INCORPORATING ENVIRONMENTAL EDUCATION CONTENT INTO A HIGH SCHOOL BIOLOGY CURRICULUM USING SCIENTIFIC INQUIRY

BY

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CHAPTER 1

INTRODUCTION

Introduction and Purpose of Study

The purpose of this thesis is to incorporate environmental education into the biology classroom using inquiry learning. Science education can be applied to all aspects of life on earth. By educating people about the natural resources used to make food, clothes, everyday products, types of transportation and housing, we are able to show how humans impact our world today. A current study done by William F. McComas (2003) showed that many Biology textbooks have tried to touch on the topic of environmental education, but none have integrated it into the biology class particularly well. Some of the textbooks observed noted ecology topics only towards the end of the book for those teachers who have the time at the end of the year to cover said material. “…possessing knowledge of ecology enables individuals to make useful explanations and accurate predictions while informing decision making and “action taking.” In this fashion, ecology provides a thread linking together various sub-domains of biology…” (McComas, 2003).

Environmental education relates to many aspects of biology because it affects the evolution and adaptation of species, anatomy and physiology of individuals living in a particular area. In addition it relates to the genetic makeup of offspring, the metabolic processes involved in plants and animals, and the utilization of a particular niche to occupy. Environmental education also impacts many important issues that students face
today and therefore would be a good way to increase student learning about biological topics because the information is relevant to their everyday lives.

Science education is a very important aspect of everyday life. Biology provides the basics for studying life on earth. By applying environmental education into a biology curriculum, students will gain a better understanding of biological diversity, interactions within ecosystems, adaptation, cycles, human impact, and even the use of technology. All of these factors are important in the science of biology and can easily show young minds the value of knowing how the environment works. It is important for the student population to become educated in all facets of the environment because of the many issues that the world and even local environments are facing, such as global warming, flooding, pollution and drastic changes in ecosystems.

Inquiry learning, an instructional strategy used in teaching science, is an excellent way for students to become active within their environment while learning valuable facts concerning science today. Inquiry instruction prepares students for future environmental decisions by creating a scientifically literate community.

Standards Based Curriculum

In order to achieve scientific literacy, a set curriculum must be established using only the best guidelines to ensure that the proper goals are reached. The National Science Education Standards have been designed to provide a specific guide for teachers to use for science curriculums in our nation today. “A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-
long learning. And the economic productivity of our society is tightly linked to the scientific and technological skills of our work force” (National Science Education Standards, 1996). Not only do the Standards set guidelines for science curriculums, they also emphasize inquiry as a new way of learning. Through the use of the National Science Education Standards, a successful science curriculum can be developed which integrates environmental science into the biology classroom using inquiry learning.

Inquiry in the Science Classroom

Inquiry learning is a relatively new instructional strategy used for science classes. According to the National Science Education Standards, inquiry is the most prominent method for enhancing scientific learning. Through the use of inquiry learning, students will gain an understanding about science content as well as the process of “doing” science (Krantz & Barrow, 2006). While practicing inquiry techniques, students will be presented with a problem or question and then use the scientific method to find the answer. This process of learning provides the students with problem-solving skills and hands-on learning. Inquiry teaches students to observe their surroundings and find what the underlying problem may be. This is why inquiry is such a beneficial process when incorporated into a science classroom. Through the use of inquiry, students can better understand biology and environmental science topics.

The Integration of Environmental Science and Biology

The ultimate goal of the National Science Education Standards is to create a scientifically literate society. “According to the United States National Center for
Education Statistics, scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (National Science Education Standards, 1996). By integrating environmental science content into a biology curriculum, we can enhance the degree to which our students become scientifically literate.

One of the ways to generate a scientifically literate student body is to create an interdisciplinary program that involves the environment in the regular classroom. An example of a program like this exists at Sedro-Woolley High School in Washington, where students use problem-solving techniques, audiovisual aids, articles, books, and school-community projects to increase their understanding of environmental issues (Reinard, 1993). The first step a teacher must take is to inform the students of environmental problems that may be occurring or that could eventually occur. The next step is for the teacher to elaborate on a biological aspect involving the environment. Lastly, students will become engaged in an activity that is focused on eliminating the environmental problem. Students need to have a solid background of information concerning biology and the environment before embarking on their journeys (Reinard, 1993).

One of the steps to implementing environment into the biology class is to select environmental topics of interest. According to Mintzes and Huber (2003), excellent topics to start with include: endangered species, habitat integrity, human ecology, land use, air and water quality, waste management, and environmental policy. The next step is to discuss biological aspects of the topics addressed using inquiry based tasks. A great way to incorporate the biology of these topics discussed is to investigate using
field work. Many schools have excellent resources at hand for inquiry learning such as rivers, lakes, deserts, forests and even oceans. By observing the areas close to a school or community the students are living in, the impact is much greater on the students’ minds. Students can set up miniature experiments within their own school grounds to test how change in environment can affect organisms living in the area. All experiments should keep in mind that a drastic change to the environment could hurt the organisms and so the students must be aware of the consequences. The students can create short term experiments which involve a slight change and observe the plant and animal life adaptations. If there is an allotted amount of time that is much longer, students can observe biological changes that include seed spreading, germination and growth, hibernation and birth of animals, as well as foraging adaptations for food. The implementation of environmental education to the biology class can be an excellent way to bring out a knowledgeable student body that will apply their new found science education to good use one day.

Definition of Terms

There are a few key terms to keep in mind during the course of this project. According to The New Merriam-Webster Dictionary (1989), environment is defined as the whole complex of factors (as soil, climate, and living things) that influence the form and the ability to survive of a plant or animal or ecological community. This clearly shows the importance of understanding the environment as it relates to the biology classroom. Another important term to the biology classroom is inquiry learning. Inquiry has many definitions but is best suited by: a systematic investigation of a matter of public
interest. In the context of a science classroom, students can use inquiry learning as a means of scientific discovery. With inquiry learning, students are encouraged to ponder an important science question. Students will construct their own knowledge while the teacher acts as a facilitator.

When discussing inquiry learning, the topic of constructivism comes into play. Constructivist learning is when students build their own knowledge based upon previous experience (Llewellyn, 2005). Within the realm of constructivism and inquiry learning, students typically are engaged in a teaching strategy known as cooperative learning. Cooperative learning involves putting the students into equivalent groups to work on a group assignment (Llewellyn, 2005). By implementing cooperative learning, inquiry, constructivist methods and environmental education into a biology classroom, students will become better prepared for the future.
CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

The world has changed significantly over the last several years, making many countries become globalized societies. Four trends that have changed the face of the world as we see it are; economics, science and technology, health and demographics. Each of these trends has an important impact on our society, but for now, the big focus is turned to science and technology, as well as health (Stewart, 2007).

As students today graduate from high school, they are thrown head first into this ever-expanding society, with little to bring to the table. When students enter the workforce, they are expected to be able to buy, sell, work with and manage people from all over the world, as well as tackle global problems such as the Avian flu pandemic and pollution (Stewart, 2007). These employment requirements are proving the increased need for a scientifically literate society. Sadly, the statistics show that the United States is behind when it comes to being ready for anything on the global level. “Surveys conducted by the Asia Society (2002) and National Geographic-Roper (2002) indicated that, compared with students in nine other industrialized countries, U.S. students lack knowledge of world geography, history, and current events” (Stewart, 2007).

There are many global issues that will affect our students such as: terrorism, war, global warming, pollution, hunger, poverty, illness, pandemics and the global economy. These are all reasons for students today to have a vast knowledge of science
and technology as it relates to their environment. Students will need to make informed decisions when voting for the next President or even their local governor. Without a good knowledge base as it relates to the politicians viewpoints, the students’ decisions to choose the correct candidate will be hindered. When voting or working at the community level, students need to be well aware of the impact a large shopping center will have on the rural community and its ecological makeup. When talks about war and terrorism turn to technological warfare and nuclear missiles, students will need to know the implications of the choices being made in order to ensure their own safety. The purchasing and use of many products in today’s society also have environmental impact on local and global communities. Many students are unaware of this and will need to re-evaluate the situation at hand in order to solve environmental problems. All of these topics tie back into a strong education in the sciences as they relate to the environment.

One of the proposed ways to increase scientific literacy among high school students is to create a more rigorous education curriculum. “A study released by the U.S. Department of Education (Adelman, 1999), for example, found that “the academic intensity and quality” of a student’s course of study was a far more powerful predictor of bachelor’s degree attainment than class rank, grade point average, or test scores”(Center, 2006). Statistics have shown that the best way to increase the rigor of a high school curriculum is to align the high school graduation requirements with the state standards and coursework required(Center, 2006).

Increasing the rigor of the program does not mean that schools should lower their expectations of the students. Students should still be expected to perform at the optimum level and get through the high school programs based on how well the subjects are being
taught. Revamping a high school science curriculum means a few things must occur. First, high expectations of the students must be set. Next, state standard alignment and assessment must be looked at. University officials need to meet with the high schools to ensure the students are learning the appropriate material in order to move on to higher education. Clear goals must be outlined that specify what will be taught. Tutoring and assistance programs should be set up to aid students whenever needed. Lastly, resources and professional development must be offered in order to increase teacher knowledge and support for the program (Center, 2006).

The development of a rigorous science program that approaches the environmental aspects of education will aid in a more scientifically literate society. This will push the U.S. to the forefront of science understanding which will help politicians, developers, educators, blue collar workers and young Americans to have an educated voice on global issues affecting our society today. “Our progress as a nation,” said John F. Kennedy (1961), “can be no swifter than our progress in education” (Center, 2006). It all starts with a demanding high school science curriculum.

Standards

“All of us have a stake, as individuals and as a society, in scientific literacy. An understanding of science makes it possible for everyone to share in the richness and excitement of comprehending the natural world. Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society” (National Science Education Standards, 1996). The National Science Education Standards advocates the use of
inquiry as an instructional tool, as well as serving as an example of scientific work involving gathering and testing data. According to recent data, only about ten percent of all biology teachers use laboratory or inquiry based techniques in the classroom (McComas, 2007).

Scientific literacy in society will take some time to incorporate because a major overhaul of the science curriculums will need to be put into place. The main aspect of revamping a science curriculum will be to integrate inquiry learning into the science classes. Using the National Science Education Content Standards for Life Science, Unifying Concepts and Process, Science as Inquiry, Science and Technology, students will be able to engage in an inquiry based program which allows them to perform a number of activities. These include observation, data collection, reflection and the use of secondary sources such as the library, books and media.

By incorporating the National Standards, students will be able to have access to the world beyond the classroom. Students should be given ample opportunities to pose questions about the natural world and investigate phenomena. “In describing the content for life sciences, the national standards focus on a small number of general principles that can serve as the basis for teachers and students to develop further understanding of biology” (National Science Education Standards, 1996).

When using the National Standards, a lesson devised in order to study evolution uses many aspects of inquiry learning. According to the National Science Education Standards (1996) a sample lesson on evolution represents the National Standards for Unifying Concepts and Processes, Life Science, and Science as Inquiry. This lesson applies students’ previous knowledge of Life Science and results in the students seeking
to answer the questions, “Do two slightly different fossils represent an evolutionary
trend?” (National Science Education Standards, 1996). This type of activity is
particularly good for the science class because students often have difficulty with the
concept of evolution. Through this type of instruction, the students and teacher will be
able to address any misconceptions about natural selection, variations, populations,
mutations and species.

The National Science Education Standards serve as a model for the
Pennsylvania State Standards; therefore both sets of standards are particularly important
in the development of a curriculum. Using the Pennsylvania State Standards for
Science and Technology as well as the Environment and Ecology Standards, a unified
inquiry-based curriculum can be easily developed. The Environmental Standards cover
areas such as watersheds, environmental health, resources, agriculture and society, pest
management, ecosystems, threatened or endangered species, environmental laws and
human impact on the environment. These standards are important when writing a
curriculum that incorporates environmental education into any science class. The
Science and Technology standards for Pennsylvania cover Unifying Themes, Inquiry
and Biological Sciences, all of which are important to the development of this particular
curriculum.

The emergence of the science Pennsylvania System of School Assessment
(PSSA) test has brought about much more of a focus on the academic standards. This
test is a criterion and standards based assessment tool that is used to gauge student
proficiency for each grade level and school district. This important test has science
teachers focusing more on developing a strong, interdisciplinary curriculum. The
Science Technology Environment and Ecology Assessment Handbook is the main assessment tool used in the production of the PSSA tests. This handbook focuses on developing questions that encompass all areas of science. The basis for the handbook starts with the standards for Science and Technology as well as Environment and Ecology. This is why it is so important to develop a curriculum that covers topics such as Environment within the context of a Biology classroom. Students will be receiving a well-rounded education all the while becoming more scientifically literate citizens of the world.

Inquiry

Inquiry learning is one of the most talked about topics among science educators today. Some of the earliest known constructivist educators who paved the way for inquiry learning include Socrates, Plato and Aristotle. Among the more famous constructivists are John Dewey, Jean Piaget and Lev Semenovich Vygotsky. These three professionals studied behaviors and observed that learning should be an active process (Llewellyn, 2005).

Inquiry includes a 5E cycle of learning that aids in the production of successful lessons. The 5E’s stand for: Engagement, Exploration, Explanation, Elaboration or Extension, and finally Evaluation. Engagement sets the stage for the students by having the teacher present a hook to grab the students’ interest in the topic. Exploration is when students are actively participating in an inquiry based laboratory activity. Explanation is when the teacher presents the data found from each group during the inquiry activity and discusses it with the class. Elaboration is when the teacher helps
the students apply the concept to a real-world problem or issue. Lastly, Evaluation is when the teacher helps the students close out the topic by summarizing the topics throughout the lesson and showing a relationship between the items discussed during the lesson (Llewellyn, 2005).

Inquiry based classrooms are often set up differently from a traditional classroom. The class is a more student/learner centered room with a friendly and open environment. In an inquiry classroom, the desks are not aligned in rows facing the front, but are sometimes arranged in groups or in a U-shaped pattern to promote discussions. Separate learning centers are set up that include access to multiple textbooks, primary sources, computer software, technology, materials and supplies for projects and a place to store student work. The type of atmosphere an inquiry environment sets, promotes typical student behaviors such as interest and imagination with science, investigative and questioning minds, communication within peer groups, connection of new knowledge with prior understandings, demonstration and reflection of the topics (Llewellyn, 2005).

Learning is made meaningful to students through inquiry learning. According to a study by Brooks and Brooks (1999), “It’s unfortunate that much of what we seek to teach our students is of little interest to them at that particular point in their lives. Curriculum and syllabi developed by publishers or state-level specialists are based on adult notions of what students of different ages need to know. Even when the topics are of interest to students, the recommended methodologies for teaching the topics sometimes are not.” (Llewellyn, 2005). An inquiry instructor needs to practice the following strategies; use the National Science Education Standards as his/her guide,
create a positive classroom culture, stimulate curiosity, limit lecturing, demonstrate flexibility, assess students’ prior knowledge, make learning relevant, use scientific demonstrations, use investigations and class discussions, ask higher level thinking questions, and establish everyday routines using good classroom management (Llewellyn, 2005).

Environmental Science

Mark Twain stated in 1897, “Everybody talks about it, but nobody does anything about it.” This remark can be applied to many situations but as scientists are beginning to discover the global impact humans have on their environment, it becomes evident that this quote can be applied to Environmental Science (Metz, 2007). One of the main focuses in the topic of climate change is that of human use and consumption of fossil fuels and how it impacts our environment. According to recent reports, humans dump 30 gigatons of carbon dioxide into the atmosphere each year, which contributes to global warming (Metz, 2007). By increasing the awareness of human impact on the environment, students can become informed citizens regarding the use of resources and pollution that could be harming the human race by destroying the environment.

Climate change is of great importance to the world today. In the media, we are constantly hearing about issues such as fires, flooding, hurricanes and other natural disasters. Each of these phenomena can be attributed to what is known as El Nino. In an article by James Mjelde, El Nino is also called ENSO (El Nino/Southern Oscillation) and may be the reason behind increased precipitation and temperatures throughout the world. Mjelde (2007) discusses how important it is to understand this phenomenon and
how it relates to school curriculum. In order to gain further understanding of this information, a website called DECIDE was created which incorporated weather and climate modules into a science and math curriculum using the National and Pennsylvania State standards (Mjelde, 2007).

The impact on student learning when it comes to incorporating environmental science into a curriculum has vast advantages. According to Irvin (2007) a small school in western Louisiana was almost ready to close due to lack of enrollment and a poor reputation. However, when science teachers overhauled the science program, changes began to occur. By implementing programs into a science curriculum such as Project Wild, Project Learning Tree & Project WET into the science curriculum, the classes became more hands on, with inquiry based instruction and less textbook dependant. “These programs all provide professional development, curriculums, lesson plans, and materials that draw on the natural environment to teach across the curriculum, as well as to foster students’ critical-thinking, collaboration, and problem-solving abilities”(Irvin, 2007). Due to the improvement to the science program, which enabled students to become engaged learners working within their communities and environment, the enrollment of this tiny school and the performance scores more than doubled as well as a marked increase in the number of staff members. This shows that the implementation of an inquiry program relevant to environmental science has a large impact on the prosperity of the students as well as the school itself.

Nature presents a vast amount of opportunities around the school setting, as well as at students’ homes in order to observe climate, human influence, reproduction and survival of organisms. Students typically understand weather, but are somewhat
confused by the concept of climates. By studying microclimates around the school
grounds as well as at home, students can observe where birds place their nests, the homes
of insects, and where plants or animals successfully reproduce. “Microclimate can have a
profound effect on local community structure and biodiversity, particularly on plants,
which are unable to move and thus often limited by local environmental conditions”
(Fontaine, et al. 2007). By studying the potential changes within a small microclimate in
their area, students can gain a better understanding of the environmental impact on a
much larger scale, helping them to master the knowledge behind environmental
education.

**Biology**

Biology is the study of life. Life processes are of great importance to the student
population because it directly affects them as humans, even though they may not be
aware of it. It is a great time to be teaching biology because of all of the recent
advancements in science and technology that allow teachers and students to access a
wealth of information. Teachers can now use resources such as online videos, video
conferences, statistics and data at the national level, as well as updated research, tools
and articles that enable students to engage in activities important to biology.

In a recent article by Burton et al (2007), an investigation used in the science
classroom enabled biology students to study patterns regarding the color changes in
leaves. In the fall, leaf color typically changes due to the angle of sunlight on the
Earth’s surface. In this article, temperature and day length both factored into the results
of leaf color changes. Students in this activity were able to use internet data to assess a
comparison between seasonal patterns and climate. With access to the wealth of information through the internet, students were able to discern between the relationship patterns using The Weather Channel and climatology departments at a local university to uncover facts and figures relevant to global climate change and its impact on organisms in the local environment.

Another biology inquiry activity was designed with the use of nematodes, more specifically, insecticidal nematodes in the science classroom. Nematodes, or roundworms are an excellent avenue to investigate in the biology classroom because they effect humans ecologically, biologically and economically (Bliss et al, 2007). Nematodes play an important role in carbon cycling as well as decomposition. Some other types of nematodes (parasites) cause serious diseases and deaths among plants and animals. One species was even used as the model for genetics and genome sequencing. The nematode that was chosen for this inquiry activity was an insecticidal nematode. This particular roundworm is important to ecology because it is an alternative to using pesticides that are harmful to the environment and sometimes other crops or animals (Bliss et al, 2007).

Biology is typically referred to as one of the keystone science courses in a high school curriculum. A well designed biology course should give students an idea of how science functions. Sadly, this is usually not the case. Most biology students are required to memorize long lists of vocabulary terms as well as remember basic concepts and facts about biology, rather than understand how to apply biology and know about the history and nature of the actual science (McComas, 2007). By creating a successful
curriculum which integrates environmental education and inquiry learning, students will gain a better awareness of the biology classroom.
CHAPTER 3

METHODS AND PROCEDURES

Methods

This thesis is important to a science curriculum because it will incorporate environmental education into the biology classroom using inquiry learning. The benefit to educating students about environmental and biological issues together is that these individuals will be making choices about our planet in the near future. By educating young minds about the natural sciences that effect our everyday lives, individuals will be better prepared to focus and make informed decisions regarding pollution, resource use, changes in weather patterns, and other major issues that impact our world today. The design of this study is to create a strong, standards based, high school biology curriculum using inquiry techniques that will integrate environmental education and biology content together in an interdisciplinary approach.

The participants involved in this curriculum will be tenth grade general biology students. The curriculum will encompass major issues in the environment today as well as how these issues relate to biological sciences. Inquiry learning and the National and State Science Standards will be used as a guide for developing the detailed curriculum. A major goal of this curriculum is to create a more scientifically literate community of individuals within the high school population so they are ready to step out into the world with science education as their guide. The typical strategies used throughout this curriculum include inquiry learning, constructivism and cooperative learning.
Students will be engaged in classroom activities that promote critical thinking skills, experimentation and planning, as well as observation, data collection and application. This curriculum consists of ten detailed lessons which incorporate environmental and biological content using inquiry techniques. Some of the lessons are extended for more than one class period. For more detail on the lessons please refer to the Appendices.

Global climate change is a great way to teach science concepts which include environmental education as well as biology. Using real-world issues helps increase student achievement and lets the students make connections between disciplines. One of the most significant documents in developing a curriculum about environmental education and biology is the National Science Education Standards. Through the use of inquiry in these standards, students will come to realize the negative impact humans have had on the climate. “Standard F asks students to use critical-thinking skills to examine global issues and develop a global awareness” (Whitsett, 2007).

Using curriculum alignment for an inquiry learning classroom is the best way to establish a successful learning program. Curriculum alignment means that three questions must be answered; 1. What do the students need to know and be able to do? (standards), 2. How will the teacher know whether the students meet the standard? (assessment), and 3. What learning opportunities will the teacher provide for students to meet the standard? (instruction). Using these three questions, a professional educator should be able to masterfully set up a curriculum that not only engages students based on the state and national standards, but also assess the power of the lesson by how well the students do (Llewellyn, 2005).
In an inquiry science classroom, a lot of activities and laboratory projects will be encountered. Students will be given general information about topics in order for the students to get the basic concept and therefore will be given regular tests regarding this material. However, they will also be graded on their ability to apply the knowledge learned through the inquiry activities. Since this is the case, students will mainly be assessed on their performance during activities and presentation of topics to the class during projects. Students will have ample opportunities for grades that show their increase in scientific learning and knowledge.

Procedures

Typically, students are engaged in classroom activities or labs that can be conducted in a one hour time frame. This is not usually how scientific investigations work. Sometimes science experiments can take a few weeks or even months. By encouraging long term investigations, students will gain a better understanding of how to be scientists and observe natural phenomena that occur over an extended period of time. Students will also have more opportunities to manipulate different variables with the use of a long term study.

There are a few ways in which a long term study can be conducted in a high school biology classroom. The teacher could encourage the students to take time out of class to observe everyday life patterns that are not normally observed in the classroom such as Moon phases, animal movement and seasonal changes. Students can also work on an extended project for a few minutes in each class period (McComas, 2005). Several examples of these types of activities are shown in Appendix A. In the photosynthesis lab, students will be observing carbon dioxide levels based on an
extended period of varying sunlight provided for each plant. Students will also observe plant growth. This lesson should take only a few days, whereas a longer lesson, the Bottle Ecosystem, encourages students to work on an activity for a few months. In this lesson, students will be observing patterns, life, sustainability and growth in their homemade ecosystems on a daily basis for an extended amount of time in order to see patterns.

An example of a lesson in biology and environment using inquiry is the one on nematodes (parasitic roundworms). To start, the topics of experimental design, scientific inquiry and nematodes were covered using other experimental design activities and an introductory teacher presentation. The next step was to have the students engage in scientific planning and experimentation using the brainstorming technique as a class. Once the students decided on a question they wanted to answer, they tested the experiment and formulated the results in a presentation. The students were assessed using several techniques. For a detailed lesson plan and assessments, please refer to Appendix A and C.

In order for inquiry activities to be successful, the teacher needs to step back and become the moderator. First, the students must know what is expected of them, and second, the teacher must avoid providing too much information. According to Leonard (as cited in McComas, 2005), the teacher should only give the students the essential materials and procedures needed for the activity, and refrain from telling the students how to partake in the investigation. The teacher should force the students to think for themselves and get their creative juices flowing. By giving the students a list of
resources in order to guide them through the process, the teacher is enabling the students to learn through inquiry.

Inquiry learning involves having the students answer a research question through data analysis. An example question states, “Did the latest El Nino impact the climate where I live?” (Bell et al, 2005). During inquiry activities in the science classroom, students can collect their own data through investigations or even use data already provided by the teacher or even the Internet, as long as they continue to find an answer for the research question at hand (Bell et al, 2005). During the lesson on seasonal changes and leaf color patterns in Appendix A, students were given ample data from the National Weather Service and the Weather Channel in order to complete their investigation.

The best possible inquiry activities for a science classroom need to be planned out by the teacher well in advance and in great detail in order to ensure proper student learning. There are several levels to inquiry that should be addressed during the activity. The first level is Confirmation, in which, according to Rezba et al (as cited in Bell et al, 2005 p33) “Students confirm a principle through an activity in which the results are known in advance.” The second level, as stated by Rezba et al (as cited in Bell et al, 2005 p33), is Structured Inquiry, where “Students investigate a teacher-presented question through a prescribed procedure.” Level number three, based on Rezba et al (as cited in Bell et al, 2005 p33), is Guided Inquiry, when “Students investigate a teacher-presented question using student designed/selected procedures.” The last level, noted by Rezba et al (as cited by Bell et al, 2005 p 33), is Open Inquiry,
where “Students investigate topic-related questions that are student formulated through student designed/selected procedures.”

When students are unfamiliar with inquiry activities it is a good idea to get them started in the correct direction. To introduce inquiry lessons, the teacher can use a data-based worksheet that enables the students to act as scientists. This type of data may also be found through the Internet which has a wealth of information for the students to explore, as long as it is monitored. Another step to breaking inquiry lessons to the students is to use a demonstration that models a scientific phenomenon or a targeted principle or action. After the demonstration, the teacher can ask the students to explore the literature (their textbook or other sources) to investigate the phenomenon even further. Once they have found detailed information on the topic at hand, the students will form groups to plan their own method of investigation and test their hypotheses. Upon completion of their experiment, students will present the information to the class. One last step to the inquiry process involves allowing the students to generate their own research questions about a significant topic, forming the investigation and carrying out the experiment (Eick et al, 2005).

Using the National and Pennsylvania State Education Standards is a good starting point for the development of a sound science curriculum. According to the National Academy of Sciences, the National Science Education Standards state that a good science curriculum gives students access to the world beyond the classroom and emphasizes student understanding through inquiry. The Life Science portion of the National Standards says that students should become proficient in the following areas: the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter,
energy, and organization in living systems, and behavior of organisms. The content regarding the cell is touched on during the photosynthesis lesson shown in Appendix A. The content with biological evolution is applied to the lesson about fossils. The largest lesson, which encompasses several months of instruction, deals a lot with the interdependence of organisms, matter, energy and organization in living systems and behavior of organisms, because it has the students create their own ecosystems within a plastic bottle. Using these standards, students will understand the major concepts in life science all while understanding inquiry which is also a content standard for Science as Inquiry.

The environmental content of the National Science Education Standards covers topics such as; personal and community health, population growth, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global challenges. During the development of this curriculum, the content of natural and human-induced hazards is discussed in the lesson on photosynthesis. Personal and community health as well as population growth are important standards that are incorporated in the bottle ecosystem lesson. Environmental quality and science and technology are both applied to lessons involving fossils and evolution, as well as microclimates and pest management. This set of National Standards focuses on the principles that apply to local as well as global phenomena (National Science Education Standards, 1996). This curriculum was developed for the Pennsylvania Certified Teacher, so the Pennsylvania State Standards for Science and Technology as well as Environment and Ecology were used as a focal point for each of the lessons. The application of the National as well as the State Education Standards in
Science is vital to creating a scientifically literate community of students in a high school biology classroom.
CHAPTER 4

RESULTS

Results

“Teaching about cross-disciplinary topics like global climate change allows students to develop a better understanding of the issues, problem-solving and critical-thinking skills needed in the 21st century” (Whitsett, 2007). Teaching environmental science in the biology classroom through inquiry is a phenomenal way to touch on many aspects that are important in students’ lives. By showing students through inquiry, that scientists do not typically do their work in a laboratory, we are showing students that they can become scientists too. During this curriculum, students will be open to explore parks, the school grounds, homes or neighborhoods, zoos and even museums which will help show students that their investigations can take place anywhere their imaginations take them (McComas, 2005).

Providing meaningful inquiry learning activities that implement scientific investigations of environmental and biological focus allows students to become more in control of their own learning. According to McComas (2005), “Eggelston (1973) and Leonard (1980) discovered that cookbook-like laboratories frequently bore students, but ‘the more involved a student is in the laboratory the more productive the educational outcomes will be’ (Leonard, 1980).” By using inquiry lab activities for the students to engage in, a science teacher has the chance to promote enhanced learning. The results
should show an increase in quiz, lab and test grades as well as an increase in student involvement and understanding in their own knowledge.

Teachers who wish to engage their students in inquiry laboratory investigations may also want to try developing a science fair type of project. It may take a great deal of organization, but if the school’s science department can arrange to have a science fair once a year, that will provide ample opportunities for students to showcase inquiry projects they have been working on. These types of activities allow students to research a topic, review literature relevant to their particular project, design an experiment on their own, analyze the results of the experiment, and show the data to judges. “Students who have become experienced in inquiry throughout the year will be better prepared to produce high-quality projects than those who simply are assigned a project during the final weeks of the year, with no prior experience in inquiry” (Eick et al, 2005). One such inquiry activity that would be perfectly showcased at a science fair is the bottle ecosystems that students have developed throughout the school year.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In conclusion, science instruction is important in creating a more knowledgeable society. The best way to create a scientifically literate community of young minds is to incorporate many disciplines in one class such as biology and environmental science. Using inquiry learning, students will have the capabilities of constructing their own learning experience and stand to learn a great deal more than their counterparts. By making science education relevant to students, it will help facilitate the process of inquiry by giving the students ample opportunities to question scientific principles. The work of changing the science curriculum to more inquiry based and cross-disciplined courses is far from being complete, but with hard work and dedication science educators can enhance their professional knowledge through workshops and classes in order to revamp the scope and sequence of biology instruction in their classrooms. By making sure the students have authentic and appropriate experiences with content and types of instruction in the biology class, we can hope that students’ knowledge will flourish in the 21st century and beyond.

Recommendations

Through a copious amount of research and development, this curriculum has been created in order to make biology students more proficient in environmental aspects
as well as inquiry learning. Inquiry is an important focus for all classrooms, not just science. This type of classroom shows students engaged in answering a puzzling question relevant to current world and local issues. Many of the students are given free reign to work on a project for an extended period of time. All the while, the topics of interest are brought into the classroom one at a time and discussed further in order to assess student understanding.

This type of instruction can be incorporated into all classrooms including Math, English, Art, and Foreign Languages. The next step in this curriculum is to implement environmental education through the use of inquiry methods in each of the disciplines taught in high schools today. Environmental education can be added to a Mathematics classroom by discussing global warming trends and actively working on a graph using the data from the Mauna Loa Research Observatory in Hawaii on global warming (Edwards & Layhue, 2007). Using the data, students can create a chart as well as a graph and plot a “line of best fit” that measures the increase in carbon dioxide levels in the earth’s atmosphere. Once they have plotted the line, students can find the slope and equation of the line using mathematical practices. Students will also be able to predict (using the current data and their graphs, when the earth’s atmosphere will become at the most dangerous levels of CO₂ (Edwards & Layhue, 2007).

By actively engaging students in answering an environmental question, any subject can be taught to the fullest while learning reading skills, mapping in geography, artistic structure of a facility, or even hot topics in a different language. If we as educators can seek to enhance student learning to the fullest capacity, students can achieve wonderful heights in the world today.
APPENDIX A

Lesson Plans
Photosynthesis

Name: Ms. Resanovich

Subject: Applied & General Biology

Grade: 10

Date Lesson is to be taught: October 8, 2007

Goal:
Importance of the lesson, relevance for students
Elements such as global warming, deforestation and pollution can have a great effect on plants and their photosynthetic properties. If a plant cannot carry out the process completely, something will be missing from the end product. Both end products are very important to us, as consumers (glucose and oxygen).

Materials: Text, worksheets, PowerPoint, potted plants, Vaseline, peanut butter, nail polish, aluminum foil, wax paper, plastic wrap, colored cellophane, laboratory supplies, sunlight.

Expected Duration: 3, 90 minute class periods.

Objectives

Academic Standards:

Pennsylvania:
3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
   • Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions
3.2.12.B.1: Evaluate experimental information for appropriateness and adherence to relevant science processes.
   • Evaluate experimental data correctly within experimental limits.
3.3.10.B.2 & 4: Describe and explain the chemical and structural basis of living organisms.
   • Identify the specialized structures and regions of the cell and the functions of each.
   • Explain cell functions and processes in terms of chemical reactions and energy changes.

National:
Unifying Concepts and Processes:
   o Form and function
Science as Inquiry:
Objectives are:

___x__ Cognitive       _____ Affective       ___x__ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:

- Describe the role of light and chlorophyll in photosynthesis.
- Describe the structures and function of a chloroplast.
- Describe what happens in the light-dependent reactions.
- Identify factors that affect the rate at which photosynthesis occurs.
- Manipulate a photosynthetic plant to test environmental factors affecting it.

Lesson Development

Anticipatory Set
1. Students record what they know about the leaf as a food manufacturing site and write down whatever comes to their minds regarding the term, “photosynthesis”. Students then share with a partner what information they have written.
2. “What would happen if you took away or changed one of the requirements for photosynthesis?”

Teaching Procedures/Instructional Process:
When students are finished sharing ideas, the teacher asks for volunteers to put their ideas into a concept map on the board. The teacher walks around to check for understanding while students use the microscopes. The teacher then shows a brief presentation regarding the structure of a leaf from a plant. The teacher poses a question to the students to begin a laboratory activity. During the lab activity, the teacher acts as moderator, while students actively engage in testing photosynthesis. Teacher reviews the information at the end of the activity by discussing important vocabulary that relate to photosynthesis with the students.

Guided Practice/ Monitoring
After the pair/share activity, students will observe prepared slides of a leaf under a microscope and compare the slides to illustrations in their text. Students are put into
groups and asked the anticipatory question regarding photosynthesis. Students are now able to choose an investigation that is most relevant to their lives and helps them observe the changes in the plant’s food making process. Students will apply one or more of the materials (see above) of their choice to a plant leaf and put it in sunlight for 2 days. Next students will test the leaf for starch using an iodine test. Students will fill in a chart to record their data and answer relative thinking questions regarding their laboratory experiment. (See lab handout for the full activity).

**Closure**

How do your findings relate to the food-making process of photosynthesis? What effect does pollution have on the growth of plants? We learned that photosynthesis is a production system that uses CO2 and sunlight to create products such as oxygen and sugars.

**Independent Practice / HW**

Students will work in workbooks, on the review worksheet & develop a concept map relating all of the steps of photosynthesis together using index cards with vocabulary words such as; upper epidermis, lower epidermis, palisade layer, spongy layer, xylem, phloem, vascular bundle, guard cell, stoma, chloroplast, chlorophyll, photosynthesis, autotroph, glucose, carbon dioxide, water, oxygen, and light.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- Pair up the students who are less proficient with those who have grasped the ideas of photosynthesis. Allow them to quiz each other on the light dependant processes and the structures of a leaf. This is a good review before the test.

**Content Notes and Questions for Students**

- List the different structures of the plant’s leaf that help with photosynthesis.
- Explain why sunlight is so important to starch production.
- Compare and contrast the results of leaves that were covered with colored plastic wrap as opposed to a different covering.
- Assess what would happen if an oil spill or other type of human induced disaster occurred in an area where a lot of plants were living.

**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried this lesson yet.

Author’s note: This is an inquiry lesson because it has students developing their own method of testing for how light or even different colored light affects photosynthesis.

*Information for this lesson was taken from:*

Climate & Seasonal Changes: A further exploration into Photosynthesis

Name: Ms. Resanovich

Subject: Applied & General Biology
Grade: 10
Date Lesson is to be taught: October 16, 2007

Goal:
Importance of the lesson, relevance for students
Climate changes may have an effect on seasonal patterns. Students will understand why it takes longer for the leaves to change color one year than it does the year before. This applies to students because climate change is a big topic today since the issue of global warming has surfaced.

Materials: Text, worksheets, PowerPoint, Internet, Journals and Science Articles.

Expected Duration: 2, 90 minute class periods.

Objectives

Pennsylvania:
3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
  • Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions
3.2.12.B.1: Evaluate experimental information for appropriateness and adherence to relevant science processes.
  • Evaluate experimental data correctly within experimental limits.
3.3.10.B.2 & 4: Describe and explain the chemical and structural basis of living organisms.
  • Identify the specialized structures and regions of the cell and the functions of each.
  • Explain cell functions and processes in terms of chemical reactions and energy changes.

National:
Unifying Concepts and Processes:
  o Form and function

Science as Inquiry:
  o Ability to do scientific inquiry
  o Understandings about scientific inquiry

Physical Science:
Chemical reactions

Life Science:
- The cell
- Matter, energy and organization in living systems
- Behavior of organisms

Science in Personal and Social Perspectives
- Natural Resources
- Environmental quality
- Natural and human-induced hazards

Assessment
- Chapter 8 test.
- Workbooks and Vocabulary/Assessment sections.
- Laboratory Investigation
- Review worksheet on photosynthesis

Objectives are:
- Cognitive
- Affective
- Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
- Describe the role of light and chlorophyll in photosynthesis.
- Identify the effect of temperature and latitude on seasonal changes.
- Describe what happens in the light-dependent reactions and how the change in day length may effect seasonal changes.
- Identify factors that affect the rate at which photosynthesis occurs.
- Plug in experimental data to find results.
- Understand how humans impact seasonal changes and why this is important to them.

Lesson Development

Anticipatory Set
Why did it take longer for the leaves to change color this year? What factors may have an impact on the leaves changing? What have you learned about photosynthesis that explains fall color changes in leaves?

Teaching Procedures/Instructional Process:
The teacher will review the topics covered in the previous lesson on photosynthesis and then open a discussion about the fall leaf changes. The teacher will provide students access to the Internet so they can conduct their own research to answer the questions that they bring about. During the discussion, the teacher writes students’ ideas on the board so everyone will have a starting point in their research.

Guided Practice/ Monitoring
Students will be encouraged to answer a question about seasonal weather changes affected by climate change. Questions they may ask: “Does latitude have an effect on color change?” “Does temperature have an effect on color change?” “Does day length have an effect on color change?” Students will then be given access to the computer lab to conduct their investigations individually. Students will visit sites such as The Weather Channel’s site, Weather Underground, Google Earth to find latitudes and elevations, the
U.S. Naval Observatory site, the University of Virginia Climatology Office, and The Foliage Network. Students will be given the sites to start with and also be allowed to explore other possibilities. Students must be sure to document their findings in a notebook and then form a position paper with explanations and references to show the data that was collected.

**Closure**

How are the photosynthetic plants affected by climate changes? Explain what you found out about the affects of latitude, day length, and temperature on seasonal patterns.

**Independent Practice / HW**

Students will work in workbooks, on the review worksheet & on their position papers.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- Pair up the students who are less proficient with those who have grasped the ideas of photosynthesis. Allow them to quiz each other on the light dependant processes and the structures of a leaf. This is a good review before the test.

**Content Notes and Questions for Students**

- List the different structures of the plant’s leaf that help with photosynthesis.
- Explain why sunlight is so important to starch production.
- Compare and contrast the results of leaves affected by different day lengths, different temperatures, and different latitudes.
- Assess what would happen if our local climate changed so drastically that we ended up with more of a tropical climate.

**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried this lesson yet. Author’s note: This is an inquiry lesson because the students are using Internet data to see if different factors in climate change affect the rates of photosynthesis and seasonal changes.

*Information for this lesson was taken from:

(Burton, Miller & Roossinck, 2007)
**Bottle Ecosystem Part 1: The Characteristics of Life**

**Name:** Ms. Resanovich

**Subject:** Applied & General Biology

**Grade:** 10

**Date Lesson is to be taught:** September 1, 2007

**Goal:**

*Importance of the lesson, relevance for students*

Students may take for granted all of the elements that are needed in order to sustain their own lives. By involving the students in this activity, they will learn what it takes to keep an ecosystem going.

**Materials:** Text, worksheets, handout, Internet, PowerPoint, video, science journals and books, a rock, a piece of coral.

**Expected Duration:** 3, 90 minute class periods.

**Objectives**

**Academic Standards:**

- **Pennsylvania (Science & Tech and Environment & Ecology):**
  - 3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
    - Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions
  - 3.2.10.C.1 & 3: Apply the elements of scientific inquiry to solve problems
    - Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
    - Design an investigation with adequate control and limited variables to investigate a question.
  - 3.3.10.A.1: Explain the structural and functional similarities and differences found among living things.
    - Identify and characterize major life forms according to their placement in existing classification groups.
  - 4.6.10.A.2-4, 8 & 9: Explain the biotic and abiotic components of an ecosystem and their interaction
    - Compare and contrast the interactions of biotic and abiotic components in an ecosystem.
    - Analyze the effects of abiotic factors on specific ecosystems.
    - Describe how the availability of resources affects organisms in an ecosystem.
• Identify a specific environmental impact and predict what change may take place to affect homeostasis.
• Examine and explain how organisms modify their environments to sustain their needs.

National:
Unifying Concepts and Processes:
  o Systems, order and organization
Science as Inquiry:
  o Ability to do scientific inquiry
  o Understandings about scientific inquiry
Life Science:
  o Interdependence of organisms
  o Matter, energy and organization in living systems
  o Behavior of organisms
Science in Personal and Social Perspectives
  o Natural Resources
  o Environmental quality
  o Population growth

Assessment
  o Chapter 1 test.
  o Workbooks and Vocabulary/Assessment sections.
  o Biosphere design/presentation
  o Worksheets on experimental design and the characteristics of life

Objectives are:
  ___x__ Cognitive  _____ Affective  ___x__ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
  o Determine the characteristics of life.
  o Explain why their structure is considered a closed ecosystem.
  o Identify biotic and abiotic factors in their ecosystems.
  o Examine what is needed in order to sustain life.
  o Create a bottle ecosystem that can sustain real life & understand the processes affecting each.

Lesson Development

Anticipatory Set
“What is life?” “What is a living thing?” Show the students a rock and a piece of coral, “Is this rock alive? Is this piece of coral alive?”

Teaching Procedures/Instructional Process:
Upon entering the class, students will be shown a short video on the surface of Mars. The teacher will then ask the students for their ideas on what characterizes something as living or nonliving while showing examples. The teacher then says, “We have been given a special assignment by NASA. Your task is to design a biosphere that would sustain humans living on the surface of Mars for 18 months.” The teacher then passes
out a fake letter from NASA that describes the students’ mission. Once the students have read the letter to themselves, they will then be taken to the computer lab to begin their research.

**Guided Practice/ Monitoring**

Students will start class with a discussion about life’s characteristics. Then students will read information on the proposed assignment. Next, students will go to the computer lab or use books and journals in the classroom in order to research the subject at hand. Students will be working in groups of 4-5 and they will design a biosphere that will enable 10 astronauts to survive on the surface of Mars for 18 months. Students will then present their designs to the whole class and compare and contrast similarities and differences among each. The students will be allowed to use posters, PowerPoint or any other materials in order to prepare their design for the presentation.

**Closure**

What are the life processes that are essential to all living organisms? What are the conditions necessary to sustain life? Now that you have proposed a design, you will actually build your own biosphere using materials such as 2-liter plastic bottles.

**Independent Practice / HW**

Students will continue their research at home on the Internet and work individually on their ideas to present to their group members. Students will also be required to do a worksheet on the characteristics of life and scientific experimentation.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.

**Content Notes and Questions for Students**

- List the characteristics of all living things.
- Explain how scientists test hypotheses.
- Compare and contrast the levels of organization within biology.
- Assess what would happen if we were to place humans in a hostile environment such as Mars and what would be necessary in order for them to survive.

**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried this lesson yet.

Author’s note: Inquiry lesson because the students develop their own biosphere to sustain life on a different planet using their research about the characteristics of life.

*Information for this lesson was taken from:*


Bottle Ecosystem Part 2: The Interdependence of Organisms

Name:  Ms. Resanovich

Subject:  Applied & General Biology

Grade:  10

Date Lesson is to be taught: September 8, 2007

Goal:
Importance of the lesson, relevance for students
Plant and animal interactions are everyday occurrences that students may not even be aware of. By involving students in an experiment that shows interdependence, students will understand why the interactions among organisms are important to life.

Materials:  Text, worksheets, Internet resources, aquarium books, PowerPoint, science journals and books, 2-liter plastic bottles, sand, gravel, small rocks, soil, snails, aquatic plants (duckweed, fanwort, hortwort), pond water, small fish, worms, crickets.

Expected Duration:  5, 90 minute class periods.

Objectives

Academic Standards:

Pennsylvania(Science & Tech and Environment & Ecology):

3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.

- Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions

3.2.10.C.1 & 3: Apply the elements of scientific inquiry to solve problems

- Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
- Design an investigation with adequate control and limited variables to investigate a question.

3.3.10.A.1: Explain the structural and functional similarities and differences found among living things.

- Identify and characterize major life forms according to their placement in existing classification groups.

4.6.10.A.4-7: Explain the biotic and abiotic components of an ecosystem and their interaction

- Describe how the availability of resources affects organisms in an ecosystem.
- Explain energy flow in a food chain through an energy pyramid.
- Evaluate the efficiency of energy flow in a food chain.
• Explain the concept of carrying capacity in an ecosystem.
• Explain trophic levels.

National:
Unifying Concepts and Processes:
  o Systems, order and organization
Science as Inquiry:
  o Ability to do scientific inquiry
  o Understandings about scientific inquiry
Life Science:
  o Interdependence of organisms
  o Matter, energy and organization in living systems
  o Behavior of organisms
Science in Personal and Social Perspectives
  o Natural Resources
  o Environmental quality
  o Population growth

Assessment
  o Chapter 3 test.
  o Workbooks and Vocabulary/Assessment sections.
  o Bottle ecosystem & journal.
  o Worksheets on food webs, energy pyramids, and trophic levels.
  o Food web poster.

Objectives are:
   ___x__ Cognitive   _____ Affective   ___x__ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
  o Explain why their structure is considered a closed ecosystem.
  o Identify the following organisms in their ecosystems: producer, primary consumer, and decomposer.
  o Create a diagram of a food chain or energy pyramid and a food web from their ecosystem.
  o Maneuver biotic and abiotic factors within the bottle ecosystem to test the effects of each.

Lesson Development

Anticipatory Set
“Your next responsibility as a research ecologist is to use one or more 2-liter plastic bottles to design a living chamber that will keep a fish or other animal alive for 3 months.”

Teaching Procedures/Instructional Process:
The teacher provides a brief lecture on ecology and interactions among organisms. Students will get involved in discussions about trophic levels and food webs. The teacher will provide an example of where to start when it comes to the bottle ecosystems and then hands out a rubric for the students’ journals on the subject.
**Guided Practice/ Monitoring**

Students will be put into groups to design a bottle ecosystem. They will use class time to brainstorm what the ecosystem will need. Students must use their research journals to record any information about their design. The journal will include a diagram and explanation of “How our bottle ecosystem works”. Students will use posters to diagram their ecosystem designs and present the designs to the class. Students will compare and contrast each other’s designs and discuss limiting factors such as space, temperature, breeding, and interactions of the organisms. Students will then use the materials available to start building their ecosystems. Students will observe and experiment with their ecosystems for 2 weeks and then the ecosystem must be closed, meaning they are not to be tampered with, for the next 3 months. Students will continue to observe the ecosystem throughout several lessons.

**Closure**

What observation have you already made concerning a food web within your ecosystem? Can you show which organisms are the producers, the consumers and the secondary consumers? Is there a tertiary consumer in your ecosystem? Why or why not?

**Independent Practice / HW**

Students from each group will be asked to individually map out the food webs that occur within their ecosystem. This food web activity will take place in class and be taken home to finish as homework. Students can use posters to draw the food web.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.

**Content Notes and Questions for Students**

- List the different trophic levels.
- Explain energy flow within an ecosystem.
- Compare and contrast autotrophs and heterotrophs.
- Assess what would happen if one organism was removed from the food web.

**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried the bottle ecosystem, but the food webs worked well. Next time I would show an example of a previous classes’ food web to give the students an idea of what theirs should look like.

Author’s note: Inquiry lesson because students develop their own food webs and begin constructing their own ecosystems using the research materials they have found.

*Some information for this lesson was taken from:
Bottle Ecosystem Part 3: Biogeochemical Cycles

Name: Ms. Resanovich

Subject: Applied & General Biology

Grade: 10

Date Lesson is to be taught: September 15, 2007

Goal:
Importance of the lesson, relevance for students
Students need to understand the cycles of matter because all living organisms need elements such as oxygen, carbon, hydrogen, and nitrogen, but they need them in a specific chemical form (such as water or carbon dioxide). These elements are necessary to sustain life within the students’ ecosystems.

Materials: Text, worksheets, Internet resources, aquarium books, PowerPoint, science journals and books, water, glass, hotplate, mirror, bottle ecosystems.

Expected Duration: 3, 90 minute class periods.

Objectives

Academic Standards:

Pennsylvania(Science & Tech and Environment & Ecology):

3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
- Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions

3.2.10.C. 1 &3: Apply the elements of scientific inquiry to solve problems
- Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
- Design an investigation with adequate control and limited variables to investigate a question.

4.6.10.A.4-7: Explain the biotic and abiotic components of an ecosystem and their interaction
- Describe how the availability of resources affects organisms in an ecosystem.

B. 4.6.10.B.1&2: Explain how cycles affect the balance in an ecosystem.
- Describe an element cycle and its role in an ecosystem.
- Explain the consequences of interrupting natural cycles.

National:
Unifying Concepts and Processes:
- Systems, order and organization
Science as Inquiry:
  o Ability to do scientific inquiry
  o Understandings about scientific inquiry

Life Science:
  o Interdependence of organisms
  o Matter, energy and organization in living systems
  o Behavior of organisms

Science in Personal and Social Perspectives
  o Natural Resources
  o Environmental quality
  o Population growth

Assessment
  o Chapter 3 test.
  o Workbooks and Vocabulary/Assessment sections.
  o Bottle ecosystem & journal.
  o Concept map on Biogeochemical cycles.
  o Worksheets on the cycles of matter.

Objectives are:
  ___x___ Cognitive  ___x___ Affective  ___x___ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
  o Describe how matter cycles among the living and nonliving parts of an ecosystem.
  o Explain why nutrients are important in living systems.
  o Describe how the availability of nutrients affects the productivity of ecosystems.
  o Understand how nutrients are important to humans as well as other organisms and life on earth.
  o Experiment with the bottle ecosystem to see what nutrients work best.

Lesson Development

Anticipatory Set
“How is water, among other elements, recycled, not just by humans, but by other organisms such as plants and animals?” The teacher does a few demonstrations using water.

Teaching Procedures/Instructional Process:
The teacher starts class by posing a question and then showing several demonstrations concerning water. Demo #1: Breath on a mirror. This shows students respiration. Demo #2: Heat a bowl of water using a hot plate. Hold the mirror above the bowl to show the water evaporating. Demo #3: A cold glass of water, sweating shows condensation. Discussion about the 4 cycles of matter will then follow using PowerPoint.

Guided Practice/ Monitoring
Students change one aspect of their bottle ecosystems to test a hypothesis. They observe the progression of the ecosystem by monitoring aspects such as pH, temperature, and dissolved oxygen rates. Students will use probes and spreadsheets to collect and record their data. After collecting their data, students will design a concept map showing how
the 4 cycles of matter are involved in their ecosystem.

**Closure**

How are the cycles of matter important to living organisms in your ecosystems? What happened when you briefly took away one of the pieces of a cycle?

**Independent Practice / HW**

Students will work on their concept maps in class and finish them for homework. Students may also take the time to collect data and observations in case they need to make modifications to their bottle ecosystem.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.

**Content Notes and Questions for Students**

- List the 4 cycles of matter.
- Explain the importance of the elements used in the biogeochemical cycles.
- Compare and contrast transpiration in plants and respiration in animals.
- Assess what would happen to your ecosystem if one part of the carbon cycle was skipped or removed.

**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried this lesson yet.

Author’s notes: Inquiry lesson because students decide on an elemental factor to remove for a short time in their ecosystem to determine the effects. Also, students are finding what is necessary to sustain life in their ecosystems.

*Some information for this lesson was taken from:


Bottle Ecosystem Part 4: Symbiotic Relationships

Name: Ms. Resanovich

Subject: Applied & General Biology

Grade: 10

Date Lesson is to be taught: September 22, 2007

Goal:
Importance of the lesson, relevance for students
Students should understand the importance of interactions among organisms. Students interact with their environment everyday and do not even realize it.

Materials: Text, worksheets, Internet resources, aquarium books, PowerPoint, science journals and books, toothpicks.

Expected Duration: 2, 90 minute class periods.

Objectives

Academic Standards:

______ Local ______x Pennsylvania ______x National Pennsylvania(Science & Tech and Environment & Ecology):
3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
- Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions
3.2.10.C. 1 &3: Apply the elements of scientific inquiry to solve problems
- Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
- Design an investigation with adequate control and limited variables to investigate a question.
4.6.10.A.4-7: Explain the biotic and abiotic components of an ecosystem and their interaction
- Describe how the availability of resources affects organisms in an ecosystem.
A. 4.7.10.B.1-3: Explain the significance of diversity in ecosystems.
- Explain the role that specific organisms have in their ecosystem.
- Identify a species and explain what effects its increase or decline might have on the ecosystem.
- Identify a species and explain how its adaptations are related to its niche in the environment.
4.7.10.B.1 & 2: Explain how structure, function and behavior of plants and animals affect their ability to survive.

- Describe an organism’s adaptations for survival in its habitat.
- Compare adaptations among species.

**National:**
**Unifying Concepts and Processes:**
- Systems, order and organization

**Science as Inquiry:**
- Ability to do scientific inquiry
- Understandings about scientific inquiry

**Life Science:**
- Interdependence of organisms
- Matter, energy and organization in living systems
- Behavior of organisms

**Science in Personal and Social Perspectives**
- Natural Resources
- Environmental quality
- Population growth

**Assessment**
- Chapter 4 test.
- Workbooks and Vocabulary/Assessment sections.
- Bottle ecosystem & journal.
- Chart with the ecosystem niches and relationships.
- Worksheets on symbiosis.

**Objectives are:**

| _____x___ Cognitive | _____x___ Affective | _____x___ Psychomotor |

**Student Objectives:** *(related to assessment)*

As a result of this lesson, the students will be able to:

- Identify the interactions that occur within communities.
- Explain how biotic and abiotic factors influence an ecosystem.
- Describe how the greenhouse effect could affect an ecosystem.
- Understand the importance of the greenhouse affect to human life on earth.
- Add/remove resources and organisms to the bottle ecosystems and observe the effects.

**Lesson Development**

**Anticipatory Set**

A short demonstration of competition using toothpicks will show students how organisms fight for similar or different nutrients.

**Teaching Procedures/Instructional Process:**

The teacher leads a brief discussion about competition and then engages the students in a short demonstration. After the demo, students will then discuss factors the affect ecosystems such as climate and the greenhouse effect. Lastly, the teacher and students will discuss symbiotic relationships such as mutualism, commensalisms, parasitism, etc.
**Guided Practice/ Monitoring**
The teacher sets up a demonstration by having the students compete with one another to pick up the same colored toothpicks and then to pick up different colored toothpicks. Students should realize that it is easier to get the toothpicks when they are going after the different colored ones. After the demo, students will work with their bottle ecosystems, observing symbiotic relationships and recording the information into a chart. Students will also record niches they notice and how all of this information is tied together.

**Closure**
What relationship did everyone notice has the biggest impact on the ecosystem? Where there any relationships you did not notice, such as parasitism?

**Independent Practice / HW**
Students will have class time to work on their charts to map out the different niches and relationships within their ecosystems. Students will also have one last opportunity to change components of their ecosystem before it becomes “closed”.

**Differentiated Instruction**
- Adapted reading workbook.
- Test modifications.
- By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.

**Content Notes and Questions for Students**
- List the different types of symbiotic relationships.
- Explain what a niche is.
- Compare and contrast environments such as the ecosystem and our own environment as they relate to the greenhouse effect.
- Assess what would happen to your ecosystem if a parasitic organism was added.

**Professional Development**
**Reflections after Teaching the Lesson:**
I have not tried this lesson yet.
Author’s notes: Inquiry lesson because students introduce different species into their ecosystems and observe the relationships. Students must research prior to putting something in to ensure survival.

*Some information for this lesson was taken from:

Investigating a Microclimate

Name:  Ms. Resanovich

Subject:  Applied & General Biology

Grade:  10

Date Lesson is to be taught:  September 28, 2007

Goal:
Importance of the lesson, relevance for students
Students will understand the affect climate can have on living organisms in their area.

Materials:  Text, worksheets, Internet resources,  PowerPoint, science journals and books, paper, pencils, clipboards, colored pencils/markers, thermometer, hygrometer, anemometer, photometer, map, datasheet.

Expected Duration:  2, 90 minute class periods.

Objectives

Academic Standards:

Pennsylvania(Science & Tech and Environment & Ecology):
3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
  • Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions
3.2.10.C. 1 &3: Apply the elements of scientific inquiry to solve problems
  • Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
  • Design an investigation with adequate control and limited variables to investigate a question.
4.6.10.A.2-4,9,10 & 12: Explain the biotic and abiotic components of an ecosystem and their interaction
  • Describe how the availability of resources affects organisms in an ecosystem.
  • Compare and contrast the interactions of biotic and abiotic components in an ecosystem.
  • Analyze the effects of abiotic factors on specific ecosystems.
  • Identify a specific environmental impact and predict what change may take place to affect homeostasis.
  • Examine and explain how organisms modify their environments to sustain their needs.
Interpret possible causes of population fluctuations.

National:
Science as Inquiry:
  o Ability to do scientific inquiry
  o Understandings about scientific inquiry
Life Science:
  o Interdependence of organisms
  o Matter, energy and organization in living systems
  o Behavior of organisms
Science in Personal and Social Perspectives
  o Environmental quality
  o Population growth

Assessment
  o Chapter 4 test.
  o Workbooks and Vocabulary/Assessment sections.

Objectives are:
___x__ Cognitive         __x___ Affective          ___x__ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
  o Identify the causes of climate.
  o Explain how biotic and abiotic factors influence an ecosystem.
  o Explain what a microclimate is.
  o Experiment with a school yard microclimate by adding or removing items.
  o Understand how microclimates apply to humans.

Lesson Development

Anticipatory Set
Introductory: What are the typical weather conditions (abiotic factors) around this area? How do you think these weather conditions affect organisms living in this climate? What exactly is a climate? Are there differences in climate just in our area (microclimates)?
Ex: different plants growing in different places around the school grounds.
Main hook: How can the variation in abiotic factors (climate) affect the variation in plant distribution among a particular location/climate?

Teaching Procedures/Instructional Process:
The teacher introduces the idea of a microclimate by reviewing concepts about climate from the previous lesson. The teacher then puts the students into groups and passes out the necessary materials. The teacher will take the student outside and demonstrate how to use the data measuring equipment correctly and then act as the moderator the remainder of the class.

Guided Practice/ Monitoring
Students begin by listing the different types of plants around the schoolyard. Students must predict what plant types grow in which microclimates. Students will then conduct an investigation to find 4-6 samples of plant types and then measure for the microclimate (temperature, humidity, and wind speed) underneath each of the plants. Students will
record their results on the datasheet and place the location on the map of the schoolyard. Students will transfer their data to a computer that has compiled all of the class data. Students will then be given the information (class averages) and asked to create a new isocline map using this data (shows temperature by circling elevated areas and labeling them with colors and numbers for the temperatures. Upon completion of the maps, students will take a short quiz, reiterating the vocabulary used in this particular section.

**Closure**

What are the preferred habitats of different plant types? What is the degree of variation in microclimates around the school grounds? How do you think microclimate measurements in the schoolyard will change throughout the year? How could an abiotic factor such as trees losing their leaves, affect the microclimates?

**Independent Practice / HW**

Students will work on the Chapter 4 worksheets and the discussion questions for homework.

<table>
<thead>
<tr>
<th>Differentiated Instruction</th>
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</thead>
<tbody>
<tr>
<td>o Adapted reading workbook.</td>
</tr>
<tr>
<td>o Test modifications.</td>
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<tr>
<td>o By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.</td>
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<table>
<thead>
<tr>
<th>Content Notes and Questions for Students</th>
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<tbody>
<tr>
<td>o List the biotic and abiotic factors that affect a climate.</td>
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<tr>
<td>o Explain how a microclimate is different from a climate.</td>
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<tr>
<td>o Compare and contrast temperature, humidity and wind speed at different microclimates.</td>
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<tr>
<td>o Assess what would happen to the local plants if abiotic factors forced a change in a microclimate.</td>
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**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried this lesson yet.

Author’s notes: Inquiry lesson because students are asked to predict the changes in microclimates based on what they learned in this lab and based on what they know about climates.

*Some information for this lesson was taken from:

(Fontaine et al, 2007)

Bottle Ecosystem Part 5: Ecological Succession

Name: Ms. Resanovich

Subject: Applied & General Biology

Grade: 10

Date Lesson is to be taught: September 25, 2007

Goal:
Importance of the lesson, relevance for students
Ecosystems are always changing. Change can occur because of an extreme change such as a natural or human-induced disaster. Other changes can occur gradually as the environment fluctuates. Students need to know this information because their environments are continually changing.

Materials: Text, worksheets, Internet resources, aquarium books, PowerPoint, science journals and books, community resources.

Expected Duration: 2, 90 minute class periods.

Objectives

Academic Standards:

Pennsylvania(Science & Tech and Environment & Ecology):
3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
- Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions
3.2.10.C.1 & 3: Apply the elements of scientific inquiry to solve problems
- Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
- Design an investigation with adequate control and limited variables to investigate a question.
4.6.10.A.4-7: Explain the biotic and abiotic components of an ecosystem and their interaction
- Describe how the availability of resources affects organisms in an ecosystem.
4.6.10.C.1-3: Analyze how ecosystems change over time.
- Identify and explain the succession stages in an ecosystem.
- Identify causes of succession.
- Analyze consequences of interrupting natural cycles.
National:
Unifying Concepts and Processes:
  o Systems, order and organization
Science as Inquiry:
  o Ability to do scientific inquiry
  o Understandings about scientific inquiry
Life Science:
  o Interdependence of organisms
  o Matter, energy and organization in living systems
  o Behavior of organisms
Science in Personal and Social Perspectives
  o Natural Resources
  o Environmental quality
  o Population growth

Assessment
  o Chapter 4 test.
  o Workbooks and Vocabulary/Assessment sections.
  o Bottle ecosystem & journal.
  o Writing prompt regarding the community’s succession.
  o Worksheets on succession.

Objectives are:
  _____x___ Cognitive          _____ Affective          _____ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
  o Identify the interactions that occur within communities.
  o Explain how biotic and abiotic factors influence an ecosystem.
  o Describe how ecosystems recover from a disturbance.

Lesson Development

Anticipatory Set
Students will be shown pictures using PowerPoint of before, during and after a volcano. Students will take note of the vegetation and life forms at that time.

Teaching Procedures/Instructional Process:
The teacher will start a brief discussion about succession within an environment. The teacher will ask students questions about succession in the local area.

Guided Practice/ Monitoring
Students will observe their ecosystems to see if they can find the pioneer species and evidence of secondary succession or marine succession. Students will collect the information and record it in their journals, as well as draw anything that is seen. Students will then be asked to start taking notes on what type of succession they believe has occurred in their area.

Closure
Is there evidence of gradual succession in your ecosystem or did an abrupt disturbance occur?

Independent Practice / HW
Students will be asked to question relatives that are older or even community members that have been around the area for a much longer amount of time. Students will ask about the changes in the area such as, “Have area that were formerly grassy been paved or developed? Have any farms, parks, or lots returned to their wild state?” Students will conduct almost a miniature interview and take notes. Using their notes students will compile the information into a writing prompt about ecological succession in the area.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.

**Content Notes and Questions for Students**

- What does succession mean?
- Explain what a pioneer species is.
- Compare and contrast environments such as the ecosystem and our own environment as they relate to succession.
- Assess what would happen to your ecosystem if natural disaster such as a volcano would occur.

**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried this lesson yet. Students will continue to observe their ecosystems throughout the next three months. Students will be asked to incorporate what the have learned each class period into the factors influencing their ecosystems. At the completion of the Bottle ecosystems, students will culminate their findings into their journals and hand the journals in for a grade. Students will also be graded on the survival of the species within their ecosystems.

Author’s notes: Inquiry lesson because students will be adding or manipulating species within their ecosystems until the last day of the 2 weeks. Students will be observing ecological succession over a long period after the system becomes closed.

*Some information for this lesson was taken from:


Malaria and the Sickle Cell Mutation

Name: Ms. Resanovich

Subject: Applied & General Biology

Grade: 10

Date Lesson is to be taught: November 2, 2007

Goal:
Importance of the lesson, relevance for students
Students will understand the causes for malaria (insect bites) and how they typically do not occur in our area, but can be deadly if you were to visit a wetland. Students will learn how human genes are affected by the environment.

Materials: Text, worksheets, Internet resources, PowerPoint, science journals and books.

Expected Duration: 2, 90 minute class periods.

Objectives

Academic Standards:

Pennsylvania(Science & Tech and Environment & Ecology):

3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
- Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions

3.2.10.C. 1 &3: Apply the elements of scientific inquiry to solve problems
- Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
- Design an investigation with adequate control and limited variables to investigate a question.

4.5.10..A. 1-3:Identify similar classifications of pests that may or may not have similar effects on different regions.
- Identify environmental effect(s) of pests on different regions of the world.
- Identify introduced species that are classified as pests in their new environments.

National:

Unifying Concepts and Processes:
- Systems, order and organization

Science as Inquiry:
- Ability to do scientific inquiry
o Understandings about scientific inquiry

Life Science:
- Molecular basis of heredity
- The cell
- Behavior of organisms

Science in Personal and Social Perspectives
- Personal and Community Health
- Environmental quality
- Population growth

Assessment
- Chapter 14 test.
- Workbooks and Vocabulary/Assessment sections.
- Malaria and Sickle Cell Anemia Pamphlet
- Chapter 14 worksheets.

Objectives are:
___x__ Cognitive         __x___ Affective          _____ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
- Describe examples of the inheritance of human traits.
- Explain how small changes in DNA cause genetic disorders.
- Identify recessive and dominant alleles.
- Describe why having a genetic disorder such as sickle cell anemia could be advantageous in an area where malaria is an endemic and why this is important to us.

Lesson Development

Anticipatory Set
How can your environment affect if you acquire a genetic disorder? Why is it that individuals living in African wetlands seem to be unaffected by malaria, which could be deadly to one of us. Why would sickle cell anemia be a good thing to have if you lived in a certain environment? What if our environment continued to change due to global warming or a natural disaster and we suddenly lived in a wetland? Would it be possible to contract malaria?

Teaching Procedures/Instructional Process:
The teacher reviews DNA and mutations. A PowerPoint lecture about malaria and sickle cell disease will follow. The teacher will hand out background information on a mutation story and show a short video about mutations. The teacher will briefly discuss probability equations so that students may participate fully in the activity.

Guided Practice/ Monitoring
Students will be posed a question, “What is the probability of getting sickle cell or of being a carrier?” “Will that probability increase based on your environment?” Students will then be given a Mutation Story and watch a video about sickle cell anemia. Students will determine a cost and benefit to having sickle cell anemia, how it develops and where or when it would be advantageous to have the disease based on the environmental conditions. Students will produce a pamphlet about the information they have learned
through the research and use of the Internet as well as print the possibilities for climate change in the future.

**Closure**

Why would it be beneficial to have the gene mutation for sickle cell anemia if you decided to take a trip to an African wetland? What would happen if our environment suddenly changed to a wetland and mosquitoes with malaria infested our ecosystem? Would the human species adapt by passing on the genes for sickle cell anemia?

**Independent Practice / HW**

Students will finish their pamphlets for homework.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.

**Content Notes and Questions for Students**

- List the factors that influence a gene mutation.
- Explain how sickle cell anemia is advantageous in areas where malaria exists.
- Compare and contrast the costs and benefits of having sickle cell anemia.
- Assess what would happen if our environment changed into a wetland where malaria became an endemic.

**Professional Development**

**Reflections after Teaching the Lesson:**

I have not tried this lesson yet. Author’s note: Inquiry lesson because students are finding where, when and how sickle cell anemia is advantageous. Students will not be performing any physical tests, but Internet research, probability and gene maps will give them valid information to see the results.

*Some information for this lesson was taken from:

(Sexton & Mason, 2007)

Nematodes as Pesticides

Name: Ms. Resanovich

Subject: Applied & General Biology

Grade: 10

Date Lesson is to be taught: December 18, 2007

Goal:
Importance of the lesson, relevance for students
Nematodes (roundworms) are among the most numerous worms on the planet. Roundworms can live anywhere, a rotting apple, garden soil, or even as parasites in the human intestine. It is important to learn about the different types of roundworm and their effects on humans. One effect is the roundworms that can be used as pesticides. These worms are parasites for the typical crop pests that we try to get rid of with harsh chemicals. The use of these organisms may help environmentalists and agriculture by protecting the environment while continuing the success of crops.

Materials: Items per group of 3-4 students: 1,000 nematodes H. bacteriophora in 1 mL of water, 1,000 nematodes S. carpocapsae in 1 mL of water, 3 1.7 mL microcentrifuge tubes, 25-30 grub worms Galleria mellonella, 6-10 medium Petri dish containers with lids, 3-4 plastic pipettes, 6-10 pieces of white filter paper, 1-2 mL of clean tap water.

Expected Duration: 5, 90 minute class periods.

Objectives

Academic Standards: Local Pennsylvania National

Pennsylvania(Science & Tech and Environment & Ecology):

3.2.10.B.2: Apply process knowledge and organize scientific and technological phenomena in varied ways.
- Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions

3.2.10.C.1 & 3: Apply the elements of scientific inquiry to solve problems
- Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
- Design an investigation with adequate control and limited variables to investigate a question.

3.3.10.A.1: Explain the structural and functional similarities and differences found among living things.
- Identify and characterize major life forms according to their placement in existing classification groups.

4.7.10.A.1-3: Explain the significance of diversity in ecosystems.
• Explain the role that specific organisms have in their ecosystem.
• Identify a species and explain what effects its increase or decline might have on the ecosystem.
• Identify a species and explain how its adaptations are related to its niche in the environment.

National:
Unifying Concepts and Processes:
  o Systems, order and organization
Science as Inquiry:
  o Ability to do scientific inquiry
  o Understandings about scientific inquiry
Life Science:
  o Interdependence of organisms
  o Matter, energy and organization in living systems
  o Behavior of organisms
Science in Personal and Social Perspectives
  o Natural Resources
  o Environmental quality
  o Population growth

Assessment
  o Chapter 27 test.
  o Workbooks and Vocabulary/Assessment sections.
  o Nematode lab presentation & notebook
  o Chapter 27 worksheets

Objectives are:
  ___x__ Cognitive  ___x___ Affective  ___x__ Psychomotor

Student Objectives: (related to assessment)
As a result of this lesson, the students will be able to:
  o Describe the defining features of roundworms.
  o Describe form and function in roundworms.
  o Identify roundworms that are important in human disease and as pesticides.
  o Understand and explain what importance these roundworms have for humans.
  o Test hypotheses about nematodes as pesticides by controlling laboratory experiments.

Lesson Development

Anticipatory Set
What if I told you we can use organisms as pesticides rather than spraying harsh chemicals on crops and hurting the environment? What type of organisms do you think would best fit the job description as a parasite that kills other parasites?

Teaching Procedures/Instructional Process:
Teacher will conduct a lecture on the properties and variations of nematodes as well as their insecticidal nature. The teacher briefly reviews lab safety procedures and then breaks the students into groups of 3 or 4 while passing out lab materials. The teacher
provides the students with some basic questions to get them started as well as some information on the species they will be working with.

**Guided Practice/ Monitoring**

Students must design their own experiment to test the insecticidal properties of two species of nematodes. Students are provided an information sheet about the 3 species of organisms used in the experiment and asked to formulate their own predictions and hypotheses. Students are required to record their experiments into a lab notebook. An example student generated lab experiment could be: Students are testing the affects of environmental conditions on the effectiveness of the nematodes’ parasitism on the grub worms and so they set up Petri dishes with varying conditions such as light, moisture level, and presence or absence of soil. Students were to record their findings over the next 2 class periods into their lab notebooks. Once the students recorded their findings, they were to present their findings to the class in the form of a PowerPoint presentation.

**Closure**

What observation have you already made concerning a food web within your ecosystem? Can you show which organisms are the producers, the consumers and the secondary consumers? Is there a tertiary consumer in your ecosystem? Why or why not?

**Independent Practice / HW**

Chapter 27 worksheets will be completed for homework.

**Differentiated Instruction**

- Adapted reading workbook.
- Test modifications.
- By making the groups varying in abilities, the less proficient learners will have the chance to work with students who grasp the concepts more quickly.

**Content Notes and Questions for Students**

- Which nematode is the more effective insecticide?
- Which environment (wet, dry, light or dark) is the best for effective parasitism?
- How many nematodes are needed to effectively parasitize the insects?
- Assess what would happen if we implemented the use of these roundworms onto farms instead of using pesticides.

**Professional Development**

I have not tried this lesson yet.

Author’s notes: Inquiry lesson because students are designing their own experiment to test the best conditions and which species of nematodes have the most affect on pests. Students will develop a plan of action for using these worms on crops instead of chemical pesticides.

*Some information for this lesson was taken from:

(Bliss et al, 2007)

APPENDIX B

Activities and Worksheets
Chapter 8 Photosynthesis Lab

Investigating Photosynthesis
If only part of a leaf receives light, does the whole leaf perform photosynthesis? What if a leaf receives only light of one color? You are going to design an experiment to test the effects of different substances in the environment on photosynthesis.

Problem
How do different colors of light, no light and minimal or a good amount of light, affect starch synthesis during photosynthesis?

Materials
- scissors
- black construction paper
- potted plant
- tape
- blue, red, and green cellophane
- vaseline
- nail polish
- wax paper
- aluminum foil
- plastic wrap
- 5 large test tubes
- glass-marking pencil
- forceps
- 400-mL beaker
- 5 petri dishes
- iodine solution
- paper towels

Information for this laboratory activity was taken from the copyrighted resources listed below. For a description of the lab activity and to view any of the omitted information please visit www.pearsonsuccessnet.com

Have a Nice Day!

(Llewellyn, 2005) and (Miller & Levine, 2008)
Chapter 8 Photosynthesis Vocabulary Review

Directions: On the lines provided, write a definition of each term.

1. ATP _________________________________________________________________
   ________________________________________________________________________
2. thylakoid _____________________________________________________________
   ________________________________________________________________________
3. NADP+ ______________________________________________________________
   ________________________________________________________________________
4. ATP Synthase __________________________________________________________
   ________________________________________________________________________
5. Calvin cycle ___________________________________________________________
   ________________________________________________________________________

Directions: On the lines provided, answer the following questions.

1. In which part of photosynthesis is glucose produced?
   ________________________________________________________________________

2. In which part of photosynthesis is oxygen produced?
   ________________________________________________________________________

3. What is the relationship between pigments and chlorophyll?
   ________________________________________________________________________

4. How do the light-dependent reactions differ from the Calvin Cycle?
   ________________________________________________________________________

5. What compounds are formed from carbon dioxide during the Calvin Cycle?
   ________________________________________________________________________

Directions: Match each term with its description below. Write the letter of the correct term on the line provided.
A. chlorophyll
B. stroma
C. pigment
D. photosynthesis
E. light-dependant reactions

1. molecule that absorbs light
2. produce oxygen gas and convert ADP to ATP
3. the region outside the thylakoid membranes
4. principal pigment found in plants
5. process by which autotrophs use sunlight to make high-energy sugars

Directions: Label the diagram by filling in the empty spaces using the words provided: H₂O, light, chloroplast, O₂, sugar, CO₂, Calvin Cycle, ATP, and NADPH.

The labeled photograph and a few other omitted questions were taken from the copyrighted resource listed below. For a full description, you may also visit www.pearsonsuccessnet.com

(Miller & Levine, 2008)
Hello! Your class has been selected to participate in a secret program for NASA named the Mars Biosphere Program. Our government is trying to find ways to establish a colony on Mars. Your mission is to design a biosphere that will allow a group of ten astronauts to survive on the planet Mars for eighteen months. You will begin by gathering team members to form a “think tank.” Your think tank needs to decide what is necessary to sustain life on the planet Mars. Your ideas will help make the Mars Biosphere Program a success. Your designs can be presented as a poster or as a PowerPoint presentation.

During this project, you will be guided by your biology teacher, Ms. Resanovich. Good luck, and remember, the success of this program depends upon you!

(Llewellyn, 2005)
Characteristics of Life

For information regarding your Mars Biosphere design, please use your text, journals and books in the classroom and the Internet. Here is a list of Internet resources to get you started:

http://mars.jpl.nasa.gov/classroom/teachers.html

http://mars.jpl.nasa.gov/odyssey/

http://mars.jpl.nasa.gov/odyssey/index.html


Good luck!

(Llewellyn, 2005)
### Journal Rubric

**Student Name ____________________  Period _____**

**FIRST SHEET IN JOURNAL**

<table>
<thead>
<tr>
<th>Possible points</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 to 0</strong></td>
<td>Topics are in chronological order from ______ to ______.</td>
</tr>
<tr>
<td></td>
<td>• 5-----All topics are in chronological order (100%)</td>
</tr>
<tr>
<td></td>
<td>• 4-----Almost all topics are in chronological order (only 1 or 2 out of order)</td>
</tr>
<tr>
<td></td>
<td>• 3-----Some topics are in chronological order (only 3 or 5 out of order)</td>
</tr>
<tr>
<td></td>
<td>• 0  More than 6 topics are not in chronological order</td>
</tr>
<tr>
<td><strong>5 to 0</strong></td>
<td>Completed journal is in a 2” 3-ringed binder and worksheets are placed in the back of the notebook (in order given) List of worksheets will be provided</td>
</tr>
<tr>
<td></td>
<td>• 5-----All separate worksheets are included and journal is correctly formatted</td>
</tr>
<tr>
<td></td>
<td>• 4-----Most separate worksheets are included and journal is correctly formatted</td>
</tr>
<tr>
<td></td>
<td>• 3-----Some separate worksheets are included and journal is correctly formatted</td>
</tr>
<tr>
<td></td>
<td>• 0  Less than 2 separate worksheets are presented/ is not correctly formatted.</td>
</tr>
<tr>
<td><strong>5 to 0</strong></td>
<td>Journal contains drawings and diagrams of each observation.</td>
</tr>
<tr>
<td></td>
<td>• 5-----All drawings and diagrams are visible and neat.</td>
</tr>
<tr>
<td></td>
<td>• 4-----All but one drawing or diagram is visible and neat.</td>
</tr>
<tr>
<td></td>
<td>• 3-----All but two drawings of diagrams are visible and neat.</td>
</tr>
<tr>
<td></td>
<td>• 0  More than three drawings or diagrams are missing and it is not neat.</td>
</tr>
<tr>
<td><strong>5 to 0</strong></td>
<td>List three examples of strengths and three examples of weaknesses in your journal. Place the list behind this sheet in your journal.</td>
</tr>
<tr>
<td></td>
<td>• 5-----All six examples are well thought-out and explained</td>
</tr>
<tr>
<td></td>
<td>• 4-----All six examples are explained</td>
</tr>
<tr>
<td></td>
<td>• 3-----Three to five examples are provided</td>
</tr>
<tr>
<td></td>
<td>• 0  No examples are provided</td>
</tr>
<tr>
<td><strong>10 to 0</strong></td>
<td>Accurately completed the charts and spreadsheets of data.</td>
</tr>
<tr>
<td></td>
<td>• 10 ---All spreadsheets of data are complete and accurate</td>
</tr>
<tr>
<td></td>
<td>• 8  ---90% of the spreadsheets or charts are complete and accurate</td>
</tr>
<tr>
<td></td>
<td>• 5  ----Sheets are between 70%- 90% completed and accurate</td>
</tr>
<tr>
<td></td>
<td>• 2  ----Sheets are between 40%- 69% completed and accurate</td>
</tr>
<tr>
<td></td>
<td>• 0  ----No sheets are included</td>
</tr>
<tr>
<td><strong>10 to 0</strong></td>
<td>Worksheets are included and are clearly visible - class notes and homework follow worksheets</td>
</tr>
<tr>
<td></td>
<td>• 10--- All worksheets are included, clearly visible with notes &amp; HW following</td>
</tr>
<tr>
<td></td>
<td>• 8  --- All but one worksheets are included, clearly visible with notes &amp; HW</td>
</tr>
<tr>
<td></td>
<td>• 5  --- All worksheets are included, with notes &amp; HW in a different section</td>
</tr>
<tr>
<td></td>
<td>• 2  ---- Some worksheets are included, clearly visible with notes &amp; HW following</td>
</tr>
<tr>
<td></td>
<td>• 0  ---- Less than 10 worksheets are included</td>
</tr>
<tr>
<td><strong>10 to 0</strong></td>
<td>Notes in the journal are complete and clearly written (easy to read).</td>
</tr>
<tr>
<td></td>
<td>• 10--- All notes are clear and easy to read</td>
</tr>
<tr>
<td></td>
<td>• 8  --- All but two pages of notes are complete and clear</td>
</tr>
<tr>
<td></td>
<td>• 5  --- All but four to five pages of notes are complete and clear</td>
</tr>
<tr>
<td></td>
<td>• 3  ---- All but six to eight pages of notes are complete and clear</td>
</tr>
<tr>
<td></td>
<td>• 0  ---- More than 10 pages of notes are not completed and writing is not clear</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Point possible</th>
<th>Total points</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 1 Review Worksheet

Directions: On the lines provided, answer the following questions.

1. What is science?
   _______________________________________________________________________

2. What is the relationship between observation and gathering data?
   _______________________________________________________________________

3. What is a theory?
   _______________________________________________________________________

Directions: On the lines provided, list eight characteristics that classify a mushroom as a living thing.

21. __________________________  25. __________________________
22. __________________________  26. __________________________
23. __________________________  27. __________________________
24. __________________________  28. __________________________

Directions: The following table describes the different systems, or levels, at which life can be studied. On the lines provided, fill in the missing descriptions.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biosphere</td>
<td>The part of Earth that contains all ecosystems</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>29. _____________________________________________________________________</td>
</tr>
<tr>
<td>Community</td>
<td>30. _____________________________________________________________________</td>
</tr>
<tr>
<td>Population</td>
<td>31. _____________________________________________________________________</td>
</tr>
<tr>
<td>Organism</td>
<td>Individual living thing</td>
</tr>
<tr>
<td>Groups of cells</td>
<td>32. _____________________________________________________________________</td>
</tr>
<tr>
<td>Cells</td>
<td>33. _____________________________________________________________________</td>
</tr>
<tr>
<td>Molecules</td>
<td>Groups of atoms; smallest unit of most chemical compounds</td>
</tr>
</tbody>
</table>

For any of the omitted questions from the copyrighted worksheet please visit www.pearsonsuccessnet.com (Miller & Levine, 2008)
Chapter 3 Review Worksheet

Directions: On the lines provided, write the letter of the term on the right that best matches each description.

1. __________ groups of individuals that belong to the same species and live together
   a. population
   b. biosphere

2. __________ different populations that live in a defined area
   a. population
   b. biosphere
   c. ecosystem
   d. biome
   e. community

3. __________ all organisms in an area, including the non-living parts of their environment
   a. producer
   b. herbivore
   c. ecosystem
   d. biome
   e. community

4. __________ a geographical region containing several ecosystems with the same climate and communities
   a. producer
   b. herbivore
   c. ecosystem
   d. biome
   e. community

5. __________ the combined portions of the planet in which all life exists
   a. producer
   b. herbivore
   c. ecosystem
   d. biome
   e. community

Directions:
On the lines provided, write the letter of the phrase or term that best answers each question.

25. ________ Which of the following types of organisms obtain energy by eating only plants?
   a. producers
   b. herbivores
   c. omnivores
   d. carnivores

26. ________ Which of the following types of heterotrophs eat other animals?
   a. omnivores and carnivores
   b. herbivores and omnivores
   c. carnivores only
   d. carnivores and herbivores

27. ________ What are organisms that feed on plant and animal remains and other dead matter called?
   a. decomposers
   b. omnivores
   c. detritivores
   d. herbivores

28. ________ What links all the food chains in an ecosystem together?
   a. trophic levels
   b. an energy pyramid
   c. a food web
   d. a biomass pyramid

29. ________ What pyramid represents the amount of energy or matter that exists in each level of a food web?
   a. a food pyramid
   b. an energy pyramid
   c. an ecosystem pyramid
   d. a biomass pyramid
b. an ecological pyramid  
d. a food web pyramid

To observe cycle diagrams and food webs as well as a long list of questions for this worksheet, please visit the copyrighted resource below, or [www.pearsonsuccessnet.com](http://www.pearsonsuccessnet.com).

(Miller & Levine, 2008)
Chapter 4 Review Worksheet

Directions: On the lines provided, answer the following questions.

1. Name and describe the two factors that determine the survival and growth of organisms in an ecosystem.

________________________________________________________________________

________________________________________________________________________

3. In which type of community relationship does one member of the association benefit while the other is neither helped nor harmed? Give an example.

________________________________________________________________________

5. Describe the process of succession in an ecosystem.

________________________________________________________________________

6. How is a niche related to abiotic and biotic factors?

________________________________________________________________________

________________________________________________________________________

7. Compare the three types of symbiosis—mutualism, commensalism, and parasitism—in terms of the relationships that exist within each type.

________________________________________________________________________

________________________________________________________________________

10. In the past century, the concentration of carbon dioxide in the atmosphere has been increasing steadily. Describe an effect this might have on Earth’s climate.

________________________________________________________________________

________________________________________________________________________

To view a concept map and questions from this copyrighted source please visit www.pearsonsuccessnet.com. (Miller & Levine, 2008)
Microclimate Discussion Questions

To view the omitted questions from this page, please visit the copyrighted source listed below.

(Fontain et al, 2007)
Microclimate Datasheet

Directions: Please fill in the datasheet below using the appropriate columns for each measurement you make during the excursion onto the school grounds. Please make sure to enter your data onto the class’s compiled list of data when finished. The first line is an example for you to go by.

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Plant type</th>
<th>Temperature (°C)</th>
<th>Humidity (%)</th>
<th>Wind speed (km/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example #1</td>
<td>Coniferous tree</td>
<td>7</td>
<td>22</td>
<td>5</td>
</tr>
</tbody>
</table>

(Fontain et al, 2007)
Food Web

1. Design a food web based on a specific biome. Your biome will be chosen randomly by pulling a paper from a basket.
   a. The food web must contain at least five food chains consisting of a producer, a primary consumer, and a secondary consumer.
   b. Each consumer must be labeled as an herbivore, carnivore, omnivore, or decomposer.
   c. At least one predator-prey relationship must be shown.
   d. Five abiotic factors must be included and labeled.

2. Posters may be drawn free-hand, or you may cut and paste pictures from magazines or computer printouts.

Good luck & Enjoy!
A Mutation Story:

A gene known as HbS was the center of a medical and evolutionary detective story that began in the middle 1940s in Africa. Doctors noticed that patients who had sickle cell anemia, a serious hereditary blood disease, were more likely to survive malaria, a disease which kills some 1.2 million people every year. What was puzzling was why sickle cell anemia was so prevalent in some African populations.

How could a "bad" gene -- the mutation that causes the sometimes lethal sickle cell disease -- also be beneficial? On the other hand, if it didn't provide some survival advantage, why had the sickle gene persisted in such a high frequency in the populations that had it?

The sickle cell mutation is a like a typographical error in the DNA code of the gene that tells the body how to make a form of hemoglobin (Hb), the oxygen-carrying molecule in our blood. Every person has two copies of the hemoglobin gene. Usually, both genes make a normal hemoglobin protein. When someone inherits two mutant copies of the hemoglobin gene, the abnormal form of the hemoglobin protein causes the red blood cells to lose oxygen and warp into a sickle shape during periods of high activity. These sickled cells become stuck in small blood vessels, causing a "crisis" of pain, fever, swelling, and tissue damage that can lead to death. This is sickle cell anemia.

But it takes two copies of the mutant gene, one from each parent, to give someone the full-blown disease. Many people have just one copy, the other being normal. Those who carry the sickle cell trait do not suffer nearly as severely from the disease.

Researchers found that the sickle cell gene is especially prevalent in areas of Africa hard-hit by malaria. In some regions, as much as 40 percent of the population carries at least one HbS gene.

It turns out that, in these areas, HbS carriers have been naturally selected, because the trait confers some resistance to malaria. Their red blood cells, containing some abnormal hemoglobin, tend to sickle when they are infected by the malaria parasite. Those infected cells flow through the spleen, which culls them out because of their sickle shape -- and the parasite is eliminated along with them.

Scientists believe the sickle cell gene appeared and disappeared in the population several times, but became permanently established after a particularly vicious form of malaria jumped from animals to humans in Asia, the Middle East, and Africa.

In areas where the sickle cell gene is common, the immunity conferred has become a selective advantage. Unfortunately, it is also a disadvantage because the chances of being born with sickle cell anemia are relatively high.
For parents who each carry the sickle cell trait, the chance that their child will also have the trait -- and be immune to malaria -- is 50 percent. There is a 25 percent chance that the child will have neither sickle cell anemia nor the trait which enables immunity to malaria. Finally, the chances that their child will have two copies of the gene, and therefore sickle cell anemia, is also 25 percent. This situation is a stark example of genetic compromise, or an evolutionary "trade-off."

(Sexton & Mason, Retrieved November, 2007)
Sickle Cell Probability

1) In this case, both parents are carriers of the sickle cell trait. They each have one normal copy of the gene (the smiley face), and one abnormal copy (the lightning bolt). What does this mean for their children?

<table>
<thead>
<tr>
<th>Parent 1</th>
<th>Parent 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>🌞      </td>
<td>🌞      </td>
</tr>
<tr>
<td>⚡      </td>
<td>⚡      </td>
</tr>
</tbody>
</table>

**Kid**
???

2.) If the kid receives either the smiley face (a normal gene) or the lightning bolt (the sickle cell gene) from each parent, how many combinations are possible? Draw them below, and label whether the kid is unaffected, a carrier, or has sickle cell anemia in each drawing.

3.) How many combinations did you draw? ______

4.) In how many is the kid unaffected? ______

5.) In how many is the kid a carrier? ______

6.) In how many does the kid have sickle cell anemia? ______

7.) In this case, one parent has sickle cell anemia and the other is unaffected. What does this mean for their children?

<table>
<thead>
<tr>
<th>Parent 1</th>
<th>Parent 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>🌞      </td>
<td>⚡      </td>
</tr>
</tbody>
</table>

Name: _____________________________ Class: __________ Date: _____________
8.) If the kid gets one of the two possibilities from each parent, how many combinations are possible? Draw them below.

9.) How many combinations did you draw? ____

10.) In how many is the kid unaffected? ____

11.) In how many is the kid a carrier? ____

12.) In how many does the kid have sickle cell anemia? ____

13.) In this case, one parent is a carrier of sickle cell anemia and the other parent is unaffected. What does this mean for the children?

Parent 1

Parent 2

14.) If the kid gets one of the two possibilities from each parent, how many combinations are possible? Draw them below.
15.) How many combinations did you draw? _____
16.) In how many is the kid unaffected? _____
17.) In how many is the kid a carrier? _____
18.) In how many does the kid have sickle cell anemia? _____

(Sexton & Mason, Retrieved November, 2007)
Chapter 14 The Human Genome worksheets and study guides. In order to view this copyrighted content you will need to visit the resource listed below.

(Miller & Levine, 2008)
Necessary information for this experiment

Insecticidal nematodes are aquatic organisms & should always be stored and applied in water.

One nematode can infect and kill a single grub worm, but to be sure it is best to use 35-50 per grub worm.

Nematodes should always be applied directly to the filter paper in each Petri dish using a plastic pipette.

White filter paper has the same characteristics of soil because it can retain water.

When the nematodes are applied to the grub worm container, the grub worms will usually die within 24-48 hours.

Grub worms killed by *H. bacteriophora* will look brick red (because they have a red pigment), while those killed by *S. carpocapsae* will look gray (because they do not produce the red pigment).

4-5 Grub worms will comfortably fit into your containers.

(Bliss et al, 2007)
Chapter 27 Worms and Mollusks worksheets. In order to view this copyrighted worksheet please visit the resource below.

(Miller & Levine, 2008)
APPENDIX C

Assessment
Chapter 1 Test

Multiple Choice

Identify the choice that best completes the statement or answers the question.

1. Which of the following is NOT a goal of science?
   a. to investigate and understand the natural world
   b. to explain events in the natural world
   c. to use data to support a particular point of view
   d. to use derived explanations to make useful predictions

2. The work of scientists usually begins with
   a. testing a hypothesis.
   b. careful observations.
   c. creating experiments.
   d. drawing conclusions.

3. Science differs from other disciplines, such as history and the arts, because science relies on
   a. facts.
   b. testing explanations.
   c. observations.
   d. theories.

4. Information gathered from observing a plant grow 3 cm over a two-week period results in
   a. inferences.
   b. variables.
   c. hypotheses.
   d. data.

5. You suggest that the presence of water could accelerate the growth of bread mold. This is a
   a. conclusion.
   b. hypothesis.
   c. experiment.
   d. analysis.

6. A hypothesis
   a. can be completely proven.
   b. may be disproved by a single experiment.
   c. does not have to be tested to be accepted as probably correct.
   d. is a proven fact.

7. Which of the following is a valid hypothesis for why a plant appears to be dying?
   a. The plant is not being watered enough.
   b. The plant is being watered too much.
   c. The plant is receiving too much sunlight.
   d. all of the above
8.A student suggests that a certain species of bacteria grows better in the light than in the dark. The student has 10 culture plates on which to grow the bacteria. Which of the following would be the best experiment to test this idea?

a. Grow 10 plates in the dark.
b. Grow 10 plates in the light.
c. Grow 5 plates in the dark and 5 plates in the light.
d. Grow 10 plates in the light, with extra water.

9. A controlled experiment allows the scientist to isolate and test

a. a conclusion.   c. several variables.
b. a mass of information.   d. a single variable.

10. Scientists publish the details of important experiments so that

a. their work can be repeated.
b. their experimental procedures can be reviewed.
c. others can try to reproduce the results.
d. all of the above

11. A theory

a. is always true.
b. is the opening statement of an experiment.
c. may be revised or replaced.
d. is a problem to be solved.

12. Biology is the study of

a. the land, water, and air on Earth.   c. animals and plants only.
b. the living world.   d. the environment.

13. Which of the following is NOT a characteristic of all living things?

a. growth and development   c. response to the environment
b. ability to move   d. ability to reproduce

14. Which of the following characteristics of living things best explains why birds fly south for the winter?

a. Living things respond to their environment.
b. Living things maintain internal balance.
c. Living things are made up of units called cells.
d. Living things are based on a universal genetic code.

15. The amount of light and temperature are examples of

a. factors necessary for life.   c. factors to which living things respond.
b. methods of energy production.   d. factors that affect reproduction.

16. The process by which organisms keep their internal conditions fairly constant is called
a. homeostasis.  c. metabolism.
b. evolution.  d. photosynthesis.

17. Which of the following levels of organization includes all of the living things on Earth?
a. population  c. biosphere
b. community  d. environment

18. What is the term for a group of organisms of one type living in the same place?
a. biosphere  c. population
b. ecosystem  d. environment

19. Which level of organization includes all of the other levels?
a. organism  c. population
b. ecosystem  d. community

20. In the metric system, the basic unit of length is the
a. gram.   c. yard.
b. liter.   d. meter.

21. The basic unit of mass in SI is the
a. meter.   c. liter.
b. ounce.   d. gram.

22. To observe a small, living organism, a scientist might use a(an)
a. electronic balance.  c. compound light microscope.
b. TEM.  d. electron microscope.

23. An instrument that allows light to pass through the specimen and uses two lenses to form an image is a(an)
a. compound light microscope.  c. TEM.
b. electron microscope.  d. SEM.

**Completion**
*Complete each statement.*

29. During an experiment, measuring the height of a plant in centimeters would be an example of collecting ________________ data.

30. The information you gather during an experiment is called your ________________.
31. In science, a theory is a well-tested explanation that unifies a broad range of
__________________________________.

32. The ____________________ microscope is generally used in high-school laboratories.

**Short Answer**

33. What is a hypothesis?

34. What is the difference between a theory and a hypothesis?

35. Which characteristic of living things is important to the survival of a group of animals rather
than an individual member of this group? Why?

36. What are five of the levels of organization that biologists study?

Interpreting Graphics, Modified True and False, and Essays (all of which have been omitted)
were taken from the Test Generator software, which came with the copyrighted resource below.

(Miller & Levine, 2008)
Chapter 3 Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.

_____ 1. The branch of biology dealing with interactions among organisms and between organisms and their environment is called
   a. economy.  c. recycling.  
   b. modeling.  d. ecology.  

_____ 2. The combined portions of Earth in which all living things exist is called the
   a. biome.  c. ecosystem.  
   b. community.  d. biosphere.  

_____ 3. All of the members of a particular species that live in one area are called a(an)
   a. biome.  c. community.  
   b. population.  d. ecosystem.  

_____ 4. Which of the following descriptions about the organization of an ecosystem is correct?
   a. Communities make up species, which make up populations.  
   b. Populations make up species, which make up communities.  
   c. Species make up communities, which make up populations.  
   d. Species make up populations, which make up communities.  

_____ 5. The simplest grouping of more than one kind of organism in the biosphere is
   a. a population.  c. an ecosystem.  
   b. a community.  d. a species.  

_____ 6. The lowest level of environmental complexity that includes living and nonliving factors is the
   a. biome.  c. ecosystem.  
   b. community.  d. biosphere.  

_____ 7. Plants are
   a. producers.  c. herbivores.  
   b. consumers.  d. omnivores.  

8. What is the original source of almost all the energy in most ecosystems?
   a. carbohydrates  c. water
   b. sunlight        d. carbon

9. An organism that uses energy to produce its own food supply from inorganic compounds is called a(an)
   a. heterotroph.   c. detritivore.
   b. consumer.     d. autotroph.

10. Which of the following organisms does NOT require sunlight to live?
    a. chemosynthetic bacteria  c. trees
    b. algae                  d. photosynthetic bacteria

11. All the interconnected feeding relationships in an ecosystem make up a food
    a. interaction.   c. network.
    b. chain.         d. web.

12. The total amount of living tissue within a given trophic level is called the
    a. organic mass.   c. energy mass.
    b. trophic mass.   d. biomass.

13. What is an ecological model of the relationships that form a network of complex interactions among organisms in a community from producers to decomposers?
    a. food web       c. food chain
    b. an ecosystem   d. a population

14. What animals eat both producers and consumers?
    a. herbivores     c. chemotrophs
    b. omnivores      d. autotrophs

15. What is the term for each step in the transfer of energy and matter within a food web?
    a. energy path    c. trophic level
    b. food chain     d. food pyramid

16. A bird stalks, kills, and then eats an insect. Based on its behavior, which ecological terms describe the bird?
    a. herbivore, decomposer  c. carnivore, consumer
    b. producer, heterotroph   d. autotroph, herbivore
17. A snake that eats a frog that has eaten an insect that fed on a plant is a
a. first-level producer.   c. second-level producer.
b. first-level consumer.   d. third-level consumer.

18. Only 10 percent of the energy stored in an organism can be passed on to the next
trophic level. Of the remaining energy, some is used for the organism’s life processes, and the
rest is
a. used in reproduction.   c. stored as fat.
b. stored as body tissue.   d. eliminated as heat.

19. Most of the energy available to a consumer trophic level is used by organisms for
a. transfer to the next trophic level.
b. respiration, movement, and reproduction.
c. producing inorganic chemical compounds.
d. performing photosynthesis.

20. Which type of pyramid shows the amount of living tissue at each trophic level in an
ecosystem?
a. a numbers pyramid   c. a biomass pyramid
b. an energy pyramid   d. a food pyramid

21. Matter can recycle through the biosphere because
a. matter is passed out of the body as waste.
b. matter is assembled into chemical compounds.
c. biological systems do not use up matter, they transform it.
d. biological systems use only carbon, oxygen, hydrogen, and nitrogen.

22. The repeated movement of water between Earth’s surface and the atmosphere is called
a. the water cycle.   c. precipitation.
b. the condensation cycle.   d. evaporation.

23. Which of the following is NOT recycled in the biosphere?
a. water   c. carbon
b. nitrogen   d. energy

22. What is the process by which bacteria convert nitrogen gas in the air to ammonia?
a. nitrogen fixation   c. decomposition
b. excretion   d. denitrification

23. Carbon cycles through the biosphere in all of the following processes EXCEPT
a. photosynthesis.   c. burning of fossil fuels.
24. How is carbon stored in the biosphere?
   a. in the atmosphere as carbon dioxide
   b. underground as fossil fuels and calcium carbonate rock
   c. in the oceans as dissolved carbon dioxide
   d. all of the above

25. Nitrogen fixation is carried out primarily by
   a. humans.  c. bacteria.
   b. plants.  d. consumers.

26. Which of the following has a direct role in the nitrogen cycle?
   a. bacteria  c. decomposers
   b. legumes  d. all of the above

27. Organisms need nutrients in order to
   a. utilize hydrogen and oxygen.  c. recycle chemical compounds.
   b. carry out essential life functions.  d. carry out nitrogen fixation.

28. The movements of energy and nutrients through living systems are different because
   a. energy flows in one direction and nutrients recycle.
   b. energy is limited in the biosphere and nutrients are always available.
   c. nutrients flow in one direction and energy recycles.
   d. energy forms chemical compounds and nutrients are lost as heat.

29. Biogeochemical cycling ensures that
   a. human activity will have no effect on elements, chemical compounds, and other forms of
      matter.
   b. living organisms will not become limited in any one nutrient.
   c. nutrients will be circulated throughout the biosphere.
   d. many nutrients will not reach toxic concentrations in the biosphere.

Essay

49. Describe the biological significance of the carbon cycle. Where is carbon found in the
    biosphere?

Modified True/False, Completion, Using Science Skills with Graphics and Short Answer
questions have all been omitted from this exam. In order to view these items you can use the Test
Generator software that comes with the copyrighted source below.

(Miller & Levine, 2008)
Microclimate Vocabulary Quiz

Directions: Please define each of the words listed and then explain their relevance to the Microclimate lab we just conducted.

1. Weather:

2. Climate:

3. Microclimate:

4. Temperature:

5. Relative humidity:

6. Biodiversity:

7. Generalist:

8. Specialist:

9. Biotic:

10. Abiotic:

(Fontaine, 2007)
Chapter 4 Test

Completion
Complete each statement.

27. Regrowth of grasses, ferns, wildflowers, and saplings after a forest fire is an example of ______________ succession.

28. Atmospheric gases that trap heat inside Earth’s atmosphere are called _______________ gases.

29. Organisms within an ecosystem are _______________ factors in that ecosystem.

30. Over time, some plants growing in an area are crowded out by other plants. The new plants use up water and nutrients needed by the previous plants. The disappearance of the first plants is due to _________________.

31. An abiotic factor that is used to determine climate but not to categorize aquatic ecosystems is _________________.

Short Answer

32. What are greenhouse gases?

33. Explain why the food that a bullfrog eats is considered a part of its niche.
34. List three biotic and three abiotic factors that determine the survival of a rabbit in a temperate forest.

35. How is mutualism similar to and different from commensalisms?

36. Describe an important role that pioneer species play in primary succession.

Essay

42. Name and define the three main classes of symbiotic relationships. Give examples of each.

43. Describe the stages of primary succession in land environments, mentioning the role played by grasses, lichens, trees, mosses, and shrubs.

Multiple choice, Modified True/False and Using Science Skills Graphics were omitted from this exam. In order to view this copyrighted information, please visit the source below using the Test Generator software.

(Miller & Levine, 2008)
Chapter 8 Test

Completion

Complete each statement.

35. Photosynthesis uses the energy of sunlight to convert water and carbon dioxide into oxygen and _________.
36. Thylakoids are arranged in stacks known as _________________.

Short Answer

39. Explain how heterotrophs get their energy from the sun even though they cannot make their own food.

40. A student exposed two plants to only red light and two plants to only green light. Which plants should grow better? Why?

Multiple Choice, Modified True/False, and Using Science Skills Graphics questions have been omitted for copyright purposes. To view this information, you must use the Test Generator Software which comes with the source below.

(Miller & Levine, 2008)
Chapter 14 The Human Genome Test has been omitted for copyright purposes. To view this information you must use the software that accompanies the source below.

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Chapter 27 Worms and Mollusks Test has been omitted for copyright purposes. To view this information you must use the software that accompanies the source below.

(Miller & Levine, 2008)
REFERENCES


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