual leaf. Later in this monograph, students will begin to see the organ, chloroplast, that is associated with photosynthesis. At this time, they should only be able to see that small portions of leaves are still producing bubbles of oxygen.
Plants and Animals

Does a plant breathe like an animal?

Materials

Per lab group: (or one set-up for a demonstration)

- Geranium plant
- candle
- converging lens (magnifying glass)
- bell jar
- flood lamp or clamp lamp
- 200 watt clear bulb
- dark cloth to cover bell jar

Procedure

Have students place a plant and a candle in a bell jar. Then have them place the system in an area so that it receives light for two days. Then have them cover the bell jar with a dark cloth for two more days. After these four days, have them try to ignite the candle using the lens and lamp.

Background

Ingenhousz was the first to carry out this experiment. From previous experiments, he knew that the plant could only restore the air if sunlight was present.

Variations

Be sure that the bell jar has a good seal so it remains air tight. Geranium plants can be obtained from most plant nurseries. This experiment could be done as a demonstration with students making the observations over a period of time.
Plants in Sunlight

What is produced by a plant in sunlight?

Materials

Per lab group:

- Elodea
- beaker
- water
- sunlight or lamp
- black cloth

Procedure

Have students place a small piece of Elodea in a beaker of water. Have them cover the plant with a funnel that has a graduated cylinder or test tube over the end. Then students place them in sunlight or under a bright lamp. After 10 minutes, have them observe the plant and make observations. Next they cover the beaker with a black cloth for 10 minutes. After the 10 minutes, have them peek and observe the plant again. The graduated cylinder will allow the students to measure how much gas is emitted.

Background

Again Ingenhousz was the first to conduct this experiment. You should see bubbles forming around the leaves and the green parts of the stems. When the plants are placed in darkness, these bubbles stop. Keep in mind these are bubbles of oxygen, but the students still have to prove this composition.

Variations

Elodea can easily be maintained in an aquarium in a classroom. It is easily found at most fish stores. Try the experiment using other aquatic plants.
Student Handouts
Animal Breathing

What gases do you inhale and exhale?

Overview

In this activity, you will investigate the air you exhale and use a phenolphthalein indicator (or limewater) to detect the presence of carbon dioxide. You will also investigate whether or not there is a difference in the carbon dioxide content of inhaled air and exhaled air.

Procedure

Using an a beaker of limewater and a piece of tubing, take a deep breath, then blow the air into the tube immersed in limewater. What do you observe? What do you conclude about exhaled air? Light a splint, blow out the flame and note how it glows in ordinary air. Breathe some air and exhale into a bag. Place the glowing splint in the bag. How does it then appear to glow? What can you conclude about the relative amounts of oxygen and carbon dioxide in air before it is inhaled and after it has been exhaled?

Questions

1. How did your breath affect the limewater?
2. Try repeating the experiment using phenolphthalein in water. What happens?
Air Purity

Does the gas produced by a green plant restore the purity of air?

Overview

You will observe the role of gas in the process of air purification.

Procedure

Using an arrangement like that shown in the figure below, place a green aquatic plant in the cold water under the funnel as shown.

The hose from the funnel should carry the gas produced by the plant into the bell jar containing only a candle which has burned itself out (no plant in the bell jar). After one day, see if the candle can be relighted. What do you observe?

Questions

1. Describe your results.
2. Why was the funnel and hose needed in this experiment?
3. How did the gas affect the relighting of the candle?
Keepers of the Gate

What are guard cells?

Overview

In this activity, you will learn the function of guard cells in process of photosynthesis.

Procedure

Take a leaf from the Zebrina plant and wrap it around your finger with the underside facing up. Use the scalpel or razor blade to make a thin cut across the leaf. Use caution with these sharp instruments. Peel back a thin portion of the upper layer using the forceps. It should appear transparent. Make a wet mount of this material and observe under both low and high power with the microscope. Sketch several cells that appear to contain chloroplasts. Label these structures in your diagram.

Questions

1. What color do the chloroplasts appear?
2. Why is it important that leaves contain chloroplasts?
3. Why do you think only some cells in this layer have chloroplasts in them?
Leaf Openings

Are there pores in leaves?

Overview

In this activity, you will examine ways in which energy is exchanged.

Procedure

Find a Zebrina or Rheo leaf and examine it carefully with a magnifying glass. What do you observe? Are there places which appear to be holes on the leaf surface? If so, are they on the top surface of the leaf or on the bottom surface? If water vapor were to pass through pores in a leaf, the pores must be open. If you cannot find any openings on the leaf, maybe it is because they are closed. What would make them open? One hypothesis would be that the leaf needs an excess of water if the pores are to be open. Thus, take a leaf, place the stem in water for some length of time, and again look for openings under a microscope or magnifying glass.

Questions

1. Are there any pores or openings? Sketch what you see below.
2. How can you detect these pores?
3. Where are they located?
Microbreweries

How do cells get the energy they need to perform their duties?

Overview

During this activity, you will observe one type of anaerobic respiration (fermentation) and investigate the system in terms of energy transfer. How efficient is this process? How useful are the products of this type of respiration to other organisms?

Procedure

This activity can be broken down into two different parts. First, you will set up a fermentation system. Second, you will perform a distillation to identify the product.

To conduct the fermentation portion of the laboratory, first measure the density of the fruit juice. Pour 100 mL into each wide-mouth bottle, and inoculate one bottle with 1 mL yeast suspension. Record any observations you believe to be necessary. Does the mixture have a smell? Does it change color? View some of the yeast with a microscope. When you have completed your observations, arrange the materials as shown in the diagram, filling the test tube with 15 mL of the bromthymol-blue solution or lime water. You will place this set-up in an incubator and observe it for three days. At the end of that period, decant 10 mL of solution and measure its density.

In the second portion of the laboratory, you will need to perform a distillation according to your teacher's instructions. When you have obtained the distillate, calculate its density. Then, pour the distillate into a crucible and carefully light it. What color is the flame? What does it tell you about the distillate?

Questions

1. What changes did you observe in the yeast population over time? Did their activity change at all over the three day period? Do you think that the yeast would continue to grow indefinitely if left in the bottle? Explain your answer.
2. How could you tell that the juice was fermented by the yeast?
3. Did the density of the juice change due to the fermentation? How could you use density to estimate the amount of alcohol present in the fruit juice?
Plant Air

Does a plant restore the air?

Overview

Does air just disappear—gone forever? In this activity, you will observe how air can be restored after it has been "used up."

Procedure

Part 1. With the geranium plant in the sealed bell jar, light the candle by focusing light from a flood lamp through a converging lens onto the candle wick. Hold the lens still until the heat lights the candle.

Part 2. It is fairly obvious that sunlight has something to do with plant growth. Our experience with plants leads us to that conclusion. But does light have anything to do with the way a plant can purify air made foul by an animal or plant? Let's find out using the bell jar, candle, converging lens, light source and geranium plant. This time, let's cover the bell jar with a dark cloth, leaving it covered overnight. The next day, light the candle with focused light and observe that the candle goes out in a short time. Cover the plant again and let it remain covered for two days. Try to light the candle again. Does it light? How long does it stay lighted? If it does light, cover the bell jar again, and let the system stand covered for another two days. Try to light the candle again. What do you observe?

Questions

Part 1

1. How does the candle behave after a short time?
2. After a day or two in the sunshine, try to relight the candle. What happens?

Part 2.

1. After the jar had been covered for two days, how was the relighting of the candle affected?
2. Predict what would happen after six days of darkness.
Plant Breathing

What about light?

Overview

In this activity, you will discover what role light plays in the process of restoring air.

Procedure

Place the plant and candle into the bell jar and cover the bell jar with a dark cloth for one night. The next day, light the candle using the light and converging lens. Observe what happens.

When it goes out, cover the plant bell jar again with the dark cloth and leave it for two days. Try to relight the candle. If it does relight, cover the jar again and leave for another day. Try to relight the candle again using the lens and lamp.

Questions

1. What happens the first time you tried to light the candle?
2. What happens when you tried to relight the candle after two days? The third day? What are your conclusions?
Plant Composition

Does a green plant make glucose? Does a plant contain starch?

Overview

In this activity, you must find whether or not a plant contains glucose, then starch.

Procedure

Part 1. You will need to prepare the onion (provided) in such a way as to maximize its surface area. How do you do this? And why is it necessary? Next you will need to add water to your plant matter, mix this with either Fehling's solution or Benedict's solution, heat the mixture in a test tube and look for some color indication. This must be done with attention to safety. What do you observe?

Part 2. It has been found that a solution of iodine called Lugol's solution will show the presence of starch. Start this observation by testing Lugol's solution with known bits of starch. You will then observe a certain color, indicating the presence of starch. You might try the solution with several other substances, like salt and sugar. To prepare a leaf, soften it by placing it in boiling water for about 10 seconds. Then place the leaf in hot alcohol for about 10 minutes to dissolve the pigments. You want to be able to see a color change, and there, want to be sure it is a color from a reaction with the test solution, and not some pigment already in the plant. Next, wash the leaf in water, and place it in the Lugol's solution (iodine solution). What do you observe? How does the color compare with what you observed when you knew you had starch? Try the same thing with the onion bulb in which you found sugar. Do you also find starch? Why would some plants make starch and others make sugar? Place a geranium plant in bright sunlight. After a few hours, quickly remove a leaf, prepare it for a Fehling's solution test for sugar, and run that test. What do you observe? Use another leaf which is out of sunlight for an hour or so to perform the starch test. What do you observe? How can you reconcile these two results?

Questions

Part 1.

1. Does a green plant make glucose?
2. What evidence supports you answer to No. 1?
3. Why is Benedict's used?

Part 2.

1. Does a plant contain starch?
2. What evidence do you have the supports No. 1?
3. What role does Lugol's play?
Plant Energy

Where did the energy come from?

Overview

In this activity you will focus on the importance of plants as energy sources.

Procedure

Take a handful of green grass, count the number of blades of grass, and dry it in an oven or with a hair dryer. Make sure you do not get it so hot that it burns. When the grass is dry, crush it into small bits and form a pile underneath a small container of water, as shown in the figure.

Measure the temperature of the water. Then light the pile of crushed grass and let the flame heat the water. Then measure the temperature of the water again. What do you observe? Now, assuming that one grass seed produces two or three blades of grass, measure out the number of seeds that would have produced this much grass. Dry and burn these seeds in the same way you did with grass.

Questions

1. Is there a difference in the energy content?
2. Has the grass gained energy while it was growing?
Plant Food

Do nutrients for a plant come from the soil?

Overview

In this experiment, you will grow a plant while controlling what can enter the plant via the soil. If you are going to find out how much soil was consumed, you must first measure the dry weight (mass) of the initial soil, grow the plant, and measure the dry weight (mass) of the final soil. If the final mass is less than the initial mass, we can conclude that the missing soil was used by the plant as food, or more precisely, as nutrient.

Procedure

Begin with, dry some top soil or potting soil under a heat lamp. When the soil is dry, find its mass. To ensure that no other organic material or soil enters the system, put the dry soil into a small glass or ceramic container.
Find the plant’s mass at the start of the experiment by measuring the mass of several seeds.
Plant the seeds in the soil, add water to moisten the soil, and place the container in a warm location on a window sill where it can receive regular sunlight.
When the seeds have sprouted and the plants have begun to grow, you will need to provide water periodically. Water the plants whenever the soil feels dry. When the plants have grown enough to have measurable mass, you are ready to make your final measurements. This can occur over a few weeks, or over months or years, depending upon how precisely you can measure mass.
Carefully remove the plants, shaking any soil from the roots, and being sure that roots are not left in the soil. This task must be done very carefully. If there are any seed fragments or unsprouted seeds, they should also be removed from the soil. You want to be sure that you have separated the seeds that were added to the soil and the plants that have grown from the soil, before drying the soil once again to see if it has lost mass.
Dry the soil with a heat lamp and weigh the dry soil, as before. How does the mass of the dry soil after the growing the plants compare with the mass of the dry soil before growing the plants? Measure the difference.
Now you need to know how much the mass of the plant has increased. Measure the mass of the green plants, stems, roots, and seed fragments of unsprouted seeds taken from the soil. Weigh it all together, and to the nearest .01 grams.

Questions

1. How does the mass gained by the plant compare with the mass lost by the soil?
2. Explain any differences in the masses.
Plant Growth and Carbon Dioxide

What happens to carbon dioxide when a green plant grows?

Overview

This activity provides proof that plants cannot produce oxygen unless carbon dioxide is present.

Procedure

Place a container of limewater inside the bell jar with a geranium plant. Note the appearance of the limewater. After a couple of days in bright sunshine, is there any change in the appearance of the limewater?

Now let's try something more definite. Let's put a substance that absorbs carbon dioxide inside the bell jar with the plant.

A small container of solid potassium hydroxide or sodium hydroxide will combine with carbon dioxide chemically and remove it from the air. After a few hours, light the candle with the lens. Let the candle burn until it goes out. Then after another two days, try to light the candle again. What happens?

You should be able to design your own experiment to see how carbon dioxide is involved in the process by which a plant produces oxygen in the presence of light. Sodium bicarbonate is a common household chemical. When it dissolves in water in the presence of a weak acid, like vinegar, it produces lots of carbon dioxide. When you boil water you can remove carbon dioxide from water. Given these two facts, design an experiment to show that a green plant cannot produce oxygen unless there is carbon dioxide present.

Questions

1. Describe your experiment.
2. How does it show that a green plant cannot produce oxygen unless there is carbon dioxide present?
Plant Pieces

Is the process of plant growth where oxygen is produced, and carbon dioxide and water are used, a process of the entire plant as an organ?

Overview

You will observe what happens to pieces of a plant when oxygen and carbon dioxide are produced.

Procedure

Take an aquatic green leaf or two, shred them into small pieces, and place them under water exposed to sunlight. What do you observe around the leaf fragments? How cover the container with a dark cloth for some length of time and again observe the small pieces. What do you see now?

Questions

1. How did the fragments behave when exposed to light?
2. When exposed to darkness?
3. How are the presence of bubbles linked to the process of photosynthesis?
Plants and Animals

Does a plant breathe like an animal?

Overview

We have seen that a plant seems to make air pure again after a flame or animal breathes it and makes it foul. But what about a plant?

Procedure

Start with a bell jar in which there is a plant and a candle. Allow the system to stand in sunlight for two or three days. This will assure that the air inside is pure enough to support a candle flame. But do not light the candle. Instead, cover the bell jar with a black cloth and let it remain covered for several days. Then try to light the candle.

Questions

1. If the candle will not light, then what must you conclude?
2. If the candle will relight, then what must you conclude?
3. Describe your results.
Plants in Sunlight

What is produced by a plant in sunlight?

Overview

You will observe the process of air restoration over a longer period of time—in effect observing that plants breathe.

Procedure

Place a small green aquatic plant into a transparent glass container of water. Place the container in bright sunlight (or use a bright light). After some length of time, observe the green leaves and stems. What do you see? Next, cover the container with a black cloth, wait awhile and look again at the leaves and stems. What do you see now?

Questions

1. Describe what happened.
2. How can you explain your results?