ABSTRACT

Creating and Implementing an Environmental Education Curriculum for an Upper Level Science Course

By:
Logan S. Minning

In fulfilling the practicum option requirement for the Master of Environmental Science (M. En.), the following project was completed. This practicum report summarizes the development and implementation of an upper level environmental science curriculum. The activities chosen for this curriculum were adapted from a variety of sources and cover topics such as: history of environmental science, ecological principles, problem solving measures, research methods including statistical analysis, sustainability, and a diverse range of environmental problems. The lessons were edited, placed into a standard format and included at the end of the project.
Creating and Implementing an Environmental Education Curriculum for an Upper Level Science Course

A Thesis
Submitted to the
Faculty of Miami University
In partial fulfillment of
The requirements of the degree of
Master of Environmental Science
Institute of Environmental Sciences

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2005

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ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Mr. Scott Charlton and the Lebanon City School District for allowing me to conduct my practicum at their high school. This has been one of the most rewarding experiences of my life, and I owe many thanks to them. Mr. Charlton inspired me to become the best teacher I can by showing me to always be open to knowledge.

My committee members at Miami University Dr. Doug Brooks, Dr. Hays Cummins, and Dr. Sandy Woy-Hazleton have provided me with assistance, knowledge, and encouragement throughout this practicum. Without their patience and support this project would never have taken place.

In addition, I would like to thank Miami University’s Physical Facilities Department, especially, Steve Gaski, Toni Swab, Indrai Pal, and Lindsay Carpenter for fostering my love for environmental education.

Finally, I would like to thank my husband, Stephen, for his continual love, encouragement and listening skills. His support and patience has truly made this project possible.
PRACTICUM STATEMENT

In partial fulfillment of the Masters of Environmental Science degree offered by the Institute of Environmental Sciences of Miami University, I have created an environmental curriculum for Lebanon High School in Southwestern, Ohio. The curriculum was created by researching literature, studying prior curricula, and obtaining a thorough knowledge of the National Science Standards. In addition to creating the curriculum, I was also charged with implementing the lessons in the classroom.

INTRODUCTION

During the fall of 2001 I was given the opportunity to student teach at an area high school. This opportunity allowed for the development of an environmental curriculum for fulfillment of my practicum at the Institute of Environmental Sciences, Miami University. The focus of this practicum was a junior/senior honors environmental science course at Lebanon High School located in Southwestern Ohio.

‘Pride’ is a term often used to describe the Lebanon City School District. This is a growing suburban district in the Cincinnati area and high values are placed on education. Lebanon High School is located in a suburban setting and provides approximately 1200 students with educational services. The school district consists of three elementary schools, two middle schools and one high school. In fact, the district has recently built a brand new multimillion-dollar high school.

The course I was assigned was comprised of twenty-three students in a 90-minute block; 14 boys and 9 girls. In addition to the honors course, I was also responsible for teaching two 90-minute sections of sophomore biology.

CURRICULUM GOAL

Constructivist or student-centered teaching will guide this curriculum from development to the implementation. Student-centered teaching is a method of instruction that aims to transform teachers into facilitators where their role is to direct students towards developing or broadening their insights or perceptions, usually through a series of discovery-based exercises which are hands-on (Brooks & Brooks, 1999). Students learn by constructing their own knowledge under the guidance of their teacher. Constructivist teaching practices require students
to become active participants in directing their own inquiries and building their own knowledge base. Student-centered learning is a broad teaching approach that replaces lectures with active learning, cooperative group situations, and inquiry challenges that ultimately hold the student responsible for his/her own advances in education. According to Clasen and Bowman “Student-centered learning environments have a heightened advantage over the traditional teacher-centered, environment in that they provide complimentary activities, interactive in nature, enabling individuals to address their own learning interests and needs and move forward into increasingly complex levels of content to further their understanding and appreciate subject matter” (Clasen & Bowman, 1974). Through this learning model one main goal exists for this project:

Through a student centered learning model each student will address
current environmental attitudes and leave the course an informed,
literate citizen in the field of environmental science.

Environmental literacy, as defined by the Environmental Protection Agency (EPA), “requires a fundamental understanding of the systems of the natural world, the relationships and interactions between the living and the non-living environment, and the ability to deal sensibly with problems that involve scientific evidence uncertainty, and economic aesthetic, and ethical considerations.”

Webster’s Dictionary defines attitude as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object". Much of the current research states that understanding and measuring environmental attitudes has become increasingly important, as the number of environmental conflicts have increased throughout the Unites States and the world. The EPA states that environmental knowledge affects beliefs and attitudes about the environment. Individuals with greater knowledge about the environment are more likely to believe that economic development and environmental protection can co-exist (EPA, 1999). This interest in future environmental behavior of students has led to many studies surveying the attitudes of school age children. These preconceived environmental attitudes must be addressed in any environmental course.
PARAMETERS

Before the student teaching began I was paired with a cooperating teacher, Scott Charlton, to guide me through the experience. Scott Charlton has been an instructor for 28 years and spent most of his years at Lebanon High School. Mr. Charlton was looking to add a new spin on the environmental course offered at the high school. He wanted to see a more hands-on and active approach to environmental education because current educational research shows that students perform to higher standards in this type of setting. In addition, he was looking for several new activities to implement. This vision became my task and therefore, the focal point of the practicum. The overall goal was to create an 16-week curriculum in environmental science for an honors high school course.

The parameters of the project, as set by Mr. Charlton, included using the text as a guide, incorporating at least one outdoor activity/lab, hands-on activities, using technology, and promoting creativity. I began by obtaining the text from Mr. Charlton and some resource materials that he wanted to keep in the curriculum. The text adopted by the district for this course was “Environmental Science: Sustaining the Earth” by G. Tyler Miller, Jr. and published by the Wadsworth Company. The text divides the chapters into six units:

1. Humans and Nature and Overview
2. Scientific Principles and Concepts
3. Biodiversity, Land Use, and Conservation
4. Human Population, Resources and Sustainability
5. Environment and Society
6. Environmental Quality and Pollution

To adhere to the coherence of the text I decided to maintain the units as they were presented. As I previewed each chapter and researched other curricula I began to determine the principal concepts I wished to highlight in the course. As with any text certain sections were eliminated due to time constraints. Such concepts included: History of environmental science, ecological principles, problem solving techniques, research methods including statistical analysis, sustainability, and a diverse range of environmental problems. I believed that competence in each of these areas would forge an environmentally literate adolescent learner.
CRITERIA USED IN SELECTING LESSONS

Given the parameters set forth for the project and the topics to be covered, I still had to determine which lessons would be appropriate for this group of learners. I developed a set of criteria to narrow down the abundance of lessons, insure the student centered model was maintained and all the parameters were upheld. The lessons for this environmental unit were chosen using four criteria to achieve the student-centered learning model: hands-on/inquiry potential, advanced level of content, National Science Education Standards, and the use of technology. The activities and lessons presented in this curriculum were adapted to meet each of these four criteria.

1. Hands-on/Inquiry Potential

Environmental science provides opportunities to engage in hands-on-learning activities, it encourages participation and inquisitiveness, it promotes group interaction and participation, and it provides a space where students with disabilities can feel successful (Zembylas and Isenbarger, 2002). In addition, hands-on science activities have been found to motivate students and produce more appropriate classroom behavior (Zembylas and Isenbarger, 2002). The focus of the lessons should be on answering a key question rather than merely providing knowledge. Students should be actively engaged in hypothesizing, experimenting, data collection, data analysis, data interpretation, and drawing conclusions based upon evidence.

The Environmental Protection Agency stated that, “Environmental education enables individuals to weigh various sides of an environmental issue. It does not advocate a particular viewpoint or course of action” (EPA, 1999, p.1) Today, the EPA encourages environmental education through inquiry and investigation, which in turn enables the learners to develop critical-thinking, problem-solving, and effective decision-making skills. They advocate moving away from text-book-driven courses and moving towards hands-on, learner-centered approaches. In addition, to make environmental education successful the EPA suggests providing a real world context to learning and linking the classroom to the needs of the community (EPA, 1999). The EPA values the importance of environmental education and the discovery methods in which it should be taught. These values are directly aligned with the National Science Education Standards.
2. Advanced Level of Content

The students in this course are upper level students who are expecting the course to be challenging and rewarding with knowledge. In order to produce this challenging atmosphere, the lessons chosen for the unit had to promote the integrity of the course name (Honors Environmental Science). The advanced lessons chosen for this unit will allow students to synthesize, apply and evaluate knowledge learned. The lessons for this unit will be more rigorous, stimulating the student’s abilities in all assignments.

3. National Science Standards

The 1996 National Science Education Standards (NSES) also support the goal of creating an environmentally literate society. These standards were created nationally and adapted by the Ohio Education Association to provide benchmarks in science education for the entire state. These standards identify many content areas where environmental concepts should be infused. The areas include the following: Physical Science, Life Science, Earth and Space Science, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science (NSES, 1996). The diversity of the issues associated with environmental education has led to an interdisciplinary approach to instruction. To address this interdisciplinary approach, the NSES outlines the connections between many subjects. Using these standards aids schools in building a curriculum where environmental education is incorporated into many areas of students’ learning. The incorporation of environmental issues into various subjects will further aid in creating a more environmentally literate society.
Table 1. National Science Education Standards (National Research Council, 1996)

<table>
<thead>
<tr>
<th><strong>National Science Standard</strong></th>
<th><strong>Topics Included</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Science</strong></td>
<td>interactions of energy and matter</td>
</tr>
<tr>
<td><strong>Life Science</strong></td>
<td>matter, energy, and organization in living systems, interdependence of organisms, and behavior of organisms</td>
</tr>
<tr>
<td><strong>Earth and Space Science</strong></td>
<td>geochemical cycles</td>
</tr>
<tr>
<td><strong>Science and Technology</strong></td>
<td>understanding how science and technology come together</td>
</tr>
<tr>
<td><strong>Science in Personal and Social Perspectives</strong></td>
<td>personal and community health, population growth, natural resources, environmental quality, natural and human induced hazards, science and technology in local, national, and global challenges</td>
</tr>
<tr>
<td><strong>History and Nature of Science</strong></td>
<td>science as a human endeavor, nature of scientific knowledge, and historical perspectives</td>
</tr>
</tbody>
</table>

4. Needed Resources

Determining what types of technology were available at the school was also important to learn before lessons could be planned. Lebanon High School has two computer laboratories and two mobile laptop carts. Each room is also equipped with five computers and a printer. The only science technologies available at the school were microscopes and a digital camera.
These four criteria were used to sort through a menagerie of environmental lesson plans provided by the text, the cooperative teacher, previous teaching experience, among other sources. Many of the lessons that were chosen were adapted to be more creative, student-centered, use technology, promote group interactions, and support challenging objectives. The adapted lessons use a combination of group and individual assessments to measure student learning. In addition, a field trip was scheduled for the students to the Warren County Conservation Club. During this field experience students performed outdoor laboratory activities and individual research projects.

IMPLEMENTATION

Three weeks prior to school starting, I received news about the environmental science course from Mr. Charlton. The school had some scheduling conflicts and was unable to offer the course. In a compromise with the school it was decided that I would instead teach an Honors Biology course. The student ratios and skill levels were to remain the same; however the topic areas would be vastly different. Energetically I worked with Mr. Charlton to set the course objectives and curriculum. It was decided to spend the first eight weeks of the semester using the environmental science program I had previously developed and the remaining time on various other biological issues that Mr. Charlton would coordinate.

Compressing a 16-week curriculum down to an 8-week curriculum was going to be a challenge. First I had to decide what principal elements must be kept in the curriculum and which lessons could be deleted. After conferring with Mr. Charlton we decided it would be best to touch on each of the five units out of the book. While maintaining the integrity of the original curriculum we downsized the lessons, being sure not to eliminate everything from one unit section. Most of the original activities were not eliminated but were reworked for time efficiency. However, the importance of outdoor education remained in this unit and the field trip was rescheduled. Many time savers included combining activities, more team projects, reworking assignments so more work could be done at home, and eliminating certain sections. Extension activities, research, and discussion time were the primary elimination targets. The final breakdown looked like the following:
<table>
<thead>
<tr>
<th>Text Book Unit</th>
<th>Name of Lesson</th>
<th>Topic</th>
<th>Type of Lesson</th>
<th>Time in Days (90-min block)</th>
<th>Materials Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Learning Styles Assessment</td>
<td>Assessment</td>
<td></td>
<td></td>
<td>0.3</td>
<td>Copies of the assessment</td>
</tr>
<tr>
<td>Multi Genre Project on an environmentalist</td>
<td>Project</td>
<td></td>
<td></td>
<td>4</td>
<td>List of Environmentalist</td>
</tr>
<tr>
<td>Scientific Principles and Concepts</td>
<td>Factors affecting the environment</td>
<td>Ecological Principles</td>
<td>Team Storm</td>
<td>1</td>
<td>Paper, Markers and Computers</td>
</tr>
<tr>
<td></td>
<td>Food Web</td>
<td>Biological Communities and Interactions</td>
<td>Activity</td>
<td>0.2</td>
<td>Paper and Markers</td>
</tr>
<tr>
<td></td>
<td>Food Web Interactions</td>
<td>Activity</td>
<td></td>
<td></td>
<td>Copies of lesson and Computers</td>
</tr>
<tr>
<td></td>
<td>Environmental Scavenger Hunt</td>
<td>Lab</td>
<td></td>
<td>2.5</td>
<td>2- liter soda bottles, 1-2 guppies, 1-2 snails, 2 cups of sand, one bunch of elodea, one bunch of duckweed, light source, tap water, 1 cup of soil, several large rocks, and grass seed (this is the list of materials for each group)</td>
</tr>
<tr>
<td></td>
<td>Environmental Legacy Project</td>
<td>Project</td>
<td></td>
<td>3.5</td>
<td>Various craft supplies</td>
</tr>
<tr>
<td></td>
<td>Zeno Debate (Biological vs. species diversity)</td>
<td>Biodiversity</td>
<td>Debate</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Statistical Analysis</td>
<td>Statistical Analysis</td>
<td>Lecture</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Research independent projects</td>
<td>Statistical Analysis</td>
<td>Research</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Airplane funnel</td>
<td>Field Research</td>
<td>Field Experience</td>
<td>0.5</td>
<td>Large Paper, String, Alcohol, and jar</td>
</tr>
<tr>
<td></td>
<td>Goldenrod galls study</td>
<td>Field Research</td>
<td>Field Experience</td>
<td>0.5</td>
<td>Copy of lab and field location</td>
</tr>
<tr>
<td></td>
<td>Independent research projects</td>
<td>Lab</td>
<td></td>
<td>2</td>
<td>Supplies for students individual labs</td>
</tr>
<tr>
<td></td>
<td>Problem Solving</td>
<td>Movie</td>
<td></td>
<td>0.5</td>
<td>VHS movie by Dr. Suess and TV with VCR</td>
</tr>
<tr>
<td></td>
<td>Problem solving process</td>
<td>Lecture</td>
<td></td>
<td>2</td>
<td>Notes of the process and examples</td>
</tr>
<tr>
<td></td>
<td>Microscope Lesson</td>
<td>Population</td>
<td>Activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yeast Lab</td>
<td></td>
<td></td>
<td></td>
<td>Molasses, water, 100ml graduated cylinder, stirring rod, 100ml, beaker, microscopes, microscope slides and covers slips, capillary pipette, Para film, and yeast solution</td>
</tr>
<tr>
<td></td>
<td>Article “Nobody ever dies of over population” and questions</td>
<td>Population and Society</td>
<td>Activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HP saw population articles and questions</td>
<td>Population and Society</td>
<td>Activity</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Over population personal perspective presentations</td>
<td>Research Presentation</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Environment and Society</td>
<td></td>
<td>Sustainability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Montessori Lab</td>
<td>Movie</td>
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<td>Copy of movie, TV, VCR and Computers</td>
</tr>
<tr>
<td></td>
<td>Renewable and non-renewable resources</td>
<td>Resources</td>
<td>Activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nectar Project/ Presentation</td>
<td>Project</td>
<td></td>
<td>4</td>
<td>Computers, Smith et., Smith dryy 30 H.d, sample reports, and Computers</td>
</tr>
<tr>
<td>Environmental Quality and Pollution</td>
<td>Waste Characterization Study</td>
<td>Solid Waste</td>
<td>Lab/Habitation</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Various Environmental Problems (water, air, and energy conservation)</td>
</tr>
<tr>
<td></td>
<td>Energy Conservation (fuel efficiency)</td>
<td>Lab</td>
<td></td>
<td>3</td>
<td>sea</td>
</tr>
<tr>
<td></td>
<td>Water Pollution (water contamination lab)</td>
<td>Lab</td>
<td></td>
<td></td>
<td>sea</td>
</tr>
<tr>
<td></td>
<td>Air Pollution (CO2 lab)</td>
<td>Lab</td>
<td></td>
<td></td>
<td>yes</td>
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<tr>
<td></td>
<td>Poster presentations of labs</td>
<td></td>
<td></td>
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<td>1</td>
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<tr>
<td></td>
<td>Final Exam</td>
<td>Assessment</td>
<td></td>
<td>1</td>
<td>Copies of tests</td>
</tr>
</tbody>
</table>
UNIT LESSON PLANS

Once the lessons were developed and finalized with the cooperating teacher at Lebanon High School they were implemented in the fall of 2001. The lessons were outlined and followed as closely as possible. As with any lesson plan, minor changes were made to meet the goals and learning styles of the students. As the unit progressed I created lists of the positives and negatives associated with each of the lessons. The following pages contain the lesson plans implemented during the unit. Included in each lesson are directions for the instructor and appendix references for student materials. Following each of the lesson plans is a reflection of my experiences teaching the lessons.
Title: Personal Learning Styles Assessment

Subject: Introductory materials

Length: 30 minutes

Materials: Copies of the Learning Styles Assessment

Objective: To assess the individual’s preferable learning styles during classroom instruction

Description: During the first days of school it is important to gain as much information about the individual students as it is the classes as a whole. With the personal learning styles assessment, the instructor can gain access to the individual’s preferable learning styles. The assessment asks the students 50 questions concerning how they see themselves during the learning process. The answers are calculated (ranging from –10 to +10) and the student is categorized as a left-brain learner, right-brain learner, or a whole brain learner.

The left-brain learner is someone who learns best visually or in a hands-on manner. The right-brain learner is someone who is more analytical and learners best. The whole brain learner is a combination of the above two types of learners.

You can use these scores to create lab teams in the science classroom. Have the student’s line themselves up across the classroom according to their scores negative ten on one side and positive ten on the other. To form teams of four, take an individual from each end of the line and two from the center. This allows you to form groups with a wide range of learning diversity. Groups with diverse learning styles are better adapted to tackle the various problems encountered in the science classroom.

See “Appendix A” for a copy of the assessment.

Learning Styles Assessment Reflection:

Each student learner is accustomed to learning in different ways. Combining students with different learning styles creates a multi-talented grouping. I have used this activity in many situations to create very diverse learning styles in group dynamics. I think it is important to group students together in the science classroom and using this technique allows the students with different abilities to work together to solve a variety of problems.
Title: Multi Genre Project and Presentation

Subject Area: Environmental history

Length: 3 days of research and 2 days for presentations; out of class time required

Materials: Examples of previous entries to aid students in project

Objective: Students will gain an understanding of the past environmental scientist in a hands-on manner. Students will also appreciate the scientist’s contribution to the field of environmental science by portraying them in a classroom skit.

Description: The students will choose an environmental scientist to portray during the project and presentation. See appendix for a list of environmental scientist.

Directions for project: To create a unique representation of the chosen scientist life using four distinctly different entries. FOR EXAMPLE: one entry could be a journal of the scientist’s data collected or field notes. One of the four entries MUST explain with what type of research the scientist was involved. (A minimum of 5 cited sources)

The entries should take on the “voice” of the genre (i.e. first person), and should move the exposition of the concept forward in a thorough manner. The entries should be as creative and authentic as possible.

Finally you must include a reflection. The reflection should clearly state your initial and final understandings of the scientist (you might want to do this in a visual way through concept mapping, diagramming, ect…). Also, the reflection should clearly provide your rationale for why you chose the particular scientist and the challenges you faced during creating the project.

Directions for presentation: After you have successfully completed the multi-genre presentation you will create a visual presentation for your classmates. You should choose one event in the scientist life that represents the whole of his/her career in science. The presentation should mimic who the scientist really was and their major life accomplishments. The use of props and costumes will help move you through the 3-5 minute presentation. The presentation should be given in the first person and should NOT resemble an oral report.

See “Appendix B” for multi-genre project examples, presentation rubric and creative genre ideas.
Multi Genre Project Reflection:

This activity was a great introduction to the topic of environmental science. It allowed the students to view the expansive and diverse field of environmental science. This lesson also set the tone for the class: student centered model. Many of the students took this project by the horns. Others were unable to be creative with the research they had unmasked. These students were the ones who needed a lot of encouragement and support from the instructor. It became apparent from the beginning that this project was going to require more than four days time. The students were working hard on the projects, but needed additional time to research their scientists and bring together all of the items needed for each genre. To insure quality in the projects I extended the work time to four days and added an additional two days for presentations. With a weekend in-between the work time and presentations, the students also had time at home to complete their projects.

In the future, it would be possible to add or delete as many genre entries as time allowed. In addition, I completed a skit for the class to introduce the expectations of the class presentation. This was useful because the students were able to visualize what was expected of them in the project. Also, I kept several of the student projects to show as examples to future classes.
Title: Abiotic Components of Ecosystems

Subject: Ecological Principles

Length: 1 class period

Materials: Textbook (illustration of an ecosystem), computers, markers, and large paper

Objective: To introduce the students to the non-living components of an ecosystem. Specifically the students will research and illustrate the various biogeochemical cycles.

Description: To begin the students will view a picture of an ecosystem. This can be found in most texts or on a handout. The students will create a t-chart: one side will include living components of an ecosystem and the second side will contain non-living components of ecosystems. The various answers should be displayed on the board and after the various answers are displayed the terms biotic “living” and abiotic “non-living” should be introduced.

Once the students are familiar with the term abiotic they are introduced to the four main biogeochemical cycles: nitrogen, phosphorus, hydrologic and oxygen/carbon cycles. The group of students should be divided into four teams. Each team is assigned one of these cycles to research, draw, and explain. Each group will create a poster by drawing their cycle and writing out an explanation of the cycles in their own words. The posters are presented to their peers as though they were teaching the class. Each poster is then displayed around the room for the entire class to use as a reference.

Abiotic Components of Ecosystems Reflection:

This lesson was a way of using the student centered learning model to allow students the opportunity to construct their own knowledge about a topic. From the beginning of the activity we used student ideas to introduce the topic. The previously created groups were each assigned a cycle to investigate. Each team illustrated and described in words the interworkings of each cycle. Each team presented its findings to the class. While the information was solid the delivery needed some improvement. The students found it difficult to take notes from their peers. Next time I think I would have each team develop notes to go along with the presentation for the class to follow along.
Title: Eco-Condos (adapted from “Bottle Ecology”)

Subject: Ecological Principles

Length: 2 days constructions, 5 minutes of class for 3 weeks

Materials: 2 2-liter soda bottles, 1-2 guppies, 1-2 snails, 2 cups of sand, one bunch of elodea, one bunch of duckweed, light source, tap water, 1 cup of soil, several larger rocks, and grass seed (this is the list of materials for each group)

Objective: This lesson is about exploring the general principles of aquatic and terrestrial ecosystems. In this lesson the student will learn about what is needed to keep a water source chemically balanced by creating an eco-condo. The student will also learn about the ratio of producers to consumers that are needed to maintain a community balance.

Description: In a previous lesson the students became familiar with the geochemical cycles needed to balance both terrestrial and aquatic ecosystems. This lesson will allow the students to apply this knowledge to a living environment. Each student group will make their own eco-condo.

Directions for building: Before the students begin they are given a list of the material, and brainstorm about he best method for construction. They are free to use their own ideas in connection with the basic guidelines the instructor provides them.

1. Cut the tip off of the first bottle. Then cut the base of the second bottle and poke holes in it to allow airflow.

2. Bottom of condo
   i. Fill bottom of bottle with sand, two inches deep.
   ii. Slowly, add water to minimize turbidity and then anchor elodea stalks in sand and sprinkle duckweed on the water's surface.
   iii. Let bottle stand overnight to allow chlorine to dissipate because if you do not do this snails and fish will die.
   iv. Add 1-2 guppies and 1-2 snails.

3. Top of condo
   i. Invert the top of the bottle so that the tip is pointed downwards.
   ii. Fill the tip with large stones and place 2 inches of soil on the top of the stones.
   iii. Over a sink pour water through the soil to remove any debris.
   iv. Sprinkle the grass seed onto the soil and push downward.
   v. Place top on condo onto bottom portion in a well light place.

4. Students will observe and record data in a journal over a three-week period.

5. After constructing the eco-condo, the students must decide how to stock their bottle in order to create the most balanced ecosystem.
Eco- Condo Reflection:

This lesson is a great introduction to the interactions of living and non-living components of an ecosystem. During the construction of the condos many of the groups were able to bring in their own special additions to the condos (fish, insects, plants. ect…) This made an even more diverse display of habitats. This activity also allowed students to get working as soon as they entered the room. Students had the first five minutes of each class to observe any changes in their ecosystem. Over all, the students enjoyed maintaining their ecosystems and observing the interactions.

This was a great lab to maintain for about 3-weeks, however many of the specimens died during the process. This was a good opportunity for students to hypothesize about the causes and the imbalances in their ecosystem. This lab tended to cost a little money so next time the students might bring in some of the supplies from home if possible.
Title: Food Web Interactions

Subject: Ecological Principles

Length: 1 ½ block classes

Materials: Computers

Objective: Students will be introduced to key terminology about ecosystems and explore the relationship of non-native species on ecosystems.

Description:

Activity 1: Students have previously studied the concept of food webs, but how easily is this balance disrupted. Students will complete the activity Food Web Interactions taken from Dodds, 2002, Freshwater Ecology: Concepts and Environmental Applications, Academic Press. This activity allows the students to map out the affects of the opossum shrimp to the Flathead Lake ecosystem in Montana. See “Appendix C”

Activity 2: Students will read the article, “Introduced Species: The Threat to Biodiversity and What Can Be Done” by Daniel Simberloff, Ph. D. and answer a list of content and discussion questions. A class discussion should be held to voice various opinions of the class. See “Appendix C”

Questions:
1. What are the different ways that introduced species affect our environment?
2. What things can we do to limit the spread of introduced species?
3. How have people and their activities helped species move from one part of the world to another?
4. Why do you think that some species are beneficial and some are harmful to our environment?
5. Simberloff said that 49% of endangered species are in trouble because of introduced species. What are ways that introduced species could threaten the continued survival of native populations?
6. The exotic pet business can contribute to the decline of imperiled wildlife populations in their native habitats. How might the exotic pet trade also become a problem of introduced species in a new habitat?
7. Simberloff mentioned that the North American gray squirrel caused disruption in Great Britain and Italy. Why are they not causing those same problems in their native habitats in North America?

Extension:
After a discussion of what invasive species are introduce other important species in an ecosystem such as keystone and indicator species.

Activity 3: Once the students are familiar with the concept of invasive species they are given the assignment to research an invasive species found in the South Western Ohio region. Some examples of invasive species in this area are: Asian Lady Beetles, North American Gray Squirrel, Zebra Muscles, Garlic Mustard, Purple Loosestrife, Japanese Honeysuckle, White Sweet-clover, Multiflora Rose, ect…) Once the information is collected on a specific species the students will create a “wanted poster” to display around the school. Each poster must contain the following:

1. A picture of the invasive species
2. A map of the areas where the species is found
3. Damages caused by the invasion of the species
4. Steps one can take to stop the spread of the invasive species

Food Web Interactions Reflection:
This activity built upon the previously learned topic of the food web. This activity investigated the role of invasive species in the food web. While the beginning of this activity did a great job introducing the topic it failed to incorporate a lot of hands-on learning. Students used learned information to illustrate a change in the food web and then read an article. The best part of this activity was the investigation by the students on local invasive species. The creation of the wanted posters was very creative, included the use of technology and educated the entire school. Next time I implement this lesson I will leave out the article and focus on the second part of the lesson.
Title: Scrap Book: Guide To Biomes

Subject: Ecological Principles

Length: 4 class periods, required out of class time

Materials: Colored paper, scissors, glue, and computers

Objective: To bring together all the comprising components of the ecosystems as studied in class in a creative manner. The students will use their knowledge of ecosystems to create a unique pop-up presentation of an assigned biome.

Description: Students are reintroduced to the concept of world biomes as studied in 10th grade biology. They are reminded about the climatogram graphs they created to illustrate the differences between temperature and rainfall and the type of ecosystems they represent. Each biome is representative of the diversity found in the biosphere. Students will work in groups of two and they will draw a biome out of a hat to determine their assignment. A list of requirements and a rubric are given to the students before they begin their project. The projects MUST be creative and colorful in addition to infusing all the information required.

Directions:

You will be given 1 biome to research and create an innovative and unique scrapbook. You scrapbook will include 11-pages, each with its own focus area. Each of the 11-pages should creatively fuse the researched material with color and pictures.

Page 1: Introduction (name, class, biome type)

Page 2: Colored World Map of your biome

Page 3: Abiotic factors of the environment; including a climatogram of the biome (additional abiotic factors: soil type, amount of surface water, weather, and mineral or rock types)

Page 4: Colored food web of biome and descriptions of producers, consumers, herbivores, omnivores, carnivores, and detritavores

Page 5: List of major animals in the biome (1-invasive species, 1-endangered species, 1-keystone species, and 1-indicator species)

Page 6: List of major plants in the biome (1-invasive species, 1-endangered species, and 1-cultivated crop [plants that are farmed])

Page 7: Adaptations of animals in this biome (example: camouflaged, thick fur, stripes, ect…)
Environmental problem I in the biome (Answer the following questions: What is the problem? What is causing the problem? And What can be done to help fix this problem? What scientific advances or emerging technologies can help solve this problem?)

Environmental problem II in the biome (Answer the following questions: What is the problem? What is causing the problem? And What can be done to help fix this problem? What scientific advances or emerging technologies can help solve this problem?)

Page 11: Rubric for assignment (See appendix D”)

Environmental Scrapbook Reflection:

This was a great activity to pull all the environmental components together. It allowed the students to collaboratively use the knowledge that they had gained about ecosystems and apply it to a specific biome. By combining all the concepts into one assessment we saved a great deal of time in class. This activity incorporated technology, environmental terminology and creative skills. The projects generated by the students were amazing. Each student infused the concepts learned and researched materials into a unique project. The students really got involved on this project, however it was very time consuming. This lesson required two to three extra days of class time.
Title:  **Zoo Debate**

Subject:  Ecological Principles

Length:  1-½ block classes

Materials:  Printed off materials for pros and cons of zoo’s

Objective:  To introduce students to the concept of species diversity verses biological diversity. Allow the student to defend a position about a major environmental issue.

Description:  The class should be divided in half: one side against the Zoological Association and one side for the Zoological Association. Each team is given a stack of materials supporting their side and allowed 30 minutes to review the resources. The teams should anticipate the other side’s arguments and determine points to counter them. Each team should strive to create 10 points or more.

After the materials have been reviewed the teams will debate the issues. The instructor will act a mediator. Each team is allotted 30 seconds to make a point, the other side is then allowed 30 seconds to defend their position. Finally, the side that introduced the point is given the opportunity to rebut their original point. The instructor will alternate who introduces the point first. Each person on each team must present one point.

**Zoo Debate Reflection:**

This activity really tested the maturity of the students. Debating is an advanced skill which can lead to in depth knowledge of a topic. The students during this lesson really enjoyed the opportunity to express their opinions. I grouped them based on their preconceived ideas on the topic of “Zoos”. Each team broke down 10 key points they wanted to make during the debate. Since each member had to participate it was really important that everyone was familiar with the all 10 topics. The rules were laid out for the students and the debate commenced. The students all made very strong points and maintained their professionalism.
Title: Statistics

Subject: Research Methodology

Length: 1-½ block classes

Materials: Copies of statistical packet provided by the American Statistical Association, t-chart, and calculators

Objective: To introduce the students to the statistical analysis procedures that scientists use to process research materials and determine the significance of their findings.

Description: An introduction to the importance of statistics in scientific research is needed at the beginning of this lesson. The basics of statistics should be covered: mean, median, mode, and standard deviation. Standard deviation should be done by hand during the first problems encountered. Calculators can be used to calculate this later in the course.

Three more advanced methods of statistical analysis will then be introduced to the students: t-test for independent samples, t test for repeated measures, and chi Square. The importance of these tests in providing the significance of research are introduced along with the null hypothesis and the use of a t-chart.

The class will then be divided into multiple groups of 3 for a Jig Saw activity (home team). Each person in the group was assigned a specific statistical test: t-test for independent samples, t test for repeated measures, and chi Square. Please see “Appendix E” for a copy of the statistical packet. The students with like assignments then form a group to work through the examples provided by the teacher. The goal of this section is for each student to master one statistical test so that they may go back to their home team and teach their teammates. By the end of the lesson each student should be familiar with all three statistical test.

Several sample problems and homework problems will conclude this lesson to ensure that each student is comfortable with these mathematical methods.
Statistical Analysis:

Statistical analysis is used to decipher the data collected from surveys and experiments. This lesson was lecture-based and introduced the students to various methods of processing data to obtain useful information and accept or reject a hypothesis. This lesson was fairly difficult for the students to catch onto because they had never encountered this type of math before. After many examples and some collaborative learning the students one by one caught onto the concept. Next time I teach this lesson I will definitely use the collaborative learning because it sparked a lot of peer tutoring among the students. Those students who understood the concept were able to assist those who were confused. This lesson was a set-up for the field trip the students would take.
Title: Field Trip to Warren County Conservation Club

Subject: Research Methodology

Length: 1 day in field 2 days follow-up

Materials: see labs

Objective: Students will examine the environment using various scientific measurements. In addition, students will design and implement their own experiment.

Description: It is important for students to study the environment in the environment. The students after creating their own research projects and studying research methodology are allowed the opportunity to investigate their hypothesis in a nature setting. The designated site for this study is the Warren County Conservation Center (WCCC). The center lays claim to 100 plus acres of fields and various forest and 3 ponds. During the students time at this center they will complete three research projects: community ecology lab ‘A Goldenrod Study’, Berlese funnel invertebrate collection study, and their independent research project.

Community Ecology Lab: A Goldenrod Study
The purpose of this lab was to statistically analyze the various locations and types of parasites found on a common species of goldenrod. The students will split into four research teams and process the North, South, East, and West side of a goldenrod field. Each group will randomly choose two five meter transects to survey for the parasitic gall-formation. The number and type of gall will be recorded.

Berlese Funnel Invertebrate Collection Study
The purpose of the Berlese funnel is to collect the macro invertebrates that feed on the detritus of forest floors. During this research project each team will construct a Berlese funnel following the instructions provided by the instructor. The four funnels will each be designated to a different location at the WCCC. The funnels will then be hung under a light to dry for two days. The contents of the funnel will then be analyzed by type of invertebrate and location.

Independent Research Project
The student’s will research and create there own methods for an independent research project. The students are able to work in pairs or by themselves. The student’s are encouraged to research in areas of their own interest by searching the internet and looking through a menagerie of classroom materials.
Please see “Appendix F” for complete descriptions of the community ecology lab and the Berlese funnel study. The community ecology lab was taken from the Miami University zoology lab manual and the Berlese funnel study was adapted from www.albany.edu/natweb/fsdetr.htm.

Field Trip Reflection:

The field trip was a wonderful experience for the students to experience hands-on research. The students implemented projects given by the instructor and projects designed by themselves. The day was spent exploring the environment using a variety of field techniques. Student generated projects included soil sampling, water sampling, water bio-inventories, bag worm surveys and many others. After the field trip the results yielded by the various experiments were statistically analyzed using the methods previously taught. This was great practice of the math skills learned and provided real life data.
Title: Problem Solving Process

Subject: Environmental Problem Analysis

Length: 2-3 90-minute classes

Materials: TV, VCR, movie the Lorax, and overhead

Objective: To introduce environmental problems and become familiar with a method for processing all aspects of the problem.

Description: During the first part of this lesson the students will watch the Dr. Seuss film entitled “The Lorax”. The movie is a cartoon that depicts multiple environmental problems caused by the greed of society. The students while watching the film are asked to reflect on several questions. Please see “Appendix G” for the worksheet containing the questions.

After viewing “The Lorax” the students will be introduced to the environmental problem solving process and outlined by the Institute for Environmental Sciences at Miami University in Oxford, Ohio. The process is one of the most important aspects of environmental education because it allows the individuals to analyze all the components of an environmental problem and recommend proactive solutions to the issue. In addition, the skills learned can transfer to issues encountered in other various areas of study.

Using an overhead projector the process is outlined for the students. Step by step the class will encounter the process unfold. Each step is introduced using a variety of sample problems. The students will be given a similar problem as homework.

**Environmental Problem Solving Process** (Taken from ‘The Institute for Environmental Sciences’ at Miami University Oxford, OH)

1. Problem Identification
2. Problem Boundaries
3. Goals
4. Objective
5. Study Design
6. Alternative Solutions
7. Selection Criteria for Alternative Solutions
8. Implementation

9. Monitoring

See “Appendix G” for more information on the Environmental Problem Solving Process and sample environmental problem prompts. This process will serve as a prelude for the environmental problems the students will encounter during the next portion of the unit.

Problem Solving Reflection:

The problem solving process is a necessary tool for analyzing environmental issues. This process was an introduction to the environmental problems the students were going to encounter later in the unit. This process is a tool the students can use to address the environmental problems encountered in school and out of school. The students practiced their problem solving abilities on the movie “The Lorax”. While the movie is aimed at small children the concepts were appropriate for this activity. The students did a great job analyzing the problems associated with the movie and identifying ways to address the issues. Practicing this tool with the movie was a great way to identify those students who didn’t catch onto the idea as quickly.
Title: Population Yeast Lab

Subject: Human Population

Length: 1 day initially for set up and 2 weeks 20 minutes per class period

Materials: Molasses, water, 100mL graduated cylinder, stirring rod, 100mL beaker, microscopes, microscope slides and cover slips, capillary pipette, Para film, and yeast solution

Objectives: To follow the growth of a yeast population over a 10 day period. During this time the students will encounter the exponential growth and carrying capacity of a population.

Description: To introduce the topic a movie showing the rapid increase of the human population will be shown. The movie is entitled “Population Growth” and is produced by PBS. After the movie is show a class discussion will be held to determine the current thoughts of the students about over population.

Once the students are familiar with the aspects of over population, a lab demonstrating the actual growth and carrying capacity of a population will be carried out. The lab uses a culture of yeast with a sugar energy source. When colonies of yeast are deprived of oxygen, they convert sugar to carbon dioxide gas and produce alcohol as a waste product. This reaction releases energy and the yeast use the energy to grow and reproduce rapidly. The decline in yeast colonies is due to the waste byproduct produced by the yeast. The goal of the lab is to graph (using Microsoft Excel) the population change over time as the yeast colonies expand and decline. The students will then calculate the carrying capacity of the yeast population and write a formal lab report of their experiment. For an outline of the lab report format and rubric please see “Appendix H”.

Directions for Lab

1. The instructor has prepared a yeast culture in solution.
2. Begin the lab by stirring the yeast cultures to assure uniformity in the solution.
3. Immediately use the dropper to collect 50mL of yeast from the culture.
4. Place the yeast culture solution in to a 100ml flask
5. Add 5mL of molasses to the 100mL flask and swirl the solution
6. Allow the yeast culture solution to sit for 30 minutes
7. Place 1-2 generous drops onto the center of a microscope slide.
8. Gently cover the yeast culture with a cover slip
9. Position the slide on your microscope (use low power for focusing on the cells, and then switch to high power.)
10. Count the number of yeast cells visible in the microscope’s field of view under high power.

11. Move the slide and repeat the count 2 more times

12. Average the number of cells from each trial and record the number on a chart in your journal

13. If the cells are too numerous to count, dilute a sample of the culture by combining 20 drops of culture with 9mL of water in a test tube prior to counting. Multiply your cell count by 10 before recording the data. If the population is still too dense, dilute further by combining 20 drops of the diluted culture with another 9mL of water, and then multiply the count by 100.

14. Repeat steps 7-13 for the next 9 days

15. After the 10-day experiment is completed, you will graph your data on the computer.

Post Lab Discussion Questions (to be addressed in the conclusion)

1. How did the yeasts population change over the course of 10 days? Why do you think this happened?

2. What was the carrying capacity (K) for the yeast population?

3. How are the limiting factors of the yeast similar to the limiting factors of the human population?

4. How do you think increasing the food supply of the yeast would affect the population curve?

5. What environmental factors does the logistic growth equation exclude from its model?
Population Yeast Lab Reflection:

This was a great lab for the students to visualize the affects of overpopulation and carrying capacity. The students at first had a difficult time creating dilutions of the yeast for counting, but after a few days they had perfected their technique. This lab also allowed the students to graph their findings and calculate the carrying capacity. This was done using an Excel spread sheet. The set up time for this lab each day was very lengthy and took more time than I had scheduled. To get out the microscopes, dilute the yeast and then count them took the students about 30 minutes each day for about 2 weeks of class. While this was a great learning tool, I am unsure if I would use this activity in a class that was on a time constraint.
Title: Article “Nobody Ever Dies of Over Population” by Garrett Hardin

Subject: Human Population

Length: 30 minutes or homework

Materials: Article “Nobody Ever Dies of Over Population” by Garrett Hardin

Objectives: To introduce the controversial issues related to over population.

Description: This article introduces the students to the controversy behind the topic of population. The students will read the article and answer a few discussion questions concerning the topic.

Discussion Questions
1. How does the author’s view of “need: relate to death by over population?

2. What is the “true” meaning of the quote by T.S. Elliot?

3. Is the implied public (social, political, economic, etc...) attitude presented by the author a true or fantasized concern, is it local (US) or World wide?

4. How does the author substantiate his title and final statement “Nobody Ever Dies of Over Population it is unthinkable.”?

5. Propose how this world attitude could be altered. Discuss all of the implications involved.

Article Reflection:
This was a small assignment used to fill in space at the end of a project. The article introduces the issues surrounding the topic of overpopulation. This is a great way to asses the student’s preconceived notions and misconceptions about overpopulation. The students were very surprised by this article and shared many opinions with each other. It really almost turned into a debate. It was great to see the interest in the topic because this made a great connection to the next activity.
Title: Population Jig Saw

Subject: Population

Length: 90 minute block

Materials: The following articles or similar articles are needed for this activity. Each of the following articles can be found in “State of the World” published by the World Watch Institute.

- Feeding 9 Billion- 1999
- Improving Women’s Reproductive Health-2000
- Ending Poverty- 1990
- Linking Population, Women, and Biodiversity-2003

Objectives: To understand the various contributions to overpopulation around the world. To work as a team to address a series of discussion questions.

Description: Over population is a multifaceted environmental problem with many stakeholders. In this activity students will be part of a home team (5 in each team). Each person will become an expert in one article concerning population and meet with others who have chosen the same article (specialty teams). The specialty teams will chew on discuss the articles writing down the main points. Upon returning to their home team the group will have to collaborate to answer three comprehensive questions.

Comprehensive Discussion Questions

1. Some scholars claim that by the year 2050 the population of the world will exceed 10 billion, with food shortages and poverty concentrated in countries and regions with the greatest concentrations of population and population growth. Others claim that population growth and concentration has never been a problem in human history, but that lack of distributive justice, democracy, access to food, and failure of entitlements will remain responsible for poverty and hunger in large parts of the world. Discuss these views from a critical perspective.

2. What is the connection between poverty, women’s rights, environmental degradation, hunger, and over population? Explain these connections fully citing specific examples from the readings.

3. Evaluate this statement. “Over population causes poverty—poverty causes over population”.

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Population Jig Saw Reflection:

This lesson introduced the students to the underlying causes of overpopulation. This activity was great because each student only read one article and worked with other students who had read the same article. After they became familiar with the articles they shared their findings with each other. This activity was a real time saver. It allowed many concepts to be learned in only one class period. The reflection questions allowed the students to pull all of the concepts together.
Title: Population Role Play

Subject: Human Population

Length: 3 blocks

Materials: Computers and reference materials

Objectives: Over population is an issue that faces many the whole of the world. Included in this are a variety of stake holders; political, ethic groups, religious, ECT... This activity introduced the students to the differing opinions each group holds on the topic of over population and how difficult a solution to the problem may be.

Description: The class will be split in half for this assignment: this split will represent the democratic and the republican parties. The goal of the lesson is to create a comprehensive population policy and to few the political split between parties when environmental issues are at hand.

Project Directions:

The United States has the highest population growth rate of all developed countries in the world and at more that 290 million, is the third most populous country in the world. The United States census bureau tells us that if current trends continue, our population will double this century, practically within the lifetimes of children born today. This doubling will have a significant impact on the environmental legacy left to future generations of all species.

The United States is seen as a role model for the entire planet and is drafting a comprehensive policy in response to the issue at hand. The goal of the policy is to decrease consumer and people population growth by the year 2040. You being the major political parties in the United States have been asked to independently draft a policy for your party.

Remember to be thorough, take into account differing views (women, religions, impoverished citizens, medical professionals, environmentalist and of course politicians) from your side, and use current research from around the globe and in the US. Your policy must be effective and must be achievable within the democratic society we live in. You will present your policy draft to Congress on __________. Each member of your should be prepared to speak on the topic.
Break down of Project (you need a visual aid: poster, handout or PowerPoint)

1. Develop a major overall goal for your program and an explanation or why that is your focus.

2. It can only have 5 main sub-goals issues or points. MAKE THEM COUNT

3. Describe what they would be, why you chose them and their predicted impacts?

4. How difficult would it be to implement your plan? What changes need to take place for this plan to happen?

Population Role Play Reflection:

After learning about the logistics and theories behind population we addressed the social and political issues surrounding the topic. Overpopulation is a sensitive topic and many stakeholders have strong opinions regarding its policy. To maintain a fair classroom environment the class was broken into two groups: Republican and Democrat. The teams were charged with creating a population control plan for the United States. Each group researched the various stances of each political party. The internet was the best resource for finding information on each party. The presentations by the students were very interesting and creative. However, the population policies were a little far fetched. After the project was over I had the students do a reflection on the problems associated with the creation of a population policy. The students soon realized that with so many stakeholders the common decisions were almost impossible to make.
Title: Natural Resource Extraction (adapted from Geographic Channels ‘Expeditions’)

Subject: Sustainability

Length: 3 days

Materials: Computers, TV, “Monster’s INC”, and VCR

Objective: Research a particular natural resource to see how it's used, where it comes from, how it's extracted, and what concerns are associated with this extraction process; and create posters or multimedia presentation to show the results of their research.

Description: Begin by presenting the following quote to the students

_Everything comes from something,
Nothing comes from nothing,
Just like paper comes from trees,
And glass comes from sand._

By the poet Carmen Agra Deedy

Have the students brainstorm a list of natural resources. Discuss students' lists and ask the following questions:

- Have they ever thought about where these materials come from?
- Have they thought about the people and processes involved in getting these materials to our markets?
- What types of processes do they think would be used, and what might be some of the impacts of these processes?

Tell the class that many of the resources that we take for granted, such as oil and coffee, have actually become quite controversial because of the environmental and cultural impacts of extracting these resources.

Divide the class into small groups or pairs, and have each group choose one of the following resources: oil, diamonds, aluminum, gold, or coffee. Have them conduct Internet research to answer as many of the following questions as they can in a power point presentation:

- How is this resource used in the United States, and why do we "need" it?
- Where does this resource come from?
- What are the environmental, cultural, and human rights concerns, if any, concerning this resource?
- What is industry doing to address these concerns?
- What, if anything, are governments doing to assist the industries and to address these concerns? (Students may or may not be able to find answers to this question.)
**Extension:**
After the students have completed their research project the movie Monsters Inc by Disney should be shown as an assessment. The movie illustrates a parody on natural resources. During the movie the students will look for the similarities between this fictional portrayal of natural resources and what they have learned during the lesson.

**Monster’s Inc Resource Activity Reflection:**

In this activity the students are introduced to the concepts of renewable and non-renewable resources. Working in groups the students researched various resources and their points of origin. After the foundation of knowledge was gained the students watched the movie Monster’s Inc. The movie may be a little childish, but the concepts presented in this film are invaluable. The students enjoyed incorporating popular culture into the classroom. This movie allowed the students to see how Pixar Animation has brought current environmental problems into their storybook. This movie shows the importance of using renewable resources. The students made the analogy with the current energy crisis facing America and the world.
Title: Simcinnati Project

Subject: Sustainability

Length: 1 week of class

Materials: SimCity 300 Cd, sample reports, and Computers

Objective: To use a simulation of city planning. The students will analyze the various stakeholders in the created city and how environmental decisions are made.

Description: Sustainability is an abstract environmental issue and is often difficult for students to comprehend. The Sim City 3000 simulation offers hands-on experience by allowing students the opportunity to see the connection between sustainability and city planning. To begin the activity students are broken into groups of 5-6 individuals and given a list of questions to answer regarding the aspect of city planning. This allows the students to become familiar with topic. Afterwards the students will play a simulation on the Sim City 3000 CD. During each 10-year period, of the simulation, the team will rotate the roles of the game and a report will be constructed. The following is the prompt for the project. For additional resources see “Appendix I”.

Directions for Project:

Before to assume you begin you must set your goals for the construction and planning of your city. What characteristics are important to the growth of a city? What are your priorities over the 60-year period? What do you hope to accomplish? In addition to your overall goals, you will set objectives for each 10-year period. These objectives are your benchmarks for success during that 10-year period. Each ten-year period everyone should assume a role in the city (Mayor, City Treasurer, City Services Director, City Welfare Director, and (2) Citizens). Everyone should have the opportunity to assume each role in the city. The mayor is responsible for writing the report for that specific time period.

1. Start SimCity 3000 and select the New City option. Make sure the settings are set to Easy, 1950, and Small City. Then click on the checkmark.

2. Give your city a unique name. Periodically save your city to a disk!!!

3. When the Terrain Window opens, accept the first terrain that is offered.

4. The game will be paused in the beginning—explore your different options for city planning. THIS IS IMPORTANT!

5. Follow the News Scroll at the bottom of the screen for updates about your town.

6. It would be beneficial to talk to your advisors and citizens often.
7. After each 10-year period you should reflect on the objectives and overall goals for your city. Make sure to review/report the data on your city (budget, pollution, population density, etc…)

Sim City Simulation Reflection:

The students have all heard about the videogame “Sim City”, but have never thought of the real life applications of this simulation. One major problem was getting the CD’s uploaded onto the computers. Finally, we had several students bring in their own lap top computers to use for the duration of the project. The students really enjoyed incorporating this activity into the class. In fact, many students came in to work on the project during their lunch period. To ensure that the students were not just playing around they were all responsible reporting the findings of their simulation for a total of 100 years 5 reports (1 for each 20 years). Each student reported that after analyzing their activities, the program became much more complex.
Title: Waste Audit

Subject: Environmental Issues

Length: 5 days (1 day to present)

Materials: Gloves, trash bags, conversion charts or a large scale

Objective: The students will characterize the output of waste at Lebanon high School and develop plans for reduction.

Description: A waste audit is a procedure, as outlined in this plan, to guide an individual or team of individuals through a series of steps which will provide data on how much waste is generated, disposed of and recycled. Many businesses and institutions are unaware of the actual composition of their waste stream.

The goal of a waste audit is to help put a focused look on how materials are purchased, what is brought into a facility and what goes out of a facility as waste, pinpointing just what and how many materials are actually recyclable.

Directions:

Your goal as a team is to design a procedure for auditing the waste produced at Lebanon High School. You should take into account the desired data needed for this project, the procedures for collecting the data, measurements to be taken during collection, the conversions necessary to compute the data, and the analysis needed to present the data in a professional manner.

Day 1: You will research through provided materials and brainstorm as a group the data desired and the procedures needed to collect the data.

Day 2: You will implement your procedures and begin collecting data

Day 3: You will finish collecting data and begin analyzing the information

Day 4: You will compile the data into a power point presentation using graphs and charts created in excel

Day 5: You will present the information obtained to your classmates in a power point presentation with graphs and charts
Teacher Notes:

- You should arrange ahead of time with the school and the custodial staff to gain access to the collected waste.

- In order to calculate the total amount of recyclables found in a waste stream the students will need a standard conversion chart (i.e. A 30 gallon container of glass weighs 74 lbs) or a large scale. Please see “Appendix J” for a copy of the conversion standards.

- Students should also where gloves at all times.

Waste Characterization Study Reflection:

This experiment was a great way to for the students to analyze the amount of waste generated by a population. At first the students were very hesitant about the project referring to the possibility of rummaging through a dumpster as ‘disgusting’. After making arrangements with the custodians and principal we began collecting data for the project. The goal was to determine how much waste was generated by the school population that could have been recycled. As a class the students determined a measurement plan based on the equipment we had readily available. Once the project began the students, obviously enjoyed, the experience that they termed ‘dumpster diving’. The data was presented in a Power Point format to the school principal. The numbers of recyclable materials was astounding and the school has since created a recycling program implemented by the students. This was an eye opening experience for many of the students who could not stop talking about event.
Title: Annual Research Assistant Symposium

Subject: Environmental Issues

Length: 2 days (1 day to present)

Materials: (see independent lab instructions)

Objective: To investigate an environmental issue in a lab setting and present the findings in a poster presentation to their peers.

Description: Due to time constraints, the students are divided into three teams. Each team will be assigned an independent lab project dealing with an environmental issue. The topics will include energy conservation, air pollution, and water pollution. Each team will collect data during the lab and present their findings at the Annual Research Assistant Symposium, a fictional seminar in the classroom.

The students will begin by researching background information from their textbooks and articles provided by the teacher. Then the proper supplies will be handed to each team and they will begin their research under the supervision of the instructor. Please see “Appendix L” for complete copies of the labs.

**Air Pollution Lab “Bringing down the Green House”**

**Materials:**

(Enough for each team of two or four students)
5 vials or test tubes
A graduated cylinder
A funnel straw
A marble-size piece of modeling clay
4 different colored balloons
4 twist-ties
A narrow-necked bottle (the neck should be narrow enough for a balloon to fit over it)
A dropping bottle of bromthymol blue indicator solution
A dropping bottle of dilute household ammonia (1 part ammonia to 50 parts distilled water)
100 mL vinegar
5 mL baking soda
Safety goggles for wear at all times

**Teacher's Lab Notes:**

The students will be filling balloons with pure carbon dioxide, exhaled air, and ambient air. For safety reasons, you should fill the balloons with automobile exhaust. You should wear thick gloves to protect your hands from being burned. Fill the balloons in an open area and when a slight breeze is blowing to keep the exhaust gases away from your face. Place a balloon over the
narrow end of a metal funnel and place the wide end of the funnel over the exhaust pipe of a running car. When inflated, the balloons should be about 7.5 cm in diameter. It may be easier to over inflate the balloon and then let a little gas escape. Twist and tie the balloon. Repeat the procedure with the same color balloon until you have one for each lab group. The ambient air solution in vial A will not turn yellow. The level of CO2 in ambient air is too low to affect bromthymol blue.

Students will need around 60 drops of the diluted ammonia to neutralize the solution in vial D (vinegar-baking soda reaction). The other two vials should require between 7 and 40 drops. Caution students to add the drops slowly and shake solutions between drops so they can get a careful record of when the color changes back to the same color blue as the control.

Since the students will have to add a relatively large amount of ammonia to the solution in vial D, the color of this sample may be affected by dilution. To equalize this effect, you can have students add some water to the other samples to make the volume in each sample equal. This is easiest to do if sample D is titrated last.

Procedure:

1. Add 15 mL of water and 10 drops of bromthymol blue indicator solution to each vial or test tube. Label the vials A, B, C, D, and Control.

2. Fill each balloon until it has a 7.5 diameter.

   Sample A (Ambient Air) - Use a tire pump to inflate the balloon to the required diameter. Twist the rubber neck of the balloon and fasten it shut with a twist tie. The tie should be at least 1 cm from the opening of the balloon. Record the color of the balloon used for this sample.

   Sample B (Human Exhalation) - Have one team member blow up a balloon to the required diameter. Twist and tie the balloon, and record balloon color.

   Sample C (Automobile Exhaust) - Your teacher will supply you with this balloon. Record the color. Sample D (Nearly pure CO2) - Put 100 mL of vinegar in the narrow-necked bottle. Using a funnel, add 5 mL of baking soda. Let the mixture bubble for 3 seconds to drive the air out, then slip the balloon over the neck of the bottle. Inflate the balloon to the proper diameter. Twist, tie, and record the color.

3. Soften the clay and wrap it around one end of the straw to make a small airtight collar that will fit into the neck of a balloon. The collar should look like a cone with the straw in its middle, and should be large enough to plug the neck of the balloon.

4. Pick up Balloon A. Keeping the tie on it, slip the balloon's neck over the clay collar and hold it against the collar to make an airtight seal. Place the other end of the straw into the vial of water and bromthymol blue labeled A. Have another partner remove the tie on the balloon and slowly untwist the balloon. Keeping the neck of the balloon pinched to control the flow of gas, gently squeeze the balloon so the gas slowly bubbles through the solution.
5. Repeat the same procedure with the other balloons and their respective vials. In some cases, the bromthymol blue solution will change color, from blue to yellow, indicating the presence of carbonic acid formed from CO2.

6. Analyze each of the samples by titrating them with drops of dilute ammonia. Ammonia neutralizes the carbonic acid. The bromthymol blue will return to a blue color when all the acid has reacted. Add drops of ammonia to each of the samples that turned yellow, carefully counting the number of drops needed until they are about the same color as your control. Record the results.

**Energy Lab “Making Bio-Diesel”**

 Procedure:  
The following lab is very extensive and the directions are long. I suggest printing a copy from “Appendix K”.

**Water Pollution Lab “Risky Business”**

Materials needed for each team:  
- 1 16–ounce plastic bottle of test solution labeled “Stock Solution __%”
- 1 3ml pipet
- 11 six–ounce plastic cups
- graph paper (one for each student)
- Marking pen

Procedure:
1. Observe the daphnia before performing test. Make sure they appear healthy and are moving around.

2. Put on safety gear (goggles and gloves).

3. Label the 11 test chambers with your assigned stock solution, and your group name and start/class time. Pour 40 mL of the test solution into ten of the test chambers. Leave the 11th chamber as the control.

4. Using the net, carefully transfer one individual daphnia to each of the test chambers. Try to limit the amount of liquid you transfer from the shipping container to the test chambers to avoid diluting the solution. IMPORTANT: Rinse the pipette with distilled water each
time you transfer a daphnia. If you don’t, the various stock solutions will be altered and could affect the outcome.

5. The daphnia must remain undisturbed in their test chambers for 6 hours before observing and recording the results. At the end of the test period, check to see which animals are alive and which have died. If they are moving in the test chamber, either actively swimming or showing some movement, the fish are considered alive. Observe each individual for several moments to determine if any movement occurs, no matter how slight. These will be recorded as live. The daphnia that do not move will be recorded as dead.

6. Record the number of living daphnia and the number that have died. Share your results with the rest of the class.

7. On the graph paper, record the results. The y-axis should be labeled concentration level and the x-axis should be labeled # of daphnia deceased (1-11).

Environmental Problem Research and Poster Presentation Reflection:

Researching and presenting are two opportunities often found in the field of science. This activity saved time by combining three labs into one time slot. The class was divided into three teams. Air pollution, water pollution and toxicity, and alternative energies were the topics of the three labs. Each team completed one lab and presented their findings in a poster presentation. These labs were very complex and did require a lot of supervision. However, each group completed the labs with very few problems. The most difficult part of this activity was supervising three groups who needed assistance. Fortunately, my supervising teacher was able to lend a hand. I recommend next time have someone to help with the implementation of these labs or choose less complicated labs.
Title: Assessment

Subject: Assessment

Length: 1 day

Materials: Copies of the exams

Objective: To test the knowledge learned during the unit

Assessment Reflection:

A variety of assessments were used during the process of this unit, but a culminating assessment was needed to measure the knowledge gained and to assess their ability to bring all the ideas and concepts together. The test was given in parts. The first test was short answer questions mixed with a few statistics questions. The second part focused on the problem solving process previously learned in class. The students watched a clip about an environmental problem and then used the problem solving process to analyze the issue. Overall the students did very well on the test. The average grade was an 84%.
CONCLUSION

Activities, projects, and labs were generally perceived by the students as the most enjoyable lessons. Specifically the environmental scrap book, outdoor research fieldtrip, outdoor waste audit, and the research presentations seemed to be the most favored lessons in the unit. Each lesson was successful for different reasons. The “environmental scrapbook” was a large assessment of the student’s cumulative knowledge of ecosystems and environmental issues. This activity allowed the students to be creative with their own knowledge and incorporate this learned information into a synthesized hands-on project. The outdoor research fieldtrip sparked a variety of interests in the students. The trip was comprised of two instructed research labs and one individual research lab. The outdoor experience assembled with the high level of research made this a motivating and pleasurable activity. The waste audit was a lesson that allowed students to conduct research and then propose a solution to the problem at hand. This activity allowed the students to design the research procedures, implement the procedures, and analyze the data. The information was very compelling and the students were further motivated to propose recycling and waste reduction plans to the Lebanon City Schools Board of Education. The research posters were another successful lesson. The class was divided into three groups each completing a lab activity investigating an environmental issue. Each team then assembled a professional poster conveying their results to their classmates. This activity allowed the students to work together in a lab setting and required them to be professional as they reported the information gathered. In addition, the project was challenging from beginning to end requiring each student to contribute in every aspect of the project.

During the implementation two problems persisted with the lessons. 1) not enough time and 2) not enough computer resources. Timing issues started at the beginning of the environmental unit. Compressing sixteen-weeks of activities into eight-weeks already caused a time constraint. This course was designed to be rigorous and fast paced because it was an honors program. However, the students were enrolled in multiple honors programs and found the amount of work quite a challenge. Without compromising the integrity of the course and the students’ learning, more time was allotted for projects and lab work. This created a problem at the end of the eight-week unit because many activities had to be further shortened and rushed.
The availability of computer resources was also a challenge during the implementation process. The classroom was equipped with four computers for a class size of twenty-three students. This meant group sizes for projects and labs were considerably larger than desired. In addition, the computer lab facilities and lap tops were frequently unattainable due to over booking. To deal with computer shortages many students brought in their own lap top computers to use during different lessons. This helped to ease the size of groups considerably from 6 to approximately 4 students. In the future I will have each student complete a survey of their technology resources at home. This would allow some of the assignments to be completed as homework.

Another technical difficulty during the lesson was the uploading of the “Sim City” resource simulation. The technical support office at the high school hit a stumbling block loading the programs onto the school computers. This problem was eventually remedied, but a delay was placed on the activity. I would only repeat this activity if more computers were available to use in the classroom.

After many challenges early on in the practicum the overall environmental unit was a success. The only changes I would make in the future to this unit are to allocate more time for each of the projects and obtain more computer resources. The final exam grades indicated that the students learned a great deal during the course of this eight-week unit. The mean grade was an 84% “B” on the final assessment and 8 out of the 23 students received an “A”. In addition to the academic achievement, many of the students showed an increased initiative to further explore environmental problems, so much that they started their own recycling program at the high school that is still being implemented today.

Completing this practicum was a great way to explore the National Science Education Standards and their place in the science classroom. I believe that the National Science Education Standards set standards for what students need to know, understand, and be able to do to be scientifically literate citizens. Developing interactive lessons has allowed me to focus my practices toward a student-centered approach. The National Science Education Standards combined with the student-centered approach allowed me to create and implement a unit that fostered student learning. The ideas and concepts generated by this unit have empowered each student with the abilities in making environmentally literate decisions.
To others who are teaching similar units or lessons I would advise to have the technology resources checked in advance. They are a great resource in the classroom, but only when they are available. In addition, the lessons that were most successful were the challenging, inquiry-based activities.
LITERATURE CITED


APPENDIX A:
Personal Learning Styles Assessment
YOUR STYLE OF THINKING AND LEARNING

CIRCLE A, B, OR C FOR THE DESCRIPTION THAT IS MOST LIKE YOU. MARK ONLY ONE LETTER FOR EACH QUESTION.

1. I remember best...
   A. names
   B. faces
   C. both names and faces

2. I prefer to have things explained to me...
   A. with words
   B. by showing them to me
   C. both ways

3. I prefer classes...
   A. with one assignment at a time
   B. where I work on many things at once
   C. both ways

4. I prefer...
   A. multiple choice tests
   B. essay tests
   C. both kinds of tests

5. I am...
   A. not good at body language, I prefer to listen to what people say
   B. good at body language
   C. sometimes good, but other times not good

6. I am...
   A. not good at thinking of funny things to say and do
   B. good at thinking of funny things to say and do
   C. sometimes good

7. I prefer classes...
   A. where I listen to "experts"
   B. in which I move around and try things
   C. where I listen and also try things

8. I decide what I think about things...
   A. by looking at the facts
   B. based on my experience
   C. both ways

9. I tend to solve problems...
   A. with a serious, business-like approach
   B. with a playful approach
   C. with both approaches
10. I like...
   A. to use proper materials to get jobs done
   B. to use whatever is available to get jobs done
   C. a little of both

11. I like my classes or work to be...
   A. planned so I know exactly what to do
   B. open with opportunities for changes as I go along
   C. both planned and open to changes

12. I am...
   A. never inventive
   B. very inventive
   C. occasionally inventive

13. I prefer classes when I am expected...
   A. to learn about things I can use in the future
   B. to learn things I can use right away
   C. both kinds of classes

14. I...
   A. would rather not guess or play hunches
   B. like to play hunches and guess
   C. sometimes make guesses and play hunches

15. I like to express feelings and ideas...
   A. in plain language
   B. in poetry, song, dance, art
   C. both ways

16. I get insights from poetry, symbols, etc...
   A. rarely
   B. usually
   C. sometimes

17. I prefer...
   A. solving one problem at a time
   B. solving more than one problem at a time
   C. both equally

18. I respond more to people when...
   A. they appeal to my logical side, my intellect
   B. when they appeal to my emotional side, my feelings
   C. both ways

19. I prefer to learn...
   A. the well-established parts of a subject
   B. about the unclear parts, the hidden possibilities
   C. both ways

20. I prefer...
   A. analytic reading, taking ideas apart and thinking about them separately
   B. creative reading, putting a lot of ideas together
   C. both kinds of reading

21. I prefer...
   A. to use logic in solving problems
   B. to use "gut feelings" in solving problems
   C. both equally
22. I prefer... A. to analyze problems by reading and listening to experts
   B. to see and imagine things when I solve problems
   C. to do both.

23. I'm very good at... A. explaining things with words
   B. explaining things with hand movements and actions
   C. both

24. I learn best from teachers who... A. explain with words
   B. explain with movement and actions
   C. have no preference

25. When I remember or think about things, I do so best with...

   A. words
   B. pictures and images
   C. both equally well

26. I prefer to... A. examine something that is finished and complete
   B. organize and complete something that is unfinished
   C. do both

27. I enjoy... A. talking and writing
   B. drawing and manipulating ( handling) things
   C. both equally

28. I am... A. easily lost in finding directions
   B. good at finding directions
   C. not bad in finding directions, but not really good either

29. I am... A. primarily intellectual
   B. primarily intuitive
   C. equally intellectual and intuitive

30. I prefer to learn... A. details and specific facts
   B. from a general overview, to look at the whole picture
   C. both ways equally

31. I read... A. for specific details and facts
   B. for main ideas
   C. for both equally

32. I learn and remember... A. only those things specifically studied
   B. details and facts in the environment not specifically studied
   C. have noticed no difference in these areas

33. I like to read... A. realistic stories
   B. fantasy stories
   C. no preference

34. I feel it is more fun to... A. plan realistically
   B. dream
   C. both equally fun
35. I...  
   A. prefer total quiet when reading or studying  
   B. prefer music while reading or studying  
   C. listen to music only when reading for enjoyment, not when studying  

36. I would like to write...  
   A. non-fiction books  
   B. fiction books  
   C. no preference  

37. If seeking mental health counseling, I would prefer...  
   A. the confidentiality of individual counseling  
   B. group counseling and sharing of feelings with others  
   C. no preference for group over individual counseling  

38. I enjoy...  
   A. copying and filling in details  
   B. drawing my own images and ideas  
   C. both equally  

39. It is more exciting...  
   A. to improve something  
   B. to invent something  
   C. both are exciting  

40. I prefer to learn...  
   A. by examining  
   B. by exploring  
   C. both ways equally  

41. I prefer...  
   A. Algebra  
   B. Geometry  
   C. both equally  

42. I am skilled in...  
   A. sequencing ideas  
   B. showing relationships among ideas  
   C. both equally  

43. I prefer...  
   A. dogs  
   B. cats  
   C. both equally  

44. I...  
   A. use time to organize myself and my personal activities  
   B. have difficulty in pacing my personal activities to time limits  
   C. pace personal activity to time limits easily  

45. I have...  
   A. almost no mood changes  
   B. frequent mood changes  
   C. few mood changes.  

46. I am...  
   A. almost never absent-minded  
   B. frequently somewhat absent-minded  
   C. occasionally absent-minded  

47. I am strong...  
   A. in recalling verbal materials (names, dates)  
   B. in recalling spatial material  
   C. equally strong in both  

48. I am skilled in...  
   A. the statistical, scientific prediction of outcomes  
   B. the intuitive prediction of outcomes  
   C. equally strong in both
49. I prefer...
   A. outlining over summarizing
   B. summarizing over outlining
   C. equally skilled in both

50. I prefer...
   A. verbal instructions
   B. demonstrations
   C. no real preference
YOUR STYLE OF LEARNING AND THINKING: 
RIGHT, LEFT, OR WHOLE BRAIN DOMINANT

LEFT (A's) _____ RIGHT (B's) _____ WHOLE BRAIN (C's) _____

1. Compute your B score minus your A score. It can be a minus or plus.

2. If your C score is 15 or higher, divide your B minus A score by 3. Round your score to the nearest number. The answer will be your score. It can be a minus or plus number. ________________

OR

If your C score is from 9 to 14, divide your B minus A score by 2. The answer will be your score. It can be a minus or plus answer. ________________

OR

If your C score is less than 9, do not divide at all. Your B minus A score is your answer. ________________

PLOT YOUR SCORE BELOW

-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

A score of 0 = Whole brain dominance
A score of -1 to -6 = Whole brain dominance favoring the left
A score of +1 to +6 = Whole brain dominance favoring the right
A score of -7 or higher = Left brain dominance
A score of +7 or higher = Right brain dominance
APPENDIX B:
Multi Genre Project
Rubric for Multi-Genre Scientist Project

Presentation
You are to choose an environmental scientist from the provided list (or choose your own but you need approval from the teacher before proceeding) and prepare a 3-5 minute presentation. The presentation should mimic who the scientist really was and their major life accomplishments. (i.e. use props and costumes)

Props, costumes appropriate 5 points
Presentation clarity, smoothness, lack of reliance on notes 5 points
Creative approach 5 points
Showed essence of the scientist 5 points
Ability to address peer questions 5 points
25 points

Project
Create a unique representation of the above scientist's life using four distinctly different entries. One of these entries needs to be the research of the scientist chosen creatively infused into the project. Please provide graphs, charts, and sources. The project should be organized, creative, and has a definitive beginning, middle and end. The entries are arranged in such a way as to move the "concept" forward for the reader. In addition, the entries should "mirror" their actual form, detailed, and illuminate key aspects of the scientist's life. The entries should take on the "voice" of the genre, and should move the exposition of the concept forward in a thorough manner. (i.e. if you create journal entries, then the entry should look like a genuine journal entry.)
Finally the reflection should clearly state your initial and final understandings of the scientist (you might want to do this in a visual way through concept mapping, diagramming, etc.) Also, the reflection should clearly provide your rationale for why you chose the particular scientist and the challenges you faced during creating this project.

<table>
<thead>
<tr>
<th>Component</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover Page</td>
<td>5 points</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>5 points</td>
</tr>
<tr>
<td>Presence of 4 complete entries</td>
<td>40 points (10 pts each)</td>
</tr>
<tr>
<td>(one being the scientific research)</td>
<td></td>
</tr>
<tr>
<td>Reflection</td>
<td>15 points</td>
</tr>
<tr>
<td>Bibliography</td>
<td>10 points</td>
</tr>
<tr>
<td>(minimum of 5 sources; only 3 internet sources)</td>
<td>75 points</td>
</tr>
</tbody>
</table>
Genre: Creative ways to express an idea

- Narrative
- Images
- Quotations from research sources
- Poetry
- Newspaper articles
- Magazine ads
- Stage or film dialogue
- Short story
- Journal entries
- Song
- Ect. (but don't stop thinking of genres just because my imaginations ran out here)
ENVIRONMENTAL HEROES AND HEROINES

People to investigate for their views on caring for the earth.

1. Abbey, Edward 37. Ehrlich, Paul 73. Long, William J.
6. Austin, Mary 42. Fabre, Jean Henri 78. Mason, Bill 113. Seton, Ernest Thompson
10. Baylor, Byrd 46. Fuller, Margaret 82. McHarg, Ian 117. Spencer, John W.
11. Beard, Daniel B. 47. Galdikas, Birute 83. Mendes, Chico 118. Standing Bear, Luther
18. Brower, David 54. Griffin, Susan 90. Murie, Margaret 125. Unsoeld, Jolene
28. Comstock, Anna Botsford 64. King, Thomas Starr 100. Petzoldt, Paul 135. Werikhe, Michael
32. Darwin, Charles 68. LaChapelle, Dolores 104. Roberts, Charles G. D. 139. Wright, Mabel Osgood
33. de Chardin, Teilhard 69. Larson, Gary 105. Rodale, Jerome Irving 140. Zahniser, Howard
34. Deloria, Vine, Jr. 70. Leopold, Aldo 106. Roosevelt, Franklin D.

Environmental Heroes and Heroines

Names in bold text have been referred to in this instructional unit.
Starting in Paris France follow the trail around the globe and back to Paris.

1. Birth Place of Jacques-Yves Cousteau
2. South of France to the Ecole Naval Base
3. How a tragic car accident turned to a wonderful discovery.
4. The Mediterranean where the Calypso was purchased by Jacques
5. New York City-birthplace of shopping
6. Live-aboard Calypso where Jacques raised his family
7. A trip around of world to the Academy Awards
8. Journal entries from Jacques many adventures
9. Creation of the Cousteau Society, an organization dedicated to the protection of our Earth’s oceans.
10. Back to Paris, the final resting place of Jacques Cousteau
Le Paisible Hospital
1433 Croissant Drive
Saint Andre-de-Dubec, France

Nom: Jacques-Yves Cousteau

Nom de mères: Elizabeth L'eau

Nom de pères: Daniel M. Cousteau

De Date: Juin 11, 1910   Période de naissance: 8:15 PM

Poids de naissance: 3.1 kg   Taille: 36 centimètres

Signature autorisée:
How a tragic car accident lead to a great discovery!

Cousteau had just graduated from the French Naval Academy at Brest in Brittany and was well on his way to becoming a naval pilot. Like most young cadets, planes and cars and girls were Cousteau's main interests, and an invitation to a friend's wedding in the Vosges mountains was a good excuse to borrow his father's Salmson sports car. The peppy car made fun of the hairpin bends and Cousteau made good time despite the darkness - until his headlights failed. He slammed on the brakes but it was too late. The car flew off the edge of the mountain. Years later Cousteau recalled that crash: "It was about two in the morning and as I lay in the wreckage, I thought I was going to die. I was losing blood and there were 12 bones broken in my body." Both arms were broken, his left arm in five places, and he was paralyzed on one side. The surgeons wanted to amputate the arm at once, but Cousteau refused. His dream of being a naval pilot was over.

On his recovery he was assigned as a lieutenant at the Toulon naval base, where he was sent to the gunnery. He found himself working with another lieutenant, Philippe Tailliez, who suggested that Cousteau's right arm, still slightly twisted, would benefit from plenty of therapeutic swimming. The two swam every day and soon found that another man was swimming from the same beach - Frederic Dumas. "Didi" Dumas swam to spear fish, and he soon taught Tailliez and Cousteau to do the same. Cousteau was 26 when he took his first look underwater under the guidance of Didi off the beach at Le Mourillon, now a suburb of Toulon. His life was changed forever. Not that he saw anything wonderful: "My feet were on shingle, some dark rocks nearby were covered with green and brown weed, and there were some little fish whose name I did not know. But it was enough. It was another world!"

-Magazine 1997

-Adapted from an article in Diver
FOR SALE
A retired US minesweeper renamed the Calypso. She is only 8 years old with 2,580 horsepower diesel engines. She is 139 feet in length, 25 feet wide, 10-foot draft and holds up to 25 passengers. In addition, she contains a Yumbo hydraulic crane and an underwater viewing chamber in the nose. She is currently a ferryboat carrying people and cars between the island of Malta and Gozo. She is a bit worn, but sturdy and maneuverable. Asking $12,000 USD or best offer. Contact Franco Izod at 1-435-489-1342.
It helped win the war in France, now you too can experience the ocean.

THE AQUA LUNG

Macy's Department Store
3 Main Street, New York, NY

Put that winter-worn skin in order with Dorothy Gray basic skin care. Banish that shut-in look with these carefully teamed-up creams and lotions. They just seem to polish dust and time off your face. Actually, your skin isn't a second younger. But it looks it.

So who cares?

Dorothy Gray

TO: CLEANSE, STIMULATE, LUBRICATION

Dry Skin: Dry-Skin Cleanser (Cream 623)
Orange Flower Skin Lotion
Special Dry-Skin Mixture

Normal Skin: Silken Cold Cream
Orange Flower Skin Lotion
Special Dry-Skin Mixture

Oily Skin: Liquidifying Cleansing Cream
Toner Lotion, Sealing Cream

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March 20, 1949
Application for Registration of a Non-Profit Organization

Name of Organization: The Cousteau Society___________________________

Address of Organization: 870 Greenbrier Circle, Chesapeake, VA 23320

President of Organization: Jacque-Yves Cousteau_____________________

Purpose of Organization: The Cousteau Society is a membership-supported organization dedicated to the protection and improvement of the quality of life for present and future generations. The Society speaks in testimony and counsel to governing bodies and leaders on issues of global concern, such as the protection of whales, fisheries, coral reefs and other habitats. The Society believes that only an informed and alerted public can make the decisions necessary to protect and manage the world's natural resources. Education efforts directed toward members, classrooms and the general population include membership publications Calypso Log and Dolphin Log, individual information packets on a variety of environmental subjects, statements on developing issues, participation in special events and the innovative Dolphin Log in the Classroom program.

Have you ever been convicted of a felony?: No____________________________________
If Yes, please explain:___________________________________________________________

Signature: ___________________________ Date: ___________________________

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Signature of Director: _____________________________________________

Date:_______________________________________________________________

Comments:_________________________________________________________

_______________________________________________________________

_______________________________________________________________
NEW YORK TIMES
World News
June 26th, 1997

Jacques Cousteau
Remembered for His
‘Common Touch’

For millions of people who see the
ocean only through the porthole of
television, the voice of the sea
had a soft French accent.

Jacques-Yves Cousteau, who opened
up the mysterious world beneath the
sea to millions of landlocked
viewers, died Wednesday at age 87.

His widow Francine Triplet said he
died of a heart attack at 2:30 at
their Paris home while recovering
from a respiratory ailment, which
had kept him hospitalized for
months. Cousteau is also survived
by his son Jean Michel Cousteau. A
memorial service will be held in
Notre Dame Cathedral Monday, but
the Cousteau Foundation did not say
where the explorer would be buried.

Cousteau’s 60-year odyssey with the
sea—much of it on his famous boat
the Calypso—was more than a great
adventure. He co-invented the
aqualung, developed a one-person,
jet-propelled submarine and helped
start the first manned undersea
colonies.

“When you dive, you begin to feel
that you’re an angel,” the
environmental and scuba pioneer
once said. Now Jacque is an angel
watching over the oceans from
above.

—Correspondent Mark Leff
1910 June 11, Jacques-Yves Cousteau was born in France

1930 Enters Ecole Naval de Brest and graduated 3 years later, 2nd in his class

1937 Marries Simone Marquise Marie Melchior in Paris

1943 Jacques co-invents the Aqualung with engineer Emile Gagnan.

1950 Captain Cousteau acquires Calypso, the ship that he will use to explore the oceans of the world.


1956 "The Silent World" becomes a full-length film, and the film receives an Oscar and a Palm d'Or in Cannes.

1961 Jacques Cousteau receives National Geographic gold medal from John F. Kennedy.

1973 Jacques, and his two sons create the Cousteau Society.

1996 Calypso II was built to replace the original Calypso

1997 June 25, Jacques dies in Paris

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**ACHIEVEMENTS**

*Officer in the French Navy-During World War II, Cousteau was involved in espionage activities for the French Resistance. After the war, he was decorated with the Legion of Honor, France's highest honor.*

*Aqua Lung-enabled divers to shed the excess pounds of heavy helmets so they could swim freely for two hours. In essence, he brought the word 'SCUBA' into existence.*

*The Undersea World of Jacques Cousteau- Television show that introduced the world to the mystery of the world's oceans. In addition, Cousteau created 100's of documentaries on the world beneath the waves. (9 years running)*

*Jet Propelled Submarine-The famous "Soucoupe" and helped start the first manned undersea colonies in the Mediterranean which allowed persons to live underwater for up to THREE weeks!*

*Wind Powered Marine Vessel-Know as "Alcyone", this ship was powered solely on the wind and travels the oceans of the world!*

---

(1910-1997)
Question: Mr. Cousteau how did you become a scientist?

Answer: During my years in the French Navy I was a victim of a tragic car accident. The accident left me with two paralyzed arms and other injuries. These injuries prevented me from furthering my career in the navy. To help regain the use of my arms I started rigorous therapy in the water. This therapy progressed and soon I was strength training against the waves of the ocean. I regained the use of my arms except three fingers. This time in the ocean sparked my curiosity and I started experimenting with ways to experience the ocean for longer periods of time. This experimentation lead to the co-invention of the Aqua Lung.

"Sometimes we are lucky enough to know that our lives have been changed. It happened to me that summer's day when my eyes opened to the world beneath the surface of the sea."

-Jacques-Yves Cousteau (1965)

In Memory of Jacques-Yves Cousteau
One Small S
If I had been strapped inside the nose-cone of a rocket and hurled light years through space to land on a blue-green world of liquid atmosphere and zero gravity, it would be easy to understand the giant leap I had taken.

I would realize who was the stranger in a strange land and extend hesitant silent greetings from curious creatures I knew nothing of, and try to tell them I was an uninvited alien.

A world where each creature, every current played its singular role to perfection in a living cycle, turning for millions of years guided only by the sculpting hands of evolution.

I gazed awestruck through the mask of my suit yet touched nothing, returning to my own world a changed man, filled with images and a passionate yearning to return.

-J. Browning 9/93
APPENDIX C:
Food Web Interactions
Activity #14: Food Web Interactions

Flathead Lake in Montana illustrates what can happen in an ecosystem when a new species is introduced. Opossum shrimp were not found in the lake until 1981, when they moved into it from rivers feeding the lake. They had been introduced into the rivers between 1968 and 1975 as food for kokanee salmon. The shrimp feed on two groups of small floating (planktonic) crustacea—copepods and cladocera—in surface waters at night, but spend the days at depths of 30 m or more. Kokanee feed primarily in the day at depths of less than 30 m. Consequently, kokanee did not feed on the shrimp, although deeper feeding fish, such as lake trout and whitefish did. The figure below illustrates the organisms primarily affected by the introduction of the opossum shrimp.

Organisms of the Flathead Lake Ecosystem

In this activity, you will analyze the food web in Flathead Lake and predict the effects of the introduction of opossum shrimp.

**TIME:** 1/2 hour for activity, 1 hour for followup

**ACTIVITY:**

1. Study the diagram, "Food Web for Flathead Lake," which represents the major organisms found in the lake prior to 1981. The arrows point from prey to predator. Make a table with two columns. In the left-hand column, list all of the organisms shown in the food web.

2. Using dotted lines, add the opossum shrimp to the web, showing what it eats and what eats it.

**FOLLOWUP:**

1. In the right-hand column of the table you made in step #1, predict the effect that the opossum shrimp would have on each organism in the food web.

2. If runoff into the lake began to increase, bringing more nutrients into the lake, what effect might this have on the system?
Introduced Species: The Threat to Biodiversity & What Can Be Done

By Daniel Simberloff, Ph.D.

There are many ways in which the introduction of non-native or exotic species negatively affects our environment and the diversity of life on our planet. The statistics are startling and more attention must be paid to the problem and devising a solution before the cost is more than we can bear.

- Compared to other threats to biodiversity, invasive introduced species rank second only to habitat destruction, such as forest clearing.
- Of all 1,880 imperilled species in the United States, 49% are endangered because of introduced species alone or because of their impact combined with other forces.
- In fact, introduced species are a greater threat to native biodiversity than pollution, harvest, and disease combined.
- Further, through damage to agriculture, forestry, fisheries, and other human enterprises, introduced species inflict an enormous economic cost, estimated at $137 billion per year to the U.S. economy alone.
- Of course, some introduced species (such as most of our food crops and pets) are beneficial. However, others are very damaging.

Introduced species are not good guests

The greatest impact is caused by introduced species that change an entire habitat, because many native species thrive only in a particular habitat.

- When the Asian chestnut blight fungus virtually eliminated American chestnut from over 180 million acres of eastern United States forests in the first half of the 20th century, it was a disaster for many animals that were highly adapted to live in forests dominated by this tree species. For example, ten moth species that could live only on chestnut trees became extinct.
- Similarly, the Australian paperbark tree has replaced native plants, such as sawgrass, over 400,000 acres of south Florida, because it has a combination of traits (for example, spongy outer bark and flammable leaves and litter) that increase fire frequency and intensity. Many birds and mammals adapted
to the native plant community declined in abundance as paperbark spread.

- In similar fashion, aquatic plants such as South American water hyacinth in Texas and Louisiana and marine algae such as Australian Caulerpa in the Mediterranean Sea change vast expanses of habitat by replacing formerly dominant native plants.
- The zebra mussel, accidentally brought to the United States from southern Russia, transforms aquatic habitats by filtering prodigious amounts of water (thereby lowering densities of planktonic organisms) and settling in dense masses over vast areas. At least thirty freshwater mussel species are threatened with extinction by the zebra mussel.

Other invaders, though they do not change a habitat, endanger single species or even entire groups of them in various ways:

- The predatory brown tree snake, introduced in cargo from the Admiralty Islands, has eliminated ten of the eleven native bird species from the forests of Guam.
- The Nile perch, a voracious predator introduced to Lake Victoria as a food fish, has already extinguished over one hundred species of native cichlid fish there.
- A parasite can be similarly devastating. The sea lamprey reached the Great Lakes through a series of canals and, in combination with overfishing, led to the extinction of three endemic fishes.
- The European parasite that causes whirling disease in fishes, introduced to rainbow trout in a hatchery in Pennsylvania, has now spread to many states and devastated the rainbow trout sport fishery in Montana and Colorado.
- Herbivores can wreak great damage. The first sailors to land on the remote Atlantic island of St. Helena in the 16th century introduced goats, which quickly extinguished over half the endemic plant species.

Some impacts of invaders are subtle but nonetheless destructive to native species:

- North American gray squirrels are driving native red squirrels to extinction in Great Britain and Italy by foraging for nuts more efficiently than the native species. Such competition for resources is not easy to observe, but the end result is the loss of a native species.
- Hybridization, or cross-breeding, of introduced species with natives is an even subtler impact (no lineage goes extinct), but it is insidious because it leads gradually to the extinction of many native species, as their gene pools inevitably evolve to become those of the invader. Introduced mallards, for instance, are driving the native Hawaiian duck to a sort of genetic extinction by breeding with them.
- Of 26 animal species that have gone extinct since being listed under the Endangered Species Act, at least three were wholly or partly lost because of hybridization with invaders. One was a fish native to Texas, eliminated by hybridization with introduced mosquito fish.
- Rainbow trout introduced widely in the United States as game fish are hybridizing with five species listed under the Endangered Species Act, such as the Gila trout and Apache trout.
- The endangered, endemic Hawaiian duck is being lost to hybridization with North American mallards introduced for hunting.
- The rarest European duck (the white-headed duck) is threatened by hybridization with the North American ruddy duck, which was originally kept as an amenity in a British game park. The ruddy duck escaped, crossed the English Channel, and spread to Spain, the last stronghold of the white-headed duck.

Often invaders interact with one another to generate a problem where either species alone would be harmless. For example, ornamental fig trees in the Miami area for over a century stayed where planted, in people’s yards, because they were sterile. Each fig species requires a particular wasp to pollinate it, and the wasps were absent. About fifteen years ago, the pollinating wasps for three fig species arrived independently in the region, and now these fig species are reproducing. At
At least one has become invasive, with seedlings and saplings being found many miles from any planted figs. More cases of this phenomenon, termed "invasion meltdown," are likely to arise as more species are introduced and have the opportunity to interact with each other.

**Warding off the intruder**

Keeping potentially damaging invaders out is the most cost-effective way to deal with introduced species. Targeting common pathways by which invaders reach our shores can slow or stop their entry. Ship ballast water, wooden packing material, and horticultural plants are three prominent pathways for invasion that could all be monitored or treated more rigorously. A species that is introduced despite precautions can sometimes be eradicated, especially if discovered quickly. In the United States, a Giant African snail population was eliminated by a long campaign in Florida, and a federal-state cooperative effort is currently underway in California to attempt to eradicate the recently discovered Caulerpa alga invasion. Even if eradication fails, several technologies often can control invasive species at acceptably low levels. No method is a magic bullet, each can have drawbacks if misused, and each has failed when used against certain invaders, but each also has successes to its credit.

- Biological control entails introducing a natural enemy usually from the native range of the introduced pest. For example, prickly pear cactus from the Americas is well controlled on hundreds of thousands of square miles of Australian rangeland by caterpillars of a moth introduced from South America. A disadvantage of biological control is that some agents attack nontarget species, and it is very difficult to remove a troublesome introduced natural enemy once it is established.

- Chemical control involves using a pesticide, such as an herbicide or insecticide. Although chemicals can effectively control some species (such as water hyacinth in Florida), they may have nontarget impacts, they are often expensive, and pests can evolve resistance to them.

- In mechanical control, hand-pulling or various kinds of machinery are employed. For example, volunteer convict labor is used in Florida to cut paperbark trees and in Kentucky to rip out Eurasian musk thistle. However, some invaders cannot be easily found for mechanical removal or occupy a habitat (for example, the marine benthos) that is not readily accessible.

- The newest technology for managing invaders is ecosystem management, in which the entire ecosystem is subject to a regular treatment (such as a simulated natural fire regime) that tends to favor adapted native species over most exotic invaders. Because it is so new, the specific ways in which ecosystem management can be employed must be determined in each type of habitat.

**Addressing the problem**

The numbers of introduced species are growing in the United States and elsewhere because of increased trade and travel, but the situation is not hopeless.

- Internationally, the Rio Convention of Biological Diversity (1992) recognized the threat and called for action to limit it.
- A Global Invasive Species Program, formed by the United Nations and other international organizations, is beginning to answer this call with a series of programs designed to deal with particular sorts of introduced species.

In the United States, a Presidential Executive Order in 1999 called for the formation of a Federal Invasive Species Council to render the federal response to introduced species more effective, and to foster cooperation among federal agencies, state agencies, and other stakeholders such as conservation organizations and private landowners. The Council has formulated a Management Plan that includes many activities to slow the influx of invasive introduced species and to deal with them more effectively once they are present.

**International cooperation and management is the best solution.**
If all these policies (or global measures) and weapons are used in the battle against invaders, there is every reason to think that most native species and ecosystems can be protected against this threat. If our interest or support falters, the current wave of invaders will surely become a flood, leading to massive habitat change and extinction as much of the earth undergoes a massive biotic homogenization.

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About the author: Ecologist Daniel Simberloff, Ph.D., is the Nancy Gore Hunger professor of environmental studies at the University of Tennessee. His interests include the ecology and evolution of introduced species, conservation biology, and the composition of biotic communities. He is a member of the U.S. Invasive Species Advisory Committee. http://eeb.bio.utk.edu/FACULTY/simberlof.html
APPENDIX D:
Scrap Book ‘Guide To The Biomes’
ENVIRONMENTAL Scrap BOOK PROJECT

You will be given 1 biome to research and create an innovative and unique scrapbook. You scrapbook will include 11-pages, each with its own focus area. Each of the 11-pages should be creatively intermingle the researched material with color and pictures.

Page 1: Introduction (name, class, biome type)

Page 2: Colored World Map of your biome

Page 3: Abiotic factors of the environment; including a climatogram of the biome (additional abiotic factors: soil type, amount of surface water, weather, and mineral or rock types)

Page 4: Colored food web of biome and descriptions of producers, consumers, herbivores, omnivores, carnivores, and detritavores

Page 5: List of major animals in the biome (1-invasive species, 1-endangered species, 1-keystone species, and 1-indicator species)

Page 6: List of major plants in the biome (1-invasive species, 1-endangered species, and 1-cultivated crop [plants that are farmed])

Page 7: Adaptations of animals in this biome (example: camouflaged, thick fur, stripes, etc...)

Page 8: Environmental problem I in the biome (Answer the following questions: What is the problem? What is causing the problem? And What can be done to help fix this problem?)

Page 9: Environmental problem II in the biome (Answer the following questions: What is the problem? What is causing the problem? And What can be done to help fix this problem?)

Page 10: Bibliography

Page 11: Rubric for assignment
<table>
<thead>
<tr>
<th>Page</th>
<th>Subject</th>
<th>Criteria</th>
<th>Pt Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>Your name, class and biome type</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Biome Map</td>
<td>COLORED map of your biome and where they are found in the world.</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Abiotic Factors</td>
<td>You must have a climatogram and several other abiotic factors including</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>soil types, surface water amount, and weather.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Food Web</td>
<td>You must have a COLORED food web from your biome. You must also list the</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>producers, consumers, herbivores, carnivores, detritivores, and omnivores.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Animals</td>
<td>List of major animals in the biome (1-invasive species, 1 endangered</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>species, 1-keystone species, and 1-indicator species)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Plants</td>
<td>List of major plants in the biome (1-invasive species, 1 endangered</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>species, and 1-cultivated crop [plants that are farmed])</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Adaptations</td>
<td>List and have pictures of the adaptations of the organisms in your</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>biome.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Environmental</td>
<td>What is the problem? What is causing the problem? And What can be done</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Problem I</td>
<td>to help fix this problem? (this can be bulleted, but should be in</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>complete sentences)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Environmental</td>
<td>What is the problem? What is causing the problem? And What can be done</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Problem II</td>
<td>to help fix this problem? (this can be bulleted, but should be in</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>complete sentences)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Bibliography</td>
<td>A minimum of 3 sources</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Rubric</td>
<td>Must include this rubric at the end of your project with the student</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>side filled out.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project is colorful, neat and organized</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project carries a similar theme through the entire scrapbook</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time was used wisely during class to prepare this project</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STUDENT GRADE</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TEACHER GRADE</td>
<td>75</td>
</tr>
</tbody>
</table>
Introduction

In our daily lives we are often confronted with statistics. We read about the most recent poll taken on some political issue, or that 9 out of 10 doctors recommend one form of aspirin over another. In each case, there is always some reference to statistics and statistical language.

In this course of study, you will often collect samples of numerical data in either an activity, or an experiment. From this data, you will be asked to make a limited number of observations, or judgments as to the meaning of these numbers. This can only be accomplished by the application of statistical methods. This manual will provide you with the necessary basic skills to "look" at data in this critical way.

While the primary goal of this manual will be in dealing with scientific information, the knowledge, experience, and skills you gain from this work and also be used in evaluating the statistical reports that confront us daily.
Statistical Terminology Quick Reference Index

It is often the case, that after completing an experiment we will want to summarize data. We do this by constructing a Summary Data Table. This may include all, or some, of the major statistical measures used in data analysis. Table 1 lists all of the statistical measures used in this handbook. Use this table as a quick reference for terminology and/or symbols.

Table 1. Statistical measures used in data analysis.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Sample size</td>
</tr>
<tr>
<td>Max</td>
<td>High value</td>
</tr>
<tr>
<td>Min</td>
<td>Low value</td>
</tr>
<tr>
<td>Range(R)</td>
<td>Max - Min</td>
</tr>
<tr>
<td>Mean ((\bar{x}))</td>
<td>Arithmetic average</td>
</tr>
<tr>
<td>Median (m)</td>
<td>Middle value</td>
</tr>
<tr>
<td>Q3</td>
<td>Median of all values greater than m</td>
</tr>
<tr>
<td>Q1</td>
<td>Median of all values less than m</td>
</tr>
<tr>
<td>IQR</td>
<td>Interquartile range, (Q_3 - Q_1)</td>
</tr>
<tr>
<td>Upper Fence</td>
<td>(0.25 + (1.5 \times IQR))</td>
</tr>
<tr>
<td>Lower Fence</td>
<td>(Q_1 - (1.5 \times IQR))</td>
</tr>
<tr>
<td>Outliers</td>
<td>List of values outside the fences</td>
</tr>
</tbody>
</table>

Sample size \((n)\) tells us how many pieces of data are in the sample. The larger the sample size the more reliable the results. That is, if the sample size is large we could expect very similar results if the experiment is repeated.

The range \((R)\) is the difference between the maximum and minimum values, \(\text{Range} = \text{Max.} - \text{Min.}\).

The mean \((\bar{x})\) is commonly known as the average and is the sum of all the data points divided by the number of data points, \(\bar{x} = \frac{\sum x_i}{n}\).

The median \((m)\) is the middle value, (or the average of the two middle values for an even numbered data set). The median is not affected by extreme values as is the mean and is therefore a more reliable measure of central tendency than the mean, especially for small samples of data. The number of the data point that is the median can be found by \(nm = (n+1)/2\).

A statistical outlier is a value that is either much smaller or much larger than the other data. Unless there is a good reason for excluding them (e.g., error or bias), outliers should be included in all calculations and representations of data.

The normal distribution (bell-shaped curve) is a theoretical frequency distribution which approximates many real world data sets, especially those based on

Prepared by the American Statistical Association
for use by Michael Kimmel and Michael Smith, Conneaut High School
in SEAQL Workshops - Revised Summer of 1997
measurements of physical quantities (see Figure 1). However, many data sets are not normally distributed (e.g., incomes).

\[ \text{MEAN — Arithmetic average} \]
\[ \text{MEDIAN — Same number of items above and below} \]

Figure 1. The normal distribution curve

**Stem and Leaf Plot**

The numbers below represent the number of yeast cells recorded by a class of 21 students in a population study. To view the entire set of data, the numbers recorded are ordered using a stem and leaf plot.

In order to construct a stem and leaf plot:

1. Determine the maximum and minimum and calculate the range of the data.

2. Use the range to determine the number of stems. List the data in ascending order from Min. to Max. in a single column. If there are many values for each stem, the stem may be divided into two or more sections to further spread the data.

3. For each data point, enter the value of the last number place to the right of the stem and in the same row. These numbers are the leaves. Keep each leaf lined up with the leaves below. Figure 2 was constructed by going across the rows of Table 2.
Table 2. Yeast cells after 24 hours

| 88 | 72 | 87 |
| 78 | 68 | 71 |
| 65 | 96 | 92 |
| 95 | 81 | 83 |
| 80 | 69 | 82 |
| 67 | 81 | 65 |
| 81 | 50 | 75 |

Stem → 8

Leaf

Key: 5 | 0 = 50 cells

To construct a summary table, it may be convenient to rearrange the leaves in Figure 2 into an ordered stem and leaf plot (Figure 3.).

Figure 3. Ordered Stem and Leaf plot of Figure 2.

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>5 5 7 8 9</td>
</tr>
<tr>
<td>7</td>
<td>1 2</td>
</tr>
<tr>
<td>8</td>
<td>0 1 1 2 3</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

Key: 5 | 0 = 50 cells

Table 3. Summary of Yeast Cell Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, n</td>
<td>21</td>
</tr>
<tr>
<td>High value, Max.</td>
<td>96 cells</td>
</tr>
<tr>
<td>Low value, Min.</td>
<td>50 cells</td>
</tr>
<tr>
<td>Range, R</td>
<td>46 cells</td>
</tr>
<tr>
<td>Median, m</td>
<td>80 cells</td>
</tr>
<tr>
<td>Sum of data</td>
<td>1629 cells</td>
</tr>
<tr>
<td>Mean $\bar{x}$</td>
<td>77.6 cells</td>
</tr>
<tr>
<td>O3</td>
<td>85 cells</td>
</tr>
<tr>
<td>Q1</td>
<td>68.5 cells</td>
</tr>
<tr>
<td>IQR</td>
<td>16.5 cells</td>
</tr>
<tr>
<td>Upper Fence</td>
<td>109.75 cells</td>
</tr>
<tr>
<td>Lower Fence</td>
<td>43.75 cells</td>
</tr>
<tr>
<td>Outliers</td>
<td>None</td>
</tr>
</tbody>
</table>

Prepared by the American Statistical Association
for use by Michael Kimmel and Michael Smith, Conneaut High School
in SEAQL Workshops - Revised Summer of 1997
Other Examples of Stem and Leaf Plots:

The data below was collected by a class determining the boiling point of water using standard lab thermometers. Since most of the variation in data occurs in nine tenths place, the tenths place is represented as leaves with all the larger number places represented in the stem.

Table 4. Boiling Point Temperatures [degrees Celsius]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100.2</td>
<td>99.0</td>
<td>101.1</td>
</tr>
<tr>
<td>102.0</td>
<td>99.6</td>
<td>101.3</td>
</tr>
<tr>
<td>101.5</td>
<td>99.1</td>
<td>100.1</td>
</tr>
<tr>
<td>101.2</td>
<td>101.6</td>
<td>101.2</td>
</tr>
<tr>
<td>100.6</td>
<td>100.7</td>
<td>100.5</td>
</tr>
<tr>
<td>102.4</td>
<td>100.4</td>
<td>99.8</td>
</tr>
<tr>
<td>100.8</td>
<td>100.5</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4. Ordered Stem and Leaf Plot

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>0 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 8</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>1 2 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 5 6 7 8</td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>1 2 2 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 6</td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>0 4</td>
<td></td>
</tr>
</tbody>
</table>

Key: \[99 \mid 0 = 99.0 \text{ C}\]

Table 5. Summary of Temperatures [C]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, (n)</td>
<td>20</td>
</tr>
<tr>
<td>High value, Max.</td>
<td>102.4</td>
</tr>
<tr>
<td>Low value, Min.</td>
<td>99.0</td>
</tr>
<tr>
<td>Range, (R)</td>
<td>3.4</td>
</tr>
<tr>
<td>Median, (m)</td>
<td>100.65</td>
</tr>
<tr>
<td>Sum of data</td>
<td>2013.6</td>
</tr>
<tr>
<td>Mean, (x)</td>
<td>100.7</td>
</tr>
<tr>
<td>(Q3)</td>
<td>101.25</td>
</tr>
<tr>
<td>(Q1)</td>
<td>100.15</td>
</tr>
<tr>
<td>IQR</td>
<td>1.1</td>
</tr>
<tr>
<td>Upper Fence</td>
<td>102.9</td>
</tr>
<tr>
<td>Lower Fence</td>
<td>98.5</td>
</tr>
<tr>
<td>Outliers</td>
<td>None</td>
</tr>
</tbody>
</table>
Since the sample size is an even number the median, \( m \), is the average of the 10th and 11th values.

\[
m = \frac{(100.7 + 100.6)}{2} = 100.65
\]

The data closely fits the normal distribution.

The data below was collected in a class trying to find the density of an unknown liquid. In the data there is a great deal of variation in the tenths place as well as the hundredths place. With such uncertainty in the tenths place the data can be rounded to the tenths place and the hundredths place dropped. Thus the ones place is the stem and the rounded tenths place the leaf.

**Table 6. Density of Unknown Liquid [g/mL]**

| 1.59 | 1.14 | 1.66 | 1.39 | 2.52 | 1.41 |
| 3.15 | 2.36 | 1.98 | 1.76 | 2.76 | 2.43 |
| 6.23 | 1.71 | 1.68 |

**Figure 5. Ordered Stem and Leaf Plot**

```
1 | 1 4 4
2 0 4 4
3 2
6 2
```

Key: \( 1 \mid 4 = 1.4 \text{g/mL} \)

**Table 7. Summary of Densities [g/mL]**

| Sample size, \( n \) | = 15 |
| High value, Max. | = 6.2 |
| Low value, Min. | = 1.1 |
| Range, \( R \) | = 5.1 |
| Median, \( m \) | = 1.9 |
| Sum of data | = 33.97 |
| Mean, \( \bar{x} \) | = 2.3 |
| Q3 | = 2.5 |
| Q1 | = 1.6 |
| IQR | = 0.9 |
| Upper Fence | = 3.85 |
| Lower Fence | = 0.25 |
| Outliers | = 6.2 |
The data is somewhat skewed to the lower end of the range as compared to a normal distribution.

**Stem and Leaf Variations:**

When constructing a stem and leaf plot, the analyst must decide on the technique that best reflects the spread and the detail of the data. Below are various examples that can be used depending on the spread and the desired detail of the data.

<table>
<thead>
<tr>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0-9</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0-4</td>
</tr>
<tr>
<td></td>
<td>5-9</td>
</tr>
<tr>
<td>6</td>
<td>0-1</td>
</tr>
<tr>
<td></td>
<td>2-3</td>
</tr>
<tr>
<td></td>
<td>4-5</td>
</tr>
<tr>
<td></td>
<td>6-7</td>
</tr>
<tr>
<td></td>
<td>6-9</td>
</tr>
<tr>
<td>6</td>
<td>0-1</td>
</tr>
<tr>
<td>50</td>
<td>xx</td>
</tr>
<tr>
<td>51</td>
<td>xxx</td>
</tr>
<tr>
<td>52</td>
<td>x</td>
</tr>
<tr>
<td>53</td>
<td>xxxx</td>
</tr>
<tr>
<td>54</td>
<td>x</td>
</tr>
<tr>
<td>55</td>
<td>xxxxxx</td>
</tr>
<tr>
<td>56</td>
<td>xx</td>
</tr>
<tr>
<td>57</td>
<td>xx</td>
</tr>
<tr>
<td>58</td>
<td>x</td>
</tr>
<tr>
<td>59</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>x</td>
</tr>
</tbody>
</table>

**Key:** 5 | 0 = 50 units
The Line Plot:

Large amounts of data can also be represented on a line plot. The line plot has a more precise number scale than the stem and leaf plot. On a line plot each value is plotted at its own location. It is best used for larger sets of data.

In order to construct a line plot:

1. Determine the maximum and minimum to establish the range of the number line.

2. Divisions on the number line should be the same as the smallest place in the data.

3. Mark an "x" for each value on the space corresponding to the number line. (In this example, boxes were used.)

4. Be sure all "x's" are the same size.

For example, suppose 6 classes collected boiling point data using standard laboratory thermometers. Since the sample size is large, a line plot would be the best way to represent this data.

```
98.4  98.8  99.2  99.6  100  100.4  100.8  101.2  101.6
```

Temperature in Degrees Celsius

Note: The mean, median, and range can also be calculated from a line plot.
The Box Plot:

A box plot is used to summarize a data set. To construct a box plot, the data is divided into quarters.

Figure 7: Box plot diagram.

Definitions:

Min. the smallest value in the data
Max. the largest value in the data
Range the difference between the largest and the smallest values in the data
Median value the value in the center of the data
First quartile (Q1) value separating the first and second quarters
Third quartile (Q3) value separating the third and fourth quarters
Interquartile range (IQR) the difference between the first and third quartiles measures the spread of the data around the median

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In order to construct a box plot:

1. Draw a number line to include the entire range of data.
2. Determine the median and draw a vertical line to represent the median.
3. Determine the first quartile by determining the median for all data points to the left of the median. Draw a vertical line to represent the first quartile.
4. Determine the third quartile by determining the median for all data points to the right of the median. Draw a vertical line to represent the 3rd quartile.
5. Make a box.
6. Determine the Max and Min values and use dots to represent each above the number line.
7. Draw a line (whisker) connecting the dots to the box.

---

Temperature in Degrees Celsius

Figure 8. Box Plot of Temperatures of Boiling Water

Table 8. Summary of boiling Point Temperatures in Degrees Celsius

<table>
<thead>
<tr>
<th>Sample size, n</th>
<th>137</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>101.5</td>
</tr>
<tr>
<td>Min</td>
<td>98.5</td>
</tr>
<tr>
<td>Range, R</td>
<td>3.0</td>
</tr>
<tr>
<td>Median, m</td>
<td>100.3</td>
</tr>
<tr>
<td>Sum of data</td>
<td>3707.4</td>
</tr>
<tr>
<td>Mean, x̄</td>
<td>100.2</td>
</tr>
<tr>
<td>Interquartile Range, IQR</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Box plots provide information about the general precision of the data, and also specific information about the middle 50% of the data set. The box plots below compare data from two classes for the mass of the same object. Period #1 data is grouped tightly as shown by the small box (small IQR). Period #2 data has a larger spread as shown by the large box (large IQR). This data is not as precise as the Period #1 data.
Mass In Grams

Figure 9. Identical Masses as Measured by Two Classes.

Percent (% Error):

Percent error is a measure of the accuracy of the data. Percent error can be calculated in several ways:

1. Percent error for an individual observation: In this case the individual observation is compared with the class or group median (Example 1).

2. Percent error for a class result: In this case the class median is compared with an accepted value (Example 2).

In either case the following general equation will be used:

\[
\% \text{ Error} = \left( \frac{\text{observed value} - \text{accepted value}}{\text{accepted value}} \right) \times 100\%
\]

For convenience, Tables 4 and 5 are reproduced here.

In this example, the asterisk indicates the individual result for which the percent error is calculated.

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Table 4. Boiling Point Temperatures in degrees Celsius

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100.2</td>
<td>99.0</td>
<td>101.1</td>
<td>102.0</td>
<td>99.6</td>
<td>101.3</td>
<td>101.5</td>
</tr>
<tr>
<td>99.1</td>
<td>100.1</td>
<td>101.2</td>
<td>101.6</td>
<td>101.2</td>
<td>100.6</td>
<td>100.7</td>
</tr>
<tr>
<td>100.5</td>
<td>102.4</td>
<td>100.4</td>
<td>99.8 *</td>
<td>100.8</td>
<td>100.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Summary of Temperatures in degrees Celsius

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, n</td>
<td>20</td>
</tr>
<tr>
<td>High value, Max.</td>
<td>102.4</td>
</tr>
<tr>
<td>Low value, Min.</td>
<td>99.0</td>
</tr>
<tr>
<td>Range, R</td>
<td>3.4</td>
</tr>
<tr>
<td>Median, m</td>
<td>100.65</td>
</tr>
<tr>
<td>Sum of data</td>
<td>2013.6</td>
</tr>
<tr>
<td>Mean, ( \overline{x} )</td>
<td>100.7</td>
</tr>
<tr>
<td>Interquartile Range, IQR</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Calculating percent error of an individual result follows:

Example 1: \( \% \) Error = \[ \frac{\text{Individual result} - \text{Class Median}}{\text{Class Median}} \] \times 100\%

\[ \% \text{ Error} = \left( \frac{99.8 - 100.65}{100.65} \right) \times 100 = 0.84 \% \text{ Error from the median} \]

Calculating the percent error of the class median follows:

Example 2: \( \% \) Error = \[ \frac{\text{Class Median} - \text{Accepted Value}}{\text{Accepted Value}} \] \times 100

\[ \% \text{ Error} \left( \frac{100.65 - 100.0}{100.0} \right) \times 100 = 0.65 \% \text{ error from the accepted value} \]

Statistical Outliers:

Outliers are data points that are unusually large or small. Outliers should not be excluded from the data set unless it is determined that they are errors. It is important to include all data collected using the correct protocol in the analysis and in determining the result.
box-plot method: A data point that is more than 1.5 times the interquartile range (IQR) below the first quartile (Q1) or above the third quartile (Q3) is an outlier. These boundaries are called the lower and upper fences, respectively.

datum \(<[Q1 - 1.5 \text{ (IQR)}]\) or \(\text{datum} > [Q3 +1.5 \text{ (IQR)}]\)

A class of chemistry students determined the melting point of wax. The class data and summary data are below. The students wish to know if the 60.0 degrees Celsius data point is a statistical outlier because it lies well above the rest of the data on the stem and leaf plot.

Figure 10. Stem and Leaf Plot. Melting Point of Wax

3
  • 5
4 0 1 1 1 2 3 3 4
  • 5 5 6 6 6 8 8 8 8
5 0 1 2 2
  •
6 0

Key: 3|5 = 35 degrees C

Table 9. Summary Table of Melting Wax Data (C).

<table>
<thead>
<tr>
<th>n</th>
<th>Max.</th>
<th>Min.</th>
<th>m</th>
<th>x</th>
<th>Q3</th>
<th>Q1</th>
<th>IQR</th>
<th>Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>60</td>
<td>35</td>
<td>46</td>
<td>45.9</td>
<td>48</td>
<td>42</td>
<td>6</td>
<td>60</td>
</tr>
</tbody>
</table>

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In order to determine any statistical outliers, it is necessary to find the lower and upper data fences.

Lower fence: \[ Q_1 - 1.5 \times IQR = 42 - 1.5 \times 6 = 42 - 9 = 33 \]

Upper fence: \[ Q_3 + 1.5 \times IQR = 48 + 1.5 \times 6 = 48 + 9 = 57 \]

It is clear that 60.0°C data is outside the upper fence and is therefore considered an outlier. When drawing the box plot, the upper whisker will only go to 52.0 degrees C, the largest data point that isn't an outlier. The outlier is indicated by an asterisk, as in the figure below.

Figure 11. BoxPlot of Wax Melting Point.

Graphing Of Data:

A graph is a visual picture of experimental data. Graphing the results of an experiment involving two or more variables helps to make the relationship of the variables more obvious. A graph also can be used in making predictions if the graph is carefully prepared and the analyst knows how to interpret it. The following rules will assist you in preparing graphs:

1. Always make graphs in pencil.
2. Use a ruler for straight edges, and a French curve to draw curved lines.
3. Use the entire piece of graph paper. Graphs should be the full length and width of the paper. (Keep at least a 1 inch margin for labeling).
4. Rule of thumb: Remember a graph is a visual picture. Keep the graph simple. There should be a lot of white space.

5. Choose an appropriate scale that allows you to get all the data on the graph. Number the axes from low to high so that the value of each box increases by the same amount. For example, values of 1, 2, 5, 10, 20, 50, or 0.1, 0.2, 0.5 are recommended.

6. Label each axis and indicate the units used.

7. Each graph should have a clear and concise title indicating the labels of the y- and x-axis. Titles are always written in the following form: “Y” plotted as a function of “X.”

8. Use point protectors when plotting data. Point protectors are distinct geometric forms such as circles or squares.

9. Draw a smooth curve, or a straight line, to represent the general tendencies of the data points.

Final words about how to draft a graph: be neat! Remember most people do not trust sloppy workmanship.

Median Fit Technique:

The median fit technique provides a simple and uniform protocol for fitting a straight line to data plotted on a graph or scatter diagram. Read each step carefully and then follow the example provided.

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Mass (g)</th>
<th>Volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.9</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>8.2</td>
<td>3.9</td>
</tr>
<tr>
<td>3</td>
<td>14.9</td>
<td>5.8</td>
</tr>
<tr>
<td>4</td>
<td>31.5</td>
<td>10.6</td>
</tr>
<tr>
<td>5</td>
<td>36.0</td>
<td>13.8</td>
</tr>
<tr>
<td>6</td>
<td>50.1</td>
<td>19.0</td>
</tr>
</tbody>
</table>

Table of data for graph construction.

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Figure 12. Mass in grams plotted as a function of volume in milliliters.

The steps needed to determine the best fit straight line using the median fit technique include:

1. Plot the data in the normal fashion following the guidelines for drawing a graph (see Figure 11).
Figure 13. Above plot with data separated into three groups.

2. Separate the data points into three equal or nearly equal groups by counting points from left to right. Clearly mark these divisions by drawing two vertical lines. If the number of data points is not divisible by three, place an equal number of data points in each of the outside data point groups. If two or more data points are identical, they should not be in different groups. In this case, the outside groups may have an unequal number of points.

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3. For each group of data points determine the median going from top to bottom along the y-axis and from left to right along the x-axis. Clearly and precisely mark the medians on the graph. The median of a group containing an even number of data points will not be a data point. For a group containing an odd number of data points the median may not be a data point either.
Figure 15. Above data with best straight line drawn using the median points.

4. Line up the two outside medians using a straight edge. Note the magnitude of the separation between the straight edge and the central median. Slide the straight edge one third of the way toward the central median being careful not to change the slope of the straight edge.

5. Draw a straight line from outside the first data point to just beyond the last data point. Be careful not to extrapolate an unreasonable distance. Check to see that the straight line is a reasonable representation of your data.

6. Determine the slope. Construct a triangle, including dotted lines to assist in reading the axes.
6. Determine the slope. Construct a triangle, including dotted lines to assist in reading the axes.

7. Report the equation of the line in terms of the quantities measured on the y and x-axes as well as the value of the slope.

Calculating The Slope

The slope of a line shows how much the quantity plotted along the y-axis increases when the quantity plotted along the x-axis increases by one unit. In order to calculate the slope, you need to pick two points that fall on the line. It is important that the points be selected on the best-fit line that you have drawn, because this line represents all of the data that you have collected. Once the slope has been calculated keep in mind that the data points include units and should be included.

Figure 16. Above data with slope indicated.

Slope equation:

\[ a = \frac{y_2 - y_1}{x_2 - x_1} \]

For this example, \( a = \frac{36.0\text{g}}{13.9\text{mL}} = 2.59 \text{ g/mL} \)
It is important to summarize the relationship of the graph by reporting the equation of the line including the y-intercept. The y-intercept is the value of y when x equals zero and is denoted by the letter b.

The general equation for a straight line is \( y = ax + b \). The equation for the line in Figure 16 is:

\[ y = 2.59x + 0.2. \]

Since we plotted mass as a function of volume, the equation may be written using these variables, including units.

\[ \text{mass} = (2.59 \text{ g/mL}) \text{ volume} + 0.2 \text{ g}. \]
References


L. Behrens, J. Selway. "Data Analysis" presented at the 1993 NSTA National Convention


"Science Education and Quantitative Literacy Project" American Statistical Association, Alexandria, VA.
Mean

The arithmetic average of all values. On the graph of the normal frequency distribution this is the highest point, the peak of the bell shaped curve. To calculate the mean, we add all the given numbers and then divide the sum by total count. A total count is a number that is equal to how many those given rational numbers we did add together.

Median

The middle value. If values are lined up in order of increasing value, the median is the one in the center of the row. If the distribution is 'normal' the median has the same value as the mean.

Mode

The most frequently occurring value i.e. the value along the x-axis at the peak of the normal distribution curve. In a truly normal distribution the mode has the same value as the median.

Standard deviation

A value which describes the spread of the population about the mean and as such is a property of the population. If the distribution is normally distributed 95% of all elements within the population are contained within two standard deviations of the mean. Use the following example

\[
\text{Variance} = \frac{\sum(x - \bar{x})^2}{n - 1}
\]

\[
\text{SD} = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}
\]
STEPS IN CALCULATING STANDARD DEVIATION

DATA SET
(2, 3, 7, and 12)

1. Find the mean of the data.
   \((2 + 3 + 7 + 12)/4 = 6\)

2. Subtract the mean from each data point.
   - 2-6= -4
   - 3-6= -3
   - 7-6= 1
   - 12-6= 6

3. Square each of these differences.
   - -4 SQUARED = 16
   - -3 SQUARED = 9
   - 1 SQUARED = 1
   - 6 SQUARED = 36

4. Find the sum of the squares of differences.
   \(16 + 9 + 1 + 36 = 62\)

5. Divide the sum we just got by the number of data points minus one
   \(62 / (4-1) = 20.6\) recurring.

6. But this is just what's known as the "variance". To get the "standard deviation" we have to find the square root of this variance
   \(\sqrt{20.6} = 4.5461\)
Minning  
September 29, 2003  

Here is data from a cloud seeding experiment. Scientists spray clouds with Silver Iodide crystals and measure the rainfall. Then they don't spray Silver Iodide and measure the rainfall.  

Your job is to calculate the mean, median, and mode of both sets of data. Then write a null hypothesis for the data sets and perform a t-test to determine if there is a significant difference in the two sets of data. Use alpha = .5

<table>
<thead>
<tr>
<th>Data for Seeded Clouds</th>
<th>Data for Normal Cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>2745.6</td>
<td>1202.6</td>
</tr>
<tr>
<td>1697.8</td>
<td>830.1</td>
</tr>
<tr>
<td>1656.0</td>
<td>372.4</td>
</tr>
<tr>
<td>978.0</td>
<td>345.5</td>
</tr>
<tr>
<td>703.4</td>
<td>321.2</td>
</tr>
<tr>
<td>489.1</td>
<td>244.3</td>
</tr>
<tr>
<td>430.0</td>
<td>163.0</td>
</tr>
<tr>
<td>334.1</td>
<td>147.8</td>
</tr>
<tr>
<td>302.8</td>
<td>95.0</td>
</tr>
<tr>
<td>274.7</td>
<td>87.0</td>
</tr>
<tr>
<td>274.7</td>
<td>81.2</td>
</tr>
<tr>
<td>255.0</td>
<td>68.5</td>
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APPENDIX F:
Field Trip Research
MAKING A BERLESE FUNNEL

Material Needed

✓ Cardboard
✓ Duct Tape
✓ String
✓ Hole Punch
✓ Light Source
✓ 1 square foot of 1/4 inch mesh, galvanized hardware cloth
✓ Cheese cloth
✓ Alcohol

The Berlese (pronounced “bur LAY zee”) funnel is an ingenious trap, based on avoidance behavior, used to remove organisms from the soil. This devise enables entomologists to separate the active stages of insects and other small invertebrates from a sample of moist soil, humus, compost, or leaf litter. The sample is placed in the funnel where it lies out over a period of days. Organisms living within the sample tend to move downward to escape desiccation and eventually fall to the bottom of the funnel.

The invertebrates that feed on detritus are a taxonomically diverse group. In terrestrial environments, they are usually classified according to their size. This is not an arbitrary basis for classification, because size dictates their access to resources, as they burrow and crawl among the cracks and crevices of the litter layer. The microfauna (animals with body widths less than 0.1 mm) includes protozoans, nematode worms and rotifers. The principle groups of the mesofauna (body widths between 0.1 mm and 2 mm) includes litter mites (Acari), springtails (Collembola), and pot worms (Enchytraeidae). The macrofauna (body widths between 2 mm to 20 mm) and megafauna (body widths greater than 20 mm) include woodlice (Isopoda), centipedes (Chilopoda), millipedes (Diplopoda), earthworms (Megascole), snails and slugs (Mollusca), and the larvae of certain flies (Diptera) and beetles (Coleoptera). The larger animals are mainly responsible for the initial shredding of plant remains. Soil bacteria and fungi complete the cycle, consuming the fragmented material. By their action, detritivores promote a large-scale redistribution of organic material, and thus contribute directly to the development of soil structure.

Adapted from http://www.albany.edu/natweb/fsdetr.html
LAB 1 - COMMUNITY ECOLOGY MATERIAL NEEDS

1. Meter Sticks 6/lab
2. Painted stir sticks 6/lab
3. Hand lens (magnifying glass) 6/lab
4. Carving knives 6/lab
5. Plastic bags 6/lab
6. Computers with Statview Student Software
7. Gall samples from the field
8. Cutting boards 6/lab
1. Community Ecology: Species Interactions

Consider the food webs introduced in lecture. Each arrow connecting two trophic levels represents an interaction between two species. Imagine the multitude of relationships that exist in a food web. Such interactions include: animal-animal, plant-plant, plant-animal, plant-fungus, and plant-microorganism. Think of specific types of interactions each of these pairs represent (e.g., animal-animal = predator-prey = barn owl-mouse).

Are all interactions harmful for the organism on the lower trophic level, e.g., the mouse? Consider the plant-animal interactions of herbivory, pollination, and seed dispersal. Herbivory of plant parts by insects and vertebrates has a negative impact on the plant. Pollination and seed dispersal have a positive impact. The latter are essential for the plant's reproduction and important for the animal's diet. When both partners benefit, the interaction is called mutualism. Common examples of mutualism are lichens (algae + fungi), mycorrhizae (fungi + flowering plants), symbiotic nitrogen-fixation (bacteria or cyanobacteria + flowering plants), pollination, and seed dispersal.

Insect-induced galls are abnormal swellings of plant tissue. They are formed in response to chemical stimuli from an insect which, depending on the species, occurs at the time of egg-laying or when developing larvae of the gall-inducer begin to feed. The swelling provides food, shelter, and partial protection from predators to the gall-causing species during certain stages of their development. The occur on a wide variety of plants. Gall insects are host-specific, i.e., they interact with only one plant species and they are highly selective as to infestation site on a given plant. Each species produces a gall with a characteristic size, shape, and color. More than 1,500 gall-causing insect species have been described from North America. This includes representatives of six insect orders (Coleoptera, Lepidoptera, Thysanoptera, Homoptera, Diptera, and Hymenoptera) which are known to induce gall formation.

A relatively complex community of additional arthropods become associated with most galls. Members of this community may include primary and secondary parasites of the insect gall-inducer, "guests" and their parasites, and general predators that feed on any available arthropod in the community. Birds also feed on the arthropod community accumulated in the gall.

In today's study, we will focus on insect-induced galls on goldenrod plants (Solidago canadensis). At least three species of insects induce gall-formation on goldenrod:

- **The elliptical gall** is caused by the larvae of the moth Gnirimoschema gallaesolidaginis. The larvae of the moths and butterflies are also called caterpillars.
- **The ball gall** is caused by the larvae of the teaphritid fly Eurosta solidaginis. The larvae of the flies are called maggots.
- **The pompon gall** is caused by the larvae of the midges Rhopalomyia spp. A midge is another type of fly and the larvae are also called maggots.
Table 1-1

Hypothesis 1.  Height of Galled vs. Non-Galled Stem  
Hypothesis 2.  Height of Gall on Stem Species Specific

Type of Gall: Mixed

<table>
<thead>
<tr>
<th>Sample</th>
<th>Galled Stem</th>
<th>Non-Galled Stem</th>
<th>Pompon Gall</th>
<th>Round Gall</th>
<th>Elliptical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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Hypothesis/Prediction 3:

If a female choosing egg-laying sites minimizes flight energy expenses, then a galled stem will be positively associated with other galled stems, i.e., a galled stem will be closer to other galled stems than to non-galled stem. Assumption: All plants are equally able to be attacked and a female lays eggs on more than one plant.
1. Find a galled stem and determine whether each of its three nearest neighbor stems is a galled stem or non-galled stem. Stems with a different type of gall is counted as non-galled stems (Table 1-2).

Type of gall: **Bell Gall**

Table 1-2. Put one tally mark for each neighboring stem

<table>
<thead>
<tr>
<th></th>
<th>Galled Neighbor</th>
<th>Non-galled Neighbor</th>
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<tbody>
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<td>Galled stem</td>
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</table>

Part B. Student-generated Questions

1. Locate the different types of galls in your section of goldenrod. Make observations of the plants and the most common type of gall. Generate five questions about some aspect of the plant-insect interaction. Keep the questions very simple. They should be testable in a short period of time (e.g., one hour of data collection).

Questions

a. Is the abundance of galls homogeneous in all sections of the field?

b. Are the different gall types distributed homogeneously within each section of the field?

c.  

d.  

e.  
1. Community Ecology: Species Interactions – Teaching Assistant Handout

Objective:

a. to become familiar with the scientific process by making observations of insect-forming galls on the plants, generating possible research questions, and deciding how to test them.

b. to determine the pattern of gall-formation on goldenrod by exploring the effects of plant height and distance to other plants.

Key Concepts:

• Interaction between species can affect the distribution and abundance of organisms.

• Interactions between organisms of different trophic levels can result in positive effects on one of the organisms, but negative effects or no effect on the other.

Scientific Method Concept:

The scientific method is a combination questions, careful observations and conducting repeated experiments and measurements to gather information from the natural world.

Materials Needed:

Room 121 should have the following:

- meter sticks
- painted sticks
- hand lenses
- Gall samples from the field
- knives
- plastic bags
- computers with Statview Student software

Procedures:

Although this lab addresses some fundamental concepts of community ecology, its primary function is to get students to think about problem solving and the nature of scientific investigation. It is designed as an inquiry based laboratory, which means that instead of telling the students the answers to questions and telling them how to solve problems, you should ask them questions that allow them to develop solutions. Most of their solutions will not be right or wrong so they have the freedom to solve the problem in many different ways. However, you may need to steer them toward or away from certain alternatives.

Have students plot data on the graph provided in the laboratory handout. When applicable data tables and any figures should specify the type of gall. Results may be different for the different types of galls. The students may expect that the abundance and distribution of different types of galls are the same.

1. Refer students to Statview Student instructions that are provided to complete an unpaired t-test and chi square, respectively.
2. Demonstrate the use of Starview Student with computer projection system.
3. Use overhead projector to project a summary of statistical results. Be sure to specify gall type.

4. Laboratory Assignment

Student will be writing results and discussion section of a scientific paper. In addition to written text, students will include as part of the assignment tables and figures. Students should read pp. vii-xii in the introductory materials of the lab manual for explicit directions concerning the content of these sections and the format for tables and figures. Emphasize the importance of proper labeling of axes and column headings on the tables, as well as accurate and explicit legends on their figures.

Students can find the criteria that will be use to evaluate laboratory reports on electronic reserve. The assignment is worth 10 points. Emphasize that the scientific writing is an important skill.

Part A. Testing Hypotheses

Hypothesis/Prediction 1:

If the female insect flies above the vegetation and uses conspicuous visual cues from the vegetation to locate egg-laying sites, then galled stems will be taller than non-galled stems. Assumption: All plants are equally susceptible to be attacked.

Hypothesis/Prediction 2:

The height of the gall is insect species-specific.

3. Use a hand lens to make observations of the various members of the arthropod community present. Are any parasites present?

Students may find bird damage i.e., deep, wide, conical holes and small round holes that parasites used to enter or exit the gall.

4. Summarize the nature of this plant-insect interaction. What is the effect of the interaction on the insect and on the plant?

The presence of an organism suggests that gall formation is induced i.e., stimulated by the activity of the insects. Gall formation is a response of the plant to isolate invading organisms. The plant gall provides protection from parasites, predators (birds), dehydration, extreme temperatures, and wind (that accelerates dehydration).
<table>
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<th>Sample</th>
<th>Galled Stem</th>
<th>Non-Galled</th>
<th>Pompon Gall</th>
<th>Round Gall</th>
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Hypothesis/Prediction 3:

If a female choosing egg-laying sites minimizes flight energy expenses, then a galled stem will be positively associated with other galled stems, i.e., a galled stem will be closer to other galled stems than to non-galled stem. **Assumption:** All plants are equally susceptible to attack and a female lays eggs on more than one plant.

1. Find a galled stem and determine whether each of its three nearest neighbor stems is a galled stem or non-galled stem. Stems with a different type of gall are counted as non-galled stems (Table 1-2).

   Type of gall ____________________________.

<table>
<thead>
<tr>
<th></th>
<th>Galled Neighbor</th>
<th>Non-galled Neighbor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galled stem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-galled stem</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1-2. Put one tally mark for each neighboring stem

**Part B. Student-generated Questions**

1. Locate the different types of galls in your section of goldenrod. Make observations of the plants and the most common type of gall. Generate five questions about some aspect of the plant-insect interaction. Keep the questions very simple. They should be testable in a short period of time (e.g., one hour of data collection).

**Questions**

a. Is the abundance of galls homogeneous in all sections of the field?

b. Are the different gall types distributed homogeneously within each section of the field?
A distinct difference in histograms may not be apparent, but statistical analysis may suggest a significant difference between height classes of galled and non-galled stems.

**Hypothesis 2.**

1. Label the two axes on Figure 1-1B. Convert data into height classes to fit into a frequency distribution. Repeat the process for the other gall types.

   **Frequency Distribution (example)**

<table>
<thead>
<tr>
<th>Height Class Intervals (meters)</th>
<th>Number of Individuals in Height Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.70 - 0.61</td>
<td>3</td>
</tr>
<tr>
<td>0.80 - 0.71</td>
<td>4</td>
</tr>
<tr>
<td>0.89 - 0.81</td>
<td>4</td>
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<tr>
<td>1.00 - 0.90</td>
<td>1</td>
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</tbody>
</table>

2. Looking at your graph, summarize the main pattern present in the data set. Provide a biological explanation (new hypothesis) for the pattern observed in your data. **Do different insect species select different heights for attack?** This is a question that can be discussed in class. Reasons for disagreement and/or agreement can also be discussed. Multiple explanations may be possible.

Figure 1-1B. Frequency distribution of gall heights for ___________________-shaped galls (solid bars), ___________________-shaped galls (dotted bars), and ___________________-shaped galls (open bars).
Part C. Data Exploration And Analysis

A. Graph and analyze for Hypothesis 1.

1. Make a graph of your data on the heights of galled and non-galled stems on Figure 2-1A. First, label the two axes. Also, calculate the mean value for each group (galled and non-galled) and indicate it on the graph with horizontal bars. Statview Student may be used to calculate means.

![Graph Diagram]

Figure 1-1A. Height of galled stems (open circle) vs. non-galled stems (closed circle) for -shaped galls. Horizontal bars indicate mean values.

Graphs for different type galls may vary dramatically. Try to encourage students to compare graphs of golden rod heights that are associated with different gall types. Are the student graphs similar?

2. Consult Appendix III and indicate the statistical test that would be appropriate for telling if these two means are significantly different. Unpaired t-test.

Instructions for the use of Statview Student are to be distributed in lab.

3. Looking at your graph, summarize the main pattern present in the data set. What can you conclude from your data set about Hypothesis 1? Provide a biological explanation (new hypothesis) for the pattern observed in your data.
Analyze for Hypothesis 3.

1. Total the number of tally marks in each cell of Table 1-2 and enter these totals in Table 1-3. Calculate the percentage of galled and non-galled neighbors for each type of stem (galled and non-galled).

Table 1-3: Number and Percentage of neighboring stems near galled and non-galled stems

<table>
<thead>
<tr>
<th></th>
<th>Galled Neighbor</th>
<th>Non-galled Neighbor</th>
<th>Row Total No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galled stem</td>
<td>No.</td>
<td>No.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Non-galled stem</td>
<td>No.</td>
<td>No.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Column Total No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Total No.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. On Figures 1-2A and 1-2B, create graphs from the percentage data. Label both axes on each graph.

3. Consult Appendix III and indicate the appropriate statistical test to use to analyze your data set. Chi Square Test. What are the expected frequencies (null hypothesis)?

The null hypothesis means no significant difference so all frequencies should be the same.

4. Summarize the main pattern found in your two graphs. What can you conclude about Hypothesis 3 from your data? Provide a biological explanation (new hypothesis) for the pattern found.
Figure 1-2A. Percentage of galled and non-galled neighbors for galled stems. The type of gall was _________________.

Figure 1-2B. Percentage of galled and non-galled neighbors for non-galled stems.
Thank you letter for field trip to WCCA

You'll know you have a good letter when you have included the following:

* To Warren County Conservation Association Board of Directors.

* Thanking them for the opportunity to do ecology field research at the nature center.

* Explained who you are and that you were there with the Honors Biology Class from Lebanon High School Supervised by your instructor, Mr. Scott Charlton.

* Brief description of the activities & other field research which you participated in during your field trip experience at WCCA.

* Suggestions that you would like a lot more opportunities to continue field research at WCCA.

* Revisit a repeated thank you

* Type your name and add your signature below it
APPENDIX G:
Environmental Problem Solving Process
After viewing *The Lorax*, please answer the following questions:

1. Who does the *Once-ler* represent from our rainforest study?

2. Who does the *Lorax* represent?

3. Who is represented by the *humming-fish, swamee-swams, and barba-loots*?

4. What does *thneed* represent?

5. Why does the *Once-ler* feel justified in destroying the *truffula* trees?

   Do you agree or disagree with this attitude? Explain why.

6. How did the *Once-ler* feel about the destruction he caused in the forest after it was all gone?

7. Do you believe it was the only the *Once-ler* who was at fault?

   Explain your answer
Problem Solving Process

- **Problem Identification**- clearly explain the details of the problem
  - Stakeholders- Who are the individuals/groups involved in this situation and what is the nature of their interest? (Don't forget to include: political, economic, and social stakeholders)
  - Questions raised- Describe several of the complex interrelationships comprising this problem. What are other questions raised by the issue?

- **Problem Boundaries**- What is the total area of interest? Include political, economic, and social boundaries.

- **Goals**- The goal indicates where you want to be at the end of the problem solving process. For example, in a footrace the goal is to win the race.

- **Objective**- An objective is one of the identified steps on the way to a goal. There are usually several objectives for each goal. In a footrace, the first objective may be to reach mile marker one in 7 minutes.

- **Study Design**- What steps will you take to meet your objectives? What exact tasks are necessary to determine the information you need to develop solutions? (Example: obtaining maps, talking with engineers, developing a committee of various individuals, sampling water or soil, etc...)

- **Developing/Assessment of Alternative Solutions**- What are several possible approaches or solutions to this issue? What are the consequences/benefits of each solution?

- **Selecting Alternative Solution**- Select what you feel is the better solution(s) to this problem. Thoroughly support your choice(s) with convincing evidence and discuss the positive and negative consequences of your solution(s). Under what conditions will the solution(s) be useful?

- **Implementation**- Who will approve your solution? Who will help the solution be executed? How long do you expect the process to take?

- **Monitoring**- Who will be responsible for assuring the problem does not come back? How will you determine if your efforts were successful?
Minning
August 25, 2003

Problem Identification
The Ohio Kentucky Indiana Council of Governments (OKI) has chosen to focus their efforts on improving the quality of streams in Ohio, Indiana, and Kentucky. In order to improve the water quality in these areas, many sources need to be examined including: construction zones, agricultural lands, chemical discharges from urban and suburban areas, and mining companies in the flood plain region. The pollutants in these areas need to be located, identified, and quantified in order to determine a plan of action. The primary stakeholders in this study include: area businesses, local and state governments, local farmers, area citizens, Ohio Environmental Protection Agency (OEPA), and the Ohio Department of Natural Resources (ODNR).

Boundaries
This study focuses specifically on the three states: Ohio, Indiana, and Kentucky. In these states the waterways and surrounding properties will be examined. Political boundaries are also of interest in this study, there for both state and local governments will be utilized.

Goals and Objectives

Goal:
1. To improve the water quality of the waterways in the Ohio, Indiana, and Kentucky regions.

Objectives:
1. Characterize non-point source pollution in the OKI region
2. Determine the extent the pollution effects the quality of the region’s waterways
3. Determine how to deal with the pollution emitted by agricultural areas and the chemical discharges from urban and suburban
4. Research the current regulations of non-point source and point source pollution
5. Determine what changes in regulatory powers are needed and, if so, what the changes should be and by whom
6. Develop a survey of land uses for area businesses, mining operations, farmers, and local citizens
7. Complete an assessment for the community needs in the areas and determine the appropriate educational awareness program
8. Compile a comprehensive plan in order to implement a prevention/remediation plan.
9. Install a monitoring system to insure the measures taken are working.

**Study Design**
1. Gather the laws and regulations for water pollution in each state
2. Characterize the non-point source pollution in the OKI region by performing water and soil sampling
3. Compare acceptable ranges of contamination with the samples taken
4. Develop a survey of land uses for area businesses, mining operations, farmers, and local citizens
5. Establish contact with the local community to identify their concerns about local water pollution
6. Develop a list of the most common practices that lead to water pollution
7. Develop a plan with local and state governments to put in place laws that prevent practices that are found to create water pollution
8. Work with the government to designate a position that will be responsible for coordinating education and monitoring of water pollution in these areas
9. Develop an educational program for businesses, citizens, and farmers on the importance of clean water systems, and the effects of pollution in their lives. In addition they should be taught ways to prevent water pollution.
10. Install a monitoring system to insure the measures taken are working.

**Data Collection**
A study would need to be completed focusing on the health of the environmental parameters. These parameters would include soil and water sampling, as well as an inventory of the biota in the surrounding areas. The results should be compared to accepted levels of contamination and common species and numbers in the areas. From this study the most contaminated areas and least contaminated areas can be pinpointed.

A land use survey can be conducted to determine possible sources of contamination. The survey will include common land practices by the locals, businesses, mines, and farmers.

In addition the results from the above studies can help develop an educational program and list of high priority targets.
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August 25, 2003

Developing Alternatives
The stakeholders should play a major role in the development of alternatives. It will depend on their communities and businesses too clean up the waterways. All ideas should be entertained if they are determined feasible. People tend to accept ideas better when they have had say in them.

Evaluating Alternatives
The evaluating the alternatives should be shared among OKI and all those who share an interest in the project. Each idea should be addressed individually and each person should have the opportunity to speak his or her mind. Each stakeholder should be aware of each other’s views and opinions. The best alternative is one that will serve the community, businesses, and protect the health of the waterways in the OKI region.

Implementation
A community campaign and educational awareness program can initiate the cleanup of the waterways, but in order to ensure that the businesses, communities, mining companies, and farmers take part in the prevention of non-point source pollution the government will have to step in. The government will have to mandate that the practices found to promote water pollution must cease. In addition educational programs must continue the reasons why keeping the water clean is important.

Monitoring and Evaluation
After implementation it will be necessary to monitor the areas citizens, businesses, mines, and farmers to ensure they do not revert back to previous land practices. This would lead to another increase in water contamination.
**Problem Analysis Prompts**

1. A local property owner wishes to give a farm to the State of Ohio Division of Natural Areas and Preserves, to be maintained in perpetuity. The owner has operated the farm for the past 25 years as a natural area, with some relatively new second-growth forests on about 20% of the land, some very old forests on about 10% of the land, agricultural fields on 40% of the land, and grasslands and a farmstead (house, barn, outbuildings) on the remainder of the land.

2. You are evaluating this offer as a staff member of the Division of Natural Areas and Preserves. Develop a complete approach to how you would prepare a recommendation to the Director of the Department of Natural Resources, from problem definition through monitoring and evaluation.

3. Secretary of the Interior Bruce Babbitt has received authority to designate a large tract of land in Colorado, adjacent to the Colorado National Monument, Grand Junction, Colorado, as an expansion of the Colorado National Monument. The exact boundaries of the tract are not as yet determined, nor has it been determined what should be said about the reasons for designating this tract of land as having National Monument status. Approximately 6 months has been set aside for investigations that would establish the unusual traits of this land that merit preservation. In addition to field studies, and consultation of existing studies and records, a public dialogue is to be maintained throughout this 6 month period, even though it is not explicitly required by law. Describe how you would proceed with this entire process, with the ultimate goal of getting the designation completed before September 30, 2000.

4. A truck carrying a full load of gasoline runs over a sharp object that flattens one of the front wheels while it approaches a railroad crossing. The truck goes out of control and hits a train carrying toxic and hazardous materials. The train partially derails and several cars overture, spilling the contents. As manager of the OEPA emergency and remedial response team, you are called by the State Highway Patrol and given fairly sketchy information about the accident and the placards on the truck and the rail cars. You are now in charge of this situation. What would you do and why?
APPENDIX H:
Population Yeast Lab
The growth of populations and the maximum population size of a habitat are affected by the availability of nutrients, physical parameters of the environment, and biotic interactions. All of these factors interact to set a limit on the population size in a habitat at a level called the CARRYING CAPACITY (K).

We will follow the growth of three yeast populations over a 10 day period. The culture medium will provide the amino acids and vitamins necessary for growth. Yeast are single-celled fungi that use sugar as a food source. When deprived of oxygen, they convert sugar to carbon dioxide gas and produce alcohol as a waste product. This reaction releases energy and the yeast use the energy to grow and reproduce rapidly.

The growth of natural populations is more accurately depicted by the logistic growth equation rather than the exponential growth equation. In logistic population growth, the rapid increase in number peaks when the population reaches the carrying capacity. The equation for this type of growth contains the factor for carrying capacity (K). Carrying capacity (K) may be defined as the maximum number of a certain species population that can be supported by a given ecosystem.

**Logistic Growth Equation**

\[ N_{t+1} = \left( r \cdot \frac{K - N_t}{K} \right) \cdot N_t + N_t \]

Where:

- \( N_{t+1} \) is the change in population size (N) for the next generation.
- \( r \) is the innate capacity for increase (a reproduction rate). It is equal to the birth rate minus the death rate (b-d).
- \( N_t \) is the population the population can size for the current generation.
- \( K \) is the maximum size attained (Sometimes called the carrying capacity).
Logan Minning  
August 28, 2003

Logistic population growth produces a characteristic S-shaped or sigmoid curve because the population increases rapidly until it reaches the carrying capacity where it begins to decelerate and stabilize. When the population size equals the carrying capacity (N = K) the growth rate is zero (I = 0) or zero population growth. When the population size exceeds the carrying capacity (N > K), I becomes a negative number and the population decreases. In the case of an uncontrolled deer population explosion with insufficient predators, the population declines dramatically because the overgrazed vegetation simply cannot support the high ratio of deer. Consequently, the deer die from starvation and disease, and the population rapidly declines.

Materials
Molasses
Water
100mL graduated cylinder
Stirring rod
100 mL Beaker
Microscope
Microscope slides with cover slips
Capillary pipette (or eye dropper)
Yeast Solution

Procedure
Your instructor has prepared three yeast cultures for you using varying degrees of food. The first culture was created by combining 45 mL of water and 5mL of molasses in a beaker, the second used 10mL of molasses, and the third used 20mL of molasses. The yeast solution was then added to each of the culture mediums.

1. Begin the lab by stirring the yeast cultures
2. Immediately use the dropper to collect a small quantity of yeast from the first culture
3. Place 1-2 generous drops onto the center of a microscope slide
4. Gently cover the yeast culture with a cover slip
5. Position the slide on your microscope (use low power for focusing on the cells, and then switch to high power.)
6. Count the number of yeast cells visible in the microscope's field of view under high power.
7. Move the slide and repeat the count 2 more times
8. Average the number of cells from each trial and record the number
9. If the cells are too numerous to count, dilute a sample of the culture by combining 20 drops of culture with 9 mL of water in a test tube prior to counting. Multiply your cell count by 10 before recording the data. If the population is still too dense, dilute further by combining 20 drops of the diluted culture with another 9 mL of water, and then multiply the count by 100.

10. Repeat steps 1-8 for the next two colors
11. Repeat steps 1-8 for the next 9 days
12. After the 10 day experiment is completed, you will graph your data on the computer. (Three graphs total)

Post Lab Discussion

How did the yeasts populations change over the course of 10 days? Why do you think this happened?

What was the carrying capacity (K) for all three yeast populations?

How are the limiting factors of the yeast similar to the limiting factors of the human population?

How do you think increasing the food supply of the yeast affected the population curve?

What environmental factors does the logistic growth equation exclude from its model?
Total length should be between 4-6 pages typed, double spaced, and 12 pt Times Roman Font!

**ABSTRACT:** This section is a brief summary of the methods, results, and conclusions. It may not be longer than 100 words, but it should be complete (i.e. 25 words will not be enough). Always state the purpose in the first sentence of the abstract. Following that, state (briefly) the methods, the results, and the conclusions. In other words, in 100 words or less, summarize your entire report.

**INTRODUCTION:** This section describes the purpose of the lab and the hypotheses tested, as well as general background theory. A good introduction starts with the general and ends with the specifics. In the beginning of the intro, describe population growth and the theory behind the experiment (both exponential and logistic growth). State explicitly what $r$ and $K$ are, and make sure you define them in English so I know you understand what "intrinsic rate of increase" really means. Explain the effect both $r$ and $K$ have on population growth. Make sure it is absolutely clear to me that you know the difference between $r$ and $r_{(max)}$. They are not equivalent.

Once you have set up the background theory, then discuss the specifics of your experiment. State the hypotheses explicitly, as hypotheses. Each hypothesis leads you to one or more predictions. You should explain the predicated effect of food and alcohol on the population growth of yeast. That is, what did we expect to happen to $r$ and $K$ in our three populations? Length should probably be about 1-2 pages.

**METHODS:** This section should describe the experimental setup, and how you did the experiment. Any problems (missing a reading, etc...) should be mentioned. State how you are testing the hypotheses here. For example, "To test the hypothesis that food affects $r$, we..."

**RESULTS:** In this section, *verbally describe* what happened. This will probably take about 1/2 to 1 page. An example of the kind of thing you might say in your results is, "The Carrying Capacity ($K$) decreased progressively with the increase in alcohol." Each time you make a statement about what happened, back it up with evidence (i.e. tell me which figure or table shows..."
what you are saying verbally). State whether your data support your hypotheses. Do not explain the biology here... just state the results.

DISCUSSION: You should write a complete discussion. Try to relate your results to the THEORY you outlined in the intro section, such as $K$ and the $r$. This is the most important part of the lab report, because it tells me whether you understood what you found. What was the effect of the different levels of food? Did it do what you predicted? If not, why not? Was there an interaction between sugar and alcohol? Describe it and explain why you think so, if so. If not, why not? While I have no absolute length requirements, I find it hard to see how this lab could be thoroughly discussed (with all of those graphs as well as the tables) in less than 1-2 pages.

REFERENCES: These should be included as necessary. Do not plagiarize. Give credit where it is due to those who thought of things you did not. This is part of the academic process. I have not assigned any points to this section but your grade will be much lower if I feel you have borrowed material from sources (such as the lab manual or lecture textbook) without crediting them. The rule of thumb is, when in doubt, cite it. You can never have too long a bibliography or too many footnotes. References should be in the standard scientific format, that is, in-text citations by author/year, and then in the reference section, a full citation. For example, you might have the following line in your Introduction section:

Ecologists generally believe that competition is an important factor in determining community structure (Stiling, 1997).

Then in your reference section, you would have:


(As a note, you should NOT try to use this as a real reference, since I made it up. There is no such book, and Stiling's initials are not "X.Y.")
APPENDIX I:
Simcinnati Project
Before you begin you must set your goals for the construction and planning of your city. What characteristics are important to the growth of a city? What are your priorities over the 60-year period? What do you hope to accomplish? In addition to your overall goals, you will set objectives for each 10-year period. These objectives are your benchmarks for success during that 10-year period. Each ten-year period everyone should assume a role in the city (Mayor, City Treasurer, City Services Director, City Welfare Director, and (2) Citizens). Everyone should have the opportunity to assume each role in the city.

1. Start SimCity 3000 and select the New City option. Make sure the settings are set to Easy, 1950, and Small City. Then click on the checkmark.

2. Give your city a unique name. Periodically save your city to a disk!!!

3. When the Terrain Window opens, accept the first terrain that is offered.

4. The game will be paused in the beginning—explore your different options for city planning. THIS IS IMPORTANT!

5. Follow the News Scroll at the bottom of the screen for updates about your town.

6. It would be beneficial to talk to your advisors and citizens often.

7. After each 10-year period you should reflect on the objectives and overall goals for your city. Make sure to review/report the data on your city (budget, pollution, population density, etc...)

Minning
September 10, 2003
SIMCINNATI QUESTIONS

1. What is a city? What purpose(s) do cities have?
2. Which is more important to a city: streets and buildings, or the things and people in them?
3. Who designs cities? Who builds them?
4. Where would you prefer to live: near water, on a hill, or on a flat, open area? Why?
5. What affect might the location of a city have on the city? On the people in the city? On the industry in the city?
6. What is land value? Is it important? Why or why not?
7. What is zoning? Why might zoning be important in city planning?
8. What is industry? Name as many industries in your town as you can and rate them for the number of people they employ, the amount of space they take up, the amount of money they make, and the amount of pollution they cause.
9. What is the difference between an urban area and a suburban area?
10. Suppose you had a choice of living in one of two houses, one of which was close to a well-traveled road and the other of which was far from any roads or other forms of transportation. What are some of the advantages and disadvantages of each location? In which location would you prefer to live? Why?
11. In addition to pollution levels and land values, what other elements of a city might be affected by a lack of sanitation service. Explain your answer.
12. How does a city get money? Who decides what that money is spent on?
13. What are taxes? Why are taxes important? How are they collected? How are they used?
14. What types of taxes are there? How are these taxes different?
15. What is a budget? What does it mean to "balance the budget"?
16. What are some of the things that might happen if a city's budget doesn't properly cover city services?
17. What is mass transportation? What are some of the advantages and disadvantages of this form of transportation?
18. What is a strike? Is a strike an effective method for letting government
Minning
September 10, 2003

officials know how people feel about those officials' decisions? Why or why not?
19. What are laws and ordinances? Who invents them? Who approves them?
20. In addition to the effects of terrain, why might different areas of cities have different land values?
SimCinnati Project/ Presentation

<table>
<thead>
<tr>
<th>Possible Points</th>
<th>Points Given</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn in Disk with at least 50 years of simulation</td>
<td>5 pts</td>
</tr>
<tr>
<td>Overall goal stated</td>
<td>5 pts</td>
</tr>
<tr>
<td>Objectives are set for each 10 year period and reflect your overall goal</td>
<td>5 pts</td>
</tr>
<tr>
<td>Each member of group participated in the simulation and presentation</td>
<td>5 pts</td>
</tr>
<tr>
<td>Assessment of city is a detailed encounter of the happenings in your development for each 10 year period. Descriptive information is given from the perspective of each group member's role.</td>
<td>25 pts</td>
</tr>
<tr>
<td>Connections are made between city planning and environmental impacts on your city.</td>
<td>10 pts</td>
</tr>
<tr>
<td>Overall Reflection</td>
<td>10 pts</td>
</tr>
<tr>
<td>Report and presentation are professionally done and organized.</td>
<td>10 pts</td>
</tr>
</tbody>
</table>
APPENDIX J:
Waste Audit
**Waste Audit Conversion Table:**  
(Source: National Solid Waste Management Association, 1990)

The following are industry standards for converting volume of waste into weights. I have taken the standards and converted them to use with 30 gallon trash bags.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Volume (cubic yards)</th>
<th>Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Paper</td>
<td>1</td>
<td>600</td>
</tr>
<tr>
<td>Aluminum Cans</td>
<td>1</td>
<td>50-75</td>
</tr>
<tr>
<td>Plastic Beverage Containers</td>
<td>1</td>
<td>30-40</td>
</tr>
<tr>
<td>Glass Bottles</td>
<td>1</td>
<td>500-700</td>
</tr>
<tr>
<td>Cardboard (flattened)</td>
<td>1</td>
<td>200-400</td>
</tr>
</tbody>
</table>

1 cubic yards = 202 US gallons

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Volume (gallons)</th>
<th>Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Paper</td>
<td>30 gallon trash bag</td>
<td>89</td>
</tr>
<tr>
<td>Aluminum Cans</td>
<td>30 gallon trash bag</td>
<td>7-11</td>
</tr>
<tr>
<td>Plastic Beverage Containers</td>
<td>30 gallon trash bag</td>
<td>4.5-6</td>
</tr>
<tr>
<td>Glass Bottles</td>
<td>30 gallon trash bag</td>
<td>74-104</td>
</tr>
<tr>
<td>Cardboard (flattened)</td>
<td>30 gallon trash bag</td>
<td>30-59</td>
</tr>
</tbody>
</table>
APPENDIX K:
Annual Research Assistant Symposium
October 9, 2003

Dear Student,

Congratulations you have just been awarded a research assistant position at Harvard University in the department of Environmental Research. During your time here you will conduct research in one of the following areas risk management and ground water control, air pollution and global warming, or Renewable and Non Renewable Energies.

Once your research is complete you will present at the annual Research Assistant Symposium in Lebanon Ohio.

✓ You will describe the background to your project including a handout for you colleagues. The handout will include important terms and concepts about your topic and interesting facts. You will actually teach your colleagues about your topic.

✓ You will identify why your research is important in the field of Environmental Science

✓ Describe your research and results

Congratulations again and I look forward to viewing your research findings.

Sincerely,

Mr. Goodbody

PS: You might find it useful to take notes over the following chapters (actually you have to do this)!
Air: 9 and 10
Energy: 17,18, and 19
Water and Risk: 8 and 11
BIO DIESEL
Using renewable resources

One of the ways in which processes can be made “greener” is to use renewable resources to replace nonrenewable starting materials. Chemical processes that rely on materials that cannot be supplied in a sustainable fashion are fundamentally harmful to the environment. Such processes can eventually deplete a resource. While it makes little sense to become dependent on any resource that exists in finite quantities, many processes are in this very position because although they are finite, they are also vast. Petroleum is a good example. Because it is presently so plentiful, too little regard has been given to finding a renewable alternative. Yet our petroleum reserves are sure to run out, possibly in a matter of decades. The conversion of plant material into usable fuel is one approach that could be part of a larger alternative to the use of petroleum. In this module, we explore the making of fuel from vegetable oil as a demonstration of the green chemistry principle of using renewable resources.

Green chemistry principle
Use renewable resources. Find ways to use renewable starting materials, such as substances derived from growing plants, rather than irreplaceable materials like the earth’s petroleum and natural gas supplies.

Curriculum links
- characteristic properties of matter
- chemical reactions
- combustion
- organic chemistry
- synthesis

Activity 1. Making biodiesel

Biodiesel is a mixture of methyl esters of fatty acids. It can be made very easily from vegetable cooking oil. Enough fuel can be produced from this lab to burn in a later activity, although it is not pure enough to actually be used as fuel in a car or truck. The synthesis is a simple chemical reaction that produces biodiesel and glycerol. Cooking oil is mixed with methanol, while potassium hydroxide is added as a catalyst. The products separate into two layers, with the biodiesel on the top. The biodiesel is separated and washed and is then ready for further experimentation.

Materials

- lab balance
- 1 250-mL Erlenmeyer flask
- 2 100-mL beakers
- 1 25-mL graduated cylinder
- 1 100-mL graduated cylinder
- 5 Beral pipettes
- distilled water
- 100 mL canola or other vegetable oil
- 15 mL methanol

Cautionary note: Flammable, dangerous fire risk, toxic by ingestion

Cautionary note: Skin contact causes severe blisters, strongly corrosive, very harmful if swallowed, extremely dangerous to eyes, generates large amounts of heat when solution is prepared. Consider immersing solution container in ice bath when preparing.

Safety

- You must wear goggles and an apron.
- Methanol is flammable and poisonous. Dispose of excess by allowing it to evaporate in a fume hood.
- Potassium hydroxide is corrosive. Dispose of excess potassium hydroxide by neutralizing with 3 M hydrochloric acid and put neutral solution down the drain with lots of water.

Procedure

1. Measure 100 mL of vegetable oil.
2. Carefully add 15 mL of methanol.
3. Slowly add 1 mL of 9 M KOH.
4. Stir or swirl the mixture for 10 minutes.
5. Allow the mixture to sit and separate.
6. Carefully remove the top layer using a Beral pipette.
7. Wash the product using 10 mL of distilled water. Mix.
8. Allow the mixture to sit and separate.
9. Carefully remove the top layer using a Beral pipette.
10. Measure the amount of biodiesel you have collected and compare it to the amount of vegetable oil you started with.

Questions

1. What changes did you see between the characteristics of the starting materials (cooking oil, methanol, and potassium hydroxide solution) and the final products (biodiesel and glycerol)?
2. What signs did you observe that a chemical reaction had taken place?
3. What is the purpose of the washing in step 7 above?
4. In the commercial production of biodiesel, 1200 kg of vegetable oil produces 1100 kg of crude biodiesel. How does your yield compare to this?

**Activity 2. Testing biodiesel**

How does biodiesel compare with other fuels? Just because we can produce a fuel from an alternative source, does that mean it is a good idea? There are many factors that go into the decision to use alternative fuels. Ideally, the physical characteristics of an alternative fuel meet or exceed those of the traditional product. But how are fuels evaluated in the first place? In this lab activity biodiesel and some other fuels are tested and compared for sootiness and acidity.

**Materials**
- Small glass (not plastic) funnel (approximately 7 cm diameter)
- 2 250-mL filter flasks
- 1 1-hole stopper to fit filter flasks
- 10 mL universal indicator
- 2 mL white gas or kerosene
- 1 aspirator to fit lab faucet
- 2 35-cm pieces of vacuum tubing
- 15-cm piece of large glass tubing (approximately 20 mm diameter) with a 1-hole stopper to fit each end
- 2 short (4 cm) lengths of glass tubing to fit stoppers above
- 90-degree glass bend to fit filter flask stopper (one leg to extend to bottom of flask)
- 2 ring stands and clamps
- Steel wool
- 2 small metal sample dishes

**Safety Note:** This procedure involves the burning of two types of liquid fuel. Be sure to store fuel in approved containers. Have fire extinguishers available if needed. Demonstrate how to smother a small fire with a wet paper towel.

**Procedure**

1. Pour 125 mL of distilled water into the 250-mL filter flask and add 10 mL of universal indicator. The solution should be violet or at the most basic end of the universal indicator color range. If it is not, add a drop of 0.1 M NaOH and gently swirl the flask.
2. Pour 10 mL of solution prepared in step 1 into a test tube labeled **control**. Set this control aside for later comparisons.
3. Assemble the apparatus illustrated in the figure at right.
4. Then turn on the water tap so the aspirator pulls air through the flask. Mark or note the position of the faucet handle so you can run the aspirator at the same flow rate later in the experiment. You should see gas bubbles
coming from the tube into the universal indicator.
5. Allow the setup to run until the solution turns yellow. Record the time and what happens in the funnel (point A), the tube (point B), and the universal indicator.
6. Refresh the universal indicator solution and repeat the experiment with biodiesel. Pour 2 mL of biodiesel onto a wad of steel wool in a metal sample cup.
7. Turn on the water and ignite the biodiesel. Position the funnel directly over the burning fuel, so as to capture the fumes from the burning fuel. Allow the apparatus to run until the universal indicator turns yellow.
8. Record the time and what happens in the funnel (point A), the tube (point B), and the universal indicator.
9. Refresh the apparatus and repeat the experiment using 2 mL of white gas or kerosene (these are very similar to diesel fuel).
10. Record the time and what happens in the funnel (point A), the tube (point B), and the universal indicator.
11. Dismantle and clean the apparatus.

Questions
1. Compare the time it took to change the color of the universal indicator in each test. Explain any differences you observed.
2. Compare the amount of soot collected in the funnel (point A) and the tube (point B) in each of the experimental runs.

Activity 3. Potential of biofuels
If we wanted to replace petroleum diesel with biodiesel, how much biodiesel could we make? An obvious limit is the amount of land available for growing plants suitable for producing oil to be converted to biodiesel.

The United States uses approximately 30 billion gallons of diesel annually. At the same time, we produce about 225 million metric tons of oilseeds, which includes soybean, cottonseed, peanut, sunflower seeds, and canola seeds. Soybeans are about 18% oil, and the others vary. Additional data are given below. Use whatever data you need to calculate your answer to question 1.

Quantities in the United States
41 pounds of soybeans are needed to make 1 gallon of soydiesel
1 ton of soybeans makes 47.33 gallons of oil
1 bushel of soybeans is 60 pounds
By weight, soybeans are about 20% oil
60 pounds of soybeans yield 1.42 gallons of oil
38.1 average bushels of soybeans per 1 acre (2000 data)
54.4 gallons of soybean oil per acre in 2000
1992 soybean yield was about 10% higher than previous averages

Agriculture in the United States
2.2 million farms and nearly 990 million acres (47.3% crops, 52.6% livestock/other)
74 million acres are in surplus

INTRODUCTION TO GREEN CHEMISTRY
Energy in the United States
Soydiesel yields 117,093 BTUs per gallon; gasoline yields 114,264 BTU per gallon
Soydiesel requires 23,620 BTUs per gallon to make
Gasoline requires about an equal amount of BTUs to make

Volume used in the United States
30 billion gallons of diesel used per year
18 million barrels of petroleum used per day (about 6.6 billion barrels per year)
42 gallons of petroleum per barrel
277 billion gallons of petroleum per year

Sources
www.afdc.doe.gov/altfuel/biodiesel.html
www.newton.dep.anl.gov/natbltn/500-599/nb543.htm
www.afdc.doe.gov/questions.html

Questions
1. Given the data above, could the United States expect to grow enough soybeans to replace fossil diesel with biodiesel? Show your calculations below.
2. Use the Web and other resources to research the annual use of diesel and oilseed production in the United Kingdom and Germany. Compare the feasibility of replacing fossil diesel with biodiesel in each of these counties.
3. What are the similarities and differences among the three countries relative to their use of diesel and potential for sustainable biodiesel programs?
4. Is biodiesel really green? Explain at least one argument in support of the idea that biodiesel is a “greener” fuel. Also present one argument that biodiesel is not a greener fuel.

Background information
Diesel is a common fuel used to power many large trucks (like the 18-wheel rigs commonly found on interstate highways) and heavy equipment (such as tractors and backhoes). Diesel fuel is made from crude oil that was formed over millions of years by the decomposition of prehistoric plants and animals. Through the use of an oil well, crude oil is pumped out of the ground and transferred (often by large ocean tankers) to oil distillation units. Crude oil contains widely varying organic (carbon-based) chemicals that range in size from small molecules with only 1 carbon atom (C₁) to very large molecules with more than 20 carbon atoms (> C₂₀). Crude oil is separated into various fractions (or components) based on the size of the molecule by using a distillation tower.

Distillation towers operate on the principles of distillation; smaller, more volatile compounds have lower boiling points, while larger, less volatile compounds have higher boiling points. A distillation tower works much like a distillation apparatus you might use in a laboratory setting. Crude oil is heated as it enters the distillation tower and then gradually cooled as it rises up the tower. Since less volatile compounds condense at higher temperatures, they are separated early on their way up the tower. The more volatile compounds rise higher in the tower before they start to
condense. Thus, fractions of crude oil can be separated by the decreasing temperature as they move up the tower.

Chemists have created a substitute for diesel by chemically changing various fats and oils. Fats and oils can be burned without any chemical alteration. (Old whaling ships used to burn the "blubber" or fat from whales in their oil lamps.) By using various chemical techniques (called transesterification), chemists can turn oils from various crops (most commonly canola and soy) into a viable diesel substitute.

One of the major advantages of using biodiesel instead of diesel is that biodiesel is derived from a renewable resource. As mentioned before, diesel comes from crude oil, which takes millions of years to form. During the next few million years, more underground pools of crude oil will be formed; however, it is consumed at a rate that is drastically faster than that at which it is forming. Most experts believe that at current production, crude oil will be economically (and thus essentially) exhausted in the next 40 years (www.wri.org/wri/climate/jm_oil_003.html).

Conversely, biodiesel is made from renewable resources, namely, oils derived from farm crops, such as soybeans. One major focus of green chemistry is to develop new chemical processes and products that eliminate the need for using nonrenewable starting materials by replacing them with renewable starting materials.

Biodiesel also creates lower sulfur emissions when it is burned, which helps reduce acid rain. It also breaks down more quickly in the environment, thus lessening the severity of an accidental spill compared with crude oil. Finally, unlike fossil fuels such as gasoline, biodiesel does not cause an overall increase in the amount of CO₂ (a greenhouse gas) in the atmosphere when the fuel is burned. Soybeans and other plants that produce oils for making biodiesel take up CO₂ from the atmosphere as they grow. When oil is extracted from the mature plants and burned, and the remainder of the plant material decomposes, CO₂ is returned to the atmosphere. Thus there is a balance between the amount of CO₂ removed from the atmosphere by growing plants and returned to the atmosphere by the same plants. No excess CO₂ is produced to contribute to global climate change (www.ott.doe.gov/biofuels/environment.html).
Teacher Instructions to Preparing Stock Solutions

Prepare a master stock solution of “effluent” using a liquid fertilizer. If safety is a concern supplement salt in place of the liquid fertilizer. Prepare a 10% solution of the product ahead of time, which will be labeled 100% Stock Solution (most effluents contain diluted rather than pure contaminants).

Persons handling this substance or stock solution should protect themselves by using personal protective equipment (such as safety glasses and gloves) and use care when pouring or mixing the pollutants. Label the master solution “100% Stock Solution”. Do the following for each concentration of the stock solution.

1. Label the nine 16-ounce plastic bottles as follows: two bottles labeled “Stock Solution 100%,” two labeled “Stock Solution 50%,” two labeled “Stock Solution 25%,” two labeled “Stock Solution 12.5%,” and one labeled “Stock Solution 6.25%.”

2. If the pollutant the class has chosen is liquid, pour 360 mL of distilled water into the bottles labeled “Stock Solution 100%.” Add 40 mL of the pollutant into each bottle, screw the cap on securely, and mix well.

3. If the pollutant is in solid form, pour 400 mL of distilled water into the bottles labeled “Stock Solution 100%” and add 30 grams of the pollutant to each. Screw the cap on securely and mix well.

4. Take one of the bottles of Stock Solution 100% and pour 200 mL of the solution into each of two bottles of Stock Solution 50%. Discard the empty bottle of Stock Solution 100%. Add 200 mL of distilled water to each of the bottles of Stock Solution 50%. Secure the lids and mix well.

5. To prepare the next dilution, pour 200 mL of Stock Solution 50% into each of the two bottles of Stock Solution 25%. Discard the empty bottle. Add 200 mL of distilled water to each of the bottles of Stock Solution 25%. Secure the lids and mix well.

6. Next pour 200 mL of Stock Solution 25% into each of the two bottles labeled “Stock Solution 12.5%.” Discard the empty bottle. Add 200 mL of distilled water to each of the bottles labeled “Stock Solution 12.5%.” Secure the lids and mix well.

7. Next pour 200 mL of Stock Solution 12.5% into the two bottles of Stock Solution 6.25%. Discard the partially empty bottle of Stock Solution 12.5%. Add 200 mL of distilled water to the bottle of Stock Solution 6.25%. Secure the lid and mix well.

8. There should now be five bottles labeled “Stock Solution” in varying percentages from 100% to 6.25%. These should be stored at room temperature and out of direct sunlight until the culture of daphnia are available.

Adopted from the Dow Chemical Company
Bringing Down the "Green" House Effect

Materials
5 Vials or test tubes
Graduated cylinder
Funnel Straw
Marble size piece of modeling clay
4 different color balloons
Twist ties
Narrow neck bottle
Bromthymol blue indicator solution
Dilute Ammonia
100 mL vinegar
5mL baking soda

Safety Concerns
Safety goggles at all times
Be cautious with chemicals they are toxic if consumed

Lab procedure

1. Add 15 mL of water and 10 drops of bromthymol blue indicator solution to each vial or test tube. Label the vials A, B, C, D, and Control.

2. Fill each balloon until it has a 7.5 diameter.

   • Sample A (Ambient Air) - Use a tire pump to inflate the balloon to the required diameter. Twist the rubber neck of the balloon and fasten it shut with a twist tie. The tie should be at least 1 cm from the opening of the balloon. Record the color of the balloon used for this sample.

   • Sample B (Human Exhalation) - Have one team member blow up a balloon to the required diameter. Twist and tie the balloon, and record balloon color.
• Sample C (Automobile Exhaust) - You will be supplied with this balloon. Record the color.

• Sample D (Nearly pure CO2) - Put 100 mL of vinegar in the narrow-necked bottle. Using a funnel, add 5 mL of baking soda. Let the mixture bubble for 3 seconds to drive the air out, then slip the balloon over the neck of the bottle. Inflate the balloon to the proper diameter. Twist, tie, and record the color.

3. Soften the clay and wrap it around one end of the straw to make a small airtight collar that will fit into the neck of a balloon. The collar should look like a cone with the straw in its middle, and should be large enough to plug the neck of the balloon.

4. Pick up Balloon A. Keeping the tie on it, slip the balloon's neck over the clay collar and hold it against the collar to make an air-tight seal. Place the other end of the straw into the vial of water and bromthymol blue labeled A. Have another partner remove the tie on the balloon and slowly untwist the balloon. Keeping the neck of the balloon pinched to control the flow of gas, gently squeeze the balloon so the gas slowly bubbles through the solution.

5. Repeat the same procedure with the other balloons and their respective vials. In some cases, the bromthymol blue solution will change color, from blue to yellow, indicating the presence of carbonic acid formed from CO2.

6. Analyze each of the samples by titrating them with drops of dilute ammonia. Ammonia neutralizes the carbonic acid. The bromthymol blue will return to a blue color when all the acid has reacted. Add drops of ammonia to each of the samples that turned yellow, carefully counting the number of drops needed until they are about the same color as your control.

7. Record the results in a chart.
Lab Discussion

1. Which samples had the most and the least carbon dioxide.
2. Why didn't the ambient air sample not turn yellow?
3. Carbon dioxide is a natural part of our atmosphere, but too much CO2 could make the Earth warmer through an increased greenhouse effect. Why is automobile exhaust a concern?
4. What ways could you reduce the amount of CO2 you create?
5. How could a city reduce the amount of CO2 they emit?
6. What's more important, to develop and adapt cars with a new fuel that's safe for the environment or to improve public transportation systems?
7. What alternative power sources could be used with cars?
8. Why might it be difficult for the public to start using an alternative source?
APPENDIX L:
Assessment
HONORS BIOLOGY EXAM I (part I)
DUE MONDAY 13th:

✓ Please write your answers on a separate sheet of paper.

✓ If you handwrite the answers skip every other line. Label each part of the questions.

✓ Please read the directions carefully and answer all parts.

1. EXPERIMENTAL DESIGN: (15 pts)
   a. You are interested in discovering whether ground squirrel populations that have access to more food have higher reproductive rates than populations where food resources are relatively scarce. This is an interesting question because for ground squirrel populations predation is often very high and thus predation pressure may regulate populations - not food availability. You have access to populations of ground squirrels at three elevations (hi, medium, and low). The lowest elevation has the highest food availability, and the highest elevation has the lowest food availability. Design a study to ask whether reproductive rates differ between habitats that differ in elevation. It is relatively easy to count the number of young produced by each female each spring.
      i. Include the following:
         1. State Purpose of Research
         2. State Null Hypothesis
         3. Define Population
         4. Define Variables
         5. Study Design
            a. Time
            b. Equipment
            c. Resources
         6. Data Analysis (How would you analysis the data)

2. STATISTICAL ANALYSIS: (10 pts)
   a. The following is the data of the reproductive rates of the squirrels at the low and the high elevations. Using your Null Hypothesis from question 1 perform a t-test for independent samples to determine if the two samples are significantly different from one another. Use a confidence interval equal to 95%. Relate your results back to the null-hypothesis.

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3. INVASIVE SPECIES: (10 pts)
   a. What are invasive species, and why are they often successful in establishment in non-native regions?
   b. Why should we be concerned about the success of these organisms in our area?
   c. List three invasive species in the Ohio Area and steps we can take to reduce their spread.

4. ECOSYSTEMS: (10 pts)
   a. Using examples, explain the cycling of nutrients and energy flow across the trophic levels of an ecosystem.
   b. Use this ecosystem as a model for explaining the biomagnification, bioaccumulation, and bioamplification of an accumulative hydrophobic contaminant like DDT or PCB’s (synthetic materials). Provide specific details. Why is this an issue?
   c. The effects of damage done to one ecosystem are rarely limited to that ecosystem. With this in mind, describe one way in which damage to tropical rain forests may result in damage to coral reefs.

5. POPULATION: (10 pts)
   a. Using graphs similar to those used in class, use human population to explain the concepts of rate of growth, carrying capacity, and the factors that influence each.
   b. Using your description of population growth as background, explain in detail three areas of human impacts that are currently damaging natural systems. What is the likely outcome of these impacts?
   c. As the human population increases, what are three specific examples of limiting factors to our growth?

6. POLITICS and ENVIRONMENT: (10 pts)
   a. Explain why a United States collective action is often very difficult to achieve. Illustrate your argument with examples from at least three different environmental issues (e.g., overpopulation, global warming, resource depletion, destruction of the ozone layer, biodiversity, lack of freshwater, etc.)
7. ZOO DEBATE: (10 pts)
   a. What have been some problems with zoos in the past and even today?
   b. Are “new zoos” sometimes known as Animal Retreats, Scientific Research enters, Public Observatories, or Conservation Centers?
   c. How do zoos contribute to global biodiversity and species diversity?
   d. Are most endangered species currently being held in zoos?
   e. What do you need to consider when managing captive populations?
   f. What direction should zoos take in the future?
HONORS BIOLOGY EXAM I (part 2)

In Class Exam (25 pts)

You will be shown a clip from a film entitled “Land Use: Americas Price for Food”.

1. You will write a problem solving analysis (including all 9 steps) for dealing with this land use issue.

2. During the movie you should take notes concerning these nine areas.

3. After the film you will have 50 minutes to write your analysis. You may use your book or other resources in the classroom to assist in your process.

4. GOOD LUCK!

HONORS BIOLOGY EXAM I (part 2)

In Class Exam

You will be shown a clip from a film entitled “Land Use: Americas Price for Food”.

5. You will write a problem solving analysis (including all 9 steps) for dealing with this land use issue.

6. During the movie you should take notes concerning these nine areas.

7. After the film you will have 50 minutes to write your analysis. You may use your book or other resources in the classroom to assist in your process.

8. GOOD LUCK!