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ABSTRACT

This biology curriculum supplement includes the North Carolina Standard Course of Study Goals, helpful resources, and suggested activities supported by inquiry-based laboratory activities. Contents include a detailed description of content which provides the goals and standards being sough), a materials list for inquiry support labs and activities, and activities including: (a) "How Do Biological Materials Respond to Acids and Bases?"; (b) "Properties of Enzymes"; (c) "Cell Respiration in Germinating Seeds"; (d) "What Are the Effects of Various Mutations on Protein Synthesis?"; (e) "The Genetics of Parenthood"; (f) "Animal Kingdom Diversity"; (g) "Biomes and Climatograms"; (h) "Environmental Factors That Affect the Hatching of Brine Shrimp"; (i) "Animal Responses to Environmental Stimuli"; and (j) "Fishy Frequencies". (Author/YDS)

North Carolina Department of Public Instruction

BIOLOGY CURRICULUM SUPPORT DOCUMENT

This support document includes the NC Standard Course of Study goals and objectives along with objective weights, a detailed content explanation, a list of helpful resources and a collection of some suggested activities. Also included is a collection of Inquiry Support Labs and Activities.

June 2002

Please address questions or comments to Bill Tucci, NCDPI Science Consultant,
telephone (919) 807-3845, email wtucci@dpi.state.nc.us

State Board of Education

NC Department of Public Instruction

Michael E. Ward, State Superintendent

301 North Wilmington Street • Raleigh, North Carolina 27601-2825 • Website: www.ncpublicschools.org

Acknowledgements

This document was developed in response to the expressed need of science teachers for materials designed to facilitate and enhance the teaching of the revised *North Carolina Standard Course of Study for Science.* The materials provide a guide for translating the goals and objectives of the Biology curriculum into good instructional design.

A group of dedicated and talented science teachers spent many hours developing these materials. The result is a resource that will facilitate the implementation of the North Carolina science curriculum.

A special thanks to the authors of these materials:

Eleanor Hasse, North Carolina State University
Judy Jones, East Chapel Hill HS
Julie Malone, Educational Consultant
Gordon Plumbee, Western Alamance High School

Comments on these materials should be addressed to:

William J. Tucci
Science Section
North Carolina Department of Public Instruction
301 North Wilmington Street
Raleigh, NC 27601-2825
e-mail: wtucci@dpi.state.nc.us

BIOLOGY CURRICULUM SUPPORT DOCUMENT

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Biology Curriculum Support Document

Introduction:

This support document includes the North Carolina Standard Course of Study goals and objectives along with objective weights, a detailed content explanation, a list of helpful resources and a collection of some suggested activities. The Inquiry Support Labs and Activities and the additional "Suggested Activities" included in the support document are in no way required but serve as guides and resources for classroom teachers.

The detailed content description should serve as minimum, not maximum, guidelines for all biology courses. This content description will also serve as a guide to developers of the N.C. Biology End-Of-Course Tests. A deliberate effort was made to reduce the required vocabulary in order that teachers could spend time developing conceptual understanding. Vocabulary and concepts listed as "deliberately excluded" may of course be taught at the teacher's discretion. These concepts may be more appropriate extensions and enrichment for an advanced or honors course.

Competency Goal 5 in the most recent revision of the standard course of study reads "students will develop an understanding of the behavior of organisms, resulting from a combination of heredity and environment." Examining the objectives in this goal, the Biology Committee believes the word behavior should be replaced with the phrase "adaptive responses." Adaptive responses is a more inclusive term, which includes plant tropisms, animal behaviors, and other adaptations such as mimicry, protective coloration and biological clocks.

Teachers should keep in mind that the strands are intended to permeate the content. Instructional emphasis should be on conceptual understanding, science as inquiry and providing students with opportunities to apply, analyze, and evaluate. The material should be taught and assessed in a manner that requires students to collect and analyze data. They should also make comparisons of concepts such as respiration and photosynthesis.

Goals and Objective Weights:

Weights have been specified as percentages for each goal and objective to guide teachers and local districts in their planning for the course. The NCDPI will use the objective weights when setting the content guidelines for Biology EOC tests.

History of Science Strand:

The figures of historical significance that have been specified by this curriculum are listed within the support document with their respective areas of contribution. Collectively they represent 1% of the curriculum and represent the history strand as it applies to the biology curriculum.

Students are expected to know the main contributions of each individual related to the objective he or she is listed with (some made major contributions to several areas of biology), have a sense of the context in which the scientist developed his or her ideas and the process these ideas went through to be accepted by the scientific community. They should be able to draw various conclusions about the nature of science as it pertains to the work of these scientists. Of course teachers are encouraged to include other scientists as appropriate. The history of science strand represents approximately 1% of the curriculum.

Objective	Scientist
2.01	James Watson and Francis Crick
2.03	Gregor Mendel
2.03	Charles Drew
2.06	Charles Darwin
2.06	Louis Pasteur
3.02	Carolus Linnaeus
4.05	Rachel Carson
5.05	Jane Goodall

General Biology/Science Internet Resources

http://www.pbs.org/teachersource/sci_tech.htm
http://www.accessexcellence.org/RC/
http://www.discover.com
http://educate.si.edu/rb/rb_fs.html - The Smithsonian
http://www.biology.arizona.edu/
http://www.enc.org/ - Eisenhower National Clearinghouse
http://www.educationplanet.com
http://www.hhmi.org/biointeractive/ (go to animations for diffusion video)

Note:
The resource list included in this document is subject to change. Internet resources are often fleeting. This portion of the document will occasionally be modified.

COMPETENCY GOAL 1: The learner will develop an understanding of the physical, chemical, and cellular basis of life.

Weight	Objective	Content	Suggested Activities	Resources
4%	**1.01** Analyze the matter-energy relationships of living and non-living things.	Living vs. non-living and the use of energy by living systems.		
	1.01a Chemical processes and regulatory mechanisms of cells.	Maintenance of homeostasis: temperature, pH, and salinity.	Inquiry Support Lab <u>How do Biological Materials Respond to Acids and Bases?</u>	
	1.01b Bonding patterns.	Bonds- • Formed by attraction between atoms • Represented by lines between the chemical symbols • Potential to be stronger or weaker • Specific bonding patterns for H, O, C, N Bonds can be discussed when teaching enzymes, respiration, photosynthesis, digestion, hydrolysis, and DNA.	Use physical models.	
	1.01c Energy use and release in biochemical reactions.	1) Generally it takes energy to make or break chemical bonds, but breaking bonds may also release net energy, which may be used by the cell to do other work. 2) Compare and contrast 4 main types of organic chemicals, listing functions and subunits. • Proteins • Carbohydrates • Lipids • Nucleic Acids 3) Contrast with inorganics such as H_2O, O_2, CO_2, and NH_3.	1) Food tests for starch, fats, and sugars. 2) Temperature measurements during endothermic and exothermic reactions like those in a peanut calorimeter activity. 3) Glowing splint test for oxygen.	
4%	**1.02** Describe the structure and function of cell organelles.	1) Structure and function of: nucleus, plasma membrane, cell wall, mitochondria, vacuoles, chloroplasts, ribosomes. *(The endoplasmic reticulum, Golgi apparatus, lysosomes, and cytoskeleton have been deliberately excluded. Cell Theory is required in the 7th grade Standard Course of Study)* 2) Proficient use and understanding of light microscopes.	1) Use microscopes to view and measure different types of cells. 2) Provide opportunities for students to manipulate, create, or examine three-dimensional models.	<u>http://www.life.uiuc.edu/cgibin/plantbio/cell/cell.cgi</u> virtual plant cell from a University of Illinois project. <u>http://www.libfind.unl.edu/wglider/tutorial/animcell.html</u> animal cell from a course at the University of Nebraska. <u>http://www.unl.edu/wglider/tutor/plant.htm</u> plant cell tutorial from the University of Nebraska.

COMPETENCY GOAL 1: The learner will develop an understanding of the physical, chemical, and cellular basis of life.

Weight	Objective	Content	Suggested Activities	Resources
1%	**1.03** Compare and contrast the structure and functions of prokaryotic and eukaryotic cells.	To include: • Meaning of term "membrane-bound organelles" • Contrasts in size • Contrasts in chromosome structure	Use microscopes to view and measure different types of cells.	http://www.biology.arizona.edu/cell_bio/tutorials/pev/page2.html interesting, little known facts about bacteria, part of a tutorial from Arizona University's Biology Project
4%	**1.04** Assess and explain the importance of water to cells, as well as transport into and out of cells.	1) Assess and explain importance of water to cells. 2) Discuss active vs. passive transport, diffusion, osmosis, and semipermeable membranes. 3) Given solution concentrations and different types of cells, students should be able to predict any changes that may or may not occur. *Vocabulary such as hypertonic, isotonic, hypotonic, pinocytosis, phagocytosis, endocytosis, and exocytosis has been deliberately excluded.*	1) Rate of diffusion experiments as in agar-block and dialysis-tubing activities. 2) Use of dialysis tubing (or cheap plastic baggies) to inquire into what crosses the membrane. 3) Activities placing cells in different concentrations, as with eggs and *Elodea*.	http://biology.arizona.edu/sciconn/lessons/mccandless/default.html lesson plans by a high school teacher including several osmosis/diffusion lab activities on the University of Arizona Science Education Connection site.
2%	**1.05** Describe the structure and function of enzymes and explain their importance in biological systems.	Enzymes are proteins, which control chemical reactions in organisms. Concepts to be covered include: • Enzymes as re-useable and specific • Effects of pH and temperature on enzymes and the denaturing of enzymes • Induced Fit theory • Many genetic metabolic disorders such as PKU are caused by defects in the genetic code for one or more enzymes.	Inquiry Support Lab Properties of Enzymes	
4%	**1.06** Analyze the bioenergetic reactions.	The emphasis should be placed on overall equations and on design and analysis of experiments. Assessment should focus on understanding of the overall reaction, evaluating design of experiments, and interpreting data from these experiments.		
	1.06a Aerobic respiration and anaerobic respiration.	Students should be able to list reactants and products, not memorize step-by-step details.	Inquiry Support Lab Cellular Respiration in Germinating Seeds *Recommended also for 3.03b.*	

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COMPETENCY GOAL 1: The learner will develop an understanding of the physical, chemical, and cellular basis of life.

Weight	Objective	Content	Suggested Activities	Resources
	1.06b Integrated: compare/ contrast aerobic, anaerobic, photosynthesis and chemo-synthesis.	Discussion should include the function of ATP, the purpose of the reactions and which types of organisms do which type of reaction when. *Students are not required to distinguish between light-dependent and light-independent parts of photosynthesis, and need only minimum details and examples of chemosynthesis.*	Inquiry activities to determine the effects of conditions such as pH, temperature, light, and food availability on these reactions. Organisms like *Elodea* and yeast are suitable for such experiments.	
	1.06c Photosynthesis	Students should be able to list reactants and products, not memorize step-by-step details.		http://photoscience.la.asu.edu/photosyn/default.html many useful links and articles at varying levels from Arizona State University's Photosynthesis Center.

Total Weight for Goal 1
19%

COMPETENCY GOAL 2: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Weight	Objective	Content	Suggested Activities	Resources
4%	**2.01** Analyze the molecular basis of heredity/DNA including:	Instruction should include: 1) The structure of DNA, base pairing, and the formation of hydrogen bonds. 2) Mutation as a change in DNA code. 3) The contributions of James Watson & Francis Crick.	1) Creation of models.	http://vector.cshl.org/dnaftb/ DNA from the Beginning – Useful for many goal 2 objectives. Cold Spring Harbor Laboratory. http://biocrs.biomed.brown.edu/Books/Chapters/Ch%208/DH-Paper.html This is a web reprint of Watson and Crick's original paper. (Link must be pasted into browser) Video – *The Race for the Double Helix*
	2.01a Replication.	Replication allows daughter cells to have an exact copy of parental DNA., is semi-conservative and takes place before cells can divide.	1) Use of models to demonstrate replication.	http://www.pbs.org/wgbh/aso/tryit/dna/index.html# PBS has an interactive tutorial for replication and protein synthesis.
	2.01b Protein Synthesis.	1) Recognition of protein synthesis as a process: • Transcription produces mRNA copy • mRNA travels to ribosome • Translation - tRNA supplies appropriate amino acids • Amino acids link to form protein 2) Mutation as a change in DNA code that can lead to a change in protein.	1) Inquiry Support Lab – What are the effects of Various Mutations on Protein Synthesis? 2) Use of models that enable students to work through the processes of transcription and translation to determine the resulting amino acid chain.	
4%	**2.02** Compare and contrast the characteristics of asexual and sexual reproduction.	1) Function of Mitosis & Meiosis including: • Attention to similarities and differences between mitosis & meiosis • Changes in chromosome number • Ability to put diagrams in order and describe what is occurring throughout the process *Students are not expected to memorize the names of the steps or the order of the step names.* 2) Sources and amount of variation including: • Crossing over • Random assortment of chromosomes • Mutation 3) The understanding of reproductive variations as adaptations, including recognition that one form of reproduction is not necessarily better or more advanced than the other (consider examples of asexual reproductive advantages to bacteria, plants, marine invertebrates, and parthenogenic lizards).	1) Observation of slides such as a plant root tip. 2) Use or creation of models that allow students to manipulate structures within a cell to demonstrate Mitosis and Meiosis.	http://biog-101-104.bio.cornell.edu/bioG101_104/tutorials/cell_division.html interactive tutorial with pictures of phases. http://www.biology.arizona.edu/cell_bio/cell_bio.html cell cycle tutorials and a web version of an onion root tip lab – many of these tutorials are also available in Spanish.

COMPETENCY GOAL 2: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Weight	Objective	Content	Suggested Activities	Resources
6%	**2.03** Interpret and use the laws of probability to predict patterns of inheritance.	1) Students should be able to solve and interpret problems featuring: • One and two traits • Monohybrid and dihybrid crosses • Test crosses • Punnett squares • Dominant, recessive and codominant alleles • Multiple alleles as in A,B,O blood types • Sex linked (X and Y) traits • Pedigrees (with and without identification of the heterozygous condition) • Polygenic traits 2) Discussion of Mendel's experiments and laws. 3) Discussion of Charles Drew and his impact on blood donation and blood banks.	1) Inquiry Support Lab – The Genetics of Parenthood 2) Solve genetic problems and analyze pedigrees. 3) Participation in probability activities. 4) Test crosses with plants or fruit flies.	http://www.horton.ednet.ns.ca/staff/selig/AP/labs/Blood activity.htm This page has a virtual blood-typing activity. http://www.stg.brown.edu/webs/MendelWeb/ links to Mendel's original paper with annotated English translation and other information about Mendel's work. http://www.carolina.com/achievements/janapr/drew.htm information about Charles Drew http://www.cdrewu.edu/about/drdrew.htm more information about Charles Drew NOVA episode – *Garden of Inheritance*
4%	**2.04** Assess the application of DNA technology to forensics, medicine, and agriculture.	1) To include: • Identification of individuals • Identification of parentage • Crime scene applications • Screening for genetic disorders including use of amniocentesis • Gene therapy • Pharmaceutical applications such as the production of insulin • Transgenic organisms (plants, animals, & bacteria) • Cloning 2) Gel electrophoresis as a technique. 3) The ethical implications and possible dangers of biotechnology.	1) Class discussion or debate of the ethical issues raised by the application of DNA technology. 2) Observation of karyotype examples. 3) Demonstrations or simulations of gel electrophoresis.	http://www.hhmi.org/biointeractive/ bacterial DNA analysis- need an up-to-date, fast computer to use http://powayusd.sdcoe.k12.ca.us/dolly/toolbox.htm A web quest on cloning with links to some good resources. http://www.gis.net/~peacewp/webquest.htm A web quest on genetic engineering of food crops. http://www.massinteraction.org/html/genome/ The Human Genome Project: Exploring the Scientific and Humanistic Dimensions. http://www.ornl.gov/hgmis/publicat/genechoice/ the book Your Genes, Your Choices raises many of the human issues related to biotechnology.

COMPETENCY GOAL 2: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Weight	Objective	Content	Suggested Activities	Resources
3%	**2.05** Analyze and explain the role of genetics and environment in health and disease.	1) Explain the interacting role of genetics and environment on human health. 2) Describe genetic conditions such as sickle cell, colorblindness, cystic fibrosis, hemophilia, Down syndrome (trisomy 21), and Huntington's disease. 3) Describe conditions with genetic and environmental components such as; cardiovascular disease, diabetes, cancer, and asthma. 4) Describe conditions with primarily environmental causes, such as malnutrition and lead poisoning. 5) Identification of environmental risk factors such as radiation and tobacco smoke. *Students are not expected to memorize detailed causes of particular diseases and conditions but are expected to recognize and analyze these genetic conditions in the context of genetic problems.*	Study of epidemiological research as tool for understanding causes of diseases and disorders.	http://www.cdc.gov/genetics/ with links to information on all sorts of diseases http://www.ncbi.nlm.nih.gov/Omim/ Online Mendelian Inheritance in Man – this site is too technical for most students but may be useful to advanced students and teachers. http://www.massinteraction.org/html/genome/sickle.html sickle cell information. see also sites recommended for 3.05.
7%	**2.06** Examine the development of the Theory of Biological Evolution including:			
	2.06a The origins of life.	1) Biogenesis in contrast to abiogenesis. 2) The contributions of Pasteur. 3) Early atmosphere hypotheses and experiments.		
	2.06b Patterns.	Instruction should include: • Discussion of what can be inferred from patterns in the fossil record. • Adaptive radiation. • Vestigial structures. • Biochemical similarities. *Patterns in embryology and homologous and analogous vocabulary are intentionally excluded.*		http://www.mnh.si.edu/anthro/humanorigins/ The Smithsonian Institution's Human Origins Program explores the fossil record left by early humans.
	2.06c Variation.	1) Variation providing material for natural selection. 2) The roles of variation and reproductive and geographic isolation in speciation.	Measure and graph variation in populations of organisms.	

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COMPETENCY GOAL 2: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Weight	Objective	Content	Suggested Activities	Resources
7%	2.06d Natural Selection.	1) Charles Darwin's development of the theory of evolution by natural selection. 2) Current applications of theory (pesticides and antibiotics).	Inquiry Support Lab – Fishy Frequencies Simulations of selection/reproduction over several generations. (Good computer simulations are available.)	http://www.tulane.edu/~guill/demonstration_module.html This is an up-to-date discussion of the peppered moth story and controversy. http://www.indiana.edu/~ensiweb/lessons/ns.chips.html one version of a selection activity. http://www.nap.edu/readingroom/books/evolution98/evol6-b.html another lesson on evolution – written for middle school but also fits high school biology.

Total Weight for Goal 2
28%

COMPETENCY GOAL 3: The learner will develop an understanding of the unity and diversity of life.

Weight	Objective	Content	Suggested Activities	Resources
3%	**3.01** Relate the variety of living organisms to their evolutionary relationships.	Current classification systems are based on the present state of knowledge of evolutionary relationships of organisms. Due to new and increased understanding of evolutionary relationships, these classification systems are undergoing change. Contributing to the increased understanding are new methods, including: • DNA analysis • Biochemical analysis • Better observation of embryological development	Activities that allow students to compare organism relationships such as those indicated by DNA or protein sequence analysis.	http://phylogeny.arizona.edu/tree/phylogeny.html The "Tree of Life" website has information about the diversity and phylogeny of life.
4%	**3.02** Classify organisms according to currently accepted systems.	Either a 5 or 6 Kingdom system may be taught with the understanding that taxonomic classification is changing as more is learned about the relatedness of various organism groups. Instruction should include: 1) Distinguishing characteristics of ❖ Animals • Chordata • Arthropoda • Annelida • Mollusca • Porifera • Cnidaria ❖ Plants • Mosses • Ferns • Gymnosperms • Angiosperms ❖ Fungi ❖ Protists (Understanding of their shifting definition) ❖ Monera. *Students are not expected to distinguish groups of Monera.* 2) Compare and contrast viruses with living organisms. 3) Examine the binomial naming system and familiarize students with the use of dichotomous keys. 4) Contribution of Carolus Linnaeus.	1) Activities that allow students opportunities to identify most related species and least related species when given taxonomy. 2) Utilization of dichotomous keys to identify organisms. 3) Activities that require students to create a dichotomous key.	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://commtechlab.msu.edu/sites/dlc-me/zoo/ This is a microbial zoo site with lots of information about microbes presented in an entertaining manner.

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COMPETENCY GOAL 3: The learner will develop an understanding of the unity and diversity of life.

Weight	Objective	Content	Suggested Activities	Resources
5%	**3.03** Determine the form and function of organisms including:	Emphasis should be placed on how the variety of multicellular organisms handles the problems of regulation, nutrition, internal transport, reproduction, support and movement.	Inquiry Support Lab Animal Kingdom Diversity	
	3.03a Organ systems of animals.	1) Animal systems to include: • Body covering • Cardiovascular • Digestive • Endocrine • Excretory • Immune • Muscular • Nervous • Reproductive • Respiratory • Support *Excessive vocabulary and detail is to be avoided. The human body is a required component of the 7th grade curriculum.* 2) Interpretation of graphs featuring hormone fluctuations and feedback systems. Focus should be on physiology, not anatomy. *For example: Students would be expected to know how neurons pass chemical messages to other neurons or muscle cells and to understand the homeostatic function of the liver, but would not be expected to memorize the parts of the brain.*	Dissection or alternative activities for the purpose of comparing systems in different phyla.	http://curry.edschool.virginia.edu/go/frog/home.html This site has a virtual frog dissection. 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.
	3.03b Functional systems of plants including: transport, reproduction, and regulation.	Focus should be on physiology, not anatomy. *Excessive vocabulary and detail is to be avoided.*	Inquiry Support Lab –Cellular Respiration in Germinating Seeds *Recommended also for 1.06.* 1) Investigations of water transport, function of stomates, seed dispersal and germination.	

COMPETENCY GOAL 3: The learner will develop an understanding of the unity and diversity of life.

Weight	Objective	Content	Suggested Activities	Resources
5%	**3.04** Compare and contrast the processes of reproduction, growth, development, & regulation of major phyla of organisms.	1) Emphasis should be placed on: • Life cycles • Characteristics of reproduction • Growth and development Major animal phyla to include: • Chordata • Arthropoda • Annelida • Mollusca • Porifera • Cnidaria Plant divisions to include: • Mosses • Ferns • Gymnosperms • Angiosperms Students should have a general idea of how these functions are carried out in the other kingdoms (Monera, Protista, Fungi). 2) Compare and contrast adaptations to life in various terrestrial and aquatic environments. *While students should be exposed to the other phyla in class or lab, memorization is not expected.*	1) Raise a local invertebrate species and follow it through its life cycle, comparing it with other species. 2) Examine, compare and contrast a variety of angiosperm and gymnosperm seeds. 3) Determine the function of different seed parts.	
2%	**3.05** Determine the internal and external factors that influence the growth and development of organisms.	Students should be able to assess the roles of: • Genetics • Nutrition • Other environmental factors in the growth and development of plants and animals (including zygote, embryo, fetus, and seed).	1) Examination of twin studies. 2) Comparison of the variety of gender determination processes (as in groups of animals like turtles, crocodiles and birds) 3) Opportunities for students to participate in plant studies.	http://www.psych.umn.edu/psylabs/mtfs/special.htm This is the University of Minnesota's site for twin studies which includes the page: "What's special about twins to science". http://www.niaaa.nih.gov/publications/aa18.htm The National Institute on Alcohol Abuse and Alcoholism presents a discussion of the genetics of alcoholism. This discussion will be too technical for most students but may be helpful to teachers and more advanced students. http://faculty.washington.edu/chudler/alco.html This page has information about the effects of alcohol on the body and links to pages on fetal alcohol syndrome.

Total Weight for Goal 3
19%

COMPETENCY GOAL 4: The learner will develop an understanding of ecological relationships among organisms.

Weight	Objective	Conteut	Suggested Activities	Resources
6%	**4.01** Identify the interrelation-ships among organisms, populations, communities, ecosystems, and biomes.	1) Including: • Importance of abiotic factors in determining biomes and ecosystems within biomes. • Interaction between biotic and abiotic factors (e.g. how rainfall affects plants and how plants affect rainfall.) 2) Concept of niche. 3) Symbiotic relationships and predator / prey relationship - Students should be able to identify various types of symbiotic relationships or a predator / prey relationship when given a description of the relationship between two organisms. 4) Limiting factors, determining whether they are density independent or dependent and the concept of carrying capacity.	1) Inquiry Support Lab - Biomes and Climatograms 2) Inquiry Support Lab – How do environmental factors affect the hatching of brine shrimp? 3) Investigate a local community, cataloging all of the organisms students can find and diagramming their inter-relationships, the flow of energy, and nutrient cycling. 4) Set up a classroom aquarium or terrarium to allow students to investigate a community.	http://ingrid.ldgo.columbia.edu/ The International Research Institute for Climate Prediction at Columbia University maintains a climate data library. http://www.ncsu.edu:80/science junction/terminal/lessons/brine.html another version of the brine shrimp lab http://ut.water.usgs.gov/shrimp/ more information on brine shrimp http://www.field-guides.com/ This site has virtual field trips with lots of information about different biomes. Warning: Some of the trips take a long time to load because of large image files and there seem to be some missing links. http://www.raptor.cvm.umn.edu/raptor/meeen/no3.html contains several lesson plans for predator/ prey simulation activities including a bio-magnification activity. (also good for 4.05c)
4%	**4.02** Analyze the cycling of matter: water, carbon, and nitrogen in systems.	Overview of each cycle including examples of human influence on each. (e.g. effects of nitrogen fertilizer factories, deforestation.)		http://www.epa.gov/surf3/ The EPA "Surf Your Watershed" site with information on watershed indicators including nitrogen runoff.
5%	**4.03** Explain the flow of energy through ecosystems.	1) Emphasis should be placed on the significance of the following to ecosystems: • Photosynthesis • Decomposers • Trophic levels • Food chains • Direction of energy transfer • Efficiency of energy transfer 2) Students should be familiar with the workings of both aquatic and terrestrial food webs.	See activities 2 &3 in objective 4.01.	http://www.marietta.edu/~biol/102/ecosystem.html page from Marietta College on ecosystems with a nice discussion of energy flow, biomass pyramids, including exceptions to the usual findings, and also bio-magnification. (useful for 4.05c)
2%	**4.04** Assess and describe successional changes in ecosystems.	Include 1) Primary succession and secondary succession after a disturbance 2) The concept of the climax community.		

COMPETENCY GOAL 4: The learner will develop an understanding of ecological relationships among organisms.

Weight	Objective	Content	Suggested Activities	Resources
5%	**4.05** Assess and explain human activities that influence and modify the environment:			
	4.05a Global warming.	1) Discussion of carbon and other emissions as the cause of global warming. 2) Discussion of the possible effects of global warming. 3) Discussion of ways to decrease carbon production.		http://www.epa.gov/global warming/index.html The EPA has a large website devoted to global warming. The educator's page provides links to other resources.
	4.05b Human population growth.	Instruction should include: 1) Factors influencing birth rates and death rates 2) Effects of population size, density and resource use on the environment.		http://www.census.gov/ftp/pub/ipc/www/idbpyr.html This site has interactive population pyramids. http://www.ibiblio.org/lunarbin/worldpop This site shows a world population clock. http://www.wadsworth.com/sociology_d/virtual/12.html# This is a virtual tour of population issues with an assignment for students, parts of which teachers may find suitable for high school students.
	4.05c Pesticide use.	Instruction should include: 1) Bioaccumulation (biological magnification) of some pesticides, resulting in unintended effects. 2) Effects of some pesticides on non-target populations. 3) Resistance to pesticides as an adaptation of some species. 4) Pros and cons of biocontrols as alternatives to pesticides. 5) Contributions of Rachel Carson (effects of DDT).	1) Activities that allow students to diagram the effects of bioaccumulation of pesticides on a community. 2) Examination of the writings of Rachel Carson or other recent research on the effects of pesticides on populations.	http://www.epa.gov/pesticides/ This site is the EPA's Office of Pesticide Programs. See predator/prey bio-accumulation activity resource in 4.01 http://www.rachelcarson.org/ information about Rachel Carson. http://onlineethics.org/moral/carson/main.html This site has summaries of some of Carson's important writings.

Total Weight for Goal 4
22%

COMPETENCY GOAL 5: Students will develop an understanding of the behavior of organisms, resulting from a combination of heredity and environment.

Weight	Objective	Content	Suggested Activities	Resources
3%	**5.01** Evaluate the survival of organisms and suitable adaptive responses to environmental pressures.	Instruction should include: 1) Examples of adaptive responses such as: • Mimicry • Protective coloration • Parental Behavior • Feeding Strategies 2) Behavioral responses to environmental changes.		http://www.accessexcellence.com/AE/AEPC/WWC/1995/mimicry.html an activity that simulates the advantages of mimicry http://www.ci.swt.edu/Faculty/Peterson/monknc/mystour2.htm a webquest investigating mimicry with some good links
1%	**5.02** Assess and examine plant tropisms and other responses.	Plant tropisms including: • Phototropism • Geotropism • Thigmotropism	Students can investigate phototropism and geotropism by growing plants in various situations.	http://www.cals.ncsu.edu/nscort/outreach_exp_intro.html experiments developed for high school students from an NCSU project on plants, gravity and space.
3%	**5.03** Assess, describe, and explain types of animal behaviors (taxes, reflexes, instincts, and learned behavior).	Instruction should include: • Chemotaxis- positive and negative • Phototaxis- positive and negative • Reflexes • Imprinting • Instincts • Types of learned behavior	1) Inquiry Support Lab –Animal Responses to Environmental Stimuli 2) Investigate reflexes such as response to light and the knee jerk response. 3) Examine some simple learned behaviors. 4) Investigations of taxes using paramecium or small invertebrates.	
2%	**5.04** Analyze the biological clocks and rhythmic behavior of organisms.	Instruction should include: • Circadian rhythms • Migration • Estivation • Hibernation • Adaptive value of biological clocks		Journey North at: http://www.learner.org/jnorth/index.html website on migration with lots of data and activities http://www.cbt.virginia.edu/tutorial/TUTORIALMAIN.html information and activities on biological clocks
2%	**5.05** Evaluate and explain the evolution of behavioral adaptations and survival of populations.	1) Instruction should include: • Evolution of behavioral adaptations • Courtship rituals • Coevolution • Social behavior 2) Contributions of Jane Goodall.		Information about Jane Goodall and her chimp research can be found at: http://www.pbs.org/wnet/nature/goodall/ and at her institute's website: http://www.janegoodall.org/

Total Weight for Goal 5
11%

Biology Inquiry Support Labs

Materials List

For labs: *Animal Responses to Environmental Stimuli, What are the Effects of Various Mutations of Protein Synthesis?, Cellular Respiration in Germinating Seeds, Properties of Enzymes, The Genetics of Parenthood, Biomes and Climatograms, Environmental Factors that Affect the Hatching of Brine Shrimp, How do Biological Materials Respond to Acids and Bases?, Animal Kingdom Diversity*

Inquiry support labs are designed to promote the use of inquiry in the biology classroom. We have tried to document the materials needed to implement these labs. However, inquiry encourages students to design some procedures themselves, thus some other materials may be needed. Some items are used in more than one lab. Class sets are needed of some of the materials while others require only enough for a single lab station. Specific amounts can be determined by consulting the individual labs.

Chemicals	**Equipment**	**Local Store**
Carbonic Acid	Mortar & Pestle	Ice Pack
pH 7 Buffer Solution	Stopwatch	Alka Seltzer
0.1M NaOH	Stirring Rod	Black Construction Paper
0.1M HCL	Thermometer	Salt
Calcium Oxide	Hot Plate or Heat Source	Lemon Juice
3M HCL	pH Meter	Antacid
3M NaOH	Petri Dishes	Aluminum Foil
Acetic Acid	Stereomicroscope	Sandpaper
3% Hydrogen Peroxide	Flashlight	Sugar
	Tuning Fork	Corn Meal
	Heating Pad	Distilled water
Organisms	Test Tube	Field Peas
Brine Shrimp Eggs	Ruler	Cotton Balls
Variety of plant and animal specimens	Dropper	Masking Tape
isopods or meal worms	100ml Beaker	Food Coloring
	50ml Beaker	Sand (pinch)
Other	30ml Graduated Cylinder	Liver
Information Resources (like those in a library)	10ml Graduated Cylinder	Acetate (transparency) Sheets
	Blender	Coins (for flipping)
		Potatoes
		Mushrooms
		Colored Pencils or Crayons
		Drawing Paper
		Goldfish Crackers

How do Biological Materials Respond to Acids and Bases?

Standard Course of Study Goals and Objectives

Biology Competency Goal 1: The learner will develop an understanding of the physical, chemical and cellular basis of life.

Objective 1.01: Analyze the matter-energy relationships of living and non-living things including: chemical processes and regulatory mechanisms of cells.

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.

$$H_2CO_3 \text{ <----------> } (HCO_3)^- \quad + \quad H^+$$

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 they are 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. Tap water in some locations has some buffering capacity, which may affect your results. You may wish to compare using distilled water.

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.

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?

Purpose To study the response of biological materials to acids and bases.

Materials

- 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 CO_2)
- 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.

1. Pour 25 ml of tap water into the 50 ml beaker. Measure the pH of the solution. Record in Table 1.

2. 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.

3. Repeat step 2 until a total of 30 drops has been added.

4. Rinse the beaker well and add another 25 ml of solution.

5. Follow steps 2 - 3 again, but this time use 0.1 M NaOH and record in Table 2.

6. Repeat the whole procedure for the buffer solution, the Alka Seltzer solution and each of the homogenates.

7. 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.

Sample Data Charts

Table 1: The pH of various homogenates after adding HCl

pH	0 drops HCl	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

pH	0 drops 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

Standard Course of Study Goals and Objectives

Competency Goal 1: The learner will develop an understanding of the physical, chemical and cellular basis of life.

Objective 1.05: 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 break down only 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 do an open-ended exploration 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 distribute the material evenly. 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.

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

Purpose To investigate the properties of enzymes.

Materials

- homogenized 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
- 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 facilitate 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.

$$2H_2O_2 + O- \xrightarrow{\text{catalase}} 2H_2O + O_2$$

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?

Conclusion to All Enzyme Activities

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

Cellular Respiration in Germinating Seeds

Standard Course of Study Goals and Objectives

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

Objective 1.06: Analyze the bioenergetic reactions: Aerobic respiration, Anaerobic respiration, Photosynthesis, Chemosynthesis

Introduction to Teacher

This lab is an adaptation of labs that have appeared in various textbooks in recent years. This lab can also serve as a lead-in to the study of seed germination. It serves as an important reminder to students that plant cells also do respiration. (A common misconception is that plants do photosynthesis while only animals do respiration.)

As cellular respiration occurs, oxygen gas is taken in from the air and carbon dioxide gas is given off. The rates at which these occur and the amounts of the gases involved are very similar. This lab features a comparison of dormant and germinating seeds to demonstrate these aspects of cellular respiration.

While a mature seed appears to be dead it is actually alive and in a dormant state. In this condition, cell respiration is occurring but at a greatly reduced rate. Seeds will germinate when conditions are right. In the presence of oxygen, favorable temperatures, and available water, most seeds will germinate. (Some seeds do have additional requirements, but not those used in this laboratory.) Soaking beans in water should initiate the germination process for the purpose of this lab. Consider the freshness of the beans that you use. Older seeds are more likely to produce poor lab results. Once germination begins, the rate of cell respiration increases greatly because the need for energy has suddenly become tremendous. The ATPs yielded by the cellular respiration are needed to support the rapid growth of the germinating seed. Half of the beans used in this laboratory will need to be soaked overnight to initiate germination.

Once students have been introduced to the process of cell respiration, they can complete this laboratory. The concepts of dormancy and germination can be introduced before, after, or even during the lab (between Days 1 and 2).

This lab requires the use of calcium oxide. Be sure to carefully read the proper handling and disposal procedures included with the agent. If handled improperly, calcium oxide may cause burns and other skin irritations. It is a strong base, so avoid contact with the eyes, skin, and clothing. During the course of the experiment the calcium oxide will become calcium carbonate, harmless limestone: $CaO + CO_2 \rightarrow CaCO_3$

Cellular Respiration in Germinating Seeds

Purpose Investigate cellular respiration in germinating seeds.

Materials

(per lab group)
- 6 pre-soaked seeds (field peas)
- 6 dry seeds (field peas)
- 3 test tubes
- 6 cotton plugs
- masking tape
- 1-1/2 teaspoons pulverized calcium oxide
- 100 ml beaker
- 25 ml colored water
- ruler

Procedure

Day 1

1. Using the masking tape, label test tubes A, B, and C.

2. Layer the materials in the test tubes as described below. The materials should not be packed in too tightly, but should be snug enough that they do not fall out when inverted.

    a. 6 presoaked seeds, cotton plug, 1/2 teaspoon calcium oxide, cotton plug
    b. 6 dry seeds, cotton plug, 1/2 teaspoon calcium oxide, cotton plug
    c. No seeds, cotton plug, 1/2 teaspoon calcium oxide, cotton plug

3. Tape or rubber band the three test tubes together.

4. Pour the 25 ml of colored water into the beaker.

5. Invert the three test tubes into the beaker.

6. Measure the height that the liquid rises to in each of the test tubes and record it.

7. Store the laboratory set up at room temperature and wait 24 hours.

Day 2

Do not remove the test tubes from the beaker.

1. Measure the height of the liquid in each of the test tubes and record.

2. Calculate the difference in the heights, if any and record.

Lab Data

Height (mm)	Tube A	Tube B	Tube C
Water, Day 1			
Water, Day 2			
Difference			

Lab Analysis Questions

1. What prevented the water from moving up into the test tubes when they initially were inverted and placed in the liquid?

2. Calcium oxide absorbs carbon dioxide. Given this information, explain how cell respiration could be responsible for the water rising into some of the test tubes.

3. What components of the lab are experiencing cell respiration?

4. What is the purpose of tube C and what does it demonstrate?

5. Compare the results of tube A to tube B. Why is there a difference?

6. The seeds in tube a were presoaked. How did this affect the rates of cell respiration? Why?

Extension Questions

1. Suppose this laboratory was allowed to run an additional day, what might you expect to encounter? What about after a week?

2. If tube a contained 10 pre-soaked seeds and tube b contained 10 dry seeds, how do you think that would affect the results?

3. If your test tube set-up had been placed in the refrigerator for 24 hours instead of being left at room temperature, how do you think that would affect the results? Why?

4. How do you think the results might have been different if the calcium oxide had been left out of the procedure?

What are the Effects of Various Mutations on Protein Synthesis?

Standard Course of Study Goals and Objectives

Biology Competency Goal 2: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Objective 2.01: Analyze the molecular basis of heredity/DNA 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.)

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?

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

- 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<u>C</u>/CAG/UCA/UC<u>C</u>/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<u>C</u>/CUU/AU<u>C</u>/ACU/GU<u>C</u> (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 are 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	________

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

14. 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?

15. 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

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

17. 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

The Genetics of Parenthood

Standard Course of Study Goals and Objectives

Competency Goal 2: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Objective 2.03: Interpret and use the laws of probability to 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 which masks the expression of another; represented by capital letters (R, V)
- **Recessive**: allele which 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

1. Have each "parent" draw the child's face. Then compare the "mother's" and the "father's" perception of characteristics.

2. Do the lab twice, comparing the genotypes and phenotypes of the resulting siblings.

3. "Marry" the children off, to produce an F_2 generation (grandchildren).

4. Instead of drawing the face, decorate an egg or a five-pound package based on the child's traits. It can then be used in the activity "Problem Solving in Genetic Disorders" by Nikki Chen, or "One + One = One" by Dorothy Josephine Cox.

References

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.

Prepared by Lenore Kop and Thomas Crowley

The Genetics of Parenthood

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

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.

1. 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

2. Name the child.

3. 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

4. On the Data Sheet, circle the allele that the parent will pass on to the child and write the child's genotype.

5. 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.

6. Some traits follow special conditions, which are explained in the Reference Sheets.

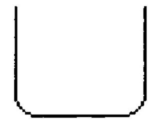
7. When the Data Sheet is completed, draw your child's portrait as he/she would look as a teenager. You must include the traits as determined by the coin tossing. Write your child's full name on the portrait.

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**: Flip coins for this trait only if chin size is very prominent. The genotype bb prevents the expression of this trait.

Round (CC, Cc)

Square (cc)

4. **CLEFT CHIN**: Flip coins for this trait only 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	3 dominant - brown mixed w/blonde
7 dominant - very dark brown	2 dominant - blond
6 dominant - dark brown	1 dominant - very light blond
5 dominant - brown	0 dominant - silvery white
4 dominant - light brown	

7. **RED COLOR TINTS IN THE HAIR**: This trait is visible only if the hair color is light brown or lighter (4 or less dominant alleles for hair color).

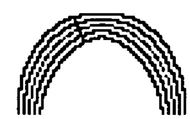
Dark red tint (L_1L_1) Light red tint (L_1L_2) No red tint (L_2L_2)

8. **HAIR TYPE**:

Curly (M_1M_1)

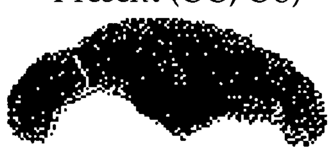
Wavy (M_1M_2)

Straight (M_2M_2)



9. **WIDOW'S PEAK**:

Present (OO, Oo)



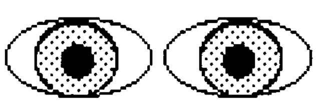
Absent (oo)

10. **EYE COLOR**:

PPQQ - black	PpQq - brown	ppQQ - green
PPQq - dark brown	PPqq- violet	ppQq - dark blue
PpQQ - brown with green tints	Ppqq - gray blue	ppqq - light blue

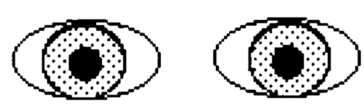
11. **EYE DISTANCE**:

Close (R_1R_1)



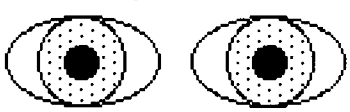
Average (R_1R_2)

Far apart (R_2R_2)

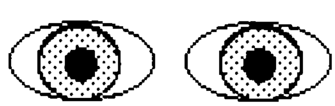


12. **EYE SIZE**:

Large (S_1S_1)



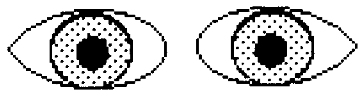
Medium (S_1S_2)



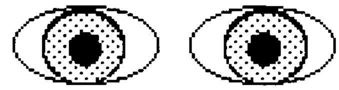
Small (S_2S_2)

13. **EYE SHAPE**:

Almond (TT, Tt)

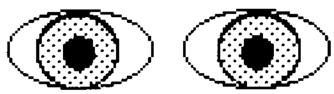


Round (tt)



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**:

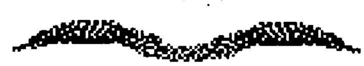
Bushy (ZZ, Zz)

Fine (zz)

18. **EYEBROW LENGTH**:

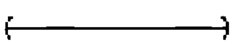
Not connected (AA, Aa)

Connected (aa)

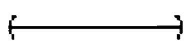


19. **MOUTH SIZE**:

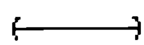
Long (B_1B_1)



Medium (B_1B_2)



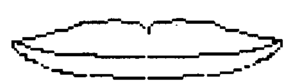
Short (B_2B_2)



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

1. What percentage does each parent contribute to a child's genotype?

2. Explain how/what part of your procedures represents the process of meiosis.

3. Using examples from this activity, explain your understanding of the following inheritance patterns:
   a. dominant
   b. recessive
   c. incomplete dominance
   d. polygenic
   e. epistasis

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

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

Animal Kingdom Diversity

Standard Course of Study Goals and Objectives

Biology Competency Goal 3: The learner will develop an understanding of the unity and diversity of life.

Objective 3.01: Relate the variety of living organisms to their evolutionary relationships.

Objective 3.02: Classify organisms according to currently accepted systems.

Objective 3.03: Determine the form and function of organisms including:

- Organ systems of animals.

Objective 3.04 Compare and contrast the processes of reproduction, growth, development and regulation of major phyla of organisms.

Introduction to the Teacher

This is a great activity to introduce students to a variety of organisms and phyla they may not have examined before. If possible, use live organisms, because these are the most interesting for students. Otherwise, use preserved specimens or large, detailed color photographs. It is important to have a wide diversity of organisms, including some that are unfamiliar to most students.

Before beginning, students need to be familiar with types of body symmetry, types of skeletal support systems, body coverings (hair, feathers, scales, shells, etc.), and sense organs. It is usually necessary to explain to students that a mollusk shell is not considered an exoskeleton.

The organisms should be set out around the room at different stations with several organisms at each station. Do not arrange the organisms in any particular order. Each organism should have a number for data recording. You may use the attached data charts or have the students develop their own charts either as a class or individually. As an extension, you may wish to have students use keys to identify the organisms.

To avoid bunching, space students out evenly around the room and have them change stations at timed intervals. Or, allow students to move around the room at their own pace, being responsible for completing a required number of stations. Two to three minutes per organism allows ample time for most students if they are not using keys to identify the organisms.

You can enhance the attached chart of major phyla and classes by adding page numbers from your student text beside each species in the example column.

This activity can lead to a discussion of evolutionary relationships and levels of complexity in animals. The third and fourth analysis questions do not have any one right answer but instead are a starting point for further investigation and discussion. It is important for students not to interpret more complex as superior or better-adapted to the environment.

You can add more analysis questions based on the particular organisms your students observe. An extension activity is to have students draw a branching diagram to show the evolutionary relationships among the organisms they observe. Another possibility is to have students create a dichotomous key for the organisms they observe.

Animal Kingdom Diversity

Purpose To observe the characteristics of organisms from a variety of animal phyla.

Procedure

1. Start at whatever station you are assigned and find the row number on your chart for the numbered organism you find there. (Do not start on row 1 unless you happen to be assigned to start at organism 1.)

2. Fill in the common and/or scientific name of the organism on the chart. Determine the type of body symmetry and fill that in. Continue to fill in all of the columns you can by observing the organism's characteristics.

3. When you have finished, use the references provided to find the phylum and class of each animal and fill in any additional information you find.

Questions to Guide Analysis

1. A sponge has no organs and can't move from place to place. Why is it classified as an animal?

2. Once you determine that an animal is a chordate, you need only observe a single characteristic—hair—to place it in the class Mammalia. What other vertebrate class placement can be determined by a single characteristic? Explain.

3. What characteristics lead zoologists to consider earthworms more complex than jellyfish?

4. List the organisms you observed in order from the least complex to most complex. Be prepared to justify your choices.

Animal Kingdom Diversity
A Sampling of Major Phyla & Classes

Phylum	Class	Examples
Porifera - asymmetrical or radial symmetry, only 4 kinds of cells, no organs, sessile, filter feeders, 5,000 species	Demospongia	Sponges
Cnidarians - radial symmetry, floating sack shape with polyp and medusa stages, have tentacles with stinging nematocysts, all live in water, almost all are marine, 10,000 species	Hydroza	Hydra Man-O-War
	Scyphozoa	Jellyfish
	Anthozoans – colonies of polyps	Sea Anemones Coral
Worms – **Platyhelminthes** (flatworms) – bilaterally symmetric, thin solid bodies, many parasitic	Cestoda	Tapeworms
	Trematoda	Flukes
	Turbellaria	Planarians
Nematoda (roundworms) – cylindrical animals with tubelike digestive system, two openings		Ascaris Hookworm Trichinella
Annelida (segmented worms) – bilateral, two body openings, bodies are cylindrical and segmented	Polychaeta – many bristles, marine	Blue Plume
	Oligochaeta – few bristles	Earthworm
	Hirudinae – no bristles	Leeches
Mollusks – soft body, mantle, muscular foot, bilateral symmetry, two body openings, nephridia to remove wastes, some with shell	Bivalves- 2 half shells protect soft inner body	Clam
	Gastropods – one or no shell, large foot, head	Snails Slugs Nudibranchs
	Cephalopods – head footed, tentacles with suckers	Octopus Squid

Arthropods – exoskeleton and jointed legs	Arachnids – 2 body sections, 2 pairs of mouth parts called chelicerae, 4 pairs of walking legs	Spiders Ticks Mites Scorpions
	Crustaceans – 2 pairs antennae, aquatic except pill bugs	Crabs Barnacles Lobster Shrimp
	Myriapods – many short legs	Millipedes Centipedes
	Insects – 6 legs, 3 body sections	Grasshopper Butterfly, Bee
Echinoderms – spiny skin, radial symmetry, endoskeleton, marine, water vascular system, larvae are bilaterally symmetric	Asteroids Holothuroids Echinoids	Starfish Sea Cucumber Sea Urchin
Chordates – **Invertebrate Chordates** **Urochordata** **Cephalochordata** - have notochord and dorsal nerve cord but no vertebrae, gill slits		Sea Squirts Lancelets
Vertebrate Chordates	Fish – Agnatha Chondrichthyes Osteichthyes	 Lampreys Sharks & Rays Bony Fish
	Amphibians – aquatic larvae, semi terrestrial adult	Frogs Salamanders
	Reptiles – scaly skin, amniotic egg, ectotherms	Lizards Snakes Turtles
	Aves (Birds) – endotherms, amniotic egg, feathers	Parrots Penguins Sparrows
	Mammals – endotherms, hair, nurse young	Mice Whales Humans

Animal Kingdom Diversity - Organism Chart

Specimen Number	Name	Body Symmetry	Skeleton *(none, endo, exo)*	Body Covering *(skin observations)*	Head *(presence or absence)*	Visible Sense Organs	Appendages	Physical Description & Other Observations	Phylum/ Class
Ex.	Human homo sapiens	Bilateral	Endo	Smooth with some hair	Present	Eyes, ears, nose, tongue, skin	2 legs& 2 arms with 5 digits each, no tail	Upright posture, hands adapted for tool use	Chordata (Vertebrata) Mammalia
1									
2									
3									
4									
5									
6									
7									
8									
9									

Animal Kingdom Diversity - Organism Chart

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1									
2									
3									
4									
5									
6									
7									
8									
9									

Specimen Number	Name	Body Symmetry	Skeleton *(none, endo, exo)*	Body Covering *(skin observations)*	Head *(presence or absence)*	Visible Sense Organs	Appendages	Physical Description & Other Observations	Phylum/ Class
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									

Biomes and Climatograms

Standard Course of Study Goals and Objectives

Biology Competency Goal 4: The learner will develop an understanding of ecological relationships among organisms.

Objective 4.01: Identify the interrelationships among organisms, populations, communities, ecosystems, and biomes.

Biology Competency Goal 5: Students will develop an understanding of the behavior of organisms, resulting from a combination of heredity and environment.

Objective 5.01 Evaluate the survival of organisms and suitable adaptive responses to environmental pressures.

Introduction to the Teacher

This exercise allows students to visualize climatic factors in six major land biomes and relate them to adaptations of animals and plants. Students will plot temperature and precipitation from locations in each of six major biomes—tundra, taiga (sub-arctic coniferous evergreen forest), deciduous forest, tropical rain forest, grassland, and desert.

The teacher should assign one set of data to each group of students and have them plot the data on a grid. Each group will then research their assigned biome to identify the specialized adaptations of at least three plant and animal species in that biome. Students may use their textbooks, atlases, encyclopedias and on-line sources. See attached table of examples (at the end of the activity). Groups can then present their findings to the whole class. Or you can use the jigsaw method in which students become experts in a topic and then teach a small group. After the students have learned about the individual biomes, conduct a class discussion to compare and contrast the different biomes.

Additional data are available from the National Weather Service data tables at http://www.nws.noaa.gov/climatex.html. Data from the NWS are in inches and Fahrenheit and will need to be converted to centimeters and Celsius.

Examples: The table below shows some examples of adaptations to the different biomes. Students should come up with other examples and explain the adaptations and how they aid survival in that biome in more detail.

	Animal	Adaptation	Plant	Adaptation
Tundra	Arctic hare	White coat	Dwarf birch	Grows only knee high
Taiga	Crossbills (birds)	Beaks specially shaped to feed on conifers	Spruce	Conical form allows snow to shed easily
Grassland	American bison	Faster than predators, herd behavior for protection	Russian tarragon	Narrow leaves to help retain moisture
Deciduous Forest	Black bear	Fat storage for winter	Red maple	Loses leaves in winter, stores food
Tropical Rain Forest	Spider monkey	Prehensile tail	Heart leaf philoden-dron	Drip tips on leaves to help shed water
Desert	Kangaroo rat	Kidney specialized to concentrate urine	Saguaro cactus	Stores water in reservoir

References

This exercise was adapted from a BSCS Green Version lab and was modified and written by Gordon Plumblee, Western Alamance High School, Elon College, NC 27244.

Biomes and Climatograms

Purpose To study the relationship between climatic factors and biomes. To study the adaptations of different organisms to their biomes.

Materials

- climatogram grids
- data set (see below)
- information resources (texts, encyclopedias, atlases, Internet)

Procedure

Climatograms are graphs that show two important abiotic climatic factors—temperature and precipitation. Different land biomes have different temperature and precipitation patterns. Plants and animals, often unique to each biome, show adaptations for surviving within their particular biome.

1. Plot climatograms of your assigned biome. Precipitation is plotted as a bar graph using the scale on the left side of the climatogram grid, and temperature is plotted as a line graph using the scale on the right side of the climatogram grid.

2. Research the types of animals and plants that live in your assigned biome. Find examples of at least three animals and three plants that show special adaptations to the biome.

3. Prepare a presentation on your assigned biome for your classmates. When the presentation is finished your classmates should have a clear idea of the climate in your biome and how animals and plants are adapted to that climate.

Biome Data

Tundra: Barrow, Alaska

Month	Temperature (° C)	Precipitation (cm)
January	-27	0.5
February	-28.2	0.5
March	-26	0.1
April	-18	0.1
May	-9	0.1
June	2	1.8
July	4	2.0
August	3	1.9
September	-2	1.5
October	-10	1.0
November	-18	0.5
December	-24.5	0.3

Coniferous Forest (Taiga): Anchorage, Alaska

Month	Temperature (° C)	Precipitation (cm)
January	-11	1.8
February	-9	1.5
March	-6	1.5
April	0	1.0
May	6	1.5
June	12	2.2
July	13	3.8
August	12	6.5
September	8	7.0
October	2	4.5
November	-3	2.3
December	-11	2.0

Deciduous (Temperate) Forest: Greensboro, North Carolina

Month	Temperature (° C)	Precipitation (cm)
January	3.5	8.5
February	4.6	8.4
March	8.9	9.5
April	14.4	7.9
May	19.2	9.1
June	23.4	9.6
July	25.0	11.7
August	24.4	10.8
September	21.1	9.3
October	14.7	7.6
November	9.0	6.8
December	4.4	8.4

Tropical Rain Forest: Iquitos, Peru

Month	Temperature (° C)	Precipitation (cm)
January	25.6	25.8
February	25.6	24.9
March	24.4	31.0
April	25.0	16.5
May	24.4	25.4
June	23.3	18.8
July	23.3	16.8
August	24.4	11.7
September	24.4	22.1
October	25.0	18.3
November	25.6	21.3
December	25.6	29.2

Middle Latitude Grassland: Lawrence, Kansas

Month	Temperature (° C)	Precipitation (cm)
January	-1	3
February	2	1
March	6	5.5
April	12	8.5
May	14	12
June	18	11.8
July	26	8.5
August	25	11.5
September	21	8.2
October	15	5.5
November	3	4.5
December	1	3.5

Middle Latitude Desert: Reno, Nevada

Month	Temperature (° C)	Precipitation (cm)
January	-1	2.5
February	2	3
March	7	1.8
April	8	1
May	12	1
June	15	0.8
July	20	0.5
August	18	0.5
September	15	0.4
October	10	0.6
November	5	1.8
December	1	2.2

Questions to Guide Analysis

1. Compare and contrast the climatograms from each of the biomes. Which biomes are wettest, driest, and which experience the greatest seasonal fluctuations? What other comparisons can you make?
2. Compare and contrast the types of adaptations found in the different biomes. Explain any patterns you find.
3. Discuss the types and causes of differences found within biomes.

Environmental Factors that Affect the Hatching of Brine Shrimp

Standard Course of Study Goals and Objectives

Competency Goal 4: The learner will develop an understanding of ecological relationships among organisms.

Objective 4.01: Identify the interrelationships among organisms, populations, communities, ecosystems, and biomes.

Competency Goal 5: Students will develop an understanding of the behavior of organisms, resulting from a combination of heredity and environment.

Objective 5.01: Evaluate the survival of organisms and suitable adaptive responses to environmental pressures.

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 the 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 interested 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.

Eggs should hatch within two days. Students should count the number of live 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.

References

This exercise was adapted from a BSCS Green Version lab and was modified and written by Gordon Plumblee, Western Alamance High School, Elon College, NC 27244.

Environmental Factors that Affect the Hatching of Brine Shrimp

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

Materials

- 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
- counting grid

Procedure

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:

    a. 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.

    b. Place each petri dish on top of the grid and count the number of live shrimp in ten different 1-centimeter-square blocks.

    c. Determine the average number of shrimp in each square centimeter.

    d. 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 $A = \pi r^2$.)

6. Analyze your data and compare them to the data of your classmates.

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?

Animal Responses to Environmental Stimuli

Standard Course of Study Goals and Objectives

Objectives 5.01: Evaluate the survival of organisms and suitable adaptive responses to environmental pressures.

Objective 5.03: Assess, describe, and explain types of animal behaviors.

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.

Animal Responses to Environmental Stimuli

Purpose To study the responses of organisms to various stimuli.

Question What stimuli does your experimental organism respond to? Design an experiment to demonstrate that the organism responds to these 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

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

2. As a group, pick an organism to experiment with.

3. 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.

4. 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.

5. 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.

6. Have your teacher review your plans. Revise if necessary.
7. Record your data neatly, clearly, and in detail. Remember you are looking for responses of the organism in relationship to the applied stimuli.
8. Summarize and analyze the results of your experiment.
9. Answer the Questions to Guide Analysis.

Hypothesis:

Experiment Procedure:

Use detailed language to describe your planned procedure.

Justification:

Data Collection:

Summary of Results:

Analysis of Results:

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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.

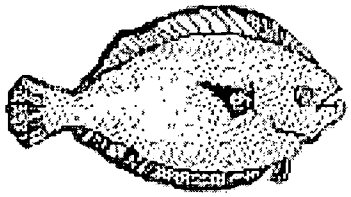
3. What sources of error can you identify within your experiment? How did you (or would you) seek to eliminate them?

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?



Fishy Frequencies

NC Standard Course of Study Goals and Objectives:

Biology Competency Goal 2: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Objective 2.06: Examine the development of the theory of biological evolution including: The origins of life, patterns, variation, and natural selection.

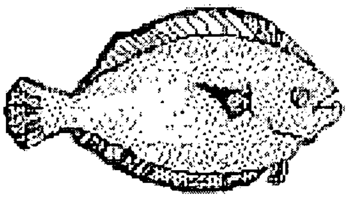
Teacher Notes:

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 fits these conditions completely. 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 that students shall 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 actual edible 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.



Fishy Frequencies

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).
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).

<u>Hardy-Weinberg:</u>

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.

<u>Procedure 1:</u>

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.

<u>Procedure 2:</u>

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							

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) Were 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?

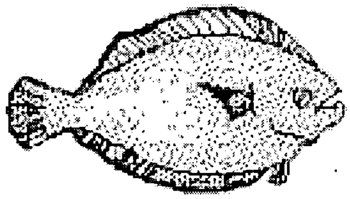
6) What would happen if it were more advantageous to be heterozygous (Ff)? Would there still be homozygous fish? Explain.

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 eat only 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?



Fishy Frequencies

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 stretch its neck permanently, the polar bear can turn itself white - all so that they can survive better 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).

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 percentages 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.

CHART (without selection) Partners:

Generation	gold	brown	% gold	% brown
1				
2				
3				
4				
5				

CHART (with selection) Partners:

Generation	gold	brown	% gold	% brown
1				
2				
3				
4				
5				

CHART (without selection) Class:

Generation	gold	brown	% gold	% brown
1				
2				
3				
4				
5				

CHART (with selection) Class:

Generation	gold	brown	% gold	% brown
1				
2				
3				
4				
5				

Analysis Questions for Percentage Method:

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 percentage (0-100). Plot both the gold and brown for both sets of class data. Label lines clearly (without selection AND with selection).

2) In either simulation, did your percentages stay approximately the same over time? If yes, which situation?

3) What conditions would have to exist for the percentages to stay the same over time?

4) Were your data different from the class data? How? Why is it important to collect class data?

5) With selection, what happens to the percentages from generation 1 to generation 5?

6) What process is occurring when there is a change in percentages over a long period of time?

7) What would happen if it were more advantageous to be heterozygous (Ff)? Would there still be homozygous fish? Explain.

8) In simulation 2, what happens to the gold fish over successive generations and why?

9) In simulation 2, why don't the gold fish entirely disappear from the population?

10) Explain what would happen if selective pressure changed and the gold fish were selected FOR?

11) What happens if the sharks eat only very large fish that have already reproduced? What happens if they eat small gold fish, before they have a chance to reproduce?

12) In what ways did these simulations represent real life? How were the simulations different from real life situations?

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