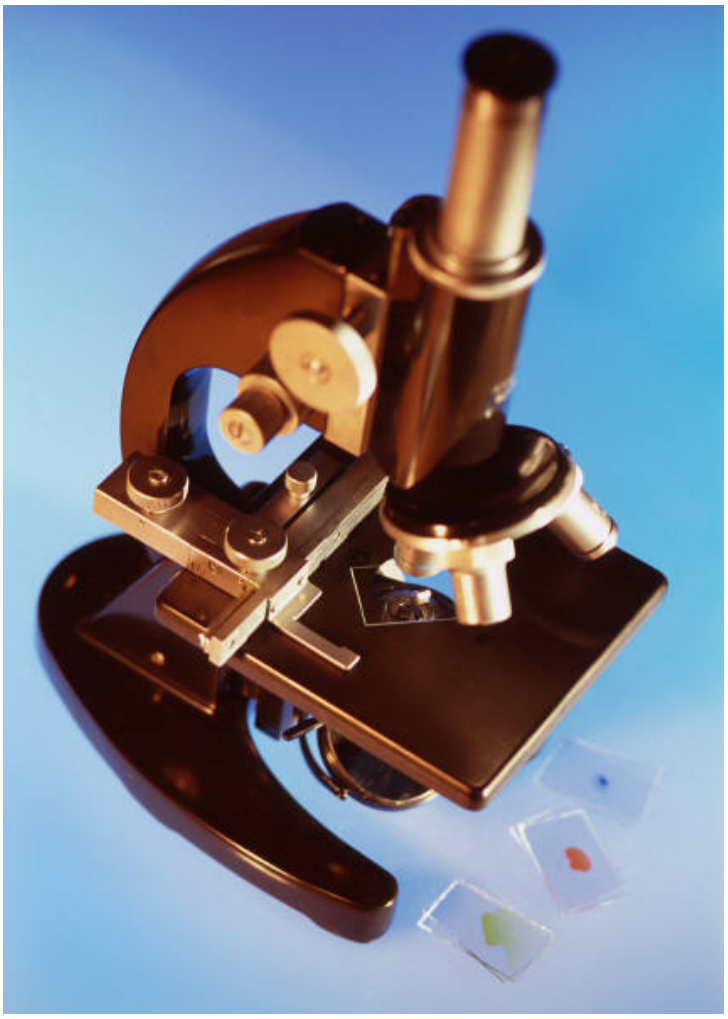

Biology
Support Documents
2004 Curriculum

Public Schools of North Carolina
Curriculum Support

July 2007

2004 revision
North Carolina Standard Course of Study
Biology

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Every effort is made to keep these materials accurate and up to date. Check the Department of Public Instruction's website http://www.ncpublicschools.org/curriculum/science/scos/ for the most current version.

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Biology Curriculum Support

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Introduction

This support document is designed to support implementation of the 2004 revision of the North Carolina Standard Course of Study for Biology. It includes each objective with a detailed content description, a list of enrichment topics, suggested laboratory materials, information about the North Carolina Total Science Safety program and a collection of laboratory investigations, classroom activities, an section on implementing the Honors Standards and other resources.

All students, not just those in honors courses, should experience challenging work and some level of independent inquiry in their courses; therefore, many of the materials and activities suggested for honors courses will also be appropriate for some students enrolled in standard level versions of the course. Teachers should include some of the enrichment topics for all students.

The particular laboratory investigations and classroom activities in the support document are not required, but if these activities are not done then similar laboratory investigations should be substituted. The biology course is intended to be a laboratory course.

The detailed content description should serve as a minimum and not a maximum for Biology. Teachers should differentiate instruction according to the needs and interests of their students.

Goal 1 was been added to emphasize the importance of science as inquiry. Students should be provided many opportunities throughout the course to design and carry out investigations and to analyze and evaluate data. They should be required to present their data and explain their conclusions.

Goals

The Biology course encourages students to continue their investigations and deepen student understanding of the biological sciences begun in grades K-8. In depth study of the following concepts is included: the cell, the molecular basis of heredity, biological evolution, the interdependence of organisms, matter, energy and organization in living systems, and the adaptive responses of organisms. The unifying concepts and program strands provide a context for teaching content and process skill goals.

Unifying Concepts

Unifying Concepts should unite the study of various biological topics across grade levels. Focus on the unifying concepts of science will also help students to understand the constant nature of science across disciplines and time even as scientific knowledge, understanding and procedures change.

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.

- Evolution and Equilibrium.
- Form and Function.

Below is a brief summary of biology topics to help teachers develop this understanding. Making connections and comparisons across the scientific disciplines will help students see these concepts in the larger context of science beyond chemistry.

General ideas for weaving unifying concepts throughout the curriculum:

- Review a unit by having students work in groups to produce concept map on how the topics in the unit connect to the unifying concepts
- Post the unify concepts on posters throughout the classroom and add topics to the posters during the year. Use these posters to review the biology content at the end of the year.

Unifying Concepts	Biology topics which demonstrate these concepts
Systems, Order and Organization	• Emphasize that systems have order and organization and involve parts that interact and influence each other. As you progress through the curriculum, you can connect this theme to many topics such the flow of matter and energy through organisms as well as throughout the ecosystem. • Help students see that systems, order and organization are found in everything from cells to the biosphere. • Have students work in groups to develop feedback and equilibrium diagrams for enzymatic reactions, for hormone behavior, and for the process of natural selection.
Evidence, Models, and Explanation	• When students write conclusions to their lab reports, help them practice supporting their conclusions with evidence from the data. • As students study the history of the discovery of the structure of the DNA molecule, have them diagram the relationship between the evidence and each proposed structure. • Have students read summaries of scientific discoveries and make lists of the evidence that supports the conclusions of the scientists. • Have students build models of cells, or organ systems. • Have students build a model of an imaginary organism that must be able to function in a particular way.

Unifying Concepts	Biology topics which demonstrate these concepts
Constancy, Change, and Measurement	• Have students work in groups to draw pictorial representations of cycles in nature. • Have students conduct laboratory investigations that involve changing variables, predicting results, and measuring effects. • Have students diagram hormone feedback mechanisms so they can see how change is also controlled in living systems. • Have students analyze human organ systems looking for examples of constancy and for examples of change. • Students could measure their pulses or blood pressure, then exercise, take the measurements again and analyze the time it takes for their systems to return to equilibrium.
Evolution and Equilibrium	• Help students understand how evolution of organisms is affected by changes in the environment • Students can study fossils to analyze how organisms have changed over time, sometimes abruptly and followed by a period of equilibrium. • Students can study how cells control what gets in and out and how that maintains the equilibrium of the cell.
Form and Function	• Have students use models to learn how the structure of an enzyme determines the effectiveness of its function. • Relate atomic and molecular structure to the nature of chemical reactions. • Have students analyze various organisms and explain how the form of that organism determines how it functions. • Show students how the evolution of fins, wings, arms, and forelimbs is related to the function of those structures.

Strands

The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

Nature of Science

This strand includes the following sections: Science as a Human Endeavor, Historical Perspectives, and the Nature of Scientific Knowledge. These sections are designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Biology is rich in examples of science as a human endeavor, historical perspectives on the development of scientific knowledge, and the nature and role of scientific knowledge.

Strands	Ideas for integrating these strands
Science as a Human Endeavor Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be taught by designing instruction that encourages students to work in groups, design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates. The content studied in biology provides an opportunity to present science as the basis for medicine, ecology, forensics, biotechnology, and environmental studies. The diverse biology content allows for looking at science as a vocation. Scientist, artist, and technician are just a few of the many careers in which a biology background is necessary. Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.	• Include examples of both individual and team contributions to the field of biology. • Design inquiry activities in which all students to collect data and report their finding to their peers for review. • Debate whether scientific peer review process is adequate to trust scientists' information in making policy decisions. • Assign students to investigate the biology knowledge needed for diverse occupations. • Invite speakers from local industries and services to discuss the use of biology principles in their work. (Waste management, water and air quality, biotechnology, pharmaceuticals, forensics, etc) • Demonstrate using newspaper and magazine articles the importance of understanding biology.

Strands	Ideas for integrating these strands
Historical Perspectives Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances.	• Be sure to include examples of both male and female scientists from diverse backgrounds and cultures. • Study the contributions of key scientists and the human drama surrounding their accomplishments (This is list is not comprehensive.) ▪ The obscurity of Mendel's work until after his death ▪ The interpersonal struggles involved in the discovery of DNA • Modern breakthroughs in gene manipulation for therapeutic purposes.
Nature of Scientific Knowledge Much of what is understood about the nature of science must be explicitly addressed: All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use.	• Compare and contrast theories and laws. • Use the theory of biological evolution for further research and as a basis for prediction on other phenomena (the diversity of species, the genetic relationships between species and the fossil record) and use the gene theory as an explanation for relationships between one generation and the next.

Strands	Ideas for integrating these strands
Science as Inquiry Inquiry should be the central theme in biology. It is an integral part of the learning experience and may be used in traditional class problems and laboratory work. The essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting all help students to build knowledge and communicate what they have learned. Inquiry is the application of creative thinking to new and unfamiliar situations. Classical experiments confirming well-accepted scientific principles may be necessary to reinforce understanding and to teach safe and proper use of laboratory techniques and instruments, but they should not be the whole laboratory experience. Instead, they should be a prelude to open-ended investigations in which the students have the chance to pose questions, design experiments, record and analyze data, and communicate their findings Having students involved in research (beyond the typical "science fair project") contributes immensely to their understanding of the process of science and to their problem-solving abilities. A solid conceptual base of scientific principles, and knowledge of science safety, is necessary for inquiry. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System*.	• Because of the importance of science as inquiry this aspect has been integrated into Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry. • This idea should be integrated into the entire course and not just taught as a separate "lab introduction" unit. • Traditional labs such as dissection and observation of plant and animal cells could lead to open-ended explorations such as the study of a particular animal's anatomy in relationship to its environment and behavior, or the effect of changing environmental conditions on the growth of yeast (or other) cells. • There is the potential for many inquiries such as: "Does the earthworm respond to light?" "Why?" "Does temperature affect the metabolic activity of yeast?" "Why?" • Students should design solutions to biological problems that interest them.

Strands	Ideas for integrating these strands
Science and Technology It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology. The methods of scientific inquiry and technological design share many common elements including objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life. Technological design is important to building knowledge in biology. For example, electron microscopes, graphic calculators, personal computers, and magnetic resonance images have changed our lives, increased our knowledge of biology, and improved our understanding of the universe.	• Provide opportunities for students to utilize technology to collect and analyze data in laboratory settings. • Allow students to brainstorm ways that technology can be used to enhance scientific study in the future. • Discuss the limitation of technology in scientific study

Strands	Ideas for integrating these strands
Science in Personal and Social Perspectives This strand helps students in making rational decisions in the use of scientific and technological knowledge. "Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges. (NSES, p. 199). The NSES emphasizes that "students should understand the appropriateness and value of basic questions 'What can happen?' - 'What are the odds?' and 'How do scientists and engineers know what will happen?'" (NSES, p. 199). Students should understand the causes and extent of science-related challenges. They should become familiar with the advances that proper application of scientific principles and products have brought to environmental enhancement, better energy use, reduced vehicle emissions, and improved human health.	• Design scientific resolutions for local or global challenges. • Encourage debate about these resolutions and their consequences. • Study issues such as nutrition, exercise, rest, and substance abuse from the perspective of an organism's needs and responses. • Develop the ability to assess the carrying capacity of a given environment and its implied limits on population growth, as well as how technology allows environmental modifications to adjust its carrying capacity. • Make decisions based on evidence in the areas of environmental stewardship and economic realities.

Sequencing Schemes

Suggested sequencing schemes are provided to show several possible ways of organizing the course and approximate recommended amounts of time to spend on the different topics. Other sequences are certainly possible. Pacing guides are **not** provided because the detail that makes a useful pacing guide depends on local factors such as the materials and resources available for laboratories and activities, available textbooks, how the teacher chooses to integrate topics and themes, whether materials are shared across classrooms, the local calendar, etc. In each scheme, approximately 20% of the total time should be spent integrating Goal #1 into each of the goals.

Scheme #1: This scheme provides students with the big picture of ecology at the beginning of the course and allows the teacher to use the ecological principles as a foundation for other topics in biology.

Goal	Objective	Topic	Days on Traditional	Days on Block
5		**Ecology**	**28**	**14**
	5.01	Interrelationships	12	6
	5.02	Cycles	7	4
	5.03	Human impact	9	4
2		**Phys., Chem., & Cellular Basis of Life**	**47**	**23**
	2.01	Organic molecules	9	4
	2.02	Cell	11	6
	2.03	Cell as a system	11	5
	2.04	Enzymes	7	4
	2.05	Bioenergetic reactions	9	4
3		**Continuity of life & Changes over time**	**55**	**28**
	3.01	Molecular basis of heredity	11	6
	3.02	Asexual vs. Sexual Reproduction	7	4
	3.03	Patterns of Inheritance	16	7
	3.04	Genomics	9	5
	3.05	Evolution	12	6
4		**Unity & Diversity of Life**	**48**	**24**
	4.01	Classification	9	5
	4.02	Representative Organisms	12	6
	4.03	Adaptations	9	4
	4.04	Health & Disease	9	4
	4.05	Animal Behavior	9	5

Schemes 2 and 3 start with the basic unit of life, the cell. The cell provides a foundation for understanding living things. Teachers build from organisms to populations and adaptations.

Scheme #2:

Goal	Objective	Topic	Days on Traditional	Days on Block
2		**Phys., Chem., & Cellular Basis of Life**	**47**	**23**
	2.01	Organic molecules	9	4
	2.02	Cell	11	6
	2.03	Cell as a system	11	5
	2.04	Enzymes	7	4
	2.05	Bioenergetic reactions	9	4
3		**Continuity of life & Changes over time**	**55**	**28**
	3.01	Molecular basis of heredity	11	6
	3.02	Asexual vs. Sexual Reproduction	7	4
	3.03	Patterns of Inheritance	16	7
	3.04	Genomics	9	5
	3.05	Evolution	12	6
4		**Unity & Diversity of Life**	**48**	**24**
	4.01	Classification	9	5
	4.02	Representative Organisms	12	6
	4.03	Adaptations	9	4
	4.04	Health & Disease	9	4
	4.05	Animal Behavior	9	5
5		**Ecology**	**28**	**14**
	5.01	Interrelationships	12	6
	5.02	Cycles	7	4
	5.03	Human impact	9	4

Scheme #3:

Goal	Objective	Topic	Days on Traditional	Days on Block
2		**Phys., Chem., & Cellular Basis of Life**		
	2.01	Organic Molecules	7	3
	2.04	Enzymes	7	3
5		**Ecology**		
	5.01	Interrelationships	12	6
	5.02	Cycles	5	3
	5.03	Human Impact	9	4
2		**Phys., Chem., & Cellular Basis of Life**		
	2.02	Cell	9	4
	2.03	Cell as a system	9	5
	2.04	Bioenergetic Reactions	9	4
3		**Continuity of Life and Changes Over Time**		
	3.02	Asexual vs. Sexual Reproduction	6	3
	3.03	Patterns of Inheritance	17	8
	3.01	Molecular basis of heredity	12	6
	3.04	Genomics	17	9
	3.05	Evolution	17	8
4		**Unity and Diversity of Life**		
	4.01	Classification	5	2
	4.02	Representative Organisms	13	6
	4.04	Adaptations	13	7
	4.05	Animal Behavior	4	2
	4.04	Health and Disease	10	5

Content Description and Suggested Activities

Goal 1

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry. Goal 1 addresses scientific investigation. These objectives are an *integral* part of *each of the other goals*. Students must be given the opportunity to design and conduct their own investigations in a safe laboratory. The students should use questions and models to formulate the relationship identified in their investigations and then report and share those findings with others.

Objective	Content Description	Suggested Activities
1.01 Identify biological problems and questions that can be answered through scientific investigations.	• Develop questions for investigation from a given topic or problem.	Activities for this goal will be embedded within the other goals.
1.02 Design and conduct scientific investigations to answer biological questions. • Create testable hypotheses. • Identify variables. • Use a control or comparison group when appropriate. • Select and use appropriate measurement tools. • Collect and record data. • Organize data into charts and graphs. • Analyze and interpret data. • Communicate findings.	• Distinguish and appropriately graph dependent and independent variables. • Discuss the best method of graphing/presenting particular data. • Report and share investigation results with others.	Student design of an experiment Qualitative and quantitative lab investigations and experiences
1.03 Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to: • Explain observations. • Make inferences and predictions. • Explain the relationship between evidence and explanation.	• Use questions and models to determine the relationships between variables in investigations.	Content rich inference vs. observation activity (eg: "Animal Responses to Environmental Stimuli")
1.04 Apply safety procedures in the laboratory and in field studies: • Recognize and avoid potential hazards. • Safely manipulate materials and equipment	• Predict safety concerns for particular experiments • Relate biological concepts to safety applications such as: o Disease transmission o Nutrition o Animal care	Safety activity

needed for scientific investigations.		
1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint including considerations of: • Appropriate sample. • Adequacy of experimental controls. • Replication of findings. • Alternative interpretations of the data.	• Read a variety of reports of scientific research.	Case Studies from recent literature in both academic (*Science*, *Scientific American*) and popular (*Newsweek*, *USA Today*) publications.

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

Objective	Content Description	Suggested Activities
2.01 Compare and contrast the structure and functions of the following organic molecules: • Carbohydrates. • Proteins. • Lipids. • Nucleic Acids.	• Examine the role and importance of organic molecules to organisms. • Examples to investigate include starch, cellulose, insulin, glycogen, glucose, enzymes, hemoglobin, fats, DNA and RNA. (*Distinguish among mono, and polysaccharides* - concept not terminology) • Interpret results of tests for starch (iodine), lipids (brown paper), monosaccharides (Benedict's Solution), and protein (Biuret's). • Emphasis should be on functions and subunits of each organic molecule. For example, enzymes are proteins composed of long chains of amino acids that are folded into particular shapes and that shape determines the specific reaction that the enzyme will catalyze. *(The terms condensation reaction, dehydration synthesis and hydrolysis have been deliberately excluded.)*	Testing for bio-molecules: starch, lipids, sugars, and proteins
2.02 Investigate and describe the structure and function of cells including: • Cell organelles. • Cell specialization. • Communication among cells within an organism.	• Structure and function of: nucleus, plasma membrane, cell wall, mitochondria, vacuoles, chloroplasts, and ribosomes. Students should be able to identify these cell organelles. • Proficient use and understanding of light microscopic techniques. Students should determine total power magnification as well as steps in proper microscope usage. • Hierarchy of cell organization: Cells →tissues→organs→ organ systems. • Structure of cells as it relates to their specific functions. • Students should view a variety of cells with particular emphasis on the differences between plant and animal cells. • Chemical signals may be released by one cell to influence the activity of another cell. For example, a nerve cell can send a message to a muscle cell or to another a nerve cell. • role of receptor proteins • hormones •	Creation of cell models Microscope experience Cell surface area to volume activity

2.03 Investigate and analyze the cell as a living system including: • Maintenance of homeostasis. • Movement of materials into and out of cells. • Energy use and release in biochemical reactions.	• Examples for exploration should include regulation of temperature, pH, blood glucose levels and water balance. • Discussion should include active vs. passive transport, diffusion, osmosis, and the porous nature of the semi-permeable plasma membrane. (P*inocytosis, phagocytosis, endocytosis, and exocytosis have been deliberately excluded)* • Given different types of cells, students should be able to predict any changes in osmotic pressure that may occur as the cell is placed in solutions of differing concentrations. **(***Emphasis is on the processes, not terminology such as hypertonic, isotonic, hypotonic, turgor pressure)* • Examine ATP as the source of energy for cell activities. • Students will describe how cells store and use energy with ATP and ADP molecules.	An osmosis lab / diffusion lab **Inquiry Support Activities:** Osmosis and the Egg How do biological materials respond to acids and bases? (Buffer lab) Activities that demonstrate when food is burned energy is given off (such as burning a peanut or cheese doodle)
2.04 Investigate and describe the structure and function of enzymes and explain their importance in biological systems.	Instruction should include investigation of: • Enzymes as proteins that speed up chemical reactions (catalyst). • Enzymes as re-usable and specific. • Enzymes as affected by such factors as pH, and temperature. Students should understand that enzymes are necessary for all biochemical reactions and have a general understanding of how enzymes work.	**Inquiry Support Activity:** Properties of Enzymes
2.05 Investigate and analyze the bioenergetic reactions: • Aerobic respiration • Anaerobic respiration • Photosynthesis	The emphasis should be placed on investigation of: • Overall equations including reactants and products and not on memorizing intermediate steps of these processes. • Factors which affect rate of photosynthesis and or cellular respiration. • Comparison and contrast of these processes with regard to efficiency of ATP formation, the types of organisms using these processes, and the organelles involved. o Anaerobic respiration should include lactic acid and alcoholic fermentation. Instruction should include the comparison of anaerobic and aerobic organisms. *(Glycolysis, Kreb's Cycle, and Electron Transport Chain have been deliberately excluded)* ***(****Students are not required to distinguish between light dependent and light independent parts of photosynthesis)*	**Inquiry Support Activity:** Yeast Fermentation Inquiry activities which allow students to investigate factors affecting rate of photosynthesis and/or cellular respiration

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

Objective	Content Description	Suggested Activities
3.01 Analyze the molecular basis of heredity including:	Instruction should include: • Structure of DNA as compared to RNA • Complementary base pairing • Understanding that the sequence of nucleotides in DNA codes for proteins – the central key to cell function and life.	Investigation of replication, transcription and translation using models. **Inquiry Support Activity:** What are the effects of various mutations on protein synthesis?
• DNA Replication	• How the process allows daughter cells to have an exact copy of parental DNA. • Understanding of the semi-conservative nature of the replication process. (nature of the process, not the term semi-conservative) • Mutations as a change in the DNA code. • The position of replication within the cell cycle. • The importance of relatively weak hydrogen bonds.	
• Protein Synthesis (transcription and translation)	The recognition of protein synthesis as a process of: • Transcription that produces an RNA copy of DNA, which is further modified into the three types of RNA • mRNA traveling to the ribosome (rRNA) • Translation - tRNA supplies appropriate amino acids • Amino acids linked by peptide bonds to form polypeptides which are folded into proteins. • Use of a codon chart to determine the amino acid sequence produced by a particular sequence of bases.	

• Gene Regulation	• All (with a few exceptions) of an organism's cells have the same DNA but differ based on the expression of genes.
	  • differentiation of cells in multicellular organisms
	  • cells responding to their environment by producing different types and amounts of protein.
	  • advantages (injury repair) and disadvantages (cancer) of the overproduction, underproduction or production of proteins at the incorrect times.	

3.02 Compare and contrast the characteristics of asexual and sexual reproduction.	Instruction should include: • Recognizing mitosis as a part of asexual reproduction and meiosis as a part of sexual reproduction. • Similarities and differences between mitosis and meiosis including replication and separation of DNA and cellular material, changes in chromosome number, number of cell divisions, and number of cells produced in complete cycle. • Putting mitosis diagrams in order and describing what is occurring throughout the process. *Students are not expected to memorize the names of the steps or the order of the step names.* • The sources of variation including: o Crossing over. o Random assortment of chromosomes. o Gene mutation o Nondisjunction o Fertilization	**Inquiry Support Activity:** Cell Cycle Investigation involving mitosis/ meiosis simulations
3.03 Interpret and predict patterns of inheritance. • Dominant, recessive and intermediate traits.	Instruction should include: • Identifying and determining genotypes and phenotypes. • Recognition that phenotype is the result of both genotype and the environment. • A discussion of Mendel's experiments and laws. • Interpreting karyotypes (gender, chromosomal abnormalities) • Understanding that dominant traits mask recessive alleles. • There are a variety of intermediate patterns of inheritance, including codominance and incomplete dominance. While teachers should not necessarily expect students at this level to distinguish between these forms of intermediate inheritance on a biochemical level they should be able to solve problems involving apparently intermediate phenotypes. The following discussion is included to help teachers with understanding these frequently confused terms. o Incomplete dominance (also called partial dominance) results in the blending of traits. (Usually results from an inactive or less active gene so the heterozygous phenotype appears intermediate. E.g. Pink flowers) o Co-dominant alleles result in the expression of both traits. (two	**Inquiry Support Activity:** Genetics of Parenthood

	different proteins are produced and both are detected e.g. roan cows and AB blood type.) • Autosomal inheritance patterns and characteristics of sickle cell anemia, cystic fibrosis, and Huntington's disease	
• Multiple alleles.	• Solving and interpreting co-dominant crosses involving multiple alleles. • A, B, AB and O blood types (alleles: I^A, I^B, and i). • Determining if parentage is possible based on blood types.	
• Polygenic traits.	• Recognizing that some traits are controlled by more than one pair of genes. • This pattern of inheritance is identified by the presence of a wide range of phenotypes (consider examples of skin and hair color).	
• Sex linked traits.	• An understanding of human sex chromosomes. • Solving crosses involving sex linked traits (examples: color-blindness and hemophilia.) • Understand why males are more likely to express a sex-linked trait.	
• Independent assortment.	• The importance of the genes being on separate chromosomes as it relates to meiosis. • How the process of meiosis leads to independent assortment and ultimately to greater genetic diversity.	
• Test cross.	• Given certain phenotypes suggest an appropriate test cross to determine the genotype of an organism.	
• Pedigrees.	• Identify the genotypes of individuals from a given pedigree. (students should be able to interpret pedigrees which show phenotype not genotype)	
• Punnett squares.	• Solving and interpreting problems featuring monohybrid crosses. (Parental, F1, F2 generations) • Determining parental genotypes based on offspring ratios.	

3.04 Assess the impacts of genomics on individuals and society. • Human genome project. • Applications of biotechnology.	Instruction should include: • The reasons for establishing the human genome project. • Recognition that the project is useful in determining whether individuals may carry genes for genetic conditions and in developing gene therapy. • Gel electrophoresis as a technique to separate molecules based on size. *(Students are not expected to know the steps of gel electrophoresis in order or great detail. They should be able to interpret the results and have a general understanding of what takes place during the process.)* • Uses of DNA fingerprinting • Applications of transgenic organisms (plants, animals, & bacteria) in agriculture and industry including pharmaceutical applications such as the production of human insulin. • Ethical issues and implications of genomics and biotechnology. (stem cell research and genetically modified organisms)	Electrophoresis lab or simulation. **Inquiry Support Activity:** Genetic Detective
3.05 Examine the development of the theory of evolution by natural selection including: • Development of the theory. • The origin and history of life. • Fossil and biochemical evidence. • Mechanisms of evolution.	Instruction should include: • Historical development of the theory of evolution by natural selection. • Biogenesis in contrast to abiogenesis with emphasis on the experiments used to support both ideas. • Early atmosphere hypotheses and experiments. • How the early conditions affected the type of organism that developed (anaerobic and prokaryotic). • Evolution of eukaryotic and aerobic organisms. • Fossils– relative and absolute dating methods • A discussion of what can be inferred from patterns in the fossil record. • Biochemical similarities. • Shared anatomical structures. (*Patterns in embryology and homologous and analogous vocabulary are intentionally excluded)* • How variations provide material for natural selection. • The role of geographic isolation in speciation. • The importance of the environment in	**Inquiry Support Activity:** Fishy Frequencies

• Applications (pesticide & antibiotic resistance).	selecting adaptations. • Discuss the evolutionary selection of resistance to antibiotics and pesticides in various species.	

Goal 4: Learner will develop an understanding of the unity and diversity of life.		
Objective	**Content Description**	**Suggested Activities**
4.01 Analyze the classification of organisms according to their evolutionary relationships. • The historical development and changing nature of classification systems. • Similarities and differences between eukaryotic and prokaryotic organisms. • Similarities and differences among the eukaryotic kingdoms: Protists, Fungi, Plants, and Animals. • Classify organisms using keys.	Students should learn about the changing nature of classification based new knowledge generated by research on evolutionary relationships. History of classification system • Originally two kingdoms (plants and animals). More kingdoms added as knowledge of the diversity of organisms increased. • Development of the seven level classification system (KPCOFGS) and binomial nomenclature *(The intention is that students understand that classification systems are changed as new knowledge is gathered. Currently, the thinking is 3 Domains with 6-7 kingdoms)* Basis of classification system • Evolutionary phylogeny, DNA and biochemical analysis, embryology, morphology • Interpret phylogenetic trees. Only basic differences and similarities should be detailed. • Membrane bound organelles – none in prokaryotes. • Ribosomes in both. • Contrasts in chromosome structure. • Contrasts in size. Compare: • Cellular structures. • Unicellular vs. Multicellular. • Methods of making/getting food and breaking down food to get energy. • Reproduction. Use dichotomous keys to identify organisms.	Use dichotomous keys to identify organisms. Activities might include student-created keys based on observable characteristics (e.g. symmetry)
4.02 Analyze the processes by which organisms representative of the following groups accomplish essential life functions including: • Unicellular protists, annelid worms, insects, amphibians, mammals, non-	Teachers should help students compare and contrast how the organisms listed accomplish the essential life functions specified below. The focus is on physiology rather than on the names of parts. • Transport – how organisms get what they need to cells; how they move waste from cells to organs of excretion. • Excretion – how organisms get rid of their waste and balance their fluids (pH, salt	Observe representative organisms from the specified groups. **Inquiry Support Activity:** Organism Newspaper Project

vascular plants, gymnosperms and angiosperms. • Transport, excretion, respiration, regulation, nutrition, synthesis, reproduction, and growth and development.	concentration, water). • Regulation – how organisms control body processes – hormones, nervous system. • Respiration – how organisms get oxygen from the environment and release carbon dioxide back to the environment and how plants exchange gases. • Nutrition – how organisms break down and absorb foods. • Synthesis – how organisms build necessary molecules. • Reproduction – sexual versus asexual, eggs, seeds, spores, placental, types of fertilization. • Growth and development – metamorphosis, development in egg or in uterus, growth from seed or spore.	

4.03 Assess, describe and explain adaptations affecting survival and reproductive success.
• Structural adaptations in plants and animals (form to function).
 	
• Disease-causing viruses and microorganisms.
 	
• Co-evolution.
	Focus should be on structural adaptations from organisms that are listed in 4.02, particularly:
	• Feeding adaptations.
	• Adaptations to ensure successful reproduction.
	• Adaptations to life on land.
	
	Instruction should include:
	• Structure of viruses.
	• Mutation of viruses and other microorganisms.
	• Variety of disease causing (pathogenic) agents (viruses, bacteria) including:
	  • HIV
	  • Influenza
	  • Smallpox
	  • Streptococcus (strep throat)
	
	Emphasis should be on the relationship between angiosperms and their pollinators.
		Investigation that includes the observation of structural adaptations

4.04 Analyze and explain the interactive role of internal and external factors in health and disease: • Genetics.	Focus should be on the **interactive role of genetics and the environment** in determining a specific response including: • Sickle cell anemia and malaria • Lung/mouth cancer and tobacco use • Skin cancer, vitamin D, folic acid and sun exposure • Diabetes (diet/exercise and genetic interaction). • PKU and diet	Use of case studies to analyze the role of genetics and environment in human health.

• Immune response. • Nutrition. • Parasites. • Toxins.	Instruction should include basic understanding of: • Function and relationship of T-cells, B-cells, antibodies/antigens. (**Overview only** of different types and roles of T and B cells: role of memory cells, B cells make antibodies, some T cells help B cells make antibodies, other T cells kill infected cells.) • Passive and active immunity. • Vaccines. Teachers should emphasize aspects of nutrition that contribute to: • Optimal health. • Poor nutrition (obesity, malnutrition and specific deficiencies.) Teachers should focus on the general life cycle (not specific details), vector, symptoms, and treatments for: Malarial parasite (Plasmodium) Understand effects of environmental toxins • Lead • Mercury	
4.05 Analyze the broad patterns of animal behavior as adaptations to the environment. • Innate behavior. • Learned behavior. • Social behavior.	Taxes and instincts, including: • suckling (instinct) • insects moving away from or toward light (taxis) • migration, estivation, hibernation Focus should be on various types of learned behavior including: • Habituation • Imprinting • Classical conditioning (e.g. Pavlov's dog – stimulus association) • Trial and error (focus on concept of trial and error learning not term operant conditioning). Focus should be on communication, territorial defense, and courtship, including: • Communication within social structure using pheromones (ex: bees and ants). • Courtship dances. • Territorial defense (ex: Fighting Fish).	**Inquiry Support Activity:** Animal Responses to Environmental Stimuli

Goal 5: Learner will develop an understanding of the ecological relationships among organisms.		
Objective	**Content Description**	**Suggested Activities/Resources**
5.01 Investigate and analyze the interrelationships among organisms, populations, communities and ecosystems • Techniques of field ecology • Abiotic and biotic factors • Carrying capacity	Students should be able to identify and describe symbiotic relationships • Mutualism • Commensalism • Parasitism Students should be able to identify and predict patterns in Predator /prey relationships. Use field ecology techniques such as sampling and quadrant studies to determine species diversity and changes over time. Explain how abiotic and biotic factors are related to one another and their importance in ecosystems. Analyze how limiting factors influence carrying capacity (e.g. food availability, competition, harsh winter). Interpret population growth graphs.	**Inquiry Support Activity:** Campus Field Study
5.02 Analyze the flow of energy and the cycling of matter in the ecosystem. • Relationship of the carbon cycle to photosynthesis and respiration • Trophic levels-direction and efficiency of energy transfer	Investigate the carbon cycle as it relates to photosynthesis and respiration. Analyze food chains, food webs, and energy pyramids for direction and efficiency of energy transfer.	

5.03 Assess human population and its impact on local ecosystems and global environments:
• Historic and potential changes in population
• Factors associated with those changes.
	Instruction should include:
	• Analyze human population growth graphs (historical and potential changes) .(See 5.01)
	• Factors influencing birth rates and death rates.
	• Effects of population size, density and resource use on the environment.
	• Discussion of human impact on local ecosystems:
	  • Acid rain
	  • Habitat destruction
	  • Introduced non-native species.
	• How changes in human population affects populations of other organisms.
		Inquiry Support Activity: Environmental Factors that Affect the Hatching of Brine Shrimp

• Climate Change.	Discussion of factors that influence climate: • greenhouse effect (relate to carbon cycle and human impact on atmospheric CO_2) • natural environmental processes (e.g. volcanoes)	
• Resource use	Investigation of the direct and indirect impact of humans on natural resources (e.g. deforestation, pesticide use and bioaccumulation research)	
• Sustainable practices/ stewardship.	Examples of sustainable practices and stewardship.	

General Biology Resources

http://www.sciencenews.org/
Science News Online -the *For Kids* section of this website has great summaries with links to the next level.

http://www.sciencedaily.com/
Science Daily New Site

http://www.pbs.org/teachersource/sci_tech.htm
PBS site with materials for students and teachers

http://www.accessexcellence.org/RC/
Information, laboratories and activity ideas

http://www.discover.com/
Discover Magazine site

http://si.edu/resource/faq/start.htm
The Smithsonian Encyclopedia

http://www.biology.arizona.edu/
The Biology Project, activities and current information

http://www.enc.org/
Eisenhower National Clearinghouse

http://www.educationplanet.com/
Useful links

http://www.hhmi.org/biointeractive/
Go to animations for diffusion video

http: //www.ncsu.edu/sciencejunction/terminal/index.html
Lab and activity ideas

http://www.askascientist.org/
Useful for teachers and students

http://www.biologymad.com/
Numerous subject modules

http://www.esp.org/foundations/genetics/classical/
Original scholarly papers – e.g. Mendel and Darwin

http://biotech.icmb.utexas.edu/search/dict-search.html
Biology dictionary

http://biodidac.bio.uottawa.ca/
Pictures useful for biology teachers

http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/
On- line text – useful for teachers

http://science-education.nih.gov/nihHTML/ose/snapshots/multimedia/ritn1.html
Research in the news

http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html
On line biology text

http://www.hhmi.org/lectures/
Howard Hughes lectures

http://science.nhmccd.edu/biol/bio1int.htm
Animation links on various biology topics

http://www.s-cool.co.uk/topic_index.asp?subject_id=3
Similar to a textbook online

http://www.biozone.co.uk/links.html
Large number of quality links

http://www.wiley.com/legacy/college/boyer/0470003790/animations/animations.htm
Interactive animated tutorials – fairly advanced

http://www.johnkyrk.com/
Animations of a large variety of biology topics

http://www.marcopolo-education.org/
Features lessons, some are interactive or animated

Objective Specific Resource List

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

Objective

1.01	
1.02	http://www.ncsu.edu/labwrite Resources for students and teachers to assist with preparing for lab, analyzing data, writing lab reports, rubrics etc.
1.03	
1.04	
1.05	Some appropriate sources for reading include: o Science News Online http://www.sciencenews.org/ The *For Kids* section of this website has great summaries with links to the next level. o Science Daily http://www.sciencedaily.com/ o Tuesday New York Times Science Section o http://science-education.nih.gov/snapshots.nsf

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

Objective

2.01	**SAS Web Inquiry**: How do structures of carbohydrates affect their functions? http://biochemhub.com/biochem/biochemhub.cfm Biology hub – many games and puzzles for review – e.g. concentration
2.02	**SAS Project**: Organelle Functions **SAS Classroom Activity**: How Big Is That Cell? **SAS Web Inquiry**: Why are cells so small? **SAS Classroom Activity:** Where Did All Those Different Cells Come From? http://www.cellsalive.com Interactive plant/animal cell, mitosis, meiosis, cell cycle http://www.life.uiuc.edu/cgi-bin/plantbio/cell/cell.cgi Virtual plant cell from a University of Illinois project http://www.nobelprize.org/medicine/educational/2001/cellcycle.html "Work" to regulate cell cycles http://www.sciencenetlinks.com/Lessons.cfm?DocID=88 Lesson plan with analogies of cell organelles, worksheets

	http://accessexcellence.org/AE/AEC/AEF/1996/rogers_cell.html Lesson and rubric for designing cell project http://accessexcellence.org/AE/AEC/AEF/1996/talbot_observation.html Activity viewing and measuring various types of cells http://accessexcellence.org/AE/AEC/AEF/1995/porter_cell.html Travel brochure of a cell project http://www.biology.arizona.edu/cell_bio/tutorials/cells/cells.html Tutorial using microscopy to understand cells http://accessexcellence.org/AE/AEC/AEF/1994/haugen_microscope.html Alternative assessment opportunity based on a forensic activity using a crime scene to develop microscopy skills http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookCELL2.html Interactive tutorial of cell organelles with many outside links
2.03	**SAS Model:** Chemiosmosis **SAS Interactivity:** Membranes **SAS Web Lesson**: Lights…Camera…Action Potential! http://science.exeter.edu/jekstrom/WEB/CELLS/Elodea/Elodea.html Tutorial on Elodea undergoing plasmolysis http://biology.arizona.edu/sciconn/lessons/mccandless/default.html Lesson plans by a high school teacher including several osmosis/diffusion lab activities http://www.sciencenetlinks.com/Lessons.cfm?DocID=65 Web inquiry and lesson plans to understand cell communication, requires knowledge of nervous and endocrine systems http://www.exo.net/~pauld/activities/food/countingcalories.html Information about calorimeters and food, link to a peanut demo http://www.michigan.gov/scope/0%2C1607%2C7-155-13497_13503_13506-43904--%2C00.html Make a tin can calorimeter http://nat.crgq.com/mainnat.html Site has a clever nutrition analysis tool – you can enter different foods and get an analysis of those foods – calories, nutrients, etc
2.04	**SAS InterActivity:** Enzymes http://accessexcellence.org/AE/AEC/AEF/1996/crumlish_enzyme.html Enzyme lab using milk, connection to hydrolysis http://web.jjay.cuny.edu/~acarpi/NSC/index.htm Mainly chemistry but some related information, enhances understanding

2.05	**SAS InterActivity:** Photosynthesis **SAS Classroom Activity:** Floating Leaves http://photoscience.la.asu.edu/photosyn/default.html Useful links and articles at varying levels from Arizona State University's Photosynthesis Center http://researchmag.asu.edu/stories/power.html The Power of Green, green chlorophyll that is

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

Objective	Resources
3.01	**SAS Classroom Activity:** Cracking the Protein Code **SAS InterActivity:** DNA Replication http://www.amnh.org/exhibitions/genomics/1_identity/work.html American Museum of Natural History, info about the genomic revolution, resource site http://glsc.genetics.utah.edu/units/basics/builddna/ Genetic Science Learning Center at Univ. of Utah, build a DNA molecule http://dnalc.org Cold Spring Harbor site – includes DNA from the Beginning, a section on eugenics, genetic disorders, DNA (the newest edition) has animations of biotechnology http://biocrs.biomed.brown.edu/Books/Chapters/Ch 8/DH-Paper.html Reprint of Watson and Crick's original paper from 1953. http://www.pbs.org/wgbh/aso/tryit/dna/index.html PBS has an interactive tutorial for replication and protein synthesis. http://www.biostudio.com/demo_freeman_protein_synthesis.htm Advanced animated demo of protein synthesis
3.02	**SAS InterActivity:** Cell Division http://www.biology.arizona.edu/cell_bio/cell_bio.html Cell cycle tutorials and a web version of an onion tip lab, some available in Spanish http://biog-101-104.bio.cornell.edu/bioG101_104/tutorials/cell_division.html Interactive tutorial with pictures of phases http://www4.ncsu.edu/unity/users/b/bnchorle/www/ Meiosis tutorial – animated
3.03	**SAS Interactivity:** Mendelian Genetics

Objective	Resources
	http://www.ndsu.nodak.edu/instruct/mcclean/plsc431/mendel/mendel9.html Discussion and an example of pedigrees http://www.biology.arizona.edu/human_bio/activities/karyotyping/karyotyping.html The Biology Project at Univ. of Arizona, human karyotyping, student interactive http://www.horton.ednet.ns.ca/staff/selig/AP/labs/Blood_activity.html Virtual blood typing and hematocrit activity http://www.hhmi.org/biointeractive/ Howard Hughes Medical Institute, animation and virtual labs on medical topics http://www.Mendelweb.org/ Information about the work of Mendel http://www.people.virginia.edu/~rjh9u/blkysc82.html The blue hill people of Virginia – genetic trait http://shs.westport.k12.ct.us/mjvl/biology/genetics/gene_history_files/frame.htm Interactive PowerPoint about the Romanoff's http://www.biointeractive.org Animations (e.g.– evolution of "Y" chromosome)
3.04	**SAS Classroom Activity:** DNA Fingerprinting: A Simulation http://onlineethics.org/biology/index.html Ethical issues in the biological sciences http://gslc.genetics.utah.edu/units/biotech/gel/ Genetic Science Learning Center, interactive gel electrophoresis simulation http://gslc.genetics.utah.edu/units/disorders/pedigree/ Genetic Science Learning Center, genetic disorder activity http://www.amnh.org/exhibitions/genomics The American Museum of Natural History, The Genomic Revolution, lots of information http://www.biointeractive.org Howard Hughes site, Transgenic Fly biointeractive laboratory http://www.genome.gov/10001772 National Institute of Health, information on the Human Genome Project http://www.genomenewsnetwork.org Genome News Network, Genetic Detective Webquest http://www.hhmi.org/biointeractive/ Bacterial DNA analysis http://www.ornl.gov/hgmis/publicat/genechoice/ Your Genes, Your Choices raises many of the human issues related to biotechnology http://ehrweb.aaas.org/ehr/books/

Objective	Resources
	Your genes your choices: exploring the issues raised by genetic research http://www.cdc.gov/genetics/ Links to information on all sorts of diseases http://www.ncbi.nlm.nih.gov/science96/ Browse genetic disorders chromosome by chromosome http://www.ncbi.nlm.nih.gov/Omim/ Online Mendelian Inheritance in Man -may be most useful to teachers http://www.people.virginia.edu/~rjh9u/forenspt.html DNA interactive paternity cases http://gslc.genetics.utah.edu Stem cell animation as well as other information http://www.stemcell.umn.edu/ Information on stem cells and current research
3.05	**SAS Classroom Activity:** Natural Selection **SAS InterActivity**: Microevolution http://evolution.berkeley.edu Univ. of California at Berkley, assistance in the teaching of evolution http://www.epa.gov/pesticides/ Information on pesticides and the issues of their use http://www.mnh.si.edu/anthro/humanorigins/ Smithsonian Institution's Human Origins Program explores the fossil record left by early humans. http://www.indiana.edu/~ensiweb/lessons/ns.chips.html Version of a selection activity http://www.nap.edu/readingroom/books/evolution98/evol6-b.html Lesson on evolution - written for middle school but also fits high school biology http://www.pbs.org/wgbh/evolution/ PBS evolution site – lots of teacher materials – on line activities and others “click” the teacher workbook http://www.pbs.org/wgbh/evolution/sex/guppy/ed_pop.html "Sex and the Single Guppy” How populations change over time

Goal 4: Learner will develop an understanding of the unity and diversity of life.

Objective	Resources
4.01	**SAS Interactivity:** Modern Taxonomy http://phylogeny.arizona.edu/tree/phylogeny.html Tree of Life site, evolutionary tree features lots of organisms life http://www.marietta.edu/~mcshaffd/Pachyderm_Web/pachyderm_web_home.htm Large store of phyla photos and current classification information http://www.mindspring.com/~zoonet/www_virtual_lib/zoos.html This site links to zoos and other animal related sites. http://www.naturalia.org/ZOO/indexing.html This is a virtual zoo site. http://biodidac.bio.uottawa.ca/ Thousands of pictures for bio teachers http://biog-101-104.bio.cornell.edu/BioG101_104/tutorials/animals.html Animal tutorials – these are wonderful online quizzes with immediate feedback
4.02	http://animaldiversity.ummz.umich.edu/site/index.html Features a large number of pictures and even a large number of sounds of various organisms http://arbl.cvmbs.colostate.edu/hbooks/pathphys/endocrine/basics/control.html This is a link to Colorado State's Endocrinology Hypertextbook - has a nice animation and discussion of feedback loops. http://www.aa.psu.edu/biology/frog/ Penn State virtual frog dissection http://biog-101-104.bio.cornell.edu/BioG101_104/tutorials/animals/animals2.html Review of animal anatomy (and physiology)
4.03	**SAS InterActivity:** Disease Dynamics http://commtechlab.msu.edu/sites/dlc-me/zoo/ This is a microbial zoo site with lots of information about microbes presented in an entertaining manner http://www.microbes.info/ User friendly information – more than just microbes http://vm.cfsan.fda.gov/~mow/intro.html "Bad Bug Book" – wonderful source for studying “germs”

4.04	**SAS InterActivity:** Disease Dynamics http://www.psych.umn.edu/psylabs/mtfs/special.htm University of Minnesota's site for twin studies http://www.niaaa.nih.gov/publications/aa18.htm The National Institute on Alcohol Abuse and Alcoholism presents a discussion of the genetics of alcoholism. Helpful to teachers and more advanced students. http://faculty.washington.edu/chudler/alco.html Information about the effects of alcohol on the body and links to pages on fetal alcohol syndrome. http://www.pbs.org/wgbh/nova/cancer/ This site allows you to watch the whole video (Cancer Warrior) http://www.cancer.org/docroot/home/index.asp The American Cancer Society site for information. http://nobelprize.org/educational_games/medicine/immunity/immune-detail.html how the immune system works http://www.cdc.gov/ The Centers for Disease Control and Prevention.

4.05	http://www.animalbehavior.org/ABS/Education Web cams of animals. Not all of good quality. http://www.nczoo.org/ The North Carolina Zoo. http://nationalzoo.si.edu/default.cfm National zoo has easy to use Web Cams. http://www.accessexcellence.com/AE/AEPC/WWC/1995/mimicry.html Activity that simulates the advantages of mimicry http://www.learner.org/jnorth/index.html Journey North : migration data and activities

Goal 5: Learner will develop an understanding of the ecological relationships among organisms.

Objective

5.01	**SAS Interactivity:** Stream Ecology http://www.cvm.umn./edu/depts/raptor center/education/lesssonplans/ Predator- Prey activity
5.02	http://www.cvm.umn./edu/depts/raptor center/education/lesssonplans/ Activities featuring food webs and other ecosystem relationships

	http://www.marietta.edu/~biol/102/ecosystem.html From Marietta College on ecosystems with a nice discussion of energy flow, biomass pyramids including exceptions to the usual findings and also bio-magnification. http://accessexcellence.org/AE/AEC/AEF/1996/linhares_lab.html Snail and Elodea in mini-environments
5.03	www.enviroliteracy.org Lesson plans and item bank of environmental items www.prb.org Population Reference Bureau, lots of information http://www.epa.gov/globalwarming/index.html The EPA has a large website devoted to global warming. The educator's page provides links to other resources. http://www.census.gov/ftp/pub/ipc/www/idbpyr.html Interactive population pyramids. http://www.ibiblio.org/lunarbin/worldpop A world population clock. http://www.wadsworth.com/sociology_d/virtual/12.html# Virtual tour of population issues with an assignment for students parts of which teachers may find suitable for high school students. http://www.epa.gov/pesticides/ E PA's Office of Pesticide Programs. http://www.epa.gov/surf3/ EPA "Surf Your Watershed" site with information on watershed indicators including nitrogen runoff. http://www.cvm.umn./edu/depts/raptor center/education/lesssonplans/ Bio-accumulation activity, aquatic issues

Safety in the Science Classroom and Laboratory

Chemical Management:

In North Carolina, it is the responsibility of the Superintendent of a school system to appoint a qualified chemical hygiene officer to direct the development of and compliance with the chemical hygiene plan for the school system. This plan must include protocols and processes for chemical management for science laboratories and preparation rooms, as well as, professional development for science teachers and administrators. Because laws, codes and standards change, the plan must be reviewed and updated annually or more often as necessary.

Instruction, Supervision, and Maintenance of a Safe Learning Environment:

In North Carolina, it is the teacher's responsibility to address safety in planning instructional activities, laboratory investigations, and to supervise students so that all activities and investigations are carried out in a safe manner. The teacher is responsible for adhering to professional standards, NC laws and codes when assessing the learning environment. Ongoing professional development is an essential part of ensuring laboratory safety.

It is the principal's responsibility to provide personal protective equipment and resources to ensure science teachers can teach the North Carolina's science curriculum safely. All *North Carolina Standard Course of Study* Science classes are designed to be laboratory courses and must include a laboratory component.

The suggestions and resources for science safety and resources included here are in no way comprehensive but may serve as a quick reference for a few common safety issues.

1) Chemicals:
    a. Order only the amounts you will use for one year. Do as much microchemistry as possible to minimize hazards
    b. Be sure you have an appropriate storage system for chemicals.
    c. You must have the MSDS available for all chemicals in your classroom/prep room (including kitchen/grocery store chemicals). You should go over the MSDS information with students each time they will be using a chemical. Document this in your lesson plan book.
    d. Use the smallest amounts and weakest/most dilute concentrations of chemicals that you can and still have a viable investigation/demonstration.
    e. Be sure you have appropriate disposal arranged before using a chemical.
    f. Avoid the use of toxic chemicals.
    g. Sulfur is a common allergen. Reactions that use or produce sulfur compounds should be performed under a working hood.

h. Go over all hazards and safety precautions with students prior to each laboratory investigation/activity and document in your lesson plan book and with student work samples (i.e. quizzes or prelab assignments).
i. Be aware of latex allergies that some students have. Alternative types of gloves must be provided when students need gloves.

2) Be sure goggles are appropriate and meet standards for the planned investigation. Goggles designed for impact are different than those designed to protect against fluid splashing. Chemical splash goggles are required anytime students are using fluids. Be sure contact lens wearers have non-vented chemical splash goggles. Visor-type goggles are NOT appropriate or safe for activities using fluids.

DISCLAIMER: Mention of any company or product does not constitute endorsement by the NCDPI. In addition the inclusion of links to websites is not intended to reflect endorsement by DPI, nor is it intended to endorse any views expressed or products or services offered by the author of the reference or organization operating the server on which the reference is maintained. Also, suggestions for activities do not mean that these are the only way to conduct an experiment or activity.

Resources and References for Science Safety:

NCDPI Total Science Safety Program: Contact Benita Tipton, Science Consultant, btipton@dpi.state.nc.us. (919) 807-3933.

NCDPI School Insurance http://www.ncpublicschools.org/fbs/insurance/
This office will help you with risk control, safe facilities, and fire safety issues. Their website has several pages that address science safety issues and has links to websites with federal and state laws and codes.

NCDPI Publications

NCDPI has a variety of science safety posters – currently available: Science Safety Signs, Goggles: It's the Law, and a Science Chemicals Poster which provides a chart for the teacher to enter the title and date of a lab exercise along with information about specific chemicals, including the NFPA Hazards Rating, Personal Protective Equipment and the Waste Disposal Method.

The NCDPI **School Science Facilities Planner** is available to download as a PDF file http://www.schoolclearinghouse.org/pubs/SCIENCE.PDF

Other Resources

American Chemical Society
American Chemical Society Safety Guidelines
Chemical Safety for Teachers and Their Supervisors: Grades 7-12
Safety Audit/Inspection Manual
Teachers can order single copies by calling ACS at 1-800-227-5558.

29 CFR 1910 OSHA
General Industry Regulations
www.oshacfr.com

CRC Handbook of Laboratory Safety
5th edition
A. Keith Furr
www.crcpress.com

2000 Emergency Response Guidebook
U.S. Dept of Transportation
Research and special Programs Administration
http://hazmat.dot.gov/gydebook.htm

A Guide to Working With Corrosive Substances
Harry E. Payne, Jr
North Carolina Occupational Safety and Health Standards for General Industry
NC Department of Labor
Division of Occupational Safety and Health
4 West Edenton Street
Raleigh, NC 27601-1092

Handbook of Chemical Health and Safety
Robert J Alalmo editor
Learning by Accident
Edited: Fariba Mojtabai & James Kaufman
Volume # 2
The Laboratory safety Institute
192 Worchester Road
Natick, MA 01760

It's Elementary… and Beyond
www.chemed.org

MSDS Sheets for Chemicals (Material Safety Data Sheets)
Numerous sources – here are some links
www.flinnsci.com/homepage/cindex.html

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www.uvm.edu/uvmsafety/labsafety/chemsafety/netmsds.html (grocery/kitchen chemicals)
www.msds.pdc.cornell.edu/msdssrch.asp
www.fishersci.com
www.osha.gov
www.cdc.gov/niosh

National Science Teachers Association www.nsta.org
Click on *Publications* and *Position Statements.*
Numerous NSTA position statements on Safety, Field Trips, Class Size, etc.
NSTA Safety Publications:
Exploring Safely: A Guide for Elementary Teachers- Terry Kwan & Juliana Texley
Inquiring Safely: A Guide for Middle School Teachers- Terry Kwan & Juliana Texley
Investigating Safely: A Guide for High School Teachers- Juliana Texley, Terry Kwan, & John Summers

The OSHA Answer Book (7th edition)
Mark Moran

Right-To Know Pocket Guide for school & University Employees
National Fire Rating System Reference Guide
Lab Safety Supply
PO Box 1368
Janesville, WI 53547-1368
1-800-356-0783

Safetycertified.com
1536 Kingsley Ave
Suite 126
Orange Park, FL 3207
1-800-597-2040

Safety in Academic Chemistry Laboratories
Volume 2
Accident Prevention for Faculty and Administrators 7th ed
(also have student version)
American Chemical Society
1155 16th St, NW
Washington, DC 20036

Safety in the Elementary (K-6) Science Classroom
Second Edition
Committee on Chemical Safety
1155 Sixteenth St, NW
Washington, DC 20036
Chemistry.org

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Safety in High School and College Laboratories
Fisher Science Education
1 800 955 1177
1 800 955 0740 (f)
www.fisheredu.com

Science Classroom Safety and the Law
Flinn Scientific Inc.
P.O. Box 219
Batavia, IL60510
E-mail: flinn@flinnsci.com
Website: www.flinnsci.com

Science Laboratory Safety Manual
Linda M. Stroud, Ph.D.
www.sciencesafetyconsulting.com

Other safety resources are available from several science supply catalogs.

Suggested Chemicals and Equipment List for Basic Biology Activities and Labs

This is not meant to be a complete list, but rather a starting point for equipping a biology classroom/laboratory. ** Please note that amounts are based on the National Science Standard recommended class size of 24. ** Remember that MSDS sheets need to be kept for every chemical in your laboratory including household chemicals!

Common Household Chemicals
Baking soda
Corn starch
Corn syrup
Distilled water
Eggs
Isopropyl alcohol
Table salt
Vegetable oil
Vinegar

Common Household Items	
Equipment	*Quantity*
Aluminum foil	1 box
Beans	4 bags
Calculator	24
Coffee filter	1 box
Cooler for ice	1
Construction paper	1 pkg
Elodea	2 bundles
Goldfish crackers	2 per class
Liver/potato for catalyse	1 pkg.
Newspaper	1
Pennies	4 rolls
Plastic cups	2 pkg
Plastic wrap	1 box
Ruler (small plastic)	24
Scissors	24
Stopwatch	12
Toothpicks	1 box

Order living and/or prepared specimens as needed based on individual preferences.

Laboratory Chemicals
Bromothymol blue
Ethanol
Hydrogen peroxide
Iodine
Litmus paper
Methylene blue
ph indicators
Protoslow
HCl
NaOH

Laboratory Equipment	
Equipment	*Quantity*
Aprons	24
Cover slips	1 box
Beaker-100mL	24
Beaker-250mL	24
Beaker-50mL	24
Beaker-600mL	12
Dialysis tubing	1 box
Dissecting pans	12
Dissecting scissors	12
Droppers	24
Forceps	12
Goggles	24
Graduated cylinder	12
Hot hands	6
Hot plates	12
Individualized dry erase boards	12
Meter sticks	12
Microscopes	12
Microscope slides	1 box
Prepared slides- mitosis	12
Prepared slides- other	Varies
Stirring rod	24
Test tube clamp	12
Test tube rack	12
Test tubes	100
Thermometer	12

All safety related equipment can be found in the Safety in the Science Classroom and Laboratory section.

Who Does Science? An Exploration of Minority Scientists, Physicians, and Inventors: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify biological problems and questions that can be answered through scientific investigations.

Essential Question(s):

What is the significance of scientific investigation?

Introduction to teacher:

As biology teachers we sometimes struggle to help our students understand that historically there have been many women and people of all ethnicities who have done the work of science. This project was originally designed to target African-American scientists and the students completed the project in February (Black History Month). But now, I have expanded the project to include a variety of minority scientists and I do the project at the beginning of the year. The intention is that students will start the year understanding that our understanding of the living world is based on the work of a huge number of scientists from many different ethnic groups and of both genders. The students also become aware of the range of biological sciences and the variety of research methods used in science.

Note: This project is very "low-tech" except for the use of the internet for research. A teacher could adapt the final product, however. Instead of a poster presentation, students could create a PowerPoint presentation or create a brochure about their scientists.

There are many books that highlight minority scientists and physicians. Your school library may be willing to purchase some of them. A source for some of these books is Amazon.com.

The student pages for this activity have a resource list of useful websites. These were all active websites at the time this activity was written. However, they should be checked and updated each year. Some of these websites have further links that might be helpful.

The list of scientists could be extended to include other (non-minority scientists) as well, but the premise behind this activity is to highlight minority contributions to biology.

Safety/Special Considerations:

Make sure there are no repeats of chosen scientists.

References: This activity was contributed by Judy Jones, (East Chapel Hill High School, NC)

July 2007

Who Does Science? An Exploration of Minority Scientists, Physicians, and Inventors: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify biological problems and questions that can be answered through scientific investigations.

Essential Question(s):

What is the significance of scientific investigation?

Introduction:

The purpose of this project is help you learn about the many Minority Scientists and Inventors who have contributed to our scientific body of knowledge and to the well-being of all people. The focus is on people who studied biology and/or medicine although there are some other people included.

A great variety of scientists have contributed to our body of knowledge about biology. Sometimes our textbooks make it seem as if only a few scientists have been involved in the work of biological investigation but in fact, men and women from all over the world have researched and explored our natural world to try and understand how living things function. They have also searched for answers to human diseases and disorders and have invented devices to improve human health. This project is designed to help you learn about just a few of these interesting people.

Materials:

- Poster board
- Computers
- Internet connection
- Markers

Procedure:

STEP 1 - Research: You will research one scientist from the list that has been provided. Each student will research a different person. The internet will give you adequate information on each of the people listed. However, you might find additional information in print resources. You should find at least two different sources; however, for some scientists there are many more sources that you can find. Be sure to keep track of the information you need for your bibliography. Try to find out the following facts about your scientists.

- Birth and possibly death dates.
- Ethnicity and gender.
- Where the person grew up and what their early life was like.
- Where the person went to school and what he or she studied.
- How they became a scientist.
- What their area of research or their contribution was/is.

STEP TWO - Project: After you get all of your information, you will prepare a "proposal" supporting your scientist for selection as "Time Magazine Man or Woman of the Year". Your proposal should include:

- Basic biographical facts about your scientist – birth and death dates, place of birth, childhood experiences, education, career pathway, etc.
- A picture (scanned, downloaded, or hand-drawn).
- A list of reasons why this person should be given recognition on the cover of "Time Magazine." (What significant contributions has this person made?)
- Bibliography

You will present your project in the form of a poster advertisement. Your advertisement should include your proposed design for the "Time Magazine" cover showing the scientist you researched. Paste your bibliography to the back of the poster. Make sure your name is in the lower right hand corner of your poster.

On the next page is a list of possible scientists.

References (for further research):

http://www.princeton.edu/~mcbrown/display/faces.html
African American Scientists

http://www.infoplease.com/people.html?link=tmplnav
various scientists

http://www.distinguishedwomen.com/subject/BlackHist.html
Women Scientists
http://www.calacademy.org/research/library/biodiv/biblio/Africansci-update.htm
African American Scientists

http://www.mclibrary.duke.edu/hot/blkhist.html
African American Scientists

http://www.ceemast.csupomona.edu/nova/scientist.html
Minority scientists

http://justgarciahill.org/webbiography.asp
Minority scientists

http://64.171.10.183/biography/default.asp
Latino and Native American Scientists

http://www.astr.ua.edu/4000WS/4000WS.html
Women Scientists

http://carnegieinstitution.org/first_light_case/horn/careers/careersindex.html
Minority Scientists (Wash. D.C.)

http://www.nlm.nih.gov/changingthefaceofmedicine/physicians/biography_142.html
Women Physicians

http://carnegieinstitution.org/first_light_case/horn/careers/careersindexh.html
Hispanics in science

Rubric:

I. **Introduction (5%):** Name scientist, statement of why they should be chosen (brief)
II. **Biography (40%):** Information listed in Step 1 as well as the steps leading to their discovery, whether or not the results were understood at the time, the value of the results, and other awards/validation of their importance
III. **Why they deserve the award (10%):** Explain and give reasons
IV. **Bibliography (5%):** Included and in the correct format
V. **Cover of magazine/poster (40%):** Quality, accuracy, includes insight to discovery (at the teacher's discretion: 3 minute presentation to class)

Scientist	Field	Birth/Death
Bath, Patricia	Physician, laserphacoprobe for cataracts	1942-
Benacerraf, Baruj	Medicine, physiology	1920-
Brown, Dorothy Lavinia	1st AA female surgery resident in south	1919-
Canady, Alexa	Neurosurgeon	1950-
Carson, Benjamin S.	Pediatric neurosurgeon	1951-
Carver, George Washington	Agricultural science	1864-1943
Chinn, May Edward	1st AA female intern Harlem Hosp	1896-1980
Cobb, Jewel Plummer	Rutgers biology professor	1924-
Cobb, W. Montague	Physician and medical education	1903-
Cole, Rebecca J.	1st AA female to estab. med practice in PA	1846-1922
Cota-Robles, Eugene	Microbiology	1926-
Dickens, Helen Octavia	1st AA female in American College of Surgeons	1909-
Drew, Charles	Physician, preservation of blood plasma	1904-1950
Dukepoo, Frank	Genetics, Native American, Hopi	1944-1999
Elders, (Minnie) Joycelyn	Physician, U.S. Surgeon General	1933-
Emeagwali, Dale	Microbiology	1954-
Garcia, Fabian	agronomist	1871-1948
Griffin, Bessie Blount	Eating device for invalids	1913-
Hall, Lloyd Augustus	Chemist and inventor (curing meat)	1894-1971
Hill, Rosa Minoka	Mohawk physician and good Samaritan	1875-1952
Ho, David	AIDS research	1952-

Hinton, William Augustus	Harvard Med School – syphilis test	1883-1959
Jemison, Mae C.	1st AA female in space, physician	1956-
Julian, Percy Lavon	Chemist – glaucoma research	1899-1975
Just, Ernest Everett	Biology researcher, graduated from Dartmouth	1883-1941
Khorana, Har Gobind	Genetic code	1922-
Kountz, Samuel Lee	Kidney specialist	1930-1981
Lushington, Augustus N.	1st AA DVM - veterinarian	1869-1939
Mahoney, Mary Elizabeth	1st AA graduate nurse	1845-1926
Maathai, Wangari	Green belt	1940-
McClendon, Dorothy	Microbiology research - army	1924-
Molina, Mario	Ozone and CFC effects in environment – Nobel Prize	1943-
Moore, Ruth Ella	1st AA female PhD in bacteriology	1903-1994
Morgan, Garrett Augustus	Inventor, including gas mask	1877-1963
Mossell, Nathan Francis	Physician, started hospital, uncle to Paul Robeson	1856-1946
Ochoa, Severo	Medicine (RNA/DNA)	1905-1993
Owens, Ida	Biochemist – detoxifying enzyme genetics	1929-
Patterson, Frederick D.	Founded only black veterinarian school-Tuskegee	1901-1988
Ramon Y Cajal, Santiago	physiology	1852-1934
Satcher, David	1st AA director CDC – U.S. Surgeon General	1941-
Staupers, Mabel	Nurse – army integration	1890-1989
Steward, Susan McKinney	1st AA grad NY state med. sch.	1848-1918
Subbarow, Yellapragada	Biochemistry (folic acid, tetracycline, antimalaria)	1895-1948
Taylor, Susie King	1st AA female army nurse	1848-1912
Turner, Charles Henry	HS biology teacher, professor, entomology	1867-1923
Lydia Villa-Komaroff	Molecular biology, professor neurology	1947-
Walker, Madame C.J.	Inventor, cosmetics	1867-1919
Williams, Daniel Hale	Physician, open heart surgery pioneer	1856-1931
Wong-Staal, Flossie	AIDS	1947-
Wright, Jane Cooke	1st AA female assoc. dean major med. sch.	1919-
Young, Roger Arliner	Zoologist, mentor was Ernest Just	1889-1964

Osmosis and the Egg

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02: Design and conduct scientific investigations to answer biological questions.

1.03: Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to:

a) Explain observations.
b) Make inferences and predictions.
c) Explain the relationship between evidence and explanation.

Goal 2: The learner will develop an understanding of the physical, chemical and cellular basis of life.

2.03a: Investigate and analyze the cell as a living system including: maintenance of homeostasis.

2.03b: Investigate and analyze the cell as a living system including: movement of materials into and out of cells

Introduction to the Teacher

Living cells prefer to be in a state of equilibrium and will regulate the passage of substances in and out through the cell membrane to maintain a balance with the surroundings. This process is called homeostasis, Water is the most important inorganic substance required by cells for life processes. As the plasma membrane is selectively permeable, these small changes in the environmental surroundings are handled by the passage in and out of cells through the membrane. Passage of some substances requires energy to be completed (active transport) while others require no energy (passive transport) and still others cannot pass through the membrane at all. Water is easily passed through the membrane via passive transport. It passes from an area of greater concentration to an area of lesser concentration. Another way of thinking of this is that water is moved to where there is more dissolved solute. As the concentration of solutes changes, water shifts to balance the concentration of dissolved solutes. A raw egg (with shell removed by vinegar) can be very effective in demonstrating osmosis, when it is placed in different environments. This lab takes 3 partial periods to complete, but only a minimum amount of time is required for each part. It could be shortened to 2 days if the teacher decalcifies the egg in vinegar ahead of time. It can be effectively carried out while introducing concepts related to homeostasis. Similar activities can he carried out by using a potato cube in water and salt water although the results are not as dramatic. Dialysis tubing is also semi-permeable as are "cheap" sandwich bags. Opposing solutions can also be set up with tubing. For example:

A) Molasses in dialysis tubing "cell" placed in a beaker of water.
B) Water in dialysis tubing 'cell" placed in a beaker of molasses.

C) Iodine solution in dialysis tubing "cell" placed in a beaker of starch and water.
D) Starch and water in dialysis tubing "cell" placed in a beaker of iodine solution.
A way to make this an inquiry activity is to allow the students to develop their own hypotheses about transport in and out of the egg (or another item that models the semi-permeability of the cell membrane) with different substances. They could bring these substances in from home and perform their inquiry labs during the class period.

Safety Considerations

Since the standard lab just involves household materials one concern is the cleanup of the syrup. Goggles should be worn if the students are handling anything that poses a danger to the eyes. If the students bring in substances from home to test, then those substances would need to be checked for any potential hazards.

References

The original source of this activity is unknown. It was modified from original use and written by Elizabeth Pressley at Bartlett Yancey High School.

Osmosis and the Egg: Activity

Purpose

Investigate the effect of different solutions on an egg cell.

Materials (per person or lab group)

- 1 raw egg
- plastic drinking cup or beaker (200-400 *ml)*
- Tap water
- Pancake syrup
- Plastic spoon
- Balance
- Marker
- Paper towels

Procedure

Day 1

1. Wear your safety goggles and lab apron.
2. Obtain a raw egg
3. Label a cup with your name.
4. Place your egg in the cup and cover with cider vinegar.
5. Place cup, egg, and vinegar in a place designated by your teacher until tomorrow.

Day 2

1. Wear your safety goggles and lab apron.
2. Using the plastic spoon carefully remove your egg. *Be very gentle as the egg will have lost its protective shell and only a thin membrane remains. This membrane is very like the membrane around each cell in living things and is selectively permeable (allowing certain substances to pass through the membrane in order to maintain homeostasis).*
3. Rinse the cup (beaker) with water and dry.
4. Rinse the egg and dry with paper towels by rolling it around gently on paper towels.
5. Weigh the dry cup and record the mass. Add the egg and record combined mass.
6. Determine the mass of the egg alone and record.
7. Predict whether you think the egg will gain, lose, or stay the same mass when placed in a cup of water for 30 minutes.
8. Cover the egg with water in your cup and leave on your table for 30 minutes while class continues.
9. After 30 minutes, remove the egg from water using the plastic spoon. Dry the cup and the egg.
10. Mass the egg in the dry cup once again and record.
11. Predict what will happen to the eggs mass if placed in pancake syrup for 24 hours.
12. Cover the egg with syrup. * Note: The egg will float up on the syrup. This is normal.
13. Place in a safe place overnight.

Day 3

1. Carefully remove the egg from syrup using the spoon.
2. Rinse the egg carefully with water to remove the syrup from the egg. Consult teacher for proper disposal of syrup.
3. Rinse the cup and dry. Again, mass the egg and record the final mass.
4. Dispose of the egg as directed by your teacher.

Lab Data

Record the mass of each of the following: (*Mass in grams*)

- Cup with group label
- Decalcified egg + cup (after being in vinegar)
- Decalcified egg alone
- Prediction of mass of egg (after being in water)
- Actual mass of egg after 30 minutes in water
- Prediction of egg mass after 24 hours in pancake syrup
- Actual mass of egg after being in syrup 24 hours

Questions to Guide Analysis

1. Did the egg gain mass in either situation? If so, which one(s) and why?
2. Did the egg lose mass in either situation? If so, which one(s) and why?
3. Did the syrup or water change in appearance after the egg was immersed for the specified period of time? If so, how did it change?
4. What is the substance that entered or left the egg in each situation that resulted in the mass change?
5. Which solution was a hypertonic environment with respect to the egg cell? Hypotonic? Isotonic?
6. Why was it necessary to remove the shell from the egg before experimenting with different solutions?
7. Why do bacteria not grow well in jellies/jams? Hint: Jellies are fruits to which much sugar has been added.
8. What do you think would happen to the egg if placed in very salty water? Why? (If time permits, try this.)

Extensions

Design and perform an experiment to determine if some other substances will or will not pass through the membrane.

How Do Biological Materials Respond to Acids and Bases?: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02: Design and conduct scientific investigations to answer biological questions.

1.03: Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to:

d) Explain observations.
e) Make inferences and predictions.
f) Explain the relationship between evidence and explanation.

Goal 2: The learner will develop an understanding of the physical, chemical and cellular basis of life.

2.03: Investigate and analyze the cell as a living system including: maintenance of homeostasis.

Introduction to the Teacher

Even small changes in pH can cause distress to organisms. The changes in hydrogen ion concentration in cells can change the rates of some chemical reactions. For example, the pH of human blood is normally about 7.4 and must be in the range of 7.0-7.8 for survival. If the pH is in the 7.0-7.3 range the person will feel tired, have trouble breathing, and may even be disoriented. If the pH of the blood is in the 7.5-7.8 range, the person will feel dizzy and rather agitated.

It is very important for organisms to be able to maintain a fairly constant internal environment (homeostasis). To prevent the hydrogen ion concentration of the cytoplasm from changing too much, cells have chemical compounds called "buffers" that will bind with hydrogen ions when their concentration increases too much. Buffers can also release bound hydrogen ions when their concentration in the solution decreases too much. In our blood stream, carbonic acid (H_2CO_3) acts as the buffer that maintains our blood pH within a normal range.

$$\mathbf{H_2CO_3 \leftrightarrow HCO_3 + H^+}$$

Products such as Alka Seltzer take up hydrogen ions and reduce the acidity of the stomach fluids. They consist of sodium bicarbonate, citric acid, and salicylate analgesic. When placed in water, sodium citrate and carbon dioxide are produced. Sodium citrate is a strong buffer. A whole tablet can be mixed with 150 ml of water. Shake to get the carbon dioxide out of the solution and then it is ready for the experiment below.

In this laboratory, students will investigate how several materials respond to the addition of an acid and a base to determine whether living materials have buffering capacity.

The teacher can decide how much information to give the students in advance. The students can follow the generic procedure using a great variety of biological materials and try to figure out the explanation for their results. Typically, when acid is added to water, the pH will drop quickly and then level out. Conversely, when base is added to water, the pH will rise quickly and then level out. When acid or base is added to buffer, the pH barely changes. The results with the homogenates is some place in between these two, which suggests that biological materials have some buffering capacity.

Some classes may be ready to design their own data tables or you may choose to provide students with the data tables provided below, modified for the homogenates you have available.

You may want to divide the class into groups so that each group only tests one homogenate and then the class can share data. This method will reduce the amount of time the lab takes.

Safety Considerations

Students should wear goggles and lab aprons while performing their experiments. Chemicals should be disposed of according to MSDS guidelines.

References

This activity was adapted from the *BSCS Biology: An Ecological Approach*, 8th edition, and was modified and written by Judy Jones at East Chapel Hill High School.

How Do Biological Materials Respond to Acids and Bases? Activity

Purpose

To study the response of biological materials to acids and bases

Materials (per person or lab group)

- pH meters (narrow range pH paper can be used)
- 50 ml beakers (flasks, beakers, or large test tubes may be used)
- graduated cylinder
- various homogenates (A typical "recipe" would be to mix 10g of biological material such as potato, celery, mushroom, yeast, liver, or egg white with 100 ml of water and mix well in a blender.)
- pH 7 buffer solution (buffer capsules are easy to use)
- Alka Seltzer solution (1 tablet for 150 ml water, shake to release CO2)
- 0.1 M NaOH
- 0.1 M HCl

Procedure

You will measure the changes in pH resulting from adding acid and base to plain tap water, each of the homogenates, the pH 7 buffer solution, and the Alka Seltzer solution. Make sure you record all of your pH measurements in your data charts.

- Pour 25 ml of tap water into the 50 ml beaker. Measure the pH of the solution. Record in Table 1.
- Add 0.1 M HCl one drop at a time, swirling after each drop. After you have added 5 drops, measure the pH again. Record in Table 1.
- Repeat steps 2 until a total of 30 drops have been added.
- Rinse the beaker well and add another 25 ml of solution.
- Follow steps 2 and 3 again, but this time use 0.1 M NaOH and record in Table 2.
- Repeat the whole procedure for the buffer solution, the Alka Seltzer solution and each of the homogenates.

Graph your results. You can put your results for all of the materials on the same graph, using different colors for each material. Use separate graphs for the response to HCl and the response to NaOH. Be sure to write the name of the material at the end of each line.

Lab Data

Table 1: The pH of various homogenates after adding HCl

	Initial pH	5 drops HCl	10 drops HCl	15 drops HCl	20 drops HCl	25 drops HCl	30 drops HCl
Tap water							
Buffer pH 7							
Alka Seltzer							
Potato							
Egg White							
Yeast							
Celery							
Liver							
Mush-room							

Table 2: The pH of various homogenates after adding NaOH

	No NaOH	5 drops NaOH	10 drops NaOH	15 drops NaOH	20 drops NaOH	25 drops NaOH	30 drops NaOH
Tap water							
Buffer pH 7							
Alka Seltzer							
Potato							
Egg White							
Yeast							
Celery							
Liver							
Mush-room							

Table 3: Summary of results

Solution Tested	Final pH	Initial pH	Change in pH
Water with HCl			
with NaOH			
Buffer with HCl			
with NaOH			
Alka Seltzer with HCl			
with NaOH			
Potato with HCl			
with NaOH			
Egg White with HCl			
with NaOH			

Yeast with HCl			
with NaOH			
Celery with HCl			
with NaOH			
Liver with HCl			
with NaOH			
Mushrooms with HCl			
with NaOH			

Questions to Guide Analysis:

1. Examine your graphs. Are the responses of the biological homogenates to the addition of acid and base more similar to the responses of the tap water or to the responses of the buffer solutions? Explain your observations.
2. Which of your homogenates has the most buffering capacity? How did you determine this?
3. What did you learn about the ability of living systems to regulate pH?
4. Explain why buffers are important to living systems.

Properties of Enzymes: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02: Design and conduct scientific investigations to answer biological questions.

Goal 2: The learner will develop an understanding of the physical, chemical and cellular basis of life.

2.04: Investigate and describe the structure and function of enzymes and explain their importance in biological systems

Introduction to the Teacher

This lab is an adaptation of labs that have appeared in the *BSCS (Biological Sciences Curriculum Study)* textbooks for decades. This version has been broken down into different procedures; each procedure addresses a specific characteristic of enzymes. Teachers can choose to use some or all of the procedures. Teachers can also choose to have students develop their own procedures for some or all of the activities.

The chemical reaction involved is the breakdown of hydrogen peroxide (H_2O_2) into water (H_2O) and oxygen gas (O_2). Catalase, an enzyme found in living cells, speeds up the breakdown of the hydrogen peroxide. Hydrogen peroxide is produced in cells as a toxic waste product.

It is recommended that the teacher have the students do Activity 1 (Specificity) first, as an exploration. After students discover that the liver homogenate will only break down hydrogen peroxide, the teacher can give a short lesson on enzyme function. As part of the discussion, the teacher can demonstrate the glowing splint test for the presence of oxygen gas. (Put 3 ml H_2O_2 into 2 ml of liver homogenate; after the reaction is completed, light a wood splint, blow it out so that it is merely glowing, and place it in the test tube. The wood splint will reignite due to the presence of oxygen gas.)

After the lesson on enzymes, the students can complete the rest of the activities. One option is to set up 5 different stations, one for each of the activities and have the students work in a jigsaw arrangement. Each group of 5 students will send one member to one of each of the stations. That student becomes an "expert" on that enzyme characteristic and reports back to his or her group. Another option is to give students the explicit instructions for the first four activities, but have the students conduct an open-ended exploration (inquiry) for the last two activities (effects of pH and temperature on enzyme activity). The students can propose their own hypotheses and design their own experiments.

Students may need to repeat the step of pouring fresh hydrogen peroxide on the used liver several times in activity 2 to decide whether the enzymes are reusable or just hadn't been

used up the first time. For activity 6, if time permits, encourage students to test a wider range of pH.

For this lab, you will be using homogenates. Using a homogenate allows some control over volume of enzyme used in each experiment. Homogenates are easy to prepare. You simply put frozen or fresh material (liver, potato, etc.) and distilled water and combine them in a blender until liquid. It is not necessary to filter the material; however, remind the students to stir up their homogenate solutions before using to evenly distribute the material. Number of drops of homogenates used in some of the activities may need to be adjusted depending on the strength of the homogenates you prepare.

Safety Considerations

Extreme care should be taken with the use of 3M HCl and NaOH. In particular, students should be advised to wear protective clothing and eyewear.

References

This activity was adapted from the *BSCS (Biological Sciences Curriculum Study)* textbook, and was modified and written by Judy Jones at East Chapel Hill High School

Properties of Enzymes: Activity

Purpose

To investigate the properties of enzymes

Materials

- homogenate chicken liver, beef liver, mushroom, potato, and celery
- chunks of beef liver and potato
- iced and boiled homogenates
- 3% H_2O_2 (hydrogen peroxide—available at drug stores)
- distilled H_2O
- acetic acid (vinegar)
- carbonic acid
- 3 M HCl
- 3 M NaOH
- droppers
- thermometers
- stirring rod
- beakers
- clock with second hand, or stop watches
- 8 test tubes per group
- mortar and pestle
- small amount of sand
- pure catalase (optional)

Introduction to Student

Enzymes are molecules that speed up chemical reactions in living cells. They are biological catalysts. The enzyme you will be studying is called catalase; it speeds up the breakdown of hydrogen peroxide which is a toxic waste product produced by living systems. In this lab, you will study the characteristics of enzymes and some of the things that affect enzyme function.

$$\mathbf{2H_2O_2 \rightarrow 2H_2O + O_2}$$

ACTIVITY 1: ARE ENZYMES SPECIFIC?

Procedure

1. Label 4 test tubes A, B, C, and D.

2. Put 3 ml of liver homogenate in each tube.

3. Put 3 ml of the following substances in each tube as noted:
   A: distilled water
   B: hydrogen peroxide
   C: acetic acid
   D: carbonic acid

4. Observe the reactions and record results on a Data Chart 1.

Table 1: Specificity of Enzymes

Test Tube	Description of Results with Liver Homogenate	Description of Results with Pure Catalase (optional)
A: Distilled Water		
B: Hydrogen Peroxide		
C: Acetic Acid		
D: Carbonic Acid		

Questions to Guide Analysis:

1. Which substances appeared to react with the liver homogenate?

2. Are enzymes specific? What evidence do you have for your answer?

3. The formula for hydrogen peroxide is H_2O_2. What are the breakdown products?

4. What kind of biological molecule is an enzyme?

5. How do you account for the differences in the reactions with liver homogenate and the reactions with pure catalase?

ACTIVITY 2: ARE ENZYMES REUSABLE?

Procedure

1. Label two test tubes A and B.

2. Put a pea-size piece of liver in each.

3. Add H_2O_2 to tube A; let the reaction come to completion. Record as reaction A on Table 2.

4. Pour only the solution from tube A onto the liver in tube B. Record as reaction B on Table 2.

5. Then pour fresh H_2O_2 onto the old liver in tube A. Record as reaction C on Table 2.

Table 2: Reusability of Enzymes

Reaction Letter	Time for Complete Reaction (sec)	Comparative Description of Reactions
A: Liver Piece + Peroxide		
B: New Liver + Old Peroxide		
C: Old Liver + New Peroxide		

Questions To Guide Analysis:

1. Which substance is reusable—the substrate or the enzyme from the liver? Support your answer with evidence.

2. In Reaction B, what is the "old peroxide?"

ACTIVITY 3: IS CATALASE FOUND IN ALL SPECIES?

Procedure

1. Label 5 test tubes A-E.

2. Put 3 ml of the following substances in each test tube:
   A: beef liver homogenate
   B: chicken liver homogenate
   C: potato homogenate
   D: mushroom homogenate
   E: celery homogenate

3. Put 3 ml of hydrogen peroxide in each test tube.

4. Observe the reactions and record data in Table 3.

Table 3: Enzymes Across Species

Test Tube	Time for Complete Reaction (sec)	Comparative Description of Reactions
A: Beef Liver		
B: Chicken Liver		
C: Potato		
D: Mushroom		
E: Celery		

*other species may be tried also

Questions To Guide Analysis:

1. What happens when you put hydrogen peroxide on the biological materials? What does this evidence suggest? Do you think they contain catalase?

2. What happens when you put hydrogen peroxide on a wound? What does this evidence suggest?

3. Explain why so many species produce the catalase enzyme.

ACTIVITY 4: HOW DOES SURFACE AREA AFFECT REACTION RATE?

Procedure

1. Label 8 test tubes A-H.

2. Put the following substances in each test tube as noted:
   A: pea-sized piece of liver
   B: pea-sized piece of liver, ground up using mortar and pestle and a little sand (to aid in grinding)
   C: pea-sized piece of potato
   D: pea-sized piece of potato, ground up using mortar and pestle and sand
   E: 1 drop of liver homogenate
   F: 3 drops of liver homogenate
   G: 5 drops of liver homogenate
   H: 7 drops of liver homogenate

3. Add 3 ml of hydrogen peroxide to each test tube.

4. Observe the reactions and record on Table 4.

Table 4: Surface Area and Enzyme Action

Test Tube	Time for Complete Reaction (in sec)	Comparative Description of Reactions
A: pea size piece of liver		
B: ground liver		
C: pea size piece of potato		
D: ground potato		
E: 1 drop liver homogenate		
F: 3 drops liver homogenate		
G: 5 drops liver homogenate		
H: 7 drops liver homogenate		

Questions to Guide Analysis:

1. How do you explain the difference in the reactions between ground liver/potato and the whole liver/potato?

2. How do you explain the difference in the reaction times with the different amounts of homogenate?

3. How does the amount of surface area of liver exposed affect the reaction rate?

4. Write a clear statement relating numbers of enzyme molecules, length of reaction time, and rate of reaction. (Assume that the amount of H_2O_2 remains constant).

ACTIVITY 5: HOW DOES TEMPERATURE AFFECT ENZYME FUNCTION?

Procedure

1. Label 6 test tubes A-F.

2. Put test tubes A and D in a beaker of ice.

3. Add 3 ml liver homogenate to test tube A and 3 ml potato homogenate to test tube D. Use the homogenate supplies that are on ice.

4. Put 3 ml room temperature liver homogenate in test tube B and 3 ml room temperature potato homogenate in test tube E.

5. Put 3 ml boiled liver homogenate in test tube C and 3 ml boiled potato homogenate in test tube F. (boiled homogenates should be cooled to room temperature)

6. Add 3 ml hydrogen peroxide to each test tube.

7. Observe reactions and record on Table 5.

Table 5: Temperature and Enzyme Action

Test Tube	Time for Complete Reaction (sec)	Comparative Description of Reactions
A: Liver on Ice		
B: Liver at Room Temperature		
C: Liver, Boiled		
D: Potato on Ice		
E: Potato, Room Temperature		
F: Potato, Boiled		

Questions To Guide Analysis:

1. What is the relationship between temperature and enzyme activity? Use evidence from your experiments to support your statement.

2. What happens to enzyme molecules in extreme temperatures?

3. Were any of your results surprising? Explain.

4. What might happen to a human being if a fever gets too high?

ACTIVITY 6: HOW DO CHANGES IN pH AFFECT ENYZME FUNCTION?

Procedure

1. Label 3 test tubes A, B, and C.

2. Add 3 ml liver homogenate to each test tube.

3. Add 3M HCl and 3M NaOH as follows to the test tubes:
   A: 1 drop 3M HCl
   B: no acid/no base
   C: 1 drop 3M NaOH

4. Measure the pH of each solution.

5. Add 3 ml of hydrogen peroxide to each test tube.

6. Observe reactions and record in Table 6.

Table 6: pH and Enzyme Activity

Test Tube	pH	Time for Complete Reaction (sec)	Comparative Description of Reactions
A: 1 drop HCl			
B: no acid/no base			
C: 1 drop NaOH			

Questions to Guide Analysis:

1. What is the relationship between pH and enzyme activity?

2. Stomach enzymes work best at a pH of 2. How might a pH of 4 in the stomach affect digestion?

Lab Data

Record the mass (in grams) of each of the following:

- Cup with group label

- Decalcified egg + cup (after being in vinegar)
- Decalcified egg alone
- Prediction of mass of egg (after being in water)
- Actual mass of egg after 30 minutes in water
- Prediction of egg mass after 24 hours in pancake syrup
- Actual mass of egg after being in syrup 24 hours

Conclusion to All Enzyme Activities

Write a clear, well-supported paragraph describing everything you have learned about enzymes in these lab activities.

Rate of Fermentation (How Yeast Get Energy)

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02: Design and conduct scientific investigations to answer biological questions.

1.03: Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to:

g) Explain observations.
h) Make inferences and predictions.
i) Explain the relationship between evidence and explanation.

Goal 2: The learner will develop an understanding of the physical, chemical and cellular basis of life.

2.03: Investigate and analyze the cell as a living system including energy use and release in biochemical reactions.

2.05: Investigate and analyze the bioenergetic reactions

Introduction to the Teacher

In this lab, students will determine the relationship between the amount of "food" (molasses) and the rate of fermentation by yeast cells. This lab makes an excellent precursor or follow-up to the microscopic observation of various cells including yeast. Historically, human beings have been very interested in the process of fermentation. In fact, until the mid 1800's fermentation was thought to have nothing to do with living organisms. It was Louis Pasteur that showed the relationship between fermentation and yeast or bacteria.

It is important to let the students propose their hypotheses after they understand the basic lab procedure. After following the procedure that is given in the lab instructions, students can be encouraged to develop their own experiments with yeast and molasses in order to test other variables. Students might vary the pH of the solutions, alter the temperatures, vary the light, or add other substances such as salt to the test tubes.

It can be pointed out to students that molasses is a mixture of the products of photosynthesis of sugar cane. Although molasses is not living, it is the product of living organisms and these products can be used to feed yeast. This lab will take about 50 minutes to introduce and set up and then about 30 minutes the next day to measure the gas, clean up, collect class data, and discuss.

Helpful notes:

a. When you select your test tubes, make sure that the smaller test tube can fit upside down within the larger test tube with a little space left between the two tubes.

Suggested sizes are 18 mm x 150 mm for the large tube and 10 mm x 75 mm) for the small tubes.

b. You can use regular grocery store dark molasses. To create the 25% solution, you can mix 75 mL of molasses with 225 mL of water – be sure to stir well. This will give you enough molasses for 7 groups per class. You might want to make some extra for mistakes!

c. To prepare the yeast, just get grocery store yeast packets. Take about 2 gram of yeast to 200 mL of water and stir well. Each group of students will need about 15 mL of yeast. You can distribute this in small flasks that have been covered.

References

This lab is an adaptation of a *BSCS Biology Lab titled "Supplementary Investigation 1 – A Biological Experiment"*.

Rate of Fermentation (How Yeast Get Energy)

Purpose

To study how the rate of fermentation by yeast cells is affected by the concentration of molasses. You will be using yeast cells (microscopic organisms) and molasses (a product of photosynthesis in sugar cane). You will measure the rate of fermentation by measuring how much carbon dioxide (CO_2) is given off by the yeast cells over a certain period of time.

Materials

- Goggles
- 6 test tubes (18mm x 150 mm, for example), rimless is best
- 6 test tubes (10mm x 75 mm, for example), rimless is best
- 50 mL graduated cylinder
- Medium sized beaker (for waste)
- Test tube rack
- Metric rule
- 6 little squares of aluminum foil (about 4 cm by 4 cm)
- 100 mL beaker with 50 mL of 25% molasses solution
- 20 mL of yeast suspension
- Dropper
- Marking pen
- Masking tape

Introduction to the Student

Even cells as small as yeast cells need to obtain the energy to carry out life processes. Because yeast cells are so small, they do not require as much energy from their food as large multicellular organisms do. Yeast uses a process called fermentation. What Is fermentation? Fermentation is a way for cells to get energy without using oxygen. Small organisms can break down complex organic substances such as sugar into simpler ones and release the energy that is in the carbon-carbon bonds. The waste products of this process are molecules such as ethyl alcohol and lactic acid, as well as other.

Human beings have known about fermentation for a long time. Food can be spoiled by fermentation, food can be made by fermentation, and muscle cells use fermentation to give us quick bursts of energy. Louis Pasteur in 19th century helped us understand that fermentation is the result of the action of small organisms such as yeast and bacteria. In this lab we will be using yeast cells. Yeast cells break sugar down into ethyl alcohol and carbon dioxide, releasing a small amount of energy to be used by the cells for other processes.

Procedure

1. Number the 6 large test tubes 1-6. Put your lab group name on some masking tape and place the tape on your test tube rack.

2. Fill test tube one almost to the top with 25% molasses solution.

3. Measure 25 mL of molasses solution in the graduated cylinder. Add 25 mL of water; mix well.

4. Fill test tube two almost to the top with the solution from step 3.

5. Pour off all of the solution in the graduated cylinder except for 25 mL.

6. Add 25 mL of water to this remaining solution; mix well.

7. Fill test tube three with the solution from step 6.

8. Continue with this serial dilution until you have filled test tubes 1-5 with molasses solutions.

9. Fill test tube 6 almost to the top with plain water.

10. Shake the yeast suspension very well and add 10 drops of yeast to each of the 6 test tubes. Shake the yeast suspension each time before you add it to a test tube.

11. Mix the yeast and molasses solutions in each test tube. You can do this by holding your thumb over the mouth of the test tube and inverting a few times.

12. This step is the tricky (and sticky!) part. Working with each tube of solution one at a time, you will do the following: Take one of the small test tubes. Fill the small test tube up to the top with some of the solution that is in large test tube #1. Then holding the large tube in one hand and the small tube in the other hand; tip them slightly so that they are aimed toward each other. Then very quickly invert the small tube into the large tube. If you get bubbles in your small tube (and you probably will!) remove the bubbles of air by placing your thumb over the top of the large tube (trapping the small tube inside) and then tilting the tubes upside down. Very slowly return the tubes to the upright position and let any bubbles slide between the two tubes and up to the top of the solution.

NOTE: If you end up with a little bubble of air at the top of the small tube, you can measure the length of this column of air, record it in the data chart, and then subtract that amount from the data that you collect the next day.

13. Lightly cover each test tube pair with a piece of aluminum foil and place the tubes in the test tube rack. Put the rack in a warm place.

14. The next day, measure the length of the column of gas in each small test tube and record these amounts.

Lab Data

1. Hypothesis: Before you record your data, state your hypothesis based on the introduction to this lab.
2. The "independent variable" in an experiment is the factor that you control, while the "dependent variable" changes depending on the conditions of the experiment.
    a. What is the dependent variable in this lab?
    b. What is the independent variable in this lab?
3. How is the activity (rate of fermentation) of the yeast measured?
4. The molasses solution used in test tube # 1 is 25%. Based on the method you used to produce your diluted solution, what are the percentages of molasses in each of the other test tubes? Put your answers in the following data chart. Also record your measurements.

TUBE	1	2	3	4	5	6
% molasses						
Length of gas (mm) day two						
Bubble length (mm) day 1						
Difference						
Class Average						

5. Graph your data on a piece of graph paper. Put the independent variable on the "X" axis and the dependent variable on the "Y" axis.
6. Graph the class data on the same piece of graph paper using a different color.

Questions to Guide Analysis:

1. What was the purpose of test tube 6?
2. Why was it important to shake the yeast suspension just before adding drops to the test tube?

3. The gas is actually filling the volume of the small test tube. Why is it acceptable to measure length of the gas column instead of volume?
4. Why is it important to look at data from the whole class?
5. Does your data support your hypothesis? EXPLAIN.
6. How could you verify your data?
7. What were some of the factors that could affect the activity of the yeast that you kept constant?
8. In the introduction, you were told that muscle cells also carry out a type of fermentation called "lactic acid fermentation." What are the advantages and disadvantages of this process to human muscles and functioning?
9. Think of some other variable that might affect the rate of fermentation in this experiment and design a new experiment to test the affect of changing this variable

What are the Effects of Various Mutations on Protein Synthesis?: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01: Identify biological problems and questions that can be answered through scientific investigations.

Goal 3: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.01: Analyze the molecular basis of heredity including:

- Replication
- Protein Synthesis (transcription, translation)

Introduction to the Teacher

This exercise provides a simple way of teaching about the molecular basis of heredity and genetic coding. It also challenges the students to analyze the effects of various types of mutations on the resulting protein (polypeptide).

The central question of the exercise is how the genetic code is translated into proteins as part of the Central Dogma of Biology (DNA→mRNA→Proteins→Traits) and what effect changes in the code (mutations) have on the protein sequence (leading to possible changes in the trait).

This activity provides the teacher with much latitude in teaching transcription, translation, and mutation. You may want to use the randomly generated mRNA strands to teach only the concept of transcription, translation and the use of an mRNA "dictionary." However, the activity is designed as an exploration of the effects of mutations on amino acid sequences.

You may also choose to have students determine the DNA sequence (both strands of the double helix) and teach DNA replication. You may design a "template" upon which students tape their individual strands to form an even larger protein.

The mutation terms and definitions are purposely not given initially to the students while they explore the actual effects of manipulating their strands of mRNA. If you wish, you may give students the terms after the activity. However, there is no real need for the students to learn the names for the different types of mutations. The main issue is that they understand how various types of mutations affect the resulting polypeptide and possibly the related trait.

In step 1, each student is given a randomly generated mRNA sequence. The student translates the sequence into the correct sequence of amino acids to form a polypeptide. Each sequence begins with an initiation codon (AUG) and ends with one of the three termination codons (UAA, UAG, or UGA).

In steps 2-4, each student changes the mRNA sequence in ways that simulate some of the types of mutations. The student is challenged to determine the mutations that have the most devastating effect on the resulting polypeptide and then to think about the implications for the expression of the trait.

Point mutations:
Step 2 has the students do a transition mutation by changing every cytosine that is the last/third base in a codon to a uracil. A transition mutation is a purine to purine or pyrimidine to pyrimidine shift.
Step 3 has the students do a transversion mutation by changing every cytosine that is the last/third base in a codon to an adenine. A transversion mutation is a purine to pyrimidine or pyrimidine to purine shift.

Frameshift mutation (insertions and/or deletions):
Step 4 has the students add one extra base (adenine) after the initiation codon.
If you wish, you may introduce the difference between missense mutations and nonsense mutations. Missense mutations occur when the amino acid sequence may still make sense after a mutation but not necessarily the right sense. Nonsense mutations occur when a transversion results in a premature termination codon that truncates the protein and renders it nonfunctional.
Students should discover the degeneracy (redundancy) of the genetic code. (Some mutations do NOT result in a change in the amino acid sequence since there are multiple codes for some amino acids.)

Safety Considerations
None

References
This activity was designed by Gordon Plumblee (Western Alamance High School, Elon College, NC 72744) and adapted by Judy Jones (East Chapel Hill High School, Chapel Hill, NC 27514).

What are the Effects of Various Mutations on Protein Synthesis? Activity

Purpose

- To learn about the molecular basis of heredity and genetic coding
- To analyze the effects of mutations in the genetic code on the resulting protein sequence

Materials (per person or lab group)

- randomly generated mRNA sequences (attached)
- "dictionary" of mRNA codons

Procedure

In this activity you will be translating strands of mRNA into small sequences of amino acids. You will also be experimenting with various types of mutations and trying to determine which mutations cause the greatest change in the polypeptide sequence.

Step 1: Using a standard "dictionary" of mRNA codons, translate your mRNA strand into the correct sequence of amino acids.

1. What did you discover about first codon in your sequence?
2. Check with some of the students near you. What is the first codon in their sequence?
3. What would you hypothesize about all strands of mRNA that code for proteins?
4. What did you discover about the last codon in your sequence?
5. Check with some of the students near you. What is their last codon and what does it do?
6. What would you hypothesize about the last codon for all strands of mRNA that code for proteins?

Step 2: Take another copy of your strand of mRNA and change every C that is the third base in a codon to a U. Now translate the new mRNA into a polypeptide sequence. Example: AUG/ACU/GU**C**/CAG/UCA/UC**C**/ACU (The underlined C's would be changed to U's.)

7. What did you discover about your new polypeptide strand (compared to the original)?

Collect some class data:
Number of strands with premature STOP codon _____
Number of strands with no new amino acids _____
Number of strands with 1 new amino acid _____

Number of strands with 2 new amino acids _____
Number of strands with 3 new amino acids _____
Number of strands with 4 or more new amino acids _____

8. How do you explain that some students had strands with no new amino acids?

Step 3: Take another copy of your strand of mRNA and change every C that is the third base in a codon to an A. Now translate the new mRNA into a polypeptide sequence. Example: AUG/UC**C**/CUU/AU**C**/ACU/GU**C** (The underlined C's would be changed to A's.)

9. What did you discover about your new polypeptide (compared to the original AND to the polypeptide from step 2)?

Collect some class data:
Number of strands with premature STOP codon _____
Number of strands with no new amino acids _____
Number of strands with 1 new amino acid _____
Number of strands with 2 new amino acids _____
Number of strands with 3 new amino acids _____
Number of strands with 4 or more new amino acids _____

10. How is the class data from Step 3 different from the class data from Step 2?

11. Which step seemed to result in the greatest number of changes in the polypeptide?

12. How do you explain the reason for your answer to question 11?

Step 4: Take another copy of your mRNA strand. This time add one extra base (A) immediately after the START codon in your mRNA sequence. Translate this into a new amino acid sequence (polypeptide).

13. How does this polypeptide differ from the original and the ones you created in steps 2 and 3?

Collect some class data:
Number of strands with premature STOP codon _____
Number of strands with no new amino acids _____
Number of strands with 1 new amino acid _____
Number of strands with 2 new amino acids _____
Number of strands with 3 new amino acids _____
Number of strands with 4 or more new amino acids _____

14. What did you discover about the type of mutation where a single base is inserted into the mRNA sequence?

15. What would have happened to the polypeptide if you had deleted a single base instead of inserting a base at the same location in the mRNA sequence?

16. What would have been the results if the insertion or deletion of a base had happened near the end of the mRNA sequence?

Questions to Guide Analysis:

1. What effect would these various mutations have on the trait that is controlled by the protein that is produced from the mRNA?

2. Summarize what you have learned about mutations and their effect on the resulting polypeptide.

1. AUGCUCUCUGGAUACCGCAAGCGAAACGGCAAUGGGGUAUUGGCACAGGACAAAGCUUUGUAUGGUUAA

2. AUGUUUGCUCCGUUUUACCCUUAUUCGAACACAGACUCCGAGUUGACAGGGGGCUACAAAGAAUAUUAG

3. AUGCCUCCGUUUAAGUAUCUAAUCCGGUUGAUACCAGACUACGAGAAGUUAGCUAUAUCUACAGCGUAG

4. AUGUCGACCCAAUGUCUGUGUAUUACGCAGUCUAUCCAAAACAUUACUCAUGUAGAUUCUCUGCGGUGA

5. AUGCUGUGGGGGCCGAUGCGGCAGUGGGAAGACUACGUGGGGCCACUGGGGUACGAAUUGAUAACUUAA

6. AUGAGCACUCCAUCACACUACGUUAGGGGGAGCAGGAGCCUUCGGUAUGUGAUGGCCGCGAAGGGAUAA

7. AUGGCACAGGAGAGCCAGCAGACGUUCCCCGUGACUGCCCUCCUAAGUACCCUCGCCGAGACGGAUUAG

8. AUGCUGUACCCAGACAAAGAAUUCUUUUACGACAGAGCAGGACAGGGCAGACAGGCAUGGUUAGAUUAG

9. AUGGAUGUUAUUCGUUACCCGAGUGAGACCAAUAGCCAGCAAAACUCUACUUUUAUGGAUUGGAACUGA

10. AUGACGUGUACGUACUCGUACAUCCGCCCACGUCGAAACAGAAGUAGCAGUCUGACGGGCGUACAAUAA

11. AUGGUGUCCGCGUCACCUGUGGAUCGGACUCAUGAGUGGAUGGGUACCCAACAACACUGGCUCACGUAG

12. AUGGCUAGGCGGACGGCGCUUACAGUGCCUGUCCAUUACAAUGUGACGUAUGUAGAACCCGUCAUUUAA

13. AUGGGGGUGGACCUCAAGAAUUCUCGCAUCACUCAUGAUGGGGCGGCCCUAAAAACGGGAGACAUUUGA

14. AUGCCAUGUCCCCAGACGCUCGCCUUUUCGUUACUUAUGGUGUACUUACAUCAUUCCAUCUCACUCUAG

15. AUGCACCGCAAAUACUACGCACGAGAUGCAAUGCGCAAAUCUUUGAUCUCUACCGCUAUCUCUGGGUAG

16. AUGUCCCGGUUACGUGGCAACGCGAACCCUCCGAACUCUUAUGCAGUGGAGCCUAGUUCAGCUGUCUAA

17. AUGGUAGGUCGCAUAGGGGACUUCAAAUAUGCCGGAGAUUCGUUACUGCUGCACCGCGCCAUUGCUUGA

18. AUGUCACGCAUUACCAAAGCCGUCCAGUCCAAGCGAGACAUCAUACGGAUGCUUGCGCCAUAUCUUUAA

19. AUGGAUAGCAUGCUGACCUUACAGCUGGAUACAUCGAACGCACGGAUUUCUGCGACUCACUUAUUCUAG

20. AUGCGACUUUACACCAAUGGCUUAAUGCCUGCGUAUAGUUGUAUUGCUGUUGAGUAUCGCAAAACAUAA

21. AUGUUCGCAUUCUGUGCCAACGAUGCAAUACCCUUAAGAGGCCACGGCUACUCGCCUCUGGUCGGAUGA

22. AUGUCGAGGACCUUCCCUGUCACCUCAAAGAGUUACCCCCUCGAAGUCGUGUCGAUCGUGAAUCGCUAG

23. AUGGGUGGAUCGUCCAACAAUAGGACGAAAAACUUGCUCUUUCCCAAUGCUUACACUCGGGGUGCGUAA

24. AUGGAGGCGUUCCGGAAACACGCAACUAUGCCAUUAGUCUGCGAUCCGGGUCCCAACAAUAGGAGUUGA

25. AUGGGUAAUAACUUAUUGCAACAUCCCGUGUUGACUCUAAGGAGUCGUUUGGCUUAUUCACUGCUCUAA

26. AUGGGCUUAACAGGAGACUUUCAGCGCAGCUCAGGCGUCCCGUACAGGCGUCCCCCUAAUAAAGCAUGA

27. AUGGCGGGACGCAGUUUCAAAUUUAGGGCGAACCAGACGAGAAUUCGCACAGGCCGUUCACUGAUGUGA

28. AUGGAACUGCGUGGGAUAGUCGCGGGGCACUUAGCCCACGUUCAGUGUACAUCGCACAAAUAUUUAUAA

29. AUGUCCCGGCGGGCCCGAUGCAGGGCAUCGAAAGACACUAGACCGAAUUUCGAGUCAAGUGCUGCCUGA

30. AUGGAUUACAACUUUGAUACCCUGGUAUGGAUCGUACGGAGAUAUUUAGCUCUCUUAGAUCCGUUAUGA

31. AUGCUAGUGCCCAUCCCGUUUAUCAACGCCGACAUUCUCUGUGUAGCCCCUCUUCGUGGCAUGCCAUGA

32. AUGAACUUUAUCGACCAGGAUCAUUACACAGGCUCUGACAUAUUGCCAAGAGGCGUUAGAAUAUUAUGA

33. AUGUCUACCCACUUUUGGGAGAGAACUGGACCUGAGUUACAUCUUGAGGCGCACGACCUUGGUCGGUAA

34. AUGGGACAUUGUAAGGUAUUCUGUGACGGAAUCUGUGUCCUAGUCCAGGCUAUCUUACAGUCCCACUAG

35. AUGUGUCUCAAAAUCAAUACCAAGAGUAGAUGUAAGGCCGAGGCGAUGAAUAUCACGUCUAGGACCUUAUAA

36. AUGCCCACAGAGAUUUCGCACCGUAAGCGGGUGGUGAUCACUGAAGCUAUAAGGAGAUGGAGUUAUUAG

37. AUGGAGAUGGCAAAGGCUUACAGGAUACUUGAUACAUCCUUGGGAGCUACGCCGUCUGGUCACCCAUAA

38. AUGCAAUACCUUCAGCGCUCCAUUGAUAUUCAAACGCGCACCGCAGUACGGCAGAUAUCUCCCGUCUAG

39. AUGCAAUACCUUCAGCGCUCCAUUGAUAUUCAAACGCGCACCGCAGUACGGCAGAUAUCUCCCGUCUGA

40. AUGUCGAGUCCCAAUUGCGGUAGUCGCGGUACACUUCAAUCUGAUAGCUCGAUAAUCAUGCAUAGCUAA

Cell Cycle Inquiry Lab: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.02: Design and conduct scientific investigations to answer biological questions.

1.03: Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to:

j) Explain observations.
k) Make inferences and predictions.
l) Explain the relationship between evidence and explanation.

Goal 3: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.02: Compare and contrast the characteristics of asexual and sexual reproduction.

Introduction to the Teacher

Through inquiry techniques, students will recognize the process by which nuclear division occurs. It is recommended that this laboratory activity be completed prior to cell cycle instruction. Onion root tip slides will be observed and the five different stages of the cell cycle will randomly be drawn. Students will then use their drawings to place the cells in the different stages of the cell cycle in a logical sequence to determine the correct order of cellular division. Upon the completion of the activity, the teacher can collect the cards for the lab grade and use the best drawings for classroom discussion.

Students may have trouble visualizing individual cells when viewed under the microscope in small groups. A solution to this would be to use a videoscope, flex cam or overhead transparency to present the students with an enlarged picture of an onion root tip. The teacher could then point out individual cells to stress the importance of what these cells look like and what they represent to prepare students for the inquiry lab. Another alternative would be to modify the laboratory into a whole class activity. Students will need a good understanding of the parts of the cell and the nuclear material before beginning this laboratory.

Some possible extensions of this lab may include the use of whitefish slides in addition to the onion root tip slides. Whitefish slides could be used for the comparison of the stages of the cell cycle. The class could be divided into an even number of groups with half using the onion root tip and half using the whitefish slides. The groups could then compare their diagrams and discuss the similarities and differences between the cell cycle in plant and animal cells. Another suggested extension would involve the use of a computer and data projector or computer lab. Once students have completed the inquiry

lab and the stages of the cell cycle have been identified, students can practice recognizing the different cells by using the Online Onion Root Tip Tutorial at **http://www.biology.arizona.edu/cell_bio/activities/cell_cycle/cell_cycle.html**.
As students view the different cells, the number of cells present in each stage can be recorded and a pie graph can be produced to show the percentage of time in each stage.

Safety Considerations

Students should be reminded of proper microscope technique.

References

This lab was written based on a suggestion from Gena Barnhardt.

http://www.bioweb.uncc.edu/biol1110/Stages.html
This website provides microscope pictures of whitefish and onion root tip slides.

http://www.biology.arizona.edu/cell_bio/activities/cell_cycle/cell_cycle.html
This website allows the student to determine how many cells are found in each stage of the cell cycle.

http://biologyinmotion.com/cell_division/
This website provides an animated tutorial of the process of mitosis.

Cell Cycle Inquiry Lab: Activity

Purpose

To study the different stages of the cell cycle

Materials (per person or lab group)

- microscope
- onion root tip slides
- five note cards
- pencil

Procedure

1. Obtain all needed materials: microscope, onion root tip slide, 5 note cards, and pencil.
2. Start your observation of the onion root tip slide on low power using the coarse adjustment. The slide should be scanned until the region directly behind the root cap can be viewed.
3. Increase the magnification of the microscope by switching to the medium power objective and use the fine adjustment to focus the microscope so that several different cells can be viewed clearly at once.
4. Observe the cells in the field of view very carefully. You should notice differences between the cells, especially with the nuclear material. Each of the different looking cells should be drawn on a separate note card. As you draw your cells, you may need to increase the magnification of your microscope to more clearly view the individual cells and their nuclear material. When you have completed your diagrams, you should have five different cells on five separate note cards.
5. Have your teacher approve all of your diagrams.
6. After your diagrams have been approved, write a description at the bottom of each note card of how each cell looks different. Be sure to emphasize the differences between the nuclear materials.
7. After carefully studying your note cards and descriptions, place your diagrams in a logical order to determine the steps involved in the cell cycle.
8. Once you have placed your cards in order, number them 1-5 in the upper right hand corner.

Lab Data

Students will turn in their note cards with the diagrams of the cells and their written description of the differences between the cells.

The Genetics of Parenthood: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.03: Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to:

m) Explain observations.
n) Make inferences and predictions.
o) Explain the relationship between evidence and explanation.

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03: Interpret and predict patterns of inheritance

Introduction to the Teacher

This is a simulation that easily captures student interest, and can be varied to meet different ability levels. Making the assumption that the P (parental) generation is heterozygous at all loci and that independent assortment occurs (no linkages), students flip coins to determine which allele they will pass on to the F_1 generation, and draw the resulting child's face. Emphasize the variation that occurs, reminding the students that all of these children are genetic siblings since all parents have identical genotypes.

Several inheritance patterns are represented in this simulation, and it is important to review these with the students beforehand. *Inheritance of the traits used in this simulation has been simplified to serve as a model*. Actual inheritance is far more complex; students may need to be reminded about this in case they get overly concerned about their own traits.

- **Dominant**: allele that masks the expression of another; represented by capital letters (R, V)
- **Recessive**: allele that is expressed only if both parents contribute it; represented by small letters (r, v)
- **Incomplete dominance**: phenotype of the heterozygote is an intermediate form; represented by capital letters and subscripts (C_1, C_2); an example is red color tints in the hair
- **Polygenic**: several genes contribute to the overall phenotype; an example is skin color
- **Sex-linked**: commonly applied to genes on the X chromosome, the more current term is X-linked; genes on the Y chromosome are **holandric** genes; no examples in this activity
- **Epistasis**: one gene masking the effects of another ; an example is hair color to red color tints

After students have completed their individual data sheets, they need to collect class data for at least traits # 2 and trait # 8 in order to answer the analysis questions. This is a good time for class discussion of the probability of individuals sharing multiple traits.

Additional Activity Ideas

- Have each "parent" draw the child's face. Then compare the "mother's" and the "father's" perception of characteristics.
- Do the lab twice, comparing the genotypes and phenotypes of the resulting siblings.
- "Marry" the children off, to produce an F_2 generation (grandchildren).

Safety Considerations

Other than the noise of all the pennies being flipped at once, there are no hazards associated with this lab.

References

Prepared by Lenore Kop and Thomas Crowley (see original on www.accessexcellence.org)

Adapted from materials from Joan Carlson, Jack Doepke, Judy Jones and Randyll Warehime

Lewis, Rikki. 1994. *Human Genetics: Concepts and Applications.* Wm. C. Brown Publishers

Stine, Gerald J. 1989. *The New Human Genetics*. Wm. C. Brown Publishers

The Genetics of Parenthood: Activity

Purpose

To model how different combinations of genes inherited by offspring can produce tremendous variations in appearance

Materials

- 2 coins (preferably different kinds to keep track of mother/father contribution)
- The Genetics of Parenthood Reference Sheets (attached)
- The Genetics of Parenthood Data Sheets (attached)
- drawing paper or white boards
- pens/crayons (Crayola has a "My World Colors" set for various skin/eye colors)

Introduction to Student

Why do people, even closely related people, look slightly different from each other? The reason for these differences in physical characteristics (called phenotype) is the different combination of genes possessed by each individual.

To illustrate the tremendous variety possible when you begin to combine genes, you and a classmate will establish the genotypes for a potential offspring. Your baby will receive a random combination of genes that each of you, as genetic parents, will contribute. Each normal human being has 46 chromosomes (23 pairs—diploid) in each body cell. In forming the gametes (egg or sperm), one of each chromosome pair will be given, so these cells have only 23 single chromosomes (haploid). In this way, you contribute half of the genetic information (genotype) for the child; your partner will contribute the other half.

Because we don't know your real genotype, we'll assume that you and your partner are heterozygous for every facial trait. Which one of the two available alleles you contribute to your baby is random, like flipping a coin. In this lab, there are 36 gene pairs and 30 traits, but in reality there are thousands of different gene pairs, and so there are billions of possible gene combinations!

Procedure

Record all your work on the Data Sheet.

- Determine your baby's gender. Remember, this is determined entirely by the father. The mother always contributes an X chromosome to the child.

  Heads = X chromosome, so the child is a girl
  Tails = Y chromosome, so the child is a boy

- Name the child.
- Determine the child's facial characteristics by having each parent flip a coin.

  Heads = child will inherit the first allele (i.e., B or N_1) in a pair

Tails = child will inherit the second allele (i.e., b or N_2) in a pair

- On the Data Sheet, circle the allele that the parent will pass on to the child and write the child's genotype.
- Using the information in the Reference Sheets, look up and record the child's phenotype and draw that section of the face where indicated on the Data Sheet.
- Some traits follow special conditions, which are explained in the Reference Sheets.
- When the Data Sheet is completed, draw your child's portrait as he/she would look as a teenager. You must include the traits as determined by the coin tossing. Write your child's full name on the portrait.

The Genetics of Parenthood
Reference Sheets

1. **FACE SHAPE**:

Round (AA, Aa)

Square (aa)

2. **CHIN SIZE**: The results may affect the next two traits.

Very prominent (BB, Bb)

Less prominent (bb)

3. **CHIN SHAPE**: Only flip coins for this trait if chin size is very prominent. The genotype bb prevents the expression of this trait.

Round (CC, Cc)

Square (cc)

4. **CLEFT CHIN**: Only flip coins for this trait if chin size is very prominent. The genotype bb prevents the expression of this trait.

Present (DD, Dd)

Absent (dd)

5. **SKIN COLOR**: To determine the color of skin or any other trait controlled by more than 1 gene, you will need to flip the coin for each gene pair. Dominant alleles represent color; recessive alleles represent little or no color. For example, if there are 3 gene pairs...
   a. First coin toss determines whether the child inherits E or e.
   b. Second coin toss decides F or f inheritance.
   c. Third coin toss determines inheritance of G or g.

   6 dominant alleles - black
   5 dominant alleles - very dark brown
   4 dominant alleles - dark brown
   3 dominant alleles - medium brown
   2 dominant - light brown
   1 dominant - light tan
   0 dominant - white

6. **HAIR COLOR**: Determined by 4 gene pairs.
   8 dominant - black
   7 dominant - very dark brown
   6 dominant - dark brown
   5 dominant - brown
   4 dominant - light brown
   3 dominant - brown mixed w/blonde
   2 dominant - blond
   1 dominant - very light blond
   0 dominant - silvery white

7. **RED COLOR TINTS IN THE HAIR**: This trait is only visible if the hair color is light brown or lighter (4 or less dominant alleles for hair color).
   Dark red tint (L_1L_1) Light red tint (L_1L_2) No red tint (L_2L_2)

8. **HAIR TYPE**:
   Curly (M_1M_1) Wavy (M_1M_2) Straight (M_2M_2)



9. **WIDOW'S PEAK**:
   Present (OO, Oo) Absent (oo)


10. **EYE COLOR**:
    PPQQ - black
    PPQq - dark brown
    PpQQ - brown with green tints
    PpQq - brown
    PPqq- violet
    Ppqq - gray blue
    ppQQ - green
    ppQq - dark blue
    ppqq - light blue

11. **EYE DISTANCE**:
    Close (R_1R_1) Average (R_1R_2) Far apart (R_2R_2)



12. **EYE SIZE**:
    Large (S_1S_1) Medium (S_1S_2) Small (S_2S_2)



13. **EYE SHAPE**:

Almond (TT, Tt)

Round (tt)

14. **EYE SLANTEDNESS**:

Horizontal (UU, Uu)

Upward slant (uu)

15. **EYELASHES**:

Long (VV, Vv)

Short (vv)

16. **EYEBROW COLOR**:

Darker than hair color (W_1W_1)

Same as hair color (W_1W_2)

Lighter than hair color (W_2W_2)

17. **EYEBROW THICKNESS**:

Bushy (ZZ, Zz)

Fine (zz)

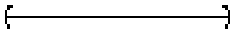
18. **EYEBROW LENGTH**:

Not connected (AA, Aa)

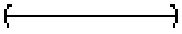
Connected (aa)

19. **MOUTH SIZE**:

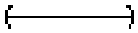
Long (B_1B_1)



Medium (B_1B_2)



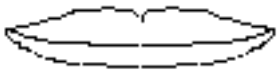
Short (B_2B_2)



20. **LIP THICKNESS**:

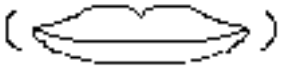
Thick (CC, Cc)

Thin (cc)

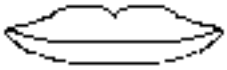


21. **DIMPLES**:

Present (DD, Dd)



Absent (dd)



22. **NOSE SIZE**:

Large (E_1E_1)

Medium (E_1E_2)

Small (E_2E_2)

23. **NOSE SHAPE**:

Rounded (FF, Ff)

Pointed (ff)

24. **NOSTRIL SHAPE**:

Rounded (GG, Gg)

Pointed (gg)

25. **EARLOBE ATTACHMENT**:

Free (HH, Hh)

Attached (hh)

26. **DARWIN'S EARPOINT**:

Present (II, Ii)

Absent (ii)

27. **EAR PITS**:

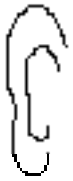
Present (JJ, Jj)

Absent (jj)

28. **HAIRY EARS**:

Present (KK, Kk)

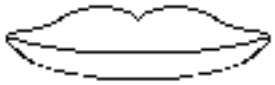
Absent (kk)



29. **FRECKLES ON CHEEKS**:

Present (LL, Ll)

Absent (ll)



30. **FRECKLES ON FOREHEAD**:

Present (MM, Mm)

Absent (mm)

The Genetics of Parenthood
Data Sheet

Parents _____ and _____

Child's gender _____ Child's name_____

Fill in the data table as you determine each trait described in the Reference Sheets. Do not simply flip the coin for all traits before reading the guide, because some of the traits have special instructions. In the last column, combine the information and draw what that section of the child's face would look like.

#	TRAIT	ALLELE FROM MOM	ALLELE FROM DAD	CHILD'S GENOTYPE	CHILD'S PHENOTYPE (written)	CHILD'S PHENOTYPE (drawn)
1	Face Shape	A a	A a			face & chin
2	Chin Size	B b	B b			
3	Chin Shape	C c	C c			
4	Cleft Chin	D d	D d			
5	Skin Color	E e F f G g	E e F f G g			
6	Hair Color	H h I i J j K k	H h I i J j K k			
7	Red Tints	L_1 L_2	L_1 L_2			hair
8	Hair Type	M_1 M_2	M_1 M_2			
9	Widow's Peak	O o	O o			
10	Eye Color	P p Q q	P p Q q			eye & eyelashes
11	Eye Distance	R_1 R_2	R_1 R_2			
12	Eye Size	S_1 S_2	S_1 S_2			
13	Eye Shape	T t	T t			
14	Eye Slant-edness	U u	U u			
15	Eyelashes	V v	V v			

#	TRAIT	ALLELE FROM MOM	ALLELE FROM DAD	CHILD'S GENOTYPE	CHILD'S PHENOTYPE (written)	CHILD'S PHENOTYPE (drawn)
16	Eyebrow Color	W_1 W_2	W_1 W_2			eyebrow
17	Eyebrow Thickness	Z z	Z z			
18	Eyebrow Length	A a	A a			
19	Mouth Size	B_1 B_2	B_1 B_2			mouth
20	Lip Thickness	C c	C c			
21	Dimples	D d	D d			
22	Nose Size	E_1 E_2	E_1 E_2			nose
23	Nose Shape	F f	F f			
24	Nostril Shape	G g	G g			
25	Earlobe Attach-ment	H h	H h			ear
26	Darwin's Earpoint	I i	I i			
27	Ear Pits	J j	J j			
28	Hairy Ears	K k	K k			
29	Cheek Freckles	L l	L l			
30	Forehead Freckles	M m	M m			

Questions to Guide Analysis:

4. What percentage does each parent contribute to a child's genotype?
5. Explain how/what part of your procedures represents the process of meiosis.
6. Using examples from this activity, explain your understanding of the following inheritance patterns:
   - dominant
   - recessive

- incomplete dominance
- polygenic
- epistasis

7. Compare the predicted phenotype ratio (Punnett squares) to the actual ratio (class data) for the following traits:
    2. trait # 2 (chin size)
    3. trait #8 (hair type)

All the children had two heterozygous parents. Use the law of independent assortment to explain why there were no identical twins produced.

Genetic Detectives – A Webquest: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.05: Analyze reports of scientific investigations from an informed scientifically literate viewpoint including considerations of appropriate sample, adequacy of experimental controls, replication of findings, and alternative interpretations of the data.

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03: Interpret and predict patterns of inheritance.

Goal 4: Learner will develop an understanding of the unity and diversity of life.

4.04: Analyze and explain the interactive role of internal and external factors in health and disease.

Introduction to the Teacher

This project was designed to

- help students learn about various genetic disorders
- introduce the problem of funding research for genetic disorders that are rare
- allow students to use the web for research
- learn how to prepare a PowerPoint presentation

The teacher may decide to expand upon the student introduction by discussing more details about the human genome project.

It is assumed that the students have already done their study of classical genetics and of the structure of DNA and how DNA provides the information for protein synthesis.

In addition to meeting the North Carolina Goals above, students will also practice communication skills, negotiating skills, and technology skills. They will be honing their abilities to present to a classroom of peers. They will learn how to use a decision rubric to make more objective decisions.

Teachers may want to present the project using a projection device and projecting the web pages (see reference below) with the instructions. Students will probably need access to a computer lab in order to carry out their research.

There are many options for teachers in assigning the process. Teachers may choose to let students select their own groups and group assignments or teachers may make those assignments themselves.

Teachers should stress that all students in a group will be participating in all aspects of research and preparation of the presentation.

It is estimated that students will need about 5 class periods of approximately 50 minutes each or 2-3 blocked periods to complete the research, the discussions and decision rubric as well as the power point presentation. Then one or two periods will be needed for the presentations and the discussion.

For this project teachers will need:

- a computer lab for on-line research (alternatively, teachers could have their students use traditional print resources in a library.
- a computer lab for students to produce their PowerPoint presentations (alternatively, students could prepare more traditional presentations)

A rubric is provided for evaluating the project. This rubric is used for the product (PowerPoint presentation) only. Students are given a copy of this rubric so that they know what is expected of them.

In addition, the teacher may want to develop a way to evaluate the group process. The teacher may also want to collect the individual student research of the three disorders and evaluate those.

This conclusion activity is designed to allow each student to individually reflect upon what he or she has learned. It gives each student a chance to write a coherent essay about the issue of funding the research into orphan diseases.

Students should be given a few days to complete the assignment. Alternatively, they could be given a class period to do the writing.

References

The following website contains the teacher background and the actual webquest activity for the students.

http://echhs.chccs.k12.nc.us/%7Ejjones/.

Genetic Detectives – A Webquest: Activity

Purpose

- To learn about some of the genetic disorders that affect human beings – their inheritance patterns, their characteristic symptoms and their treatments
- To learn how to work collaboratively to investigate a question and derive a proposal to answer that question.

Materials

Computers with internet connections or collection of print resources about genetic disorders

Introduction to Student

The 20th century was an amazing one for genetics. A variety of important experiments early in the century led to the remarkable discovery of the structure of DNA by Francis Crick and James Watson in the 50's. Since that time, much research has gone into understanding what genes do and how they determine the characteristics of human beings as well as those of other organisms. Many scientists of the 21st century are now focusing on "proteomics" – the study of proteins and how they determine functioning. And of course, our genes determine our proteins!

The news has been flooded with articles about the Human Genome Project and the discovery of many different genes that affect human health and behavior. The entire human genome has been sequenced and chromosome charts have been published that highlight the many genes that are being studied. Almost all of our genes function well and do exactly what they are supposed to do. However, one of the great hopes of our new genetic knowledge is that we will be able to help those who are afflicted with a genetic disorder.

This is leading to great dilemmas! How do we decide where to place our research funds? Which disorders are the most important ones to study first? Who decides which disorders will be studied?

Procedure

Following are some handouts to help guide your procedure.

FIRST DAY – SELECTION OF ROLES AND DISORDERS

GROUP LETTER_____

Name of Group Member	Role in Group	List of disorders that person is researching

RESEARCH GUIDE **NAME_____**

DATE_____PER___

Name of Disorder: _____

a. What are the symptoms of the disorder? List all of the symptoms that you can find.

b. How is the disorder inherited? What chromosome is the gene carried on? Is the disorder a chromosome number disorder? Is the disorder sex-linked? Dominant? Recessive?

c. At what age does this disorder first become evident? (Is this disorder a late onset disorder?)

d. Is the disorder variably expressed? Does the environment or other genes affect how this disorder is expressed? What are the variables that affect how this disorder is expressed?

e. Can the disorder be detected before birth? How can you detect the disorder before birth?

f. Can the parents be tested to see if they are carriers? If so, how does the test work?

g. Can the environment be altered to affect the expression of the disorder? If so, how would you change the environment so that the disorder is less severe?

h. What is the treatment for the disorder?

i. What are the costs for treating the disorder?

j. How does this disorder affect the rest of the family?

DECISION RUBRIC

You should use the following rubric as a model. You can choose different criteria if you think of others that are more important. And you can have more criteria than just four. You can choose your own weights depending on how much you think each criterion should count relative to the others. For example, if you thought each of the criteria below should be of equal weight then you would have them each worth 25 points. The rubric below shows different weights just for illustration. Look at the column titled "How common?". You would give 40 points to the disorder that is most common and many fewer points to the disorder that is the least common IF you decide as a group that you are more interested in funding a disorder that is relatively common. When you finish ranking each disorder, you would logically decide to fund the one that receives the most points.

Decision Rubric for Genetic Detectives Project **Group Letter_____Per_____**

Disease with most points_____

CRITERIA with point totals

DISEASE	Points:	Points:	Points:	Points:	Points	TOTAL POINTS 100 possible
Cystic Fibrosis						
Duchenne Muscular Dystrophy						
Fragile X						
Hemophilia						
Huntington Disease						
Marfan Syndrome						
Neurofibro-matosis						
Niemann-Pick						

Disease						
PKU Phenylketo-Nuria						
Sickle Cell Disease						
Tay Sachs Disease						
Werner Syndrome						

Final PowerPoint Presentation

In preparing your final presentation (about 20 minutes) you should include the following areas:

- review of why and how you chose your disorder
- description of your disorder
- how your disorder is inherited
- symptoms of your disorder
- age at which your disorder shows up
- possibilities of testing parents and/or fetus
- effect of the disorder on the patient and on the family
- treatment of the disorder and costs of treatment

Your presentation should

- have accurate information
- be free of spelling or grammar errors
- have some graphics that are relevant to the topic
- use a font that is readable for a class presentation
- have a design that is clean and clear

Questions to Guide Analysis:

Once you finish your group project, consider the problem of "orphan diseases." These are diseases that affect so few people that it is very hard to find funding for the research to develop treatments and cures. The following questions will continue to challenge human beings:

- What role do you think government should have in finding funds for research into orphan diseases?

- What role do you think private industry and philanthropic organizations should have?
- Is it preferable to research a better aspirin or cough syrup or to put money into finding treatments for diseases that only affect a few people throughout the world?

After considering these questions, discuss your thoughts and ideas about this problem in a well-organized paper. Make sure that you provide evidence for each of your arguments.

DISORDER LIST AND SUGGESTED LINKS

These links are general and will have information about several of the listed disorders:
National Center for Biotechnology Information -
http://www.ncbi.nlm.nih.gov/disease/index.html

National Center for Biotechnology Information - Online Inheritance in Man
http://www3.ncbi.nlm.nih.gov/Omim/

Med Help International http://medhelp.org

National Organization for Rare Diseases http://www.rarediseases.org/

These links are specific for each of the 12 disorders:

Cystic Fibrosis
Cold Spring Harbor - Your Genes Your Health http://vector.cshl.org/ygyh

Duchenne's Muscular Dystrophy
Cold Spring Harbor - Your Genes Your Health http://vector.cshl.org/ygyh

Fragile X
Cold Spring Harbor - Your Genes Your Health http://vector.cshl.org/ygyh

Hemophilia
Cold Spring Harbor - Your Genes Your Health http://vector.cshl.org/ygyh
National Hemophilia Foundation http://www.hemophilia.org

Huntington Disease
Huntington Disease Association http://www.hda.org.uk/

Marfan Syndrome
Cold Spring Harbor - Your Genes Your Health http://vector.cshl.org/ygyh
March of Dimes http://www.modimes.org/

Neurofibromatosis
March of Dimes http://www.modimes.org/
National Neurofibromatosis Foundation http://www.nf.org

Niemann-Pick Disease
National Niemann-Pick Foundation http://www.nnpdf.org

PKU - Phenylketonuria
March of Dimes http://www.modimes.org/
PKU News http://pkunews.org

Sickle Cell Disease
Sickle Cell Information Center http://www.scinfo.org/
Sickle Cell Disease Association of America http://www.sicklecelldisease.org
March of Dimes http://www.modimes.org/

Tay Sachs Disease
National Tay Sachs Disease Association http://www.tay-sachs.org/
March of Dimes http://www.modimes.org/

Werner Syndrome
University of Washington
http://www.pathology.washington.edu/research/werner/

Fishy Frequencies: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 3: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.05: Examine the development of the theory of evolution by natural selection including: Development of the theory, the origin and history of life, fossil and biochemical evidence, mechanisms of evolution and applications

Introduction to the Teacher

This activity shows allele frequencies changing over time as a result of selection and remaining stable without selection. It can be done with or without using the Hardy-Weinberg equilibrium equation depending on the needs of your students. Two different sets of activity sheets are provided so that you can choose. The Hardy Weinberg equilibrium equation allows you to figure out the frequency of alleles and genotypes from the frequency of observable phenotypes in populations that meet the conditions for Hardy Weinberg Equilibrium. These conditions include an infinitely large population, random mating, and no selection, mutation, migration or genetic drift. Of course, no real population completely fits these conditions. When a population or sub-population is not in equilibrium, population biologists can study the factors affecting the distribution of alleles. If your students do the activity using the Hardy Weinberg equation they can see how population biologists estimate the number of organisms heterozygous for a trait from the number of organisms with the recessive phenotype. You can also relate the Hardy Weinberg equation to Punnett squares and use this as an opportunity to show students an application for squaring binomials. Punnett squares can be used to calculate expected phenotype frequencies for populations as well as the expected ratios from individual crosses. You can also take the opportunity to discuss the conditions for equilibrium and in what ways this simulation does and does not meet these conditions.

If you decide that your students are not ready to learn the Hardy-Weinberg equilibrium equation, you can do this same activity and have the students simply calculate the percentages of brown and gold fish in successive generations. By conducting the simulation twice (once without selection and once with selection) students will see changes in percentages and you can help them understand that this means a different percentage of each allele – in other words, allele percentages will have changed over time when a population responds to selective pressures.

In either case, one important difference to be sure students note between this simulation and selection in a natural setting is that in this case the population experiencing selection is being replenished from the "ocean" which is not experiencing selection.

This activity can be done using fish crackers or it can be simulated with paper fish or other materials. You will need a place for each group to provide their data in order to calculate the class data

Safety Considerations

Care should be given that students do not consume any fish.

Fishy Frequencies: Activity

Purpose

Understanding natural selection can be confusing and difficult. People often think that animals consciously adapt to their environments - that the peppered moth can change its color, the giraffe can permanently stretch its neck; the polar bear can turn itself white - all so that they can better survive in their environments.

In this lab you will use fish crackers to help further your understanding of natural selection and the role of genetics and gene frequencies in evolution.

Background: Facts about the "Fish"

1) These little fish are the natural prey of the terrible fish-eating sharks - YOU!
2) Fish come with two phenotypes - gold and brown:
    a) gold: this is a recessive trait (ff)
    b) brown: this is a dominant trait (F_)
3) **In the first simulation**, you, the terrible fish-eating sharks, will randomly eat whatever color fish you first come in contact with. (There will be no selection.)
4) **In the second simulation**, you will prefer to eat the gold fish (these fish taste yummy and are easy to catch) you will eat ONLY gold fish unless none are available in which case you resort to eating brown fish in order to stay alive (the brown fish taste salty, are sneaky and hard to catch).
4) New fish are born every "year"; the birth rate equals the death rate. You simulate births by reaching into the pool of "spare fish" and selecting randomly.
5) Since the gold trait is recessive, the gold fish are homozygous recessive (ff). Because the brown trait is dominant, the brown fish are either homozygous or heterozygous dominant (FF or Ff).

Hardy-Weinberg:

G. H. Hardy, an English mathematician, and W.R. Weinberg, a German physician, independently worked out the effects of random mating in successive generations on the frequencies of alleles in a population. This is important for biologists because it is the basis of hypothetical stability from which real change can be measured. This also allows you to figure out the frequency of genotypes from phenotypes.

You assume that in the total population of fish crackers, you have the following genotypes, FF, Ff, and ff. You also assume that mating is random so that ff could mate with ff, Ff, or FF; or Ff could mate with ff, Ff, or FF, etc. In addition, you assume that for the gold and brown traits there are only two alleles in the population - F and f. If you counted all the alleles for these traits, the fraction of "f" alleles plus the fraction of "F" alleles would add up to 1.

The Hardy-Weinberg equation states that: $p^2 + 2pq + q^2 = 1$

This means that the fraction of pp (or FF) individuals plus the fraction of pq (or Ff) individuals plus the fraction of qq (ff) individuals equals 1. The pq is multiplied by 2

because there are two ways to get that combination. You can get "F" from the male and "f" from the female OR "f" from the male and "F" from female.

If you know that you have 16% recessive fish (ff), then your qq or q^2 value is .16 and q = the square root of .16 or .4; thus the frequency of your f allele is .4 and since the sum of the f and F alleles must be 1, the frequency of your F allele must be .6 Using Hardy Weinberg, you can assume that in your population you have .36 FF (.6 x .6) and .48 Ff (2 x .4 x .6) as well as the original .16 ff that you counted.

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Materials

- Fish crackers – brown and gold

Procedure

1) Get a random population of 10 fish from the "ocean."
2) Count gold and brown fish and record in your chart; you can calculate frequencies later.
3) Eat 3 fish, chosen randomly, without looking at the plate of fish
4) Add 3 fish from the "ocean." (One fish for each one that died). Be random. Do NOT use artificial selection.
5) Record the number of gold and brown fish.
6) Again eat 3 fish, randomly chosen
7) Add 3 randomly selected fish, one for each death.
8) Count and record.
9) Repeat steps 6, 7, and 8 two more times.
10) Provide your results for the class. Fill in the class results on your chart.

Procedure 2:

1) Get a random population of 10 fish from the "ocean."
2) Count gold and brown fish and record in your chart; you can calculate frequencies later.
3) Eat 3 gold fish; if you do not have 3 gold fish, fill in the missing number by eating brown fish.
4) Add 3 fish from the "ocean." (One fish for each one that died). Be random. Do NOT use artificial selection.
5) Record the number of gold and brown fish.
6) Again eat 3 fish, all gold if possible.
7) Add 3 randomly selected fish, one for each death.
8) Count and record.
9) Repeat steps 6, 7, and 8 two more times.
10) Provide your results for the class. Fill in the class results on your chart.

FINALLY: Fill in your data chart and calculations, prepare a graph showing the frequency of the alleles in each generation (see directions in analysis question 1) and answer the analysis questions.

PART 1 - Without selection

CHART (**without selection**): (Partners)

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

CHART (**without selection**): Class

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

PART 2 - With Selection

CHART **(with selection):** (Partners)

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

CHART **(with selection):** Class

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

Questions to Guide Analysis:

1. Prepare one graph using both sets of class data (without selection AND with selection). On the "x" axis put generations 1-5 and on the "y" axis put frequency (0-1). Plot both the q and p for both sets of class data. Label lines clearly (without selection AND with selection).
2. In either simulation, did your allele frequencies stay approximately the same over time? If yes, which situation? What conditions would have to exist for the frequencies to stay the same over time?
3. Was your data different from the class data? How? Why is it important to collect class data?
4. With selection, what happens to the allele frequencies from generation 1 to generation 5?

5. What process is occurring when there is a change in allele frequencies over a long period of time?
6. What would happen if it were more advantageous to be heterozygous (Ff)? Would there still be homozygous fish? Explain.
7. In simulation 2, what happens to the recessive alleles over successive generations and why? Why don't the recessive alleles disappear from the population?
8. Explain what would happen if selective pressure changed and the recessive allele was selected FOR?
9. What happens if the sharks only eat very large fish that have already reproduced? What happens if they eat small gold fish, before they have a chance to reproduce?
10. In what ways did these simulations represent real life? How were the simulations different from real life situations?

Organism Newspaper Project: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 4: The learner will develop an understanding of the unity and diversity of life

4.02: Analyze the processes by which organisms representative of the following groups accomplish essential life functions:

- Unicellular protests
- Annelid worms
- Insects
- Amphibians
- Mammals
- Non-Vascular Plants
- Gymnosperms
- Angiosperms

4.03: Assess, describe, and explain adaptations affecting survival and reproductive success

4.05: Analyze the broad patterns of animal behavior as adaptations to the environment

Introduction to the Teacher

Newspaper projects can be adapted to many topics. I have a version of this project in Genetics and also just focusing on Chordates. This version focuses on all of the groups of organisms that are found in Goal 4 of the curriculum. Teachers could adapt and modify this project in many different ways.

I like to have my students work in groups of three on this project. The positive aspect of this is the collaboration, excitement, and creative synergy. The negative might be that each student does not get the complete overview of information. However, teachers could have all students do the research first and then break into groups and divide up the parts of the newspaper. The project could be done by pairs of students or by single students also. The positive is the depth that each student would experience with the material, but the negative is the loss of some of the excitement.

My students were completely focused for a week of research and writing. The products were amazing. They were informative and creative. One group created a "tabloid." Other groups were more straightforward. All groups did a great deal of the bonus work. My experience has been that students learn a great deal from projects that involve research and then presentation of what they have learned in a way that allows them to express their creativity.

References

Students will need to use a variety of resources including books, magazines, internet sites, videos, etc.

Below are some useful websites that have information about student newspaper projects.

http://litsite.uaa.alaska.edu/workbooks/kidpaper.html
(creating a newspaper book report)

http://www.glc.k12.ga.us/BuilderV03/LPTools/LPShared/lpdisplay.asp?LPID=30599
(creating a Civil War newspaper – part of a webquest)

http://www.amistadamerica.org/new/main/html/curriculum/newspaper.html
(creating a newspaper about the Amistad)

http://schools.portnet.k12.ny.us/~rmclean/Latin_America/lesson_newspaper.html
(Latin American topics newspaper)

http://www.twingroves.district96.k12.il.us/NewspaperProj/Newspaper.html
(American History topic newspaper)

Organism Newspaper Project: Activity

Purpose

- To learn about the various groups of organisms listed below
- To learn how different organisms handle the functions of life
- To learn about some of the behaviors that help the survival of organisms
- To enjoy being creative

Materials

- Microsoft Publisher or some other program for formatting a newspaper
- Computers
- Books and internet access for research

Introduction to the Student

In this project, you will be researching different groups of organisms and the functions that they need to carry out in order to stay alive. You will be writing a variety of news articles about these organisms and their functions. You will also get the opportunity to be creative by adding other newspaper features to your product.

Procedure

This project involves

1. Researching information about animals in the following groups
    a. Unicellular protists
    b. Annelid Worms
    c. Insects
    d. Amphibians
    e. Mammals
    f. Non-vascular plants
    g. Gymnosperms
    h. Angiosperms

2. Writing various types of articles about these organisms
3. Presenting these articles in a newspaper format.

Focus of Research:

- Structural characteristics of the organisms; structural and functional differences among the various groups of organisms, lifestyles and behaviors of the organisms.
- Systems (transport, excretion, respiration, nutrition, synthesis, reproduction, growth and development)
- Other behaviors (individual and group)

Types of Articles and Items for your newspaper (without descriptions):
Requirements:

- Lead Story 1
- Lead Story 2
- Personal Interest News Story
- Feature Story
- Review
- Editorial
- Letter to Editor

Optional: two of the following

- Editorial Cartoon
- Advice Column
- Obituary
- Cartoon Strip
- Wedding or Birth Announcement
- Want Ad
- Puzzle
- Sport
- Weather
- Advertisement
- Horoscope
- Police Log

Types of Articles and Items for your newspaper (with descriptions):

Lead Story - Scientific News Story about the characteristics of each group of organisms. You will focus on the differences and similarities that cause these organisms to be grouped differently. This type of article usually is about a newly breaking story. You may be writing about something that is NOT "newly breaking" but you write the article as if it was. Your story should answer the 5 W's – who, what, where, when, and why. There should be a great deal of factual information. For this item you are writing as a reporter. There should be no bias or point of view in this article.

Second Lead Story - Scientific News Story about the different systems and their general functions and how they relate to each other. You should mention at least two major organs and functions for each system.

Personal Interest News Story about a specific organism. Describe its characteristics, its lifestyle, its adaptations to increase survival, its behaviors, and its endangerment status. A story such as this is a "human interest" story. It will also answer the 5 W's but also evokes sympathy in the reader.

Feature story that includes a mock interview with an organism from a different group than the one you used in your personal interest news story. You will deal with the same topics as the previous article, but you will write it up as an interview. You can use the Q/A format if you wish.

Review of a magazine article, movie, or chapter in a book about an organism from a different group than the personal interest and feature story. First you need to read the article or watch the movie. Then you need to review the item. You should state the title, author, date, and any other relevant information. Then you need to summarize the information. Finally, you will state whether you liked the item or not and why.

Editorial where you argue some ethical issue involved with the organisms. Editorials are written in essay form and express the opinion of the editorial board. An editorial usually has four parts (opinion about something, examples, conclusion, and suggestions for actions that the reader might take). Examples: you might write about whether we should have zoos; you might discuss whether we should be cloning animals; you could write about experimenting on animals; you could write about the value of protecting endangered species.

Letter to the Editor from someone who argues the other side of the ethical issue discussed in the editorial. This letter should also use examples. This will be written from the point of view of some character that you invent.

Other Items – you need to include at least TWO of these:
Editorial Cartoon related to the behavior of organisms. Editorial cartoons express opinions using humor – often ironic or sarcastic.

Advice column where you write a question from the point of view of an organism and then answer that question from your point of view. The question should involve a behavior or other aspect of that animal's life. (For example, if you were researching invertebrates, you might write: "Dear Dr. Bugs, I am a lonely female praying mantis. I have just eaten the head off my mate and I am left with all these children. I would like a new mate. What should I do?"). Make sure you answer the question.

Obituary about someone who was important in research involving organisms. (Carolus Linnaeus, Jane Goodall, and Rachel Carson are good examples.) An obituary of this type will tell about the famous person and describe their career, discoveries, and awards, as well as a little about their personal life. (You could write an obituary about an organism if you prefer).

Cartoon Strip that you create yourself. You can use characters from the comic pages of a real newspaper – but you should credit your source. But the topic and frames need to be original and should focus on organisms – structures, functions, behaviors, etc.

Want Ads (this could be something that an organism is selling– that is related to its behavior or structures or lifestyle – ex: "nest for sale, carefully crafted from sticks and stray pieces of lint")

Advertisements (this would be for a product related to an organism – ex: "sale male pine cones")

Puzzles (should include biology terms related to organisms)

Sports (This could be a article about organism "athletics" – like bears catching salmon with their claws, how fast cheetahs can run, how well plants disperse seeds, etc. But write it up like a real sports article.)

Wedding Announcements or Birth Announcements (ex: "birth of new paramecia")
Police Log (ex: young male baboons stealing females from a troop)
Horoscope (ex: characteristics of a "virgo" frog)
Weather (ex: description of beautiful weather for an earthworm)

Other details you should include in your newspaper:

- Masthead and Banner - runs across the entire width of the top of the first page – gives the time of the paper (i.e.: "The Organism Times"), the day of the week, the date, the cost
- Index – table of contents should be in a box somewhere on the first page.
- Headline for each story - a title over a story that sort of summarizes the story.
- Box (at least one) – this is a very small article or a headline that is enclosed in a box to give it emphasis
- Byline – Each story should have the name of the writer, placed above the article and under the headline.
- Pictures – you should have at least 3 pictures in your newspaper
- Caption – each picture should have an explanatory note above it
- Credit Line – you should give the source of each picture
- Cutline – below each picture should be a more detailed description of what is in the picture.

Writing Tips:

- In the first one or two sentences of your articles you should give the who, what, when, where and why of the subject. You should also try to "hook" your audience. Find something unique or clever or surprising to start with.
- Be sure to include details and examples. Quotes are useful.
- Have a concluding paragraph that ties everything together. A memorable last sentence can conclude a news article nicely. Avoid words such as "In conclusion… or "To finish….."
- Use active words – verbs that are exciting! "The man dashed headlong into the crowd" is better that "The man ran fast."
- Generally, for your main feature articles, you should write in the 3rd person.
- Keep your articles focused on the topic – don't include unrelated information.

- In your interviews, use some verbs other that "said." You could use words such as "commented," "uttered," "declared," "voiced," etc. (Use a thesaurus!)
- Do not use flowery descriptions in news articles. Those types of descriptions are for novels!
- Create your headline AFTER you have written the report – you will be better able to create a catchy headline, then.
- You should use graphics and pictures – very important in newspapers! You can even use your own artwork.
- BE SURE YOU DO CAREFUL research so that you know what you are talking about.
- DO NOT copy work from the internet – this writing must be original.

Questions to Guide Analysis:

Evaluation Rubric

Low				High
Criterion	1	2	3	4
1st Scientific Lead Story				
2nd Scientific Lead Story				
Personal Interest				
Feature Story				
Review of item				
Editorial opinion				
Letter to Editor				
OPTIONAL – Do two				
Editorial Cartoon				
Advice Column				
Obituary				
Cartoon Strip				
Birth/Death Announcement				
Want Ad				
Puzzle				
Sports				
Weather				
Police Log				
Advertisement				
Horoscope				

Meanings of 1, 2, 3, and 4:

Rating of 1
Written expression and form are weak
Language is not appropriate to newspaper writing
Article is lacking depth – too short, no examples

Organization of article is poor
Grammar, paragraphing, spelling errors
Graphics and/or pictures are missing

Rating of 2
Written expression and form are average
Language is usually appropriate to article
Article needs more depth – length and examples
Organization could be improved
A few grammar, paragraphing, spelling errors
Graphics and/or pictures are limited

Rating of 3
Written expression and form are good
Language is generally appropriate to article
Article is about the right length and has examples
Article is fairly well organized
Only 1-2 grammar, paragraphing, spelling errors
Graphics and/or pictures are good.

Rating of 4
Written expression and form are excellent
Language is very appropriate to article
Article is a perfect length and has good examples
Article is extremely well organized
No grammar, paragraphing, spelling errors
Graphics and/or pictures are excellent

Animal Responses to Environmental Stimuli: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 4: The learner will develop an understanding of the unity and diversity of life.

4.03: Assess, describe and explain adaptations affecting survival and reproductive success.

4.05: Analyze the broad patterns of animal behavior as adaptations to the environment.

Introduction to the Teacher

In this lab, students will learn about the ability of organisms to respond to environmental stimuli. They will learn that a response is a reaction to a stimulus and that this ability to respond to environmental stimuli is crucial for living organisms. While response to stimuli may be very obvious in larger vertebrates, the ability is often unappreciated in smaller, seemingly simpler, organisms. Students will realize that even the unassuming organisms used in this lab have effective nervous systems that enable them to respond.

You will provide a variety of small, harmless invertebrates for this activity, such as mealworms, crickets, earthworms, and pill bugs. Knowing that all of the organisms provided can respond to certain stimuli, students will devise a hypothesis and a subsequent test for each of the organisms to determine just what those stimuli might be. Students will create stimuli using materials such as flashlights, black construction paper, ice packs, heating pads, salt, warm and cold water, lemon juice, antacids, aluminum foil, sandpaper, sugar, cornmeal, tuning forks, distilled water, etc.

Do not assume that students are familiar with the organisms. It is helpful to provide them with some background information on the organisms being used including discussion of humane treatment. Remind students to create hypotheses that are testable within the classroom lab setting and time constraints.

Versions of this experiment can be found in most textbooks but may not be as open ended in their approach to inquiry. You might choose to provide a more structured initial activity depending on the needs of your students.

Safety Considerations

Care should be given to the selection of test organisms with particular concern to any allergies. In addition, students should be reminded to wash their hands at the completion of each experiment. All live organisms should be treated with extreme care and dispose of in accordance with the regulations provide by the supply company.

Animal Responses to Environmental Stimuli: Activity

Purpose

To study the behavior patterns of different invertebrates by designing an experiment that demonstrates how a particular organism responds to certain stimuli

Materials

This list gives an idea of materials you might find useful. However, you might be able to think of other materials to use as well.

- invertebrates (teacher will specify number and species)
- flashlight
- black construction paper
- ice pack
- salt solution
- lemon juice
- antacid
- aluminum foil
- sand paper
- sugar
- corn meal
- tuning fork
- distilled water
- warm water
- cold water
- heating pad

Procedure

Review any information your teacher gives you about the invertebrates available for today's laboratory exercise. Consider the list of lab supplies offered.

1. As a group, pick an organism to use during the experiment.

2. Knowing that all of the organisms provided have the ability to respond to certain stimuli, devise a testable hypothesis. Record your hypothesis in the space provided below.

3. The experiment that you create to test your hypothesis must be humane and workable within the time period available. Record your plans in the space provided below.

4. In the appropriate space below, discuss your reasoning and your thinking as you created your hypothesis and experiment. Relate your decisions to the knowledge you have of the organisms.

5. Have your teacher review your plans. Revise if necessary.

6. Record your data neatly, clearly, and in detail. Remember you are looking for responses of the organism in relationship to the applied stimuli.

7. Summarize and analyze the results of your experiment.

Lab Data

Hypothesis:

Experiment Procedure:
Use detailed language to describe your planned procedure.

Justification:

Data Collection:

Summary of Results:

Questions to Guide Analysis:

1. Was your hypothesis correct? If not, how might you revise it? If so, what portion of your results appeared to support it?

2. Identify the variables and the constants within your experiment.

3. What sources of error can you identify within your experiment? How did you (or would you) seek to eliminate them?

4. If given the opportunity to run your experiment again, what would you do differently?

5. Describe the responses that the organism demonstrated during the course of this lab.

6. How does what you demonstrated in your experiment relate to the ability of the organism to survive in its environment?

7. How do the responses that the organism demonstrated today relate to invertebrates as a group?

Campus Field Study

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01: Identity biological questions and problems that can he answered through scientific investigations

1.02: Design and conduct scientific investigations to answer biological questions.

1.03: Formulate and revise scientific explanations and models of biological phenomena using logic and evidence

Goal 5: The learner will develop an understanding of the ecological relationships among organisms.

5.01: Investigate the interrelationships among organisms, populations, communities, and ecosystems.

5**.02:** Analyze the flow of energy and the cycling of matter in the ecosystem

Introduction to the Teacher

The best way for a student to understand a topic is for them to experience it. Unfortunately, we do not all have access to the variety of ecosystems that are present in our state. We do, however, have the ability to study the land on which our schools are located. Whether you choose to take your class out to the football field, or another area, they will gain an appreciation of the interdependency among organisms while developing and participating in their on laboratory activity.

This lab is set up to be an on-going activity to use as you progress through your ecology unit. Before you begin, you should obtain permission to utilize a part of your campus and request that it not be disturbed (e.g. not mowed. etc.) for the duration of your unit. You should also check the area for any potential hazards (e.g. poison ivy, bees, nests, etc.) and identify any relevant student allergies. You will also need to obtain a way to mark quadrants to study **(**irrigation system flags are available at home improvement stores or you can make your own tags). Each student will need 4 flags and it is helpful to number them (i.e. four #1 flags, four 2 flags. etc.).

It is helpful if you plan your entire ecology unit to determine appropriate times to go outside for your field study. It may not be possible for you to go outside every day (since there are many concepts to cover and other activities you will want to do). You will want to make sure that you have covered certain topics before visiting the quadrant. For example, before they can explain how the carbon and water cycles are occurring in their quadrants, they need to know how these cycles work. Having the students keep a field study journal will allow them to make entries even when they do not visit their quadrant. Since temperature and precipitation may have an impact on the species present, you may

want them to record this data for the duration of the study. You will also want to check the students' investigation plans to make sure they are appropriate and will not harm the environment. They should "leave no trace" at the conclusion of the experiment.

If possible, have students work individually on this laboratory. It will be a better assessment of each individual's understanding.

Extensions of this laboratory could involve the students using their quadrants to investigate objectives 2.05 (respiration/photosynthesis), 4.03 (structural adaptations), and 5.03 (human impact on ecosystems).

Safety Considerations

Check the area where your students will work for poison ivy, nests of insects, and other potential hazards. Also, make certain you are aware of any potential health risks for the students (especially for those who have severe allergies). Keep the class together as a group, and do not allow students to leave your range of sight while outside. Students should wash their hands after every visit to their quadrant.

References

Similar versions of this lab can be found elsewhere, but this version was developed by Zoe Welsh, Leesville Road High School, Raleigh, North Carolina.

Campus Field Study: Activity

Purpose

You do not have to travel to a wildlife refuge or state park to study ecological relationships. The purpose of this activity is to study how ecology relates to an area on your school's campus. You will do this by explaining how your area relates to key concepts in ecology and by developing and conducting your own lab investigation to increase the number of species present in your area.

Materials (per person or lab group)

- Flags to mark quadrant
- Metric ruler
- Acetate with 1cm x l cm squares
- Materials needed to conduct your individual lab investigation

Procedure

1. Obtain flags and mark the area to study. Your area should be a minimum of 30cm x 30cm.
2. In the journal (each time you make an entry, make sure you include the date):

    a. Indicate which numbered flags you have and describe your location (imagine if the flags are removed and you have to locate your quadrant).

    b. Indicate the dimensions of your quadrant (in cm).

    c. Conduct a preliminary species count by listing all of the species present. If species is unknown, then describe it so you can research what it is. Each quadrant must have living things in it.

    d. List the abiotic components of your quadrant.

    e. Indicate the high and low temperature of the day (in Celsius) and precipitation. http://www.weather.com/ or http://wunderground.com/ are helpful web sites. This data should he taken each day of the investigation, regardless of whether you visit your quadrant or not.

3. Begin planning an investigation to increase the number of species in your quadrant. Plan is due on: _____ (with hypothesis, control. independent/dependent variables, steps that will be taken). Plan should be written in your journal.

4. On your next visit to your quadrant, add the following information to your journal:

    a. How does your quadrant relate to the carbon cycle? How does it relate to the water cycle?

b. How does the quadrant relate to the cycling of energy?

5. Use the acetate sheet (with 1cm x 1cm squares) to sample portions of your quadrant.

   a. First, determine how many squares make up your quadrant.

   b. Second, randomly choose ten squares of your quadrant, lay the acetate over those portions and count the number of each individual species present. Determine the estimated sample size of each species using the following equations:

      $$\text{Population \%} = \frac{\text{\# of squares randomly counted (10)}}{\text{Total \# of squares in quadrant}}$$

      $$\text{Species estimate} = \frac{\text{Total number of individual species counted}}{\text{Population \% (from above)}}$$

6. Turn in journal for investigation plan approval.

7. Once your plan has been approved, get materials ready to start lab investigation.

8. On your next visit to the quadrant, set up and begin your lab investigation. Note any problems in setup and/or changes in species number. In addition, answer the following in your journal:

   a. How does the entire area (all quadrants) show that the populations have changed over time? Explain.

   b. Which areas do you think are older than the others? Explain.

9. On subsequent visits to your quadrant: use the acetate sheet to estimate population sizes and take other data relevant to your investigation in your journal.

10. Once you have concluded your investigation, publish your results in a lab report and/or class presentation as directed by your instructor.

Questions to Guide Analysis:

1. Why was there a minimum size your quadrant could be?
2. Why was it important to date each journal entry?
3. What effect did temperature and precipitation have on the number of species in your quadrant? If they did not have a significant effect, why did you have to take the data?
4. Why would the method you used to estimate population size not be appropriate for estimating all animal populations?
5. What factors influence population *size?*

6. Was your hypothesis supported by the data you collected? Why or why not?
7. How could you have made your lab better? What would you do differently?
8. Why did you have to answer questions about the biotic/abiotic factors, the cycling of matter, the cycling of energy, and changes in populations over time in your lab journal?

Extensions

Investigate ways humans have tried to increase species size and/or diversity. Did these attempts help or hurt the environment? Why or why not? Where in North Carolina might such an enterprise be beneficial?

Environmental Factors that Affect the Hatching of Brine Shrimp: Background Information

Targeted *Standard Course of Study:* Goals and Objectives

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01: Identify biological questions and problems that can be answered through scientific investigations

1.02: Design and conduct scientific investigations to answer biological questions.

1.03: Formulate and revise scientific explanations and models of biological phenomena

Goal 5: The learner will develop an understanding of the ecological relationships among organisms.

5.01: Investigate the interrelationships among organisms, populations, communities, and ecosystems.

5**.03:** Assess human population and its impact on local ecosystems and global environments

Introduction to the Teacher

This open-ended exercise will allow the student to design an experiment to test the effect of environmental factors on living organisms. The central question of this exercise is how two abiotic factors (temperature and salinity) affect the hatching of brine shrimp eggs. This laboratory provides an excellent opportunity for students to design an experiment, learn a sampling technique, use math skills, share and compile data, and plot data on graphs.

The teacher may begin by leading a class discussion about formulating hypotheses and designing experiments. You may need to remind students to test only one variable at a time. Discuss how environmental factors may affect organisms. Have students investigate the natural history of brine shrimp. Lead students to develop hypotheses on how either temperature or salinity (or both) might affect the hatching of brine shrimp.

Students should use a variety of salinities, ranging from approximately 0% to 20%. (Brine shrimp hatch best in 1% to 4% salinity). Suggested temperatures might include the refrigerator (4°C), room temperature (21°C), and an incubator (30°C). If testing only the effect of temperature, use a 2% salt solution. If you like, you can tell students the salinity and temperature ranges to use, or you can have students research the natural habitats of brine shrimp and choose their own ranges. Students will probably need to be taught the sampling technique explained below. (When discussing sampling it may be interesting to draw parallels with polls and the census.)

Students should measure 10 ml of solution into each petri dish. Then they should place brine shrimp eggs into each dish. The volume of brine shrimp eggs should be uniform and may be standardized using some type of volume measure. For example: make a line on a piece of glass tubing with a marker or piece of tape and fill the tubing up to the mark by poking the tube into the vial of eggs and releasing excess eggs back into stock vial. Five millimeters of eggs in the tubing should be plenty of eggs. Another method is to mark a toothpick five millimeters from the end. Dip the toothpick in saline solution and then dip it in the container of brine shrimp eggs up to the line.

Eggs should hatch within two days. Students should count the number of shrimp in each dish by using a sampling method. Make a grid with 1 cm x 1 cm squares on transparency (acetate) sheets and cut to fit on the stage of your stereoscopes. Place the petri dishes on top of the grid and count the number of live shrimp in ten different cm^2 blocks and determine the average number of shrimp in each square centimeter. Have students determine the approximate total number of live shrimp in each dish by multiplying the average in each square centimeter by the total number of square centimeters in the dish. The total number of square centimeters in the dish can be determined by the formula $A = \pi r^2$.

Before students begin their experiments, they should hand in a detailed outline of their procedure. Teams with acceptable plans can begin to carry them out. Other groups will revise and refine their procedures as appropriate. After completion of this lab, students could conduct further investigations on the impact of habitat change on brine shrimp (or other organisms) as well as do research on the global effect of these changes.

Safety Considerations

Goggles should be worn if the students are handling anything that poses a danger to the eyes. Students should also wash their hands after handling the brine shrimp. The brine shrimp should be disposed of according to the information given by the supply company.

References

This exercise was adapted from a *BSCS* keen Version lab and was modified and written by Gordon Plumbee, Western Alamance High School, Elon College, NC 27244. Updates were added by Zoe Welsh, Leesville Road High School, Raleigh, NC 27613 with information from http://ut.water.usgs.gov/shrimp/ used for "Introduction to Student".

Environmental Factors that Affect the Hatching of Brine Shrimp: Activity

Purpose

To investigate how salinity and temperature affect the hatching of brine shrimp

Materials (per person or lab group)

- brine shrimp eggs (Carolina Biological # 14-2240 for a 1 oz bottle)
- petri dishes
- salt (sodium chloride) solutions, ranging from 0%-20%
- graduated cylinders, 10 ml
- stereomicroscopes
- $1cm^2$ counting grid

Introduction to Student

Brine shrimp, also known as "Sea Monkeys", belong to the phylum Arthropoda and the class Crustacea. There are several species of brine shrimp, or *Artemia,* worldwide, and they live in marine environments. Females will switch from producing live young to producing cysts when conditions become harsh. These cysts can survive for many years if kept dry. Exposing the cysts to the ideal water temperature and salinity will begin development

Procedure

Day 1

1. Design an experiment to test the effect of temperature or salinity on the hatching of brine shrimp.
2. Design a data table to record your experimental data.
3. Once your procedure has been approved by your teacher, begin your experiment.
4. Carefully monitor your set-up over the two-day period.
5. After two days the shrimp should be hatched. Count the number of live shrimp in each dish as follows:
    - Make a grid with 1 cm x 1 cm squares on a transparency (acetate) sheet.
    - Cut the sheet to fit on the stage of your stereoscope.
    - Place each petri dish on top of the grid and count the number of live shrimp in ten different 1-centimeter-square blocks
    - Determine the average number of shrimp in each square centimeter.
    - Multiply the average in each square centimeter by the total number of square centimeters in the dish. (The total number of square centimeters in the dish can be determined by the formula $A= \pi r^2$).
6. Analyze your data, compare it to the data of your classmates, and then graph your data.

Questions to Guide Analysis:

1. What environment is best for the shrimp eggs to hatch?
2. Did everyone in the class get similar results? Explain why or why not.
3. What advantages does sampling have over counting every shrimp? What disadvantages?
4. What other types of data do we usually get from sampling?
5. Would a mark and recapture method of determining population size be feasible for this lab? Explain why or why not.
6. If other species have temperature and salinity ranges similar to brine shrimp, what impact would humans have on those organisms? Explain at least two situations of when humans would help or harm the organisms.
7. What would be the overall environmental impact if a factory was responsible for changing the salinity and/or temperature of the brine shrimp habitat

Extensions

You could also choose to test the effect of alcohol levels on brine shrimp hatching and relate to fetal alcohol syndrome or test other factors and determine what the overall effect to the environment would result.

Honors Biology
Support Documents
2004 Curriculum

Public Schools of North Carolina

July 2007

Honors Biology Curriculum Support for the 2004 revision of the *North Carolina Standard Course of Study* for Biology

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We make every effort to keep these materials accurate and up to date. Check the Department of Public Instruction's website http://www.ncpublicschools.org/curriculum/science/scos/ for current versions.

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Introduction

These materials were developed to assist in the development and implementation of Honors Biology courses. It should be noted, however, that **this document is not an honors teaching portfolio**. Each individual LEA and/or honors biology teacher needs to create a portfolio to document their own honors biology course. The materials included in this document are sample activities and suggestions provided to help in the portfolio development process. Honors courses may be developed at the LEA, school or teacher level. A local review and monitoring process should be put in place. As teachers develop their honors portfolios, they should use this opportunity to document what they are already doing well, while further developing the rigor in their courses. This should be seen as an on-going process. Courses should be revised and reviewed each year.

Essential Questions: Essential questions may be organized by teaching units rather than by the *Standard Course of Study*. Their purpose is to help focus teachers and students on the most important or essential concepts. Often an essential question bridges between objectives or serves as an organizing question for a unit that brings in concepts from several goals and objectives. Sometimes after writing the overarching question, teachers will need to consider "entry point" questions to help students do the research and understand the background to access the topic at a higher level. Below are some internet resources related to essential questions.

http://www.myprojectpages.com/support/ess_questpopup.htm

http://www.essentialschools.org/cs/resources/view/ces_res/137

http://members.tripod.com/~ozpk/0000000EQ - this page starts with a bunch of links to other essential question sites and then has some examples - the ones in this site will help teachers make interdisciplinary connections to beyond the sciences.

Precautions:

- **All students**, not just those in honors courses, should experience challenging work and some level of independent inquiry in their courses.
- Many of the materials and activities suggested for honors courses will also be appropriate for some students enrolled in standard level versions of the course.
- Teachers should include some of the enrichment topics for all students.
- **Independent does not mean unsupervised!**
    - Teachers must still provide appropriate supervision at all stages.
    - For independent projects teachers should give choices of topics or have a process in place for topic review and approval.
    - Teachers should always review project design carefully for safety reasons and to be sure the project will provide an appropriate learning experience.
    - Actual laboratory work must be supervised. Younger and less experienced students will need more scaffolding to make this a productive learning experience.
    - Independent **DOES** mean that the teacher will **NOT** provide all of the structure and step by step instructions.

- Independent does not mean alone or unsupported!
    - Just as adults in all sorts of industries usually work in teams, students may also work in teams.
    - Teachers may need to provide some assistance to students in finding appropriate sources and models of appropriate performances.

A more extensive introduction to the development of honors courses is in the *Honors Course Implementation Guide* available for download at http://www.ncpublicschools.org/curriculum/honorsguide

Course Description

Honors Biology

Honors Biology is designed to give the student a more challenging and in-depth experience of the *North Carolina Standard Course of Study* (*SCS*) in Biology. In Honors Biology, students are expected to work independently on a variety of assignments and accept greater responsibility for their learning. In addition to the *SCS* goals and objectives, students are expected to: design and carry out several independent investigations of biological questions, read and report on recent research in biology, and demonstrate a more in-depth conceptual understanding of all biology objectives.

Honors biology is intended as a ninth or tenth grade course for highly motivated students who have demonstrated an interest in science. The Biology EOC exam is required to receive credit for this class. Students may not take Honors Biology in addition to standard level *Standard Course of Study* Biology.

The honors committee designated one required extended objective for Honors Biology 1.02-H.

1.02-1 H Design and conduct independent scientific investigations to answer biological questions

- Perform inquiry activities that extend over time
- Relate the investigation(s) to recent research
- Use statistical techniques such as chi square to analyze data
- Communicate findings in a formal written laboratory report
- Evaluate possible sources of error and ways to improve the investigation(s)
- Present findings to members of the community

Rather than creating additional objectives for honors biology, the honors guidelines committee has suggested that each existing objective be studied in greater depth. Students should demonstrate understanding by giving more detailed, quantitative and molecular explanations of biological phenomena and be able in more cases to explain the key experiments and insights behind current knowledge.

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

Objective	Essential Questions/Extended Content	Suggested Activities
1.01 Identify biological problems and questions that can be answered through scientific investigations.	**What is the significance of scientific investigation?**	***Research Design***
1.02 Design and conduct scientific investigations to answer biological questions. • Create testable hypotheses. • Identify variables. • Use a control or comparison group when appropriate. • Select and use appropriate measurement tools. • Collect and record data. • Organize data into charts and graphs. • Analyze and interpret data. • Communicate findings.	**How does a scientist design and perform a scientific investigation considering controls, variables, and data analysis?** **What is the relationship between independent and dependent variables?** **What is a control in a scientific investigation? What types of biological investigations do not typically have controls? Which do have controls? When is it important to have a control?**	***Design an Experiment for Farmer Cletus***
1.03 Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to: • Explain observations. • Make inferences and predictions. • Explain the relationship	**How do you distinguish between an observation and an inference?**	

between evidence and explanation.		
1.04 Apply safety procedures in the laboratory and in field studies: • Recognize and avoid potential hazards. • Safely manipulate materials and equipment needed for scientific investigations.	**What are some potential hazards that can occur in a lab?**	
1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint including considerations of: • Appropriate sample. • Adequacy of experimental controls. • Replication of findings. • Alternative interpretations of the data.	**What is the difference between quantitative and qualitative data? When would you use one over another?**	

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

Objective	Essential Questions /Extended Content	Suggested Activities
2.01 Compare and contrast the structure and functions of the following organic molecules: • Carbohydrates. • Proteins. • Lipids. • Nucleic Acids.	**How is protein differentiation (different functions in the context of the cell) significant?** Hydrolysis and condensation reactions *Structure and function of cellulose and phospholipids in organisms*	
2.02 Investigate and describe the structure and function of cells including: • Cell organelles • Cell specialization. • Communication among cells within an organism.	**How do the differing structures of cells relate to specialized functions?** Making microscopic measurement Comparison of light vs. electron (SEM and TEM) microscopes Following scientists and their contribution to understanding of the cell as well as the development of a theory: Leeuvenhoek, Brown, Schleiden, Schwann, Virchow, Hooke, and Just. ER, Golgi, lysosomes, and cytoskeleton Connect cell communication with cell specialization	
2.03 Investigate and analyze the cell as a living system including: • Maintenance of homeostasis. • Movement of materials into and out of cells.	**How do organisms maintain homeostasis in changing conditions?** **How does the surface area to volume ratio of cells affect diffusion rates?** Relate properties of water (studied in middle school) to cell membranes and functions.	***Demonstration Lab—Osmosis and Diffusion*** ***Smooth Moves: The Jello Cell Family Story***

• Energy use and release in biochemical reactions.	Regulation of osmotic pressure within the human body	
2.04 Investigate and describe the structure and function of enzymes and explain their importance in biological systems.	Modern drug design based on genomics	
2.05 Investigate and analyze the bioenergetic reactions: • Aerobic respiration • Anaerobic respiration • Photosynthesis	Glycolysis, Kreb's Cycle, and Electron Transport Chain Light dependent vs. light independent reactions	

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

Objective	Content Differentiation/ Essential Questions	Suggested Activities
3.01 Analyze the molecular basis of heredity including: • DNA Replication • Protein Synthesis (transcription and translation) • Gene Regulation	**What are the ramifications to the organism if these processes (DNA replication, protein synthesis, and gene regulation) go "wrong?"** Chargaff's ratio Semi-conservative vs. Conservative model Contribution of Franklin and Wilkins in addition to Watson and Crick **How does gene regulation lead to cell specialization?** Lac operon	
3.02 Compare and contrast the characteristics of asexual and sexual reproduction.	**How does one single cell with a set number of chromosomes become thousands of different types of cells in mature multi-cellular organism?**	
3.03 Interpret and predict patterns of inheritance. • Dominant, recessive and intermediate traits. • Multiple alleles. • Polygenic traits. • Sex linked traits. • Independent assortment. • Test cross.	**How do genes and the environment interact to produce a phenotype?** *Interpretation of pea experiments that led to Mendel's Principles*	***Using Chi Square with "Genetics of Parenthood"***

• Pedigrees. • Punnett squares.	Dihybid crosses **Can we simulate a model illustrating the principle of independent assortment while supporting the probability of a dihybrid heterozygous cross?** Genetic testing: blood tests, ultrasound, amniocentesis, and chorionic villi sampling	**Dihybrid Crosses**
3.04 Assess the impacts of genomics on individuals and society. • Human genome project. • Applications of biotechnology.	Research genetic diversity in human populations Analysis of ancestry based on genetic patterns Reproductive cloning Reading and using restriction maps	
3.05 Examine the development of the theory of evolution by natural selection including: • Development of the theory. • The origin and history of life. • Fossil and biochemical evidence. • Mechanisms of evolution. • Applications (pesticide & antibiotic resistance).	**Do allelic frequencies change over time in response to natural conditions?** Scientific controversy Endosymbiotic hypothesis Gradual vs. punctuated equilibrium Reproductive isolation The rate of evolution **How does pesticide and antibiotic resistance support the principle of natural selection?**	***Fishy Frequencies (with Hardy-Weinberg)***

Goal 4: Learner will develop an understanding of the unity and diversity of life.

Objective	Essential Questions/Extended Content	Suggested Activities
4.01 Analyze the classification of organisms according to their evolutionary relationships. • The historical development and changing nature of classification systems. • Similarities and differences between eukaryotic and prokaryotic organisms. • Similarities and differences among the eukaryotic kingdoms: Protists, Fungi, Plants, and Animals. • Classify organisms using keys.	**How has modern technology allowed scientists to develop more sophisticated schemes for classification?** Explore the phylocode controversy (new system vs. Linnaeus) **What are the advantages and disadvantages of simplicity vs. complexity in cellular/organism structure and function?** Creation of a dichotomous key	
4.02 Analyze the processes by which organisms representative of the following groups accomplish essential life functions including: • Unicellular protists, annelid worms, insects, amphibians, mammals, non-vascular plants, gymnosperms and angiosperms.	**How do various organisms accomplish essential life functions?**	***Plant WebQuest***

• Transport, excretion, respiration, regulation, nutrition, synthesis, reproduction, and growth and development.	Plant tropisms	
4.03 Assess, describe and explain adaptations affecting survival and reproductive success. • Structural adaptations in plants and animals (form to function). • Disease-causing viruses and microorganisms. • Co-evolution.	**How is society affected by disease?** **What characteristics of viruses and microorganisms result in epidemic/pandemic outbreaks of diseases such as SARS and bird flu?** **Why do different populations respond differently to the same disease (e.g. cold virus in Europeans vs. South American tribes)?** Disease transmission Epidemiology Types of viruses (how the type influences mutation rate and production of vaccines) Plague of 1918 **How does the flu co-evolve with humans and other organisms (e.g. ducks)?**	
4.04 Analyze and explain the interactive role of internal and external factors in health and disease: • Genetics. • Immune response • Nutrition • Parasites • Toxins	**The body is able to recognize self vs. non-self. What are the consequences of mistakes in recognition?**	

4.05 Analyze the broad patterns of animal behavior as adaptations to the environment. • Innate behavior. • Learned behavior. • Social behavior.	**How do pheromones allow for the social behaviors of colonial organisms to adapt to their environment?** **What are the advantages and disadvantages of using pheromones adaptations?**	**Termite Behavior**

Goal 5: Learner will develop an understanding of the ecological relationships among organisms.

Objective	Essential Questions/Extended Content	Suggested Activities
5.01 Investigate and analyze the interrelationships among organisms, populations, communities and ecosystems • Techniques of field ecology • Abiotic and biotic factors • Carrying capacity	**What tools do scientists use to study biodiversity?** **What factors influence biodiversity?** **How is carrying capacity different for two organisms living in the same environment?**	**Field Study on School Grounds**
5.02 Analyze the flow of energy and the cycling of matter in the ecosystem. • Relationship of the carbon cycle to photosynthesis and respiration • Trophic levels- direction and efficiency of energy transfer	**What roles do cellular respiration and photosynthesis play in the carbon cycle?** Nitrogen cycle, Phosphorus cycle **How do trophic levels determine how energy is transferred through ecosystems?** **How are trophic levels related to food webs?** **What are the effects of biomagnification with respects to the food chain?**	***Food Chains and Biological Magnification***

5.03 Assess human population and its impact on local ecosystems and global environments: • Historic and potential changes in population • Factors associated with those changes. • Climate Change. • Resource use • Sustainable practices/ stewardship.	**What factors influence the J and S-shaped population curves? How are they significant?** **How do human activities affect ecosystems?**	

Design an Experiment for Farmer Cletus: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Essential Question(s):

What is the significance of scientific investigation?

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

What is the relationship between an independent variable and a dependent variable?

What is the importance of having a control in a scientific investigation?

How do you distinguish between an observation and an inference?

What are some potential hazards that can occur in a lab?

What is the difference between quantitative and qualitative data? When would you use one over another?

Introduction to teacher:

This is a good activity to use at the beginning of the course to help review the scientific method and to introduce inquiry-based investigations. Students will first identify a hypothesis to address Cletus' problem of identifying which fertilizer will work best on his crop. They should also identify the other important components of the experiment and get teacher approval.

After getting approval, the students should each perform their experiments. These could be done in the classroom or at home. If needed, you could have supplies for them to use. Since the students will be testing different types of fertilizers, you may want them to analyze the effects of organic vs. inorganic (Miracle Gro) fertilizers.

Both quantitative and qualitative data could be collected during the course of their experiments and students should be encouraged to keep a lab journal.

This is a good experiment to use to introduce the formal lab write up. Since the emphasis in this particular exercise is on design you may wish to have students do a formal write up only for the methods section. There are a wealth of resources at NCSU's Labwrite site to assist teachers and students in developing lab writing skills. http://www.ncsu.edu/labwrite/

Differentiation from Standard-level:

A standard level class may need more teacher guidance in designing the experiment, in organizing the data, and in writing up their results. In addition to performing the lab, possible extensions include integrating ecology and the nitrogen cycle into the lesson.

Safety/Special Considerations:

Goggles and gloves (for handling fertilizers) should be worn during experimentation.

References:

Brunswick County Biology Teachers, North Carolina

Design an Experiment for Farmer Cletus: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Essential Question(s):

What is the significance of scientific investigation?

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

What is the relationship between an independent variable and a dependent variable?

What is the importance of having a control in a scientific investigation?

How do you distinguish between an observation and an inference?

What are some potential hazards that can occur in a lab?

What is the difference between quantitative and qualitative data? When would you use one over another?

Introduction:

This is a story about Farmer Cletus. He grows corn in Nebraska, and lately his crop yield (how much corn he grows per acre) has been steadily decreasing. Currently, Farmer Cletus uses the fertilizer Grow-Fast and it appears that Grow-Fast is no longer working well. Cletus wants to change fertilizers to Miraculous-Gro, but the switch will be very expensive. To help with this, Cletus wants to apply for a federal aid program that will pay for his fertilizer.

The federal aid program requires that Farmer Cletus design an experiment to test which of the fertilizers will most benefit his crops. This experiment must be a controlled, one variable test of fertilizer effects on corn yield. Unfortunately, Farmer Cletus is a little rusty on his experimental design since he didn't take good notes in biology. However, there is hope since Farmer Cletus has commissioned you to help him.

Assignment:

Answer the following based on the story above:

1. The scientific "question" being asked by Cletus is:

2. Design a procedure for a controlled, one variable experiment for Farmer Cletus' corn. Since we do not have access to Gro-Fast or Miraculous-Gro, we will test other fertilizers. In your experiment, you will need to test two fertilizers. Be sure to clearly identify the dependent and independent variables, your control group, and the variables you need to hold constant.

    a. What is your hypothesis?

    b. The independent variable is:
    c. The dependent variable is:

    d. The control group would consist of:

    e. The variables to hold constant:

Materials:

Various fertilizers
Pots
Soils
Seeds
Light source

Procedure:

Describe what you will do (step by step) on another sheet of paper. Determine if there are any safety issues with the lab you develop (and indicate on your procedure). Also indicate the types of measurements you will make and justify your choices.

Safety:

Wear goggles when you experiment and gloves when you handle fertilizers. Wash your hands at the end of each lab day.

Questions to Guide Analysis:

1. What possibilities could you infer could cause the decrease in Farmer Cletus' crop yield?
2. What are the negative and positive aspects of using two different fertilizers?
3. What considerations should use when selecting fertilizers (e.g. crop yields, costs, pollution, etc.)? Why?
4. What data (qualitative, quantitative, or both) would be best to make decisions about which fertilizer to use?

References (for further research):

Recent EPA articles about runoff and fertilizer pollution problems within North Carolina
http://www.epa.gov/owow/nps/Success319/state/nc_neu.htm
http://www.epa.gov/owow/nps/Section319II/NC.html

Research Project: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Essential Question(s):

What is the significance of scientific investigation?

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

What is the relationship between an independent variable and a dependent variable?

What is the importance of having a control in a scientific investigation?

How do you distinguish between an observation and an inference?

What are some potential hazards that can occur in a lab?

What is the difference between quantitative and qualitative data? When would you use one over another?

Introduction to the teacher:

This is an **example** of the type of assignment that may be used to satisfy the independent research component of the honors science curricula. It should be modified by teachers to meet their individual classroom needs.

This is a long-range project that is student driven in focus. It begins by having the students submit a question that they hope to answer in the course of their research. If approved, the students conduct a 14-week study of the topic of their choosing. The instructions are very detailed, however the research and laboratory activities are student-driven.

There are checkpoints throughout the project that will keep the students on task, and will give valuable feedback to the teacher on the students' progress towards their goals.

Since the students will generate the topics of their research, it is vital that they receive not only teacher approval, but also parent approval before they begin their investigation.

It is essential to provide all students the opportunity to be successful with this project. Therefore some organisms, space, apparatus and time will need to be available at school to students who for whatever reason are not able to carry out this kind of a project in their home environment. You may wish to brainstorm with your classes what would be low cost, easily available organisms and apparatus to work with. It should be clear to students that the project grade is not dependent on the use of expensive apparatus. Teachers may need to provide a disposable camera or loaner camera.

Differentiation from Standard-level:

This exemplifies a long-range "Independent Investigation" that typifies honors-level.

Safety/Special Considerations:

Students need to identify possible hazards in their own labs (and refer to appropriate MSDS).
Students also need to gain teacher and parent approval before they begin.

References:

Stockdale, Maureen (Wakefield High School, Raleigh, North Carolina)
Stiles, Laura (Wakefield High School, Raleigh, NC) *Project Guidelines*.
Gallant, Trevor (KV High School, Canada)
http://kvhs.nbed.nb.ca/gallant/biology/lab_report_format.html

Research Project: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Essential Question(s):

What is the significance of scientific investigation?

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

What is the relationship between an independent variable and a dependent variable?

What is the importance of having a control in a scientific investigation?

How do you distinguish between an observation and an inference?

What are some potential hazards that can occur in a lab?

What is the difference between quantitative and qualitative data? When would you use one over another?

Introduction:

This research project was developed with several objectives in mind. As a scientist you question things that are going on around you and the best way to get an answer is to design and conduct an experiment. You also need to develop and practice your skills of observation, analysis and communication. This project will provide the opportunity for you to practice what a scientist does on the job. Your experience with research will help you in your other high school and college lab classes.

Deadlines:
This assignment is ***not*** to be completed in one evening. In order to do a good job with this assignment you will need to start early and not procrastinate. Think of this as an English term paper that is combined with a Biology lab activity. You need to complete sufficient background research before you can design your experiment. Then you need to set aside enough time to conduct your experiment ***at least*** one time. As you are designing your project schedule be realistic with your previous time commitments. After your experiment is finished you then need time to analyze your results so that you can communicate your findings and conclusions.

Basic outline of your Biology Research Project:

1. Topic selection & approval
2. Identify & confirm components that need to be researched
3. Thoroughly research the above components & use the information to make a hypothesis.
4. Completion of a typed Introduction Paper.
5. Designing your experiment.

6. Performing the experiment.
7. Recording & summarizing all data (charts, data tables, graphs, daily journal, photographs, etc.)
8. Analysis of data and conclusion.
9. Completion of Final Research Paper.
10. Presentation of research and experimental results at the science symposium (the date will be announced as soon as possible).

Below is a tentative list of deadlines (which are subject to change at the teacher's discretion):

- **(Week 1)** Topic / Question to be answered must be turned in and APPROVED!

- **(End of Week 1)** Identify/confirm components to be researched (Organism, Independent Variable & Dependent Variable).

- **(Weeks 2 and 3)** Locate sources of information about your topic. You should find at least four reliable resources. At least one must be a book and a second must be an internet site. Other possible sources include newspaper articles, magazines, and people with expertise in your topic.

- **(Week 4)** Background Research Due for Peer Evaluation (Intro Paper) along w/a page of Sources Cited). Don't forget to have your sources sited in the body of your paper as well.

- **(Week 5)** Intro Paper due for Teacher Evaluation (including changes made from Peer Review)…peer evaluations must be turned in with your paper.

- **(Week 7)** Experimental Design Due (materials & methods and sample data tables, graphs & charts)

- **(Week 14)** Rough Draft of your final research paper is due.
  - This paper will be the result of combining your: Introduction Paper + Experimental Design + Results. You should include actual data, tables, graphs, charts & pictures that will be in your final paper.
  - A new and VERY IMPORTANT component that must be included is the Analysis of your data and the final conclusion.

- **(Date TBA)** Science Symposium 6-8pm
  - Final draft of Research Papers Due
  - Presentation of research & results

Selection of Topic

In this project you are asked to investigate the effect of some environmental factor on some organism. When you pick a topic please take the time to find something that interests you. Consider the amount of time that you will be able to give daily once your experiment begins. You need to be able to make thorough observations at roughly the same time each day.

Since every experiment is different, I cannot give you an exact length of time that your experiment needs to run. However, it is important that you are **realistic** about the length of time needed to provide valid & reliable results. Some experiments may require up to 6 weeks. For example, measuring plant growth for one to two weeks is generally not sufficient, especially if you are starting with seeds.

***Due to the complexity of vertebrates you are not allowed to conduct any experiments with them. ***

Part 1: Introduction to Research Paper

Part I: Introduction

This is the part of the paper that sets the stage for your reader. In this section you will offer a rationale for your experiment as well as provide sufficient background information starting with the general and becoming more specific.

Problem/Question:
Begin by identifying the question you are attempting to answer through research & experimentation.

Rationale:
This is where you explain why you want to answer the above question. In other words, why are you doing the experiment? Go beyond the obvious, that you are doing this as part of a class assignment; instead explain why you selected this specific topic. Why does this topic interest you? Also, try to think on a broad scale. Stay away from saying you selected working with hamsters because you think they are cute or that you are working with bacteria because it is easy. Concentrate on the benefit of your results; how can your results be used in the future?

RESEARCH / Background Information:
In this part of the introduction you are laying the foundation for your hypothesis. You need background information on both the organism used and the environmental factor (independent variable) changed. For the organism you are concentrating on what is normal behavior/growth/color, etc.

> **Example:** Background information on plants might include normal growth requirements such as, amount of light, temperature, quantity and frequency of water, proper pH, and type of soil. Also look for information to describe normal color and growth – paying attention to the factors that will be measured during the experiment.

The information on environmental factors (in most cases, the independent variable) should explain what it is and how it is supposed to affect organisms. If you can find examples of how it affects other organisms, include it.

> **Example:** Information on the formation of acid rain and why it is important to study it should be provided (this helps to support the rationale). The harmful effects of acid rain – its corrosive properties should be provided. When possible provide examples of how acid rain affects nonliving materials such as marble and brick, as well as living things as it lowers the pH of the environment. Also, include information on ways to combat the effects of acid rain, and examples of areas currently affected by acid rain.

Things to remember while researching:
As you are searching, keep detailed records. Make sure you **record the sources you have used,** whether helpful or not, and the keywords that you worked with. This will help you if you have to do more research and in compiling the sources used in the bibliography.

Research Design

Your research paper should include 'RESEARCH' or information that you have taken from other sources. Each time you include information from a source you should cite that source in the body of the paper using parenthetical references (the author's last name and page number(s) are placed in parentheses in the text to give credit to sources).

For each draft of your research paper that you turn in, you will be required to provide a list of sources that you have either quoted or used to support the information in your paper.

Note – Be very careful to avoid plagiarism. **There are various forms of plagiarism:**

- **The most obvious is simply copying information word for word from a source without using quotation marks and identifying the source. Though it may be ok in just your notes, after all you may be the only one who will see them, when it is time to write your paper you may forget that those are not your own words. Just copying information also leads to a poor understanding of it. You are better off writing everything in your own words.**
- **Putting information in your paper that is not considered general knowledge without citing the source is also another form of plagiarism.**

Hypothesis

Your rationale and background information should lead into your hypothesis. The information that you have presented in the preceding two sections should provide the reader with an understanding of why/how you developed this hypothesis. Again, make sure your hypothesis is:

- clear
- testable
- supported by the background information
- written in the form of a statement (not a question)

Example: The weekly application of acid rain (pH 4.5) will make the plant lighter in color and will stunt the growth.

❖ **Once approved, any changes to your project/hypothesis must be cleared with the teacher. Changing your topic without notifying the teacher may result in a failing grade for your research project.**

Sources Cited

This is what you usually call a bibliography. The difference is that the only sources listed here are ones that you refer to in the body of your paper. The sources are to be listed in alphabetical order by the author's last name. You are not allowed to cite a general encyclopedia – it can be used to help you find background information, but you need to find more specific details in a different source. Also single space within an entry but double space between them and have the first line start at the left margin while indenting the other lines. Be sure to follow proper MLS format.

You need a minimum of four sources (one must be a book and another must be a reputable internet site) that you cite in your paper. **Example:**

McMillan, Victoria E. 1997. Writing Papers in the Biological Sciences, 2nd Ed. Boston: Bedford Books. pages 120–145.

Stover, Dawn. 1999. Sizing Up Terror Crocs. Popular Science. 255(3):33.

Research Design

Part 2: Experimental Design (Materials & Methods)

Materials:

In this part of the paper you will list (bullets are a nice touch) ***all*** *the materials that are needed to conduct the experiment from start to finish. The quantity of each item should also be included.*

❖ *This should not be done in paragraph form.*

Methods:

This is the procedure that you plan to follow. You need to write it with enough detail so anyone could do the experiment EXACTLY the same way you did. Follow the guidelines below:

- Provide details, especially of those methods that are unique to your experiment.
- Write out the procedures in a step-by-step format.
- Number each step.
- Write in past tense (you have already done the experiment) and use passive voice.
  Example: use "The plant was watered every day . . ." instead of "I watered the plant every day . . ."
- Identify the organism used with the scientific and common names, also mention age if appropriate and where you obtained it.
- Describe any apparatus/chemical that is unique to your experiment – don't assume that your reader is familiar with all equipment/chemicals.
- Identify the difference between the control and the experimental organisms.
- Describe the normal care of the organisms (this is typically the care of the control) such as feeding/watering schedule, temperature and humidity of habitat, living accommodations, light source and distance from other organisms (if applicable).
- Explain when you will make observations and what those will be – measure length/height/width/mass, behavior, color changes, respiration changes, performance of a task.
- **Provide a <u>photograph</u> (not a sketch) of the set up on the first day of your experiment.**
- Include any safety precautions that you need to follow – address any possibilities, no matter how insignificant you feel they are. If you have a light or heater for your organism, be sure to address fire safety!
- Identify the ways that you will be disposing of the materials after they have been used; include clean up procedures for when the experiment is in progress.
- Make sure your experiment tests your hypothesis.

Part 3: Results

This is the section where you show how you plan to present your data. You must include a data table, graph & pictures/diagrams. Do not make any comments <u>about</u> the results in this section. Simply report the data and any observations.

- *Do say: A leaf from the "sunny" plant was observed to contain starch.*
- *Do not say: A leaf from the "sunny" plant was observed to contain starch* because it was exposed to sunlight.

You need to make sure the presentation of your data/observations is clear and easy to read. Don't assume that your reader knows exactly what you were doing. You can clear up any potential confusion by avoiding the use of abbreviations (except units for measurements), writing a detailed title for any figure or table, using units with each measurement, and providing a reference point for any descriptions (exactly what is meant by "big" or "greenish"?).

Tables and Figures

- A table is what you might call a chart – it is information presented in rows and columns
- Every *table* should be labeled by a number and have a title at the top so that they can be easily referred to in the discussion.
  Example: "Table 3: Daily change in height of each plant"
- If it is a picture/diagram or a graph then it is called a *figure.*
- A figure should have a number and title at the bottom – leave space for it
- Make sure the axes of the graph are spaced evenly (one square has the same value all along the axis) and labeled
- Label the units with all measurements – at the top of the columns in a table and along the axes of a graph
- Use grid lines around the information in a table – this makes it easier to read
- Group similar data in a column, not a row.

Journal/Daily Log

- A daily/weekly log or journal of observations needs to be kept in a composition notebook. This will need to be turned in with your final research paper.
- Qualitative and quantitative data should be recorded for each entry.
- Use descriptive words to provide as much detail as possible. You want to create a mental picture.
- Sketches or drawings may be used in addition to your observations.
- The interval of each entry will vary depending on the experiment. If you are uncertain about the minimum number of observations that should be recorded, check with your teacher.

Part 4: Discussion

The discussion is perhaps the most important part of your lab report - but often the most challenging. This is where you provide an interpretation or explanation of your results. Do not simply restate your results - you already did that in the results section. You must discuss what they mean and why they are important. Discuss what you were able to learn from your results. In this section the author (you) is expected to analyze and interpret the investigational data relative to the objectives described in the Introduction.

In this part of the paper you will pull all the parts together. Readdress your hypothesis and relate your results to it. Determine the success of the experiment and support this with specific results. When you are discussing the success of your experiment consider the significance of your results. An 10 cm experimental plant that is only 0.1 cm bigger than the control plant is not significant. But a .1 cm difference in the average growth of 100 earthworms might be. This would be a good place to calculate percent difference/error. If a calculation is not possible, use your best judgment on what is a significant difference. Perhaps your decision could be that the experiment was successful in testing the hypothesis, but did not significantly support the hypothesis. You may conclude that more experimentation is needed to support or reject the hypothesis. When discussing your success/failure start with specific information – the important results of your experiment by referring to the data and the table/figure in which the information can be found. Remember, it is ok if your experiment did not support your hypothesis. You have not failed the assignment; you just have to provide a reasonable explanation for your results.

> **Example:** The plants watered with acid rain (pH 4.5) grew considerably less than the control plants (average of 2 inches compared to 5 inches) as shown in Table 1.

Offer a detailed explanation of your results. Pick the most likely explanation; don't mention every possible option-as some obviously won't apply to your work. As you are explaining your results you should refer to information gathered while you were doing your background research – you can pull in points mentioned in your introduction. You should also refer to similar experiments. This will help to support your results by agreeing with your findings or showing that your hypothesis was correct but results were flawed. Don't worry if similar experiments don't agree with your own; the comparison still needs to be made.

> **Example:** Acid rain stunted the growth of the plant because the acid burned the roots, making it more difficult for them to absorb the necessary minerals and water. The acid also reacts with the minerals and nutrients in the soil making them unavailable to the plant. A study conducted by Jane Doe (15) showed pine trees exposed to acid rain (pH 5.0) grew 3 times slower than those watered with normal rain water (pH 6.5)

Discuss possible sources of error. These could include:

- error due to not following directions
- design errors – not having the right living conditions
- sampling errors – sample size, population/organism selected
- measurement, record keeping or calculation errors

Only mention errors that are most likely to have affected your experiment. If I knew that I measured the pH of the acid rain accurately I would not include this as a part of my error. One

error that should always be included is sample size. You are not using enough organisms and need to consider individual differences and their influence on your results. For each error you mention you should offer a reasonable and detailed improvement. Don't just say "The sample size should be larger" but give a specific sample size.

End your discussion by referring back to the rationale in your introduction. Discuss whether or not your results can be used in the way you stated. Give other examples of how you can use your results. A good experiment also generates more questions than it answers. This would be a good place to make suggestions for future experiments – those that will expand on your findings.

Part VI: Sources Cited

This is what you usually call a bibliography. The difference is that the only sources listed here are ones that you refer to in the body of your paper. The sources are to be listed in alphabetical order by the author's last name. You are not allowed to cite a general encyclopedia – it can be used to help you find background information, but you need to find more specific details in a different source. Also single space within an entry but double space between them and have the first line start at the left margin while indenting the other lines. Be sure to follow proper MLS format.

You need a minimum of four sources that you cite in your paper. **Example:**

McMillan, Victoria E. 1997. Writing Papers in the Biological Sciences, 2nd Ed. Boston: Bedford Books. pages 120–145.

Stover, Dawn. 1999. Sizing Up Terror Crocs. Popular Science. 255(3):33.

Overall / Misc. Requirement:

- **Experiment tests hypothesis**
- **Paper is clear/concise**
- **Proper sequence is followed.**
- **Typed**
- **Double spaced**
- **1 inch margins**
- **Times New Roman, 12 point font (or something comparable)**
- **All components included**
- **Spell Check performed**
- **No major grammatical errors**

Sources:

- Gallant, Trevor (KV High School, Canada) http://kvhs.nbed.nb.ca/gallant/biology/lab_report_format.html
- Stiles, Laura (Wakefield High School) *Project Guidelines*.

Research Design

Safety:
Before you begin your experiment, you must first gain teacher and parent approval. You then should research any potential safety hazards, consult MSDS, and make sure you follow all necessary safety precautions throughout your experimentation.

Questions to Guide Analysis:
Embedded in the instructions.

References (for further research):
Textbook	Library	Commercial Laboratory	Internet
Scientists	Teachers	Science Supply Companies (Carolina/Ward's)	

Rubric: See planning sheets.

Honors Biology Research Paper – Part I		
Component: Place a check next to each question, once you have completely answered it (in the provided space).	**List all sources of Information used to support these statements**	**Number of the Corresponding paragraph(s)**
I. Topic		
___ What question are you trying to answer? ♦ **This must be a question you can answer *scientifically*!** ♦ **You must be able to obtain *measurable* results?**		
II. Rationale		
_____ Why does the topic interest you?		
_____ How will anyone else benefit from your results?		

Honors Biology Research Paper – Part I		
Component: Place a check next to each question, once you have <u>completely</u> answered it (in the provided space).	**List all sources of Information used to support these statements**	**Number of the Corresponding paragraph(s)**
III. Background Information (RESEARCH):		
A. Organism used in the experiment	***Source Cited***	**Paragraph #**
_____ What is the common name?		
_____ What is the scientific name (2 word name, in Latin, usually italic print. The first word always begins with a capital letter, the rest is lower case)?		
_____ Normal behavior/appearance (what would I see if I was looking at it – how is it different from other organisms like it)		

Honors Biology Research Paper – Part I		
Component: Place a check next to each question, once you have <u>completely</u> answered it (in the provided space).	**List all sources of Information used to support these statements**	**Number of the Corresponding paragraph(s)**
_____ Normal growth (How rapidly does it grow? Is there a particular time that it grows best? How long does it take to complete a normal life cycle? Reproduction rate?...)		
_____ What time of year can your organism be found. When is it most likely to survive/grow (consider when you will be conducting your experiment).		
_____ What needs to be done to keep the organism alive throughout your experiment (normal care and feeding).		

Honors Biology Research Paper – Part I		
Component: Place a check next to each question, once you have <u>completely</u> answered it (in the provided space).	**List all sources of Information used to support these statements**	**Number of the Corresponding paragraph(s)**
_____ Did you use any other sources to support the above information? If so, list them below.		
B. Environmental Factors (a.k.a. independent variable):	***Source Cited***	**Paragraph #**
_____ What is the variable that you are going to manipulate or change? (Tell me information about it - not common knowledge!!!)		
_____ How is it supposed to affect the organism/test subject?		

Honors Biology Research Paper – Part I		
Component: Place a check next to each question, once you have <u>completely</u> answered it (in the provided space). _____ How does it affect other similar/related organisms?	**List all sources of Information used to support these statements**	**Number of the Corresponding paragraph(s)**
_____ How do you expect to be able to measure the change caused by the environmental factor? **WHAT IS YOUR DEPENDENT VARIABLE???**		
_____ Did you use any other sources to support the above information? If so, list them below.		

Honors Biology Research Paper – Part I		
Component: Place a check next to each question, once you have <u>completely</u> answered it (in the provided space).	**List all sources of Information used to support these statements**	**Number of the Corresponding paragraph(s)**
IV. Hypothesis	***Source Cited***	**Paragraph #**
_____ What is your hypothesis?		
_____ Do you have background information that supports your hypothesis? (This is what makes your guess *educated…why have you made this prediction?*)		
The above hypothesis: **_____ Is clear & concise (easy to understand without using a bunch of extra words).** **_____ Is testable** **_____ Attempts to answer your initial question.** **_____ Is written in the form of a statement (not a question).** **_____ One to two sentences long (not a paragraph).** **_____ Includes the dependent and independent variable.** **_____ Shows a cause & effect relationship between dependent & independent variables.**		
IX. Sources Cited / Bibliography		
_____ Include a Sources cited section at the end of your paper. This lets me know where you got your information from (list **<u>all</u>** sources in alphabetical order):		

Honors Biology Research Paper – Part I		
Component: **Place a check next to each question, once you have <u>completely</u> answered it (in the provided space).**	**List all sources of Information used to support these statements**	**Number of the Corresponding paragraph(s)**
_____ Have you followed the proper MLS format (see the handout from class) **_____ Is it listed in alphabetical order?** **_____ Are there at least four sources?** **_____ Is one of the sources a book?** **_____ Is one of the sources a reputable internet site?** **_____ None of the 4 required sources are a general encyclopedia.**		
X. Misc. Criteria		
_____ *Paper is Typed* _____ *Cover Page includes project title, student name(s), and block number* _____ *12 Point Font (maximum)* _____ *Margins should be exactly 1 inch (this includes top & bottom too)* _____ *Double spaced* _____ *Paper has a professional appearance* _____ *Information is organized; appears if time was spent putting it together.* _____ *Spell check was performed* _____ *Proper grammar* **_____ You have read through your paper to see if it logical and flows smoothly.** **_____ Peer reviews have been done and appropriate changes have been made.**		

Peer Review: Honors Biology Research Paper – Part I	
(+) The component has been effectively addressed (2 Points). **(-) The component has been addressed but more information is needed (1 Points).** **(0) They have failed to address the component adequately (0 Points).**	
I. Topic	
_____ The question they are trying to answer has been stated _____ The question can be answered *scientifically* _____ It is possible to obtain *measurable* results	
II. Rationale	
_____ They have addressed why the topic interests them _____ They have identified how others will benefit from their results	
III. Background Information (RESEARCH):	
A. Organism used in the experiment	**Comments**
_____ The common name is given	
_____ The scientific name is stated	
_____ Normal behavior/appearance _____ What would I see if I was looking at it? _____ How is it different from other organisms like it?	
_____ Normal growth _____ How rapidly does it grow? _____ Is there a particular time that it grows best? _____ How long does it take to complete a normal life cycle? _____ Reproduction rate	

Peer Review: Honors Biology Research Paper – Part I	
_____ What time of year can the organism be found?	
_____ What needs to be done to keep the organism alive throughout the experiment (normal care and feeding).	
B. Environmental Factors	**Comments**
_____ They identified the variable they are going to change.	
_____ How is it supposed to affect the organism/test subject?	
_____ How does it affect other similar/related organisms?	
_____ How do they expect to be able to measure the change caused by the environmental factor? (this is the dependent variable)	
IV. Hypothesis	
_____ The hypothesis has been stated. _____ The research supports the hypothesis. _____ The hypothesis is clear & concise (without a bunch of extra words). _____ It is testable. _____ Attempts to answer the initial question. _____ The hypothesis is written in the form of a statement (not a question). _____ It is one to two sentences long (not a paragraph). _____ The hypothesis includes the dependent and independent variable. _____ Cause & effect relationship shown between dependent & independent variables.	

Peer Review: Honors Biology Research Paper – Part I
V. Sources cited / Bibliography
_____ Includes a Sources Cited section at the end of your paper.
_____ Sources are cited in the body of the paper.
_____ Proper MLS format
_____ Listed in alphabetical order?
_____ Are there at least four sources?
_____ Is one of the sources a book?
_____ Is one of the sources a reputable internet site?
_____ None of the 4 required sources are a general encyclopedia.
Misc. Criteria
_____ ***Paper is Typed***
_____ ***Cover Page includes project title, student name(s), and block number***
_____ ***12 Point Font (maximum)***
_____ ***Margins should be exactly 1 inch (this includes top & bottom too)***
_____ ***Double spaced***
_____ ***Paper has a professional appearance***
_____ ***Information is organized***
_____ ***Appears if time was spent putting the paper together***
_____ ***Spell check was performed***
_____ ***Proper grammar is used throughout the paper***
_____ The information in the paper is logical.

Peer Review: Honors Biology Research Paper – Part I
_____ The content of the paper flows smoothly.

Honors Biology Research Paper Grade Sheet		
(+) You have adequately addressed this component (4 Points). **(-) You have addressed the component, but more information is needed (2 Points).** **(0) You have failed to address the component adequately (0 Points).**	**Source Cited**	**Corresponding paragraph(s) Identified**
I. Topic		
_____ You have identified what question are you trying to answer?		
_____ It is a question you can answer *scientifically*.		
_____ You can obtain *measurable* results?		
II. Rationale		
_____ Why does the topic interest you?		
_____ How will anyone else benefit from your results?		
III. Background Information (RESEARCH):		
A. Organism used in the experiment		
_____ What is the common name?		
_____ What is the scientific name?		
_____ Normal behavior/appearance		
_____ Normal growth		
_____ What time of year can your organism be found. When is it most likely to survive/grow (Does this time coincide w/your experiment?).		
_____ What needs to be done to keep the organism alive throughout your experiment (normal care and feeding).		

Other comments/questions about your test subject that may need to be addressed.		
B. Environmental Factors (a.k.a. independent variable):		
_____ What is your independent variable?		
_____ How is the independent variable supposed to affect the organism/test subject?		
_____ How does your independent variable affect other similar/related organisms?		
_____ How do you expect to be able to measure the change caused by the independent variable (what is your dependent variable?)		
Other comments/questions about the environmental factors that may need to be addressed.		
IV. Hypothesis		
Your hypothesis: _____ Is supported by your background information? _____ Is clear & concise (easy to understand without using a bunch of extra words). _____ Is testable _____ Attempts to answer your initial question. _____ Is written in the form of a statement (not a question). _____ One to two sentences long (not a paragraph). _____ Includes the dependent and independent variable. _____ Attempts to show a cause & effect relationship between dependent & independent variables.		

Questions/Comments about your hypothesis.
Miscellaneous
_____ Sources were cited in the body of the introduction _____ Sufficient research and effort are evident in the product that was turned in.
Additional Comments:
V. Materials
_____ All materials are included. _____ List format. _____ Quantity of each item is included. _____ Identify where item can be obtained if not a common household item.
VI. Procedures

_____ Numbered/step by step format (not in paragraph form).
_____ Written in complete sentences.
_____ Includes details/ procedures are complete.
_____ Logical.
_____ Written in past tense
_____ Describes care/upkeep of organism(s).
_____ Includes a **PHOTOGRAPH** of the actual **SETUP (Day 1)**.
_____ Explains when observations were made/recorded.
_____ Explains how observations were taken and recorded.
_____ Safety precautions are addressed.
VII. Data/ Results / Observations
A. Data Tables
_____ At least one data table has been provided
_____ Data table is labeled with a number (Table #:) and a title
_____ All rows & columns are clearly labeled.
_____ Table is set up in a logical manner
_____ All units are labeled
B. Graphs
_____ At least one graph has been provided
_____ Graphs are labeled with a number (Figure #:) and a title
_____ Each axis is labeled.
_____ Graphs are set up in a logical manner (remember the rules of graphing indep. & dep. variables)
_____ All units are labeled (use SI units when possible)

C. Observations
_____ A journal or daily log was kept throughout the experiment to record observations.
_____ Qualitative & quantitative observations were made throughout the experiment
_____ Observations are descriptive and appear accurate.
_____ **Includes photos of results**
VIII. Analysis and Conclusion
_____ You have attempted to explain the outcome (or trends) of your graph.
_____ Was your experiment actually set up to answer your initial question?
_____ If your experiment does not answer your question, have you explained why it doesn't?
_____ Did your data *support* or *reject* your hypothesis. Explain!
_____ Why do you think it did/did not support your hypothesis (possible causes).
_____ You have identified some things that went well with your experiment.
_____ You have identified some things that did <u>not</u> go well with your experiment.
_____ You have listed the most probable sources of error.
_____ Show the value of your results (readdress your rationale… is there any worth to your finding?).
_____ Describe possible future experiments that could be conducted (to expand upon your findings).
_____ Spell Check performed
_____ No major grammatical errors
IX. Sources cited / Bibliography

_____ Have you followed the proper MLA format (see the handout from class)
_____ Is it listed in alphabetical order?
_____ Are there at least four sources?
_____ Is one of the sources a book?
_____ Is one of the sources a reputable internet site?
_____ None of the 4 required sources are a general encyclopedia.
X. Misc. Criteria
_____ Paper is Typed
_____ Cover Page includes project title, student name(s), and block number
_____ 12 Point Font (maximum)
_____ Margins should be exactly 1 inch (this includes top & bottom too)
_____ Double spaced
_____ Paper has a professional appearance
_____ Information is organized; appears if time was spent putting it together.
_____ Spell check was performed
_____ Proper grammar
_____ You have read through your paper to see if it logical and flows smoothly.
_____ Peer reviews have been done **and appropriate changes have been made.**
_____ Peer reviews have been turned in with the final paper

Science Symposium Presentation Requirements*:*

1. Let the audience know what you were researching. Tell them your hypothesis.
2. Explain how you tested your hypothesis.
3. Describe your results. Address whether there is any significance between the differences that are observed.
4. Explain whether or not your results support your hypothesis or not.
5. Identify major sources of error with your experiment.
6. Describe specific problems that you may have had to fix or overcome.
7. Describe any changes that you would make to your experiment, if you were to do it again.
8. Make reference to the research that you obtained before conducting your experiment. Do your results agree or disagree with your research.
9. It is evident that time and thought was spent on presentation
10. It should sound as though you thoroughly understand the topic you are presenting.
11. *Your presentation should captivate the audience (interesting/engaging)*
12. Have at least one visual aid as part of your presentation (ex: pictures, models, a sample of your setup or the actual setup of your experiment).
13. Make reference to your visual aid(s) during your presentation.
14. Utilize time: 5-10 minutes.
15. Dress Professionally.
16. Speak clearly and enunciate.
17. Do not read directly from notes, make eye contact.
18. Presentation should be organized and flow smoothly.

Cell-ebration: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

2.02 Investigate and describe the structure and function of cells including:
- Cell organelles.
- Cell specialization

Essential Question(s):
How do the differing structures of cells relate to specialized functions?

Introduction to teacher:
Sometimes it is difficult for students to visualize the cell and its structures. This series of activities allows the students the ability to visualize each organelle, determine how structure is related to function, and conclude how each organelle is important to the functioning of the cell.

While a number of activities are listed, you should not assign all of them. The students should instead do an **in-depth** survey of their organelle(s).

Differentiation from Standard-level:

These activities are in-depth studies of cellular organelles and their relationships within the cell. In comparison to a standard-level, the expectations of the honors classes should be higher with more emphasis on how structure/function are related and a more in depth look at the structure of the organelles. The same activities could easily be used in a standard-level.

Safety/Special Considerations:
None

References:
Caudill, Scott (Cary High School, NC)
Dobbin, Christie (Leesville Road High School, NC)
Eisenmenger, Sandy (Roanoke Rapids High School, NC)
Wilson, Erika (Newton-Conover High School, NC)

Cell-ebration: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

2.02 Investigate and describe the structure and function of cells including:

- Cell organelles.
- Cell specialization

Essential Question(s):

How do the differing structures of cell organelles relate to the specialized functions of the organelles?
How are cell organelles related to specialized cell functions?

Introduction:

Cell organelles are the structures within a cell that perform specific functions. All organelles are essential for the cell to function properly. In this activity, you will focus on at least one of the following organelles:

Nucleus	Plasma Membrane	Cell Wall
Vacuole	Chloroplast	Mitochondria
Ribosome	Endoplasmic Reticulum (rough)	ER (smooth)
Lysosome	Golgi Apparatus	Cytoskeleton
Cilia/Flagella		

Materials:

Varies depending on activity type.

Procedure:

- Research your organelle(s) using your textbook and at least two other sources.
- Determine the structure and function of your organelle(s).
- Once you know the structure and function, describe how the structure **relates** to the function (for example: how do the inner membranes of the mitochondria make it easier for the mitochondria to do it's "job?").
- Be able to describe how your organelle(s) relates to the other organelles within the cell.
- Compile your findings in the activity type specified by your teacher and present to the class:

Activity Type Choices:

Act Out the Cell:

- Create a costume to make yourself "into" your organelle
- Prepare a script where you will present yourself to the class
- Present all relevant data (in a creative way) to the class (while in costume).

Cell-ebration

Sell the Organelle:

- Create a 2-3 minute commercial to "sell" your organelle
- Include a catchy slogan and visuals
- Commercial should also include all relevant information in a creative way

Cell Catalogue:

- Work in pairs to create a "mail order" catalogue for an animal or plant cell
- In addition to having full color pictures, descriptions (sales pitch), and prices for all organelles, catalogue should have a cover and table of contents.
- Catalogue should be bound together neatly

Cell Factory:

- Create a short story that a fifth grader could read.
- The story should relate all cell organelles to a factory and be interesting and entertaining.
- All relevant information should be included.
- Color pictures should be included

Doctor-Patient Conversation:

- *Create a doctor-patient conversation based on how cells of the body differ*
- *Would there be any difference in the number of certain organelles in cells that help with: secretion, immune response, comprises bone, comprise muscle, etc?*
- *Include all relevant information*

Questions to Guide Analysis:

1. Is your organelle found in prokaryotic, eukaryotic, or both types of cells? How did you determine this?
2. Does your organelle have a membrane? Does it have more than one membrane? What is the function(s) of the membrane(s)?
3. Does your organelle have any internal structures? If so, what are their functions?
4. Does your organelle have more than one part to their structure? How is this significant?
5. Where in the cell is your organelle located? How is this significant?
6. Does your organelle require anything else to function properly? If so, where does it come from?
7. How do cells make more of your type of organelle?
8. In which kingdom(s) is your cell found? What characteristic(s) determine which kingdom the cell is in?

Cell-ebration

Grading Guide

Organelle(s) structure	10 points
Organelle(s) function	10 points
Relationship between structure & function	20 points
Diagram of organelle(s)	10 points
Answers to Analysis Questions	20 points
Creativity/ Presentation	20 points
Following Directions	10 points

Total Points: ***100 points***

Osmosis and Diffusion

Demonstration Lab- Osmosis and Diffusion: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

2.03 Investigate and analyze the cell as a living system including:

- Maintenance of homeostasis.
- Movement of materials into and out of cells.

Essential Question(s):

What is the significance of scientific investigation?
How do organisms maintain homeostasis in changing conditions?

Introduction to teacher:

This lab is designed as a series of demonstrations. In the course of their observations, students will take data and form conclusions about the processes that are occurring (or have occurred). Setting this lab up as demonstrations allows the students to spend more time on analysis, since they are not spending as much time on set up.

Before beginning the activity, it is important to introduce the students to the terms hypotonic, hypertonic, isotonic, solute, and solvent.

You can modify this lab by having the students set up the materials (thus making it more of a "lab" and less of a demonstration). It also could include using Elodea and the effects of salt water on this aquatic plant, since this is a plant that is frequently used in biology studies.

Differentiation from Standard-level:

Honors level students should be expected to understand and use the more technical terms associated with osmosis, diffusion and solutions. This lab requires more in depth analysis than is typical in standard level courses.

Safety/Special Considerations:

Some of the demonstrations need to be set up in advance. The eggs need to have their shells removed (by soaking them in vinegar for a day), and then be soaked in 0% and 50% sugar solutions for another 24 hours. The "Osmosis in Carrots" also needs to be set up 24 hours in advance.

Students should wear goggles and aprons and avoid contact with iodine.

References:

Stockdale, Maureen (Wakefield High School, Raleigh, NC)

Demonstration Lab- Osmosis and Diffusion: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

2.03 Investigate and analyze the cell as a living system including:

- Maintenance of homeostasis.
- Movement of materials into and out of cells.

Essential Question(s):

What is the significance of scientific investigation?
How do organisms maintain homeostasis in changing conditions?

Introduction:

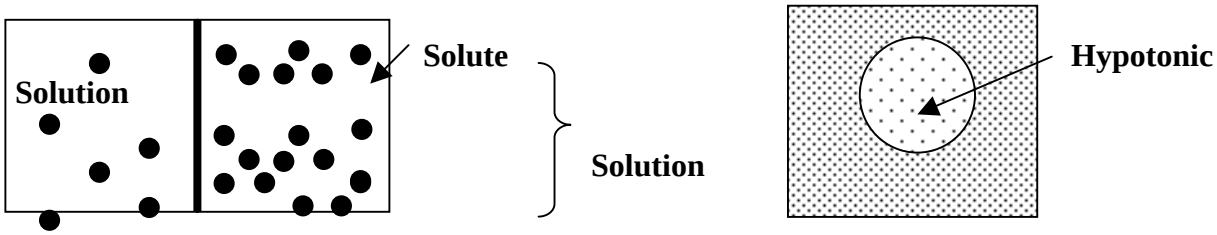
Terms to Know:

- **Solute – material or particles that are dissolved in a liquid (i.e. sugar).**
- **Solvent – the liquid that the above material is dissolved in (i.e. water).**
- **Solution – the combination of the solute and the solvent (i.e. sugar water).**
- **Hypotonic – an area of lesser solute concentration.**
- **Hypertonic – an area of higher solute concentration.**
- **Isotonic – an area of equal solute concentration.**
- **Osmometer – a meter used to measure the process of osmosis.**

The molecules that make up solids, liquids, and gases are in constant motion. They move from areas of higher concentration to areas of lower concentration by the process of ***diffusion***. Some molecules are also able to ***diffuse*** into and out of living cells, providing a source of nutrients and allowing for the export of cell products or wastes.

A cell is surrounded by a ***cell membrane*** made mostly of lipids and proteins. The membrane is ***selectively permeable*** because it allows some materials, but not others to move across the membrane. Small ions and molecules of oxygen (O_2), carbon dioxide (CO_2), water (H_2O) can move across freely. Other molecules, especially those that do not mix well with lipids (oily or fatty substances) and large macromolecules, must move through special pores or channels in the cell membrane made up of proteins.

The movement of water through a selectively permeable membrane is a special type of diffusion called ***osmosis***. Water moves from an area of lesser solute concentration (***hypotonic***) to an area of greater solute concentration (***hypertonic***).



Osmosis and Diffusion

- **Generally animal cells are adapted to an isotonic environment**. If placed in pure water, the water will move into the cell and the cell will expand until in bursts (cytolysis). The cell membrane is very elastic (like a balloon). Special adaptations allow some animal cells to live in hyper and hypotonic solutions.

- **Plants generally depend on a hypotonic environment for water uptake.** When placed in water, the water will move into the plant cell, but the ***cell wall*** surrounding the cell membrane is not very expandable. Pressure builds up within the cell from the influx of water. The pressure or force directed against the cell wall is called ***turgor pressure***. If you put limp celery or a wilted flower into water, the cells will take up water and become ***turgid***.

Water molecules, in the process of osmosis never stop moving. Even when the concentration of solute is equal on both sides (**isotonic**), the water molecules move in and out of a cell at an equal rate. The same number of water molecules move in and out, so the system remains in **equilibrium**.

Part I: Egg Osmosis

In the lab, we will explore the movement of water into and out of a cell, by using an egg as an osmometer (a meter to measure the process of osmosis). Remember that an egg is a single cell, a very large single cell. Using our egg osmometers, we will measure the effects of hypertonic and hypotonic solutions on animal cells.

<u>Use the information you just read to answer the following questions.</u>

1. If more water moves into an egg than moves out, you would expect the egg to have a _____ mass than before it was placed in a solution. Would the solution surrounding the egg be hypertonic or hypotonic compared to the solution (cytoplasm) inside the egg?
   _____

2. If more water were to move out of the egg than in, you would expect the egg to have a _____ mass than before it was placed in a solution. Would the solution surrounding the egg be hypertonic or hypotonic compared to the solution (cytoplasm) inside the egg?
   _____

Purpose:
What will happen to eggs when we put them in different concentrations of sugar solutions?

- The sugar that we are using is sucrose. Its molecules are too large to pass though the egg (cell) membrane.

- If sugar can't move across the cell membrane, then what molecule moves across the cell membrane to change the concentration inside or outside of the cell?

3. Make observations of the eggs. Other than not having their shell anymore, does it look like it has changed in anyway? If so, how?

4. Use your observations to fill in the table below. Determine which solution was hypertonic and which was hypotonic

	% Sugar Concentration	Apparent Change of Mass (gained or lost)	Hypotonic or Hypertonic (solution surrounding the egg)
Egg 1	0% SUGAR		
Egg 2	50% SUGAR		

Part II: Iodine and Starch

A dialysis tube is similar to a cell membrane in that it allows certain molecules to pass through, but keeps other molecules out. A starch solution is placed inside the dialysis tubing and then sealed. The tube is then placed in an iodine solution. I_2KI (iodine), a yellow-brown liquid, turns bluish black when mixed with of starch.

Examine the iodine and starch set up. Answer the questions below.

5. Observe the water in the jar. At the beginning of the setup, the water was an orange color. What color is it now?

6. Observe the dialysis tube. At the beginning of the setup, the inside of the bag was a cloudy white color. What color is it now?

7. Why do you think that the inside of the tube is this color?

8. Why is the jar not a bluish-black color?

9. What two molecules were small enough to pass through the membrane?

Part III: Osmosis in Beets

Recall the information given in the introduction about hypotonic, hypertonic and isotonic solutions and osmosis of water. Observe the beet slices placed in the culture dishes in the demonstration. In one of the dishes the beet was placed in tap water; in the other, the beet was placed in 10% salt water.

10. Notice the difference in the colors of the water and the beets in the two culture dishes. Describe these differences:

Beet: Tap Water Observations	Beet: Salt Water Observations

11. Explain the difference in terms of osmosis.

Part IV: Osmosis in Carrots

When the vegetables in your salad wither, they do so because of osmosis. In this part, you will determine how osmosis affects plants.

Examine the two beakers labeled "Salt Water" and "Fresh Water." The two carrots sticks placed in solution were of the same relative size, and have sat undisturbed for 24 hours. Examine the carrot sticks for the tightness of the threads and squeeze the carrot stick to determine its texture. (***DO NOT BREAK THE CARROT STICK!)***

Use your observations to answer yes or no to each of the questions in the table.

Condition of Carrot Stick	**… in salt water?**	**… in fresh water?**
▪ Was the thread loose		
▪ Did the cells gain water		
▪ Did it have a soft texture		
▪ Was the thread tight		
▪ Did it have a firm texture		
▪ Did the cells lose water		

12. Did water move into or out of the carrot in the salt water?

13. Did water move into or out of the carrot in the fresh water?

14. One way to prevent salad and vegetables from wilting is to cover them with plastic wrap. Why is this? (Explain in terms of osmosis.)

15. Supermarket workers spray fruits and vegetables with water to make them more desirable to consumers. Why does spraying vegetables with water prevent them from drying out?

Safety:
Be sure to wear goggles and an apron as you are making observations in the lab and do not come in contact with the raw egg or the iodine.

Review Questions:

1. Why is it important for the cell membrane to be selectively permeable?

2. Why do animal cells need to be surrounded by isotonic solutions?

3. Why do plant cells need to be surrounded by hypotonic solutions?

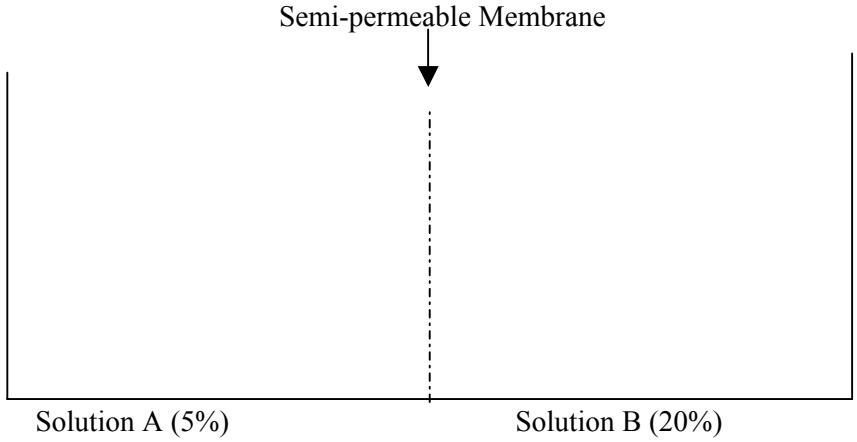
4. What would happen to a cell if it were placed into a solution that was hypertonic to its cytoplasm? Why? (drawing the diagram may help you answer the question)

5. Why do plant cells not burst when placed in pure water?

6. Does osmosis ever "stop"? Explain your answer.

7. What is turgor pressure?

8. Solution A has 5% (95% water) solute. Solution B has 20% solute (80% water). If these two solutions are placed on opposite sides of a semi-permeable membrane, which side is hypertonic? Which side is Hypotonic? Use the picture below to shows this scenario. **Draw in the solute (dots)**.



9. **Draw an arrow** on your diagram to show which way the water (solvent) will move. Be sure to **label the arrow** with the word 'water'.

10. If we assume that the solute was able to pass through the membrane, **draw a second arrow** on your diagram to show direction the solute would move. Be sure to **label the arrow** with the word 'solute'.

Questions to Guide Analysis:

1. What was the purpose of this lab activity? Explain.

2. Why can't fresh water fish live in salt water?

3. Why do submarines have to decompress?

4. Why do divers have to adjust levels?

5. Why do airlplanes have cabins that maintain pressure and what would happen if there were holes?

Grading Guide

Data	20 points
Analysis/Conclusion	40 points
Review and Analysis Questions	40 points

Jello Family

Smooth Moves: The Jell-O Cell Family Story: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

2.03 Investigate and analyze the cell as a living system including:

- Maintenance of homeostasis.
- Movement of materials into and out of cells.

Essential Question(s):

What is the significance of scientific investigation?
How do organisms maintain homeostasis in changing conditions?
How does diffusion relate to the surface area to volume ratio of cells?

Introduction to teacher:

This lab could be used after students have been introduced to the concepts of diffusion and osmosis. It could be an introduction to a unit on mitosis, and why cells cannot continue to grow indefinitely.

In preparation for the lab, you will need to prepare the cubes of "Jell-O", which are actually made of agar.

This recipe makes one 3 cm deep tray of agar--enough for 2-3 classes.

- Bring 2L water to a boil. (The microwave works well for this procedure).
- Slowly add 40g plain agar stirring to dissolve.
- Pour into a standard sheet cake pan (9 x 13).
- Allow to cool for 10-15 minutes.
- Mix a 1-2 teaspoons phenolphthalein powder in small amount of water. Swirl into partially cooled agar so it is distributed evenly.
- Allow agar to set overnight.
- For the KOH, dissolve 32 pellets of KOH in 2L of water.
- Use a ruler and roughly cut papa cells 3 x 3 x 3cm, mamas 2 x 2 x 2cm and babies 1 x 1 x 1cm.
- The students have to measure their cubes to the nearest tenth of a cm. (example: Papa may be 3.1 x 2.8 x 2.7)

Due to the expense of agar, you might try to develop the lab using unflavored gelatin.

Differentiation from Standard-level:

Jello Family

This lab is a more in-depth and mathematical study of the ways in which surface area to volume ratio affects movement of materials into and out of cells.

Safety/Special Considerations:

Students should wear goggle, aprons, and gloves while performing this lab and should NOT eat the cubes!

References:

Caudill, Scott (Cary High School, Cary, NC)

Smooth Moves: The Jell-O Cell Family Story: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Goal 2: Learner will develop an understanding of the physical, chemical and cellular basis of life.

2.03 Investigate and analyze the cell as a living system including:

- Maintenance of homeostasis.
- Movement of materials into and out of cells.

Essential Question(s):

What is the significance of scientific investigation?
How do organisms maintain homeostasis in changing conditions?
How does diffusion relate to the surface area to volume ratio of cells?

Introduction:

Cells use passive and active transport to move things across the plasma membrane. These processes are vital to the survival of the cell. The purpose of this lab is to understand the importance of the surface area (plasma membrane) to volume (cell contents) ratio, and how it is connected to transport.

Before you begin, consider the following story….

Once upon a time, there was a family of three gelatin cells: Papa cell, Mama cell, and Baby cell. Their food source was a tasty Potassium Hydroxide (KOH) solution. However, since they had no mouths, they depended on diffusion to feed their cytoplasm.

Your job will be to feed the Jell-O Cell Family and investigate how size is an important factor in the life of a cell. But, before you start, **create a hypothesis** about which cell will "eat" the most KOH (relative to their size).

Your Hypothesis:

Materials:

3 Jell-O cells: Papa, Mama and Baby
Potassium Hydroxide (KOH) Solution
Metric Ruler
Beaker
Plastic Knife
Plastic Spoon

Procedure:

- Spread a lot of paper towels on your desk and work on this area.
- Put on your goggles, apron and gloves.

Jello Family

- Begin by accurately measuring the length, width and height of each cube. (It doesn't matter which measurement is which, just as long as you measure 3 different dimensions.)
- Measure in centimeters to the nearest tenth of a cm. (Ex. 4.1 cm)
- Record these numbers in the table below.

	Papa Cell	Mama Cell	Baby Cell
Length			
Width			
Height			

- As soon as you measure Papa, start feeding him.
- Fill your beaker half full of KOH and lower him into the solution with the spoon.
- Begin timing; he should feed for exactly 10 minutes.
- Calculate the Volume, Surface Area, and Surface Area to Volume Ratio by using the following formulas. Then fill in Table 1 below.

Volume = l x w x h
S.A. = (l x w x 2) + (l x h x 2) + (w x h x 2)
S.A. to Vol. Ratio = S.A. ÷ Vol.

Table 1:

Cell\ Measurements	Volume (cm^3)	Surface Area (cm^2)	S.A./Vol. Ratio (cm^{-1})
Papa Cell			
Mama Cell			
Baby Cell			

- Remove Papa from the feeding solution after exactly 10 minutes.
- Feed Mama and Baby together, again for exactly 10 minutes.
- You will notice that feeding the cells causes a color change. Pink represents living/fed cytoplasm and white represents dead cytoplasm.
- To determine how well Papa was fed, we will perform surgery on him. Using the plastic knife, carefully trim away all the pink Jell-O. Start thinly along one side. When you are done, you should have the largest all-white cube possible.
- Do the same for Mama and Baby after they have fed for 10 minutes.
- Now calculate the volume of the new clear cube (dead cytoplasm) for each cell.
- Fill in the new and original volumes in Table 2 below. Calculate the percentage of dead cytoplasm with the following formula:

New Volume ÷ Original Vol. x 100

Table 2:

Cell\ Measurements	New Volume (cm^3)	Orig. Volume (cm^3)	% Dead Cytoplasm
Papa Cell			
Mama Cell			
Baby Cell			

- Clean up by rinsing off your knife, spoon and beaker and setting them back in your tray.
- Wad up all the Jell-O in the paper towel and throw in the garbage.

Safety:

Wear goggles, aprons and gloves during this lab. Do NOT eat the cubes they are not real Jell-O!

Questions to Guide Analysis:

1. Which cell has the greatest surface area to volume ratio?
2. Which cell has the greatest percentage of dead cytoplasm?
3. Which cell has the lowest percentage of dead cytoplasm?
4. If you were designing the best cell, would you want it to be like Papa, Mama, or Baby cell? Why?
5. Explain which type of cells diffusion works best for and why?
6. List three reasons why cells might need to divide.

References (for further research):

Internet

Rubric: (on a scale of 1-4)

4: Students show complete understanding of surface area to volume ratio and how diffusion is affected by the ratio. All questions are answered correctly and correct lab procedures are followed.

3: Understanding of surface area to volume ratio and understanding of diffusion, but students cannot tie them together. Not all questions are answered correctly and/or correct lab procedures are not followed.

2: Students understand diffusion but do not understand the importance of surface area to volume ratio. Few questions are answered correctly and correct lab procedures may or may not be followed.

1: Students show no understanding of the importance of surface area to volume ratio and how diffusion relates. Very few (or none at all) questions are answered correctly and correct lab procedures are not followed.

Dihybrid Crosses

Dihybrid Crosses: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify biological problems and questions that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer biological questions.

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03 Interpret and predict patterns of inheritance.

Essential Question(s):

What is the significance of scientific investigation?

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

How do genes and the environment interact to produce a phenotype?

Can we simulate a model illustrating the principle of independent assortment while supporting the probability of a dihybrid heterozygous cross?

Introduction to teacher:

Before beginning this activity, the students should understand basic genetics vocabulary, have studied Mendel's Principles, and should be able to perform monohybrid and dihybrid crosses. The students should be able to indicate genotypic and phenotypic ratios from these crosses. This activity allows the students to compare the probable outcomes of a heterozygous dihybrid cross with actual outcomes that they generate and analyze these results.

The activity requires that the students use 2 "silver" coins (quarters, dimes, nickels) and 2 pennies. You may want to tell the students of this requirement the day before and have extras on hand just in case. They will also need graph paper, so either you will need to provide it, or they must bring it in.

You could change this lab so that, instead of coins, the students use M & M candies. Use different colors to represent the homozygous dominant and homozygous recessive (so you would need 4 different colors of M&Ms- two colors for each trait). Students would draw M&Ms out of paper bags (one for father and one for mother).

Differentiation from Standard-level:

Honors level students should thoroughly understand dihybrid crosses. The extension and analysis questions also make this activity higher-level. You may further support the independence of your students by removing the data charts supplied and asking students to create their own charts to record their results. At the end of this lab you should also introduce the idea of the chi square test and statistical testing for the difference between observed and expected.

(an introduction to this is in the Genetics of Parenthood with Chi-square activity in this document.) At this point what is important is for students to understand why a statistical test is needed, they do not necessarily need to be able to carry out such a test. http://waynesword.palomar.edu/lmexer4.htm provides a good review of this topic and there are several other websites listed in the references.

Safety/Special Considerations:

Keeping the coins in a Styrofoam cup and having them pour them out in a tray with sides will reduce the amount of noise generated and keep the coins from rolling away.

References:

Caudill, Scott (Cary High School, NC)
McGougan, Melissa (Brunswick High School, NC)

Dihybrid Crosses

Dihybrid Crosses: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify biological problems and questions that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer biological questions.

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03 Interpret and predict patterns of inheritance.

Essential Question(s):

What is the significance of scientific investigation?

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

How do genes and the environment interact to produce a phenotype?

Can we simulate a model illustrating the principle of independent assortment while supporting the probability of a dihybrid heterozygous cross?

Introduction:

In this activity, you will study two different genes in corn, each with two alleles.

Purple and white are alleles of a gene that influences the color of the grains (kernels). Purple is dominant to white.

Smooth and wrinkled are alleles that also influence the appearance of the grains. The smooth grains are round and plump in appearance because of the accumulation of starch. The wrinkled ones are shrunken because of the accumulation of sugar. Smooth is dominant to wrinkled.

These two pairs of alleles will illustrate the most common type of inheritance—the type observed when two genes are on different chromosomes. One pair of chromosomes carries the alleles for color. The alleles for texture are carried on a different pair of chromosomes. Since the different pairs of alleles are carried on separate pairs of chromosomes, they are inherited independently from each other.

Your parent corn plants will be heterozygous for both seed color and texture.

Materials:

2 silver coins (heads = P and tails = p)
2 pennies (heads = S and tails = s)
Styrofoam cup (for coin shaking)
Tray with sides (to pour coins into)

Dihybrid Crosses

Procedure:

In this lab, you will be simulating the random inheritance of genes in a dihybrid cross. The silver coins will represent the alleles for the color gene in corn. The pennies will represent the alleles for texture in corn.

1. Name Mendel's Principle that is described in the background information:
   _____
2. What letter would you use for purple? _____ for white? _____
3. What letter would you use for smooth? _____ for wrinkled? _____
4. What will be the parental phenotypes?_____ and _____
5. In the space below, create and fill in a Punnett Square to predict the expected offspring ratio from a PpSs and PpSs cross.
   You will use this chart to determine the expected results.

6. Using the chart, give the genotypes that represent the following phenotypes
   a. Purple and smooth:_____
   b. Purple and wrinkled: _____
   c. White and smooth: _____
   d. White and wrinkled: _____
7. Using the chart, count all the genotypes that will produce corn seeds that are:
   a. Purple and smooth: _____
   b. Purple and wrinked: _____
   c. White and smooth: _____
   d. White and wrinkled: _____
8. Using your chart, determine the expected % of offspring with the following phenotypes:
   a. Purple and smooth: _____ %
   b. Purple and wrinkled: _____%
   c. White and smooth: _____%
   d. White and wrinkled: _____%

Actual Results from Activity:

9. Place all four coins in the Styrofoam cup.
10. Shake the cup and pour the coins into the tray with sides.
11. Tally the combinations that are showing. For example, if one silver coin is heads and the other is tails, then that represents Pp. Both heads for silver would be PP and both tails would be pp. Do the same thing for the pennies (using S instead of P) and then mark the appropriate tally line on Chart A.
12. Shake, pour, and tally for a total of 100 times.
13. Count your tally marks and record them as the ***Actual Count.***
14. Then record what each combination would look like (phenotype).

Chart A

Combination	Tally of Combinations	Actual Count	Appearance
PPSS			
PPSs			
PPss			
PpSS			
PpSs			
Ppss			
ppSS			
ppSs			
ppss			

15. Summarize your results by determining **Percentage of Grains**. Fill in **Chart B.**

Chart B

Appearance	Number of Grains	Percentage of Grains
Purple, smooth		
Purple, wrinkled		
White, smooth		
White, wrinkled		
Total		

16. Give your **"Number of Grains"** data from #15 to the teacher. He/she will determine the entire class' observed percentage. This will help to answer some of your questions.

Comparing Expected Results with Actual Results

17. Now, you will compare the **expected results** with your silver coin/penny **actual (real) results.** Do this by filling in **Chart C**.

Chart C

Appearance	Observed %	Expected %
Purple, smooth		
Purple, wrinkled		
White, smooth		
White, wrinkled		

18. Do your results support the expected outcome? _____
19. If not, do you think more data could cause it to be closer? Why or why not?

_____

20. Do you have to have the exact number (no decimals) to fit the ratio? Why/why not?

_____

21. Do the class results support the expected outcome? _____
22. Are they any closer to the expected results than your results? Why or why not?

_____

23. How do the class results compare with Mendel's results with his garden peas?

24. Make a graph that shows both the class observed percentages for each type of appearance and your group's observed percentages for each type of appearance. Think about which type of graph would best represent this data and make sure your graph has all the correct components.

For Further Research

Biologists use statistical tests to determine if observed results are significantly different from the expected results. The appropriate test for a dihybrid cross is a Chi Square test. To learn more about this you may use the following website as a reference.
http://waynesword.palomar.edu/lmexer4.htm.

Safety:

Don't throw your coins!

Questions to Guide Analysis:

Included within procedure.

References (for further research):

http://www.biologycorner.com/bio4/corn_chi.html
http://www.blc.arizona.edu/courses/mcb422/MendelStarFolder/merChiSquare.html

Grading Guide

Formal lab write up:

Introduction (including background information in your own words, essential questions, purpose, hypothesis) **10 points**

Class and individual data **20 points**

Analysis/ Graph **20 points**

Conclusion (including answers to all questions, whether or not hypothesis was supported and what was learned from the lab activit) **50 points**

Fishy Frequencies with Hardy-Weinberg

Fishy Frequencies (with Hardy-Weinberg): Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify biological problems and questions that can be answered through scientific investigations.

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03 Interpret and predict patterns of inheritance.
3.05 Examine the development of the theory of evolution by natural selection

Essential Question(s):

What is the significance of scientific investigation?
How do genes and the environment interact to produce a phenotype?
Do allelic frequencies change over time in response to natural conditions?

Introduction to teacher:

This activity shows allele frequencies changing over time as a result of selection and remaining stable without selection. The standard-level can be done with or without using the Hardy-Weinberg equilibrium equation, however the honors level will include Hardy-Weinberg.

The Hardy Weinberg equilibrium equation allows you to figure out the frequency of alleles and genotypes from the frequency of observable phenotypes in populations that meet the conditions for Hardy Weinberg Equilibrium. These conditions include an infinitely large population, random mating, and no selection, mutation, migration or genetic drift. Of course, no real population completely fits these conditions. When a population or sub-population is not in equilibrium, population biologists can study the factors affecting the distribution of alleles. When your students do the activity using the Hardy Weinberg equation they can see how population biologists estimate the number of organisms heterozygous for a trait from the number of organisms with the recessive phenotype. You can also relate the Hardy Weinberg equation to Punnett squares and use this as an opportunity to show students an application for squaring binomials. Punnett squares can be used to calculate expected phenotype frequencies for populations as well as the expected ratios from individual crosses. You can also take the opportunity to discuss the conditions for equilibrium and in what ways this simulation does and does not meet these conditions.

Fishy Frequencies with Hardy-Weinberg

This activity can be done using actual edible fish crackers (one bag of pretzel and one bag of cheddar for each class) or it can be simulated with paper fish or other materials. You will need a place for each group to provide their data in order to calculate the class data.

Differentiation from Standard-level:

Honors students should be introduced to the concept of Hardy-Weinberg equilibrium and the accompanying mathematical calculations. Both forms of this activity can be found in the standard support document

Safety/Special Considerations:

Be aware of any student food allergies. Also, you may want the students to experiment with one large "ocean" of fish and then offer untouched fish to snack on at the end.

References:

Jones, Judy (East Chapel Hill High School, NC)

Fishy Frequencies with Hardy-Weinberg

Fishy Frequencies (with Hardy-Weinberg): Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify **biological problems and questions that can be answered through scientific investigations.**

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03 Interpret and predict patterns of inheritance.
3.05 Examine the development of the theory of evolution by natural selection

Essential Question(s):

What is the significance of scientific investigation?
How do genes and the environment interact to produce a phenotype?
Do allelic frequencies change over time in response to natural conditions?

Introduction:

Understanding natural selection can be confusing and difficult. People often think that animals consciously adapt to their environments - that the peppered moth can change its color, the giraffe can permanently stretch its neck, the polar bear can turn itself white - all so that they can better survive in their environments.

In this lab you will use fish crackers to help further your understanding of natural selection and the role of genetics and gene frequencies in evolution.

Background: Facts about the "Fish"

1) These little fish are the natural prey of the terrible fish-eating sharks - YOU!

2) Fish come with two phenotypes - gold and brown:

a) gold: this is a recessive trait (ff)

b) brown: this is a dominant trait (F_)

3) **In the first simulation**, you, the terrible fish-eating sharks, will randomly eat whatever color fish you first come in contact with. (There will be no selection.)

4) **In the second simulation**, you will prefer to eat the gold fish (these fish taste yummy and are easy to catch) you will eat ONLY gold fish unless none are available in which case you resort to eating brown fish in order to stay alive (the brown fish taste salty, are sneaky and hard to catch).

5) New fish are born every "year"; the birth rate equals the death rate. You simulate births by reaching into the pool of "spare fish" and selecting randomly.

6) Since the gold trait is recessive, the gold fish are homozygous recessive (ff). Because the brown trait is dominant, the brown fish are either homozygous or heterozygous dominant (FF or Ff).

Hardy-Weinberg:

G. H. Hardy, an English mathematician, and W.R. Weinberg, a German physician, independently worked out the effects of random mating in successive generations on the frequencies of alleles in a population. This is important for biologists because it is the basis of hypothetical stability from which real change can be measured. This also allows you to figure out the frequency of genotypes from phenotypes.

You assume that in the total population of fish crackers, you have the following genotypes, FF, Ff, and ff. You also assume that mating is random so that ff could mate with ff, Ff, or FF; or Ff could mate with ff, Ff, or FF, etc. In addition, you assume that for the gold and brown traits there are only two alleles in the population - F and f. If you counted all the alleles for these traits, the fraction of "f" alleles plus the fraction of "F" alleles would add up to 1.

The Hardy-Weinberg equation states that: $p2 + 2pq + q2 = 1$

This means that the fraction of pp (or FF) individuals plus the fraction of pq (or Ff) individuals plus the fraction of qq (ff) individuals equals 1. The pq is multiplied by 2 because there are two ways to get that combination. You can get "F" from the male and "f" from the female OR "f" from the male and "F" from female.

If you know that you have 16% recessive fish (ff), then your qq or q2 value is .16 and q = the square root of .16 or .4; thus the frequency of your f allele is .4 and since the sum of

the f and F alleles must be 1, the frequency of your F allele must be .6 Using Hardy Weinberg, you can assume that in your population you have .36 FF (.6 x .6) and .48 Ff (2 x .4 x .6) as well as the original .16 ff that you counted.

Materials:

“Ocean” with equal amounts of gold and brown fish

Graph paper

Procedure:

Procedure 1:

1) Get a random population of 10 fish from the "ocean."

2) Count gold and brown fish and record in your chart; you can calculate frequencies later.

3) Eat 3 fish, chosen randomly, without looking at the plate of fish

4) Add 3 fish from the "ocean." (One fish for each one that died). Be random. Do NOT use artificial selection.

5) Record the number of gold and brown fish.

6) Again eat 3 fish, randomly chosen

7) Add 3 randomly selected fish, one for each death.

8) Count and record.

9) Repeat steps 6, 7, and 8 two more times.

10) Provide your results for the class. Fill in the class results on your chart.

Procedure 2:

1) Get a random population of 10 fish from the "ocean."

Fishy Frequencies with Hardy-Weinberg

2) Count gold and brown fish and record in your chart; you can calculate frequencies later.

3) Eat 3 gold fish; if you do not have 3 gold fish, fill in the missing number by eating brown fish.

4) Add 3 fish from the "ocean." (One fish for each one that died). Be random. Do NOT use artificial selection.

5) Record the number of gold and brown fish.

6) Again eat 3 fish, all gold if possible.

7) Add 3 randomly selected fish, one for each death.

8) Count and record.

9) Repeat steps 6, 7, and 8 two more times.

10) Provide your results for the class. Fill in the class results on your chart.

FINALLY: Fill in your data chart and calculations, prepare a graph showing the frequency of the alleles in each generation (see directions in analysis question 1) and answer the analysis questions.

PART 1 - Without selection

CHART (without selection): (Partners)

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

Fishy Frequencies with Hardy-Weinberg

CHART (without selection): Class

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

PART 2 - With Selection

CHART (with selection): (Partners)

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

Next page, please!

Fishy Frequencies with Hardy-Weinberg

CHART (with selection): Class

generation	gold	brown	q^2	q	p	p^2	2pq
1							
2							
3							
4							
5							

Safety:

Alert the teacher if you have a food allergy that relates to this lab that he/she is unaware of. Do not really "eat" the fish unless you are told to do so.

Questions to Guide Analysis:

1) Prepare one graph using both sets of class data (without selection AND with selection). On the "x" axis put generations 1-5 and on the "y" axis put frequency (0-1). Plot both the q and p for both sets of class data. Label lines clearly (without selection AND with selection).

2) In either simulation, did your allele frequencies stay approximately the same over time? If yes, which situation? What conditions would have to exist for the frequencies to stay the same over time?

3) Was your data different from the class data? How? Why is it important to collect class data?

4) With selection, what happens to the allele frequencies from generation 1 to generation 5?

5) What process is occurring when there is a change in allele frequencies over a long period of time?

6) What would happen if it were more advantageous to be heterozygous (Ff)? Would there still be homozygous fish? Explain.

7) In simulation 2, what happens to the recessive alleles over successive generations and why? Why don't the recessive alleles disappear from the population?

8) Explain what would happen if selective pressure changed and the recessive allele was selected FOR?

9) What happens if the sharks only eat very large fish that have already reproduced? What happens if they eat small gold fish, before they have a chance to reproduce?

10) In what ways did these simulations represent real life? How were the simulations different from real life situations?

Extension Question:

Are organisms genetically predisposed to be better fit for survival or is "survival of the fittest" all environmentally controlled? Indicate research that supports your point.

References (for further research):

Internet

Charles Darwin's Origin of Species

Story of the peppered moth

Fishy Frequencies with Hardy-Weinberg

Grading Guide:

Purpose: 10 points

Procedure: 10 points
Data/Graph: 20 points
Analysis/Conclusion: 30 points
Extension: 30 points

Using Chi-Square with Genetics of Parenthood

Using the Chi-Square Test with "Genetics of Parenthood": Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify biological problems and questions that can be answered through scientific investigations.

1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03 Interpret and predict patterns of inheritance.

Essential Question(s):

What is the significance of scientific investigation?
How can the Chi-Square Test be utilized to evaluate genetic hypotheses?

Introduction to teacher (background information):

If you need some tutorial in what Chi-Square is, visit the following sites:
http://www.mste.uiuc.edu/patel/chisquare/intro.html
http://www.unc.edu/~preacher/chisq/chisq.htm
http://www.ndsu.nodak.edu/instruct/mcclean/plsc431/mendel/mendel4.htm
(please note that these websites are subject to change—you may just want to Google "Chi Square Test")

Using the Chi-Square Test, researchers can determine if their results are random. This is important because, in genetics, we can then make judgments about whether or not the variation in our results is significant or non-significant. This relates to the standard-level support activity, "Genetics of Parenthood" because sometimes during the process of flipping pennies to determine their "offspring's traits", the students will select for or against a trait (does anyone really want a child with a uni-brow?). Analyzing the class data using Chi-Square will indicate if such manipulation occurred.

Introducing the students to the concept of statistical analysis is the first step. You can then extend this activity by having them research how Chi Square is used in other "real world" applications that relate to biology (genetic counseling, transfer within populations, genetic anomalies that occur after a catastrophic event, etc.).

Based on the mathematical abilities of your students, you may have to teach this concept a little slowly at first, but they should be able to get it after some practice! Make sure they have their calculators!

Using Chi-Square with Genetics of Parenthood

Differentiation from Standard-level:

This activity is an extension of the standard-level "Genetics of Parenthood" Activity requiring a more mathematical analysis.

Safety/Special Considerations:

None

References:

Jones, Judy (East Chapel Hill High School, NC)

Using Chi-Square with Genetics of Parenthood

Using the Chi-Square Test with "Genetics of Parenthood": Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify biological problems and questions that can be answered through scientific investigations.

1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint

Goal 3: Learner will develop an understanding of the continuity of life and the changes of organisms over time.

3.03 Interpret and predict patterns of inheritance.

Essential Question(s):

What is the significance of scientific investigation?
How can the Chi-Square Test be utilized to evaluate genetic hypotheses?

Introduction:

The Chi-square test is a method we can use to evaluate a genetic hypothesis. It allows scientists to determine if their results are due purely to chance, or if there was some selection involved. If the results are completely random, then we say there is a "nonsignificant" amount of selection. If there is a "significant" amount of selection, then the results are not due to chance.

With the Chi Square Test, we can convert deviations from expected values (predicted by the hypothesis) into the probability of such deviations occurring by chance. This test takes into consideration the size of the sample and the number of variables (degrees of freedom).

Example: When we toss a coin many times, we expect to get 50% heads and 50% tails. However, frequently there is deviation from our expected results. The question is: how much deviation should be allowed before we reject the *null hypothesis* that the deviation is due to chance. Conventionally, the *null hypothesis* is rejected when the deviation is so large that it could be accounted for by chance less than 5% (0.05) of the time.

$$X^2 = \sum \frac{(\text{observed value} - \text{expected value})^2}{\text{expected value}}$$

Stated the above equation is: Chi-square equals: all the individual observed values minus the expected values squared, then divided by their expected values, and then summed.

The chi-square number is then located in the chart opposite the degrees of freedom and the probability is read. The probability figure on the chart refers to the probability of the deviation being due to chance. If the probability is 5% (0.05) or less, then the deviation from expected has only a 5% or less chance of being random. Therefore the differences are probably NOT due to

chance. If the probability is greater than 5% (0.05) then the deviations have a greater than 5% chance of being random and ARE probably due to chance.

Degrees of freedom (df) is n-1. For example: in the case of tossing a penny, there are two possibilities, heads or tails. Out of 100 tosses, we can get any number of heads, but once the number of heads is established, the number of tails is then fixed as 100 - # of heads. Therefore, the degrees of freedom is 1 or (2-1). For a simple dominant/recessive pair of alleles the degrees of freedom is also 1. But for a typical co-dominant trait where there are three phenotypes, the degrees of freedom are 3-1 or 2. In this case, out of 100 individuals, there can be any number of the first phenotype, any number of the second phenotype, but the last phenotype will have to be a number that causes the total to be 100.

Degrees of Freedom	PROBABILITY										
	Nonsignificant								Significant		
	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.01	0.001
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.28	18.47
5	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	15.09	20.52
6	1.63	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	16.81	22.46
7	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	18.48	24.32
8	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	20.09	26.12
9	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	21.67	27.88
10	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	23.21	29.59

Example 1: In a class of 28 students, the following results were collected from the "Genetics of Parenthood" Activity. Having a widow's peak is dominant.

16 babies had widow's peaks
12 babies had no widow's peaks

Is this difference due to chance (or are the students controlling the outcome!)?
The expected is 3/4 widow's peaks (21) and 1/4 no widow's peaks.

$$\frac{(16-21)^2}{21} + \frac{(12-7)^2}{7} = 1.1905 + 3.5714 = 4.7619$$

Since the degrees of freedom are 1, we look in the chart and see that 4.7619 is between 3.84 and 6.64 which gives us a probability of between 5% and 1% that the deviation is due to chance. According to convention we say that the deviation is NOT due to chance. (I suspect the students are practicing "selection!")

Example 2: In a class of 28 students the following results were collected from the "Genetics of Parenthood" Activity. This is modeled as a co-dominant trait.

8 curly hair 15 wavy hair 5 straight hair

Using Chi-Square with Genetics of Parenthood

Expected would be 7 curly, 14 wavy, and 7 straight.

$$\frac{(8-7)^2}{7} + \frac{(15-14)^2}{14} + \frac{(5-7)^2}{7} = .14286 + .071428 + .57142 = .78571$$

When we look up this number in the chart under 2 degrees of freedom, we see that it is very close to .71 which gives us a probability of about 70% that this deviation is due to chance. According to convention, the deviation would be accepted as probably due to chance

Materials:

Calculator!

Procedure:

Using the class data from the "Genetics of Parenthood" activity, analyze different traits using the Chi Square Test. Your teacher will tell you which traits you are responsible for analyzing. Be sure to show all your work!

Questions to Guide Analysis:

1. How can the Chi Square Test be used to evaluate genetic hypotheses?
2. What professions utilize the Chi Square to interpret data?
3. Why are statistical analysis tools valuable to biologists?
4. How did the expected frequencies of the "Genetics of Parenthood" activity compare with the actual frequencies?

References (for further research):

If you need some additional information about Chi-Square, visit the following sites:
http://www.mste.uiuc.edu/patel/chisquare/intro.html
http://www.unc.edu/~preacher/chisq/chisq.htm
http://www.ndsu.nodak.edu/instruct/mcclean/plsc431/mendel/mendel4.htm
(please note that these websites are subject to change—you may just want to Google "Chi Square Test")

Rubric:

Lab write up (10%): Essential questions, background information, purpose, hypothesis, materials, methods
Class data (35%)
Using Chi Square to Calculate Frequencies (35%): Show all your work!
Conclusions (20%): Answers to "Questions to Guide Analysis", what did you learn, was your hypothesis supported (why or why not)

Plant WebQuest: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint

Goal 4: Learner will develop an understanding of the unity and diversity of life.

4.02 Analyze the processes by which organisms representative of the following groups accomplish essential life functions including:

Essential Question(s):

How do various organisms accomplish essential life functions?

Introduction to teacher:

Because this activity is dependent on the ever-changing internet, you will want to check that the site is still up and running before you begin this activity. The site is one from a public television station, but you never know!

Also, make sure that you have gone to all the websites and completed the activity yourself before you assign it to your students. This will allow you to speak knowledgeably about any potential problems/questions.

Differentiation from Standard-level:

As an honors-level activity, this activity should be completed as an independent study.

A standard-level course could complete this exact activity, although it is recommended that they complete it in a computer-lab setting under teacher supervision. This will allow any questions to be answered immediately as the teacher guides the students through the activity.

Safety/Special Considerations:

Be aware that there might be some students who do not have access to computers once they leave school. These students should be encouraged to use the computers available at school (either before school, during lunch, or after school).

References:

Mallard, Debbie (Cary High School, NC)

Plant WebQuest: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint

Goal 4: Learner will develop an understanding of the unity and diversity of life.

4.02 Analyze the processes by which organisms representative of the following groups accomplish essential life functions including:

Essential Question(s):

How do various organisms accomplish essential life functions?

Introduction:

Different types of plants have different characteristics. In this activity, you will find out just how different they are by gathering information on plant diversity.

Materials:

Computer with internet access

Procedure:

Visit the indicated websites and answer the following questions about plants

Bryophytes

- http://www.nhptv.org/natureworks/nwep14c.htm
  1. What anchoring structure do mosses have instead of roots?
  2. Why are mosses usually restricted to moist habitats?
  3. What is the first generation produced in mosses?
  4. What is the second generation produced in mosses?
  5. What structures are absent in liverworts?
  6. Where are hornworts found?

Ferns

- http://www.nhptv.org/natureworks/nwep14ferns.htm
  1. Where do ferns grow best?

2. What are fern leaves called?
3. What are the horizontal stems of ferns called?
4. What do ferns have instead of seeds?
5. What is the gametophyte stage of a fern called?
6. About how many species of ferns are there?

Gymnosperms

- http://www.nhptv.org/natureworks/nwep14e.htm

1. Spruce, cedar, and pine trees are all examples of _____.
2. How does the cone shape help protect the plants from snow?
3. About how many species of conifers are there?
4. What is the cup of a yew tree called?
5. Why do birds sometimes eat only the cup and leave the seeds of yew trees?
6. What type of gymnosperm resembles a palm, but is not really a palm?
7. What group of gymnosperms has only one surviving species?
8. Where are ginkgo biloba trees originally from?

- http://faculty.fmcc.suny.edu/mcdarby/Animals&PlantsBook/Plants/04-Gymnosperms.htm

1. What adaptation allowed plants to make the move to life on land?
2. List the four groups of gymnosperms and give an example of each.
   -
   -
   -
   -

3. Gymnosperms were the first widely distributed plant group; what major animal group are gymnosperms linked to?

4. What is the "main plant" of gymnosperms?

5. What are cones?

6. In pine trees which is larger, the male or female cones?

7. What structure encases the fertilized egg cell?

8. What is the advantage of a needle over a flat leaf?

9. What is the function of a cuticle?

- http://www.mcwdn.org/Plants/GymnoQuiz.html

  Take the gymnosperm quiz and email your teacher the answers.

Angiosperms

- http://www.nhptv.org/natureworks/nwep14f.htm

1. Angiosperms are _____ plants.
2. Where are angiosperm seeds found?
3. What process must angiosperms go through before they can reproduce?
4. What are the male sex organs of angiosperms?
5. Where is the pollen made in angiosperms?
6. What are the female sex organs of angiosperms?
7. Where is the pollen left on angiosperms?
8. What does cross-pollinate mean?
9. How many seed leaves do monocots start with?
10. How many seed leaves do dicots start with?
11. About how many species of monocots are there?
12. About how many species of dicots are there?

- http://faculty.fmcc.suny.edu/mcdarby/Animals&PlantsBook/Plants/05-Angiosperms.htm

1. Even though most plants are angiosperms, gymnosperms still have an advantage in certain environments. In what type of environments are gymnosperms more successful than angiosperms?

2. Angiosperms get their name because the _____ are produced inside a _____.
   - Besides the sporophyte embryo, what is in a seed?
   - What is the function of the fruit in an angriosperm?

3. Seeds are designed to travel in different ways.
    - List two types of fruits that are designed to fly through the air.
        -
        -
    - List one type of fruit that is designed to float across water.
        -
    - List one type of fruit that is designed to attach to passersby.
        -
4. Angiosperms are vascular plants with xylem and phloem.
    - In which direction does xylem flow?
    - In which direction does phloem flow?
5. Angiosperms have true roots; what are the two functions of roots?
6. Angiosperms have stems; what are the two functions of stems?
7. What structure is the site of photosynthesis in angiosperms?
8. How can a plant control the amount of carbon dioxide it takes in and the amount of water it loses?
9. What type of stem is capable of photosynthesis?
10. What type of stem is present in trees?
11. What are the male and female gametophytes in angiosperms?
    - Male:
    - Female:
12. What is the ovary converted to in angiosperms?
13. What type of environmental cues do plants wait for before germinating?
    -
    -
    -
14. Fill in the missing information for the chart below.

Monocots	Dicots
	Two-piece seeds
Flower parts in multiples of 3	
Parallel leaf veins	
	Root systems have one major root
Stems don't grow in ring pattern	

15. Animals and plants have evolved together, with animals acting as pollinators for plants. List two examples of this type of coevolution.
    -
    -

- http://www.mcwdn.org/Plants/AngioQuiz.html

  Take the angiosperm quiz and email your teacher your answers.

Questions to Guide Analysis:

Now that you're finished, write a paragraph comparing and contrasting the bryophytes, ferns, gymnosperms, and angiosperms. Include an explanation as to why angiosperms have been more successful than other plants. Discuss the value of co-evolution as it relates to angiosperm success.

References (for further research):

Internet

Rubric:

All questions should be correctly completed.
Online quiz answers should be emailed to the teacher.
Use the rubric on the next page for the paragraph:

	Excellent	Fair	Needs Improvement
Science Content	Accurate; Connected to big ideas in science	Mostly accurate; Connections to big ideas are not clear	Inaccurate; Not connected to big ideas in science
Information Sources	Multiple sources; Wide range of resource types; Reliable sources; Current sources	Two or more sources; Two types of resources; Some reliable sources; Some current sources;	One source (often personal knowledge or text only); Narrow range of resources; Unreliable sources; Out of date sources
Organization & Presentation	Main ideas are clearly presented; Ideas are presented in an appropriate order; Ideas are supported by information and logic; Appropriate conclusions are based upon evidence presented; Effective use of models, diagrams, charts, and graphs	Main ideas are presented to some extent; Ideas are not presented in an order that adds clarity; Some ideas are supported by information and logic; Conclusions do not follow from ideas presented; Some appropriate use of models, diagrams, charts, and graphs	No main idea presented; Ideas are presented in an order that distracts from clear communication; Ideas are not supported by information and are illogical; Inappropriate conclusions are presented No use of models, diagrams, charts, and graphs
Conventions	Generally error free in regards to sentence structure, punctuation, capitalization, spelling, and standard usage	Sentence structure, punctuation, capitalization, spelling, and standard usage errors are noticeable, but do not seriously impair readability	Errors in sentence structure, punctuation, capitalization, spelling, and standard usage impair readability
Use of Science Language	Consistent use of appropriate science language and terminology	Partial use of appropriate science language and terminology	Inaccurate use of science language and terminology

Rubric from www.uen.org/Rubric/rubric.cgi?rubric_id=14

Termite Behavior: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer biological questions

Goal 4: Learner will develop an understanding of the unity and diversity of life.

4.05 Analyze the broad patterns of animal behavior as adaptations to the environment.

Essential Question(s):

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

How do pheromones allow for the social behaviors of colonial organisms to adapt to their environment?

What are the advantages and disadvantages of using pheromones as behavioral adaptations?

Introduction to teacher:

Before beginning this lab activity, it is important that the students have participated in discussions on innate, learned, and social behaviors of organisms. You should also review sensory input.

The student introduction section is filled with a lot of good information that you will want to review with your students before the lab.

Termites can be obtained through science catalogs, but also by contacting your local pest exterminators or looking in rotted logs in local wooded areas. Many times, the termite exterminators will give you termites for free. One thing to consider, however, is the timing of the lab and whether or not there has been a lengthy dry spell in your area. If it has been dry for a long period of time, then termites will be in shorter supply, so you may have to obtain them through the science catalogs.

Keeping the termites in one large container and then putting small amounts in closed Petri dishes (for each lab table) does well. Keep the large container closed and keep it moist and the termites should stay alive for a while. The students can return their termites to the large container when they are finished with them.

Have the students use small paintbrushes to move the termites from place to place. This will reduce the number of termite fatalities. Remember that a portion of the students' grade will be based on the well being of their termites.

Differentiation from Standard-level:

Students have to design their own experiment. There are not specific directions on how to set it up. A standard-level class would probably need more explicit directions and scaffolding to design their own experiments.

Safety/Special Considerations:

Keep the termites in closed containers whenever possible. Do not let them get loose in the school. Have students wash their hands at the end of the lab activity.

References:

Stockdale, Maureen (Wakefield High School, Raleigh, NC)

Termite Behavior: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer biological questions

Goal 4: Learner will develop an understanding of the unity and diversity of life.

4.05 Analyze the broad patterns of animal behavior as adaptations to the environment.

Essential Question(s):

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

How do pheromones allow for the social behaviors of colonial organisms to adapt to their environment?

What are the advantages and disadvantages of using pheromones as behavioral adaptations?

Introduction:

Sensory input is processed by the central nervous system, which then directs a response from muscles or glands. ***Behavior*** may be simple and reflexive, such as rapid withdrawal from a source of pain, or it may be complex, such as detecting, approaching, and courting a potential mate. Broadly defined, behavior includes everything that animals do.

Human behavior is governed by emotions as well as by intellect and reasoning skills. Since we are capable of understanding our own behavior, we often find it difficult to adopt a scientific perspective on animal behavior. For many of us, association with pets has created a most unscientific tendency to ***anthropomorphize***, or attribute human thoughts and feelings to animal behavior. For example, when a kitten pounces on a ball of yarn and tumbles it around, we might characterize its behavior as recreation, as if the kitten intentionally decides to relax and have a bit of fun. In fact, this play behavior is probably a rehearsal for the cat's predatory habits later in life. The ball of yarn is a stand-in for a field mouse, and the kitten is learning to chase, capture and subdue its prey.

Many animals, possibly even humans, communicate with chemical signals. They may be used for many purposes, for example, to attract mates, to warn of danger, to point to a food source or to mark a territory. Substances that animals use to communicate with members of their own species are called ***pheromones***. These chemicals are generally effective in extremely small quantities.

Termites are ***social insects***. They live in cooperative groups, called ***colonies***, whose members are specialized for particular tasks. This type of organization requires elaborate communication within the population, and pheromones are used for a variety of purposes. For example, in some

species of termites, when an individual discovers a break in the wall of the nest, it becomes alarmed and moves away from the wall and back toward the center of the nest. As it travels, its physiological state of alarm causes it to leave a chemical trail. When other members of the colony encounter the trail, they follow it to the breach and repair it. Because every termite that wanders across the trail is compelled to follow it, numerous individuals are recruited to carry out the repairs. It's as if the termite that discovered the break originally had posted a sign saying "Red alert! All hands on deck!"

In this lab exercise you will investigate this behavior. One or more of the writing implements you will be given contains the same chemical pheromone produced by termites. Follow the directions on the lab and try to identify which writing implement contains the pheromone. And, identify the behavior that is elicited by the pheromone.

Materials:

Petri dish with termites
Newsprint
Assorted pens
White paper
Paintbrushes

Procedure:

Step 1. The "trail" made by one or more of the writing implements that you have been given attracts termites. Look at the selection of writing implements and list the possible characteristics that could attract the termites (hint: think about what makes each one different from one another).

- _____
- _____
- _____
- _____
- _____

Step 2. Spread a large piece of newsprint on the bench. Count the number of termites that are in your stock container. Use the paintbrush to **gently** transfer them from their container onto the paper. **Be sure to keep ALL termites on the paper. Loss, injury or death to any of the termites will cause you to lose points on your lab!!!**

Step 3. Observe the termites for approximately 5 minutes and then record their behavior in Table 1 (next page). Things you may want to address:

- Do the termites walk in any particular pattern or direction?
- Do they stay together, or go off in different directions?
- Do any termites look different from the others?
- Do you hear any sounds? Do you think they are communicating?

Table 1: Termite Observations (5 minutes)

Step 4. Next you will design and conduct an experiment. Design a test to see which writing implements cause a noticeable change in the behavior of the termites. Design a table (Table 2) to organize, record and display your results.

Step 5. Have your teacher check your plan and table before continuing.

Step 6. Carry out your plan and record your observations in your table.

Step 7. Based on your observations, what characteristic of the specified writing implement do you think caused the termite to exhibit the above behavior?

Step 8. Compare your results to those at other lab tables. **Are you still sure of your conclusion? Explain.**

Step 9. Return your termites to the stock container. Make sure you return the same number (alive) to the container that you took out.

Step 10. CLEAN UP!!!

- **Return all writing implements to the container.**
- **Throw away the newsprint.**
- **Wipe the table down with cleaner and a paper towel.**
- **WASH YOUR HANDS!**

Safety:

Wash your hands at the conclusion of the lab. Put your termites back in the large closed container at the end of the lab. Do not let the termites loose. Do not kill the termites.

Questions to Guide Analysis:

1. What advantage might there be to using chemical communication rather than visual (such as a flashing light) or auditory (such as clicks or whistles)?

2. What disadvantage might there be to using a chemical signal?

3. Why is it especially helpful to termites to use chemical communication?

4. Beside nest repair, can you think of any other advantages (or uses) that a trail-following behavior might have for termites?

5. Japanese beetles are a serious pest that attacks garden and ornamental plants. Instead of spraying with an insecticide, you can buy Japanese beetle traps that contain a pheromone to attract the beetles. Based on what you know about pheromones, give positives and negatives for using these types of traps.
   - ❖ Positives –
   - ❖ Negatives-

Extensions:

To study symbiosis, use the gut of the termite. Squeeze the gut so that the fluid is expelled. Put this on a microscope slide and view under the microscope. You should be able to see the protozoans that are in the termite's gut. Draw these and describe the importance of the relationship between these two organisms.

References (for further research):

Internet

Rubric (See next page)

Termite Behavior Rubric

	1(15 points)	2 (19 points)	3 (22 points)	4 (25 points)
Participation level	Little or none	Very limited	Adequate	Efficient and Precise
Step 1-3 & Table 1: Writing Implements /Termite Observations	Meaning not clear/ work incomplete	At times unclear/ work partially incomplete or lacking essential elements	Meaning conveyed/ work adequately completed	Meaning conveyed effectively/ work completed to highest extent
Conclusions: Table 2 and Step 4-10…	Very difficult to understand and follow	Can be understood with some effort from the reader or listener	Comprehensible but not always clearly stated	Clearly stated and comprehensible

Analysis Questions (5)= _____ [% correct _____x 25]

Final Score:_____

The Effects of Acid Rain on Seedling Growth: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer biological questions.

Goal 5: Learner will develop an understanding of the ecological relationships among organisms.

5.03 Assess human population and its impact on local ecosystems and global environments

Essential Question(s):

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

How do human activities affect ecosystems?

Introduction to teacher:

In this activity, there are numerous learning goals: standard curve, line graph, variables, measurement, calculation of surface area, and understanding of the effect of acid rain. Students develop their own hypotheses and are able to use their lab data to make conclusions.

You will need to create the grid sheets with 4 grids for each $1cm^2$. The original lab listed cucumber seedlings as the plant, but this lab should work with other seedling plants. You will want to watch that the plants are not being over-watered, and may want to remove the "wick" portion of the lab for that reason.

To extend this activity, students could create a standard curve using the pHs given on the lab sheet. They then could test other water sources (tap water, rain water, pond water, etc.) and see how the effects of these sources compare with the standard curve of known pHs. Using these "real" world samples would make the lab much more applicable to their daily lives.

Another extension is to tie this lab in to the problems farmers face in North Carolina. Identify crops that are grown and ideal pH ranges for those crops. How would acid rain affect them? How has acid rain affected the western part of the state?

Differentiation from Standard-level:

Honors level students are expected to do a more in depth analysis and then to connect the data they collect to "real" world situations.

Safety/Special Considerations:

Acid precautions (goggles, aprons, gloves should be worn)

References:

Caudill, Scott (Cary High School, Cary, NC)

July 2007

The Effects of Acid Rain on Seedling Growth: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: Learner will develop abilities necessary to do and understand scientific inquiry.

1.02 Design and conduct scientific investigations to answer biological questions.

Goal 5: Learner will develop an understanding of the ecological relationships among organisms.

5.03 Assess human population and its impact on local ecosystems and global environments

Essential Question(s):

How does a scientist design and perform an inquiry-based scientific investigation considering controls, variables, and data analysis?

How do human activities affect ecosystems?

Introduction:

In this lab you will study how plants respond to various pH levels. Environmental conditions can change in an area, and acid rain is a concern to many people. You will use seedlings and track their growth and appearance for a week. In addition to testing known pH values, you will also experiment with another water source of your choosing and hypothesize about the changes that will occur in your seedlings over time.

Materials:

plant seedlings
4 "acid" water solutions
spray bottles
wicks
graph paper
pH paper
masking tape
metric ruler
watering trays
scissors
other water (rainwater, pond water, etc.)

Procedure:

Before the first day:

1. Hypothesize what will happen when you expose the seedlings to various pHs.
2. Choose an additional water source you will test and obtain a sample.
3. Hypothesize what will happen with your additional water source.
4. Develop the procedure that you will perform with your seedlings (be specific) and have your teacher approve it.

First day:

1. Obtain needed supplies from your teacher.

2. Label each seedling with a piece of masking tape that has the group name and relevant water information. Test the pH of your additional water sample and record it.
3. Create a data table.
4. Fill out the data table on Day 0 (setup). Your description of the plants should include qualitative (appearance, color, texture, etc.) and quantitative data (height in cm).
5. With the scissors, cut apart the plastic tray to separate your plants. Make sure each plant has a wick sticking out of the bottom. DO NOT REMOVE THIS WICK!
6. Using a spray bottle or graduated cylinder, water your plants with the experimental solutions. Be sure you determine how much water each receives (why is this important? Should the amounts be equal for all of your seedlings? Why?)
7. Take your plants to the watering trays near the window and place them inside. The wick will water your plants from below.
8. Repeat steps 6 and 7 each day for several days. Be sure to fill in your data table with descriptions and height each day.

Last day:

1. Do not spray your plants today. Fill out your data table (description and height), and then remove them from the soil, keeping track of which is which.
2. Choose the largest leaf from each plant and remove it entirely from the stem.
3. Calculate the Leaf Surface Area using the method described below.

Calculation of Leaf Surface Area:

Place a leaf onto the grid below and trace around the edges of the leaf. Count the number of grids that are completely within the leaf. Then estimate the number of partial grids and add the total number of grids for the leaf together. The grid below has been constructed so that each group of 4 grids equals 1cm^2. The total surface area of a leaf can be calculated by the following formula:

$$\text{\# of grids in a leaf} \div 4 = \text{Leaf Surface Area}$$

Record this value (in cm^2) in the Leaf Surface Area Data Table. Calculate the surface area for the remaining three leaves. (Your teacher has more grids if you need them.)

Safety:

Wear goggles, gloves, and an apron when working with acids. Listen carefully to safety instructions given to you by your teacher. Wash your hands at the end of lab each day.

Questions to Guide Analysis:

1. After you make your calculations, create a graph of pH vs. leaf surface area.
2. Which type of graph (line or bar) should you create? Why?
3. Plot given pHs as well as leaf surface area of plants sprayed with "real" world samples.

4. The pH solutions may have been made with different chemical compositions. How might that variable have affected your results?
5. Consider other variables in the "real" world water samples that may affect plant growth. Discuss.
6. Why do we try to keep the amount of water each day the same amount?
7. What is the pH of your other water sample? Does the pH account for the growth of the plant?
8. Besides measuring the leaf surface area, what alternative measurements can be made to determine the effects of acid rain on plant growth?
9. What can you conclude from your experimental findings about the effects of acid rain on plant growth?
10. What are the sources of acid rain?
11. What effects of acid rain are present in North Carolina?

References (for further research):

Internet

Grading Guide

Before lab day activities (have checked by teacher prior to lab) 30%
Data chart: 10%
Graph: 10%
Answers to Questions to Guide Analysis: 50%

Field Study on School Grounds

Field Study on School Grounds: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01: Identify biological questions and problems that can be answered through scientific investigations.

1.02: Design and conduct scientific investigations to answer biological questions.

Goal 5: The learner will develop an understanding of the ecological relationships among organisms.

5.01 Investigate and analyze the interrelationships among organisms, populations, communities and ecosystems

5.02: Analyze the flow of energy and the cycling of matter in the ecosystem.

Essential Question(s):

What tools do scientists use to study biodiversity?

What factors influence biodiversity?

Introduction to teacher (background information):

The best way for a student to understand a topic is for them to experience it. Unfortunately, we do not all have access to the variety of ecosystems that are present in our state. We do, however, have the ability to study the land on which our schools are located. Whether you choose to take your class out to the football field, or another area, they will gain an appreciation of the interdependency among organisms while developing and participating in their own laboratory activity.

This lab is set up to be an on-going activity to use as you progress through your ecology unit. Before you begin, you should obtain permission to utilize a part of your campus and request that it not be disturbed (e.g. not mowed, etc.) for the duration of your unit. You should also check the area for any potential hazards (e.g. poison ivy, bees' nests, etc.) and identify any relevant student allergies. You will also need to obtain a way to mark quadrants to study (irrigation system flags are available at home improvement stores or you can make your own flags). Each student will need 4 flags and it is helpful to number them (i.e. four #1 flags, four #2 flags, etc.).

It is helpful if you plan your entire ecology unit to determine appropriate times to go outside for your field study. It may not be possible for you to go outside every day (since there are many concepts to cover and other activities you will want to do). You will want to make sure that you have covered certain topics before visiting the quadrant. For example, before they can explain how the carbon and water cycles are occurring in their quadrants, they need to know how these cycles work. Having the students keep a field study journal will allow them to make entries even when they do not visit their quadrant. Since temperature and precipitation may have an impact on the species present, you may want them to record this data for the duration of the study. You will also want to check the students' investigation plans to make sure they are appropriate.

If possible, have students work individually on this laboratory. It will be a better measure of each individual's understanding.

Another suggestion is to have wire hangers formed into squares and use these to mark off areas for the students.

Extensions of this laboratory could involve the students using their quadrants to investigate objectives 2.05 (respiration/photosynthesis), 4.03 (structural adaptations), and 5.03 (human impact on ecosystems).

Differentiation from Standard-level:

Most standard-level classes would need more structure and scaffolding to do this activity.

Another possible honors-level extension is for the students to explore the concept of intermediate disturbance. They could compare three quadrants of different proximity to a potential disturbance (for example, a walkway). Three possible areas might be: in the woods, at the edge of the woods, and in the ball field. They could make a hypothesis about where the greatest diversity will be found.

Use the Shannon-Weaver Index.

Safety/Special Considerations:

Be sure to clear your plan with your school administration. A class set of orange vests can be used to make it clear to you and administrators that these students are participating in a field activity. Some schools prefer that teachers carry a communication device (phone or radio) to communicate with the office while in the field. Make sure the students are not out of your sight while they are outside. Check to make sure that none of the students have insect bite allergies before going outside.

References:

Welsh, Zoe (Leesville Road High School, Raleigh, NC)

Field Study on School Grounds

Field Study on School Grounds: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01: Identify biological questions and problems that can be answered through scientific investigations.

1.02: Design and conduct scientific investigations to answer biological questions.

Goal 5: The learner will develop an understanding of the ecological relationships among organisms.

5.01 Investigate and analyze the interrelationships among organisms, populations, communities and ecosystems

5.02: Analyze the flow of energy and the cycling of matter in the ecosystem.

Essential Question(s):

What tools do scientists use to study biodiversity?

What factors influence biodiversity?

Introduction:

You do not have to travel to a wildlife refuge or state park to study ecological relationships. The purpose of this activity is to study how ecology relates to an area on your school's campus. You will do this by explaining how your area relates to key concepts in ecology and by developing and conducting your own lab investigation to increase the number of species present in your area.

Materials:

- Flags to mark quadrant
- Metric ruler
- Acetate with 1cm x 1cm squares
- Materials needed to conduct your individual lab investigation

Procedure:

1. Obtain flags and mark the area to study. Your area should be a minimum of 30cm x 30cm.
2. In the journal (each time you make an entry, make sure you include the date):
    a. Indicate which numbered flags you have and describe your location (imagine if the flags are removed and you have to locate your quadrant).
    b. Indicate the dimensions of your quadrant (in cm).
    c. Conduct a preliminary species count by listing all of the species present. If species is unknown, then describe it so you can research what it is. Each quadrant must have living things in it.
    d. List the abiotic components of your quadrant.

   e. Indicate the high and low temperature of the day (in Celsius) and precipitation. http://www.weather.com/ or http://www.wunderground.com/ are helpful web sites. This data should be taken each day of the investigation, regardless of whether you visit your quadrant or not.
   f. What other environmental variables should you track during the course of your investigation? Determine these and keep a running log of any changes in conditions.
3. Begin planning an investigation to increase the number of species in your quadrant. Plan is due on: _____ (with hypothesis, control, independent/dependent variables, steps that will be taken). Plan should be written in your journal.
4. On your next visit to your quadrant, add the following information to your journal:
   a. How does your quadrant relate to the carbon cycle? How does it relate to the water cycle?
   b. How does the quadrant relate to the cycling of energy?
5. Use the acetate sheet (with 1cm x 1cm squares) to sample portions of your quadrant. First, determine how many squares make up your quadrant. Second, randomly choose ten squares of your quadrant, lay the acetate over those portions and count the number of each individual species present. Determine the estimated sample size of each species using the following equations:

$$\text{Population \%} = \frac{\text{\# of squares randomly counted (10)}}{\text{Total \# of squares in quadrant}}$$

$$\text{Species estimate} = \frac{\text{Total number of individual species counted}}{\text{Population \% (from above)}}$$

6. Turn in journal for investigation plan approval.
7. Once your plan has been approved, get materials ready to start lab investigation.
8. On your next visit to the quadrant, set up and begin your lab investigation. Note any problems in setup and/or changes in species number. In addition, answer the following in your journal:
   a. How does the entire area (all quadrants) show succession? Explain.
   b. Which areas are older than the others? Explain.
9. On subsequent visits to your quadrant: use the acetate sheet to estimate population sizes and take other data relevant to your investigation in your journal.
10. Once you have concluded your investigation, publish your results in a lab report and/or class presentation as directed by your instructor.

Safety:

Be safe while you are outside! Stay where your instructor can see you and notify him/her if you have any insect (or other related) allergies.

Questions to Guide Analysis:

1. Why was there a minimum size your quadrant could be?
2. Why was it important to date each journal entry?
3. What effect did temperature and precipitation have on the number of species in your quadrant? If they did not have a significant effect, why did you have to take the data?

4. Why would the method you used to estimate diversity and population size not be appropriate for estimating all animal populations?
5. What factors influence population size and diversity?
6. Was your hypothesis supported by the data you collected? Why or why not?
7. How could you have made your lab better? What would you do differently?
8. Why did you have to answer questions about the biotic/abiotic factors, the cycling of matter, the cycling of energy, and succession in your lab journal?

References (for further research):

Website on Shannon-Weaver Index
Statistical methods to measure changes in biodiversity

Grading Guide:

Hypothesis: 5%
List of variables in experimental plan: 5%
Journal entries complete with date and observations: 25%
Answers to Questions to Guide Analysis (correctness) 25%
Lab report (all parts complete, neatness): 40%
Is conclusion reasonable and based on findings? 5%
Was student able to resolve inconsistencies or problems encountered? 5%

Field Study on School Grounds

Food Chains and Biological Magnification: Background Information

Targeted *Standard Course of Study* Goals and Objectives:

Goal 5: Learner will develop an understanding of the ecological relationships among organisms.

5.02 Analyze the flow of energy and the cycling of matter in the ecosystem.

5.03 Assess human population and its impact on local ecosystems and global environments

Essential Question(s):

How do trophic levels determine how energy is transferred through ecosystems?

How are trophic levels related to food webs?

What are the effects of biomagnification with respects to the food chain?

Introduction to teacher:

Before beginning this activity, you should have already re-introduced your students to the concepts of food chains, food webs, and energy transfer. These concepts are a part of the middle school curriculum. You should also have covered the different levels of an energy pyramid and how organisms from a food web would fit into a particular energy pyramid.

Assign organisms from a given food web. You may want to use a food web that is prevalent in your geographic area. Try to include at least one endangered or threatened species. Students will need to research their assigned organism before the activity.

You will need to either create the "chips" you will use or buy some before the activity. You could use something as simple as plain white paper cut into squares or colored candy pieces. You should also come up with a class data sheet that you can fill in as the students transfer energy/DDT.

Differentiation from Standard-level:

The main differentiation of this activity that makes it an honors-level is the research the students do prior to the activity.

Safety/Special Considerations:

None (unless candy is used as the "chips" and then you would need to check for food allergies).

References:

Caudill, Scott (Cary High School, Cary, NC)

July 2007

Food Chains and Biological Magnification: Activity

Targeted *Standard Course of Study* Goals and Objectives:

Goal 5: Learner will develop an understanding of the ecological relationships among organisms.

5.02 Analyze the flow of energy and the cycling of matter in the ecosystem.

5.03 Assess human population and its impact on local ecosystems and global environments

Essential Question(s):

How do trophic levels determine how energy is transferred through ecosystems?

How are trophic levels related to food webs?

What are the effects of biomagnification with respects to the food chain?

Introduction:

In ecosystems there is a relationship between autotrophs and heterotrophs. Without energy from the autotrophs, the heterotrophs would cease to exist. Most autotrophs get their usable energy by undergoing photosynthesis. Energy from the sun is converted into chemical energy in the form of glucose. As energy moves from one level of the food chain to another, only 10% of the original energy is passed on. This decrease in usable energy creates an energy pyramid.

Not only energy moves throughout the food web, however. Contaminants (such as pesticides) can accumulate in organisms as one organism eats another. This is called biomagnification and is very harmful to ecosystems.

Materials:

Energy "chips"
Pesticide "chips"

Procedure:

Before the lab activity:

1. You will be assigned a role as an organism in a particular food web. You need to research the organism and determine:
    a. How they are important in the ecosystem
    b. How they get their energy
    c. What they eat

   d. What eats them
   e. Whether or not they are endangered or threatened (and what that means)
   f. How abundant they are
   g. Their natural habitat
   h. Other interesting facts
2. Write this information up in a short paper before activity day!

Part One: Energy Transfer

1. You will be assigned a role as an organism on a particular trophic level from producer to 3rd -level consumer (this may or may not be the same organism you researched).
2. The chips spread around the room represent the energy available in the bodies of producers.
3. First, the producers will photosynthesize and collect 4 energy chips each.
4. Next, the primary consumers will enter the ecosystem and "tag" a producer. This tag represents the death of the producer and the transfer of energy up the food chain. However, since there is energy lost between each trophic level, the primary consumer gets 3 of the producer's chips. Each primary consumer may tag/eat up to three producers.
5. Now the secondary consumers enter and can eat up to 2 primary consumers. Due to energy loss, only 2 chips are transferred from each primary consumer that is eaten.
6. Finally the tertiary (3rd level) consumer can enter and eat all the secondary consumers. They each transfer one energy chip.
7. Your teacher will be recording the data after each round of feeding.
8. Repeat this activity with the threatened/endangered species sitting out.

Part Two: Biomagnification

1. Spread all the chips back out around the ecosystem. The exercise will be repeated, except this time the chips will represent a pesticide (such as DDT) that was sprayed in the ecosystem and this pesticide will be present in the producers. The activity will begin with the primary consumers this time.
2. Primary consumers enter first and collect as many chips as they can in 15 seconds.
3. The secondary consumers enter next and can eat up to 3 herbivores. Since the chips represent a toxin that does not naturally break down, **all** the chips are transferred from the consumed herbivores.
4. The tertiary consumers enter and each consumes 2 secondary consumers obtaining all their pesticide chips.
5. Your teacher will be recording the data after each round of feeding.

Safety:

Do not throw any of the chips.

Questions to Guide Analysis:

1. Create an energy pyramid with the energy data collected. Draw it and label its parts.
2. How did we simulate energy loss in Part One?
3. In "real" situations, would the consumers gain ¾ of the energy of the things they ate? Why or why not?
4. Why were the primary consumers limited to eating 4 energy chips? In other words, why didn't they eat all the producers?
5. At which trophic level was the total amount of energy the least? Why?
6. Why did we treat the transfer of pesticides differently than the transfer of energy?
7. What was the average amount of individual pesticide accumulation for these trophic levels?
    a. Primary consumers: _____
    b. Secondary consumers: _____
    c. Tertiary consumers: _____
8. In your own words, explain why the tertiary consumers had the largest amount of pesticide in their bodies.
9. How did the results change when the threatened/endangered species sat out? Why?
10. Why are the organisms in the highest trophic levels more likely to be threatened or endangered?
11. Which other organism in the class food web had the greatest impact on your organism?

References (for further research):

Why Big Fierce Animals Are Rare

Internet

Rubric:

Research on individual organism (50%)
Analysis Questions (40%)
Participation (10%)