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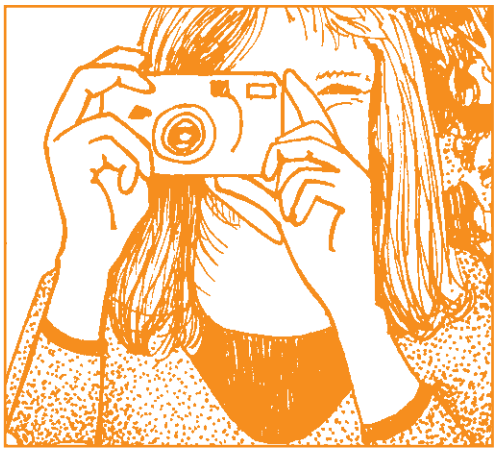
THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®



Living Science:

Humane, Student-Inquiry Science Projects for Middle and High School

letter to teachers

Dear Colleague,

If you are teaching science, there is a very good chance that you were one of those students who took an immediate love to the excitement of discovery. You enjoyed honing the skills needed to conduct a successful experiment. Developing hypotheses, collecting data, and analyzing the results may have come easily for you. As a teacher, you've accepted the challenge of passing on these skills and excitement to another generation. Your role has never been more important. We will need plenty of new scientists in the coming decades. You can help to plant and nourish the early seeds of interest in science careers. More important still is that many of the most critical policy decisions that our nation and world face will depend on an understanding of how science works. Students who pursue careers in law, politics, business, or education will need to know more information than previous generations. They will need to understand the rigorous process required by the Scientific Method to understand its strengths and limits. Only then will they be able to make informed decisions that will affect not only their own lives but those of many others as well.

Living Science arose for several different reasons. Foremost, because we at ASPCA believe that science is an important part of education for all students. The projects included were developed to meet the requirements of the National Science Education Standards. They provide you and your students with activities that will engage your minds, imaginations, and hands. We also wanted to dispel the notion that people interested in protecting animals and the environment were "anti-science." We believe that science achieves its highest calling when it is humane and responsible. Finally, we simply enjoy science just as much as you do, and wanted to share some exciting and fun projects that we think your students will enjoy as well.

Stephen Zawistowski, Ph.D.
Senior Vice President of National Programs and Science Advisor
ASPCA

We at ASPCA understand the need for and difficulty of bringing humane student inquiry into the modern classroom. And we wanted to do something about it. With generous financial assistance from the Kenneth A. Scott Charitable Trust, we were able to bring together a team of widely experienced people to create *Living Science*.

Our goal was daunting. We wanted innovative and practical projects based on current research and best science practices. We wanted students to study animals and nature in ways that preserved the life they studied. We wanted ideas that were feasible given the very real constraints of time and money. Phew! It was a tall order. We searched for exemplary teachers who found ways to do all of this successfully. To our pleasant surprise, we found that this is being done by teachers across the country. In large part, this collection is the story of their successes.

Living Science demonstrates that science not only can be humane, but that humane issues are well-informed by science. As projects like "Animal Advocate Hall of Fame" and "Pandas, Sperm Banks, and Vavilov Centers: Habitats vs. Test Tubes" demonstrate, many scientists care deeply about animal issues. "An Owl Eats *What*? Owl Pellet Dissection" can replace activities like frog dissection with environmentally friendly alternatives that are even more scientific and educational; ones like "pHishing for Answers" and "Terraria Hysteria" bring nature into the classroom in humane ways.

These projects not only teach good science—they are based on it. They incorporate different learning modalities and support formative assessment. They often employ student inquiry to help them construct authentic learning experiences. Projects like "That's So Random: Island Biogeography and Stochastic Events," "Population Explosion: Feral Cats in our Communities," "Vive la Difference: Biodiversity and the Shannon Diversity Index," "The Dark Tower: Do Communications Towers Kill Birds?," and "What's in Your Garbage?," encourage participatory action research in a format usable by teachers across the country to work on important issues right in the students' neighborhoods.

Science is exciting. To reflect this, we sought out projects that are engaging and relevant. "Picture This! Using Photography in Research" puts students into nature to "capture" wildlife while "We're On the Case: Animal Cruelty and Criminal Forensics" blends interesting labs with the serious issue of animal cruelty. "Says You: Environmental Science Debate" brings contentious issues into the class in ways that foster critical thinking and articulate communication. "Show 'Em What You're Made Of: Extracting DNA" lets students see firsthand what all the fuss is about: actual DNA molecules. "Field-based Research Projects" and "Cool Birds for Science Nerds: Bird Observations" even let the students participate in actual university and government research projects.

The projects address a range of ability levels, from early middle school to preparation for advanced placement exams. In general, however, we chose projects that are workably challenging. We wanted to demonstrate the exciting and sophisticated projects actual students have completed to inspire yet more students to realize their true potential. Learner-centered projects like these can be adapted quite easily, and all students should benefit from the authentic, hands-on, multi-modal approach of many of the lessons. Giving students whose first language is not English, or those with special needs, extra time and attention—especially in peer discussion groups—can help them all enjoy science.

Of course, a premium was placed on the projects being feasible. Not only do many of the projects come from classes where they have already been done successfully, but they have been reviewed by other teachers, animal behaviorists, psychologists, etc. The projects are solid and diverse because of the great depth of expertise and breadth of variety of those who have contributed projects and reviewed them.

project creators

Project 1: An Owl Eats *What*?
Owl Pellet Dissection
Cindy Taylor

Project 2: The Dark Tower:
Do Communications Towers Kill Birds?
Susan Frey
Allison Graham
Paul Niles
Peter Trull

Project 3: Picture This!
Using Photography in Research
Jane P. Gardner

Project 4: Backyard Bonanza
Tara Eppinger

Project 5: Terraria Hysteria
Tara Eppinger
Bill Samuels, Ph.D.

Project 6: Add Water and Stir:
Building A Pond Habitat for Scientific Inquiry
Tara Eppinger

Project 7: That's So Random:
Island Biogeography & Stochastic Events
Robert Corbin

Project 8: Vive la Difference:
Biodiversity and the Shannon Diversity Index
Robert Corbin

Project 9: Walking the Talk:
A Forest Transect Study
Hartmut Dobel, Ph. D.
Susan Frey

Project 10: Ecotones:
Living on the Edge
Cindy Taylor

Project 11: You Read My Mind!
Scientific Observation of Human Behavior
Bill Samuels, Ph.D.

Project 12: The Tail Wagging the Dog: Observation of Canine Behavior
Bill Samuels, Ph.D.

Project 13: Cool Birds for Science Nerds: Bird Observations
Bill Samuels, Ph.D.

Project 14: Like a Moth to a Flame:
Insect Optics
Bill Samuels, Ph.D.

Project 15: The Budding Ethologist:
Observing Pet Behavior
Bill Samuels, Ph.D.

Project 16: Field-Based Research Projects: The Jane Goodall Environmental Middle School Model
Susan Frey
Mike Weddle

Project 17: Population Explosion:
Feral Cats in Our Communities
Jane P. Gardner

Project 18: We're On the Case:
Animal Cruelty and Criminal Forensics
Bill Samuels, Ph.D.

Project 19: You Say You Want an Evolution: An Introduction to Natural Selection
Bill Samuels, Ph.D.

Project 20: Genes, Cookies, and Natural Selection
Rebecca L. Seipelt

Project 21: Show 'Em What You're Made Of: Extracting DNA
Bill Samuels, Ph.D.
Cindy Taylor

Project 22: Pandas, Sperm Banks, and Vavilov Centers: Habitats vs. Test Tubes
Robert Corbin

Project 23: Wanted: A Second Chance – Research on Endangered Species
Joyce Bailey
Susan Frey

Project 24: What's in Your Garbage?
Jane P. Gardner

Project 25: pHishing for Answers
Tara Eppinger

Project 26: Erosion:
A Series of Unfortunate Events
Neely Gutierrez

Project 27: How Big Are Your Ecological Feet?
Robert Corbin

Project 28: Animal Advocate Hall of Fame
Neely Gutierrez

Project 29: Says You:
Environmental Science Debate
Susan Frey
Bruce Peacock

Joyce Bailey teaches biology and AP environmental science at the Global Environmental Studies Program at Poolesville High School in Montgomery County, Maryland. She also coordinates a program that offers students year-long internships to learn more about environmental issues. Joyce won the Montgomery County Outdoor Educators Association's Outdoor Educator of the Year Award.

Robert Corbin is a National Board Certified Science Teacher at E.E. Waddell High School. He is a founding member of the Bank of America Teaching Fellows and Affiliates program for Charlotte Mecklenburg Schools. Robert has taught a variety of technology and science courses in a variety of public high school, middle school and university settings for about 20 years. He is a Christa McAuliffe Fellow, Duke University Sawyer Fellow, Whitehead Educator of Distinction, and NAGT Outstanding Earth ScienceTeacher of the Southeastern United States. Robert has received grants and awards from the EPA, NAGT, NSTA, Bank of America, First Union Bank, Toyota Tapestry Program, International Paper Corporation, Virtual High School Concord Consortium, Noyce Foundation, North Carolina Department of Public Instruction and Christa McAuliffe Foundation. He has a B.S. in Environmental Science and an I.M.A. in Natural Science Education.

Hartmut Doebel, Ph.D. is trained as an insect ecologist and has taught high school biology and chemistry for 10 years at the Washington Waldorf School, and teaches biology at the University of Maryland.

Tara Eppinger is a former high school science teacher and swimming coach. She taught biology, AP biology and physical science for two years at Riverwood High School in Atlanta, Georgia, and then spent five years at Durham Academy in Durham, NC, teaching biology, AP biology, and chemistry. Tara graduated with a B.S. in Biology from Duke University and an M.A. in Education from Wake Forest University. Tara is now a full-time mother in Durham, NC, where she lives with her husband, Tom, and their two children, Tate and Taylor. She is an avid runner and reader.

Susan Frey is the Director of Education for the Walden Woods Project. In collaboration with Dr. Jane Goodall, Susan created *Lessons for Hope*, a web-based curriculum for middle and high school classes on learning how to implement service-learning projects. Susan has also managed the evaluation of the Kids' Network, a TERC/ National Geographic Society educational curriculum. Susan began her career in education teaching middle school at the Winnetka Public Schools. Susan earned her Master's in Education at the Harvard Graduate School of Education, and was certified to teach at Bank Street College of Education.

Jane P. Gardner is a freelance science writer and editor. She has a B.S. in Geology from the University of New Hampshire, an M.S. in Geochemistry from Virginia Tech, and an M.S. in Education from the University of Massachusetts in Boston. Jane taught science to college students at Radford University, Virginia Western Community College and Bentley College. She also spent four years as a high school science teacher in Littleton, MA where she developed and taught courses in environmental science, biology, earth science and chemistry. Jane left public education to work in educational publishing and has worked as a freelance science writer and editor since the birth of her first son. Jane lives in Massachusetts with her husband and two sons.

Allison Graham teaches health and physical education at the Cape Cod Lighthouse Charter School. Allison is an avid birder and co-leads the Cape Cod Youth Council on Sustainability and the Roots & Shoots Club.

Neely Gutierrez is an independent education consultant in Charlotte, NC. She graduated with degrees in Biology and History from Duke University and has a Master's in Science Education from the University of NC at Chapel Hill. She taught middle and high school science for five years and continues to work closely with students, providing academic support outside of the classroom. In her spare time, Neely enjoys reading, travel and spending time with her family.

Bruce Peacock has taught high school biology and environmental science classes ranging from at-risk to advanced placement classes at Badger High in Lake Geneva, WI. Prior to teaching, Bruce was a wildlife technician and later a park supervisor at the Wisconsin Department of Natural Resources.

Paul Niles founded and teaches 8th grade science at the Cape Cod Lighthouse Charter School in Eastham, MA. In addition to teaching middle school, Paul serves as the Associate Director for Curriculum. He is co-facilitator of the award-winning Cape Cod Youth Council on Sustainability and the Roots & Shoots Club.

Bill Samuels, Ph.D., the ASPCA's Director of Humane Education, earned his doctorate in Experimental Psychology and Psychometrics at the University of Texas at Arlington for research conducted on the resilience of college-level students. His Master's degree involved research on animal cognition. Bill has designed lessons and materials for all grades and adults on various subjects, including humane education for most. He has also published and presented research on education program evaluation, constructivism and teacher professional development.

Rebecca L. Seipelt, Ph.D., teaches genetics, human genetics, and non-majors biology in the Biology Department at Middle Tennessee State University. As the Director of the Biotechnology Resource Group, a NSF-funded program, she also coordinates biotechnology internships with local industry, helps train high school teachers in the use of biotechnology and conducts hands-on laboratory activities with local middle and high school students. She has won awards for her use of instructional technology. Her current research includes aminopeptidase biochemistry, B cell maturation, concept map use in upper division courses and peer genetics education projects. She received her B.A. in Biology from Berea College and her Ph.D. in Medical Microbiology and Immunology from the University of Kentucky College of Medicine.

Cindy Taylor is the assistant principal at Avery Trace Middle School, a 7th and 8th grade school of 1000 students in Cookeville, TN. She taught 18 years in a public high school, teaching biology, honors chemistry and honors biology II. She especially loves epidemiology, genetics and forensic science. Cindy has published numerous articles for educational magazines, as well as consulting with VH1 to write health lesson plans for "Tracking the Monster: AIDS in Africa." A frequent presenter at local, state and national science conferences, Cindy is a science consultant to Topics Education and a former national teacher advisor to Cable in the Classroom. Cindy's educational background includes a B.S. in science education with a minor in environmental studies, an M.A. in Curriculum & Instruction and an Ed.S. in Educational Leadership. She is married to her wonderful husband, Craig, and has two grown sons.

Peter Trull teaches 7th grade science at the Cape Cod Lighthouse Charter School. He was formerly the Education Director at the Cape Cod Museum of Natural History and at the Center for Coastal Studies in Provincetown. He has taught high school science. Peter has written three books about Cape Cod natural history and is currently conducting long-term research on Eastern Coyotes. He has also completed several research projects focusing on bird life on Cape Cod.

Mike Weddle has been teaching for 33 years, the past 6 years at the Jane Goodall Environmental Middle School (www.jgems.net). He has worked overseas for the Jane Goodall Institute in Tanzania and South Africa, for the Snow Leopard Conservancy in India and the Smithsonian Institution in Myanmar. He currently teaches conservation biology and technology at JGEMS. He also won the Milken Education Award and set up an environmental education foundation in honor of his father.

reviewers

Donelle Blubaugh is the former VP of Education for Topics Education. Prior to joining Topics Education, she served as Director of Education for Cable in the Classroom. Donelle has participated in several national education reform efforts including the Partnership for 21st Century Skills and the CEO Forum. She has 12 years of public school teaching experience and is past president of the National Coalition for Technology in Education and Training (NCTET).

Jennifer Doyle graduated from St. John's University in Jamaica, NY, with a B. S. in Environmental Science and a minor in Secondary Education. Jennifer returned to St. John's a short time thereafter and earned an M. S. in Secondary Education with a concentration in biology. She recently returned to St. John's for an M. S. in School Administration. She teaches at Christ the King RHS in Queens. Jennifer is in her ninth year of teaching science and is currently the chairperson of the science department.

Charles Levenberg-Engel started teaching biology in 1965, having spent the last 30 years or so at the Bronx High School of Science in New York City. There he helped the students to found their ecology/animal welfare club, LEAP (League for Environmental & Animal Protection), and served as Animal Room Squad Coordinator; Charles has continued to do both even though he has retired. He was an active member of the New York Biology Teachers Association, co-chairman of the Jerome Park Conservancy education committee, and chairman of the Bronx Council for Environmental Quality's Education Committee. Charles now serves as the BCEQ President.

Joseph Pentangelo is a member of the Humane Law Enforcement Department at ASPCA. Joe received his B.S. in Criminal Justice from the City University of NY and is a 21-year veteran detective of the NYPD. He worked in assignments as varied as the Mounted Unit, the Special Investigations Division, and retired as the lead spokesperson for the department. He is frequently seen acting on television and in films, and also appears in the reality series *Animal Precinct* on Animal Planet.

Pamela J. Reid, Ph.D., is a certified applied animal behaviorist. She received her Ph.D. in Psychology with a specialization in animal learning and behavior from the University of Toronto. She began her professional career by establishing a successful referral practice for owners of pets with behavior problems: Animal Behavior Services, Inc., in Toronto, Canada. She specialized in evaluating the behavior of dogs and cats and designing modification programs for those exhibiting problematic behavior. Pam is now vice-president of ASPCA Animal Behavior Center. The Center offers educational programs on pet behavior for veterinary staff, animal trainers, shelter personnel, legal counselors and pet owners. Pam also oversees two very unique programs dedicated to the fostering of new professionals in the field: (1) ASPCA Animal Behavior Fellowship — a two-year mentorship of recently graduated Ph.D.'s in animal behavior wishing to pursue a career in applied animal behavior, and (2) the University of Illinois Biology Masters program in applied animal behavior — a graduate thesis degree in applied animal behavior. Pam publishes in both scientific journals and the popular press. She lectures on animal behavior and training around the world. Pam is also an accomplished dog trainer, sharing her life with dogs who compete, or have competed, at the elite levels of agility, obedience and flyball.

Franco Scardino earned his B.A. from NYU in History and Economics and his M.A. in Social Studies at the Teachers College at Columbia University. He has been teaching at Townsend Harris High School at Queens College for five years. He teaches a four-semester social science research course and Advanced Placement US Government and Politics. His students enter the NYC Quality of Life research Competition as well as Intel, NYC Science and Engineering Fair, and the Junior Science and Humanities Symposium. Franco is currently a national member of NCSS and has served on a civics education advisory panel for Oxford University Press.

Jacque Lynn Schultz, over the last 15 plus years with ASPCA, has run ASPCA behavior and training department; written award-winning pet care materials; lectured to trainers, shelter staff and pet owners across the country; and served as a media resource. She is co-author of *ASPCA Complete Guide to Dogs* and project consultant on *ASPCA Complete Guide to Cats*. She is a certified pet dog trainer and ASPCA's Director and Companion Animal Programs Advisor. Jacque has a B.A. in Film History and Analysis and an M. A. in Film Theory from the University of Wisconsin-Milwaukee, and completed a post-graduate internship at the International Museum of Photography at George Eastman House, where she also taught Film History at the University of Rochester (Rochester, NY).

Sheila Schwartz, Ed.D. has worked as an elementary school teacher for the New York City Department of Education for 30 years, and she has chaired the United Federation of Teachers Humane Education Committee (UFT/HEC) since 1989. In that capacity, she has organized humane education conferences and edited newsletters for educators in grades pre-kindergarten to 12 as well as developed curricula materials concerning companion animals, wildlife issues, farmed animals, vegetarianism, and alternatives to the use of animals in education and research. She has judged the New York Academy of Sciences annual Science Expo for outstanding humane science projects since 1990.

Scott Silver, Ph.D. has been the Curator of Animals for the Wildlife Conservation Society's Queens Zoo since 1998. He began his career with WCS in 1984, first as an assistant elephant trainer, then as a keeper in the mammal department and later an instructor in the education department. In 1993, he began graduate research in the tropical forests of Belize, in Central America. He earned his M.S. and Ph.D. through Fordham University. Scott is also the Survey Coordinator for WCS's Jaguar Conservation Program and currently coordinates the Cockscomb Basin Jaguar Project in Belize, with his wife, Dr. Linde Ostro. This project generated the first statistically robust estimate of wild jaguar densities anywhere in the world. He also currently serves as the Spectacled Bear Species Survival Program Coordinator for the American Zoo and Aquarium Association.

Ethel Tobach, Ph.D., received her B.S. degree from Hunter College, and her M.A. and Ph.D. from New York University. She is a comparative psychologist who has been working at the American Museum of Natural History since her graduate days (1950) to the present. Her interests are the study of social/emotional activity of all species, including the human; evolutionary processes that distinguish differences and similarities among species; and the education of people in the relatedness of all life processes so that appropriate policies to sustain life of all on the planet can be developed.

Andy Wood is the Education Director for Audubon North Carolina, a post he began in October 2000. Prior to his post with Audubon, he served for 13 years as the Education Curator for the North Carolina Aquarium at Fort Fisher where he developed indoor and outdoor education programs for schools and other visitors. Andy earned a B.S. degree in Wildlife and Fishery Science from Texas A&M University in 1981. In his role with Audubon, Andy is building partnerships with rural schools and other community organizations to develop content-based teacher workshops that will enable teachers to infuse outdoor-based environmental education into their classroom lesson plans. Andy and his wife, Sandy, live in Hampstead, NC, with their two sons, Robin and Carson.

Stephen Zawistowski, Ph.D., CAAB, is Senior Vice President of National Programs. He joined ASPCA in 1988 as head of the Education Department. Before ASPCA he was a faculty member at Indiana University and then at St. John's University, where he taught biology and psychology. He currently serves on several advisory boards related to animal welfare, and chairs the Animal Behavior Society's Board of Professional Certification. While at ASPCA "Z" has authored, edited or consulted on over 20 books on pet care and animal welfare, in addition to editing a peer-reviewed journal.

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standards matrix

	A. Science as Inquiry		B. Physical Science	C. Life Science					D. Science & Technology		E. Science in Personal & Social Perspectives						F. History & Nature of Science			G. National Council of Teachers of Mathematics		
	Abilities necessary to do scientific inquiry	Understandings about scientific inquiry	Chemical reactions	Molecular basis of heredity	Biological evolution	Interdependence of organisms	Matter, energy, and organization in living systems	Behavior of organisms	Abilities of technological design	Understandings about science and technology	Personal and community health	Population growth	Natural resources	Environmental quality	Natural and human-induced hazards	Science and technology in local, national, and global challenges	Science as a human endeavor	Nature of scientific knowledge	Historical perspectives	Measurements	Data Analysis & Probability	Problem Solving
An Owl Eats *What*?	x						x						x									
The Dark Tower	x	x				x		x							x					x	x	
Picture This!	x	x						x	x	x								?				
Backyard Bonanza	x	x				x	x	x							x						x	
Terraria Hysteria	x	x				x	x					?	?	?						?	?	
Add Water and Stir	x	x				x	?	?					?	?	?					?	?	
That's So Random		x					x	x					x		x						x	x
Vive la Difference	x	x			x	x	?		x	x			x			x	x	x			x	x
Walking the Talk	x	x					x	x					x							x	x	
Ecotones						x		x			x	x	x		x	x	x	x	x			
You Read My Mind!	x	x						x										x		x	x	
The Tail Wagging the Dog	x							x										x		x	x	
Cool Birds for Science Nerds	x	x					x	x		?					?	?				x	x	
Like a Moth to a Flame	x				x			x													x	
The Budding Ethologist	x	x						x												x	x	
Field-Based Research Projects	x	x				?	?	x		?	?		?	?	?	?				?	?	
Population Explosion	x	x				x	x	x			x		x		x	x						x
We're On the Case	x	x	x													x				x		
You Say You Want an Evolution					x													x				x
Genes, Cookies, and Natural Selection	x			x	x																	
Show 'Em What You're Made Of	x			x															x			
Vavilov Centers	x	x											x	x		x	x					
Wanted: A Second Chance						x	x	x					x		x		x					
What's in Your Garbage?		x				x	x				x			x	x	x				x		
pHishing for Answers	x	x	x			?							?		x					x	x	
Erosion	x	x				x	x							x	x	x				x		
How Big Are Your Ecological Feet?							x				x	x	x	x	x	x				x	x	
Animal Advocate Hall of Fame						?					?		?	?	?	x	x	?	?			
Environmental Science Debate	x						?				?	?	?	?	?	?	x	x				

X = Meets standard

? = May meet standard, depending on actual use of project

table of contents

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Grade Level: MS

Type: Lab

Topic: Predator/prey relationships

An Owl Eats *What*?! Owl Pellet Dissection

What looks like poo but doesn't smell like poo? What contains animal remains but is sterile? What tells you what a bird ate without being ooey, gooey and gross? Why, it's an owl pellet of course. An owl pellet dissection lab is a great way for students to learn about predator/prey relationships and practice important laboratory skills.

INTRODUCTION

Owl pellet dissections are one of the best ways to conduct a survey of what an organism eats without destroying the organism itself. Scientists use owl pellets to census the animals in an area, determine the amount of energy that owls use and study other aspects of the life and times of owls' habitats.

Most people think of dissection as cutting up an organism to see what it is like inside. Owl pellet dissection allows for a critical examination of the owl without the death of the organism. In addition, many of the frogs and other animals used in dissection are collected from the environment, ironically harming the world that biologists are trying to study.

As predators, owls swallow their prey whole. After the nutrients from the prey are absorbed in an owl's stomach, the fur, bones, teeth and claws of the prey are compressed into a pellet in the stomach. This pellet is then regurgitated and left to collect below the owl's nest. Scientists such as you and your students can then dissect the pellet to determine what the owl ate.

OBJECTIVES

After completing this activity, students will be able to:

1. dissect an owl pellet.
2. identify the bones of the prey contained in the pellet.
3. construct the skeleton(s) of the prey.
4. calculate the biomass of the prey.

MATERIALS NEEDED

- Owl pellets (purchased from science lab suppliers or collected during field studies)
- Forceps
- Probe or needle
- Bone and skull identification charts
- Construction paper
- White glue

CLASS TIME REQUIRED

One to two 40-minute periods

LESSON STEPS

1. For pre-dissection practice, go to www.froguts.com. Click on "demos" then "owl pellets." Students will practice placing bones in a skeletal design online. Another online dissection of an owl pellet may be found at www.kidwings.com/owlpellets/index2.htm.

2. Students will use scientific journals throughout the dissection to list what they predict about the behavior of owls from the food they eat (for example, have students predict what types of organisms might be eaten by a silent, flying hunter in the night sky), questions they would like to have answered as the dissection progresses, what astounds or confounds their thinking and how their findings compared to their original predictions.

3. Have students unwrap pellets and use either a dry or wet method to take apart the pellet; they can either carefully pick apart the fur and bones from the pellet or soak the larger masses in water. Students may like to use both methods to take apart the pellet. Remind them to be careful because some of the bones will be tiny and can be easily crushed or lost.

4. Have students arrange bones into specific categories. If more than one skull is present, for example, students will separate the bones into groups, then into skeletons of different animals.

5. Once the skeletons are sorted, students will glue skeletal remains onto construction paper as if the animal were lying on the paper and identify, using Internet resources or lab posters, what type of organism(s) the owl ate. They will probably be amazed that an entire skeleton of a rodent or bird may be found in the owl pellet. Remind students to comment on their findings in their science journals.

BIOMASS CALCULATION

How much food value is contained in prey eaten by owls? Prey sizes vary. Biomass calculations will explain how much energy is obtained from each prey. For example, moles have a greater biomass than field mice, giving more energy to the owl for its biological needs.

- As a class, complete the biomass chart using total numbers of prey found during the dissection. Frequency refers to the number of skeletons of that species found in the owl pellets. Multiply the Mean Mass in grams by the Frequency to determine biomass units. Add all the biomass units together to find total biomass. Then, find percentages of each species using the total biomass.

Prey	Average Mass (g)	Frequency (#)	Biomass Units	Biomass Percentage (%)
House Mouse	17			
White-footed Mouse	40			
Deer Mouse	30			
Meadow Vole	42			
Shrew	5			
Mole	55			
Eastern Gray Squirrel	400			
Small Bird	100			
		Totals:		**100 %**

EVALUATION OF LEARNING

A. Formative Evaluation:
- Students communicate understanding of process that creates an owl pellet.
- Students accurately complete dissection and identification of bones found.

B. Summative Evaluation:
- Students accurately reassemble and identify skeletons on paper.
- Students draw simple food chains representing the producers and consumers found in the lab through the dissection of the owl pellets.
- Students draw a food web of a meadow, using a different predator-prey relationship (must trace from the Sun to producers to primary and secondary consumers)

As predators, owls swallow their prey whole.

SOURCES

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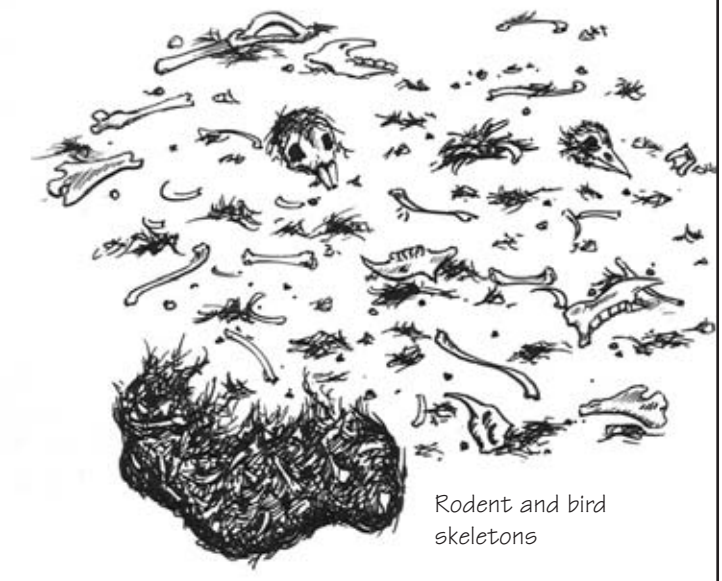

Rodent and bird skeletons

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Grade Level: MS, HS

Type: Field study

Topic: Communications towers and avian mortality

The Dark Tower:
Do Communications Towers Kill Birds?

In various parts of the country, people have been debating about whether wind turbines and communication towers kill birds. A discussion designed to help students assess the issues around the wind turbine debate led one group of students to ask if the communication towers that already exist and are being built, without debate, kill many birds. This study is designed to help answer that question. It not only provides students with an opportunity to engage in authentic inquiry, but it also sheds light on how human technology directly affects migrating birds.

INTRODUCTION

This study is designed to engage students in authentic, participatory action research. The example given focuses on studying the effects of cell towers on avian mortality. This is an important issue for both local and migrating birds throughout the country. Nonetheless, classes can use this example as a template to investigate other issues in their area in which they are especially interested, such as death of wildlife from tall buildings, wind turbines and transmission lines.

This study is best conducted in the fall and spring during annual bird migrations. Contact your local nature center to find out dates of migrations in your area. Due to the nature of the study, it should be mentioned that this research will expose students to the grim reality that at certain times of year and under certain weather conditions, many songbirds die by flying in and around communication towers at night. Consequently, it is especially important to let students see that by learning how to conduct scientific research they can make a positive difference. By letting students present their research findings in the community, they can help influence the debate about communication tower policies regarding migratory birds.

OBJECTIVES

After completing this activity, students will be able to:

1. practice the critical thinking and scientific skills needed to participate in authentic inquiry.
2. classify bird species.
3. collect, manage, and analyze data.

CLASS TIME REQUIRED

Varies depending on location of study site, frequency of site visits, and number of birds found in study site.

LESSON STEPS

A project of this sort can be structured in many different ways. The process of designing such an investigation is a valuable part of the student's learning experience, so the project description will center on the process instead of prescribing exactly how one should proceed.

1 Students complete a literature search of previous similar studies, allowing them to gain information on how to plan and carry out the study.
- For a summary of research, read information on Journey North's site at www.learner.org/jnorth/tm

2 Plot communication towers on a local map online at sites like www.towerkill.com, www.mapcruzin.com/radiofrequency, and www.celltowerinfo.com/CellTowerLocationMapsIndex.htm. Find the height of the towers if possible. Use the information to choose a tower to study. Consider factors such as accessibility, proximity to the school and the tower's location with respect to local avian flyways. Check with local nature centers about migration flyways.

3 Visit towers to help assess their suitability. If there are several towers clustered together, consider selecting the tallest. Make note of the color of blinking lights at night.
- Check to see if the school needs permission to visit the communication tower on a regular basis. Request the ability to mark off a 50-meter and 77-meter radius around the tower at the study site. The 77-meter radius is a control area beyond the one immediately around the tower. One hypothesis could be that the number of dead birds within the 50-meter area will be greater than those in the 77-meter area. Why 77 meters? An annulus with an inner radius of 50 meters and an outer radius of a little over 77 meters has the same area as a circle with a radius of 50 meters. (The formula for the area of an annulus is $A = p(R^2 - r^2)$ where R = outer radius and r = inner radius.) Another control area could be one similar to the area around the tower but without a tower in it.
- (Optional) Invite a speaker from a cell phone company to talk about how communications towers work and answer students' questions.

4 Develop a study protocol, including how often to visit, when to visit, how long to search, how much data will be collected at the location and how to remain safe during the study. Search the site early in the morning from March through early June during spring migration or August through early November during fall migration (dates may vary in your location).

5 Prepare for the study by having students sign up to work on specific days; by holding bird identification workshops and a research protocol workshop; and by obtaining the necessary permits required to examine dead specimens.
- Create local field guides for birds for your zip code at Enature.com.

6 Scan the study site according to a set schedule, such as every morning or once a week on a designated day at a certain time. For example, visit the tower Tuesday and Thursday mornings before 8 a.m. Using gloves and plastic bags, examine all dead birds, weigh each and/or take digital photos of each, and identify each by family and by species if possible. Once a week, scan a 77-meter radius.

7 While collecting the data, also record lunar phase and meteorological data, such as temperature, precipitation, cloud cover, and wind direction and velocity at the site. The web sites below provide relevant data:
- www.weather.com
- Moon Phases: http://tycho.usno.navy.mil/vphase.html

8 Use various techniques to analyze the data with students. These involve setting up spreadsheets to catalogue data, counting and graphing species and family mortalities, and techniques to look for correlations between mortality and cloud cover, wind direction and lunar phase.

CONCLUDING DISCUSSION

Discuss with students how we can balance the need for cell phone towers with the needs of migrating birds. Brainstorm possible solutions as a group. What are some of the questions that should be answered to reach this balance? What then can students do to help—such as sending letters to local decision makers (legislators, the owners of the cell towers, etc.)? Include a copy of the students' research findings.

ADDITIONAL RESOURCES

To learn more about birds and other migrating animals, visit Journey North, a study of global migration at www.journeynorth.org; Flap, which works to find practical solutions at www.flap.org; and American Bird Conservancy at www.abcbirds.org.

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Grade Level: MS, HS

Type: Observation

Topic: Observing animal behavior

Picture This! Using Photography in Research

Scientists often use video and still photography during their observations of wildlife in the field. Just like microscopes and magnifying lenses, cameras can help sharpen the observer's view of his or her subject when the goal is to study small details. When the goal is to gather information about an animal's environment or interactions with other animals, a camera lens can help the observer record a broader picture. Videos, photographs, sound recording—all of these media help scientists capture data over time and check the accuracy of data from other sources, including their own observations. In this project, students will use still photography to record and study animals' physical and behavioral characteristics as well as their habitats.

INTRODUCTION

This activity is a great opportunity to collaborate with a photography or art teacher at your school, or to bring in a guest photographer to do an introduction to taking pictures. For tips on photographing wildlife, see the following websites:

1. www.questacon.edu.au/html/bg_wildlife _ teacher_notes.html
2. www.acnatsci.org/kids/phototips.html

People often shy away from wildlife photography because they think that it requires very sophisticated equipment. Good cameras can help, but it is also important to get to know your wildlife, make regular observations and plan what picture to take. Digital cameras are wonderful because you can instantly see the picture that you have taken. However, standard film cameras or disposable cameras work fine too. Because the students will ultimately be digitizing their pictures to create presentations, make sure that you have a method to achieve this. If using regular film, get a CD made of the pictures. Make sure that all students have access to cameras and film developing (if necessary). Students may wish to record sound and video as well, and can add this to their presentations.

OBJECTIVES

After completing this activity, students will be able to:

1. Discuss the advantages and disadvantages in using photographs as an observational tool.
2. List similarities and differences in using the human eye versus a camera lens to document observations.
3. Explain how photos can be used to capture information about wildlife, including the types of information that can be gathered.
4. Describe physical and behavioral attributes of two neighborhood organisms.
5. Create a multimedia presentation to illustrate the information they have gathered through photographs of neighborhood organisms.
6. Discuss ways to help preserve the habitats they have photographed.

MATERIALS NEEDED

- Camera (digital, standard 35mm, or disposable)
- Map of the neighborhood
- Binoculars
- Magnifying glass
- Pencil
- Paper
- PowerPoint or similar presentation program

CLASS TIME REQUIRED

Two to three 40-minute periods

MOTIVATION

Prior to beginning this activity, have each student bring in a photograph of wildlife from a magazine, web site, newspaper, etc. This is a good chance not only to discuss what we can learn from pictures, but is an opportunity to discuss observations versus inferences and the role that each plays in the scientific process.

Discuss the term "wildlife." People often think only large game animals such as lions, deer and elephants constitute wildlife. In fact, wildlife is anything other than domesticated animals and farm animals. Plants and fungi are also considered wildlife. You may find it helpful to have students brainstorm a list of the wildlife present in your area.

Give a brief explanation of the activity by telling students they will be taking photographs of wildlife both to capture observations and educate others about what they have seen. Discuss qualities of a good photograph and basic picture-taking skills (or if collaborating with a photographer, have them handle this step).

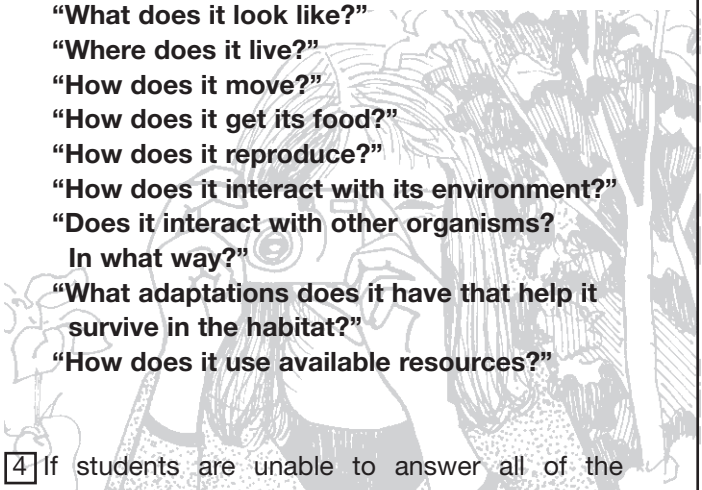
LESSON STEPS

1 Spend time discussing the procedure students should follow when they are observing organisms "in the wild." Students will observe wildlife in their natural habitats, leaving them undisturbed and only taking away images (in the form of photos) of the wildlife. Consider this request: "Take nothing but memories; leave nothing but footprints." The National Park Service asks park visitors to do just that, and it describes the mindset students should have during this exercise and in the future.

2 Decide how you want to assign organisms to students after each student has a priority list of five organisms. You may want to have students pair up and observe/photograph similar organisms in different habitats. You may want to make sure that not every student is going to be photographing the same organism. You may want to make sure that multiple trophic levels are addressed. Give some thought as to what will best suit your needs and how you want to structure this process prior to the activity.

3 Make sure that each student has come up with 10 acceptable questions for each organism he/she will be photographing. You may need to help students as they develop their questions. Accept all reasonable questions from students. Possible questions include:

"What does it look like?"
"Where does it live?"
"How does it move?"
"How does it get its food?"
"How does it reproduce?"
"How does it interact with its environment?"
"Does it interact with other organisms? In what way?"
"What adaptations does it have that help it survive in the habitat?"
"How does it use available resources?"



4 If students are unable to answer all of the questions through observations, consider having them do some research to find the answers. In addition to library resources, several web sites listed at the end of this activity may be helpful.

5 Pair students for the creation of a presentation. This is good practice in collaboration. There are many possibilities for student pairing (similar or different organisms, similar or different habitats, similar or different trophic levels, etc.).

DISCUSSION NOTES

Decide how you would like the students to share their presentations. You could have each group give an oral presentation to the class; you could require each student to look at a certain number of presentations on his or her own time; or, you could structure presentations in small groups.

After students have shared what they learned about their organisms, try to develop common themes or characteristics based on the data. Students will probably offer ideas about similar needs of the organisms (food, water, shelter), resource acquisition and adaptations.

The final part of the discussion should be process-oriented and the questions provided on the student handout should be a good starting point. Here are some potential answers to those questions:

1. In this activity, you made observations in real time as you watched your organisms in action. In addition, you captured observations in photographs. What are the advantages and disadvantages to each method as a scientific tool?

Photographs allow a moment to be preserved and thus can be used for proof or as supporting evidence. A picture captures one moment in time; you can study it for an eternity and, therefore, you can find pieces of information that you may not have otherwise seen. Using pictures is a less intrusive way to gather information because you can observe from afar, with less environmental tampering.

Making observations in real time allows you to record things that a camera cannot, such as smells, sounds, and temperature. You are able to use all of your senses, rather than relying solely on your eyes. You can watch processes unfold as well as movements and actions, all of which cannot be captured by a single snapshot.

2. Give one argument for and one against the well-known adage, "A picture is worth a thousand words."

Expect answers similar to the arguments in question 1.

Pro: The details that can be gleaned from a picture are endless. A good picture can capture a single moment that would take a writer pages to describe.

Con: A picture cannot show other variables like weather, sounds, smells, feelings and processes, and all of these can be explained in writing.

3. As a photographer, what was the most challenging part of the activity? What was most rewarding?

Answers will vary based on student experience. Most likely, patience and difficulty in getting a picture to represent their observations will be high on the list for challenges.

ADDITIONAL RESOURCES

World Wildlife Fund Wildfinder
www.worldwildlife.org/wildfinder/

Tree of Life Web Project
www.tolweb.org

BG Wildlife Teacher Resources
www.questacon.edu.au/html/bg_wildlife_teacher_notes.html

The Academy of Natural Sciences: Top Ten Tips for Wildlife Photography
www.acnatsci.org/kids/phototips.html

IS A PICTURE REALLY WORTH A THOUSAND WORDS?

What wildlife is in your neighborhood? Insect larvae or worms may be living in the soil. A colony of bees or wasps may be camping out under the shed in your backyard. Pigeons and squirrels may live on your block. You may have native perennial flowers in your yard, such as bee balm or black-eyed Susan. There may be two beavers building a dam at a nearby stream. Ants could be foraging along the sidewalk. Maybe a swallow has built a nest in the doorway to your apartment building. There is probably more wildlife in your neighborhood than you think.

In this activity, you will be practicing the scientific process of observation using your eyes and a camera lens as a way to learn more about the characteristics of two different organisms and the communities in which they live.

MATERIALS NEEDED

- Camera (digital, standard 35mm, or disposable)
- Map of the neighborhood
- Binoculars
- Magnifying glass
- Pencil
- Paper
- PowerPoint or similar presentation program

PROCEDURE PART A:
Choosing your organisms

1. Decide which organisms you want to study by asking yourself the following questions:

   (a) What type of organisms interest me? Animals, plants, or fungi? Big or small? Noisy or quiet? Solitary or communal? Nocturnal or diurnal?

   (b) What type of conditions can I work under? Do I mind getting dirty? Do I have the patience to wait long periods of time to see something? Do I want to observe organisms at twilight or during the early morning hours?

   (c) What organisms are available to observe in my neighborhood? Note: This will require you to spend time observing wildlife outside near your home.

2. After answering the questions, create a list of at least 10 potential organisms that would be considerations for observation. Then, narrow this list to five top choices and bring your list to class.

3. As a part of a class discussion, narrow your top five list down to two organisms. Your teacher will moderate this process in class, with the only requirement being that the two organisms you observe be members of different trophic levels.

PROCEDURE PART B:
Preparing to Photograph

1. The goal of the pictures you take is to tell the story about a day in the lives of your organisms (or as much of it as you can). For each organism that you plan to observe, come up with a list of 10 questions that you would like to answer. For example, "How does the organism move?" or "What does it eat?" Have your teacher approve your questions.

2. Create two data tables (one for each organism) to record the answers to the questions you have generated. In addition, you should provide space to record the following information:
   - time of day of your observations
   - latitude and longitude of organisms and of yourself
   - other environmental conditions such as temperature, wind speed and direction, precipitation, and other organisms in the area

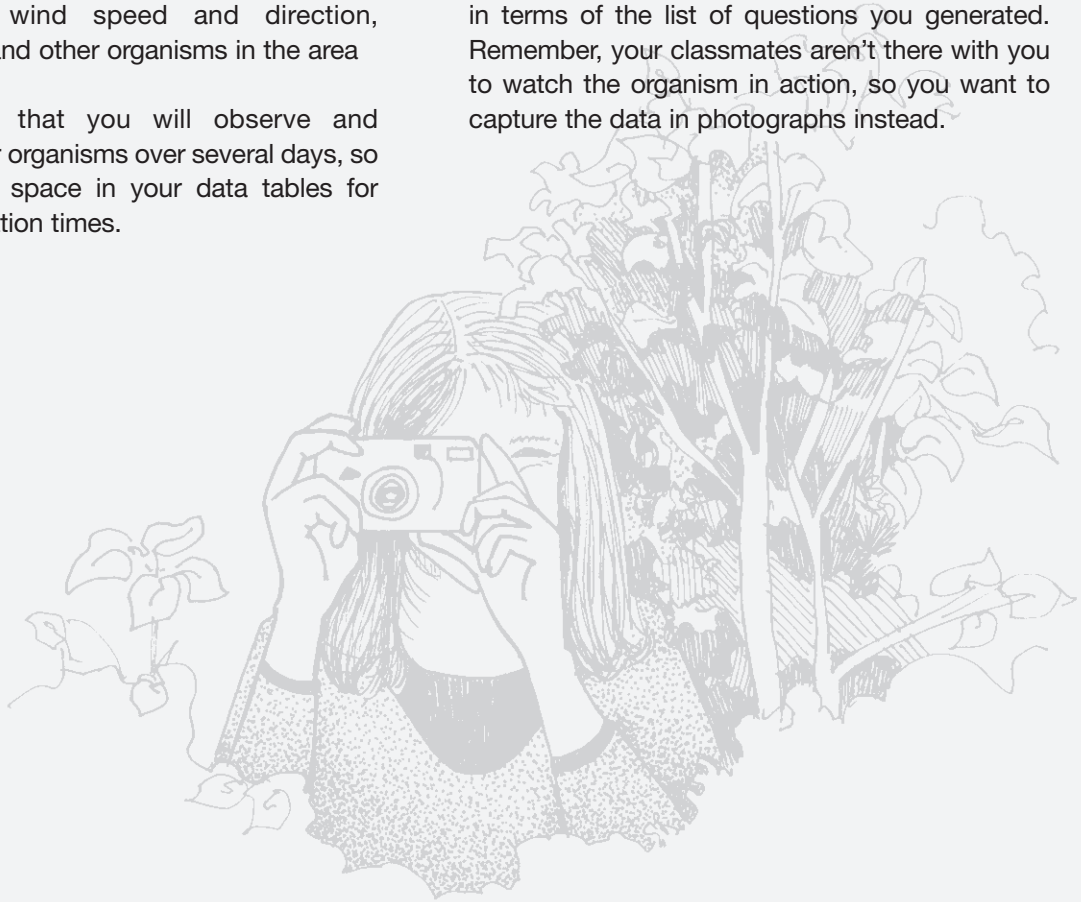
   Keep in mind that you will observe and photograph your organisms over several days, so provide enough space in your data tables for multiple observation times.

PROCEDURE PART C:
Just Say Cheese!

Over a period of a few days to a week, observe your chosen organisms. You are going on a local wildlife hunt with the intent of capturing some amazing footage of your organisms in their daily lives. Be sure to find a location where you can observe the wildlife without disturbing them. Your goal for this part is two-fold:

1. Complete as much of your data tables as possible through observations you make of the organisms. (Use a topographic map or handheld GPS unit if available to approximate the latitude and longitude of your position on the map of your neighborhood.)

2. Take as many pictures as you can that will teach your classmates about your organisms, especially in terms of the list of questions you generated. Remember, your classmates aren't there with you to watch the organism in action, so you want to capture the data in photographs instead.



DATA SYNTHESIS:
Sharing What You Have Learned

You have now spent several days observing and taking pictures of wildlife in your neighborhood. Hopefully, you have captured some amazing images of the organisms that illustrate traits, behaviors, and interactions. You may have grown quite attached to your organisms and feel like you are an expert. Exchange the information you have learned (along with your pictures!) with one of your classmates. Then, begin creating a presentation (using PowerPoint or similar program) to share with your class.

Your presentation should include the following items:

1. A list of the organisms you observed, which should include both their common names and scientific names (genus and species).

2. Photographs you have taken to illustrate the information you have gathered (via answers to your questions). For example, show how your organisms live, how they get their food, how they interact with members of the same species, how they respond to other wildlife or objects in their environment, and how they use the resources available to them.

3. Two similarities and two differences between the organisms in the presentation in terms of how they interact with other organisms and/or their environment.

4. Two behaviors you witnessed that could be lessons to humans regarding how we interact with our environment.

5. Any relationship(s), direct or indirect, that exist between the organisms in your presentation.

REFLECTING ON THE PROCESS

Be prepared to answer the following questions as part of a class discussion.

1. In this activity, you made observations in real time as you watched your organisms in action. In addition, you captured observations in photographs. What are the advantages and disadvantages to each method as a scientific tool?

2. Give one argument for and one argument against the well-known adage, “A picture is worth a thousand words.”

3. As a photographer, what was the most challenging part of the observation process? What was most rewarding?

EXTENSION ACTIVITIES

1. Take several pictures of one place over a period of time and compare to see how the wildlife (plants and animals) have moved or changed.

2. Use photographs and your field notes to create a field guide to the animals that live in your area.

3. Upload photographs and field notes to a class blog.

4. Begin an exchange with students in another region or country. Use photographs and notes to compare the species and habitats common to different areas.

5. Expand the project to include other media such as audio files or animation.

6. Write a fictional story or poem about one photograph.

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Grade Level: MS/HS

Type: Observation, habitat development

Topic: Biodiversity, ecosystems

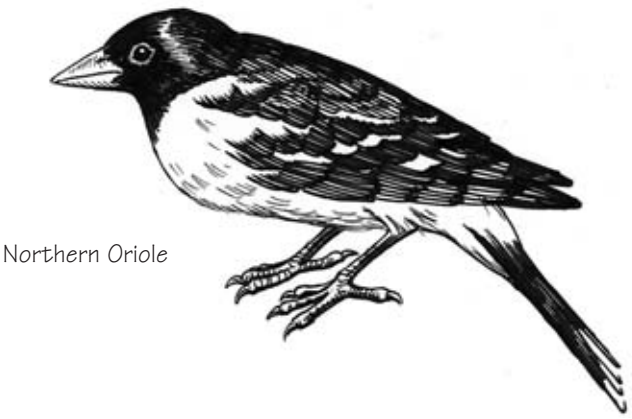
Backyard Bonanza

Helping students gain awareness of and appreciation for the nature that surrounds them is a goal of all science teachers. Building on the concept of "ecological address" is a way to personalize students' understanding of ecosystems and the importance of sustaining biodiversity in their own backyards or school grounds.

INTRODUCTION

Like a street address, an ecological address helps locate a place, but rather than using a street name and numbers, the components used to define an ecological address are the water systems, geology, climate, biodiversity, and land use of an area. For more information about ecological addresses, see www.audubon.org/bird/at_home/Explore.html.

This project focuses on the biodiversity component of an ecological address as students observe the ecosystems found in their own backyards. Depending on the time available, this activity can be used solely to discuss backyard habitats and ways to create and sustain them, or it can be expanded to include creating a wildlife habitat at school. It can also serve as an entry point to more in-depth study of ecosystems.



Northern Oriole

OBJECTIVES

After completing this activity, students will be able to:

1. design a planting schematic to attract native animals to their homes/yards to learn about the interdependence of organisms (and possibly give them chances to study the wildlife that it attracts).
2. draw a food web using organisms found in the garden they have designed.
3. learn about the concept of ecological address and consider ways to preserve the biodiversity of their own ecological addresses.

MATERIALS NEEDED

- Internet access
- Graph paper
- Observation site

CLASS TIME REQUIRED

Time required will vary, depending upon size of habitat and number of organisms found.

IMPLEMENTATION SUGGESTIONS

1. Before beginning the activity, make sure that all students have a place to make the observations suggested in the homework assignment. Do some of your students live in apartments, or places where there is little or no yard? Where and how can you arrange for these students to do observations? Some possibilities include allowing students to make observations in one area of the school property or at a local park. If a large number of students do not have yards to observe, you may consider taking a class field trip to a park or nature preserve to do observations.

2. In addition to written observations, consider having students take pictures or make drawings of the organisms (both animals and plants) they see.

3. For safety reasons, be sure your students are aware of any dangerous organisms in your area; for example, black widow spiders, brown recluse spiders, poisonous snakes, poison ivy, etc. Check with your state or local cooperative extension or poison control center for a complete list. It is important not to scare students away from the wonders of the outdoor world but to educate them about safety measures.

4. The optimal time of year to do this activity will depend on your geographic location. It is possible to attract native species during all seasons in some areas, but in others, there will be certain seasons that will allow for more student success.

5. The National Wildlife Foundation has a program in which you can certify your yard or schoolyard as a Backyard Wildlife Habitat. Students may be interested in creating such a habitat. The web site www.nwf.org/backyardwildlifehabitat/ has more information and a questionnaire to determine if your yard meets the criteria, and what additional items you need so that the yard will qualify.

MOTIVATION

A week before you plan to begin the discussion phase of this activity, assign students to conduct an observation of the wildlife that already visits their yards, parks, or neighborhoods. (See sample assignment at the end of this activity. You will want to adjust the assignment for students who don't have access to yards.) As you discuss the assignment, consider the following questions with your students. Tailor your discussion of the assignment to meet the needs and ability levels of your students.

1. What factors should you consider when structuring observations? Responses may include observing at different times of the day, observing by walking around (to see small organisms), and observing from a distance (to avoid frightening larger organisms, like birds).

2. Where should you look for organisms and organism interactions in your yard? Brush, bushes, dirt, logs, flowers, edges of two areas (e.g., forest edge, river edge), etc.

3. What organisms do you think you will observe? Insects, spiders, birds, squirrels, caterpillars.

4. What interactions do you think you will observe? Butterflies drinking nectar from butterfly bushes, birds eating berries from hollies, birds singing to each other.

5. What signs can you look for if animals are not readily observable? Tracks, webs, egg casings, scat, signs of burrowing, empty nutshells, strewn trash, etc.

LESSON STEPS

Facilitate a class discussion to gather and record data from the students' observations. Consider writing information somewhere in the classroom where it can stay for the remainder of the activity (large sheets of paper as opposed to the chalkboard). The key data you should collect are the organisms observed, where they were found, and interactions that were observed involving those organisms. It is okay if students do not have all of the information about each particular organism; they can do research in the next phase to gather more information.

Research/Information Collection

Provide students with field guides and gardening books to help them conduct their research. There are excellent websites available as well. For example, the National Wildlife Foundation has a website called eNature that offers a native plant finder and field guides for plants and animals (www.enature.com).

1 Have students research the various organisms listed on the data charts to fill in missing information. Many of the most important organisms, such as scavengers, are rarely observed directly. They should find the common and scientific names for each organism. In addition, students should find out about the particular needs of the organisms. For example, what types of food does a cardinal eat? What type of shelter does a goldfinch need? What do ants eat? Do hostas need sun or shade? This step can be done as an individual assignment or a group assignment. One suggestion would be to put students into small groups (2-4 students) and give each group 5-8 organisms to research.

2 Each student should find information about one native plant and one native animal that have not already been listed on the class data table.

3 After students have collected information, ask them to contribute what they have learned to complete the large data charts in the classroom. Be sure to add the new native organisms as well.

Making Sense of the Data

1 Ask students to make conclusions and predictions based on the data they have collected in terms of the needs of organisms. For example, all plants need sunlight and water, or all animals need food, shelter, and water.

2 Each student should design a scale model or blueprint of a garden that can sustain backyard wildlife such as birds, small mammals, invertebrates, and beneficial insects. Provide students with graph paper and field guides. Start with the following guidelines:

(a) The area of the garden should be four meters x four meters. The goal is to diagram a habitat that will include all of the elements needed to attract and sustain indigenous plant and animal life.

(b) The garden should contain at least five types of native plants that will attract at least five different animals. (You can alter the number to suit your needs and you can make it more/less challenging by being more/less specific about the types of organisms.) Students should not focus only on wildlife they have observed but include any native plants and animals they wish (the data charts in the classroom are good references). However, students should keep in mind that they are trying to create a wildlife habitat that is sustainable. Therefore, trying to attract animals like deer, raccoons, voles, and woodchucks is not advisable because they are big and voracious enough to

eat too much of the garden. If these animals are present in large numbers in your area, you may want to find out the plants they do and don't like to eat.

(c) On the graph paper, students should show where each element will be placed and how much space (diameter) plants will take up when mature. (They can find this information in a field guide.) Students may have multiples of each type of plant, as long as there are five different plant species in the garden.

(d) Each plant should be labeled with its scientific name.

(e) Have students consider the needs of the plants and animals and expand the diagram so that these needs are fulfilled. For example, they may choose to add a birdbath or small pond to supply water for the animals, or add bushes that can act as shelter for animals.

(f) On a separate sheet of paper, students should give the following information about each type of plant in their garden:
- Common and scientific names of plant
- Common and scientific names of animal(s) attracted to each plant
- Tips for planting, including water, fertilizer, and sunlight needs

3 Have students diagram a food web that could exist in their garden by beginning with the plants and animals they have already included in their design. Ask them to add higher order consumers (including an apex predator) that could be found in the food web. Remember that all organisms need to be native to your area. Ask students to add potential decomposers to the food web as well.
Note: As an assessment tool, you could have students or groups swap their diagrams and make food webs based on their classmates' diagrams.

4 Discuss the importance of the various abiotic components of an ecosystem (sunlight, water, soil, air). What positive and negative effects do humans have on these abiotic components?

5 If you have not already done so, discuss the concept of ecological address. Finding out about the biological communities in an area is one step in determining your ecological address. Discuss the importance of preserving an ecological address, and ask students what they can do to continue providing a habitat for the organisms in their own ecological address. Challenge them to think of other native components they could add to their yards to make them even more welcoming to organisms.

EXTENSION ACTIVITIES

1 After the scale models are finished, have students find a creative way to represent their model. For example, they may want to take pictures or find pictures (online or in magazines) of the organisms they have in their garden and display them on a poster or website in an effort to show what the garden would actually look like when planted.

2 Choose one of the planting schematics and use it to create a wildlife habitat at your school. It does not have to be a large area, and it should be an ongoing project that students work on from year to year. In choosing the location, the students will need to consider how animals will get to the plot and be sure that animals that are attracted to the area are not in danger from automobile or foot traffic, for example. Once established, this garden can be a legacy that generations of students can tend and use to observe native organisms; this is especially attractive if students don't have ready access to these organisms around their houses or apartments. See the “That’s So Random: Island Biogeography & Stochastic Events” project for additional ideas.

3 Just as there are many plants that attract animals, there are also plants that animals avoid. Discuss ways that plants protect themselves from invasive species and predators; for example, some plants have poisonous fruit or some have textures that animals avoid. This is a good opportunity to revisit evolution and natural selection if you have discussed them previously in your course.

4 Create the sounds of biodiversity: Ask students to think about the sounds made by the plants and animals they observed (the buzzing of bees, the whir of a hummingbird's wings, birdsongs, rustling in the underbrush, etc.). Have students decide on ways to collect and record these sounds. Consider putting the recording on a class website and adding pictures and text to accompany it.

5 This project can provide scaffolding for the "Add Water and Stir: Building a Pond Habitat for Scientific Inquiry", "Terraria Hysteria", and "Cool Birds for Science Nerds: Bird Observations".


Mourning Dove

Websites on Backyard Habitats:
Ohio State University Extension Fact Sheet
http://ohioline.osu.edu/w-fact/0010.html

National Wildlife Federation
www.nwf.org/backyardwildlifehabitat/

National Audubon Society
www.audubon.org/bird/at_home/Plants.html

Website on Ecological Address:
National Audubon Society
www.audubon.org/bird/at_home/Explore.html

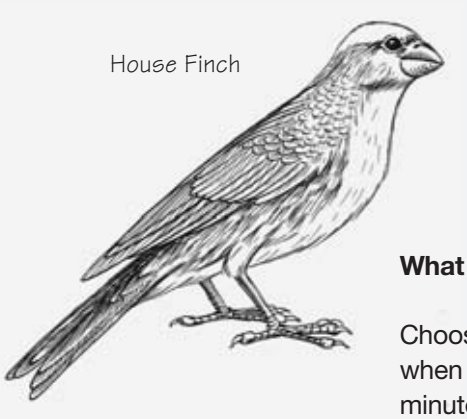
Websites on Native Species:
National Wildlife Federation eNature
www.enature.com

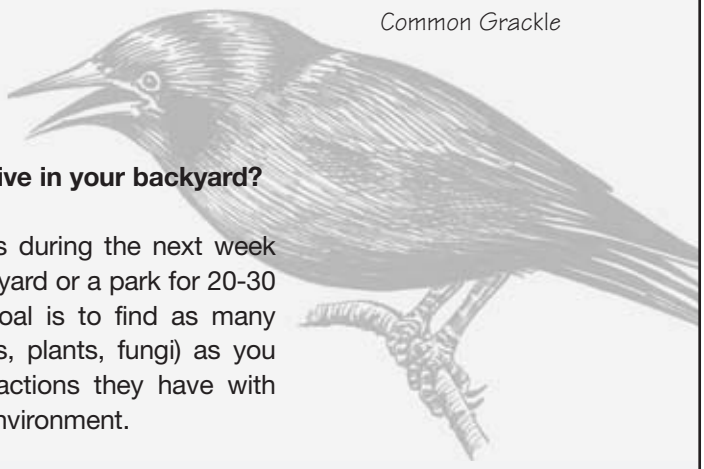
PlantNative
www.plantnative.org

SOURCES

National Audubon Society, Inc. *What's Your Ecological Address?* [2005; cited 15 October 2005]. Available from www.audubon.org/bird/at_home/Explore.html.

Handout: Backyard Bonanza


House Finch


Common Grackle

What kinds of organisms live in your backyard?

Choose at least three times during the next week when you will observe your yard or a park for 20-30 minutes each time. Your goal is to find as many different organisms (animals, plants, fungi) as you can and observe the interactions they have with other organisms and their environment.

Make a data chart to record your observations. Your data chart should include: time of day you are observing, weather conditions, organisms seen (include genus and species name — consult a guidebook to get these names or a description if you don't know names) and where the organism was seen. In addition, record any interactions you see between organisms or between an organism and its environment (for example, you may see a bee getting nectar from a flower, or birds drinking water from a stream).

did you know?

Graduates of the Animal Institute of Technology?

Have you ever wondered how your dog can anticipate the flight of a frisbee and make a flying catch without the aid of radar or a backfield coach? Ever spend any time studying the near-perfect 3-dimensional hexagons that make up a beehive and wonder how the little buzzers learned enough geometry to do that when you're still struggling with basics of the isosceles triangle? Ever really look at a beaver dam and wonder how those furry, long-toothed creatures learned that making the dam convex to the flow of the stream was more effective than a concave-shaped dam? If you have considered any of these mysteries, you're in the good company of wonderers who date back many centuries. For example, for over 2,000 years, scholars and mathematicians have marveled at the bee's ability to accept the hexagon as an ideal compromise of space and strength for their homes; it's almost as strong as a triangle and almost as spacious as a rectangle. There are several theories — but no agreement — on how the bee, the beaver, and the dog seem to know intuitively how to perform these feats.

There are just as many other theories and explanations about how and why millions of monarch butterflies make a pilgrimage to the same spot every year — yet none of them have ever been there before. Or how salmon can navigate thousands of miles of ocean and arrive at their spawning grounds without a sextant or compass to chart their route. The simplest explanation is simply to say, “It’s the nature of the beast” (or fish, bird, or insect) and let it go at that. But if you'd like to know a little more about some of these puzzles and the theories that explain them, you'll find some fascinating facts and some very interesting explanations described in scientific terms like *instinct, learned behavior, adaptation, hormones, neuroendrocrinology, entropy, order* and *chaos.*

Here are a few websites to start your own mystery tour:

The Math Instinct
www.mathinstinct.com

Animal Planet News
http://animal.discovery.com/news/briefs/20050905/smartbee.html

Good Vibrations: Honeycomb geometry helps dancing bees gather an audience
www.nature.com/news/2001/011206/pf/011206-4_pf.html

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Grade Level: MS

Type: Construction, observation

Topic: Terrarium construction

Terraria Hysteria

A terrarium can be used for many purposes in a science classroom. Teachers can use it as an introduction to the water cycle, photosynthesis and respiration, as well as a means by which to discuss the balance of nature. Students can practice organism identification and make observations of the plants and animals in the terrarium over an extended period of time.

INTRODUCTION

A terrarium is a clear container, partly or completely closed, used to grow plants and sometimes hold small animals like reptiles, spiders and insects. If set up properly, it is practically a miniature, self-contained, self-sustaining ecosystem. In a terrarium, the moisture (water) stays in balance through the processes of transpiration and photosynthesis. The plants release water into the air during transpiration and then use it during photosynthesis. Carbon (in the terrarium, mostly as carbon dioxide) and oxygen each remain balanced through the processes of photosynthesis and respiration.

In this activity, students will set up a terrarium, and then design and carry out their own experiments on factors that affect its balance. It can be used in the beginning of a class to introduce the scientific method or as a final project or way to synthesize many concepts from the entire course.

OBJECTIVES

After completing this activity, students will be able to:

1. design and execute a controlled experiment.
2. explain how a terrarium works, including how it can remain balanced for extended periods of time, as well as understand factors that disrupt its balance.
3. explain ways in which humans disrupt the balance of earth's ecosystems, including short- and long-term effects on the ecosystems.
4. explain how water, carbon dioxide, oxygen and nitrogen are cycled in the terrarium.
5. list similarities and differences between the terrarium and actual terrestrial ecosystems.

MATERIALS NEEDED

- One or more 10- or 20-gallon glass tanks
- Screen or plastic cover that allows in air but doesn't allow occupants to escape
- Various biotic and abiotic elements for the terrarium

CLASS TIME REQUIRED

Time required will vary, depending on size and complexity of terrarium.

MOTIVATION

Begin by asking students the following question: "How does an ecosystem remain balanced?" Students may give answers about photosynthesis and respiration, the water cycle, decomposition, or the food chain/food web. Accept all reasonable answers, as this is the introduction to the activity. Specifics can be discussed at the conclusion of the lab.

Next, ask the students what they know about terraria. Some students may have them at home or have had experience with them in other science classes. This is an opportunity to visit or revisit Latin roots, as terra- means "earth" and -arium means "place." Ask students to think of other prefixes that could be substituted for terra- (aqua-: water, insect-: insect, vive-: living, paluda-: marsh).

Ask students about the needs of the plants and animals inside the terrarium. Plants need sunlight, water and carbon dioxide. In addition, plants need nutrients like nitrogen and potassium, which they absorb from the soil. Animals need water, nutrients and oxygen.

Tell the students that a well-balanced terrarium can remain in balance for months with no need for intervention by humans. Ask them to describe what factors they might look for to assess whether or not a terrarium is in balance. Possible answers include: looking at the state of the plants with wilted or dead plants indicating lack of balance; looking for the presence of mold; smelling a rotten or foul smell; and looking for excess or inadequate amounts of water.

Pass out the student handouts and explain that in this activity they will be doing an investigation on factors that may affect the balance in a terrarium.

LESSON STEPS

Procedure

Design Phase

1. Students research the organisms that fill the niches in local ecosystems of producers, primary and secondary consumers, and reducers that make more or less complete cycles.

2. Students decide upon which organisms to include in their terrarium. Having three or four levels to the food chain is plenty, although students may wish to include more than one organism at a given level (e.g., more than one reducer). Let students discuss why it may be beneficial to have more than one species at a given level—especially at the reducer and producer levels.

A terrarium representing aspects of a pond or marsh could include: lizard's tail (*Saururus cernuus*), common duckweed (*Lemna minor*), algae/scuds (*Hyalella azteca), Daphnia, Gammarus,* planaria *(Procotyla fluviatilis*), and a large diving beetle (*Dytiscus*) larva or adult. Note that classes that conducted the "pHishing for Answers" project can use the microfauna from that experiment as the foundation of a terrarium that represents a local ecosystem.

Latin roots of the word "terrarium":
terra means "earth"
arium means "place"

To represent aspects of a Sonora basin, a terrarium could include desert lichens, devil cholla (*Opuntia stanlyi*), plains prickly pear (*Opuntia polycantha*), tuberous prickly pear (*Opuntia macrorhiza*), cactus longhorn beetle (*Moneilema gigas*), cochineal bug (*Dactylopius confusus*), and a giant crab spider (*Olios fasciculatus*) or a wolf spider (*Hogna carolinensis*).

A somewhat complex terrarium for a north-eastern forest floor could contain an oak log with common greenshield lichens (*Flavoparmelia caperata*), forest snails (*Anguispira alternata*), earthworms, North American millipedes (*Narceus americanus*), a black ground beetle (*Pterostichus melanarius*) or two, and maybe even a rabid wolf spider (*Rabidosa rabida*).

We strongly recommend focusing on arthropods as the top consumers and not including larger, complex organisms like reptiles or mammals. Their needs are also complex, and it is too difficult to maintain a proper environment in an enclosure the size of a terrarium.

3. Students investigate the abiotic needs (e.g., heat, moisture, and soil composition) of the terrarium.

4. Students prepare a calendar of responsibilities for the terrarium, such as who will clean, water, and monitor it, both when school is in and out of session. A well-built terrarium balanced, interacting biotic components should be largely self-contained; nonetheless it cannot be neglected. The students will be taking these organisms into their care and cannot shirk their responsibility.

5. After the students have designed their terrarium's ecosystem and thoroughly cleaned and prepped the tank, they can carefully collect its denizens. Firmly point out that students must not hurt the real environment or the organisms they collect when gathering their specimens to care for. And, of course, students need to make sure none of their organisms are endangered or dangerous before they collect them. Finally, teachers should make sure that the terraria are as tightly sealed as they need to be to prevent any inhabitants from escaping and making the entire classroom their ecosystem.

When populating the terrarium, students can use the Rule of 10s to determine roughly how much/many of each organism to include. Generally speaking, one level of an ecosystem can support 1/10 of its weight of the next higher level. For example, 10 ounces of grass can support 1 ounce of grasshopper. This is because about 90% of the energy at any given level does not transfer up to the next. Of course, students may wish to verify this as an experiment.

Unfortunately, while only about 10% of the energy (calories) transfer to the next trophic level, some chemicals do transfer—and concentrate tenfold. This means that a chemical like mercury that may not be present in sufficient amounts to significantly poison organisms lower on the food chain, can be intensified—or "biologically magnified"—in higher levels. Thus, those that eat other animals are more at risk of these poisonings than those who eat plants like fruits and vegetables.

6. After populating their terrarium, the students can monitor the changes in the number and dispersion of the organisms. For example, the initial colony may not represent what will ultimately become the climax community. Monitoring the changes can be very fun and informative.

Investigation Phase

After establishing a healthy terrarium, the students can use it as the basis of many observational and naturalistic studies. If they are careful not to disrupt the balance or harm the organisms (and not disturb the studies of others!), students can even manipulate parts of the terrarium for study.

Some examples of hypotheses that the students can test are:

- The number of primary consumers will rise and fall shortly before the number of secondary consumers do.
- The number of reducers will increase over the course of the terrarium's life until outside factors (cleaning, adding food, etc.) intercede.
- Except for X, Y, and Z abiotic factors, the terrarium is a fully self-contained ecosystem.
- Primary consumers are more active than secondary consumers.
- The Rule of 10s applies to our terrarium.
- When a top predator is temporarily removed (or dies of natural causes), X, Y and Z change in the terrarium.
- Consumers will use different predatory behaviors with different producers.

Students can also use the terrarium as a starting point to study photosynthesis and respiration, as well as the life cycles of the organisms.

Tips on General Terrarium Care:

1. If there is always water on the inside of the terrarium plastic or glass, or if you have mold growing, you have too much water. Open the lid for a day or so until it dries out. Then replace the lid. You may or may not be able to get rid of the mold.

2. If plants begin to wilt, there is not enough water. Add a little more and keep a close watch on it.

3. The following are recommendations for good plants and animals for terraria:

Plants	Animals
Moss	Crickets
Lichens	Sow bugs
Maidenhair ferns	Snails
African violets	Worms
Small begonias	Isopods

CLASS DISCUSSION/LAB DEBRIEF

Analysis Questions

1. What data were helpful in determining whether your terraria were in balance?

2. What did your results tell you? Give your answer in terms of the question you posed at the beginning of the experiment.

3. Compare and contrast a terrarium with an actual terrestrial ecosystem.

4. In what ways do humans upset the balance of ecosystems on earth? Give at least three examples.

5. After doing this experiment, what would you choose to investigate next with your terrarium?

Discussion

1. Have each group briefly explain the experiment they did and the results they obtained.

2. Discuss the various components of the terrarium and their functions. For example, the gravel is used for drainage, plants release oxygen into the air for organisms (plants and animals) to use in respiration, etc. The various functions and levels of detail you are able to discuss will depend on the ability level of your students and where this activity has been placed in the context of your course.

3. Ask students how ecosystems remain balanced. Use this to begin a discussion of the water cycle, as well as the carbon, oxygen, and nitrogen cycles as they occur in ecosystems.

4. Discuss ways in which humans upset the balance of ecosystems (deforestation, ozone depletion, pollution, and over-fishing are a few possible answers). Have students consider the short- and long-term effects of these actions. For example, deforestation leads to a loss of species and therefore a reduction in species diversity. In addition to their intrinsic value, there is also a good chance that some of these species could be used for medicine, etc. Furthermore, trees help improve air quality, prevent erosion, and keep soil fertile. They are an important part of the water cycle, releasing water back into the atmosphere through transpiration. This water ultimately falls back to the earth as rain.

Assessment

1. Students responsibly care for all organisms in their terrarium.

2. Given the class discussion material on the cycles, students explain how a terrarium works, by explaining and drawing how these cycles function in the terrarium.

3. Students design, conduct, analyze and report the results and conclusions of a scientific study.

4. Students express knowledge of the various elements needed to maintain a balanced ecosystem within the terrarium.

5. Students express knowledge of the needs, behaviors, etc. of the organisms in the terrarium as well as their larger role in the world around them.

EXTENSION ACTIVITIES

If students create two or more terraria representing the same ecosystem, they can vary the exact organisms in each to see how these differences affect the overall ecosystem.

ADDITIONAL RESOURCES

Notes on ecosystems and their components
www.mansfield.ohio-state.edu/~sabedon/biol1535.htm

Community and Ecosystem Dynamics
www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookcommecosys.html

The Concept of the Ecosystem
www.globalchange.umich.edu/globalchange1/current/lectures/kling/ecosystem/ecosystem.html

There are several fine "organism menus" online. Some, like the one listed below, even give common relationships of an organism with others in its ecological community.

Fairfax County Public Schools Organism Menu
www.fcps.k12.va.us/StratfordLandingES/Ecology/mpages/organism_menu.htm

Interactive Graphic Representations of Food Webs
www.foodwebs.org/index_page/ wow2.html

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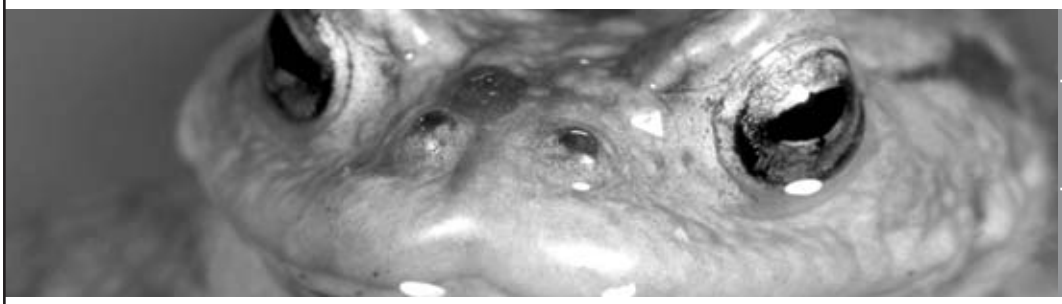


Grade Level: MS, HS

Type: Lab

Topic: Building an environment for science activities

Add Water and Stir: Building a Pond Habitat for Scientific Inquiry

Educators face many financial and logistical barriers in their efforts to provide students with field experiences that support authentic, inquiry-based explorations in natural habitats. One way to break down these barriers is to bring the habitat to the school by creating a schoolyard pond that can meet the needs of teachers and students for many years.

INTRODUCTION

Creating and maintaining a pond ecosystem at school generates many opportunities for students to enjoy hands-on scientific inquiry—the kind of stuff that really inspires careers in science. From exploring animal behavior and interactions to investigating water chemistry to drawing and reflective journaling, the addition of a pond can span all disciplines and many generations of students. Moreover, the process of building and maintaining a pond offers opportunities for teacher collaboration and a great demonstration of authentic student learning. In addition, students can construct a simple, above-ground pond for as little as $100, depending on the size and materials used. This activity outlines considerations for teachers prior to building a pond, explains the pond construction process, and offers suggestions for student activities. In addition, sources for more extensive pond construction are included.

CLASS TIME REQUIRED

Time required will vary, depending on size and complexity of pond.

PRE-PLANNING PHASE

Use these questions as a guide as you begin the planning process for the pond.

1 Who will build it?

The best way to get students invested and interested in a schoolyard pond project is to include them in all aspects of the planning and construction. Planning the pond with students is an entire set of lessons/activities in and of itself, and is not fully addressed in this document. However, the process of planning and implementing the pond is an excellent oppor-tunity to involve your students in the holistic approach to the project, providing them with a stronger feeling of ownership in the project overall. Consider the following ideas:

(a) Have students pick the location, based on criteria that you determine along with the students.
(b) Have students determine how much soil and water will be needed to fill the pond.
(c) Have students figure out what types and quantities of plants, animals, and decom-posers will make the pond a sustainable ecosystem.

There are many excellent online resources readily available, so you may be able to put older students entirely in charge of the design and construction. If your school offers science electives, consider offering a semester elective dedicated solely to pond planning, construction, and study. You may be able to enlist the help of students in a science or outdoor club. Consider the help that parents can offer as well, and use parents' knowledge about construction, local flora and fauna, etc. to show students the knowledge resources right around them. Classes can also work with local conservation societies.

2 Is this an opportunity for collaboration with other teachers?

As teachers, we frequently ask our students to collaborate but may not collaborate often enough ourselves. Collaboration is an excellent way to learn from other teachers and create lasting relationships that strengthen the school community. A pond project offers many ways to work with other teachers in the planning and construction phases, as well as in the use of the pond for inquiry-based science projects for students.

For example, if you are a biology teacher, consider collaborating with a chemistry teacher who can use the pond water for various water chemistry investigations. In addition to collab-orating with science teachers, teachers in other disciplines such as English or art may have ways to incorporate the pond habitat into their curricula.

Collaborating with a teacher one grade above or below you would allow students to work with the pond ecosystem for two years, perhaps in different contexts. If you collaborate with a teacher from a different grade level, consider setting up a mentoring program so older students can teach and work with younger students.

3 What is the lifespan of the pond?

This is an important consideration because it may affect the type of pond you decide to construct. An above-ground pond allows you to keep the pond in place for as short or as long a time as you wish. Perhaps you only want the pond in place for one unit of study, or you would like new students to recreate the pond each year. Perhaps you live in an area that is very cold in the winter and would like to disassemble the pond during the winter months. All of these are reasons to build an above-ground pond. On the other hand, if you want the pond to be a permanent fixture at the school, one that can be used for many years and that will allow for successive pond studies, consider installing an in-ground pond. If you decide to go this route, it is important that the maintenance and upkeep on the pond can be continued even if you leave the school.

It is also important to consider the lifespan of the pond in terms of the impact on the animals using the pond. It is best to stock the pond with locally caught ditch and pond animals. When the time comes to break down the pond, students can collect the animals with nets and using buckets for transport, relocate the animals to their original habitat(s), especially the aquatic invertebrates and amphibians.

4 How will the pond be used?

Decide how the classes will use the finished product. Are your students going to use it for one particular unit, or will it be an ongoing study, perhaps a semester or a yearlong project? Consider the ways a pond can be used to touch on many of the national science standards at all grade levels. Having a plan for its use will be helpful not only for the students, but for generating interest and approval from the school administration. The schoolyard pond will provide ample subject matter to help teachers infuse science with language arts, math, and social studies. And by using ecological concepts demonstrated in a small pond, teachers can help their students use this knowledge to better conceptualize large-scale natural communities, including lakes and rivers, and the role they play in region-scale ecosystems. All life is connected, and most of it by water.

Consider the following activity, which briefly explains how the pond can be used for interdisciplinary study. This activity incorporates math, science, and social studies.

Begin by asking students to construct food chains that occur in your pond. One potential food chain might consist of micro-algae that are eaten by *Daphnia* that are, in turn, eaten by small fishes including mosquitofish, killifish, or shiners whose wastes feed the algae. In turn, these small fishes are eaten by larger fishes, including sunfish and young bass. In a natural pond ecosystem, one may find an adult largemouth bass as a top-level predator that eats the sunfish and the younger bass; and even though a small schoolyard pond may not support a largemouth bass, it serves as a connecting point for students to other, larger ecosystems they may study.

From this point, you can introduce the concept of an ecosystem pyramid to demonstrate the amount of energy required to climb up one trophic level in the food pyramid. For example, in order for a small fish (like a mosquitofish) to add 1 g of mass to its body, it must eat about 10 g of *Daphnia*, which in turn had to eat 100 g of algae. You can have students do the calculations to figure out how much algae is necessary to support the growth of a mid-level fish such as a 1 kg sunfish and on up to a top-level predator, such as a 5 kg largemouth bass. In order to grow 1 gram of mosquitofish, 10 grams of *Daphnia* are required. To grow a 1 kg sunfish, at least 10 kg of mosquitofish are required. In turn, the mosquitofish had to eat at least 100 kg of *Daphnia*. Add a 1 kg bass and the formula grows to include 10 kg of sunfish to feed the bass; 100 kg of mosquitofish to feed the sunfish and 1000 kg of *Daphnia* to feed the mosquitofish. This, of course, lends itself to a great science project in itself. For example, instead of telling students what weight of *Daphnia* small fish must eat, have the students investigate to learn the answer themselves. The students that make these investigations can then give their recommendations to other students (in another class, perhaps) to inform them on feeding or caring for the pond.

This is a good way to illustrate the importance of the organisms at the lower levels of the food chain and the need for their protection. You can also discuss the concept of carrying capacity and even discuss why your pond cannot support a predator such as the largemouth bass. Using the largemouth bass in your food chain allows you to make the link between science and the economy, as the bass fishing industry is a multibillion dollar industry in the United Sates. You can discuss the pros and cons of fish farms, discuss and investigate ways to increase revenue in the bass fishing industry, as well as discuss potential problems that the industry may encounter in future years.

5 Do I need approval?

Most likely you will need some level of approval from your administration before constructing the pond. In addition, be sure the grounds maintenance personnel at the school are aware of the pond and understand how it will affect their normal routines. For example, having fertilizer or other chemicals enter the pond will be detrimental to the pond ecosystem. Collecting aquatic animals from the wild often requires a permit from a state agency. This is usually easy to do with a call to the main office (often in the state's capital) and is another teaching opportunity for the classroom. Getting familiar with state and federal wildlife laws will help students to learn about environmental stewardship.

6 How will it be maintained?

Maintenance of the pond is ongoing and can be year-round. Who will take care of it on a weekly basis? Who will take care of it during school vacations and over the summer? You may decide to put a group of students in charge (from a club or an elective) or rotate maintenance duties through your classes. Ultimately, you will be in charge of the maintenance so be sure to have a plan in place. Fortunately, once the pond is established, the upkeep should be minimal—especially compared to what the students can learn and teach each other.

MATERIALS NEEDED

- Container (pre-formed pond liner or plastic wading pool; flat bottom, 16-18 inches deep, 100 gallon minimum)
- Carpenter's Level
- Gardening tools (shovel, rake, etc.)
- Cushioning material (sawdust or mulch)
- Garden soil
- Mud
- Aquatic plants
- Aquatic animals

The materials listed are for the installation of an above-ground pond. Materials can be purchased at local hardware stores as well as from biological supply companies that often offer pond kits with everything included to set up a pond, if you prefer that approach. You can purchase aquatic plants and animals at pet stores or from biological supply companies, as long as effort is made to use native species to enhance the lesson. Of special note, Carolina Biological Supply Company sells a 100-gallon pond set for use indoors or outdoors that is very attractive. In addition, if you are interested in more extensive pond construction, such as adding pumps and filters or building an in-ground pond, detailed instructions can be found at the following site:

National Gardening Association's Kids Gardening
www.kidsgardening.com/growingideas/projects/june04/pg1.html

PLANNING AND CONSTRUCTING THE POND

1 Choose the site for the pond. Check with your school administration to determine if there are preferred places for the pond. You need a level site with few or no trees because falling leaves will alter the chemistry of the pond water (if time permits, a class could study this first to see if leaves would negatively impact the ecosystem). Because you will have to fill the pond initially and periodically to compensate for evaporation, your pond should be close to a water source. The pond needs at least five hours of sun a day. However, too much sun can cause the water temperature to fluctuate widely, a problem for the pond ecosystem. Some daily shade is optimal, especially if your pond is small. Enlist the help and ideas of your students in choosing the site.

2 If you are putting your pond on a hard surface like concrete, place mulch or sawdust underneath the liner to provide a cushion and to help keep the liner stable.

3 Prior to stocking the pond with plants and animals, do an exploration of native and exotic species. You should only be adding native species to your pond. Have students do research to find out what species of plants and animals are native to your area and would be suitable for the pond. This is an opportunity for students to learn about invasive and exotic species and the problems they bring to native ecosystems.

4 Before adding water to the pond liner, fill it with mud from a local pond mixed with clean play sand (1:1 mixture) to a depth of 2-4 inches. Consider taking a class field trip to harvest the mud. When gathering the mud, you should scoop it from the top few inches of the pond floor. This mud will load your pond with microbes and algae, necessary components of a pond ecosystem. The mud also provides an anchor for plants. If you are going to have plants that stand above the water, create areas where the soil is deeper, perhaps on the sides of the liner, or in the middle to create an island effect.

5 If carrying that much mud to the pond is problematic, you can lay a 1–3 inch base of clean play sand down first, and then cover that with only 1 inch of mud. If you are unable to harvest any mud, your class can use only garden soil instead, but the process of the pond becoming a more stable and native environment will move more slowly.

6 Add water to the pond liner. Let it sit for 5–7 days before adding any organisms to the pond. This will allow chlorine to dissipate from the water because chlorine can harm aquatic organisms. Also, allowing the water to settle will provide time for the pond to start going through its natural nitrogen cycle. Ammonia from decomposing muds will be reduced to nitrites by bacteria, and these nitrites will be further reduced into less harmful nitrogen by denitrifying bacteria. Aerators and wind action that breaks the water's surface will enable excess nitrogen gas to escape the water.

7 Plants should cover 50–75% of the water surface to help control algae growth and keep the water temperature stable. Investigate which native plants would work well. Be sure to consider submergent plants, like elodea and stonewort, as well as floating plants, like lily pads. Emergent plants, such as cattails, help to attract insects.

8 If you decide to add fish, the proper ratio is 1 inch of fish per 5 gallons of water, if your water does not circulate. Be careful not to overload the pond, as excessive waste causes nitrates to build up, causing algal blooms, which use up the dissolved oxygen and suffocate the fish and other animals. Wait about two weeks after you have added plants to add the fish to the pond. Minnows and mosquito fish (*Gambusia sp.*) are native to North and Central America, and so they are good choices. They also control mosquitoes.

9 Scavengers such as snails are a necessity. If you have brought in mud from a local pond, you have most likely imported snails. If not, you should add native snail species.

POND MAINTENANCE

1. If you have fish in the pond, the pH should be kept between 6.5-8.5. Water testing kits can be purchased at a local fish or pet store.

2. Remove any dead leaves that accumulate in the pond, as they will lower the pH of the water.

3. Remove and replace 20% of the water each month to keep the pond healthy. Be sure to add only dechlorinated water to the pond.

4. If you live in an area where the water in the pond will freeze in the winter, set up an indoor aquarium where the fish can live during the winter.

5. A pond like this can be a great way to showcase student learning. Consider taking photos and highlighting what your classes are doing in your school newsletter. (This can even help spread the message of the need to create healthier environments.)

Be careful not to overload the pond, as excessive waste causes nitrates to build up, causing algal blooms, which use up the dissolved oxygen and suffocate the fish and other animals.

STUDENT ACTIVITIES

The potential uses of the pond are endless. Here are a few suggestions.

1. **Pond observations.** Have students keep a pond journal in which they record what they see and hear. In addition, water and mud samples can be taken in order to identify organisms. Provide students with hand lenses, microscopes, and a pond organism identification book. Do behaviors that they see or hear change at different times of the day (or year)? Have students pick key species of animals and plot the variations they observe.

2. **Organism adaptations.** As part of a unit on evolution and natural selection, use the organisms found in the pond to investigate adaptations.

3. **Population studies.** Students can keep track of population changes throughout the year for different species. Students can make charts and graphs of the populations.

4. **Water chemistry investigations.** Students can monitor water temperature, pH, and levels of various chemicals, such as nitrates and phosphates, throughout the year.

5. **Food webs/relationships.** Study the food web that exists in the pond as well as the interrelationship between plants, animals, scavengers, decomposers, and the abiotic components of the pond. This can lead to a discussion of ecosystems, energy flow, the cycling of matter, the pyramids of biomass and energy, and carrying capacity.

6. Student investigations. Students can collect pond water and create mini-biospheres for observation and scientific study. For a complete description, see ww.kidsgardening.com/growingideas/projects/june04/pg2.html#bottle

   This is a wonderful opportunity for students to design and perform their own experiments.

7. **Macroinvertebrate sampling.** Certain invertebrates are considered indicator species for healthy and unhealthy aquatic environments. See "pHishing for Answers" for examples. For a detailed explanation and lesson plan ideas, see www.ncsu.edu/sciencejunction/depot/experiments/water/lessons/macro/.

8. **Life Cycle studies.** Study the life cycles of organisms in your pond such as the frog or mosquito. For lesson plans on the mosquito life cycle activity, see www.woodrow.org/teachers/bi/1997/mosquito/

9. **Balance of Nature/Preservation.** Use your pond ecosystem to represent a microcosm of the larger world. Have students determine factors that will keep the pond healthy, as well as factors that will upset the balance of the pond.

SOURCES

1. National Gardening Association, "Creating a Pond Habitat," National Gardening Association, www.kidsgardening.com/growingideas/projects/june04/pg1.html (accessed November 4, 2005).

2. True Value (truevalue.com) for an article on building a pond (type pond into search box), and to locate local stores for supplies (accessed November 17, 2005).

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: HS, AP

Type: Calculation

Topics: Habitat Fragmentation, biodiversity

That's So Random: Island Biogeography & Stochastic Events

Random—or stochastic—natural events such as fires, disease, or genetic changes can have significant impact on species diversity, particularly in more isolated ecosystems such as small islands. This project will help students see concretely how and why human intrusions to available habitat create "habitat islands" where species are vulnerable to local extinction.

INTRODUCTION

Edward O. Wilson of Harvard University believes that the number of species on an island at any given time is the result of equilibrium between extinction and colonization. Larger islands that are near the mainland can support a greater number of species because migration from the mainland is easy and the threat from stochastic (random) events is distributed over a greater area. These are more favorable to colonization and long-term stability.

In contrast, smaller islands can support fewer species and are more vulnerable to stochastic events that often cause local extinction of resident species. These species are then replaced by other species that emigrate from the nearby mainland. There are three types of stochastic events which affect the small island wildlife populations:

- **Environmental stochasticity:** natural disasters such as fire and flood and year-to-year fluctuations in weather
- **Demographic stochasticity:** random events which affect births and deaths in a population. For example, if ten birds remain on an island and only three of the surviving offspring are female, future reproduction will be hindered.
- **Genetic stochasticity:** events that affect the passing of genes from one generation to another. For example, a decreasing population increases the likelihood of interbreeding that results in unhealthy offspring and a weakening gene pool.

Human intrusion creates its own brand of random events when parking lots, roads, buildings, etc. split habitat into fragments of land called "habitat islands." The distance between these islands makes it difficult for wildlife to migrate from one island to another. An aerial view of most counties in the United States will show how farmland, roads, houses, and other human development chop up the forestland into fragments. The perimeters of these small fragments create a greater amount of edge compared to the previously larger, unbroken pieces of habitat. Edge is where two habitats meet, and the first hundred meters of edge is generally open to predators and invaders. For example, the cowbird is a nest parasite that lays its eggs in the nests of other birds that live on forest edges. The cowbird chicks grow faster than the nest-builder's chicks that are then forced out of their own nest. Fragmentation increases the amount of forest that is susceptible to these predators and parasites.

Using the Species-Area Relationship Equation, students can determine how changes to available habitat will affect the number of species in a given area and how smaller, isolated populations of animals are more likely to be threatened by stochastic (random) events. Then, by surveying the number of species in schoolyard or neighborhood plots, they will test plots in the schoolyard or neighborhood to test Wilson's and others' theory of island biogeography.

Edge is where two habitats meet, and the first hundred meters of edge is generally open to predators and invaders.

OBJECTIVES

After completing this activity, students will be able to:

1. better understand the impact of habitat fragmentation on biodiversity.
2. provide background information for students to do the Shannon Diversity Project.
3. quantify the loss of species resulting from habitat destruction.
4. use the Species-Area Relationship Equation to determine how changes to available habitat will affect the number of species in that area.
5. describe how smaller, more isolated populations of animals are more likely to be threatened by stochastic (random) events.
6. survey the number of species in plots in the schoolyard or neighborhood to test the theory of island biogeography.
7. write a report making recommendations concerning what areas of their region should be preserved if the maintenance of biodiversity is the primary goal.

MATERIALS NEEDED

- Meter sticks
- Calculator
- Graph paper
- Specimen containers
- Markers
- Thermometer
- Hand lens
- Trowels
- Newspaper
- Tray
- Hammer
- Stereoscopes
- Moisture probe
- String

CLASS TIME REQUIRED

Two 40-minute class periods

SPECIES-AREA RELATIONSHIP

The relationship between the area of a habitat island and the number of species living on that habitat island can be expressed by the following equation:

$$S = CA^z$$

S	number of species		C	fitted constant
A	area of the island		z	fitted constant

The variable S can be thought of as the number of species on an island or isolated patch of habitat. The exact meaning and values of C and z are debated in the literature because it is determined somewhat subjectively through sampling and observation by the researcher. In other words, it is a judgment call. C and z depend generally upon the type of ecosystem (arctic versus temperate, lots or rainfall versus arid, etc.) Also, C varies depending on the diversity within the group (insects will have a much higher C value than mammals). The ranges of z are typically from .15 to .35 and depend on the kind of organisms being considered and the ability of an organism to disperse. When species are able to move easily from one place to another, the z value is low. For example, because birds can fly, they have a low z value. The equation is logarithmic (and so, not linear) but a useful rule of thumb is that when an area is reduced to one-tenth its original size, the number of species will drop by one-half.

The first mathematical description of the Species-Area Relationship was proposed by Arrhenius in 1920 and modified by Gleason in 1922 and an excellent illustration of the derivation of the equation may be found via the Internet at: www.helsinki.fi/~ihanski/Articles (click on Ecol Lett 2003. March 10, 2005).

Let's see an example of how this works.
If z (the exponent) is approximately 0.33 and the constant C = 7, then we get:

If Area (A) =	Then Species Number (S) =
1 hectare	9 species
2 hectares	11 species
5 hectares	15 species
10 hectares	19 species

You can see that this relationship predicts that to double the number of species, one must increase the area by about 10 times.

LESSON STEPS

1 Ask students to predict the percentage of land in their county being used for human purposes such as farming, roads, buildings, etc. If possible, ask students to cite examples of recent human development in their region.

2 Ask students to brainstorm the possible impacts that human development might have on animal welfare. Specifically, ask students to consider the rate of development and total area of land used for human purposes.

3 Ask students to find an aerial photograph of their county on the Internet. www.terraserver.com, www.terrafly.com, and http://earth.google.com/ are excellent for this purpose.

4 Ask students to study the photographs and describe the areas that are likely to contain the greatest number of species. (The largest contiguous areas that are not isolated from other areas are likely to contain the greatest number and diversity of species.)

5 Ask them to explain their reasoning.

6 Break students into groups of four or five.

7 Distribute copies of the Fictional Habitat Before and After Human Development 1890-1990 diagram and ask students to discuss and answer the four questions that accompany it.

8 Have students calculate the ratio of perimeter (edge) to area of boxes 1, 2, and 3 of the reproducible. Ask students to discuss what the results of this calculation mean.

9 Ask students to apply the Species-Area Relationship, assuming that they will use the areas they calculated for the boxes in step 8, where z (the exponent) = 0.33 and the constant C = 7. If time allows, illustrate the evolving nature of scientific knowledge and the "art of science" by talking to students about the fact that the assigned values of C and z are not yet established with great precision by scientists.

10 Ask student groups to design and implement a practical method for testing the general prediction of increasing species richness (number of different sorts of species) with increased habitat island area and proximity to larger islands. Ask them to determine what factors they think determine or influence the basic pattern of increasing species richness with increased area. See steps 6–9 for a general recommendation for this method. Ask students to delegate these tasks among group members.

***See the "Vive la Difference: Biodiversity and the Shannon Diversity Index" project for details on how to calculate species abundance and diversity, as well as for more detail on this method.**

11 Ask students to select areas in the schoolyard or neighborhood, one of which is significantly smaller in area and/or more isolated than the other, and using a meter stick, twine, and markers, mark off the two different square meter plots taken from the same ecosystem. Again, one plot should be part of a smaller, more isolated habitat and the other plot should be part of a larger, uninterrupted habitat.

12 Ask students to sketch the square meter plot (top view). Include prominent features. Record date, time, and weather conditions.

13 Ask students to observe, identify, and count flora and fauna community and also collect samples. You may wish to ask students to focus on just a few taxonomic groups. Plants may be best since they are easier to count and do not move.

ASSESSMENT ACTIVITY

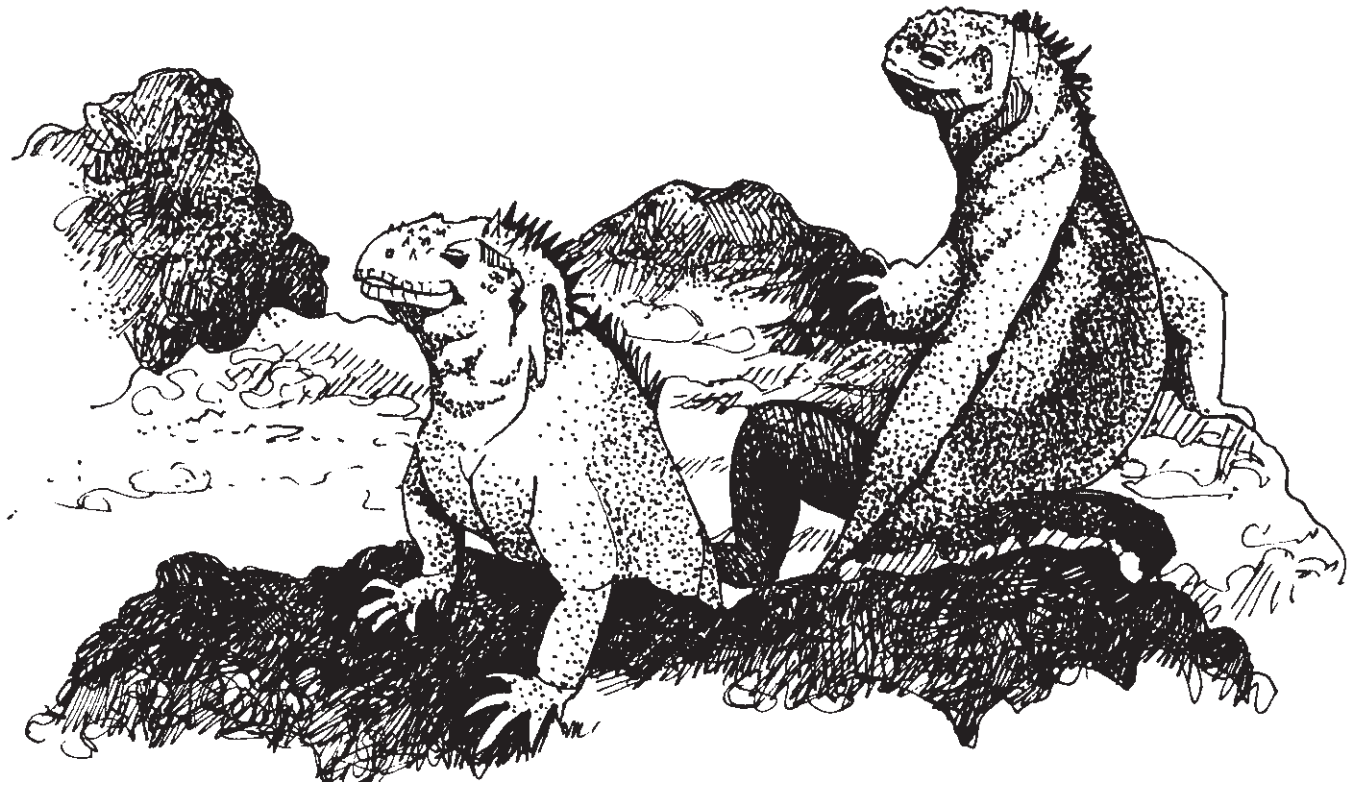
1. Using the data, calculate the Species-Area Relationship for each schoolyard or neighborhood plot. Calculate frequency, relative frequency, abundance, density, relative density, dominance, relative cover, importance value, and diversity for plants and soil animals.

2. Ask students to develop criteria based on the calculations in step 1 and other research for deciding which areas in their region should be preserved.

3. Ask students how they would recommend handling requests to convert some of the plots for human use (parking lots, buildings, roads etc.), especially given the need for maintenance of biodiversity.

4. Ask students to write a report that describes their qualitative opinions that are supported by their quantitative assessments (Species-Area Relationship and other calculations) and rationale.

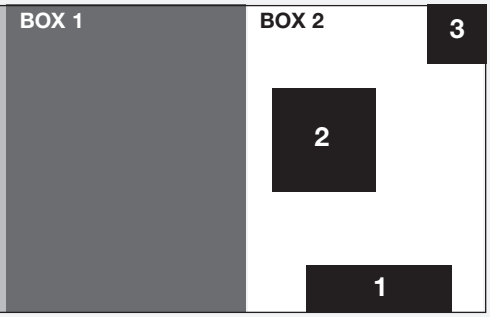
5. In a two-minute presentation, ask students to justify why their recommendation would be beneficial to biodiversity in the region.



FICTIONAL HABITAT BEFORE AND AFTER HUMAN DEVELOPMENT 1890-1990

The gray box 1 represents uninterrupted habitat in 1890.

The black squares in box 2 represent what is left of the habitat by the year 1990, with the white area having been converted to human use.



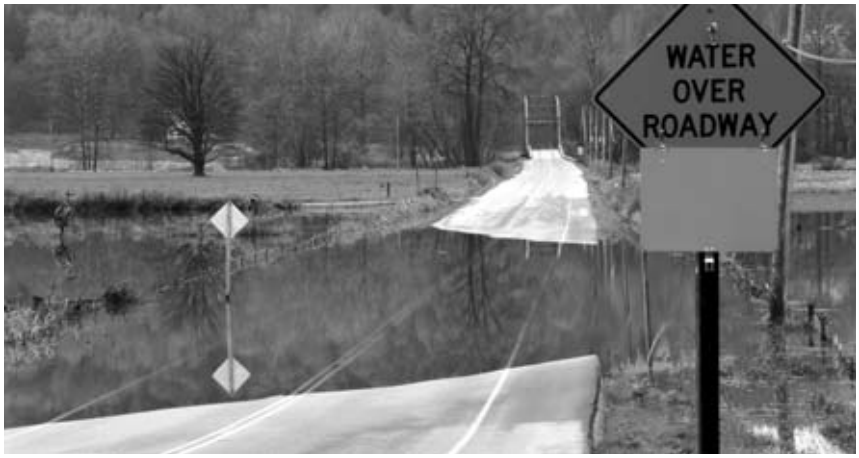
- Of the three areas, which is predicted to have the most species both before and after isolation and why?
- What would you recommend to increase biodiversity?
- How could you utilize quadrants to test the theory behind the Species-Area Relationship?
- Which area would be more likely to suffer from the consequences of genetic, demographic, and environmental stochasticity and why?
- How accurate is the Species-Area Relationship Equation in your opinion? Can you think of anything else that should be considered before using the equation?

did you know?

Wildlife Corridors

The constant fragmentation and shrinkage of wildland areas are very serious problems to the diversity and health of animal populations right around us. Areas which once were connected and that allowed wildlife to travel easily from one area to another are now interrupted or even replaced by roads, community growth, and sprawl. There is a very serious threat to many species—including humans. In addition to the erosion of a healthy, diverse environment and the staggering tolls imposed on both wild and domestic animals, animal-vehicle accidents cause human deaths, injuries, and over a billion dollars in damage every year. One solution to this problem is to reconnect the wildlands (the largest of which are called Core Reserves) with passageways, or greenbelts, that allow animals to move naturally from area to area as easily as humans use the interstate highway system. This helps restore the natural balance and maintains healthy populations of animals large and small. Of course, this sounds much easier than it really is. Eco-passages cost money and can require rethinking how roads and bridges are designed. In addition, people and animals view roads differently, and we are still learning how to best build underpasses, overpasses, and bridge extensions in order to link habitats in animal-friendly ways.

Happily, we are learning not only how important this effort is, but how to achieve it successfully in places like US 441 in Florida, Highway 164 in Wisconsin, and I-90 in Washington State. Organizations like the Sierra Club and The Wilderness Society are working together to help design and create a network of mega-linkages between the core reserves and a smaller network of linkages in each region of the country.



Check out:

Conservation Economy
http://www.conservationeconomy.net/content.cfm?PatternID=21

National Geographic News
http://news.nationalgeographic.com/news/2004/05/0512_animaloverpasses.html

I-90 Wildlife Bridges Coalition
http://www.i90wildlifebridges.org/

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Grade Level: HS, AP

Type: Calculation

Topic: Biodiversity and how it is measured

Vive la Difference: Biodiversity and the Shannon Diversity Index

Biodiversity is an important concept for students (and responsible citizens) to understand. Although the term is often used, it is not as often correctly or concretely understood. This project presents students with biodiversity as a measurable phenomenon. It also draws parallels to students' intuitive and direct observations to bring the concept home.

INTRODUCTION

"Biodiversity" is one of the most popular buzzwords used in ecology and conservation today. Most people believe that humans should attempt to conserve the planet's biodiversity. But what does "biodiversity" really mean?

There are three generally accepted components of biodiversity:

- ***Genetic diversity*** refers to the variety of genes that exist in individual organisms and within populations of those organisms. As a general rule, species with the most genetic diversity have the best chance to survive changes in the environment.
- ***Ecosystem diversity*** refers to the variety of ecosystems that exist in a region. Over the past two centuries, the ecosystem diversity of North America has been changed greatly as humans converted natural ecosystems into areas for farms, homes, businesses, schools, roads etc. As with genetic diversity, a region that contains more ecosystems is better able to support the existence of organisms through this and other forms of environmental change.
- ***Species diversity*** refers to the number of different species (richness) and total number of individuals of a species (abundance). The loss of one species can cause major disruption of an ecosystem that has few species (low richness). Ecosystems that are rich (high species diversity) are usually more stable and so are the species that live within them.

OBJECTIVES

After completing this activity, students will be able to:

1. conduct an assessment of different plots on the school grounds or in the neighborhood in order to determine relative diversity.
2. calculate the Shannon Diversity Index of their plots.
3. draw bar graphs, comparing richness and abundance of each plot.
4. understand biodiversity and one way that it may be measured

MATERIALS NEEDED

- Meter sticks
- Calculator
- Graph paper
- Specimen containers
- Markers
- Hand lens
- Dichotomous keys

CLASS TIME REQUIRED

Four 40-minute periods

PREFERRED HABITAT OF THE BARRED OWL

Every species has a unique set of environmental conditions that it needs for survival. Even without habitat destruction, competition forces all organisms to occupy niches that are less than optimum for survival. Among the most important of these niches are the *fundamental niche* and the *realized niche*.

- The *fundamental niche* includes all the conditions needed for a population to reproduce itself.
- The *realized niche* is the actual set of conditions that an organism contends with at a particular time and place.

Human activities tend to reduce the probability that all conditions necessary for survival can be found at the same place at the same time. Because human activities tend to simplify or reduce the complexity of ecosystems, the *realized niche* becomes smaller and smaller and organisms struggle to survive.

For instance, the barred owl (*Strix varia*)—a native of the Northwest, across southern Canada, and throughout the eastern states—prefers a breeding ground of relatively heavy, mature forestland that can range from upland woods to lowland swamps. But for roosting, it requires a wooded area of densely foliaged conifers or deciduous trees that provide year-round cover—preferably oak stands or mixed stands of oaks and white cedar (*Thuja occidentalis*). The habitat should also be near open land that provides forage and it should be relatively free of dense understories of brush and herbaceous plants. The lack of brush makes for excellent hunting since the owl can see its prey more easily on the forest floor. Further, dead or dying trees also provide habitat for mice and squirrels that are an important part of the owl's diet. All of these factors show that the barred owl requires a highly complex forest habitat that is partly dependent on old growth trees for nesting. And it is this complexity that is creating a struggle for survival in the southeastern part of its range, as community growth and lumbering have led to habitat destruction and fragmentation. The example above deals with just one resident of a complex ecosystem. So how do we go about defining the complexity or richness of an entire ecosystem? We can start by using the following formula for assessing the richness and abundance quantitatively.

Barred Owl

DETERMINING BIODIVERSITY QUANTITATIVELY

A comparison of two different ecosystems allows us to understand species diversity in relative terms. The simplest—and the least scientific—way to do this is to make a rough "naked eye" judgment of species diversity by simply observing and counting the species that exist within two geographic areas. These data can then be compared and some general conclusions drawn. For a more detailed and accurate measurement of species diversity, students should calculate a diversity index. The Shannon Index uses the relative proportion of individuals in each species to calculate a value, H, that ranges from 0 to infinity. Low H values correspond to low biodiversity. Here's how the index is used:

$H = -\Sigma [(N_j/N)[\log(N_j/N)]]$

Where N_j is the number of individuals in species of a particular type. N is the number of individuals in all species. Σ (Sigma) is the summation sign and it indicates that you should sum the values of $(N_j/N)\log(N_j/N)$ for every species in the system.

* As you read the next paragraph, please refer to the two ecosystems in the table within the handout below entitled **Richness and Abundance of Two Fictional Ecosystems.**

Both ecosystems have the same number of species and the same total number of organisms, but the individuals in Ecosystem #1 are much more evenly distributed among the ten species. Because most of the individuals in Ecosystem #2 are of only one species (species A), many people would say that Ecosystem #1 has more biodiversity than Ecosystem #2. However, biodiversity has two components: richness and abundance. A system such as Ecosystem #2 can have great richness but still lack great biodiversity. Since the overall number of species present does not always give an accurate indication of the relative biodiversity of a system, ecologists use diversity indices to describe both richness and abundance.

Here is the calculation for the value for H using the abundance data for species A through J in the given table below:

Ecosystem #1:
H = -[(10/100)log(10/100) + (10/100)log(10/100) + (10/100)log(10/100)] = 1.00

Ecosystem #2:
H = -[(91/100)log(91/100) + (1/100)log(1/100) + (1/100)log(1/100)] = 0.217

The Shannon Index assigns Ecosystem #2 a lower biodiversity value than Ecosystem #1, as intuitively predicted. The Shannon Diversity Index is very useful to ecologists because it permits a standardized comparison of biodiversity between communities and ecosystems.

LESSON STEPS

1 Divide students into three or four groups.

Ask groups to:

2 Discuss the relative biodiversity of their region compared to other areas of the world such as the Sahara Desert or the Amazonian rainforests.

3 Discuss the values of biodiversity (ecological, scientific, commercial, aesthetic) and why these are important to their own region.

4 Seek out information concerning the habitat requirements of an animal species of interest which might be found in their region. See the list below for potential sources of this information.

5 Invent a method that can be used to compare the biodiversity of two different areas of a selected ecosystem in the region.
- If students need help, tell them that they could conduct an inventory of all of the species of trees in a particular area plots (quadrants).

6 Review the use of dichotomous keys for identifying species.

The dichotomous key is a method/instrument created by taxonomists and employed by scientists for identifying unknown organisms. It is a document or book constructed of a series of couplets (coupled statements), each consisting of two separate statements. Think of it as a funnel moving from broad to increasingly more narrow identifying characteristics. Ultimately, the statements will home in on the species being examined. For example, a class of students can be broken down by: male versus female (broad characteristic), then eye color (less broad characteristic), then height (narrow characteristic).

The following interactive websites will help students to understand dichotomous keys:

1. National Park Service: How to use a Dichotomous Key www.nps.gov/goga/parklabs /library/plantkey.htm

2. Michigan State University: Tree Identification Key http://forestry.msu.edu/extension/ExtDocs/Identkey/opening.htm

The following is an abbreviated example involving trees:

couplet 1. Trees with broad leaves
1. Trees with needles 2 (this statement indicates that you go to couplet "2")

couplet 2. Needles in groups of five
Eastern White Pine
2. Needles in groups of two
Virginia Pine or Red Pine

7 Brainstorm the materials that will be needed to conduct a field study.

8 Discuss how they will approach the investigation, share equipment, delegate responsibility etc.

9 Conduct a field study of a 10-meter by 10-meter plot in order to identify scientific names and numbers of species in their plot. Different groups of students might want to measure different plots (e.g., city park vs. grass plot near school) to compare biodiversities.
- Plants can't move so suggest to the students that they inventory the trees or plants that their species require.
- Be sure students systematically count and categorize every tree and large plant in the plot. If identification of every species is not possible, then they may be named species A, B, C, etc.
- If fieldwork is not possible, different seeds can be used to represent species taken from different plots. For example, rice could be white oaks; lima beans could be red maples; etc.

10 Write a one page qualitative assessment of the biodiversity (richness and abundance of plant species) of their plot and whether or not it would provide the components of habitat needed by their animal species of interest.

11 Discuss, compare, and contrast their qualitative statements with the other groups in class.

12 Discuss the precision of the information provided by these qualitative statements. Then, lead the students to the need for a quantitative assessment using the Shannon Diversity Index.

13 Calculate a sample Shannon Diversity Index using the ***Richness and Abundance of Two Fictional Ecosystems*** handout to get students familiar with the calculation.

14 Use the data gathered on the plots in conjunction with the Shannon Diversity Index formula to calculate diversity for their particular plot.

15 Create bar graphs of species richness and abundance of their plot.

16 Post the results in your classroom of their calculation and graphing from greatest diversity to least diversity in the classroom.

17 Hypothesize about reasons for the differences in the plots in biodiversity.

18 Brainstorm ways that humans have caused decreased Shannon Diversity Indices in the region.

19 List ways that they can positively impact plants and animals in their region, as well as reviewing why it's important.

Here is a partial list of activities that can increase the Shannon Diversity Index:

Conserve Habitats
- Protect habitats from National Parks to wilderness area to grassy patches next to roads.
- Preserve some old trees and areas in your yard or on your farm for wildlife to nest and hide.
- Plant species that are native to your area and remove invasive plants. Native grasses, flowers, shrubs and trees are more likely to attract native birds, butterflies and other insects, and maybe even some threatened species.

Encourage Wildlife
- Make feeders and nesting boxes for birds and bats.
- Use compost rather than fertilizers and pesticides.

Recycle, Reduce, And Reuse
- Learn your Ecological Footprint (see project entitled "How Big Are Your Ecological Feet?" in this book).
- Use public transit, turn off lights, take your own reusable bags to the grocery store, etc.
- Purchase organic foods.
- Many organizations work to conserve and protect wildlife. Join one!

Make Your Voice Heard
- Write your decision makers and newspapers concerning the welfare of wildlife.

20 Ask students to implement one or more of the activities from the list brainstormed in #19 above.

ASSESSMENT ACTIVITY

Students will write or present the results of the class in a way that shows they:
- understand the different types of biodiversity.
- understand what the Shannon Diversity Index measures and what this means.
- understand the reasons biodiversity is important.
- understand the implications of biodiversity on land conservation (e.g., it's not just setting land aside to be safe from human development; in fact, there are ways biodiversity and development can co-exist).

Students will use results of their calculations and data representation to write a recommendation concerning:
- why plots should be preserved if a goal is to preserve the best habitat for their animal of interest.
- what practical modifications could be made to land use in the region to benefit their animal of interest.

ACADEMIC EXTENSION MODIFICATION

1 Using the data collected, calculate the diversity index using other diversity indices such as the Simpson or Shannon-Weiner. This project dovetails very well with the project entitled: "That's So Random: Island Biogeography & Stochastic Events." Students can measure biodiversity throughout the months and even years in their area. They can also investigate the biodiversity around the plot to see if a small slice of heaven helps create more heavens.

2 Not all diversity is good. The students might assume that introducing a non-native species helps an area because it increases the area's biodiversity. Discuss this issue with the students. Are there introduced species in their areas (e.g., starlings, kudzu)? How has this affected the environment?

RICHNESS AND ABUNDANCE OF TWO FICTIONAL ECOSYSTEMS

The Shannon Diversity Index is calculated as follows:

$$H = -\Sigma [(N_j/N)[\log(N_j/N)]]$$

Where N_j is the number of individuals in species of a particular type. N is the number of individuals in all species. Σ (Sigma) is the summation sign and it indicates that you should sum the values of $(N_j/N)\log(N_j/N)$ for every species in the system.

Use the Shannon Diversity Index to calculate the biodiversity of the two ecosystems in the table immediately below:

Ecosystem 1		**Ecosystem 2**	
Species name	# of organisms	Species name	# of organisms
A	**10**	A	**91**
B	**10**	B	**1**
C	**10**	C	**1**
D	**10**	D	**1**
E	**10**	E	**1**
F	**10**	F	**1**
G	**10**	G	**1**
H	**10**	H	**1**
I	**10**	I	**1**
J	**10**	J	**1**
Total	**100**		**100**

Links for Fauna of North America

NATIONAL ZOO SMITHSONIAN SITE
http://nationalzoo.si.edu/Animals/AnimalIndex/

E NATURE www.nature.ca/notebooks/english/namerica.htm

E SPECIES FACT SHEETS
www.kidsplanet.org/factsheets/map.html

did you know?

A Salmon Is More Than Fish

So what's the big deal if the salmon don't make it back to their spawning sites for a couple of years? You don't really like mom's salmon loaf anyway and sushi (yuck) is overrated, overpriced, and way undercooked. Besides, there are plenty of salmon nurseries around to satisfy all the fish fanatics, so there's nothing to worry about, right?

Wrong! Big-time wrong!

Salmon is a *keystone* species that has a major impact on the biodiversity of the entire ecosystem that runs from the sea, all the way upstream to the waters where the salmon were hatched. Along the way, they have to make the transition from sea water to freshwater, survive the gauntlet of bears waiting for a salmon buffet (talk about fresh sushi), and swim up a series of cliff-like waterfalls just to get back to their hatching site where they can spawn and die. Here are just a few of the many ways that salmon affect and are affected by the ecosystem:

- They are a seasonal staple food for bears and eagles. Their carcasses provide food for other fish, shellfish, ducks and other fowl, otters, wolves, and other animals in the watershed.
- Many species of water creatures, birds, and mammals feed on their eggs.
- Salmon bodies and excrement provide phosphorous and other chemicals for the stream and nearby trees and vegetation.
- Their sensitivity to water quality and temperature makes them one of the best indicators of the health of the ecosystem.
- Runoff from over-cleared forestland creates a hazard to the health of the salmon and the species that rely on them.
- Over-harvest poses a huge threat to salmon survival because it takes the *survival of the fittest* aspect out of the picture.
- Hatchery-bred salmon are not as strong as wild-bred salmon, and they lack the *spawning run* instinct and the ecological benefits that those runs produce.
- Connectivity to and from the salmon streams is critical for the species that are affected by a healthy salmon population.
- No other creature affects the health of the salmon and biodiversity of the world more than humans.

Questions:

- What can we do to repair the damage to the salmon population and its habitat?
- What would hinder those corrective measures?
- What are some other keystone species? How do they help sustain healthy ecosystems?

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Grade Level: HS

Type: Field study

Topic: Biodiversity, history, ecology

Walking the Talk: A Forest Transect Study

It's one thing to read and talk about biodiversity, ecology, and environmental issues, but true understanding of the relationships among humans, wildlife, and the environment comes only with time spent in nature. A transect study is a great way for you to introduce the scientific process of data collection and classification to your students and to learn to know the natural world firsthand. This project provides guidelines for a forest transect study but can easily be adapted to fit other locations.

INTRODUCTION

Have you ever walked through a forest and wondered at the differences in the distribution and abundance of the various trees, shrubs, wildflowers, and animals that you encountered during your hike? For example, why do certain species grow by themselves or in clusters, while other species are much more interspersed with each other? Why are some species rare while others appear to be dominant? Have you ever noticed the absence of a lot of really old trees in many of our habitats? Why are there so many more species at the edges of forests compared with wooded areas in the heart of the forest? How is an urban forest or park different from a forest in the country?

These and other questions are on the minds of biologists who study population and community ecology. While there are many different ways of finding answers to these questions, there is one approach that is easily accessible and even fun for a group of students: going on a walk, albeit a more scientific-minded walk, called a transect study. Traditionally, transect studies have been used in ecosystems to gather enough data about a series of different biotic and abiotic variables along a transect in order to explain differences within the ecosystem. While this can get very involved and require the use of sophisticated statistical techniques to analyze the data, transect studies can give enough information about a habitat or ecosystem, without the use of complex statistical methods, to be useful in high school or even college classes.

OBJECTIVES

After completing this activity, students will be able to:

1. better understand the relationship between humans, wildlife, and the environment.
2. better understand the scientific process of data collection and classification.
3. organize a comprehensive transect study.

CLASS TIME REQUIRED

Varies depending on location of the study site. This project would work well for your school's environ-mental club.

MATERIALS NEEDED

- Obtain or create a detailed map of the study area and make copies for participants.
- If available, bring a GPS instrument to record exact locations of significant findings on your map.
- Field guides for participants to use
- Binoculars
- Notebook (or clipboard and paper) and pencil
- Water bottles and first aid kit
- Gloves for examining human trash
- Cell phone
- Additional adults to chaperone
- Lots of enthusiasm and curiosity!
- Empty, clean dog food or tuna cans
- Soft-lead pencil (HB or softer)
- Wide cellophane tape
- Magnifying glass(es)
- Large re-sealable plastic bags
- Superglue
- Aluminum foil

LESSON STEPS

1 Select a site for your transect. You don't have to study transects in pristine nature areas. Actually, consider yourself fortunate if your chosen forest ecosystem is in a disturbed area (e.g., an urban location or the suburban area of a bigger city) because you can also look for cultural signs that humans have left behind. Thus, you can expand the number of responsibilities by noting the abundance of trash (e.g., bottles, cans, plastic, and other types) in relationship to parking lots, roads, or especially interesting areas in your ecosystem. You may want to record ruins of old buildings or stone walls as well.

2 Find out if you need permission to access the land.

3 Using the map, scout out the area to see if you can find a pathway through it. The degree of complexity of a transect study is entirely up to you, the size and expertise of your group, and what you want to learn from this exercise. And by the way, it's important to remember that you choose the path, your transect does not have to be a straight line, it does not have to travel through impenetrable habitats, and it can be of any length.

4 Decide what kind of observations you want to include in your data. For example, within five yards on both sides of your path (i.e., transect) you may want to record and identify all mosses, ferns, wildflowers, and trees with a circumference of more than 20 inches at shoulder level. You may want to measure the circumference of a really old tree and estimate its age. You may notice a lot of fallen trees and decide to record data about those as well. You may decide to include all birds you see and/or hear, all butterflies you see, and all signs that indicate the presence of mammals.

5 Once you decide which data your group will collect, create a data sheet. You may want to ask your students to help create a local field guide listing plants, trees, animals and insects. A good place to start is the National Wildlife Federation's ZipGuides at www.enature.com. Students can provide the zip code for your study area to view a local field guide for your site. Be sure to print and share with the group. Bring other field guides and binoculars.

6 Break into small groups, each of which has been assigned recording and identification responsibilities.

7 In your chosen study area, you and your group simply note everything you can see and observe along a path you choose. Be sure that groups have field guides and other equipment.

8 Set the ground rules for staying together as a group.

9 Remind everyone to note the time of day and all weather conditions (wind, sun, overcast, precipitation, etc) on the data sheets.

10 If you do your transect study in spring, include birds as one of your data categories. Come back several times to the same transect and you may discover some very interesting patterns. For example, you may hear the same bird song(s) in the same places over and over again as male birds are establishing their fixed territories. Or, you may find that different bird species require different habitats along the transect.

These and other questions may be asked regarding a variety of other animals, such as rodents, beetles, bees, wasps, and ants. Obviously, some of these animals are more difficult to work with because they require stronger observational skills and more time and patience. You should start with whatever you are comfortable and increasingly add more unfamiliar species to your transect study as you become more knowledgeable about the flora and fauna in the area.

11 As the transect leader, pause from time to time to address especially interesting or important observations with the whole group. Create an opportunity to share observations among the group. In relationship to one of your landmarks, e.g., a parking lot, here are some sample questions you can investigate:

- **How many species of your different organisms groups did you find and ID along your transect?**
- **Are there changing/repeating patterns of species in your transect?**
- **Where do you find more bottles, cans, plastic, etc. along the transect?**
- **Do you find large and old trees? If not, what can you learn about the cultural events that might have taken place in the forest, composed of mostly small and young trees?**
- **Encourage students to ask questions about what they are seeing.**

EXTENSION ACTIVITIES

1 Now that you have completed your first transect, go ahead and repeat the scientific walk using a different transect in a different area, or return from time to time and walk the same transect during the course of an entire year. Note and discuss changes across time and among different habitats. Try to learn about the cultural and historical events that might have shaped the ecosystem.

2 Write up your findings and compare with other groups studying transects of similar eco-systems in different geographical areas.

3 Learn about Mike Fay, a National Geographic Explorer, who did a Megatransect across part of Africa collecting data on plants and animals. http://michaelnicknichols.com/gallery/megatransect.

4 Last, but not least, allow yourself to be captivated by nature's diversity and be filled with wonder.

Who lives near the edges of the forest, in the center of the forest, in the habitat with old trees, or in a habitat with a lot of brush and shrubs?

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Grade Level: MS, HS

Type: Research/debate

Topic: Human/animal interaction

Ecotones: Living on the Edge

An ecotone is the interface, or edge, of two or more ecosystems. The overlap of two ecosystems (i.e. the banks of a river or the meeting of freshwater with salt water) is a region of high biodiversity that supports plants and animals usually not found in either of the bordering ecosystems. Many biologists call this area of complexity the "edge effect."

INTRODUCTION

What kind of "edge" do you and your students live on—the leading edge, the cutting edge, the front edge, the reflecting edge, the forward edge?

Humans have always been fascinated with edges. Some of our favorite vacation spots and activities include beaches at the ocean, lake shores, and hiking through forest meadows. However, humans can change an ecotone, damaging both wildlife and plants. Because humans are attracted to ecotones, we often build subdivisions and businesses there, and in the process, disturb natural habitats and reduce the diversity of plant and animals species in these areas.

As human populations expand and natural habitats shrink, people and animals increasingly come into conflict over living space and food, often with dramatic impact. When the two worlds collide, people may lose livestock, crops, or property. Human-wildlife conflict is one of the main threats to the continued survival of many species in many parts of the world.

OBJECTIVES

After completing this activity, students will be able to:

1. better understand the concept of an environmental ecotone.
2. better identify and discuss issues with wild animal/human interaction and potential solutions for these issues.
3. better understand how to take a position on the issue and defend their ideas.

MATERIALS NEEDED

The three included scenario articles

- Scenario 1 – Stalking the Elusive
- Scenario 2 – Biologists Say Coyotes Losing Fear of Humans
- Scenario 3 – It's a Bear!

CLASS TIME REQUIRED

One to two 40-minute periods

LESSON STEPS

Discussion

1. Ask students to describe what they think of when they hear or read a phrase like "living on the edge." Students will likely think of "the edge" as a place where risks are taken, where outcomes are uncertain, or the area where two places with different characteristics overlap.

2. Present students with the term "ecotone" and solicit their ideas about the term's definition. Help students understand the term as the interface of two ecosystems.

3. Ask the class to generate examples of edges and ecotones. If their examples are primarily from their own region, help students arrive at additional examples from other geographic areas and ecosystems.

4. Discuss the kinds of conflicts that can occur when human and wildlife habitats intersect at an ecotone. What are the likely effects on wild animals and their habitat? Responses are likely to include threats to habitat and species diversity. What are the likely effects on human populations? Responses may range from humans being harmed by wild animals to increased respect for and understanding of animal life and habitat.

5. Ask students to identify common solutions that are implemented when the needs of humans and wild animals come into conflict in an ecotone.

6. Have students read the three examples of wild animal/human interaction.

7. After reading the three included articles, each student should define the ecotone represented in each article, the nature of the human/wildlife encounters discussed in each article, and the problem that needs to be resolved. Finally, ask each student to write his or her personal perspective on the problem and potential resolutions. What should be done about the animals? Should lethal or non-lethal controls be used to manage the animals? What should be done with/by the humans? Tell them to be ready to defend their ideas.

Scenario 1 - Stalking the Elusive

I am hot on the trail of my quarry and I am very close. Using binoculars, I scan a fairway that is covered with three inches of slushy snow. Although it is blocked behind heavy clouds, the full moon illuminates the open, snowy landscape of the golf course.

Materializing from the dark woods like ghosts, three large bodies magically emerge onto the back of the fairway. They gracefully lope across the golf course. The two animals in front notice something ahead and chase it at full speed. The third animal, 100 feet behind, pursues the action.

When the last animal is out of sight, I drive to a trail that leads in the direction where the animals are heading. I grab my receiver and track my quarry on foot. The weather is truly miserable. Golfball-sized chunks of hail blow into my face. The chase leads me across a main road and back to the golf course where I first observed the animals. I walk along the south edge of the fairway, very close to the houses that border it, staying out of sight of my subjects. Inside, people watch television in their living rooms, completely oblivious to me and to the animals that I am tracking. After tracking them for half a mile, I see four bodies running back and forth on the golf course fairway and realize what two of the animals had been chasing: a member of their own group. All four animals are wagging their tails and appear to be having a great time as they take turns chasing one another. I am amazed to watch these creatures frolicking in such nasty weather, seemingly oblivious to the harsh climate. Since the wind is in my favor, none of my subjects notices me standing at the edge of the fairway; they are too intent on releasing excess energy. After their game of tag, they casually retreat.

Scenario 2 - Biologists say coyotes losing fear of humans

While the debate over killing coyotes continues to swirl throughout North County, biologists say the evidence is clear that the predators are growing less afraid of humans every year.

Robert Timm, a biologist with the Hopland Research and Extension Center in Hopland, recently presented a paper to the North American Wildlife and Natural Resources Conference in Spokane, Wash. The paper, titled "Coyote attacks: an increasing suburban problem," concludes that coyotes have, indeed, become much less afraid of humans. "In the absence of harassment by residents, coyotes can lose their fear of people and come to associate humans with this safe, resource-rich environment," the report states.

This latest concern over coyotes started when a small senior community in southeast Oceanside declared last month that it would hire a private exterminator to capture and kill coyotes that residents said were attacking family pets. After conducting 19 interviews in the Ocean Hills community, investigators found that coyotes had killed three small dogs in recent months and that they did so in close proximity to their owners, making them a threat to public safety.

The controversy escalated when the state Department of Fish and Game got involved, declaring the coyotes a public safety hazard and calling in federal trappers, who killed four of the animals July 22. The news seemed to polarize the populace. From call-in radio shows to TV broadcasts and letters to the editors of local newspapers, public opinion seems to have fallen into two camps: Some favor killing coyotes when they get too close to humans and their pets, and others see killing coyotes as simply unconscionable.

Those who favor trapping and killing coyotes generally argue that nothing else will put the fear of man back into coyotes that have grown accustomed to the presence of humans. Those who favor leaving the coyotes alone say humans haven't done enough to help keep the coyotes wild, providing easy food for hungry predators who have been in the area much longer than the latest crop of suburbanites.

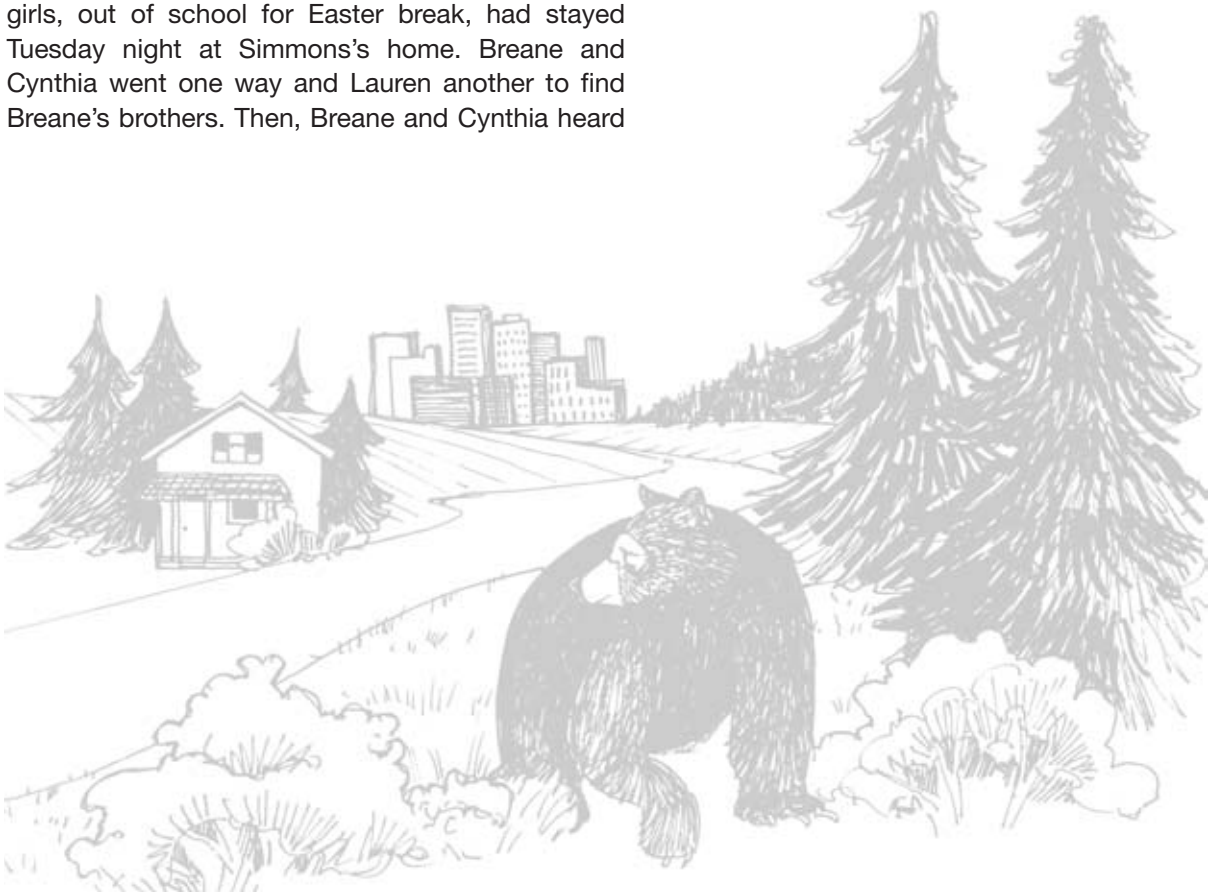
Scenario 3 - It's a Bear!

Cynthia Ellington, 12, thought she had looked into the eyes of a lion Wednesday. But her friends—Breane Simmons, 11, and Lauren Patrick, 12—convinced her there were no lions near Bayou Rapides. The three Brame Junior High students finally realized the critter staring at them was a bear. "We ran screaming through the woods," Breane said. "We never thought we would see a bear."

Breane's mother, Tiffany Simmons, believes she saw the same bear last week. Louisiana Wildlife and Fisheries agents said bear sightings are not unusual in Louisiana. The Louisiana black bear roams residential yards to find food, biologist Maria Davidson of Wildlife and Fisheries said.

On Wednesday, the three girls were out in the woods behind Simmons' house playing hide-and-seek. The girls, out of school for Easter break, had stayed Tuesday night at Simmons's home. Breane and Cynthia went one way and Lauren another to find Breane's brothers. Then, Breane and Cynthia heard noises but thought they had stumbled onto some armadillos. They said they called Lauren to join them, then heard footsteps. They squatted to hide; they thought the footsteps came from Breane's brothers. Then Cynthia found herself staring into the eyes of a black bear. All three screamed and ran toward the house.

Davidson, the biologist, said the Bayou Rapides sighting has not been confirmed. She said area residents should remember that bears are opportunistic eaters. If cat or dog food, birdseed or garbage is left out, bears could wander up to eat. She urged residents to remove temptations from yards and porches. She also advised not to approach or feed a bear. Davidson said it is illegal to shoot Louisiana black bears, which are a "threatened" species.



Research

When students look carefully at the other side of an issue, they become more tolerant of others' opinions.

Once students have read the scenarios and recorded their individual thoughts, group the students who favor lethal controls together and the students who favor non-lethal controls in another.

Discuss the concept of bias, emphasizing that one of the challenges of scientific inquiry is setting aside personal opinions and assumptions in order to arrive at conclusions that are the result of evidence rather than personal preference. Tell students that to practice the challenges of overcoming bias, each group will conduct research to collect evidence supporting the point of view *opposite* the personal opinion expressed in their earlier writings.

Frame the research assignment to meet your class or school research protocols. The Internet is the new encyclopedia for students. Guide them to use it ethically—for main ideas and information, not plagiarism. Help them identify reputable sites and to review sites for bias and inadequate documentation. Explain how to find highly regarded web sites grounded in scientifically based research. Be specific about the research requirements and time frames for the assignment. Specify the number of sources to be consulted as well as formats for student notes and bibliographic information.

The research activity can be organized as a collaborative group effort with individual students taking on specific research jobs that will be incorporated into the final report. Or, you may require each student to submit an independently researched and written report if that better suits your instruction goals.

Debate

Once students have completed their individual or group research and reporting, they will work together to combine individual knowledge and information into their group's arguments for or against lethal or non-lethal control of wild animals in areas inhabited by humans. One person from each group will represent each side in a formal debate. Each side will have five minutes to present its argument, followed by a two-minute rebuttal from the other side. The debate will end with each side giving a two-minute closing argument. Consider inviting outside experts or school volunteers to judge the debate.

Debrief

After the debate, it will be important for students to discuss the activity and reflect on the value of the process of exploring and defending a point of view that does not match their personal views. Did their research help them become better informed about ecotones? Is there a single, correct answer to the issue of wild animal management in ecotones? Are there both long-term and short-term solutions? Did any of the students change their original personal opinions as a result of the research and debate?

EXTENSION ACTIVITIES

Without even knowing it, many people live on the edge—the edge of ecosystems that often cannot compete with human activity. The issue is complex and debates seldom point to clear winners. Learning to recognize the existence and value of wildlife on the "edge" can help us all make better decisions about the expansion of human habitats. Learning how to better deal with possible conflicts in humane ways will sustain wildlife and lessen the negative impact humans have on areas rich in biodiversity.

1 Students can create an ecosystem map or model of your community. Indicate the location of the principal ecotones. Have students identify the wildlife habitats that are located in these areas and conduct studies of the impact of building or road construction on ecotones (also see the "That's So Random: Island Biodiversity & Stochastic Events" and the "Pandas, Sperm Banks, and Vavilov Centers: Habitats vs. Test Tubes" projects).

2 Invite a state wildlife biologist or district wildlife manager to discuss the students' findings and how wildlife is managed in areas where human interests and wildlife welfare are in conflict.

3 Students can explore how construction zoning decisions are made in your community. Is adequate attention paid to potential impact on ecosystems and wild animal habitats? What scientific data should be considered?

SOURCES

Scenario 1
Way, Jonathan G. "The Eastern Coyote: Documenting the Habits of One of Cape Cod's Newest Residents." *Conservation Perspectives—the on-line journal of NESCB* (Spring 2001), www.nescb.org/epublications/spring2001/coyotes.html

Scenario 2
Paul Sisson, "Biologists Say Coyotes Losing Fear of Humans," *North County Times*, August 8, 2004.

Scenario 3
Mandy M. Goodnight, "3 Brame students encounter furry creature near bayou," *The Town Talk*, March 29, 2002.

ADDITIONAL RESOURCES

Human-Animal Conflict
www.panda.org/about_wwf/what_we_do/species/problems/human_animal_conflict/index.cfm

Spotlight on The Endangered Species Act
www.bagheera.com/inthewild/spot_spesa.htm

Folktales and Ecology: Animals and Humans in Cooperation and Conflict
http://edsitement.neh.gov/view_lesson_plan.asp?id=380

Animal Myths and Legends
www.planetozkids.com/oban/coyofire.htm

Coexisting with Wildlife
www.api4animals.org/a7a_coexist.php

A Howl Over Coyotes
www.wnrmag.com/stories/1999/dec99/coyote.htm

Urban Wildlife: Live and Let Live
www.api4animals.org/articles?p=414&more=1

Non-Lethal Methods Can Resolve Conflicts Between Humans and Bears
www.wcs.org/353624/192080

Living With Wildlife
www.livingwithwildlife.org/wildlifehelp/helpspecies.html

Predatory Management Policy
www.azgfd.gov/w_c/predator_management.shtml#

Wisconsin Department of Natural Resources: Coyotes
www.dnr.state.wi.us/org/land/wildlife/PUBL/wlnotebook/coyote.htm

California Department of Fish and Game
www.dfg.ca.gov/hunting/bear/

National Park Service: Bear Management
www.nps.gov/seki/snrm/wildlife/bear_overview.htm

Get Bear Smart Society: Non-lethal Bear Management
www.bearsmart.com/bearsBackyard/Alternatives.html

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Grade Level: MS, HS

Type: Observation

Topic: Human behavior

You Read My Mind! Scientific Observation of Human Behavior

Many of the projects in this book require students to conduct and record objective observations of animals or phenomena. Practicing and discussing these skills before students begin field or lab work will help them conduct their experiments with more confidence and success.

INTRODUCTION

Animal behavior has captivated humans throughout our existence; prehistoric cave paintings and petroglyphs were often of animals. From reading other people's body language to discovering tool use (a sign of abstract thinking) in chimpanzees, captive bonobos, woodpecker finches, and now gorillas, there is much to discover about ourselves and other animals. Observing animal behavior also makes an excellent way to let students practice the observational skills that are key to many aspects of science and to practice thinking objectively instead of letting their subjective preconceptions cloud their observations.

In this project, the class explores and practices recording data objectively by watching student volunteers act out scenes. Students first watch a scene and collect data however they feel is best. Based on their results, students discuss better ways of collecting data. Then, the class uses improved methods to collect data from a second scene. After recording and aggregating their observations for the second scene, the class is challenged to hypothesize the emotions and feelings that the pantomiming volunteers were expressing. Follow-up discussion centers on the importance of objective observations in scientific study.

OBJECTIVES

After completing this activity students will be able to:

1. understand how and why scientists objectify behavior so that their work may be freer of prejudice or bias.
2. objectively observe and record behaviors.
3. appreciate and understand the ways people communicate their emotions and intentions.

MATERIALS NEEDED

- Pantomime script (see handout)

CLASS TIME REQUIRED

One or two 40-minute periods

LESSON STEPS

Introduction: *We interpret the intentions and feelings of others through their behaviors, including speech, a very complex behavior. Although we have a lifetime's experience interpreting behaviors, our interpretations are not always correct. If a person were to come into a room with eyes watering, nose red, and sniffling, we might assume they have been crying; Or that they are having an allergic reaction. Neither assumption can be presumed correct without additional, objective data. Both in everyday life and in science, we use context and previous experience to guide us. However, in science we must be more thorough in our observations and more careful in our interpretations.*

First Observation

1 Ask for two student volunteers to act out a scene in front of the class as part of an observation exercise. Choosing demonstrative students (those most likely to volunteer in the first place) who you believe have relatively high emotional intelligence and empathy will help the class identify behaviors.

2 Give each of the two volunteers a copy of the script handout. Tell the class and volunteers that the volunteers should try to move and act a little slower than normal to give the class time to take notes.

3 Ask the volunteers to leave the room to review and practice it while you explain the observation process to the other students. Explain to the rest of the class (the observers) that they are to take notes describing the scene they will be watching. They are free to use whatever methods they wish but should not discuss what they do before they begin.

4 The volunteers are brought back in and act out the scene. The scene should take about five minutes to complete. If it starts to take much longer, simply end the scene and work with only as much of the scene as the volunteers completed.

5 Have students discuss how they collected data.

6 Discuss what they concluded from the scene. This step is probably the most critical. Carefully guide the students through a discussion of how objective and detailed their notes and conclusions are. Most likely, the students will not take detailed notes. In addition, they will probably either conclude very little from the scene or assume too much.

7 Using the students' notes and conclusions as the launching point, discuss better ways of categorizing (or codifying) the behaviors. It may help to use common real human body postures as examples before codifying those in the script. It may help for the students to develop a table to keep track of the behaviors.

Second Observation

1 Ask the volunteers to act out the script again. This time, the class uses their new method of codifying and recording the data.

2 Have the class work to interpret the scene as objectively as they can. You may wish for them to work in small groups first and then discuss their conclusions as a whole class. Alternatively, you may wish to guide the students through the entire process to help streamline the learning process.

POINTS OF DISCUSSION

1. Some of the behaviors in the scene may not be intuitively obvious. For example, we might expect that when a person holds his or her arms across the stomach tightly, he or she is being more withdrawn than when the arms are held more loosely—but the opposite also appears to be true: for some people, holding arms loosely is more withdrawn than holding them tightly. Our intuition sometimes fails us with real animals, too. Chimpanzees, for example, perform a loose-lipped "smile" when they are frightened or submitting. Ask students if they have ever seen a chimpanzee performing this smile. When? Why was the chimp made to "smile"? How might it have been made to do so?

2. All of us use informal observations and theories to make assumptions about our world and the people in it. How is this the same as and different from the formal scientific process?

3. Explore the concept of objectification as it applies to scientific study. Why is it so important?

4. Point out that we know of the feelings of other people by what they say and how they act. Can we infer the same about dogs? Cats? Birds? Lizards? Bees? How would we know for sure? The more communicative a person (or social an animal) is, the better we as observers can assess his or her emotions. Dogs are social animals and seem adept at showing and especially reading emotions. Cats are social but differently so. Some birds are very social, others not. So, we may assume that more social birds are more emotional. Does this seem like a reasonable theory?

5. Discuss the ethics of observation. For this project, students volunteered to be observed. What if we had covertly monitored two people in the class having a conversation instead? How do you think they would have felt? Are there times when it would be okay or necessary not to ask for permission? Are there times when we shouldn't conduct a study under any circumstances? Are there times when we should conduct it anyway? Who decides? What does this mean for conducting research in general? We really can't ask animals to volunteer. What does this mean about studying them?

We know the feelings of other people by what they say and how they act. Can we infer the same about animals?

ASSESSMENT

1. Students understand the difference between observing and inferring.

2. The students objectify (operationalize) their descriptions of behaviors into ways that can be recorded.

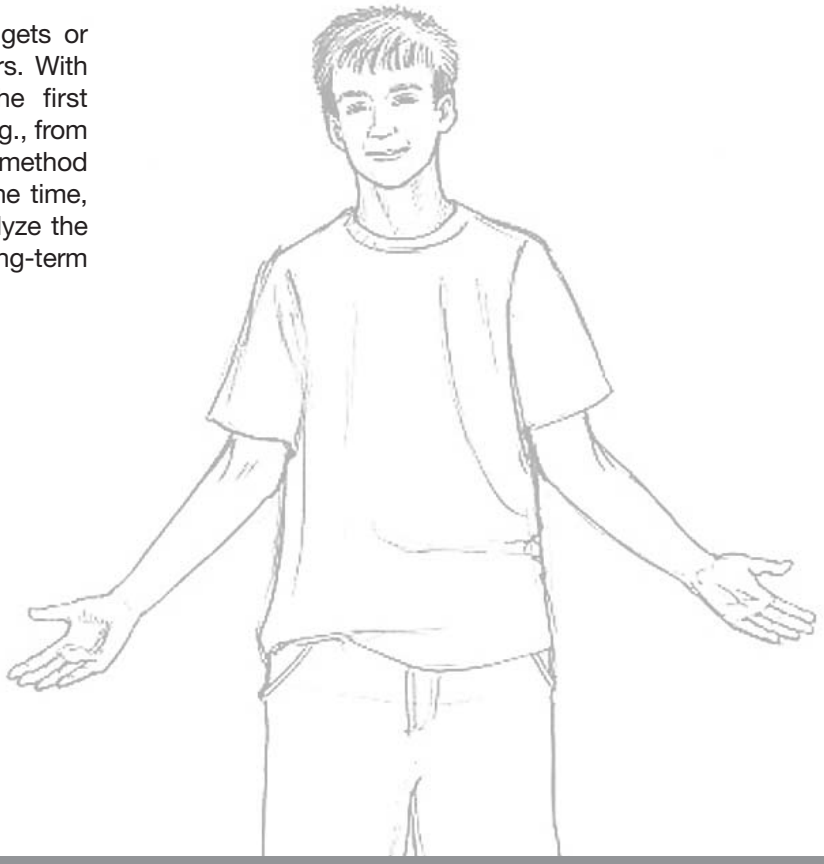
3. The students make accurate recordings of the behaviors.

4. Students analyze the data and make objective inferences about why the volunteers behaved the way they did.

EXTENSION ACTIVITIES

1. Using a videotape of a TV show with the sound off, have students observe and record the behaviors of the actors. Sitcoms and children's shows work well.

2. Ethologists use ethograms like time budgets or transition matrices to categorize behaviors. With the class, choose a situation (e.g., the first observation of a new species) or scene (e.g., from a video) to study and then discuss which method they believe would best study it. Given the time, the students can actually record and analyze the data. Projects like this work very well for long-term projects or science fairs.



DIRECTIONS:

A silent film was rediscovered in the archives of the American Museum of Natural History. Recorded on the film was a scene of two people from a poorly understood culture.

1. You are going to play the part of the two people on the silent film from that culture.

2. You can have this script with you to remind you of what you are doing. The parts in normal type tell you what to do. The type in italics let you know what you are feeling and why you are doing the actions. Do not let the observers know why you are acting the way you are until asked to by your teacher.

SCRIPT:

Person 1: Stand with your arms across your stomach. Have each hand hold the other elbow.

You are at a party, but you are feeling nervous and unsure of yourself. So, you are standing away from the action. It is noisy and hard to talk, so both you and Person 2 rely on making gestures common to your culture to communicate.

Person 2: Walk up to Person 1 and place your left hand below your throat and your right hand on top of your left.

You are greeting Person 1.

Person 1: Take your hands from your stomach, move them about half way towards your throat, and then put them back so that you're holding your elbows again.

You are making a half-hearted greeting to Person 2.

Person 2: Lean to the left and then lean to the right.

You are beckoning to Person 1 to come with you. You want him/her to come join the party.

Person 1: With your hands still on your stomach, bend at your knees and roll your shoulders forward. Next, move your hands so you're holding your forearms.

You are saying no and withdrawing into yourself.

Person 2: Lean far to the left and then far to the right.

You are beckoning Person 1 a bit more insistently.

Person 1: Bend down farther and move your hands so that you are now holding your hands across your stomach.

You are saying no more emphatically and withdrawing further away into yourself.

Person 2: Lean to the left and stay leaning for a few seconds. Then, lean to the right and stay leaning for a few more seconds.

You are being almost rudely insistent in asking Person 1 to come with you.

Person 1: Bend far down again, and move your hands so that you are holding your hands in front of your stomach.

You are stubbornly and strongly saying no. This is somewhat akin to an American folding his/her arms tightly in front and shaking his/her head.

Person 2: Step to the left, and bring your right foot over to your left foot. Then, step to the right, and bring your left foot over to your right foot.

You have decided to change your tactics. You are now not insisting the Person 1 come, but gently, politely beckoning.

Person 1: Move your hands so that you are holding your elbows again.

You are happy that Person 2 is being kinder, and you are starting to soften up.

Person 2: Step slowly to the left and bring your right foot to your left slowly. Step slowly to the right then bring your left foot in slowly too.

You continue to beckon politely.

Person 1: Hold your hands behind your back.

You say yes, agreeing to go with Person 2.

Person 1 and Person 2: Walk away together.

You are both happy.

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Grade Level: Upper MS, HS

Type: Observation

Topic: Animal behavior

The Tail Wagging the Dog: Observation of Canine Behavior

A wagging dog is a happy dog—or is it? Only the objective observer knows!

INTRODUCTION

In this activity, students will develop the ability to gather ethological data by testing their understanding of why dogs wag their tails. The students are guided through preparing the study before they go out to observe actual dogs (or videos of dogs) to test their hypotheses.

Many people live with dogs. But even those who don't have dogs know that dogs wag their tails because they're happy. Or do they? Dogs are not bashful about letting us know what they're feeling, but are we always right in interpreting their messages? Investigating this simple question allows students to apply what they learn in the classroom to address their preconceptions about their world and the animals that share it. It shows the students one way that science has a direct impact on their daily lives.

OBJECTIVES

After completing this activity, students will be able to:

1. practice collecting and interpreting objective data.
2. gain an appreciation and understanding of the ways dogs communicate.

MATERIALS NEEDED

- Clipboard
- *ASPCA's Reading Canine Body Postures* (available online at www.aspca.org or write ASPCA Education Dept., 424 East 92nd Street, New York, NY, 10128 for free copy.)

CLASS TIME REQUIRED

Two or three 40-minute class periods, one of which can be a field trip to watch dogs. The latter one or two periods can be substituted with homework.

LESSON STEPS

1 Begin a conversation about dogs with the class. Bring up the issue of tail wagging. Ask the students why dogs wag their tails. You will probably hear several students say that they wag their tails because they're happy. Ask them how they know this. Are they sure this is true?

2 To begin formalizing the conversation about tail wags into one about designing an experiment, let the students discuss their personal experiences with dogs wagging their tails. Why do they believe the dogs were happy (or whatever they thought they were feeling)? How would they try to convince someone else that their dogs were feeling what they think they were? Help the conversation evolve from one about subjective interpretations to one about objective observations. However, make sure that the students don't lose sight of the fact that even though we cannot look into a dog's head or heart to know what he or she is thinking or feeling, this doesn't mean that we can say that dogs don't think or feel.

3 Returning to their hypothesis that dogs wag their tails because they're happy, ask students how they could try to prove or disprove this. A question that begins simply should develop into a rather sophisticated discussion about scientific inquiry.

- First, how can they objectively codify (or break into rules) tail wags? Do they need to consider other aspects of a dog's behaviors? Do dogs always wag their tails the same way? Brainstorm types of tail movements, ways of objectifying tail movements, such as the speed of a wag, tail height, and perhaps the "size" of the wag (i.e., little movement—maybe of just tip—versus large wags that involve a dog's whole body). They may wish to include circular tail wags, too. The behaviors can begin as general descriptions, but the goal is to describe the behaviors well enough that someone who had never seen a dog before could replicate the study. In general, when interpreting the postures of dogs (and many other mammals), students can look for **THEMES**:

Tail - up, down, moving, level with back
Hair - erect on back/shoulders, smooth, puffed on tail
Eyes - dilated, narrow, staring, averted
Mouth - open, closed, yawn, drawn lips
Ears - forward, back
Stiffness of body - body taut, body relaxed

They will also want to consider how features like long ears or docked tails will influence their study. This will also give you the opportunity to point out that dogs with docked tails and cropped ears have a harder time conveying information with these two very important parts of their bodies. Not only is it difficult for people to read the dogs' postures, but other dogs can't read their postures as well either; the dog has effectively been made less able to "speak."

- Second, how can they know if the dog is happy? This conversation could take a long time, so we suggest that you take a more active role here. It should soon become apparent that trying to objectify happiness is difficult. Instead, have the class do some brainstorming and research about dog body postures. Based on your time constraints, you may wish to have students learn about pre-established postures and their accepted meanings (e.g., from *ASPCA's Reading Canine Body Postures*), or look at videos and photos of dogs to make their own descriptions.

- Finally, the class will need to consider where and how they will study dogs. Dogs communicate quite a bit through their bodies, and can do so with speed and subtlety so we highly recommend studying videotapes of dogs. Based on time and resources, students can use pre-existing videos (such as *Dogs, Cats, and Big Kids*) or create their own videos. If they are going to create their own, there are two general ways to proceed. Which they choose depends not only on logistics, but also how the class decides they want to try to answer their question. Both methods have advantages and disadvantages the students will want to weigh.

Method 1: Videotape dogs in a natural setting or at a local dog park or at a doggy day care center. You can search for local dog parks in the US and Canada at www.thedogpark.com. If the class is to create their own video at a dog park or day care center, make sure they get permission from the dogs' owner or caretakers. Also, because dog parks and doggy day care centers can be chaotic places, students will need to video carefully and try their best to follow one dog at a time. It is best if they can videotape three or four dogs for about five minutes each. The teacher may wish to do the videotaping himself/herself outside of class as the presence of a large number of people will impact the dogs' behavior.

Method 2: Ask students who have dogs at home to videotape their pets, with the help of classmates. They will be setting up a few situations and videotaping how the dogs react in the different situations. Let the class brainstorm about different study designs that would not only allow them to control for things effectively, but will also allow them to study a range of dog behavior including times when the dogs would normally express positive reactions.

One idea would be to film the dogs' reactions to someone knocking on the door. First, have all of the students come inside and be with the dog until the dog is used to their presence. Then, have an unfamiliar student knock on the door and then enter the room while the dog is being taped. Next, have the dog's owner go outside, knock, and enter. Examine the different reactions by the dog.

Another way would be for all students to sit in a room with the dog until the dog is used to them being there. The room should be one the dog knows well. Tape the dog when someone the dog knows well (e.g., the mother, father, or guardian) walks in the room. Have that person then give the dog a small treat. Then, tape the dog while someone the dog does not know well walks in. Then have that person give the dog the same treat. Note differences in the dog's body posture and behavior.

RESULTS

1 As the students interpret their findings, ensure that they remain objective. By recording what types of tail wags the dogs display in different conditions, the students should come to see that dogs wag their tails for different reasons. They should also become more aware of the range and richness of dog body postures.

2 You may wish the students to give oral presentations, create a poster or bulletin board displays, or write reports about their study.

ASSESSMENT

1 The students develop a testable hypothesis and design a workable study to test it.

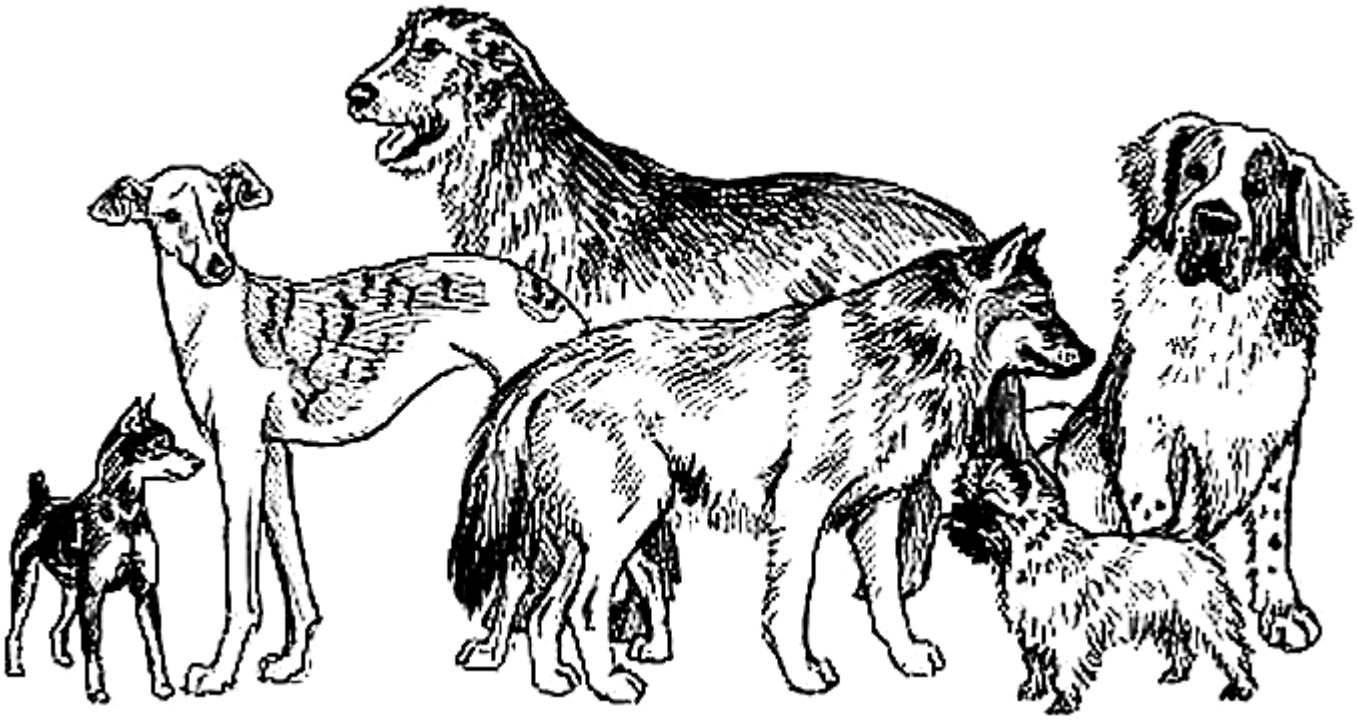
2 Students collect quality, objective data.

3 Students analyze and interpret their data, and communicate their findings through oral presentations, writing, etc.

4 Students learn to interpret dog body postures (and that a wagging tail does not always signal joy and the invitation to approach).

EXTENSION ACTIVITIES

Dogs descended from wolves. So, do wolves show the same body postures that dogs do? Video clips of wolf behavior can be found at http://projects.coe.uga.edu/fowler/WolfHabitat/EthoIntro.php. Students can study these behaviors and compare them to those of dogs.



did you know?

The Truth About Dogs and Wolves

The relationship between wolves, dogs, and people is a popular theme in books and films. In *Dances With Wolves*, we see a wolf and man trying to understand each other and co-exist together; in *The Call of the Wild*, we see reverse domestication as a sled dog answers the call of the pack and enters the primeval forest that his ancestors left many generations ago.

Both of these fictional pieces depict a generally accepted recognition that there is a link between the wolf and the dog, and that humans probably had a major role in how dogs became dogs. But how and when did all that happen? And why do dogs from different geographical areas look so different?

For many years, it was generally accepted that the wolf-to-dog changes occurred around 15,000 years ago, as the wolf joined man as a hunting companion. Each new generation of wolves lost a little more of its need for a pack and turned over the leadership of the alpha male to its human companion/master.

As DNA/molecular technology and behavioral research became more sophisticated in the late 1900s, several new studies and theories changed—or challenged —

accepted beliefs about the wolf-dog connection. For instance, one study concluded that over the centuries, wolves moved closer to the comfort of the fire, the convenience of a reliable food source (town dumps) and the companionship and protection of humans. This thesis cited a Russian study in which foxes were transformed from wild creatures to domesticated pets in just 20 generations. Another study places the ancestral wolf-to-dog split at more than 135,000 years ago—much earlier than the accepted time frame.

The truth is that there still is no agreement on how and when the wolf's descendants and mankind learned to co-exist and even communicate with each other so well. And it could very well be that in the next hundred years, someone will have a theory on why and how the wolf/dog has trained us so well.

Many of today's dog breeds are the result of humans tailoring domestic canines to their own needs and tastes. For instance, Dachshunds were bred with short legs, floppy ears, and long bodies so that they could follow foxes and rabbits into their burrows. See if you can find how and why the following breeds were developed:

Borzoi, German Shepherd, the Mexican Hairless, Akita, Chinese Shar-Pei, Bulldog, Poodle.

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Grade Level: MS

Type: Observation, data collection and analysis

Topic: Bird habits and behavior

Cool Birds for Science Nerds: Bird Observations

Birding is among the most popular avocations in the United States. Urban, rural, older, and younger students can all enjoy watching and learning about birds. This project can help students learn about the relationship between diet and behavior and about the characteristics of introduced species and their interactions with native species. In addition, the students can use this project as the launching point for participation in one or more studies led by Cornell, the Audubon Society, or possibly local organizations.

OBJECTIVES

After completing this activity, students will be able to:

1. understand the diets and behaviors of local birds.
2. understand the relationship between the components of various foods and the needs, behaviors, and ecological niches of various native and introduced bird species.
3. design, conduct, analyze, and report the results of an experiment.
4. understand some of the characteristics of introduced species that allow them to successfully invade an area, and the effects this may have on native populations of birds (and possibly other floral and fauna).

American Goldfinch

MATERIALS NEEDED

- Internet connection
- Two bird feeders, preferably pole-mounted feeders (optionally, the materials for students to create two feeders)
- Two of the following bird foods: sunflower kernels, peanuts, millet, peanut butter, corn, fruit, suet, or niger seeds
- Binoculars (optional)

CLASS TIME REQUIRED

One or two 40-minute periods plus approx. 5–10 minutes a day for one school week.

LESSON STEPS

This project is composed of two phases—the design phase and the investigation phase. In the design phase, students decide what type of feeder to put up and where to put it. In the investigation phase, they conduct one or more studies of their new neighbors. If time is short, the first three steps of the design phase can be substituted for a simple teacher-supplied list of local birds and their preferred methods of getting food.

Design Phase

1 Take students on a nature walk around the school campus. Ask each student to record what birds he or she sees *and* hears. Unless their school is in a city, they will probably hear more birds than they see. When the students see/hear a bird or birdsong that they do not recognize, they are to make as detailed a record as they can for later investigation. The illustrations accompanying this project detail some birds common to many parts of the continental states.

2 Back in the classroom, the students compare notes. Next, they conduct research using the library and Internet to compare their collective notes to birds and birdsongs. Birdsongs for many North American birds can be found at www.naturesongs.com/birds.html and www.math.sunysb.edu/~tony/birds/links.html. The feedback from comparing their observations with actual records will help students develop both their visual and auditory observational skills.

3 As students conduct research to identify what birds they observed, also have them compare the birds they observed to the ones listed for their area. Censuses of birds from the Great Backyard Bird Count can be found at www.birdsource.org/gbbc/Results. They may be surprised at the number of birds that live in their area. Students can also investigate which birds are native and which are introduced.

4 Choose a few of the local birds you would like the students to study. The students then find out what each of the birds eats and how they gather their food.

5 With your help (and permission from the administration), students decide upon a place to build two feeders on the campus in a location that can be observed from their classroom. However, placing it too close to large windows may cause birds to fly into the windows by accident (bird silhouettes on the windows can help but usually not enough) and placing them close to trees will encourage squirrels to come to the feeder (which is fine if you wish to study squirrel behavior instead). The feeders should be placed in an area where the seeds will be able to dry after it rains or snows. Also, keep in mind that there will be litter under the feeder. For more ideas and suggestions, visit www.birds.cornell.edu/pfw/AboutBirdsandFeeding/BirdFoods.htm and http://magazine.audubon.org/backyard/backyard0001.html.

The feeders should be identical. Metal feeders on poles are often best because they discourage squirrels and are easy to clean. Students can make the feeders (especially if they are wooden tray feeders with holes for drainage), or they can be purchased.

An alternative to installing feeders is to plant native shrubs. Certain native bushes provide not only a varied diet but also other things that birds need like shelter, nesting spots, etc. This could be done as part of the "Add Water and Stir: Building a Pond Habitat for Scientific Inquiry." If it is done, then plant two different types of bushes and investigate which birds prefer which bush, instead of which food the birds prefer.

Investigation Phase

1 Based on what the students have learned about their area's birds and their feeding habits, the students hypothesize about which birds would be attracted to which of these foods:

sunflower kernels	**peanuts**
millet	**peanut butter**
corn	**fruit**
suet	**niger seeds**

Not only will the students want to consider which of these most resemble the birds' natural diet but also that some of these foods have higher fat than others, and that some may appeal to a broader range (e.g., peanut butter versus fruit). Therefore, students should find out which of these foods have higher fat content and more calories, as well as more or different nutrients.

Students should also hypothesize about native versus introduced birds: Will introduced birds eat and/or behave differently than native birds? Why or why not?

2 Students choose two of the foods above to test for the birds they attract. (Note that some of the foods—like niger seeds—are more expensive than others—like corn.) The students should make their choice based on two that would make an interesting comparison.

3 Students put one of the foods each in different feeders.

4 At the same time of the day, students observe the number and types of birds that visit each feeder for five minutes. As the students gain experience, they can also investigate the behavior of the birds —like dominance patterns between and within species.

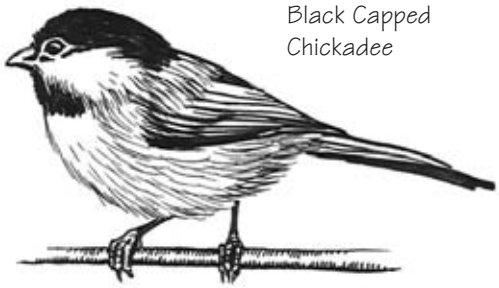
RESULTS

1 After a week of daily, five-minute observations, the students aggregate their data to test their hypotheses about food preferences. Did the foods the students expected to attract more birds indeed attract more? Did birds they expected would prefer one food over the other indeed do that? Students can now compare their results to the food preferences listed in any of several websites (including those mentioned in step 5 of the design phase).

2 If the students completed steps 1–4 of the design phase, they should also compare the composition of the population at their feeders with what they observed in their initial census of the area. In addition, the students can look at the data to see which birds came to the feeders first. Are there traits that the first-comers share with each other but not with the late-comers?

3 Finally, the students can compare generalist feeders versus specialists and native versus introduced species—both in numbers and food preferences. What do their findings suggest about both generalists and introduced species? Do the students believe that any bird that is introduced to their area will behave the same way?

4 The students should create a report of their findings. If the students have access to cameras, this project lends itself well to photography.



Black Capped Chickadee

EXTENSION ACTIVITIES

1 The data the students collect can be used not only for their own scientific studies but also in the studies of scientists at universities! There are three major studies in which the students can participate: the Great Backyard Bird Count, the Audubon Christmas Bird Count, and Project Feeder Watch.

Participants in the Great Backyard Bird Count tally birds that visit their yards or campuses during a four-day period in February. Check out www.birdsource.org to find out exactly when this takes place. The website is also a great resource for the results of previous years' studies as well as plenty of other information about birds.

According to their website, the Audubon Christmas Bird Count (CBC) is the oldest and largest citizen science event in the world. The time during which people can collect data for the CBC is also longer than the Great Backyard Count: from December 14 to January 5. Each group does their count on one day during this period. Of course, there is a methodology that participants are asked to follow to maintain this excellent and important tradition. More information is available at www.audubon.org/bird/cbc/getinvolved.html.

Finally, students can collect data for Cornell's Project Feeder Watch throughout the winter; visit www.birds.cornell.edu/pfw/ for more information. There is a small fee to join the study, but that is used to keep this valuable research going. In addition, members get a research kit, a quarterly newsletter, and other materials that are well worth the fee ($15 in 2005).

2 Students can learn about critical local efforts to conserve "important bird areas." This Audubon program exists in nearly every state and can be used to tie the information about the number and types of birds the students learn about at their feeders into important local conservation programs. Find out more at www.audubon.org/bird/iba.

3 The number and types of birds that visit the feeders will change throughout the year. This project can be extended beyond one week, perhaps with students taking weekly shifts observing the birds. Do the students notice these changes? Do they predict and find changes that track the migration patterns of birds? During migration, do they see birds visit their feeders that don't at any other time of the year?

ASSESSMENT

1 Students understand the diets and behaviors of local birds.

2 Students understand the relationship between the components of various foods and the needs, behaviors, and ecological niches of various native and introduced bird species.

3 Students successfully design, conduct, analyze, and report the results of an experiment.

4 Students understand some of the characteristics of introduced species that allow them to successfully invade an area, and the effects this may have on native populations of birds (and possibly other floral and fauna).

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Grade Level: HS

Type: Lab

Topic: Insect optics

Like a Moth to a Flame: Insect Optics

Why do they do it? Why do moths incessantly bump against lights? Is this a sign of great stupidity, or perhaps ingenious design?

INTRODUCTION

Through careful and respectful study, students begin with a mundane example of odd insect behavior and finish with a sophisticated understanding of insect optics. This project is designed to provide a framework that allows for flexibility while still providing sufficient direction.

OBJECTIVES

After completing this activity, students will be able to:

1 articulate the physiology of a compound eye.

2 explain the use of polarized light, and the advantage of this type of light as a navigation tool.

3 more proficiently design and conduct an experiment.

MATERIALS NEEDED

- Sturdy, cardboard box (a copier paper carton is ideal)
- One pair of polarized sunglasses that can be taken apart
- Other materials as dictated by the class's particular design
- Two or more small dishes
- Nylon stocking
- Sugar
- Insects

CLASS TIME

One 40-minute period for set-up and one period for data collection. The project can be expanded to include other projects or reduced to one period if teacher does preparation beforehand.

LESSON STEPS

Introduction

1 Ask students why moths are attracted to light. Of course, let them air their theories—many of which may not be flattering to the moths. Are moths the only insect that is attracted to light? Ask students if they have ever gotten a fly out of a room by turning out the lights in the room, opening the door, and instead turning on an outside light? Ask students what kind of eyes moths have. Are their eyes similar to a fly's? Do any other insects have compound eyes? Might there be something special about compound eyes and light?

2 Yes, flies and moths are hardly the only insects with compound eyes. And there *is* something special about light and these eyes. Bring the students into an exploration of this.

3 Help students design an experiment in which they can study the effects of light on insect navigation. The example given here studies the effect of polarized light, but other possibilities exist. Students can study the effect of color or light intensity. They can study whether warm incandescent light is preferred to cold fluorescent. They can also study the ability to detect infrared or ultraviolet light.

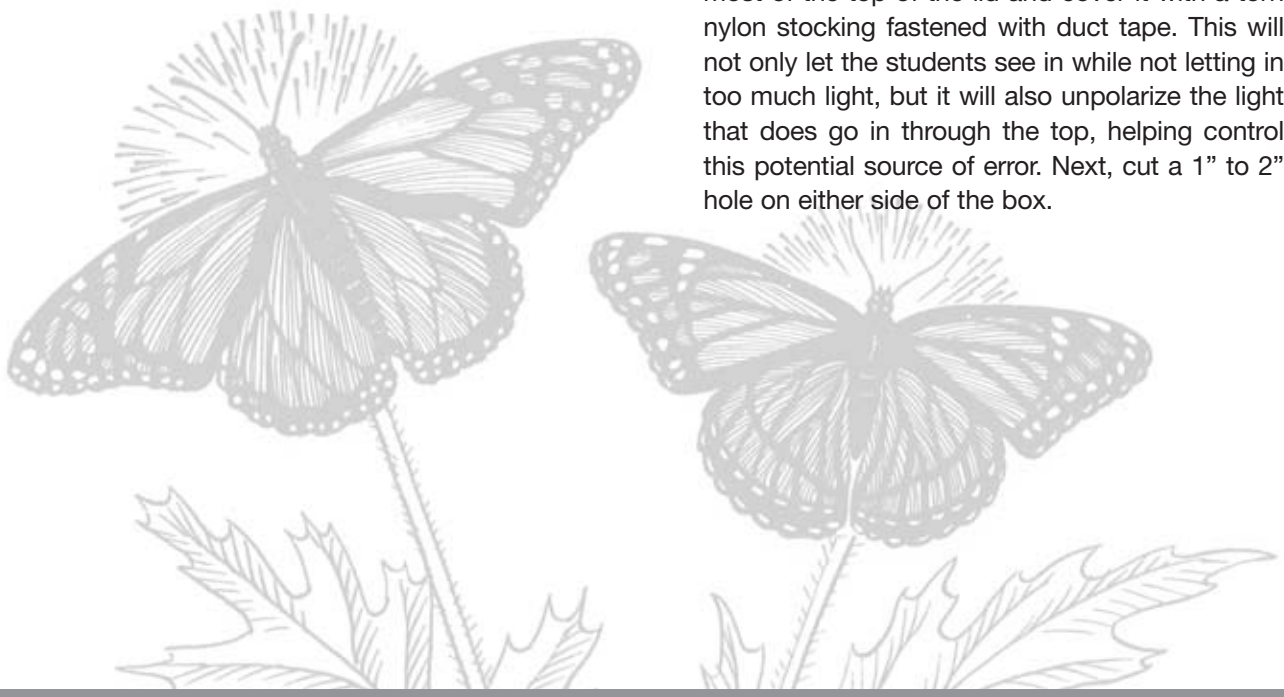
To study infrared, use two dark pieces of metal that are placed behind glass (for example, under two baby food jars). One of the pieces is heated enough that it's warm but not so much that it's glowing. The other can be chilled.

To study ultraviolet light, create two holes in a box (as described below). Cover one hole with glass, which blocks most ultraviolet light (which is why we can't easily get a tan through a window). Cover the other with a light screening material.

Preparation

1 There are many types of insects that students can study—as long as whichever they choose, they treat well and release when finished. Ants, butterflies, and flies are three excellent choices. Ants and flies are, of course, readily obtainable, but this project is meant to be applicable to a wide variety of subjects. Butterflies provide some additional, exciting opportunities. Butterfly eggs can be purchased inexpensively from reputable sources. The class can then raise them in the classroom, study them, and release them. They can also create a butterfly garden for their butterflies. If students choose to study Monarchs, they can contribute to the exciting work being done by Journey North (www.learner.org/jnorth/).

2 Create a chamber to temporarily house and study the insects. It is best to create a chamber with five opaque sides, and one side that is semi-transparent. A stiff cardboard box works well. You may want to reinforce it with more cardboard folded into strips or slats of wood. Next, make a lid that can be opened. If you use a cardboard box that copier paper comes in, its lid is ideal. Cut out most of the top of the lid and cover it with a torn nylon stocking fastened with duct tape. This will not only let the students see in while not letting in too much light, but it will also unpolarize the light that does go in through the top, helping control this potential source of error. Next, cut a 1" to 2" hole on either side of the box.



3 Create a source of polarized light. There are two easy ways to do this. One way is to use a pair of sunglasses that polarize light. Take the lenses and duct-tape one over each of the holes in the side of the box. Another way is to cover the holes with glass. Then, attach a small mirror at a 45° angle just next to the hole. Mirrors tend to polarize light. This also can help students better understand how an insect can see polarized light even if the image casting the light is too small for the insect to see.

4 Create two (or more) feeding stations. Depending on the insects, these can be dishes of sugar water, candy tins with a hole cut in the side, or cubes of sugar. The food should not give off any odor. A typical formula for sugar water is 1 part sugar dissolved in 4 parts warm water.

Insects cannot see well beyond a few feet, but that's already pretty far to an inch-long animal.

Investigation

1 Train the insect to eat out of the feeding chamber on one side of the box by sending polarized light into the test chamber through only one of the two holes in the sides. The students will have to decide on how to control for possible confounds like the presence of liquid, smells, other external cues, etc. For example, note that ants will leave a pheromone trail to the food, so the chamber will need to be wiped out after each trial.

2 After the insect is reliably going to the feeding station, switch the side from which the polarized light enters the chamber. Does this affect which station the insect visits?

POINTS OF DISCUSSION

1 Why use polarized light? (Maybe give a clue that mirrors are good signaling devices.) Ask students how compound eyes work. Compound eyes do not reflect myriad copies of the same image, but make up the parts of a low-resolution image. Check out this site for some excellent examples: http://cvs.anu.edu.au/andy/beye/beyehome.html.

Because insects have such low resolution vision, they cannot see well beyond a few feet, but that's already pretty far to an inch-long animal. A compound eye may not have the resolution for detail that our eyes do, but they are better than our eyes at discerning motion or slight changes in their visual environment—a quite useful trait when avoiding predators or flying. Because of this, scientists are investigating using compound eyes as a type of navigation system for flying robots.

Insect eyes not only see a different resolution image, but they also use different colors and properties of light than we do. Some (like mosquitoes) can see infrared light, while others (like honeybees and Monarch butterflies) can see ultraviolet light. Something else many insects can see is polarized light. This makes sense, actually. By and large, the light from the sun (or even the moon) is polarized, coming to us from one direction. By being able to see polarized light, insects are able to navigate by the sun or other light sources even though their eyes don't have the acuity to actually see the sun.

What are some other sources of polarized light? One turns out to be butterfly wings. The iridescent sheen to butterfly wings comes largely through their polarization of light. Why would a butterfly want to do this? More on this can be found at http://optics.org/articles/news/9/5/6/1

2 Many (but not nearly all!) moths are more active at night. Why would a nocturnal animal use light to navigate? What are some nighttime sources of light, and why might moths want to navigate by them? Do moths have other modes of navigating? Physiologically, how to do moths' senses differ from butterflies? How do diurnal and nocturnal moths differ?

ASSESSMENT

1 Students design, run, analyze, and communicate a well-controlled experiment that answers a clearly stated hypothesis.

2 Students understand the physiology of compound eyes and their relative advantages and disadvantages to other types of eyes. Students also understand the adaptive advantages of each for the respective animals.

3 Students take good care of their subjects.

EXTENSION ACTIVITIES

This project was designed to provide a concrete example, but also to allow students the opportunity to participate in the creation of their own studies of insect perception and learning. There is a wondrous and fascinating world behind something as mundane as bugs bumping against a light. What other worlds lie behind other prosaic events?

1 Many great ideas for studying butterflies and their relationship with plants and gardens can be found at www.kidsgardening.com/growingideas/projects/feb04/pg2.html.

2 The chamber can be modified in several ways—adding more holes, placing the feeding stations radially from the center or all on one end, etc. Do the insects tend to travel in different directions relative to the polarized light at different times of the day? The sun, after all, moves across the heavens—do insects account for this, especially before they've learned how the chamber works?

3 Ants and bees are both expert foragers that use some different cues to find and keep track of food. Do they learn using the same cues? Do they "unlearn" where food is at different rates? Bees, of course, should be studied cautiously and outdoors.

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Grade Level: Upper MS, HS

Type: Observation, collecting and recording data

Topic: Observing animal behavior and using ethograms to record data

The Budding Ethologist: Observing Pet Behavior

Being able to decide how best to collect data to answer a given question is a very important skill for students to learn—and not only in science class. For this project, students practice using ethograms to record animal behavior observations and learn how different conditions can affect behavior. And understanding the process behind scientific conclusion can help students think more critically about information they will encounter throughout their lives.

INTRODUCTION

Being able to decide how best to collect data to answer a given question is a very important skill for students to learn—and not only for science class. Transition matrices are great for answering some questions about animal behavior but not all. Many of the sorts of questions that can't be answered very well by transition matrices can be answered by time budgets, a type of ethogram. Time budgets are good for studying how different conditions/contexts change overall behavior.

Students will become familiar with the time budget as they study the behavior of companion or other animals. It can be used on its own, or after introducing students to ethology with "You Read My Mind! Scientific Observation of Human Behavior" or "The Tail Wagging the Dog: Observation of Canine Behavior."

OBJECTIVES

After completing this activity, students will be able to:

1. practice deciding upon a testable question and designing a way to study it.
2. gain experience collecting and interpreting objective data.
3. gain an appreciation and understanding of the behavior and personality of cats or other animals.

MATERIALS NEEDED

- Time budget ethogram
- Watch with second hand or stopwatch
- Clipboard

CLASS TIME REQUIRED

Two 40-minute periods, one of which may be a field trip to watch animals (e.g., if available and permission granted, cats in a cattery at a local animal shelter)

LESSON STEPS

Preparation
This project gives students considerable freedom to explore their particular interests in animal behavior. For instance, cats are sometimes perceived as mysterious and unpredictable. But we can gain insights into their behavior through observations. All it takes is a curious mind and careful study.

1 Inform students that they are to conduct a study of animal behavior. For the next class, ask them to think of three questions about the behavior of animals they would like answered.

2 The next class day, record the questions on the board. Using these questions as a starting point, ask students to identify or add questions that can be addressed through observational study.

3 Have students vote on which ideas they like best and then assign students to investigate these questions. For most questions, it is best if they work in pairs or small groups.

Some of the questions that can be answered are:

- **Are birds, fish, insects, cats, hamsters, etc. more active at certain times of day than other times?**
- **Do animals have daily schedules and patterns?**
- **Cats are sometimes seen as cautious. Do cats indeed act differently around novel objects or in novel environments?**
- **How do cats mark new objects in their environments?**

This project gives students the chance to see their own pets in a new light and to understand nature better. The teacher must guide them in choosing questions that they can answer in a brief study.

4 Some of the questions posed above lend themselves to be answered through use of an ethogram called a time budget. Time budgets record how much time an animal spends doing different behaviors. By measuring how much time their animals spend doing different behaviors, we can learn about what affects their actions.

Give students the time budget explanation and data sheet handouts. Go over this with the class so they understand how this method works and the sorts of questions it can answer. Even if you don't believe a particular question can be answered with a time budget, this can help students understand how to form a testable question and record relevant behavior.

5 After the students have settled upon a question to ask, they should form their question into a hypothesis or a statement that is testable. Help students discuss the best ways to try to answer their hypotheses and whether or not a time budget would be useful. For example, a testable hypothesis might be that cats spend less time sleeping at dusk and dawn than they do midday.

The previous questions can all be answered with time budgets. For example, to answer if an animal is more active at a certain time of the day, the students can record their subject's behavior in the time budget at pre-determined times of the day (and night) for five minutes each time. They can simply measure if the animal is awake, or how many different activities it does during the sessions.

Set up students to work in teams. In most cases, they will not need to videotape their animals, but most data collection techniques will be easiest when students work together, each having a specific role to play. In addition to working in teams to collect data on one animal, students can work in teams to collect data on different animals and compare their animals' behaviors. For example, are cats and mice active at the same times of the day? Are the two performing different behaviors at different times?

A somewhat more involved question is whether animals have daily schedules. To answer this, students record what the animals do at different times of the day and see if there are day-to-day patterns.

To determine whether cats act differently around novel stimuli, students can put a cat in a familiar room and introduce both novel and familiar objects into the room one at a time. The students then measure how much time the cat spends exploring or avoiding stimuli that are new or familiar to it.

A more challenging question to answer is why cats rub their chins. To gain insight into whether cats rub their chins to spread their scent, students can record how often the cats rub various objects in their homes. They can look at these objects. Do some of them have more discoloration than others? Alternatively, using time budgets, students can present cats with an old versus new object. Do cats spend more time rubbing against new objects or will they also spend time rubbing against familiar items that have been moved into another room?

6 Of course, the student will need to have a catalogue of behaviors. The THEMES points described in "The Tail Wagging the Dog: Observation of Canine Behavior" project can work well for most mammals. Catalogues of behaviors for several other animals are given in resources below.

Data Collection

1. After the students have helped each other decide upon questions to answer and ways to answer them, they should collect the data.

2. One student observes the animal subject while the other keeps careful track of time. (The students can switch roles after set periods of time.) The student who is watching the animal records the behavior the animal is doing (or this could be the job of a 3rd student). When the animal begins its first behavior, the animal-watcher quietly says "Start 1." The timekeeper marks down the time in the bin for the beginning of Behavior 1.

3. When the animal stops the first behavior, the animal-watcher says, "Stop 1" and the time-keeper marks down the time in the Stop 1 bin. The second behavior will probably start as soon as the first behavior stops, so the timekeeper probably doesn't need to mark this down.

4. The animal-watcher records the animal's second behavior. When that is done, the animal-watcher says "Stop 2" and the timekeeper marks that time. This continues until the session is over.

RESULTS

The students will be able to compare the amount of time spent doing various activities and plot them in either bar charts or pie graphs. If they have formulated their hypothesis such that they expect their subjects will spend more time doing behavior A versus behavior B, then these graphs should very nicely return their answers for them. Students should organize their study into an oral report, poster, and/or written report.

Students may find it fun and useful to think about their animals' behaviors in light of the recommendations made by Niko Tinbergen, a pioneer of ethology, about the ways ethologists should consider animal behaviors:

Causation: What caused the behavior to happen (i.e., what stimuli elicited that response?)?

Function: What function does the behavior have that increases the animal's chances of survival (i.e., living long enough to pass its genes on to as many offspring as possible)?

Development: How does the animal's age or past experience (i.e., learning) influence the behavior? For example, students could study dogs of different ages.

Evolutionary History: How does the behavior compare with those of related species, such as bobcats and tigers for cats or wolves and foxes for dogs?

Students can consider these in light of the observations they've made in this project and any write-ups they do on them. For example, if they find that their cats are most active at dusk and dawn, what might this imply about the behavior of the animals upon which they prey?

If students measure when their animals are most active, are there any implications from their findings? For example, if hamsters are most active at night, what does this say about when we should interact with them? If animals bite out of confusion more often when they are sleeping or tired, does that imply we should treat them differently at different times of the day?

EXTENSION ACTIVITY

As the name implies, time budgets (also called energy budgets) are useful for determining how an animal manages his time or energy. For example, students can use this method to measure if squirrels allocate their time differently during the fall or spring, or if ants do different things when they have just established a colony versus when they are part of a well-established colony. Whenever an environmental factor may affect how an animal uses its time, time budgets can be used as a tool. Even the measurements collected in "pHishing for Answers" are a modified time budget.

ASSESSMENT

1. The students objectify (operationalize) their descriptions of their animal's behaviors into ways that can be recorded.

2. The students make accurate recordings of their animal's behaviors.

3. Students analyze the data and make objective inferences about why their animals did what they did.

ADDITIONAL RESOURCES

ASPCA's *Reading Feline Body Postures* (one free copy is available by writing to ASPCA Education Dept., 424 East 92nd Street, New York, NY, 10128-6804.)

Compelling stories about animal emotions from prominent scientists
Bekoff, M (Ed.) (2000). *The smile of a dolphin: remarkable accounts of animal emotions*.
New York: Discovery Books/Random House.

A List of multiple animal behavior links:
www.kensbiorefs.com/animalbehavior.
html#anchor76019

Wildlife Viewing (focused on Florida, but useful elsewhere)
http://floridaconservation.org/viewing/

Behaviors of Rabbits
www.rabbit.org/behavior/body-language.html

CREATING TIME BUDGET ETHOGRAMS

1. Choose a subject.

2. Watch the animal for a given period of time (e.g., five minutes) and list every single behavior you observe.

3. Take notes on any behaviors or events that occur but that don't easily fit into the ethogram. Record these in the Notes below the ethogram.

4. Codify (describe objectively) the behaviors after you've assembled a good list.

5. If the animal starts one behavior and then starts another before the first is done, write the second down below the first and record the times for each. For example:

Behavior Number	Behavior Code	Time at Start of Behavior	Time at End of Behavior	Notes
1	Sit	0:00:00	0:01:24	
2	Groom	0:00:16	0:00:50	

6. Sometimes, behaviors will occur that aren't easily broken down or even described. These can be the most interesting and important but don't always fit well into an ethogram. In Notes below the ethogram, write out these observations and be sure to discuss them later.

Handout: Budding Ethologist

ETHOGRAM FOR:

DATE:

LOCATION:

Behavior Number	Behavior Code	Time at Start of Behavior	Time at End of Behavior	Notes
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

NOTES:

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®



Grade Level: MS

Type: Research, data gathering, presentation

Topic: Field-based research

Field-Based Research Projects: The Jane Goodall Environmental Middle School Model

Students may be used to practicing science, but do they expect that they may be able to help conduct real experiments? They can. Using the experience of one school as a guide, classes participate in authentic research.

INTRODUCTION

Teachers are always looking for engaging and meaningful projects for their students. At the same time, government or non-government conservation organizations are seemingly always shorthanded when it comes to conducting all the research projects they would like to do. At the Jane Goodall Environmental Middle School (JGEMS) in Salem, Oregon, they have been able to use student scientists to conduct these research projects, providing both the assistance needed by the organizations and the engaging and meaningful projects that students need.

Field-based research projects may not be feasible for every classroom. They require a commitment of time, transportation, and adult supervision. Projects done in collaboration with non-school organizations provide an incentive and a relevance to research work that may be missing from research done in school. In addition, collaborating with outside organizations can provide expertise, equipment, and maybe even funds that may not be normally available to the classroom teacher.

Students at JGEMS have been doing these field-based research projects for six years and have established a reputation for thorough and careful research. Each year the number of requests for projects increases, giving the students more choices for projects and more opportunities to make connections and apply their skills and knowledge to engaging and meaningful "real life" projects. They do this as a yearlong project, building the conservation biology curriculum around the various project topics. This is a great way to tie content to process.

Before you begin, visit the JGEMS web site (www.jgems.net). There you can download a variety of teaching materials needed to guide students in writing a formal scientific research paper and examples of data collection sheets. See Resources section for more details.

OBJECTIVES

After completing this activity, students will be able to:

1. work in collaboration with a local government or non-government conservation organization to conduct field-based research to solve an environmental issue.

2. design a research project including data gathering protocols, data analysis and communication of results.

3. communicate their project results with their partnering organization.

THE PROCESS

Start with an introduction to scientific research. This begins by teaching or reviewing the scientific method with the students. Discuss the difference between experimental, descriptive, and historical research. A good resource for this is *Looking for Data in All the Right Places: A Guidebook for Conducting Original Research with Young Investigators* by Alane J. Starko, Creative Learning Press, Inc., publisher.

You will need to come up with a list of possible research areas or topics. There is no shortage of research that organizations want to have done. You just need to ask. You can contact the U. S. Fish & Wildlife Service (USFWS). Local national wildlife refuges will always have research that needs to be done, and they are mandated to work with schools as part of their outreach. Local natural resources departments at the city or state level often have projects that are appropriate for students. Local watershed councils, neighborhood associations, Audubon Society chapters, local accredited zoos, and outdoor education facilities are all good sources for research projects.

In one year, for example, JGEMS students conducted the following research:

- Studied stereotypic behavior in polar bears for the Oregon Zoo.
- Conducted a stream transect to determine salmon spawning suitability in Gnat Creek for the Oregon Department of Fish & Wildlife.
- Examined owl pellets to determine the small mammal population in Nestucca Bay National Wildlife Refuge for the USFWS.
- Used infrared camera traps to photograph the large carnivores at the Opal Creek Ancient Forest Center and to develop a handbook on using the camera traps.
- Evaluated the effectiveness of certain fencing techniques to facilitate the movement of wildlife through rangeland in winter for a local ranching organization.
- Evaluated the effectiveness of riparian restoration efforts in local streams for the City of Salem's Natural Resources Department.
- Censused the macroinvertebrate population in two local streams for Oregon Watersheds.

Once the possible research projects have been collected, you will need to establish research groups and have each group choose a project. More guidelines for devising the methodology are available at www.jgems.net. Students generally choose a research topic for one of three reasons: 1) they like the topic; 2) they like the location of the research site; or 3) they want to do what their friends are doing. Once the groups choose their topics, arrange for the groups to meet their collaborating partners in the field at the research project site to talk about the best way to set up the research design. You will want the students to design their research project in a way that will be most useful to the partnering organization.

DATA GATHERING

The motto for JGEMS is, "Bring home the data." Stress to the students that when they start their data collecting in the field, they need to be thorough and accurate in collecting their data. Teach the importance of sample size and controlling variables—both important concepts in any research design. Have the students return to the site as many times as finances allow and the project demands. JGEMS has had projects that demanded monthly visits throughout the year and others that required only one visit in the fall and one in the spring.

Students will need to design data sheets that work efficiently in the field and can easily be transferred to digital spreadsheets back in the classroom. It is critical to transfer the data as soon as possible so students can remember the experience and the data.

THE RESEARCH PAPER

As the students are collecting their data, they should also be working on their formal research paper. An example is available at www.jgems.net. This should start with a review of the literature and an introduction. Provide a model for the students so they can see how this works. Students can search the web, the local university library, or resources from their partnering organization. They need to know the background of their issue and what other scientists have learned about their issue in previous studies. The introduction should end with an explanation of their research project—what they are doing and why.

The methods section of the paper is pretty straightforward. The results section will include their analysis of the data. They should include well-labeled graphs to help in the interpretation of the data. Students might also use geographic information system (GIS) software to further analyze their results. GIS data sets are available from most of the organizations you are likely to partner with.

The discussion will be just that, a discussion of the results. Did the results meet their expectations? What surprises did they find? What problems did they discover as they were collecting their data? The conclusion will include the final thoughts from the students about the topic for the partnering organization. They should also include recommendations for further research. For many organizations, long-term studies are incredibly helpful. JGEMS students, for example, have been collecting data on red-legged frog egg clusters for five years, and the data from the fifth year shows a remarkable change that would not have been seen if they had stopped after one year.

The ultimate goal of any project is to share the research results with the partnering organization. You can do that in one or all of these ways:

- Present the students' formal research papers to the partnering organization.
- Prepare a scientific poster display to give to the organization.
- Invite representatives from the organization to a presentation at your school or have the students present at the organization offices. Students can use PowerPoint or other digital presentation software for the presentation. They can prepare speeches explaining their work and they should be prepared for questions from the staff. They should be able to "defend" their results.
- Students can put their research on the Web, using either the school website or the website of the partnering organization.

CONCLUSION

Whether this research project is done in a month, a semester, or a year, providing students with an opportunity to apply their skills and knowledge to engaging and meaningful real-life projects is a great way to not only make science exciting, but also to establish links with the broader community. The effort and resources you need for this are extensive, but the rewards in student achievement and respect from the community make it all worthwhile.

ADDITIONAL RESOURCES

To help you set up a research project and bring participatory action research into your classroom, the following resources are available online at www.jgems.net:

- A guide to writing a scientific research paper.
- Worksheets designed to break the research steps (introduction, methods, results and discussion) into manageable lessons.
- Literature summary sheet.
- Examples of students projects.
- Sample data collection sheets.




ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: HS

Type: Research and simulation

Topic: Feral cat population control

Population Explosion: Feral Cats in Our Communities

Feral cats are in trouble. The cats often live in unhealthy conditions where they are easy victims. In addition, they affect local wildlife. In this project, students explore the problem of feral cats and identify ways to humanely control feral cat populations in their communities.

INTRODUCTION

Explain to students that feral cats are the unsocialized offspring of domestic cats that have been abandoned and allowed to breed uncontrolled without significant human interaction. Feral cats may be found living behind shopping areas, in alleys, parks, abandoned areas, and in rural areas. Feral cats are usually skittish and untrusting of humans.

Feral cats are a big problem. The average lifespan of a feral cat is considerably less than an indoor cat due to the unhealthy and unsafe conditions in which they usually live. In addition, a population of wild cats can spread disease and alter the populations of local birds and animals. Allowing these cats to run feral and breed in an uncontrolled manner is not humane. Many have tried to help feral cats. In this activity, students will learn about the problems of feral cats and will work to develop a plan to help improve the quality of life for these animals that may be in their neighborhood.

OBJECTIVES

After completing this activity, students will be able to:

1. identify information that needs to be gathered and conduct the research necessary to find this information.
2. model a population of feral cats.
3. create a flyer or poster to spread the word of their plan to help feral cats.

MATERIALS NEEDED

- Internet access
- Graph paper
- Calculators
- Large piece of poster board
- Markers
- Colored pencils
- Rulers
- Poker chips, counters, or strips of colored construction paper

CLASS TIME REQUIRED

Two to three 40-minute periods

LESSON STEPS

What Do You Already Know?

Begin a classroom discussion with the students by asking them if they know what feral cats are. Record student responses on the board. Students may have had experience with feral cats and may know some basic facts about them.

1 Separate students into groups of three or four. Provide each group with a large piece of poster board, markers, and colored pencils. Students create a web diagram with the term "Feral Cats" in the middle.

2 Have students brainstorm the potential problems that may arise in a community if a feral cat population was allowed to grow unchecked. Students should include ideas about the potential impact on the community at large, health conditions, environmental factors, and impacts on the feral cats themselves.

3 Monitor students' progress on this task. They should focus their energy on three major problems: overpopulation, poor living conditions, and destruction to the environment. Guide the individual class discussions so that students are headed in that direction. Encourage students to write questions from their brainstorming session that they would like to have answered.

Questions may include things such as:

"How many kittens do feral cats have in a litter?"

"How fast do cats reproduce?"

"How is the feral cat population being controlled now?"

"How can feral cats be caught humanely?"

"What happens to feral cats that are caught?"

"What services are available to help feral cats?"

"What is life like for a feral cat?"

"Why is feeding without altering problematic?"

"What places in your neighborhood would not be good places for feral cats to live—either because of dangers to themselves or to wildlife? And what places could safely house a colony of feral cats?"

WORKING TOGETHER

Provide students time in the computer lab or on the classroom computers connected to the Internet to research the feral cat issue. Encourage students to start a chart with their original question on one side and the answer to the question on the other side. Students may start to discover that there are many agencies and action plans that have been started to help feral cats. Students will probably come across the Trap-Neuter-Return (TNR) strategy. After students have answered their questions, explain that they are going to see the impact that the TNR plan will have on a hypothetical feral cat population.

A Fictional Feral Cat Community

1 Divide the class into four groups. Provide each group with graph paper, colored pencils, rulers, calculators, and "cats." These can be colored poker chips, counters, or small strips cut from colored construction paper. Just be sure that there are only two colors for each group (one for male cats and one for female cats), and provide students with a large quantity of both.

2 Explain to students that they will be simulating the growth of a population of feral cats and analyzing the effectiveness of different control programs, like TNR, euthanizing, and catching to take to a shelter.

3 Students should use the information they gathered on the reproduction rate, mortality rate, and number of litters to estimate the growth of an initial feral cat population of 4 females and 4 males. A female cat can start having kittens when she is about 6 months old (some even at 4 months), and can have an average of three litters of 4-6 cats each. In a typical litter, only two of the kittens will live long enough to be weaned. As a group, let the class explore different ways to simulate the growth of the feral population.

4 Students should see how the population will grow over the span of two years. Every year, have the students add or remove cats from the population due to new cats coming in (e.g., from people letting their cats go) or leaving (from death, etc.). One way is to roll a die and subtract 2 from the number. This is the number of cats to either add to the population—from 2 leaving to 4 coming in. Flip a coin to determine which are male and females. Have students graph their data on a sheet of graph paper. If there are the facilities for it, students can use a spreadsheet program like OpenOffice.org Calc to graph their results.

5 After calculating for two years of uncontrolled and unchecked reproduction, have each group of students implement a different control program with their simulated population of feral cats. One group should implement a TNR program.

6 Students assess how quickly their population becomes controlled or grows. Have students graph this information on another sheet of graph paper.

7 The exact results of their simulations will vary. In addition, since this is a simulation, many natural factors are simplified or not included. Nonetheless, the students will probably find that TNR is the most effective and humane method of control (and possibly even elimination) of a population of feral cats. They may find that disease or predators can kill an entire population. If so, discuss whether this represents an accurate portrayal of reality, and whether or not it's humane.

TAKING IT ONE STEP FURTHER

Students now have a solid rationale in support of a TNR plan. Encourage students to create a public service announcement telling the citizens of their community what can be done about this problem. This information should be compiled in a manner that is interesting and informative so that word of the feral cat problem can be spread to many. Students may want to contact a few veterinarians in the area to see if they will sterilize feral cats and what this might cost. Students should also include a list of agencies in the area which try to find homes for the socialized kittens of feral cats.

ASSESSMENT

1. Students understand the factors affecting feral cat populations and the effects of these populations on the health of the cats and their environment.

2. Students understand the various population control programs used with feral cats.

3. Students successfully complete a simulation that accurately portrays the relative effectiveness and humaneness of population control strategies.

4. Students understand the advantages and limitations of TNR programs.

5. Students appreciate the value of spay/neuter programs and public education on the feral cat problem.

EXTENSION ACTIVITIES

1. In this simulation, students work with populations that begin with eight cats and grow from there. In reality, poorly informed people will release or abandon their cats to the wild as well. Investigate the impact of this on the population and the effectiveness of the population control strategies. This extension will underscore the need for spaying/neutering and public education efforts.

2. In the simulation, there were no cats that wandered in from other areas, nor did any of these cats wander off. These factors can be included in the simulation. However, discuss with the students how cats do tend to stake out and adhere to a territory. Students can also investigate male/female differences in regards to territories they stake out. Unneutered males don't stay in a small territory as much as females.

3. Poll students to see if they are aware of feral cat colonies in their community. Discuss why feral cats tend to stay within human-populated areas. Discuss how this underscores the fact that domesticated animals like cats are not adapted for non-human environments. The flip side of this is that wild animals are not adapted for human environments.

4. The students can change the simulation to accommodate different factors for urban, suburban, and rural colonies.

Resources

ASPCA
www.aspca.org/cruelty_tnr

Alley Cat Allies
http://www.alleycatallies.org

Slater, Margaret R. (2002). Community Approaches to Feral Cats. Washington, DC: Humane Society Press.

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Grade Level: MS, HS

Type: Lab

Topic: Investigation and forensics

We're On the Case: Animal Cruelty and Criminal Forensics

A dog is found near death in an empty building. No one saw anyone leave the dog there. There are only a few suspects—and no one is confessing. Using just a handful of clues taken from the scene and their scientific prowess, can the class figure out "who dunnit?"

INTRODUCTION

Students will be aiding the investigation of a case of animal cruelty. Using background information and evidence collected from the crime scene, they try to figure out who is the guilty suspect.

This project is made up of several, smaller labs placed into two sets. The students complete one set on one day, and the other set on another day.

The class does not need to conduct all of the labs in the case. In the interest of time, you may prefer that the class skip some of the labs. This is fine—simply give them the results they would have found. For example, instead of going through the process of confirming that the case is one of criminal neglect (phase 1), simply tell them that it is, and move on to the other labs.

OBJECTIVES

After completing this activity, students will be able to:

1. learn about animal cruelty.
2. gain facility with chemistry laboratory techniques.
3. practice forming and testing hypotheses, and applying information to arrive at an overall picture.

CLASS TIME REQUIRED

Three to four 40-minute periods (can be easily tailored to take two days)

LESSON STEPS

MATERIALS NEEDED

- Newspaper clipping (at end of project)
- Incident report (at end of project)
- Pedro's testimony (at end of project)

Introduction

1 Read (or have volunteers read) the newspaper article, Pedro's testimony, and then the incident report to the class.

2 Explain to the class that they will take on the role of members of a criminal forensics laboratory, conducting tests in the case of Sam, the abused dog left to die in a building.

3 Tell the students that upon arriving at the ASPCA's Bergh Memorial Animal Hospital, Sam was put under very close supervision. He needed care, and he needed to be guarded carefully — after all, he himself was part of the evidence that there was a crime. Blood work done at the hospital found that Sam had very low blood sugar and red blood cell count: these indicate poor nutrition. Of course, the staff wanted to see if Sam would eat and drink. Indeed he did do both — and lots! When Sam arrived, he weighed 22 pounds. Over the course of ten days, he gained 10 pounds simply by being fed. One more thing, when Sam was given his physical, the veterinary technician saw that the collar had been on Sam so long, it had become embedded in the skin! While carefully removing the collar, the vet tech's sharp eyes found two hairs caught in the collar's buckle. He said they looked more like human hair than dog fur.

4 Read (or have a student read aloud) "A message from Special Investigator Pentangelo," and the case begins!

LAB TEST, SET 1

FINGERPRINT ANALYSIS

MATERIALS NEEDED

- Empty, clean dog food or tuna cans
- Soft-lead pencil (HB or softer)
- Wide cellophane tape
- Magnifying glass(es)
- Large re-sealable plastic bags
- Superglue
- Aluminum foil

Preparation

Leaving prints on the evidence

1. Clean the cans of dog food/tuna.

2. Wipe your forehead or nose with your thumb and forefinger to collect natural oils, and then press them on either side of the cans. Make sure that you get a print from the bottom of your finger and thumbprint — this is the area that contains the most information.

Creating comparison prints

1. Rub a soft-lead pencil onto a piece of paper.

2. Press your thumb, forefinger, and any other fingers you used to leave prints into the graphite.

3. Gently press your graphite-covered finger pads onto the sticky side of the tape. Turn the tape over and attach it to a piece of white paper. Make sure you have clean prints. Alternatively, you can use an inkpad to make the prints on the paper. Label this paper "Ali."

4. Have three other colleagues also make prints to put on paper. Label these sheets "Bill," "Clarita," and "Debbie."

5. Print out examples of different types of fingerprints for the students from one of the sites in the Resources section below.

Analyzing Prints

It may take more than half an hour for fuming to reveal prints. If you prefer for the students to finish more quickly, they may dust for prints instead. To dust, students sprinkle talcum powder or cornstarch on the cans and then very gently brush excess powder away with a soft brush. Then, they place cellophane tape sticky-side down on the print to lift it, putting the tape on dark paper for analysis. Dusting is quicker than fuming but more susceptible to errors. If the students use the fuming method, make sure there is more than adequate ventilation in the room.

1. Careful not to leave their own prints, students place the items each into separate plastic bags. Instead of plastic bags, you can make a fuming chamber out of a small cardboard box. If you do this, you can also put a cup of hot water in with the evidence and superglue to facilitate the process.

2. Students tear off square pieces of aluminum foil and make small cups out of them.

3. Students put 15 drops of superglue into the small aluminum foil cups and then quickly put one cup in each of the bags with each piece of evidence.

4. Students seal the bags and set them aside. The fuming works better and more quickly under mild heat (a light bulb is plenty). Without heat, it could take about 40-60 minutes for the fumes to attach to the oil and moisture of the fingerprints. With heat, it should take 10-20 minutes.

5. Optionally, students can dust the prints after fuming them, to further clarify them.

6. Students analyze the prints on the evidence and compare them to the samples.

HAIR ANALYSIS

MATERIALS NEEDED

- Microscope(s)
  (Magnifying glasses can work in a pinch)
- Microscope slides (4+)
- Cover slips (4+)
- Water and droppers (2+)
- Paper envelopes (6)
- Human hair samples (4)
- Tweezers (4+)

Procedure

There are two ways of carrying out the hair analysis. The first way is to be used for younger, less experienced classes. In this way, the hair from the crime scene belongs to Debbie. It is one piece of evidence linking Debbie and Bill to the crime scene.

In the second way, the hair from the crime scene *resembles* the hair from Debbie, but in fact, did not come from *any* of the suspects. The crime scene hair is inconclusive evidence. This second way can be used for older, more scientifically sophisticated classes that can tolerate and learn from a degree of uncertainty in an analysis.

1. Choose four colleagues, family members, etc. whose hair lengths and colors are similar. Cut all hairs to be about the same length. Get the long hairs from a dog's coat as a control.

2. Choose one to be both the hairs from the crime scene and from Debbie. Put two hairs from that person in the "Evidence" envelope, and the rest in the "Debbie" envelope. Put the rest in envelopes labeled "Bill," "Ali," "Clarita," and "Sam."

3. Tell students that warrants have been issued to gain hair samples from the suspects. They are to compare these hairs to the one found at the crime scene.

4 Give students the envelopes with the hairs in them. There are several hairs from the suspects, but only two from the crime scene. If students lose any of the hairs, they can be replaced *except for the evidence hair* — if they are lost, they cannot be replaced.

5 Let students analyze the hairs and determine their characteristics, including how to try to objectify their analyses. After students have analyzed the characteristics of the cortex and medulla, they can better study the cuticle by gently pulling the hairs out from between the slide and cover; the scales should remain behind while the cortex and medulla are pulled away.

Results

Here are some of the ways students may find to characterize their hair samples. The cortex, the middle of the three layers of the hair shaft, will probably yield the most information for the students, especially in the color, amount, and distribution of pigments. The medulla, the inner layer of the hair shaft, may not be present or may be broken into pieces if it is present. It may also vary in thickness. If your microscopes have rulers, students can measure the exact thicknesses of the hairs. The cuticle scales may vary in size, thickness, how much they overlap, their overall shape, whether they have pigments, and how much they stick out from the hair. Cuticle characteristics will vary much more between the dog and human hairs than between the different people.

LAB TEST, SET 2

Introduction

Read or have students read:

- *A message from Special Investigator Pentangelo*
- *The suspects' testimonies*
- *A second message from Special Investigator Pentangelo*

The previous evidence points to the culprit being either Bill or Debbie. They both deny having had Sam for the last year. The critical piece of evidence comes down to a receipt of sale for Sam. Did Bill sell Sam to Debbie?

LAB TESTS

RECEIPT
Handwriting Analysis

MATERIALS NEEDED

- Pens (4, one of which should be a large-nibbed felt pen)
- Heavyweight, white, letter or legal size paper
- Two other sheets of paper (can even be the backs of receipts, envelopes, etc.)
- Magnifying glass(es) (optional)

Procedure

1 Have a colleague write the following grocery list on a piece of paper and let students know that Debbie prepared this list:

Groceries
- *Apples*
- *Bananas*
- *Those little potatoes*
- *Onions*
- *Ice cream*
  (the good kind—not that cheap stuff)
- *Peanut butter and crackers*

2 Trying to imitate your colleague's handwriting, write the following on a piece of heavy, white paper. To ensure that the ink liquid chromatography lab goes well, leave about a 4" margin on the left side of the paper and write big letters. You may also want to use a large-nibbed felt pen. Use one of Bill's pens for the text and Bill's other pen for the signatures.

This is a receipt for the sale of Sam the dog to Deborah Hendrickson by Bill Ames for $100.

Date: [Put in a date from about six months ago]

Signed:

_____ _____

Deborah Hendrickson *Bill Toomes*

3 Write the following on a third piece of paper in your own handwriting:

Super—Could you check out the radiator in my bedroom again? It keeps making this gurgling sound like it's got water coming out. I don't think it's fixed.

Thanx—Bill

4 Make enough photocopies of these exhibits so students in groups of three or four will each have a copy. They can come to you to refer to the originals if they need to.

5 Have students analyze the handwriting sample. They will need to deconstruct aspects of the writing (loops, pressure/extent of indentation, speed at which it seemed to be written, etc.). To test pressure, have students lightly run the paper between their thumb and forefinger. To get a feel for the overall flow of the writing, it can help to look at the writing upside down.

6 Give the students 20 minutes to work on the analysis, guiding them as needed.

7 When the time is up, guide the entire class through aggregating their analyses and a group decision about the analysis.

8 Have students add this conclusion to the overall investigation report.

Results

Your students should be able to make a subjective assessment indicating that Debbie did not write the receipt. However, objectifying their argument will take more thought. Remind them that even expert witnesses must back up their claims if they want to convince a jury.

CHROMATOGRAPHIC ANALYSIS OF INK

This is one lab that you as the teacher might want to do yourself before having the class do it. The reason for this is to make sure that the ink from the four pens you choose will all create different patterns during the lab. You can instead leave it to chance (and chances are the patterns will differ if the pens are from different manufacturers) and let the students handle results that may be inconclusive.

MATERIALS NEEDED

- Filter paper (or heavy coffee filters or even paper towels)
- Long, narrow, shallow tray(s)
- Rack(s) for hanging ink samples
- Clips to hold paper down from racks
- Heavyweight paper cut into approx. 3" x 6" strips
- Four (or more) pens from different manufacturers, all with the same color ink
- Rubbing alcohol (or nail polish remover)

Procedure

If you would prefer your students not be exposed to the rubbing alcohol or nail polish remover fumes, simply make sure the inks you use are water soluble and use water as the solvent instead. If your students do use rubbing alcohol or nail polish remover, make sure the windows are open and there is plenty of fresh air circulating through the room both during and after the lab.

1. Set up the racks over the trays so that the paper strips will just touch the bottom of the tray. If the strips are a little long, it's not a problem.

2. Cut off the strips of the receipt that have ink on them. Put those in an envelope labeled "Ink Analysis Exhibits."

3. Tell your students that two pens have been subpoenaed from both Bill and Debbie. These pens are those that Bill and Debbie use very often, have been used recently, and that are fairly unique. Students will analyze the ink of these pens to see if any match the ink used to write and sign the receipt of sale of Sam.

4. Have the students use each pen to make approximately 1/2" diameter dots exactly 4" from the end of different strips of paper, being careful to label their samples.

5. Students clip the samples to the rack so that the dots are 4" from the tray and the bottom of the strips touch the bottom of the tray.

6. Gently pour the solvent into the tray.

7. Let the solvent separate the ink for about 30 minutes, then compare the samples to ink pattern from the receipt.

Results

Any given color of ink is actually made up of several colors. The solvent will dissolve these components and "carry" them down the strips, creating bands of color at different places on the strips. The students can compare these patterns to those made by the ink on the receipt. However, the pattern on the receipt may not be as strong as the samples so the students will need to look carefully to be sure of their results.

ASSESSMENT

1 Students show clear, objective thinking in their analysis of both the lab data and the overall case.

2 Students demonstrate good lab skills, including carefulness, cleanliness, precision, and safety.

3 Students work together well as teams.

EXTENSION ACTIVITY

This simulation differs from the real world in a few very unfortunate ways. Although the ASPCA and law enforcement agencies do conduct tests of evidence, rarely can anyone conduct all of them. This is for two reasons. First, resources are scarce—there are not many people working on the cases, and they are already getting the most they can out of the tight budgets they have. Second, it is very rare for this much evidence to be found at any crime scene (a fact that TV forensics shows gloss over for the same reason we did—it makes a richer story with more going on). In short, evidence is harder to find and harder to process successfully than it is here. Discuss this and ways the students should keep their pets and themselves safe.

ADDITIONAL RESOURCES

Fingerprinting
Ridges and Furrows
www.ridgesandfurrows.homestead.com/fingerprint.html

Northeastern University
www.ccs.neu.edu/home/feneric/cyanoacrylate.html

Western Carolina University
http://et.wcu.edu/aidc/BioWebPages/Biometrics_Finger.html

The New York State Animal Cruelty Law
Misdemeanor Animal Cruelty in New York State (Agriculture and Markets Law section 353); Failure to provide an animal with necessary food, drink or sustenance

Under New York State law, a person is guilty of cruelty to animals when he or she deprives any animal, whether belonging to himself or to another, of necessary sustenance, food, or drink, or neglects or refuses to furnish it such sustenance or drink, or causes, procures or permits any animal to be deprived of necessary food or drink, or who willfully instigates, engages in, or in any way furthers any act of cruelty to any animal, or any act tending to produce such cruelty.

LAB GROUP 1 INTRODUCTION

Newspaper Clipping

Burglars Break In, Leave Guard Dog
Manhattan, New York

Pedro Martinez was surprised to find that someone had forcibly entered his building property—and put in a guard dog. Martinez, a Park Slope resident, said that nothing appeared to have been stolen, but he called the police to be sure—and to save the dog. "Whoever left the dog didn't leave enough food for him," said Martinez. "The poor dog would have died if I didn't get there that same day, I know it!" Animal cruelty is a crime, and police must respond. NYPD referred the case to the ASPCA. Officer Joe Pentangelo of the ASPCA agreed that the dog—his collar said "Sam"—was close to death. "Sam was in very poor health. He was nothing but skin and bones. We had to be very careful taking him out." Sam is now in the custody of the ASPCA, where he is being nursed back to health. Says Pentangelo, "Mr. Martinez saved this dog's life. He did the right thing by calling the police—or us. As a decent guy, Pedro has my vote. Whenever you suspect animal cruelty, notify the authorities. With hurt or sick animals, you never know what to expect." The same could be said of burglars.

Pedro's Testimony

I have just come back from visiting my family in Venezuela. I had been there for a little over four weeks. Thirty days including a day to get there and a day to get back. So, I was away 32 days. The same day I came back to New York, I went to check on the Rennet Building—the building where I found the dog. When I'm away so long, I like to check on my properties to make sure everything's O.K. A few people have keys to the building, but I'm usually the only one who ever goes there. Good thing I did go to check on it! When I went inside, I saw that someone had chained their dog to a railing inside, next to where the cars can be parked. The poor dog hardly looked up and was in really bad shape. He was kind of hiding under Clarita's car—he was chained up right next to it. He looked starving! I went and called the cops right away. They came, saw the dog, and called the ASPCA. The ASPCA cops came, and took the dog to their hospital. They also asked if they could take some things as evidence. I said sure! I hope the dog is O.K.

Incident report

At 13:15, this officer was contacted by the New York City Police Department that they had responded to a call from a building's owner about a possible burglary and wounded dog. The NYPD officers stated that upon investigating the building, they found that a small window in the rear of the building was broken and that an emaciated dog was chained to a stairs railing next to a small two-car carport inside the building. NYPD indicated they interviewed the building owner, who identified himself as Mr. Pedro Martinez. The following is the sum and substance of that interview: The owner said the window was not broken when he surveyed the building approximately one month ago. The dog was also not in the building before the owner left to go on vacation. At this time, the NYPD turned the case over to the ASPCA to handle the investigation of the dog.

This officer arrived at the scene at 16:40 and entered the building with Mr. Martinez, who employed a key to open the building's entrance. Accompanied by Mr. Martinez, this officer did enter the building at 16:52. This officer found a medium-sized, mixed breed dog hiding under a silver 2004 Toyota Celica parked next to the stairs to which the dog was chained. Mr. Martinez indicated that the car belonged to a Ms. Clarita Myers, who paid Mr. Martinez a monthly fee to store the car. The dog was extremely emaciated and largely unresponsive. There was very little feces within the dog's radius. Next to the stairs and within the dog's reach were three empty, open cans of dog food and two empty, open cans of tuna. An empty, plastic bowl was found upside down against the car's right, rear wheel.

Photos were taken and a line was used to direct the dog to the cruiser. Although weak, the dog was ambulatory. Upon exiting the building with the dog, I was approached by a male who identified himself as Mr. Ali Shaif. This officer interviewed Mr. Shaif.

After obtaining Mr. Martinez's written permission, this officer then collected the following items from the building:

- One (1) plastic bowl
- Three (3) empty cans, dog food
- Two (2) empty cans, tuna
- One (1), 5' chain
- Two (2) cigarette butts on the floor next to the stairs to which the dog was chained

Contact information was taken and identification verified for Mr. Martinez, Ms. Myers, and Mr. Shaif.

The dog was taken to ASPCA's Bergh Memorial Hospital and examined. That examination yielded the following: scars on his head, neck, chest, back, forelegs, and back left leg, consistent with injuries sustained in a fight with another canine. The dog was found to be timid and hand shy.

A message from Special Investigator Pentangelo:

Dear Forensics Team,
I've been doing some investigating since I made my incident report and brought Sam to Bergh Memorial—and I think we've had a few breakthroughs in the case! The scars on Sam's head and body looked like damage from several dog fights. While Sam was being treated, I was talking more with Mr. Martinez. He gave me a manifest of all the people who he knew had copies of the keys to the building. There weren't many people he gave them to. I did some homework, and one of these people, a Bill Toomes, was arrested in 2003 for attending a dog fight just outside of New York City. He and his ex-girlfriend used to have a carpet cleaning business and stored the equipment in Mr. Martinez's building. I've talked to Ali, Clarita, Bill, and his estranged girlfriend, Debbie.

Testimonies

Ali

I live near the building where that poor dog was found. Just across the alley, there. At first I heard these barks and whines, and didn't know where they came from. That was over two weeks ago. Two weeks ago last Sunday, I think. Didn't think much of them at first, actually. But they kept up—especially the whining. After a while—I mean like a couple of days—I really started getting concerned. So, I went out looking for this dog to see whose place he was at or something. I really didn't expect to find him in that building! I mean I could see him through the window, is what I mean. That poor thing, I really wished someone would help him, but I think I was the only person who saw him in there. I didn't see anybody else even go near that building. And I started to look and see when I knew that that dog was in there because I was worried. But no one went there, and that dog was getting skinnier and looking worse and worse. And it just would whimper.

Bill

Nope, I've never seen that dog before in my life. Did I ever have a key to Pedro's building? Yeah, sure. Debbie and I had keys to that building cause we used to use it to store our tools. But I can't say what happened to my key. Maybe Debbie took it.

Clarita

Yeah, I have a key to Pedro's building. I store my car there. It's cheaper than paying for a space in a parking lot, and safer, too. But I wish it were safer. I've seen people hanging around outside that building. I'm afraid they'll see my car and try to break in. I told Pedro he should get a security system or a guard dog or something. But he won't do it. I think he's too trusting of a guy. Too nice, you know? No, that dog doesn't look familiar, but that's not a very good picture. It looks all shadowy and stuff. That's how it really looks?! Really?! It's in pretty bad shape, huh? What happened to it? It was left in Pedro's building?! What, you think I did it? No! I wouldn't do that! That's horrible!

Debbie

Bill and I used to use Mr. Martinez's building to store our tools and supplies for the business we had. But, Bill and I stopped our business a while ago and I haven't been back to that building since. What? Have I ever seen that dog before? Let me see the photo. No, I've never seen it. Why? Who's it belong to? It was in the building? How did it get there? No, I don't know how it did. Like I said, I've never seen it before.

LAB GROUP 2 INTRODUCTION

A message from Special Investigator Pentangelo:

Hi team,
I went back to talk to Ali, Bill, and Debbie, and told them separately about what you had come up with. Before I talked to each of them, I "Mirandized" them. Surprise, surprise, they changed their stories.

Testimonies

Ali
Yes, all right. I admit it. I broke the window and trespassed. I could hear the poor dog in there, and I looked and saw that it looked bad. The first I heard the dog was about two weeks before Mr. Martinez got back and called the cops. The dog got worse, and I swear I didn't see anyone going in there to take care of it. I tried to get a hold of Mr. Martinez, but he was on vacation or something and no one I talked to had keys. So, finally, I tried to get in, and had to break in. I would leave the dog food and water. I should have called the cops myself, I know. But I didn't know animal cruelty was a crime and that they would have to come. I thought I was on my own.

Bill
Yeah, all right, I know that dog. It was my and Debbie's dog. But you can't blame me for saying it wasn't ours, I mean look at it. It doesn't look anything like it did when I saw him. When Debbie and I broke up, I sold it to her and she's had it ever since. And that was like a year ago or something. I kind of forgot about it.

Debbie
Oh my gosh, that's Sammy?! He looks horrible! What? Bill said he sold him to me? No! Are you crazy? When Bill and I broke up, he didn't let me have anything. He took Sammy. This is the first I've seen him ever since. Oh, he looks awful! Is he O.K.?

A second message from Special Investigator Pentangelo:

When I got to Bill's residence, he was cleaning out his car. As we talked, he threw a bag out in the garbage. I asked Bill for the receipt for selling Sam to Debbie. He went inside and got it. Just on a hunch, I opened that bag of trash. Among other things, there were two pens in it, so I took them. Before I went to talk with Debbie, I got a search warrant issued by a judge to get two pens from Debbie too.

Epilogue

After the project is over, let the class know what happened to Sam and the case.

Sam
After being nursed back to health and given behavior training, Sam was put up for adoption at the ASPCA. The weeks went by. One weekend, the ASPCA Cares mobile adoptions unit took Sam to an adoption event in the Bronx, where a family immediately fell in love with him and adopted him.

Read the class this epilogue if they correctly identified Bill as the perpetrator after having successfully completed the following labs: handwriting analysis, and ink chromatography.

Bill Toomes was arraigned before the court on one count of criminal animal cruelty. After a speedy trial, Mr. Toomes was found guilty as charged, and sentenced to a fine of $1,000 and a week in jail. He was also forbidden from ever owning an animal again.

If the class did not successfully find enough evidence to convict Bill Toomes, read them this:

Although Sam finally found a loving home, no one was ever convicted for the crimes committed against him.

did you know?

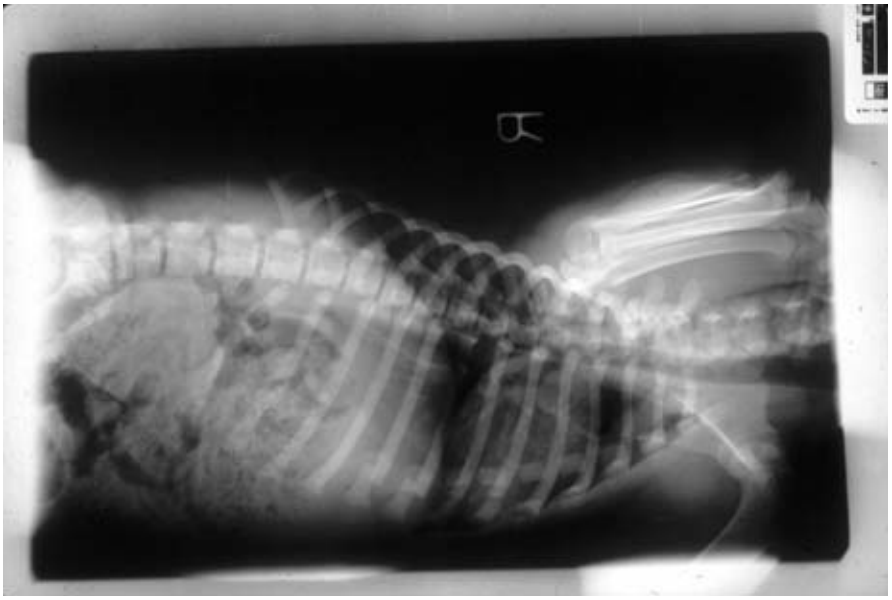
Wildlife Forensics

Given the popularity of forensics detective shows on television, it's not absurd to think that a TV drama called Animal Kingdom-Crime Scene Investigations may be just round the corner. If it does happen, don't be surprised if the technology and methods portrayed are quite familiar to those used by TV's current investigators. There probably won't be any fingerprints (unless a chimp is involved), but there will be DNA fingerprinting, autopsies, evidence tags, ballistics tests, tissue typing, fiber analysis, bone marrow tests and crime scene investigations in which the smallest possible clue is bagged and tagged. They'll also look for GSR (gunshot residue) on people's hands and clothes, use ultraviolet lights to look for blood traces, and make tire track molds to keep as evidence.

The only thing that makes animal forensics different from other forensic investigations is that the subjects and victims are animals, not people. Why would we be interested in investigating the death of animals? Two of the major areas of forensic investigation are poaching (killing game animals illegally) and acts committed against endangered species, especially for the sale of animal parts like eagle claws, walrus tusks, and bear gall bladders.

The wildlife forensics field also deals with genetic identification of ancient bones and tissue remains. Did the remains belong to a mastodon, an elephant, or a St. Bernard with a big nose? Was or is this a common species or a mutant form with slightly different characteristics? What caused its death?

How does this apply to today's animal kingdom? To learn more about the intriguing science of Wildlife Forensics, go to the website of the U.S Fish and Wildlife Forensics laboratory at www.lab.fws.gov/.



ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: MS

Type: Simulation

Topic: Natural selection

You Say You Want an Evolution: An Introduction to Natural Selection

As with many things, the mechanisms by which a species adapts to its environment may be easier to understand when students explore them hands-on. This project lets students explore evolution in a fun and flexible simulation.

INTRODUCTION

There are many factors influencing the evolution of a species. Teasing these factors apart in real-world examples is beneficial, but it can be easier to begin a discussion about it with an interactive simulation to help students grasp what can be a somewhat difficult topic to understand correctly. Students simulate how predation exerts evolutionary pressure on a population of colored objects or candies.

Predators can influence the evolution of a species by "selecting" which members live long enough to reproduce most successfully. An effective and common means of avoiding predators is *crypsis*. A cryptic animal blends into its background. The incredible color and texture changes of octopi and cuttlefish are striking demonstrations of crypsis, as is the better-known ability of chameleons. Walking sticks are also very cryptic animals, but a spotted fawn, a snowshoe hare, and even a cockroach are also cryptic animals. Note that jaguars, tigers, and praying mantises (e.g., the flower and bark mantids) also use crypsis to help them ambush prey.

Discuss the mechanisms of evolution with the students. Begin by letting the students explain what they understand about evolution. Then, discuss the factors that underlie evolution. What is a species? Are all members of a species the same? Are some better suited to their environment than others? Could it be that some members of a population already carry traits that might be better suited for another environment?

OBJECTIVES

After completing this activity, students will be able to:

1. understand the processes by which a species adapts to its environment.

2. understand the environments to which wild and domestic animals are adapted.

MATERIALS NEEDED FOR EACH STUDENT STATION

- 1 piece of solid, grass-green fabric such as felt or twill, approximately 18" x 24"
- 1 piece of flat cardboard, cut larger than the cloth
- 1 bag of solid green jellybeans or other candy, or an equivalent number of green beads or plastic tokens
- 1 bag of solid red jellybeans or other candy, or an equivalent number of red beads or plastic tokens
- Stapler or thumbtacks

It's fine to use another color for the cloth and the candies. However, it is important that the color of one of the candies closely matches the cloth color.

Center the cloth on the cardboard and attach with staples or thumbtacks. Then bend the edges of the cardboard up to create a barrier to hold the candies on the cloth surface.

CLASS TIME REQUIRED

One or two 40-minute periods

LAB INSTRUCTIONS

Procedure

1 Ask the students to imagine that the red and green candies are a type of animal that thrives in a certain environment—the cloth mat at each student station. Ask what they expect will happen to the number of red and green candies over time. How would the introduction of a predator alter those expectations? Ask them to formulate a hypothesis to express their expectation. For example, "If the predator selects more red than green candies, then over subsequent gen-erations, there should be more red than green candies in the population." Ask them to consider what will be the best way to display the data they will be collecting.

2 Divide students into groups of three. One student will be the tosser, one the predator, and the third the timer.

3 In each group, the timer and predator sit or stand around the mat. The tosser sits or stands at one end.

4 The predator looks away from the mat while the tosser randomly scatters 10 red and 10 green candies around the mat.

5 The timer gets ready and tells the predator to turn to the mat. The timer then gives the predator 3 seconds to pick up as many candies as he or she can, one at a time. The strength of the selective pressure of the predation can be varied by shortening or lengthening the time allowed for predation.

6 The candies that were *not* selected by the predator from the mat are the ones that were lucky enough to reproduce. The next generation of candy will contain the same proportion of red and green candies as those that were left on the mat after the predators have made their selection. Suppose the first generation started with ten red and ten green candies, and the predator selected nine red candies and six green candies. Of the five candies that survived to reproduce, there are one red and four green. In the next generation, 20% (1/5 = .4 or 40%) will be red; 60% will be green. This means that eight (20 x .4 = 8) will be red and 12 will be green.

7 Keeping track of the numbers of red and green candies per generation, the students repeat the process five times.

Questions

1 ***How does the frequency of each color change over time?***

2 ***Is this directional, stabilizing, or disruptive selection?***

In ***directional*** selection, a trait is linearly related to the organism's fitness. For example, the more a candy stands out from the substrate, the higher its fitness.

In ***stabilizing*** selection, there is an optimal level of a trait; if an organism has more or less of the trait, it is less fit for that environment. For example, body size in many organisms is stabilized. If a buck is small, it will be more easily overcome by predators or compete less successfully for mates. If a buck is too large, it will have a hard time finding enough food to eat. Stabilizing selection can "trim the edges" of a population and lead to refinement of the trait. In the real world, the size of deer varies. Some are rather small, some are rather large, and most are in between.

Stabilizing pressures make extreme levels of a trait less fit. ***Disruptive*** selection is the opposite. Disruptive selection makes extreme levels of a trait more fit. For example, all male African swallowtail butterflies, *Papilo dardanus*, look alike, having yellow swallowtail wings with black markings. However, most female African swallowtail butterflies occur in two distinct body types (or "morphs"). The African swallowtail is not poisonous, but the female morphs resemble colorful and poisonous butterflies in the genera *Danaus* and *Amauris*. Predators avoid the edible, African swallowtails females because they confuse them with other, poisonous butterflies. If a female swallowtail were born that didn't look like any other poisonous butterfly—but something in between—it would be at greater risk of predation since it wouldn't be mistaken for a poisonous butterfly. African swallowtails that live in regions without *Danaus* or *Amauris* do not have a prevalence of females who resemble those poisonous butterflies.

3 ***What would happen if half of the offspring of green candies were red and half of the offspring of red candies were green?***

4 ***What might happen if the candies were of different sizes?***

5 ***What would happen if we used red, green, and blue candies? What about if there were five colors?***

POST-LAB CLASS DISCUSSION/ACTIVITIES

1 Wolves *(Canis lupus)* and African wildcats *(Felis libyca)* are both well-adapted to their wild environments. However, dogs and cats that most likely evolved from these animals are not. Discuss (and possibly research) the evolutionary pressures that may have shaped the evolution of dogs and cats, and how these have made dog and cats well-suited to live with people, but not to live in the wild.

2 The reverse is also true: wild animals are adapted, of course, to a life in the wild—not to a life as a pet. Some animals (like chimpanzees and tigers) are docile enough while they are young that they will rarely harm someone. However, this is a short-lived period of artificial safety for the humans. Being isolated from their families during critical periods of social development, these animals would be put at a disadvantage were they ever to be returned to their natural environment. Unfortunately, even that is rare; most exotic animals that are former pets are extraordinarily lucky if they end up in animal sanctuaries.

3 Evolution can work only with traits that already exist. After the students understand this, you may want to then ask them how new features can appear. One way is the extreme development of already existing traits over many generations—such as the change from scales to feathers in dinosaurs or evolution of wings in bats. Other traits come about from mutations that let traits appear that weren't represented before. At a point in the simulation when students are ready to tackle this issue, introduce a candy that is different from the others. For example, one that is a very different color, shape, or size. Does this mutation catch on, or is it quickly quashed? If the mutation endures, was it actually selected for or simply not selected against?

There is some evidence that traits like floppy ears and a piebald pattern in dogs may not have actually been selected for; rather, they simply were not selected against. Russian geneticist Dmitry Belyaev and his team argue that their work with domesticating silver foxes has found that features like floppy ears and a piebald pattern come hand-in-hand with breeding for tameness. These traits need not be actually selected for by themselves.

Peppered Moth, light background

4 This brief simulation includes simple, passive "organisms" whose evolution is determined by only one type of natural selection. The real world is more complex, but parallels can be drawn.

To complement the simulation, you may wish to talk about a real-world case of directional, natural selection from predation. The current activity strongly resembles the case of the peppered moth *(Biston betularia)* in England and other places in Northern Europe and the U.S. Some peppered moths are mostly white with black flecks and others are nearly all black. Before the nineteenth century—when they were given their name—most peppered moths were white with black flecks. After the Industrial Revolution, there were very few peppered moths that were white with black flecks: most were now black. What seems to have happened? The soot and pollution from the increasingly industrial cities darkened the landscape. The black moths blended in better with the darker habitat than their lighter relatives. An amateur moth collector, J. W. Tutt, theorized that the lighter moths were easier to see against the tree trunks darkened by the pollution. Although the situation does not appear to be as simple as Tutt imagined, evidence supporting the general situation came when another Englishman named Bernard Kettlewell released equal numbers of white and black peppered moths in two areas: the then-heavily polluted city of Birmingham and the unpolluted area of Dorset. A little later, Kettlewell counted how many moths were left in each area and found that there were higher percentages of black peppered moths around industrialized Birmingham and higher percentages of white moths in unpolluted Dorset.

In 1956, England enacted clean air legislation. What happened to the populations of the white and black peppered moths? Bruce Grant and his colleagues sampled the moth population in an industrialized area of England every year from 1956 through 1995. As the landscape became lighter with a reduction in pollution, the percent of white peppered moths increased from a low of 6% in 1960 to its current high of 81% in 1994. Both the polluting and cleaning of the English landscape exerted directional selection on the peppered moths.

ASSESSMENT

1 Students correctly complete the simulation and record their data.

2 Students can verbally (or in writing) explain and elaborate upon the basic tenets of evolution explored here.

3 Students understand how and why domestic and wild animals are adapted to different environments, and the implications of this on our treatment and care of these animals.

Peppered Moth, dark background

EXTENSION ACTIVITIES

This project lends itself to several adaptations.

1. Some animals do not try to hide from predators at all. Instead, they advertise their presence! Monarch butterflies have benefited from drawing predators' attention to themselves with bright coloration. How could this unlikely scenario evolve? As a hint, some other animals that have also adapted bright coloration to ward off predators are bees, some salamanders, and poison dart frogs.

2. Use two mats of different colors that are attached along a long edge, and candies that match the mats' colors. You may wish to either double the number of candies or cut the mats in half. Does a more complex habitat change the evolution of the species? What would happen if there were two different colored mats and a third color of candy? What would happen if the choosers only chose mates from one mat and predators only chose prey from the other?

3. To create a situation more analogous to that of the peppered moth, you can let the candies evolve on a green mat for three generations, then have the next three generations evolve on a red mat before finally returning to the green mat for the last three generations.

4. As the project is conceived, either the candies blend in or they don't. Another way of conducting the simulation is to allow degrees of crypsis. Instead of using red and green, use blue, blue-green, and green (or yellow, yellow-green, and green). Does the population of candies find a happy compromise between mate-enticing colors and camouflaging colors?

ADDITIONAL RESOURCES

Hosler, J. (2003). T*he sandwalk adventures: An adventure in evolution told in five chapters.* Columbus Ohio: Active Synapse.

Zimmer, C. (2001) *Evolution: The triumph of an idea.* New York: HarperCollins Publishers.

Explanation and examples of directional, stabilizing, and disruptive selection
http://taggart.glg.msu.edu/isb200/select.htm
www.sparknotes.com/biology/evolution/naturalselection/section1.html

Outstanding collection of evolution resources, information, discussions, and activities
www.pbs.org/wgbh/evolution/library/index.html

In-depth, but easy-to-read explanation of evolution
http://science.howstuffworks.com/evolution.htm

Detailed timelines of the history of evolution
www.ucmp.berkeley.edu/history/evothought.html

Detailed discussion about the molecular evidence for the history of canine evolution
www.idir.net/~wolf2dog/wayne2.htm

Octopus demonstrating crypsis
www.cephbase.utmb.edu/viddb/vidsrch3.cfm?ID=132&CephID=

Summary of some examples of evolution, including the peppered moth
www.txtwriter.com/Backgrounders/Evolution/EVpage05.html

Primary resources on the history of the theory of evolution
www.bigchalk.com/cgibin/WebObjects/WOPortal.woa/ Homework/High_School/Science/Life_Sciences_(Biology)/Evolutionary_Biology/History_of_Evolution_30539.html

Evolution activities and simulations

www.accessexcellence.org/AE/SH/NSTA_NOR/vavala_evol.html

www.bbc.co.uk/beasts/evolution/evolution_game..shtml

dmoz.org/Computers/Artificial_Life/Artificial_Worlds/

www.biologyinmotion.com/

http://dllab.caltech.edu/avida/

www.ai.mit.edu/people/unamay/trellix/edmar20/id5_m.htm

www.evotutor.org

www.ventrella.com

Clarke, C.A. & P.M. Sheppard (1960a). The evolution of mimicry in the butterfly *Papilio dardanus*. *Heredity, 14,* 163-173.

Clarke, C.A. & P.M. Sheppard (1960b). Super-genes and mimicry. *Heredity*, 14, 175-185.

Clarke, C.A. & P.M. Sheppard (1963). Interactions between major genes and polygenes in the determination of the mimetic patterns of *Papilio dardanus. Evolution,* 17, 404-413.

Grant, B. S., Owen, D. F., and Clarke, C. A. (1996). Parallel rise and fall of melanic peppered moths in America and Britain. *Journal of Heredity*, 87(5), 351-357.

Sheppard, P.M. (1962). Some aspects of the geography, genetics, and taxonomy of a butterfly. In D. Nichols (Ed.), *Taxonomy and geography* (pp.135-152). Oxford: Systematics Association.

Talyn, B. (n.d.). Macaroni for teaching evolution of behavior: New applications for a classic simulation. Handout.

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: HS

Type: Simulation

Topics: Evolution, natural selection, and genetics

Genes, Cookies, and Natural Selection

The exercise presented here is a novel, time-effective, student-centered simulation in which students learn about the intricate connection between genes, traits, the environment, and natural selection by exploring the effect of mutation and phenotype on survival.

INTRODUCTION

Use the squirrel stencil to trace a squirrel image on brown, tan, and white paper. Cut out the three squirrels. Place three pieces of brown construction paper on a table. Then, place a cut-out image of a squirrel on each piece of paper. One squirrel should be brown (same as the paper), one squirrel should be tan, and one squirrel should be white. Ask students which squirrel will most likely be eaten by the red-tailed hawk that is passing through and which squirrel will be most likely to survive to have the most offspring.

OBJECTIVES

After completing this activity, students will be able to:

1. understand how genes and mutations affect enzyme activity.
2. understand how enzyme activity correlates to phenotype.
3. understand how the environment plays a role in selecting which phenotypes are advantageous and which are not through natural selection.

MATERIALS NEEDED

- Brown, tan, and white construction paper
- Squirrel stencil
- A three-pound package of sandwich cookies per group of 3-4 students
- A set of "job" cards and "allele" cards for each group (see the cards at the end of the activity)

CLASS TIME REQUIRED

One or two 40-minute periods

Background

Evolution deals with change in the traits of a population over a long period of time. Traits that change are determined by the organisms' genes (genotype), the trait as it appears in the organisms (phenotype), and the environmental conditions under which they live. Individuals that reproduce or survive better in a particular environment will have offspring with those same traits. These individuals will have offspring or relatively more offspring than individuals that do not have these traits.

Within a population, there are many versions of a gene (alleles) that are produced by random mutation of the genetic material (deoxyribonucleic acid or DNA). A mutation alters the DNA so that an altered protein, usually an enzyme, is produced. Enzymes perform many functions in the cell and organism, including producing the coloring in the hair, fur, and skin.

One enzyme, tyrosinase, is involved in producing skin and hair pigment in humans and other mammals. This enzyme converts a substrate (tyrosine) to a product (3,4-dihyroxyphenylalanine or DOPA) in a pathway that eventually produces melanin.

Absence of the gene encoding tyrosinase yields an organism with no coloration, an albino, such as Onya-Birri, an albino koala born at the San Diego Zoo. Other alleles for this gene encode enzymes that function partially.

Animals with albinism are easily visible to predators so they are not likely to survive very long in the wild. Their lack of coloring, due to mutations in genes such as tyrosinase, is not successfully passed to future generations.

tyrosine —(tyrosinas)→ DOPA —(tyrosinase)→ melanin (pigment)

LESSON STEPS

1 Divide students into groups of 3-4. Hand out the "job" cards and a three-pound package of sandwich cookies. **Note:** The "closed" sandwich cookies represent the substrate that will be acted on by the enzyme tyrosinase (one of the students) to generate the product (an "open" sandwich cookie) that eventually produces the skin pigment melanin (see below).

2 Have each student draw a card from the "job" pile. Examples of job cards are at the end of this document. All jobs should be taken. Any member of the group can have more than one job, except for the enzyme. The responsibility of each student in the group is noted in the table below.

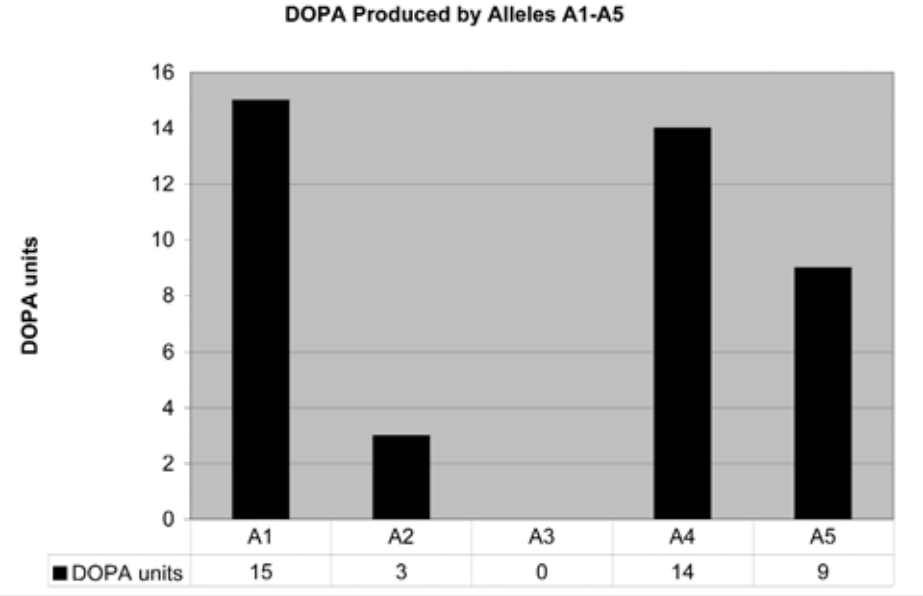
3 Give the "allele" cards to the person who is the allele chooser. Examples of allele cards are at the end of this project.

4 Have the allele chooser find the A1 allele card and read the instructions written on the card. In this instance, the enzyme will act on the substrate (closed cookie) and break open as many cookies (product) as possible in 15 seconds.

5 Have the allele chooser draw another card from the pile and read the instructions on that card. Repeat step 4 for the remaining cards. **Note:** The remaining alleles (A2-A5) are mutant and generate a different challenge for the enzyme (i.e., using only one hand or standing on one foot), which will be played out by the student and be observable in the number of cookies that the student can open and thus, the melanin that can be produced.

6 You may choose to have the students graph their data. A histogram works very well to illustrate results. A typical histogram is shown below.

Job	Student's Responsibility
Enzyme	Break open as many sandwich cookies as possible in 15 seconds according to the directions on each allele card.
Allele chooser	Read the allele cards one at a time and tell the "enzyme" what to do according to what the allele cards say.
Recorder	Record the number of cookies opened by the enzyme in 15 seconds for each allele.
Time monitor	Start and stop the enzyme precisely.



Seipelt R. 2006. Cookie-ases: Interactive Models for Teaching Genotype-Phenotype Relationships. American Biology Teacher. In press.

DISCUSSION ACTIVITIES AND ASSESSMENT QUESTIONS

1. Arrange the names of the alleles from "most melanin produced" to "least melanin produced."

2. If 10 units of DOPA per 15 seconds are necessary to produce a normal brown color squirrel, which alleles would produce a normal-looking squirrel?

3. What do you think the other squirrels will look like?

4. If your squirrels lived in a forest that is mostly dark brown trees, which ones would survive best? Which would likely not survive? After many generations in this environment, would you expect to find mostly brown, tan, or white squirrels? Why?

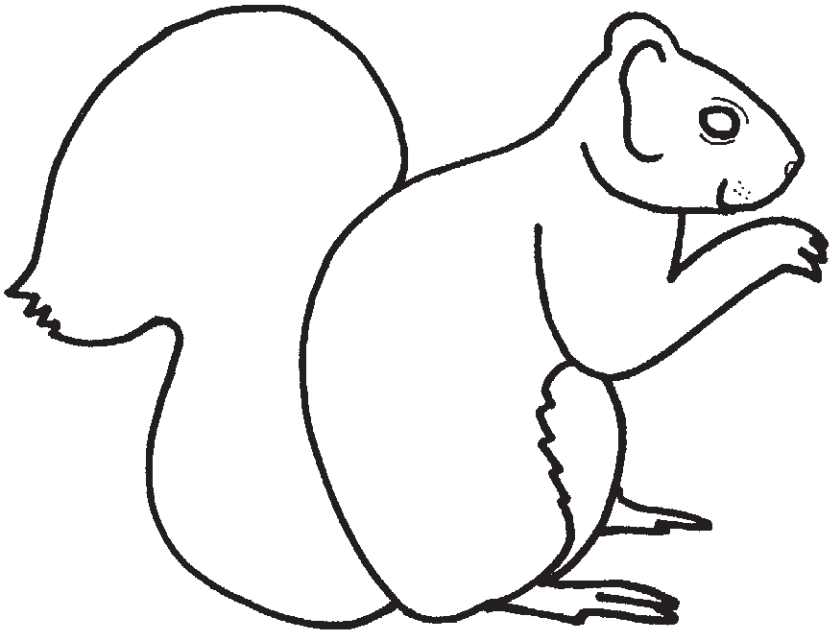
5. If your squirrels lived in a forest that is mostly light gray trees, which ones would survive best? Which would likely not survive? After many generations in this environment, would you expect to find mostly brown, tan, or white squirrels? Why?

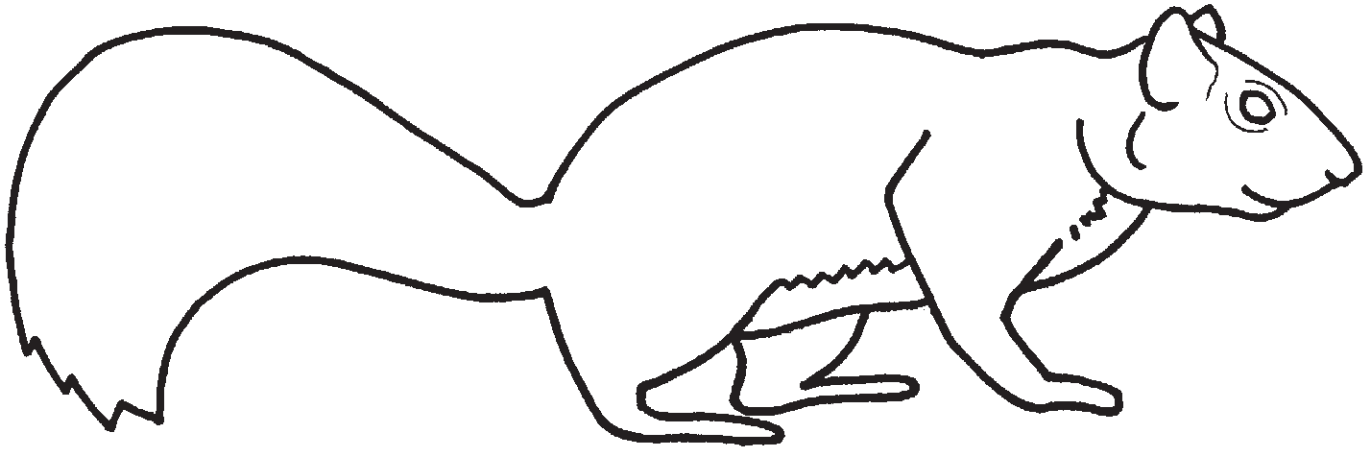
6. What are some other phenotypes that allow some individuals of a species to survive better than other individuals of the same species? What are the environmental conditions that allow this version of the trait to have an advantage?

7. What are some other phenotypes that allow some individuals of a species to reproduce more often than other individuals of the same species? What are the environmental conditions that allow this version of the trait to have an advantage?

8. If there were no random mutation, would there be natural selection? Why or why not? Would there be evolution?

9. Is it possible for a phenotype that was advantageous in one environment to be harmful in another environment?





Job: You are the **mutation chooser**.

Pick a mutation card and read the instructions to your group.

Job: You are the **timekeeper**.

Start and stop the enzyme at the correct time.

Job: You are the **recorder**.

Record the numbers of cookies opened at 15 seconds for each mutation.

Job: You are the **enzyme**.

Open as many cookies as you can in 15 seconds for each mutation.

Allele A1:
Normal gene is able to generate a fully functional protein.

Enzyme should open as many cookies as possible.

Allele A2:
Frameshift mutation destroys most of protein function.

Enzyme uses only little fingers.

Allele A3:
Gene deletion removes gene completely, so no protein present.

Enzyme should be removed.

Allele A4:
Point mutation changes a base, but doesn't affect the protein function.

Enzyme stands on one foot.

Allele A5:
Point mutation changes a base and destroys an important area of the protein.

Enzyme uses only one hand.

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Grade Level: HS

Type: Lab

Topic: DNA Extraction & Collection

Show 'Em What You're Made Of! Extracting DNA

Students should know that DNA is a molecule that holds the blueprint for life, but most students may not know that they can actually see this molecule with their naked eyes. This project lets students extract and see the molecule that everyone is talking about.

INTRODUCTION

We all start from the same point: The same molecule that makes us human makes every other living thing what it is, too. The genetic differences between humans and onions is great, but the genetic differences between humans and many other animals is strikingly small.

For example, we share 95-98% of our genes with chimpanzees. We haven't decoded chimp DNA to the extent that we have decoded human DNA, so we don't yet know exactly which genes we share with our chimp relatives; but there is strong evidence that the main differences between humans and chimps are not in what structures are built, but how long is spent building them. For example, the chimp brain is very much like ours—ours simply develops longer and becomes more complex. This may mean that, in ways, the cognitive ability of chimps resembles that of a very young person. On the other hand, chimps develop arms and legs like ours, but their arms are longer, their legs shorter, and their body much stronger. An adult chimp is about as strong as five to eight adult men.

What about the genetic differences between people? Gender causes the largest differences among people, but even so, men and women share about 99.9% of the same genes. That means that the genetic difference between any two people (no matter their heritage or gender) is only about 1 DNA "letter" in every 1,200. To be sure, that 0.01% difference leads to a magnificent array of individuals, but the differences are not all where you might expect. For example, the differences among races are largely isolated to a few superficial traits in skin color and a few facial characteristics. There are larger differences within each race than among them, and a great deal of overlap. In any case, there is certainly no compelling evidence that genes for intelligence or personality differ among the races.

DNA is a "macromolecule" made up of many smaller molecules called nucleotides. There are four nucleotide "letters" in DNA: adenine, cytosine, guanine, and thymine. The nucleotides are arranged in pairs, and the pairs are stacked on top of each other to form a very long chain. If the DNA in a typical human cell were laid out end-to-end, it would be about 5.5 feet long! If the DNA in every cell of your body were laid out end-to-end, it would make 3,000 round-trips to the moon!

An onion's DNA is about 20 times longer than a human's. An amoeba's is almost 200 times longer than a human's. In addition to having shorter DNA than an onion, we also have fewer genes on our DNA.

As amazing as DNA is, it remains an abstract concept to students, like radio waves and magnetic fields. Being a molecule, students rarely expect to be able to see it with their own eyes. Not only is it a memorable experience to see DNA, its extraction is the first step in many studies of DNA conducted in laboratories across the world. In this activity, DNA will be extracted in two steps. First, the cells will be lysed so the DNA is exposed. Second, DNA will be collected.

Ask students how long they believe a typical DNA molecule to be. Ask them if they feel they would be able to see it with a microscope. What about their naked eyes? If they could see it, what would it look like?

OBJECTIVES

After completing this activity, students will be able to:

1. understand the steps required to extract DNA.
2. use laboratory skills to manipulate a delicate macromolecule.

CLASS TIME REQUIRED

Approximately two to three 40-minute periods on at least two separate days. Also includes about one to two hours of teacher preparation.

MATERIALS NEEDED FOR EACH STUDENT STATION

(For 20 children)

- 1 100 ml graduated cylinder or beaker (larger containers are fine as long as they are graduated)
- 1 150 ml beaker (or other glass container; can be larger than 150 ml)
- 1 10 ml graduated cylinder
- 1 test tube for each child
- 1 glass (not plastic!) rod for each student (a clean pipette would also work)
- 1 Pasteur pipette for each student
- 1 or more thermometers
- 1 large funnel
- 1-3 large, fresh onions
- 1 sharp knife for cutting onion
- 1 cutting board
- Dishwashing detergent (light, gentle detergents work well)
- Paper coffee filters (3 or 4 layers of cheesecloth would also work)
- 95% isopropyl (rubbing) alcohol
- Salt (either iodized or non-iodized)
- Meat tenderizer that contains papain
- Ice
- 1 or 2 large casserole dishes
- Distilled water
- Refrigerator

LESSON STEPS

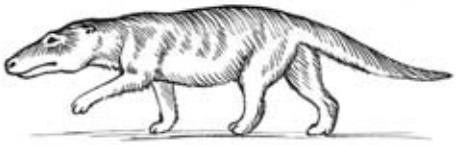
Preparation

Place the isopropyl alcohol in the freezer at least several hours before beginning this activity so that it chills to at least 0° C. The alcohol will not freeze.

Students may appreciate this activity best after they have an understanding of DNA's role in heredity, evolution, etc. You may wish to let students conjecture about what DNA will look like (few should expect it to resemble mucus).

Procedurally, the steps for extracting DNA are relatively simple, but the chemistry behind it is complex. Nonetheless, you may wish to have students brainstorm about how they might go about extracting DNA and what things they should be careful of. For example, in order to remove DNA, they must first open up the cells to get to it. Second, even if they don't know what the special characteristics of DNA are, they should decide that they must find some characteristic of DNA that will allow them to extract it and not other molecules instead. Third, once they learn how long and thin DNA is, they should realize how carefully they should gather it on their glass rods.

Mesonychius

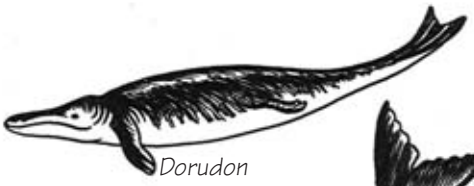


Pakicetus

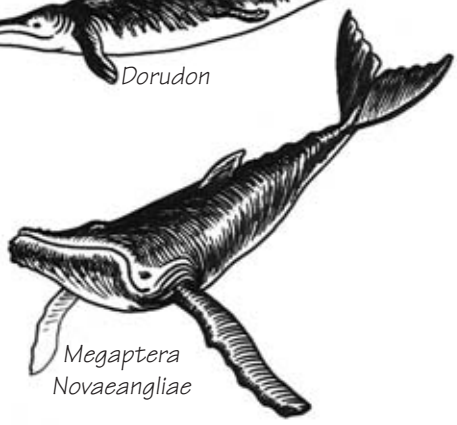
Ambulocetus

Dalanistes

Rodhocetus



Dorudon



Megaptera Novaeangliae

Lysing the Cell Membranes and Deproteinizing the Cells

1 Prepare a hot (60°C) water bath in one of the large casserole dishes. You can simply use hot tap water if you use a large enough volume to maintain its temperature throughout the experiment.

2 Create at least 100 ml of a 10% (volume/ volume) detergent, 10% (weight/volume) salt solution in distilled water. Students can be guided in calculating how much detergent and salt to add. For example, if they prepare 100 ml of solution, they should add 10 ml detergent and 10 g salt, and then enough distilled water to fill the container to 100 ml. Be careful to stir the solution carefully so that it doesn't froth.

3 Cut a roughly 5 cm (2")-sized cube out of the center of each onion. This is the freshest part of the onion. If the onion is very fresh, a larger part can be taken out.

4 Coarsely dice the onion centers. Pieces should have sides roughly 5 mm (1/4"); they shouldn't be too small.

5 Add the diced onion centers to the detergent/salt water solution. The detergent dissolves the cell membranes by breaking the covalent bonds between the lipids in the cell membranes. The salt occupies ions on the DNA strands that normally repel each other. Since the ions are attached instead to the salt ions, the DNA contracts into a tighter, thicker form that precipitates out more easily and can be seen more easily.

6 Place the beaker with the onions and solution in the hot water bath and let stand for 12 minutes. The heat helps to denature enzymes in the cytoplasm that would otherwise destroy the DNA. It also helps soften the cell walls so that they are broken down more easily by the detergent.

7 Remove the beaker with the onions from the hot water bath and cool it down in the ice water bath. Gently stir the mixture to help it cool more rapidly. If left in the heat too long, the DNA itself will also denature. If there is a lot of foam on the top of the solution, you may want to skim most of it off the top of the solution.

8 Place a coffee filter inside the funnel and place the funnel point-down into a clean, empty 150 ml (or larger) beaker. Gently pour the solution through the coffee filter. Try not to let any foam pour onto the filter—the foam is mostly detergent and could harm the DNA as it works its way through the filter. The solution will take a while to filter through, so you may want to place the containers in a refrigerator and let it filter overnight.

9 Add 50 ml 5% (w/v) meat tenderizer solution to the onion solution and mix it gently enough that it doesn't foam. Let the solution stand for about 5 minutes. This will dissolve most of the proteins that are left in the solution so that only the DNA precipitates out.

Precipitating Out and Collecting the DNA

1 Prepare an ice water bath in one of the large casserole dishes.

2 Cool the solution to about 10°C in the ice bath. If you have let the filtering solution stand overnight in the refrigerator, this won't take long at all.

3 Pour about 5 ml of the chilled solution into chilled test tubes. There should be enough solution for 20 students.

4 Using a pipette, very gently place 5 ml of the ice-cold alcohol onto the onion solution. This works best when the alcohol is very cold. It is important that the alcohol does not mix with the onion solution, but instead rests in a layer on top of the onion solution. This can be difficult to do; the students should pay extra attention that they pour the chilled alcohol very slowly and gently. If the alcohol is slowly poured down the side of the test tube, it will be easier to layer it on top of the onion solution.

5 White wisps of coalesced DNA should start to form at the interface of the alcohol and onion solutions. After the DNA has precipitated out for about 5 minutes, collect the DNA by gently swirling it around a glass rod. Watch closely as you swirl the DNA onto the rod so you can see the long strands. If the DNA appears fluffy, this means that the molecules have been broken by the process. Gently collecting the strands with the glass rod should help minimize this. The DNA clings to the glass of the rod. By the way, it is not such a coincidence that the DNA looks like mucus; similar long strands of protein are what make mucus able to stretch into long strings.

POST-LAB CLASS DISCUSSION/ACTIVITIES

1 Why does the DNA "stick" to the glass rod? Why couldn't we use a plastic rod? What are some properties of glass that make the ionized DNA molecule stick to it? For example, what happens to the glass rod if it is rubbed with a rough cloth? Do the same things happen to a plastic rod that's rubbed? Do certain other things stick to it as well? Does rubbing the glass make the DNA stick to it better or worse? How could you tell?

2 We mentioned that heating the onion mixture when lysing the cell membrane helps protect DNA by destroying (denaturing) enzymes in the cytoplasm that would break up DNA if they could. Why do you think these DNA-destroying enzymes might exist in a cell's cytoplasm?

ASSESSMENT

1 Students successfully extract DNA.

2 Students create a lab report of their experiences.

EXTENSION ACTIVITIES

1. Using a microscope, it is easy to find cells undergoing mitosis in onion root tips. Students can follow up the extraction of DNA from an onion by observing DNA in the act of moving to each daughter cell in the roots of the same onion from which they've extracted DNA.

2. If you can obtain electrophoreses gel and Carolina Blu Stain, classes can conduct DNA fingerprinting. A protocol is available at www.nal.usda.gov/bic/Education_res/protocols/dna.finger.html. More information is available at www.howstuffworks.com/ dna-evidence.htm.

3. If you can obtain diphenylamine, acetaldehyde, sulfuric acid, and glacial (photographic) acetic acid, then the students can test the onion precipitate for DNA. Diphenylamine binds with deoxyribose and turns blue. This will confirm how much of the precipitate is DNA, and not RNA or another molecule. A spectrophotometer could measure the amount of blue to quantify the amount of DNA present. Can your students think of any reasons a researcher would want to measure how much DNA there is? What if they had weighed the amount of onion used? Or, what if they had extracted DNA from another specimen as well? More information is available from the National Centre for Biotechnology Education at this and other sites: www.ncbe.reading.ac.uk/NCBE/ PROTOCOLS/DNA/PDF/DNA05.pdf

ADDITIONAL RESOURCES

High-school level tutorial about DNA and genetics
http://www2.mtroyal.ab.ca/~tnickle/ExploreIT/

Extensive, well-organized information about DNA and heredity. Includes animations, review questions, etc.
www.dnaftb.org/dnaftb/1/concept/index.html

More detailed information about DNA
www.geneticengineering.org/chemis/Chemis-NucleicAcid/DNA.htm

World Health Organization site about vitamin A deficiency
www.who.int/nut/vad.htm

Information about eugenics
http://www.eugenicsarchive.org/eugenics/

General and Miscellaneous

Reprint of James Watson and Francis Crick's 1953 *Nature* article in which they announce their discovery of the double-helix structure of DNA
www.nature.com/genomics/human/watson-crick

Animations of DNA and other related cellular processes and scientific procedures
http://academy.d20.co.edu/kadets/lundberg/animations.html
www.hhmi.org/biointeractive/dna/index.html

Article conjecturing why onions have longer DNA molecules than humans
www.news.harvard.edu/gazette/2000/02.10/onion.html

Flemming's discovery of lysozomes (and some insights into his discovery of penicillin)
http://web1.caryacademy.org/chemistry/rushin/StudentProjects/CompoundWebSites/2000/Penicillin/Home%20page.htm

SOURCES

Ellen Averill, E. (1993). *Isolation of DNA from Onion*. Woodrow Wilson Biology Institute
www.accessexcellence.org/AE/AEPC/WWC/1993/isolation2.html

Fehr, W. R. (revised 1994). DNA Extraction From Onion. *United States Agricultural Library.*
www.nal.usda.gov/bic/Education_res/protocols/onion.extract.html

Hayes, L. Introduction to DNA Extractions. *Access Excellence Activities Exchange.*
www.accessexcellence.org/AE/newatg/Hayes/onion.html

National Human Genome Research Institute (includes educational resources and a map of the human genome)
www.genome.gov/

did you know?

The What-if Factor

Most new inventions, improvements, theories—in fact, almost anything new that is not accidental—start with a simple question: *What if…?* When it comes to GMOs (Genetically Modified Organisms), there is virtually no limit to the what-ifs.

For instance, *what if* we could inject daffodil genes that are rich in Vitamin A into a strain of white rice that is deficient with Vitamin A? And in the spirit of Jurassic Park, *what if* we could insert the DNA of a wooly mammoth into an elephant or the DNA of saber tooth tigers into lions so that people in this century could see what those creatures were really like? *What if* we could produce a chicken or turkey that had 50% more breast meat? *What if* we found a non-toxic way to keep that pesky little mosquito from breeding? Would that be bad for anyone but the bug spray companies? *What if* we used stem-cell materials to grow body parts for people who are waiting for a transplant? *What if* we could use DNA technology to alter our family genetics and create stronger, disease-resistant children? *What if* we could implant human genes into pigs that could then be used for human organ transplants? *What if* we could clone a sheep? Oops, that's already been done! Ok then, *what if* we could clone a twin just like your teacher?

What-if questions often lead to more questions that lead to a host of good news/bad news scenarios. Consider these: If white rice were enriched with Vitamin A, millions of kids who might have died would be alive and healthy in already overpopulated countries with low employment and little food. Will they simply become victims of other socio-economic factors? Will their survival create hardships on others? Even if that is not an issue, would it be more sensible to educate all citizens on the health advantages of brown rice that has Vitamin A and other nutrients not found in white rice? How would that affect the agricultural and economic balance? Sure, the large-breasted chicken may feed more chowhounds at Sunday dinner, but what does the extra top weight do to its balance and mobility in the chicken yard? Will each generation become weaker, lazier, and more susceptible to poultry disease? Will that lack of exercise affect the quality of the meat or the reproduction capabilities of the breed?

Are there any negative economic, environmental, moral and ethical consequences that would offset the benefits of the GMO what-ifs below?

- Stop mosquito breeding
- Saber-toothed tiger and wooly mammoth re-creations
- Replacement parts from stem cells
- DNA changes to create stronger gene pool
- Transgenic pig organ transplants
- Animal cloning
- Human cloning (teachers don't count!)

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: HS

Type: Academic research

Topics: Biodiversity, endangered species

Pandas, Sperm Banks, and Vavilov Centers: Habitats vs. Test Tubes

Today's captive breeding programs at zoos and animal sanctuaries are providing scientists and the public with ways to observe, learn about, and conserve many endangered species. These activities also trigger some important questions about our priorities in regard to wildlife conservation. Should we invest in captive breeding programs, seed banks, sperm banks, and cryogenically frozen tissues in order to conserve wildlife, even as we continue to destroy essential natural habitats? Are these species-based approaches the best ways to save endangered species? This project offers students the opportunity to look closely at a range of species survival plans and to offer suggestions for improved practices.

INTRODUCTION

Vavilov Centers and Sperm Banks

Russian scientist Nikolai Ivanovich Vavilov (1887-1943) discovered that most of the crops we depend upon for food can be traced back to only about a dozen places on the planet. For example, corn came from Mexico, wheat from Turkey, potatoes from Peru, and oranges from the Himalayas. Scientists call these places where an organism originally evolved Vavilov centers. Many believe, as Leopold probably would, that these areas must be protected because they are the only source of the original genetic makeup of our food plants. And since domesticated varieties of crop seldom survive when placed among native varieties, we may be weakening the long-term survivability of our food crops. Vavilov centers are our insurance policy. If our crops should catastrophically fail or if our genetic engineering efforts should drift too far from the original, we can always start again by going back to the origin (Vavilov centers). The Vavilov center debate recently received attention when Mexican researchers detected widespread contamination of traditional varieties of corn and then determined that the problem originated from imports of genetically engineered corn.

Vavilov centers raise important questions about species-based approaches that ignore the importance of habitat in the survival equation. For instance:

- Can we save the original crop (like the Mexican corn) by storing seeds in a bank?
- Can a plant or animal species be saved independently of its habitat?
- Should we invest in captive breeding programs, seed banks, sperm banks, and cryogenically frozen tissues to conserve wildlife? If so, can we really cryogenically freeze tissues of animals and clone them later if we lose the habitat of these organisms?
- Can we store all the seeds and sperm of every endangered plant and animal on earth and reanimate them "Frankenstein style" if/when we need to go back to the drawing board?

- Can a flower exist outside of its pollinator and symbiotic root fungi?
- Does an individual seed or sample of tissue contain all of the genetic variability necessary to assure that the entire species can survive if we bring them back?

Also, it is important to know how Vavilov centers relate to animal welfare, for there is a symbiosis between plants and animals. A giant panda cannot live in a habitat that has no bamboo; a Koala cannot live in a habitat which has no eucalyptus. The "habitat-based approach" recognizes that, if we are to be safe, we cannot rely solely upon individuals warehoused in zoos or upon sperm banks, for these fly in the face of Aldo Leopold's warning that we must keep track of all of the "cogs and wheels" of the land organism. To secure the survival of these species, logic dictates that we must preserve their habitats. In short, we must invest in "last ditch" conservation efforts designed to save "species on the brink" such as the California condor or the white rhino. It is no easy matter as zoos throughout the world have had different levels of success in trying to breed endangered and threatened species in captivity and then release them in the wild. And while genetic engineering now makes it possible to extract genes from the chromosomes of one species to place them within chromosomes of another, there are still no clear-cut standards of how far this can go or what is the best approach to preserve our biodiversity.

MATERIALS NEEDED

- Internet access or other sources of information dealing with wildlife conservation

A giant panda cannot live in a habitat that has no bamboo; a koala cannot live in a habitat which has no eucalyptus.

OBJECTIVES

After completing this activity, students will be able to:

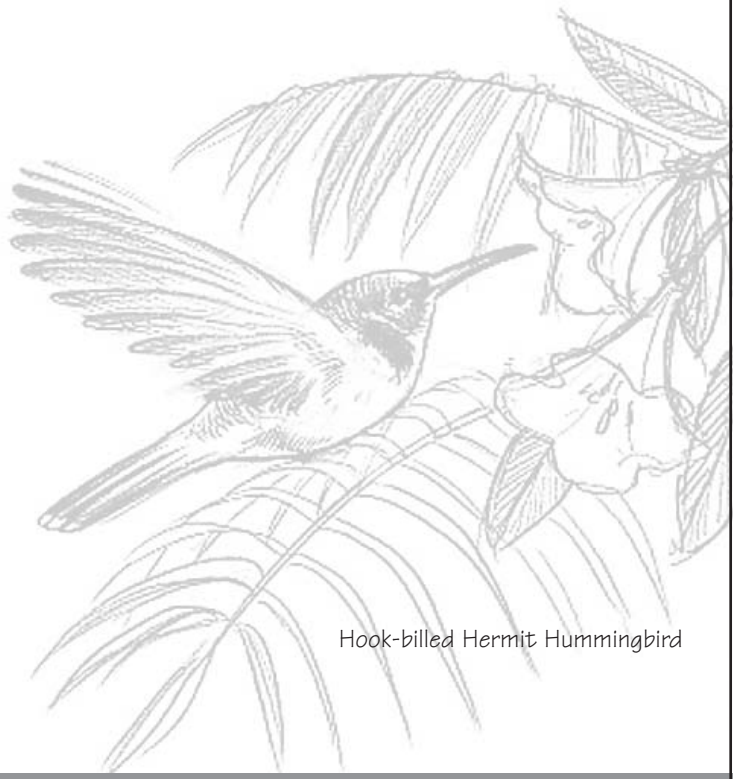
1. seek out and synthesize information in order to debate the idea that humanity must preserve wildlife through sperm banks (repositories of the genetic material of plants and animals) and/or Vavilov centers (the habitat of our original food sources).

2. discuss and evaluate the strengths and weaknesses of the species-based versus habitat-based approaches to conservation (captive breeding, reintroduction programs, zoos, and the aesthetic versus ecological value of species).

3. explore alternative arguments concerning wildlife conservation.

CLASS TIME REQUIRED

Four 40-minute periods



Hook-billed Hermit Hummingbird

Aldo Leopold (1887-1948) and Intelligent Tinkering

Conservation is a state of harmony between men and land. By land is meant all of the things on, over, or in the earth. Harmony with land is like harmony with a friend; you cannot cherish his right hand and chop off his left. That is to say, you cannot love game and hate predators; you cannot conserve the waters and waste the ranges; you cannot build the forest and mine the farm. The land is one organism. Its parts, like our own parts, compete with each other and co-operate with each other. The competitions are as much a part of the inner workings as the co-operations. You can regulate them—cautiously—but not abolish them. The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little we know about it. The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

From: Leopold, Aldo: *Round River*, Oxford University Press, New York, 1993, pp. 145-146.

LESSON STEPS

Ask students to:

1. Investigate a captive breeding program, animal sanctuary, and/or species-survival plan for an endangered or threatened plant or animal.

2. Orally share the goals, difficulties, problems, and benefits of the captive breeding and/or species-survival plan.

3. Discuss as a class whether they support or oppose zoos.

4. Read the background information "Aldo Leopold and Intelligent Tinkering" and "Vavilov Centers and Sperm Banks" provided.

5. Construct a reasoned argument in support of or in opposition to one of the following:
   - The preservation of a species outside of its habitat through captive breeding or sperm banks
   - The identification and preservation of Vavilov centers
   - Storing plant and animal tissue cryogenically for future use in lieu of habitat preservation

6. Present their arguments in front of an audience (the rest of the class).

7. Field questions and critical comments from an audience (the rest of the students in class).

8. Write a reaction essay to the debate, after both sides have made their arguments, addressing the following questions:
   - The best ways to preserve species and diversity
   - Whether it is important to preserve habitats, sperm banks, and Vavilov centers

EXTENSION ACTIVITIES

Ask students to:

1. Research and assess the success of a species survival plan for a regional animal of their choice.

2. Identify reasons that their animal or plant is endangered.

3. Write a summary of problems with the species survival plan and a modified recovery plan for their plant or animal. The summary should include:
   - A classification of their plan as being a habitat-based or species-based approach to conservation
   - Description of how the new plan will affect the economy, people, other wildlife and the environment

4. Send their recovery plans to those in positions to affect the species in question and solicit responses from them. Examples of such agencies and individuals include:
   - State departments of natural resources
   - State and national senators and representatives
   - The United States Secretary of the Interior
   - The United States Fish and Wildlife Service Division of Endangered Species
   - The IUCN World Conservation Union
   - Directors of conservation programs at major zoos

5. Write a report on the response(s) that includes:
   - Bulleted summary of the response, including pro/con reaction to the plan's major points
   - Students' evaluation of the response
   - Adjustments in approach if the students were to revise the plan

Northern Spotted Owl

ADDITIONAL RESOURCES

Hanson, Royce. "Protecting Montgomery's Agricultural Reserve for the Next Generation." Symposium on the Agricultural Reserve. Dickerson, Maryland. 31 July 2004. www.audubonnaturalist.org/cgi-bin/mesh/issues__actions/articles/threats_to_ag_reserve

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: AP

Type: Field research

Topic: Biodiversity, endangered species

Wanted: A Second Chance – Research on Endangered Species

The loss of biodiversity is one of the major environmental challenges facing us today. Becoming familiar with one endangered or threatened species of wildlife is an excellent way to understand the dynamics behind this process and how that species contributes to a diverse ecosystem. With this increased understanding, we can take steps to slow or prevent the loss of species and biodiversity on our planet.

INTRODUCTION

This project is organized around the five E's—Engage, Explore, Explain, Extend, and Evaluate—to help teachers and students manage and benefit from a rich learning experience. The material in this project covers major topics in Advanced Placement (AP) Environmental Science and prepares students for the AP exam, including:

- Organisms and adaptations to their environments
- Populations and communities
- Evolution of life
- Environmental ethics
- Environmental law and regulations
- Endangered species

OBJECTIVES

After completing this activity, students will be able to:

1. research and present information on an endangered animal using a variety of resource materials, including at least one web site.
2. conduct an original research project on an endangered animal at the zoo or other suitable location.
3. undertake some activity to assist in the recovery of this endangered species either by a monetary contribution, an educational outreach activity, or other action of their choice.

MATERIALS NEEDED

- Presentation software, such as OpenOffice.org Impress or Microsoft PowerPoint
- Access to a wildlife sanctuary or American Zoo and Aquarium Association accredited zoo or aquarium

CLASS TIME REQUIRED

About three 40-minute periods—one of which should be a field trip to a zoo or wildlife sanctuary if possible—plus homework

LESSON STEPS

Engage

1 Tell students the definition of "endangered" and "threatened." According to the Endangered Species Act of 1973, an endangered species is "in danger of extinction within the foreseeable future throughout all or a significant portion of its range."

2 Ask students to name some animals that are endangered. Most likely, they will name large mammals and birds in distant places.

3 Let students explore the species in their area and elsewhere that are threatened or endangered. To find examples of endangered species, view current research projects aimed at protecting biodiversity organized by the Earthwatch Institute, www.earthwatch.org/subject/biodiversity. html. Can they name any other species of animals or plants that are endangered? Can they name any in their area? For lists of endangered and threatened species in your area, visit http://ecos.fws.gov.

4 Discuss the purpose and methodology of current research targeted at protecting that animal.

Explore

1 Divide students into groups of four.

2 Allow each group to pick an endangered species to research following the guidelines laid out in the handout "Wanted: Presentations on Endangered Species."

3 Arrange a field trip to a wildlife sanctuary, a zoo, or an aquarium so that students can conduct research on their chosen endangered species. See the handout "Research Project at the Zoo." Provide a list of animals on exhibit at the zoo.

4 Explain several behavioral study techniques. See handout.

5 Go over the various components of the form giving explanations where needed, such as gender:
- Distinguish between dominant, breeding males, and bachelor males
- Distinguish between lactating females and non-lactating females.

Note: *Caution students that depending on the size of the animal group they are studying and unexpected problems that they may face while attempting to complete this research project, they may not be able to complete all parts of the project. For instance, it may take the entire day to observe and determine who is the dominant male in the group. All groups will write a one-page typed conclusion of what they accomplished by the end of the day's research period. This conclusion should explain what the purpose of their study was; what they learned; what challenges they faced; what, if anything, they were not able to accomplish and why; and finally, what changes they would make to this research design if they were to repeat the project in the future. Groups who did not finish the entire project should be sure to explain where they got bogged down and how they attempted to solve the problems they had.*

Explain
Each group will present its presentation on their endangered species to the class. In addition, they will present their research project and their findings.

Extend
Each student will do something to contribute to the well-being of the animal they studied.

Evaluate

1 Students understand what endangered and threatened mean.

2 Students can name at least three endangered or threatened species, at least one of which is in their state.

3 Students can enumerate the challenges faced by at least one endangered or threatened species, including the reasons why it is in trouble.

4 Students can articulate the implications for the loss of this species.

5 Students can express a way to help this species' situation and successfully complete an action to do this.

ADDITIONAL RESOURCES

- For additional lesson plans about endangered species and primate behavior research, go to unit four in Jane Goodall's Lessons for Hope. www.lessonsforhope.org
- Earthwatch Institute offers grants and stipends for high school students and teachers to go on research expeditions. www.earthwatch.org
- The Endangered Species Act www.fws.gov/endangered/wildlife.html www.fws.gov/laws/lawsdigest/esact.html

EXTENSION ACTIVITIES

1 Students can create an art project based on their endangered or threatened species. At your discretion, displaying this can count as an action to help the species.

2 Students can explore extinct species or ones that are thought to be extinct—especially those that have become extinct recently. They can explain why the species went extinct and what people could have done to prevent it. Would the species go extinct soon if it were still alive today?

Sugar Glider

WANTED: PRESENTATIONS ON ENDANGERED SPECIES

The loss of biodiversity is one of the major environmental challenges facing us today. Becoming familiar with one endangered or threatened species of wildlife is an excellent way to understand the dynamics behind this process and how that species contributes to a diverse ecosystem. With this increased understanding, we can take steps to slow or prevent the loss of species and biodiversity on our planet. Studying endangered species is also excellent preparation for the upcoming AP test.

For this project, you will conduct research on an endangered or threatened species of your choice and present this information in digital format to the class. You may work with up to three other classmates.

Requirements

Part I: Presentation

1. Illustrated title page including the name of the organism being studied, names of all group members, your teacher's name, and the date of the project

2. A map indicating the location of the endangered species, indicating the countries and biomes where it can be found

3. A detailed food web or food chain indicating your species' placement in it. Be specific. For example, for producers, "plants" is not specific enough.

4. A fact sheet in bulleted format explaining:
   a. Life cycle (gestation time, years to recruitment age, etc.)
   b. Role of this species in its ecosystem
   c. History of the species and its interaction with humans
   d. Cause(s) of the species' decline
   e. What is being done (or needs to be done) to help restore its populations
   f. Reasons why this species should be preserved

5. Bibliography of at least three sources used

Part II: Action

As part of this project promoting stewardship, you will undertake an appropriate course of action to help this species. It could include such things as presenting this information to a younger group of children, presenting this information at a local Earth Day event, writing letters to appropriate officials, conducting a fundraiser, making informative brochures that you would leave at libraries, participating in a restoration project in this area, joining an "Adopt a _____" program, etc.

Date due:

_____ _____

Presentation *Action*

The loss of biodiversity is one of the major environmental challenges facing us today.

RESEARCH PROJECT AT THE ZOO

Conducting field studies on a particular endangered species provides crucial information that is then used to draw up a management plan to help the species recover. You and your group have been studying a particular endangered animal and have a good understanding of its basic life cycle and environmental requirements. With this information in mind, what questions do you have about this animal? Brainstorm a few in the space below. Then, select one question that you will attempt to answer by observing this animal at the zoo.

Research Team:

Question to focus on at the zoo:

Questions:

1.

2.

3.

Hypothesis or comparative study objective:

Procedure

1. List the individuals present in the enclosure. Be sure to indicate any unique marks that will allow you to tell one from the other.

"Name" or Number	Gender	Age	Distinguishing Marks

2. Describe the specific animals that you are using for your behavioral study. If you are doing a scan sample or focal animal study, define the behaviors that you are focusing on.

3. In the space below, design your data sheet.

Research Report:
Working together, type a detailed conclusion to your project. Include what the purpose of your study was; what you learned about the animal you were studying; what challenges you faced; what, if anything, you were not able to accomplish and why; and finally, what changes would you make to this research design if you were to repeat the study in the future.

BEHAVIOR STUDY TECHNIQUES

Index of Association (IA)

Formula:
IA = (2C/A + B) * 100 = % of association

where
A = number of sightings of A (with or without B)
B = number of sightings of B (with or without A)
C = number of sightings of them together

For example:
Let's say you recorded the association of two targeted individuals 50 times at three-minute intervals between each sighting and at the end, you got the following data:

A = 50
B = 50
C = 50

This would mean that each time you looked at A and B they were together. Their Index of Association would be:

(2*50/50+50) * 100 = 100%

Questions to ask with this data:
- How does this Index of Association compare with IA of another pair of individuals in this group? What might this indicate? What are the implications of this for survival?

Caution: Be sure to clearly define what "together" means.

Time budget using focal animal sampling
1. Work in pairs with one person as the observer and one person the recorder.

2. Define the behaviors you will be recording and have an abbreviation for each behavior.

3. Set your stopwatch to zero. When the observer says begin and calls out the first behavior, the recorder records the time as 0.00 and records the behavior.

4. Each time the observed animal changes behavior the observer calls it out and the recorder records the time to the nearest second and the behavior.

5. Continue in this manner for an appropriate amount of time (15 minutes is good).

6. Make several timed observations.

7. Determine the amount of time each animal spent doing various behaviors.

8. Questions to ask with this data: How does the time budget of each member of the group compare between males and females? Between different roles in the group? What might this indicate about their role in the group? What are the implications of this for survival?

   Example:

Time	Behavior
0.00	W
0.07	G
1.15	W

Time budget using scan sampling

1. Work in pairs with one person as the observer and one person as the recorder.

2. Define the behaviors you will be recording and have an abbreviation for each behavior.

3. Determine how often you will scan the group. (Select between every 3-5 minutes depending on the species.)

4. At each time interval, the scanner looks from right to left and calls out the behavior of each and every individual in the group.

5. Continue in this manner for an appropriate amount of time.

6. Determine the amount of time each animal spent doing various behaviors.

7. Questions to ask with this data: How does the time budget of each member of the group compare between males and females? Between different roles in the group? What might this indicate about their role in the group? What are the implications of this for survival?

Example:

	Male	Lactating Female	3-6 month Foal	Non-Lactating Female	Yearling
0 min	**W**	**G**	**G**	**V**	**G**
3 min	**G**	**G**	**G**	**G**	**V**

Key:
W= walking
G= grazing
V= vigilant/looking for predators

Note: Behaviors will vary.

Note:

- There is a trade-off between using the focal animal sampling and the scan sampling technique. With the focal animal sampling, you know for certain what an individual did for the defined period of time. However, you only know about the behavior of the few individuals that you can sample. With scan sampling, you know what the entire group is doing, but you only know it for discrete points in time.

- In general, let us assume that if there is more than a 10% difference between the behaviors of individuals, then the difference is statistically significant.

- Consider determining the mean range, standard deviation, and standard error for your data measurements.

The Elephant Sanctuary

In the hills of southwest Tennessee exists the most unlikely of sanctuaries. The Elephant Sanctuary is the nation's largest natural habitat refuge for endangered Asian and African elephants and is currently home to 12 female elephants.

These elephants come to Tennessee from far away places such as Burma, Sumatra, Sri Lanka, India, South Africa, and Zimbabwe. These elephants were all caught in the wild and were often performers in circuses or residents of zoos around the world.

As the elephants were retired from their zoos or circuses, they were brought to the Elephant Sanctuary. Here, they are part of a 2700-acre refuge that provides two separate and protected natural habitat environments for Asian and African elephants. The elephants here have warm shelters, food, and the freedom to roam through pastures and forests. These elephants are not asked to perform for people or to entertain anyone. They are here to live like elephants do in the wild — something that they haven't done for quite some time.

The Elephant Sanctuary was designed not only to help old, sick, or needy elephants but also to educate people about elephants, their fascinating individual traits, and their highly organized social interactions. The sanctuary brings attention to the ethical issues surrounding the capture and commercial use of these gentle and intelligent giants. The Elephant Sanctuary's website, www.elephants.com, has information on each of the elephants at the sanctuary and about efforts to bring more neglected elephants to safety. Click on the site's live EleCam to observe the elephants' behavior as they live their lives unchained in the forests, ponds, and rivers of their refuge. Check out the website and think of your own way to educate people about the threats to African and Asian species in their native habitats and in captivity.

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Grade Level: MS

Type: Demonstration and simulation

Topic: Implications of personal trash disposal

What's In Your Garbage?

When your batteries are out of juice, they've still got more to let loose. The life of trash doesn't end when it leaves our sight. Some of the things we throw away move on to a darker life poisoning animals and the environment. This project will help students understand how the small packages of toxins that are too often discarded with the family trash can lead to big problems for animals.

INTRODUCTION

Middle school students are likely to be aware of the importance of reducing, reusing or recycling the trash that humans generate in the course of their daily lives. They will easily recognize the need to control pollution, conserve energy and reduce the volume of garbage that goes to landfills. However, they may not grasp that households can generate a large amount of hazardous waste that can have devastating effects on the animals in our backyards and beyond.

Students will begin this activity by looking at common household trash from the point of view of domestic and wild animals that can be harmed by seemingly benign refuse like yogurt cups and metal cans. Then, they will take a scientific look at the hidden, toxic dangers in hazardous waste that is too routinely tossed into household garbage bins. Finally, students will devise action plans to help households reduce the dangers to wildlife that their trash may present.

OBJECTIVES

After completing this activity, students will be able to:

1. recognize items in household trash that may harm or injure domestic or wild animals in their neighborhoods.

2. identify "hidden" toxins that are present in items they use every day.

3. understand why these substances threaten the well-being of animals even in small amounts.

4. describe proper disposal methods that could reduce this danger.

A. DUMPSTER DIVING

This activity will make the point that recycling and proper treatment of garbage is not just about reducing the amount of space devoted to landfills or wiser use of natural resources. It's also about reducing direct and indirect harm to animals and being aware of the hidden hazards in household garbage.

MATERIALS NEEDED

- Garbage bag
- Household trash items
- Latex gloves

Lesson Steps

Prior to the class session, fill a garbage bag with examples of common household trash representative of what a family that does not recycle would accumulate over a day or two: paper products, food scraps, plastic and glass

containers, metal cans, rags, cleaning products, etc. Be sure to include at least one of the plastic "binders" that hold six-packs of soda and one battery (the smaller the better). You will use these items to make the point that recycling and proper treatment of garbage is not just about reducing the amount of space devoted to landfills or wiser use of natural resources—it's also about reducing direct and indirect harm to animals.

1. Ask students what wild and domestic animals are common in their neighborhoods. Answers will vary from region to region, but common animals like dogs, cats, squirrels, deer, raccoons, birds, etc. are likely to make the list.

2. Tell students that they are going to examine the contents of a bag of typical household trash (minus any unsanitary items) from these animals' points of view.

3. Don plastic or latex gloves and dump the trash bag contents onto a table. As you point out various items (keeping the presence of the battery to yourself for the time being), have students think out loud about how some of them could harm the animals that come in contact with what humans throw away. A raccoon's head can get stuck in a jar that still contains traces of peanut butter; a large amount of chocolate can make a dog ill; a small amount of antifreeze can be lethal. Household cleaners can be poisonous, birds can get tangled in the plastic rings from soda six-packs, meat or poultry bones can potentially choke a fox. You won't need to spend a lot of time on this. Students will readily get the point and be ready for a quick review of proper methods of recycling and disposing of garbage (those plastic rings should be cut into pieces, cans and jars should be rinsed and placed in a tight-lidded recycling bin) to reduce negative effects on the environment and to keep animals safe.

4. As you are returning the trash to the garbage bag, "discover" the little battery that you "missed" in the initial trash examination.

5. Ask students if a small battery could harm a neighborhood animal. (It could be swallowed.) Could a small battery potentially harm an animal that lives far away?

6. Some students may know that batteries are made from acids and other toxic substances that can eventually ooze from their casings. Even so, share this list of battery "ingredients" with the class:

   - Acid
   - Cadmium
   - Lead
   - Mercury
   - Nickel

   Explain that even small amounts of mercury, nickel, lead, or cadmium can be very harmful to humans and animals. Give students the opportunity to think out loud about all of the battery-powered items used regularly in their households. What becomes of all those dead batteries?

7. Tell students that in humans, large doses or extended exposure to small doses of these substances can cause:

   - **Nervousness, irritability**
   - **Tremors**
   - **Personality change**
   - **Suicidal tendency**
   - **Impaired hearing**
   - **Speech disorders**
   - **Visual disturbance**
   - **Abnormal reflexes**
   - **Disturbed gait**
   - **Impaired nerve conduction**
   - **Kidney damage**
   - **Infertility**
   - **Lung disease**
   - **Brain cancer**
   - **Death**

8. Ask students if they know how scientists express concentrations of toxins when they are found in very small amounts. Ask them if they know how much mercury it takes to make a human or an animal ill.

9. Provide students with a copy of the handout "Improper Disposal of Mercury."

B. VISUALIZING TOXINS (ADAPTED FROM *AQUATIC PROJECT WILD: DEADLY WATERS*)

The purpose of this activity is for students to make inferences about the impact of human caused pollution on aquatic habitats and ultimately animals, and to visualize the idea of parts per million.

MATERIALS NEEDED

- Hole punch
- Construction paper
- Graph paper

Lesson Steps

Prior to this lesson, use a hole punch and 6-10 different colors of construction paper to create a pile of multicolored tokens. Assign a color to correspond with 6-10 of the following categories of waste pollution: sediments, animal waste, petroleum products, organic wastes, inorganic compounds, fertilizers, pesticides, herbicides, fungicides, heavy metals (mercury, lead). Be sure to "stack the deck" by having comparatively fewer dots representing mercury or heavy metals. ***Note: For steps 1-4, have students work individually.***

1. Get 1/4 teaspoon of the construction paper tokens. Tell the students that the tokens represent a sample taken from a fictional river.

2. Ask students to separate the colored tokens into piles according to the categories identified above.

3. Ask students to count the number of each kind of pollutant and use a piece of graph paper to construct a simple bar graph.

4. Ask students to arrange the pollutants from left to right from the most dots to the least dots. Purposely avoid telling students the units associated with each dot.

5. Ask the students to "pair and share" to interpret the results. Specifically, ask them which pollutant is of greatest concern in their fictional river. Students will likely select the pollutant represented by the greatest number of dots. In fact, certain toxins are far more harmful in smaller doses.

6. Ask students what determines the consequences of animal exposure to toxic substances. Guide them to a discussion of *dose*—how much of the substance the animal is exposed to and the *length of time of exposure*—how long an animal is exposed to a toxic substance. To relate this to the experiences of the student, ask them what determines the severity of a sunburn. What matters is how direct and hot the sun is (dose) and how long the person is in the sun (length of time of exposure).

7. Ask students what must be known to make a scientific interpretation of the fictional river. Do three dots of heavy metals equal three dots of sediment? (Concentration of toxin, how long animals are exposed to the concentration.)

8. Explain to students that toxins are expressed in terms of parts per million (ppm) or parts per billion (ppb).

9. To help them visualize ppm and ppb, tell students that 1 part per million is like 1 drop of water in a typical car gas tank, and that 1 part per billion is like 1 second of time in 32 years!

C. VISUALIZING CONCENTRATION

The Maximum Contaminant Level that the U.S. Environmental Protection Agency has established for mercury is a limit of 2 parts mercury per billion parts of drinking water (2 ppb). This activity will help students understand that even a little mercury is much too much.

MATERIALS NEEDED

- Food coloring
- Clear plastic cups
- Eyedroppers

Lesson Steps

1. Divide students into groups of three.

2. Provide students with a bottle of food coloring and clear plastic cups.

3. Tell students that food coloring is to represent mercury in the river.

4. Ask each group to place one drop of food coloring in a cup that is 3/4 full of water.

5. Hand out one eyedropper and five smaller clear plastic cups.

6. Explain that food coloring is usually a 10% solution; that is, one part (by volume) of food coloring dye is dissolved in 10 parts (by volume) of solution. For example, 1 ml of dye dissolved in 9 ml of water makes a total of 10 ml of a 10% solution.

7. Ask one member of each group to use the eyedropper to add nine drops of water to the cup containing the food coloring.

8. Ask students to write down the concentration of the food coloring (1 part in 100 (10 x 10) parts of solution).

9. Ask students to use the eyedropper again to transfer one drop of the 1 part in 100 solution to a third small plastic cup. Ask them to add nine drops of water to this solution. This is 1 part in 1,000.

10. Ask students to transfer one drop of the 1 part in 1,000 parts of solution into the next small plastic cup and add nine drops of water. This is 1 part in 10,000 parts of solution.

11. Ask students to continue the procedure to obtain 1 part per 100,000 and then one part in 1,000,000.

12. Ask students to discuss and or write answers to the following questions:

   a. Can mercury be seen in all of the cups in the progression? Ask students to relate this to the batteries in the trash and mercury in the river.

   b. Since you cannot see mercury in a river, how do we know it is present?

   c. Can you think of an experiment using your samples of food coloring that you could use to prove that the food coloring (mercury) is in a sample of water? (Run the samples through filter paper.)

13. Ask students to take a look back at the bar graphs that they created. Ask them to assume that the units are: 1 dot equals 1 part per million. Ask them to make inferences concerning the likely source, consequences for animals, and remediation of their river.

14. Ask students to write a paragraph of interpretation to be stapled to the bar graph and displayed in the classroom or other public place.

15. Ask students to present recommendations concerning the clean-up of the river to the rest of the class.

D. SO, IS IT HOPELESS?

This activity will help students identify what individuals and communities can do to reduce hazardous waste pollution.

Lesson Steps

1. Tell the students that they have probably found many instances where trash is a hazard to the lives and health of animals in the area.

2. Ask students if this means that people need to stop using batteries in their flashlights, eating yogurt, using paint, drinking soda, or chewing bubble gum.

3. Ask students if all trash is created equally. Is a battery as serious of a concern as a plastic container? Why or why not?

4. Ask students to formulate a plan, which can easily be implemented by families, to reduce the danger that trash and hazardous waste items may have on local wildlife, domestic animals, and the environment. This plan can involve changes that occur within the home, as well as changes that may take place at the curbside on trash-pickup days. Ask students to be sure that the plan correlates directly with the items found in the trash bag examined in class, including toxins and other hazardous waste.

5. Ask students to research what their community or municipality does with trash. Do they have a plan to deal with toxic substances? Ask students what ideas, policies, procedures, or technology they would like to use for their own plan.

6. Ask students to present their plan to the rest of their classmates, in the form of a poster or public service announcement.

Sources

The Western Regional Environmental Education Council, Inc. “Aquatic Project Wild.” Printed in U.S.A., 1994, pp. 137-141.

Additional Resources

Edugreen categories of solid waste
http://edugreen.teri.res.in/explore/solwaste/types.htm

EPA Hazardous Education Materials
www.epa.gov/superfund/students/clas_act/haz-ed/hazindex.htm

EPA Surf Your Watershed
www.epa.gov/surf

EPA Recycle City
www.epa.gov/recyclecity/mainmap.htm

University of Missouri household hazardous products
http://muextension.missouri.edu/xplor/wasteman/wm6003.htm

National Geographic article on computer trash
www.nationalgeographic.com/news/2001/06/0621_pccleanup.html

Pennsylvania Department of Environmental Protection: Household Hazardous Waste
www.depweb.state.pa.us/landrecwaste

IMPROPER DISPOSAL OF MERCURY

The Maximum Contaminant Level that the U.S. Environmental Protection Agency has established for mercury is a limit of 2 parts mercury per billion parts of drinking water (2 ppb). This is an extremely tiny amount. Yet, almost all animals including people have at least trace amounts of mercury in their bodies. Elemental or metallic mercury is the liquid metal used in button cell batteries, thermometers, and electrical switches. If we do not dispose of these products properly, mercury can harm the developing nervous system of animals and human beings. The primary way people in the U.S. are exposed to mercury is by eating fish containing methylmercury. But how did mercury get into fish?

Improper disposal of these products can cause mercury to enter the ground as well as the water cycle. Certain microorganisms in soils convert some part of it into methylmercury which is highly toxic. Small organisms take up methylmercury as they feed. When animals higher up the food chain eat the smaller ones, they also take in the methylmercury. As this process (known as biological magnification) continues, levels of methylmercury increase up the trophic levels of the food chain. Fish that are higher in the food chain such as sharks have much greater methylmercury concentrations than fish that are lower on the food chain. People and fish-eating wildlife become exposed when they eat fish and shellfish that contain methylmercury. If you put your toe in a body of water anywhere on earth you are connected to the hydrological (water) cycle of the entire earth. Streams connect to rivers, and rivers go to the ocean. The things we place in our toilets or place in landfills can be dissolved in or transported in this water and can travel through the water cycle. The most dangerous threat to water comes from inadequately controlled landfills. Chemicals from our trash dissolve (leach) into the water in these landfills. The leachate generated from landfill materials can escape to the surrounding and underlying ground and bodies of water. The make-up of leachate depends on what we put in our trash, the age of the landfill where we place our trash and the leaching rate. Animals may be affected by ingesting or coming in contact with this water that has come in contact with our trash. Data on what concentrations of mercury vapor can lead to chronic intoxication of humans under everyday conditions are contradictory. Some sources show that chronic intoxication can develop within two months after contact with mercury in concentrations less than 0.02 parts per million.

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Grade Level: MS

Type: Lab

Topic: Acid Rain

pHishing for Answers

This project will help students understand the effects of acid rain on ecosystems and animals. It also teaches students about actions citizens can take to reduce major sources of pollution that can lead to acid rain formation and result in harm to wild animals and their habitats.

INTRODUCTION

Acid rain is produced when sulfur and nitrogen compounds are released into the atmosphere, where they combine with water to form sulfuric acid and nitric acid. Some sulfur compounds are found in decomposing organic matter, volcanoes, and geysers. However, most of the sulfur and nitrogen compounds that are the culprits in acid rain formation come from the burning of fossil fuels such as coal (to produce electricity) and oil, and from automobile emissions. The following equations represent the formation of sulfuric acid (1) and nitric acid (2), key components of acid rain:

(1) $SO_2(g) + 1/2\ O_2 \rightarrow SO_3(g)$
$SO_3(g) + H_2O(l) \rightarrow H_2SO_4$

(2) $NO(g) + 1/2\ O_2(g) \rightarrow NO_2(g)$
$3\ NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$

When acid rain flows into aquatic ecosystems, it lowers the pH of the water. Healthy lakes have a pH of about 6.5, whereas a lake affected by acid rain can have a pH as low as 4.2. A decrease in the pH has a negative effect on the organisms in the ecosystem. Some organisms, such as phytoplankton and crayfish, cannot survive in such an environment. In addition, the acid rain sets into motion a series of other detrimental effects. For example, acid rainwater flowing through soil on its way to streams and lakes releases aluminum from the soil, depositing it into the streams and lakes. High levels of aluminum are toxic to fish. For more information on acid rain and its effects on ecosystems, see www.epa.gov/acidrain.

In this inquiry-based activity, students design and conduct an experiment to learn about how acidification affects pH levels and the health of aquatic organisms. The beauty of this fairly simple experiment lies in the myriad ways it can be used as a learning tool. It can be used at the beginning of a unit on humans and the environment, offering a starting point from which to discuss acid rain, the ripple effects of acid rain on earth's ecosystems, and steps that we as a society can take to help reduce acid rain formation. It is also a great activity to use at the beginning of a science course to introduce the process of "doing" science because it offers many opportunities to discuss experimental design, sources of error, and data analysis.

MATERIALS NEEDED FOR EACH STUDENT STATION

- Dropping pipettes
- 10ml graduated cylinder
- Watch glasses or petri dish halves
- Stereomicroscope or 10X hand lens
- Sterilized beakers (multiple, for storing water samples)
- pH meter, or pH papers and color chart

MATERIALS NEEDED FOR CENTRAL DISTRIBUTION STATION

- Beakers of microfauna cultures
- Empty beakers to collect retired microfauna—one for each site from which microfauna were collected

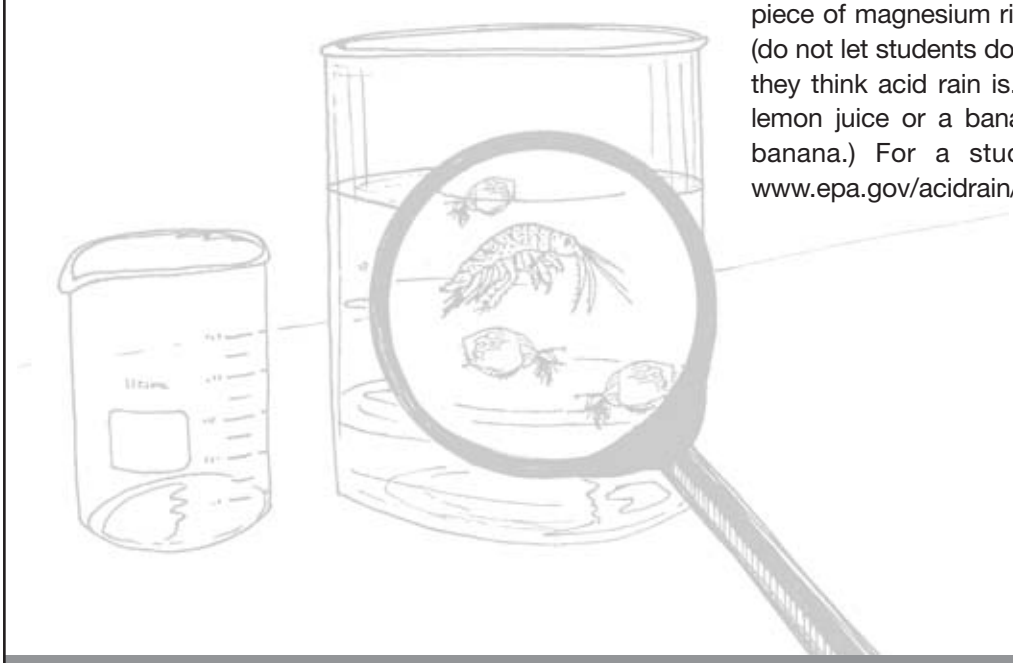
OBJECTIVES

After completing this activity, students will be able to:

1. design and execute a controlled experiment.
2. discuss the effects of low pH on organisms and the subsequent effects on an ecosystem.
3. create a list of actions individuals can take to help decrease acid rain formation.

CLASS TIME REQUIRED

Two to three 40-minute periods



LESSON STEPS

Begin by asking students what they know about acid rain. What is acid rain? What are the causes and effects of acid rain? Students may think that only the pollutants coming out of smokestacks produce acid rain; they may see no connection between themselves and those types of pollutants. It is okay to leave these misconceptions alone until a more extensive discussion can take place after the lab.

You may want to find out what students know about acids by asking them to name different substances that are acidic, as well as characteristics of acids. You can demonstrate the effects of acids by adding some baking soda to a beaker of vinegar, or by putting a piece of magnesium ribbon into a beaker of 6M HCl (do not let students do this). Ask students how acidic they think acid rain is. Is it more like the acidity of lemon juice or a banana? (It's closer to that of a banana.) For a student-friendly pH scale, see www.epa.gov/acidrain/site_students/phscale.html.

Design

1 After discussing the causes of acid rain, have students brainstorm about possible local bodies of water that may be affected by acidification. The bodies of water do not have to be large and may be in places the students often overlook. After the initial brainstorm, students can use aerial photographs (available online at sites like www.terraserver.com, www.terrafly.com, and through the programs available at http://earth.google.com/) to identify likely locations. If you are fortunate enough to live near an area that has been recently cleaned up, your class could compare animals from healthy, recovering, and polluted areas.

2 Decide as a group which bodies of water to sample for acidification. Two or three locations close to the school are plenty. If the class does not consider the need for control groups (or at least areas of more or less contamination), guide them to do this. Students will need to be careful not to plan to collect water samples from restricted or dangerous areas.

3 Work with students to determine what questions they want to answer. Students may need guidance in developing specific, testable questions. If students do not have previous experience with this, you will want to practice this prior to the lab. Be sure students have designed a controlled experiment. You may need to remind students that their goal is to find out the effects of acid rain, so their experiment should mimic the conditions found in a lake affected by acid rain. Thus, there is no need to test the effects of a solution with a pH of 2 on organisms since there are no aquatic environments with such a low pH.

4 Students will be watching for changes in behavior between the animals from healthy and acidified/unhealthy water samples. Students should first discuss what types of behaviors they will measure and how they will measure them. For example, will they measure how long an animal swims (thus needing a stop watch), and/or the number of behaviors it displays in a certain amount of time (and so needing a checklist—perhaps created as they go but standardized among the class)? They may measure the amount of time it spends swimming or near the top or bottom of the tank during a pre-determined time period. All observations should be as quantifiable as possible, but overall, qualitative observations about behavior or organism movement can also be made. Caution students about anthropomorphism when making observations, as they are often apt to say things like “the organisms are acting sick, crazy, or tired.” Students can also census the microfauna to investigate any differences between the healthy and acidified samples.

For example, one organism they may encounter is *Gammarus sp*. Under normal conditions, *Gammarus* will swim for several inches and then stop to breathe and rest, all the while their legs moving to keep oxygenated water flowing through their gills. While they are stopped, they will start to sink towards the bottom, usually curled up. After a few seconds, they will uncurl and start swimming again but still usually remain near the bottom. They generally avoid each other but will swim in tandem when mating. The starting and stopping is erratic. All of these are behaviors the students can investigate. In sub-optimal, acidic conditions, *Gammarus* will swim more actively, stopping less to rest. They will spend more time near the surface.

Lab Preparation

1. Collect water samples. Make sure that the containers in which they collect the samples are sterilized first. If the class goes to the locations as a field trip, you may wish to incorporate elements of the "Backyard Bonanza," "Ecotones: Living on the Edge," or "Walking the Talk: A Forest Transect Study" projects. Otherwise, the teacher may collect the samples. If students do go on a field trip to the sites, they can test the water quality using a simple yet powerful benthic key used by field biologists. Students look under rocks, etc. for these three organisms: mayfly nymphs, stonefly nymphs, and caddis fly larvae. If students find all three, the water is very healthy and clean; if they find two, it's considered okay quality; finding one is bad; finding none is very bad. More info and photos of these bellwether species are listed in the Resources section. Of course, students must be careful to not damage the animals or environment they are studying.
2. Give each student the handout "pHishing for Answers" and have them read through the background information and lab instructions. You may want to have one or two students summarize what they have read and what the task is.
3. Provide students with background information (either oral or written) on the organisms you expect to find. Alternatively, students can collect this information themselves as homework. The resource list at the end of this project provides some helpful websites.
4. Students measure the pH of the water samples.
5. Students examine the microfauna. At first, they should simply get used to watching them. After maybe five minutes, they can start collecting their data. If the same organisms are not found in both samples, the students may census the organisms and compare the numbers.
6. Using a large dropper or sterile spoon, students can place organisms from the unhealthy water sample(s) into a beaker containing distilled water. Note that it may take a day for the transplanted organisms to show a change in behavior. Instead of removing the organisms from the samples, students may decide to use distilled water to raise the pH of all of the water samples to about 7. This step is especially useful if the different water samples have different populations of microfauna. Let students decide if they also should transfer from the healthy water to a neutral water container and study the organisms in order to be more thorough in controlling their experiment.
7. If time permits, allow students to repeat the experiment, making necessary changes to their procedure.

It may take a day for the transplanted organisms to show a change in behavior.

Proper Care and Treatment of Organisms

Spend time discussing treatment of the organisms with your students prior to doing the lab. The goal of the experiment is not to kill the organisms, but to witness the physiological effects of the acidic environment. The organisms should be kept in their original culture containers until the students are ready to use them. For example, caution students against taking the organisms out and laying them on their lab benches, or keeping them in the pipettes for extended periods of time. These are not appropriate behaviors and can harm the animals. The organisms that have been used in the lab should be separated from those that are still available for use. Have a container of distilled water (pH 7) for each location from which water was taken to put the organisms into after the students have completed their observations.

After the lab has been completed, the organisms should be returned to the wild. Alternatively, they can be maintained in a classroom aquarium, or fed to other fish. (See the "Terraria Hysteria" project for more on this.) If they decide to keep the organisms, make sure they understand they must be cared for—even over weekends, holidays, and summer vacation.

EXPECTED OUTCOMES

Students should see differences in the behavior of organisms at lower and higher pH levels. However, there are many reasons why this may not actually happen. If organisms are transferred to higher pH solutions, they may not be in that environment long enough for students to see positive effects. Experimental error may come into play as well; students have to be accurate in making their vinegar solutions and in collecting data.

Students typically predict that the organisms will struggle and/or die at lower pH levels and often will look only for this outcome. This is a good opportunity to discuss preconceived notions and how they affect the scientific process. Upon seeing the changes and comparing them to their predictions, the students can conjecture about why the microfauna's behaviors changed as they did.

POST-LAB CLASS DISCUSSION/ACTIVITIES

The questions at the end of the student handout provide a good starting point for a discussion. Here are some additional ideas:

1. Gather class data and discuss reasons for similarities and differences between lab groups.

2. Discuss the need for control conditions, objectivity, quantified results, etc. to speak clearly about the experiment.

3. Discuss the merits and limitations of the experimental setup in mimicking a real aquatic ecosystem.

4. Discuss the effects of the loss/impairment of one species to the food web.

5. Consider a more extensive discussion of the effects of acid rain, such as the effects on fish growth and development, plant growth, forests, and the subsequent effects on entire ecosystems. See www.epa.gov/acidrain/effects/index.html for more information.

SPREADING THE WORD: AN OPPORTUNITY FOR STUDENTS TO EDUCATE

Discuss the human-generated pollutants that contribute to acid rain formation and make a list of actions that students can take to decrease their own contribution to acid rain. Have each student take a copy of the list home and with his or her family, choose one item that the family would like to do to reduce acid rain formation. For example, the family may choose to take one less car trip each week or set the thermostat one degree lower in the winter (or higher in the summer). As a class, discuss the items that each family chose and consider tracking family progress for a month or two. This could also be organized as a school-wide activity. For information on causes of acid rain and preventative measures that citizens can take, see www.epa.gov/acidrain/site_students/ whatcauses.html

ASSESSMENT

1 To assess student learning, invite students to educate others about the effects of acid rain. Students can, individually or as a class, write letters outlining the experiment they performed, the results they obtained, and the importance of the results. The letters should include specific information about how efforts to reduce acid rain can improve life for wild animals. Letters can be directed to students, parents, school administrators, city officials, utilities commissioners, newspaper editors, etc. This same information could be disseminated in other ways, including creating a broadcast for a school television channel, radio show, or podcast, or creating a website that could be linked to the school web site.

EXTENSION ACTIVITIES

1 Entire ecosystems have been devastated by acid rain, particularly in Canada, Europe, and the Northeastern U.S. Students can research what has happened to animal populations in these areas.

2 If you know of an area currently being cleaned up, you can have classes study the changes in microfauna behavior and diversity over several years. This helps students learn that scientists often work as a community and build on the work of their predecessors.

3 Compare results with other students from around the world at: www.k12science.org/curriculum/waterproj/index.shtml

Project Alternative: If it is not feasible to study water from natural sources, students can study the behavior of organisms such as *Gammarus, Daphnia magna*, or *Artemis* that are purchased through most biological or pet supply companies and cared for in simulated environments. When buying these amphipods, make sure there are enough so that each student group has access to at least 20 organisms. Water to maintain these organisms (culture water) should be distilled water with a pH of 7.

Unlike those actually borrowed from the wild, these store-bought organisms should not be released into the wild when the students are finished conducting their experiments. Although some microfauna the students may study are widespread, the distribution of others is unknown; introducing any non-native species is dangerous—both for the ones introduced and for those already there. Instead, a healthy habitat needs to be set up for them. Refer to the "Terraria Hysteria" project for details on setting up such a habitat for the microfauna.

ADDITIONAL RESOURCES

Benthic Key
www.epa.gov/bioindicators/html/benthosid.html
www.iowater.net/benthickey.htm

For Information on Freshwater Microfauna
Rainis, K. G. & Bruce, B. J. (1996). *Guide to microlife*. London: Franklin Watts.
Voshell, J. R. (2002). *A guide to common freshwater invertebrates of North America*. Granville, Ohio: McDonald and Woodward.

Field Guide to Freshwater Invertebrates
www.seanet.com/~leska/Online/Guide.html

Key to the Order of Benthic Keys
http://kywater.org/ww/bugs/orderkey.htm

For Further Information on Acid Rain and Freshwater Ecology

Ellison, A. M. et al. (2005). Loss of foundation species: Consequences for the structure and dynamics of forested ecosystems. *Frontiers in Ecology and the Environment*, 9, 479-486. Available at: http://harvardforest.fas.harvard.edu/personnel/web/aellison/publications/ellison_etal_2005_frontiers.pdf

U.S. Environmental Protection Agency
www.epa.gov/airmarkets/acidrain/effects/surfacewater.html
www.epa.gov/acidrain/

U.S Geological Survey
http://ga.water.usgs.gov/edu/acidrain.html

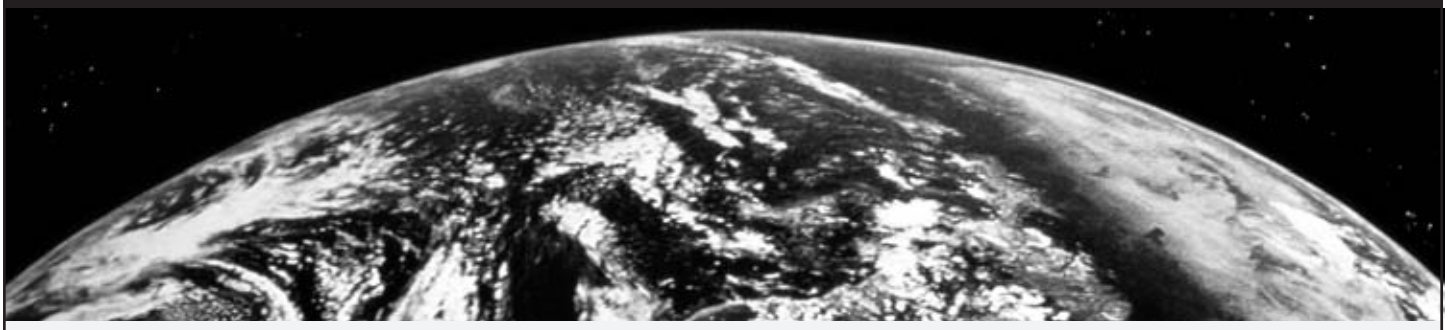
About.com article, "Ten things you can do to help reduce acid rain"
http://weather.about.com/library/weekly/aa032602a.htm

Water on the Web
http://waterontheweb.org/index.html

Lost Wetlands
http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/peril_wetlands.html

Sierra Club: Clean Water and Wetlands
www.sierraclub.org/wetlands/

Handout: pHishing for Answers



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The following equations represent the formation of sulfuric acid (1) and nitric acid (2) — key components of acid rain:

(1) $SO_2(g) + 1/2\ O_2 \rightarrow SO_3(g)$

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4$

(2) $NO(g) + 1/2\ O_2(g) \rightarrow NO_2(g)$

$3\ NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$

Acid rain is measured using the pH scale. pH is a measure of acidity — the lower the number, the greater the acidity. Pure water has a pH of 7, which is considered neutral. Natural rainwater is slightly acidic, with a pH of 5.6, because carbon dioxide is dissolved in it. So, rain with a pH lower than 5.6 is considered acid rain. When acid rain flows into aquatic ecosystems, it lowers the pH of the water. Healthy lakes have a pH of about 6.5, whereas a lake affected by acid rain can have a pH as low as 4.2. In this activity, you will begin to investigate some of the effects acid rain can have on aquatic organisms.

Materials Needed

- Dropping pipettes
- 10ml graduated cylinder
- Watch glasses or Petri dish halves
- Stereomicroscope or 10X hand lens
- Sterilized beakers (multiple, for storing water samples)
- pH meter, or pH papers and color chart

Handout: pHishing for Answers

Procedure

1. Read steps 1-6. Formulate at least two testable questions about how pH affects small organisms such as Gammarus. Have your teacher approve these questions.
2. With your partner, choose the testable question you would like to investigate.
3. Design a controlled experiment to test the questions you choose. Refer to the list of Materials Needed as you design your experiment. Your experimental design should include:
   (a) the questions you would like answered, expressed in a way that can be answered with observations.
   (b) a description of your experimental setup.
   (c) an explanation of the process you will take to set up the experiment and how it answers the questions; usually, experiments compare two conditions against each other.
   (d) a description of the data you will gather (consider both qualitative and quantitative measurements).
   (e) a statement about how and when you will gather the data.
   (f) a prediction about the results of your experiment.
4. Create a data table to record your results.
5. Have your teacher approve your design.
6. Set up and conduct your experiment.

Analysis

1. Discuss the following questions with your lab partner.
   (a) What do the results of your experiment show?
   (b) How do the data compare to your prediction? Can you account for any discrepancies? Were you able to answer your question?
   (c) Were the pH levels in your experiment similar to those found in lakes affected by acid rain? If so, what does this tell you about the effects of acid rain on organisms like Gammarus?
   (d) What sources of error did you find in your experiment? What would you do differently if you could conduct the experiment again?
2. In freshwater lakes, Gammarus, Daphnia, and Artemis eat algae and/or protozoa and are, in turn, a major source of food for animals like trout. Draw a food chain that includes these organisms and add four additional organisms of your choosing to construct a food web. How would decreasing pH levels in a lake affect the organisms in the food web directly or indirectly?
3. What are some activities in your community that contribute to acid rain formation? What are some actions you can take to reduce acid rain formation?
4. When the sulfur and nitrogen compounds are released into the air, they are often carried by wind to places far away from their origins. Thus, pollutants that are released hundreds or thousands of miles away may actually cause the acid rain falling in your area. Does this mean you and the other members of your community are not legally responsible for the damage done by acid rain in your community?

Sources

U.S. Environmental Protection Agency. Acid Rain. [updated 3 January 2005; cited 11 Oct. 2005]. Available from www.epa.gov/acidrain/.

did you know?

Frog Freaks Mystery

Amphibians such as frogs, toads, and salamanders have survived all sorts of environmental catastrophes for many, many centuries. However, over the last thirty years, there has been an alarming decline in the world's amphibian population. This is an extremely disturbing trend because amphibians are considered bioindicators—bellwether or sentinel species which signal changes in the environment. At first, researchers point to the usual damaging suspects—pesticides and chemicals in the habitat, shrinking rainforests, global warming, and even parasites and infectious diseases. **But, is there one primary cause for the population decline?** The answer to this question is simply not yet known.

Concern over this issue intensified in the mid-1990s when children in Minnesota found frogs with extra eyes, extra legs, eyes on the shoulders or back, and other deformities that raised a number of questions:

Are these abnormalities related to an increase in ultraviolet light from loss of the ozone layer?

Or, are they the result of pesticides or parasites?

How do we find the answers to this mystery?

What do we do when we find the answers?

Scientists have been gathering evidence but the solution to this mystery may be several years down the road. Preliminary evidence suggests that the problem may not come from one source but from a combination of sources, each contributing its own impact. We'll have to wait for the evidence on this one.

Can you think of ways to solve this mystery without harming any wildlife?

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Grade Level: HS

Type: Simulation, Measurement, Observation

Topic: Erosion and its effects on animals and ecosystems

Erosion: A Series of Unfortunate Events

When the topic of endangered species comes up in science classrooms, students often assume that most threats stem directly from poachers, hunters, or rainforest destruction. This simulation lab will help students understand that erosion is often a negative consequence of human activity and a serious threat to wildlife. Students will also learn about ways they and other people can minimize or prevent erosion.

INTRODUCTION

What do Chinook salmon, Eastern tiger salamanders, leatherback sea turtles, and whooping cranes all have in common?

How would your students answer this question? How would YOU answer this question?

Most students' first response would be the obvious one—*all of the organisms listed above belong to the Animal Kingdom.* In fact (you might point out), they represent four different classes of vertebrates: *Osteichthyes, Amphibia, Reptila*, and *Aves*.

A few students might even recognize that all of the organisms listed are either threatened or endangered species and are protected by state or federal laws.

How did these animals end up in this predicament?

A species is endangered if there is a danger of extinction throughout a significant part of its range. A species is considered to be threatened if it is likely to become endangered soon. When the topic of endangered species comes up in science classrooms, students often assume the animals are threatened directly by poachers, hunters, or rainforest destruction. While all of these are true causes of animal endangerment, they all seem removed from the daily lives of most young people. In fact, there are other real threats to animals that directly relate to daily human activity and our lifestyle choices.

All of the animals listed above are threatened by contamination or loss of habitat due to erosion. A species' survival is dependent on the health of its habitat. Ironically, as humans have attempted to improve our own "habitat" by building bigger communities, better roads, and larger dams and pipelines, we have in turn transformed and degraded the habitats of our animal friends.

Erosion is a natural process that occurs when wind, water, and movement of ice remove the topsoil. However, we have "helped it along" by our activities such as stripping the land of vegetation to build roads and communities, overgrazing herds on the grasslands, and by not taking into account natural barriers known as riparian buffer zones existing along rivers, streams, and the coast.

During this study, students will get the opportunity to model the process of erosion, as well as to explore the effect that erosion has on wildlife in a specific ecosystem. By studying the process of erosion and its effects in different ecosystems, students will begin to realize that even a "small" disturbance can throw nature's delicate balancing act out of sync.

OBJECTIVES

After completing this lesson, students will be able to:

1. describe causes of erosion and the impact on wildlife.
2. describe human activities (including those they see happening around them) that can speed up or worsen the process of erosion.
3. list several ways they and others can minimize erosion.

MATERIALS NEEDED

- Shallow foil baking trays
- Plastic trays to collect runoff
- Various types of soil and sod and/or small plants (herbs or flowers work well)
- Watering cans
- Rocks, water, fans, wooden blocks to angle trays
- Computer with Internet access and multimedia applications
- Digital camera(s)

CLASS TIME REQUIRED

One to two 40-minute periods

LESSON STEPS

Defining Erosion

Introduce the topic of erosion to your students by asking them to define the term in their own words. As a class, come up with a definition and discuss several examples of erosion in your own community (i.e. along roads, along coastlines, around water drains). If time and equipment allow, have students walk around the school campus or their own neighborhoods with digital cameras to capture evidence of erosion on a small scale. Younger students might need a few hints as to where to begin looking. Remind them that erosion is often evident along sidewalks, at the base of gutter drains, and next to buildings. As they look for evidence of erosion, ask the students to think about specific examples of wildlife that might be affected by erosion in these areas.

Erosion simulation

In order for students to visualize the process of erosion and to determine both natural and man-made causes, divide students into groups and ask them to perform the following experiments using the materials provided.

#1 - Control

1. Fill one shallow foil tray with bare sod and angle the tray on a wooden block to create an incline.
2. Pour a fixed amount of water (1 liter) onto the top end of the tray using a watering can.
3. Collect the runoff in the plastic tray and measure the volume. Record.

#2 - Experiment A

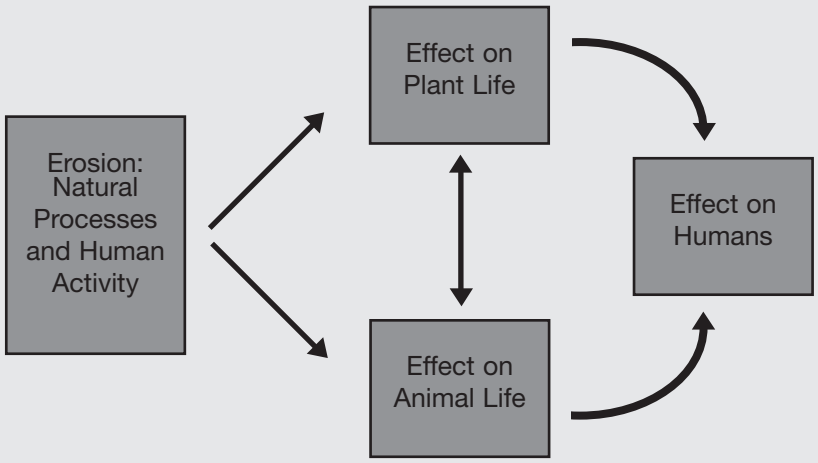
1. Repeat the steps from above using sod with grass and/or small plants.
2. Collect and measure the runoff. Record.

Repeat this process several times, manipulating one variable at a time to see the effect on collection volume. Suggested variables: amount of water, force of water, angle of incline, type of soil, addition of rocks (barriers), wind (fans), addition/removal of ground cover. Record all measurements and observations, including the amount of soil, etc. in the runoff.

Human impact discussion

Following the erosion simulation, facilitate a discussion about the causes and effects of erosion. The following questions and diagram might be helpful to guide your class discussion.

- **What are the natural causes of erosion?** *Running water, movement of ice, wind, waves*
- **How does human activity influence erosion?** *Construction and overgrazing strip the land of vegetation (the anchor) holding topsoil in place; warmer climate increases sea level by melting ice caps; jetties, dredging, man-made harbors and inlets*
- **What is the impact of erosion on plants?** *Sediment clouds the water, blocking light and decreasing photosynthesis.*
- **What is the impact of erosion on animals?** *Animals are affected indirectly because decreased photosynthesis decreases the food supply. They are affected directly because sediment can clog fish gills, limiting respiration, and smother eggs.*
- **What is the impact of erosion on humans?** *We are affected by the loss of food supply, reduction in biodiversity, and diminished numbers of wildlife and lands.*
- **Can erosion be eliminated?** *No*
- **What methods can we use to minimize erosion?** *Respect riparian buffer zones, build back from coasts, minimal construction, plant anchor vegetation, etc.*



ASSESSMENT

To determine what students have gleaned from the simulation activity and class discussion, have students create a multimedia presentation on the effects of erosion in a particular ecosystem. Divide the students into small groups of 3-4 and assign each group an animal and corresponding ecosystem from the chart to research. If necessary, information about additional animals can be found on one of the following websites:

www.worldwildlife.org/species
www.fws.gov/endangered/wildlife.html

The following are suggested guidelines to give the students:

Content - Please include the information below in your presentation:

- Clearly identify your animal species and the ecosystem in which it makes its home.
- Describe the process of erosion in your area, including the natural process and human-induced erosion.
- Describe the effect of erosion on the wildlife of your ecosystem, giving special attention to your assigned animal.
- Make suggestions for minimizing the impact of erosion in your area.

Format - Please include each of the following pieces in your presentation:

- Background audio (song, nature sounds corresponding to the ecosystem, narration, etc.)
- Video component
- Still pictures
- Text

Animal	Ecosystem
Chinook salmon	Stream ecosystem, western US
Eastern tiger salamander	Shallow pond ecosystem, NE US
Leatherback sea turtle	Coastal ecosystem, FL
Whooping crane	Wetlands ecosystem, US
Indiana bat	Forest ecosystem (near wetlands)
Monito gecko	Monito Island ecosystem
California red-legged frog	Wetlands and riparian zones

EXTENSION ACTIVITIES

- Develop a class website with links to all multimedia presentations.
- Expand the project to include other natural processes affected by human activity (i.e. global warming).
- Add local examples of wildlife affected by erosion to the multimedia presentation.
- Develop a food web for the ecosystem and demonstrate the effect of erosion from producer to top consumer.
- This project can be done in tandem with either the "pHishing for Answers" or "Terraria Hysteria" projects. Students could explore how the runoff from the control and experimental group differentially affects the organisms in those projects or determine if the extra nutrients and soil from the runoff upset the balance of the system and affect the lives of its organisms.

ADDITIONAL RESOURCES

Endangeredspecie.com
www.endangeredspecie.com

World Wildlife Fund
www.worldwildlife.org/species

U.S. Fish and Wildlife Service
www.fws.gov/endangered/wildlife.html

Penn State Sustainable Forestry Teacher Resource Center
http://sftrc.cas.psu.edu/LessonPlans/Water/ProtectStreams.html

CNNfyi.com Lesson Plans
http://archives.cnn.com/2000/fyi/lesson.plans/09/21/erosion.lp/

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: MS/HS

Type: Calculation

Topics:
Resource consumption and sustainability

How Big Are Your Ecological Feet?

It is easy for us to think that most of the damage done to the environment is from "other, bad people." In this project, students will not only learn about many of the factors that affect the health of the earth, but also about ways they can change their own habits to make a real difference every day. They will also have the opportunity to explore the different relationships people around the world have with nature.

INTRODUCTION

The concept of an ecological footprint allows us to measure the impact of our daily activities on the environment and then to respond accordingly so that the negative consequences are reduced or negated. Several online Ecological Footprint Calculators allow students to determine exactly how many "earths" would be required if everyone on the planet lived like they do. This experience can be enlightening, as students will see how our daily routines—like our eating habits, the products we purchase, and the energy and water we consume—can have a dramatic impact on biodiversity and animal welfare. Often, the negative impact of environmental damage is well-known to students (in the case of high-profile endangered species for example). However, for many students, the negative consequences of common practices are less obvious as are the far-reaching benefits of adjusting our behavior.

For example, students may not be aware that:

- Decreasing fossil fuel consumption will reduce carbon dioxide, nitrous oxide, and sulfur dioxide pollution and what these pollutants do.
- Purchasing food from sustainable sources will help protect important pollinating insects and reduce the use of fertilizers, dyes, packaging, and pesticides.
- Reducing our consumption of meat will encourage more eco-friendly farming practices.
- Riding bicycles and walking will help reduce fossil fuel consumption and air pollution and have positive health benefits.
- Buying products made in the US protects endangered plants and animals because of more rigorous enforcement of laws dealing with trade in endangered species.

OBJECTIVES

After completing this activity, students will be able to:

1. calculate the amount of land required to sustain their lifestyles.
2. identify behaviors that, if modified, would be beneficial to animal welfare and a sustainable relationship with nature.
3. understand why it is important to develop sustainable relationships with nature.
4. discuss reasons why different ecological footprint calculators sometimes get different results.
5. connect personal resource consumption choices to animal welfare.

MATERIALS NEEDED

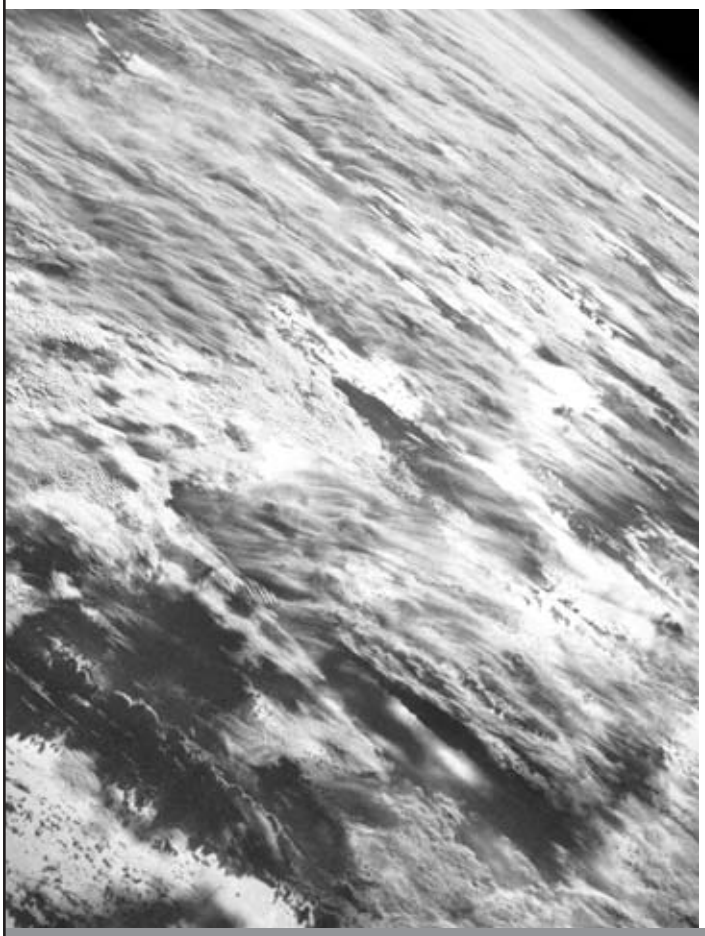
- Internet computer station
- Calculator

CLASS TIME REQUIRED

Two 40-minute periods

LESSON STEPS

1 Explain that an *Ecological Footprint* is the amount of productive land area required to support the resource demands and to absorb the wastes of a given population or specific activities. When humanity's footprint exceeds the amount of renewable biocapacity, it becomes unsustainable. For a more detailed definition, visit: www.rprogress.org/newprojects/ecolFoot.shtml



2 Ask students to think about themselves as consumers of natural resources and to individually rank their consumer behaviors on a scale from 1-10, with one representing consumption that sustains biocapacity and ten representing consumption that can dramatically deplete natural resources. Have students note their self-rankings on paper or index cards. Collect the data and calculate the class average.

3 As a class, share the behaviors that students considered in order to arrive at their individual rankings. Ask students to share their thoughts; record them on the board. Responses are likely to include daily activities such as driving, eating, using heat and electricity, consuming paper products, etc. During this conversation, prompt students to begin thinking in specifics by asking questions like the following: is most of their food purchased at a store or homegrown and cooked? Which do they eat more of—meat protein or grains? Do they drive, take a bus, or walk to school?

4 Once you feel students have a "group snapshot" of their consumer activities, share the following indicators of the relative size of an ecological footprint:

- Protein consumption per person
- Number of acres of farmland required per person
- Average annual income per person
- Average quantity of energy consumed per person
- Average consumption of beef or milk products per year

Point out that each of these indicators connects in some way to the consumer behaviors they have just identified and that they also connect to the well-being of plants, animals, and ecosystems—in other words, connection to biocapacity or sustainability.

5 Ask students to predict which of their own behaviors has the greatest impact on plants, animals, ecosystems and sustainability. Divide students into groups of four and have them develop a hypothesis that expresses how their impact compares to one of the following countries as assigned: China, Japan, United States, Australia, Costa Rica, India, and Sweden.

6 Each group will then:

A. Estimate the following for their assigned country:
- Protein consumption per person
- Number of acres of farmland required per person
- Average annual income per person
- Average quantity of energy consumed per person
- Average consumption of beef or milk products per year

B. Conduct research for data that will confirm or reject their estimates.

C. Represent their findings in graphical form.

D. Compare findings to hypotheses/predictions made in step 5.

E. Write a brief conclusion comparing the data they collected to their predictions.

7 Each group will present their findings to the class.

8 The class will then discuss the findings and compare the results. The following questions can be used to keep the discussion on track.
- Does every citizen of every country require the same amount of land to support his or her style of living?
- What are possible explanations for the differences between countries?
- What aspect of our lifestyles requires the most land?
- What aspect of our lifestyles has the greatest impact on wildlife?

9 The class will estimate how many "earths" would be required if all six billion people on the planet lived like the average citizen of the United States.

A. Calculate their individual ecological footprint by visiting http://www.myfootprint.org/

B. Tabulate their data on the board.

C. Calculate the mean number of planets and mean number of acres required to sustain the members of the class.

D. Prepare a bar graph of all of the data.

E. Discuss how the mean is affected by both the high and the low values.

10 Ask students to use the variables in the ecological footprint calculator to:
- Identify personal behavior changes that would reduce the number of acres required to sustain them.
- Write a two-page position paper that:
  - Identifies the variable(s) in the ecological footprint calculator that are most related to animal welfare.
  - Provides sample output from the calculator and logical argument to support their positions.

EXTENSION ACTIVITIES

1 Ask students to work in pairs to calculate each student's ecological footprint from at least three of the following websites:

The Powerhouse Museum's Ecotown simulation:
http://www.powerhousemuseum.com/education/ecologic/ecotown/mid/

Earth Day Network's Ecological Footprint quiz:
http://www.earthday.net/footprint/index.asp

Victoria (Australia) EPA Eco-Footprint Calculator
http://www.epa.vic.gov.au/Eco-footprint/Households/Calculator.asp

Ecological Footprint Calculator
http://greatchange.org/ng-footprint-ef_household_evaluation.xls

Best Foot Forward Ecological Footprint Calculator
http://www.bestfootforward.com/footprintlife.htm

2 Each pair will discuss the results of the footprint calculations and/or co-write answers to the following questions:

- How is each parameter in the calculator derived? Where does it come from?
- Who decides what numbers to put in the calculator?
- Do you believe the results of the calculation? Why or why not?
- Do you have any habits that are quite different from classmates?
- How does your footprint compare to other citizens of the world?
- What could you do in the calculator and in your real-life behavior to decrease the negative impact that you have on wildlife?
- Are you actually willing to do any of these things? Why or why not?
- Did all of the calculators give similar results for you? Why or why not?
- Do you have reason to suspect bias on behalf of any of the designers of the ecological footprint calculators?
- How could the ecological footprint of the entire school or community be calculated?
- Do all schools, districts, cities, communities, and states in the United States have the same ecological footprint? Why or why not?

3 Instruct students to calculate the ecological footprint of their school if the number of students were increased by 20%.

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: MS

Type: Research and presentation

Topic: Advocacy

Animal Advocate Hall of Fame

When teachers ask their classes to research and report on people, it is easy for the assignment to become little more than a routine exercise in copying and pasting. By providing students with a realistic scenario and encouraging them to look beyond encyclopedic facts, students practice important analytical skills and explore science education as a path toward making positive differences in our world.

INTRODUCTION

During this project, students act as staffers at the fictional Wildlife Conservation Institute. They are charged with identifying candidates for induction into the Animal Advocate Hall of Fame. Students will work together to research candidates, analyze their contributions, and present their findings to their executive director and fellow staff members. In small groups, they will create presentations to support the nomination of one of several possible candidates for inclusion in the Animal Advocate Hall of Fame. Following the presentations, all staff members will vote to determine which nominees should be selected for induction.

OBJECTIVES

After completing this activity, students will be able to:

1. identify several leading contributors to conservation and animal protection.
2. describe how the nominees' work has influenced our understanding of animal life.
3. recognize the range of professions that directly or indirectly have positive outcomes for animals.

MATERIALS NEEDED

- Copies of the scenario and the nominee list below
- Computers with Internet access
- Presentation tools such as PowerPoint
- Poster materials

CLASS TIME REQUIRED

One to two 40-minute periods

LESSON STEPS

1. Make copies of the nominee list and the assignment scenario handout.

2. Determine how to assign groups to research.

3. Familiarize yourself with the list of nominees. Depending on your class size, you may want to include additional nominees. If so, check out the following websites for more information:
   www.ecotopia.org
   www.nationalgeographic.com/council/eir/

4. Initiate a class conversation about the power of one—the ability of one person to make a positive difference in the world. If you know of a local example, use that to anchor the topic and make it even more salient for the students. Ask students to name people from any field of endeavor whose

individual efforts changed something for the better. Be prepared for responses that include often-cited names of historical and cultural heroes (Abraham Lincoln, Rosa Parks, Albert Einstein, Thomas Edison, Sally Ride, et al.) and to provide examples from other fields (Jonas Salk, Ellen Swallow Richards, or Dean Kamen, for example).

5 Facilitate development of a list of characteristics that people who make a difference are likely to have in common. Traits such as bravery, perseverance, strong ethics, and intelligence are likely to emerge. You may need to guide students to identify traits such as devotion to a cause, personal sacrifice, or specialized training and knowledge.

6 If they haven't done so already, ask students to name scientists or activists that have made important contributions to our understanding of animal life or environmental stewardship. Introduce the class to the scenario handout. Explain their role as Julia Green's staff members in identifying individuals who should be honored in the Animal Advocate Hall of Fame and distribute the list of 16 candidates.

7 As a class, determine the criteria students will use to narrow the field of candidates. What questions should they attempt to answer as they explore the work of each candidate? Criteria to consider might include:

- The candidate has made contributions of national and global importance.
- The candidate has influenced others to change or redefine their views regarding animal welfare and conservation.
- The candidate's impact has been long-lasting.

8 Divide students into groups of 2-3. Each group is responsible for researching the work and impact of one nominee and creating a presentation to support the group's decision to nominate the individual for inclusion in the Hall of Fame. Each presentation should:

- include general biographical information.
- communicate the nominee's path toward "fame," including his or her education as a scientist or naturalist.
- clearly indicate how the candidate meets the criteria determined by the class.

9 Each group will present its candidate to the entire "staff" in a way that would convince others that the candidate should be inducted into the Hall of Fame.

10 Following the presentation, each staff member will evaluate the candidates based on the selected criteria and vote for the three individuals that they feel should be inducted into the Hall of Fame.

11 The top five candidates will be presented for induction.

ASSESSMENT

In addition to voting for the three candidates who they feel should be the initial inductees into the Hall of Fame, each student will submit an analytical essay defending their choices. These essays should clearly evaluate the candidates' contributions, compare their impact to those of other candidates, and provide concrete examples of how they have influenced others' views.

EXTENSION ACTIVITIES

Students can create an Animal Advocate Hall of Fame display in the school media center to showcase the nominees and their work. This is a good way to call attention to the value of science education and to build awareness of animal welfare and environmental issues across the school population.

ADDITIONAL RESOURCES

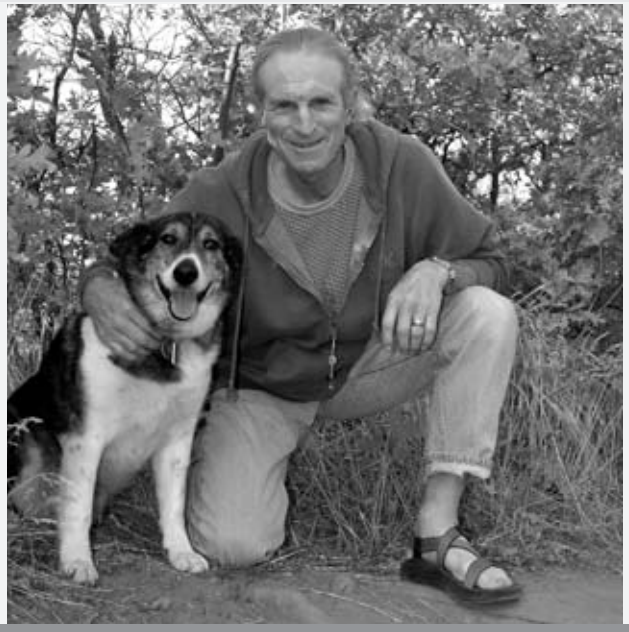
EcoTopia
www.ecotopia.org

National Geographic Explorers in Residence
www.nationalgeographic.com/council/eir/

The Wildlife Conservation Institute (WCI) is establishing an Animal Advocate Hall of Fame. Julia Green, the organization's executive director must recommend a slate of five candidates to the WCI's board of directors for consideration. Julia began her research and created a list of sixteen potential candidates, but then was called out of town for an emergency meeting. The deadline for submitting nominees to the WCI board members is three days away. Julia needs YOU, her dedicated and loyal staff members, to help complete the task.

ANIMAL ADVOCATE HALL OF FAME NOMINEES

1	Jacques-Yves Cousteau	9	Rachel Carson
2	Jane Goodall	10	Richard O'Barry
3	Marc Bekoff	11	Cynthia Moss
4	Roger & Deborah Fouts	12	Dian Fossey
5	William O. Douglas	13	Theodore Roosevelt
6	John Muir	14	John James Audubon
7	Aldo Leopold	15	Edward O. Wilson
8	Albert Schweitzer	16	Temple Grandin



Marc Bekoff

Photo by Cliff Grassmick for the Boulder Daily Camera

did you know?

Green Collar Jobs

Not long ago, it seemed like those who wanted a career in wildlife management had few choices beyond forest ranger or fish and game managers. Today, there are hundreds of careers to pursue and enough variety to suit almost any personality and academic ability. If you'd like to spend your time learning the song of the whale, check out the many positions in marine biology. If you'd rather live out in the "boonies" and find out how beavers and bears spend their days, there are a lot of opportunities in the U.S. Forest Service. If lab life is more your style than wildlife, why not go with a company that specializes in environmental studies? If you'd like to reverse the damage we are doing to our wildlands, consider a career as an environmental lawyer or an animal rights advocate. And maybe you'd feel more at home helping injured birds at one of the may fine raptor centers across the country.

Here are just three of the many fine web sites you can use to find a career path that suits you.

USDA Forest Service
www.fs.fed.us/fsjobs/whatdo.html#top

Vocational Information Center
www.khake.com

Smithsonian National Zoo Park
http://nationalzoo.si.edu/Education/WildlifeCareers/

Careers with NOAA
http://www.wfm.noaa.gov/careers.html

ASPCA® THE AMERICAN SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS®

Grade Level: HS and AP environmental science

Type: Class debate

Topic: Current environmental issues

Says You: Environmental Science Debate

Debates are a great way to challenge students to gain more insight on important societal issues and to demonstrate analytical and communications skills. The format suggested here is a lively approach to preparation for the AP Environmental Science written exam.

INTRODUCTION

Students divide into teams to research and debate both sides of animal and environmental issues. Depending on what topics are discussed, this project can meet state standards requirements for several different topics, including those that may be on the AP Environmental Science written exam. This exercise also gives the students an opportunity to improve their presentation skills and to think quickly on their feet when answering questions or refuting their opponents' statements.

OBJECTIVES

After completing this activity, students will be able to:

1. gain experience in conducting literature research and reviewing environmental science concepts.
2. work in teams to practice presentation and communication skills.
3. understand the role of science in the lives of humans, animals, and the environment.
4. practice their critical thinking and evaluation skills.

MATERIALS NEEDED

- Access to library for one class period of research.

CLASS TIME REQUIRED

Three to four 40-minute periods (one for research, two to three for debates).

LESSON STEPS

1. This project can be conducted as a stand-alone project, or it can be done in reaction to issues that come up during another humane science project class discussion or from topics in the news.

2. If used as a stand-alone project, the class should brainstorm issues to consider for discussion. Students may be unaware of the significance of some issues, so the teacher should be prepared to give the students some background on what makes the issues interesting and relevant.

   The goal is for students to think deeply and critically about real issues affecting the well-being of humans, animals, and the environment. Science plays a critical role in these issues.

Topics that classes have explored recently include:

- Should the United States drill in the Arctic for natural gas and oil?
- Should Canada allow seal hunts?
- Should the United States allow diversions of water from the Great Lakes?
- Should we remove areas of old growth forest to reduce fire danger?
- Should scientists use animals in scientific research?
- Is the Endangered Species Act effective, or should it be changed?
- Should the United States sign the Kyoto Climate Treaty?
- Should the United States and other countries have a mandatory improvement in automobile fuel efficiency?

Students will be most interested in local events that directly influence their lives and the animals in their communities. Nonetheless, problems that seem remote and enduring, like revisions to the Endangered Species Act and the Kyoto Climate Treaty, can be discussed in local, immediate terms. Students should explore both the local and global implications of decisions made by scientists and policymakers.

3 Guide the class in choosing issues to discuss. Classes can usually cover four different topics, with teams of 2-3 students each researching their assigned topic. Each team should consist of both boys and girls or be picked at random.

4 Before research begins, take a census of where students stand on the selected issues. Students can physically line up on a continuum to indicate their personal stances. Another method is to have students state their pre-research positions on index cards. It is also interesting to have students rate their level of commitment to their positions.

Save the information and revisit it after the debates to determine whether the debates led to changes in opinion among the students.

5 Allow students at least one period of library research time to gather information for their presentations. Allow a week before the debates to prepare their arguments outside of class time. Encourage students to incorporate graphics into their presentations.

6 The pro and con teams argue their positions using the format below. A coin flip determines which team presents first.

First Team:

5 minutes - State all the reasons for your position. Statements should be based on literature research.

3 minutes - Answer audience questions.

Second Team:

5 minutes - State all the reasons for your position. Statements should be based on literature research.

3 minutes - Answer audience questions.

First team:

3 minutes - Rebut position of the opposing team.

Second team:

3 minutes - Rebut position of the opposing team.

Teams should be able to complete their debates within 25 minutes. The short time periods encourage students to get to the main points and facts and also enhance the challenge and efficiency of the AP exam review. During the debates, teachers should correct any misinformation in the presentations.

7 At the end of the class period have students revisit their pre-debate positions to see if and where they have moved on the continuum of opinion. If time permits, students can discuss why they have or haven't changed their positions.

ASSESSMENT

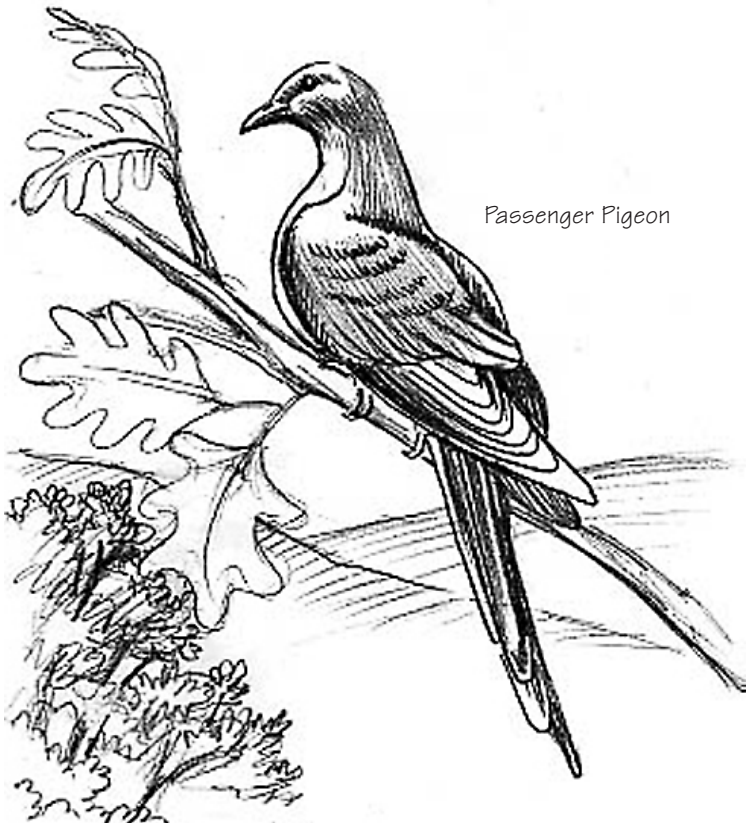
Give a single point for each legitimate statement made during the initial presentation and during the rebuttal and deduct a single point for each incorrect statement made during these presentations. For example, a team may earn 7 points during the initial statement, but then make one incorrect statement (-1) and one correct answer (+1), but one incorrect reference during the questioning (+1), and two positive statements made during the rebuttal (+2), for a total score of 8 (7-1+1-1+2=8). After the debates, the team scores are graded on a curve, with the highest scores getting an A.

EXTENSION ACTIVITIES

1 Students can write a position statement about their views before the debate, what they have learned during it, and if they have changed their positions/thinking on the issue and why.

2 Students can develop their debate presentations into posters or bulletin board or web site presentations.

3 Podcasting is a way to widen the audience for the debates and to create an archive of student work.



Passenger Pigeon

The Inside Story on Dissection

Whether it's a frog, cow's eye, fetal pig, or something else, dissection is a common rite in science classes across the country. Barbara Orlans (1993) estimated that 6 million animals are dissected each year in high schools alone. Many of these are taken from the wild. By dissecting frogs, classes are contributing to the harm and destruction of the animals they are studying.

Fortunately, there are alternatives to dissecting animals. Many of the projects in this book were created to provide pedagogically superior ways to teach students about animals and their environments. In addition, a growing array of alternatives is available for studying many animals—including cats, cockroaches, cow eyes, crayfish, earthworms, fetal pigs, frogs, grasshoppers, humans, lampreys, perch, pigeons, rats, sharks, sheep's brains, starfish, etc., etc. The most popular of these alternatives are computer-based simulations, videos, and actual models.

Dissection alternatives do more than save animals' lives — they help the environment, reduce risk of injury for students, and can create less of a shock for students. Of the approximately 25 studies that have been conducted, nearly all have found that these alternatives are at least as effective at teaching anatomy, physiology, and other aspects of biology as actual dissection. For example, Kinzie, Strauss, and Foss (1993) found that high school students learned frog anatomy at least as well as from an interactive videodisc as they did from actual dissections. In another example, Waters et al. (2005) reported that undergraduate students who learned anatomy by building a clay model of a person demonstrated greater knowledge than did undergraduates who dissected cats. More examples can be found in the annotated bibliography available at www.hsus.org/animals_in_research/animals_in_education/comparative_studies_of_dissection_and_other_animal_uses.html.

Not only are alternatives typically found to be as instructive, they are also more economical. First, most alternatives require less (and safer) set-up and clean-up. Second, most can be reused indefinitely. Third, buying a model, video, or program is usually less expensive than supplying a whole class with cadavers. But, if cheap isn't cheap enough, there are programs available free online (a couple of these are listed in the resources). In addition, Animalearn also allows teachers to borrow CDs, videos, models, and mannequins for many animals. Visit www.animalearn.org for more details.

For more information on alternatives to dissection, more online resources, and more information in general, check out "Alternatives to Dissection" in the Real Issues section of www.animaland.org.

To find a very large list of alternatives to dissection, as well as articles and other resources, check out *From Guinea Pig to Computer Mouse: Alternative Methods for a Progressive, Humane Education* by Nick Jukes and Mihnea Chiuia, second edition published in 2003 by InterNICHE (www.interniche.org).

For more information on the problems with dissection in addition to other issues and alternative, also check out *The Use of Animals in Higher Education: Problems, Alternatives, and Recommendations* by Jonathan Balcombe, published by the Humane Society Press.

Resources

Online Dissections

Cow's Eye
www.exploratorium.edu/learning_studio/cow_eye/

Earthworms
http://biog-101-104.bio.cornell.edu/BioG101_104/tutorials/animals/earthworm.html

Fetal Pig
www.whitman.edu/biology/vpd/main.html

Frog
http://curry.edschool.virginia.edu/go/frog/

Frog Nervous System
www.umanitoba.ca/faculties/science/biological_sciences/lab18/biolab18_1.html

Starfish
http://library.thinkquest.org/13008/

Grasshoppers
http://entomology.unl.edu/charts/refchrts.htm

Cockroach
http://everest.ento.vt.edu/~carroll/insect_video_dissection.html

Sheep's Brain
www.exploratorium.edu/memory/braindissection/

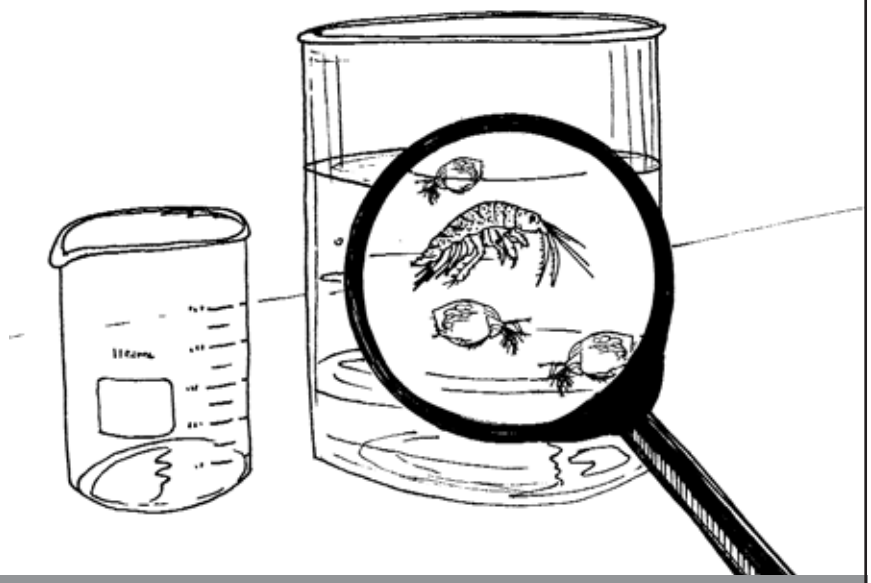
Articles

Gibbs, E. L., Nace, G. W., and Emmons, M. B. (1971). The live frog is almost dead. *BioScience*, 21, 1027-1034.

Kinzie, M. B., Strauss, R. and Foss, J. (1993). The effects of an interactive dissection simulation on the performance and achievement of high school biology students. *Journal of Research in Science Teaching 30*(8), 989-1000.

Orlans, F. B. (1993). *In the name of science: Issues in responsible animal experimentation*. New York: Oxford University Press.

Waters, J. R., Van Meter, P., Perrotti, W., Drogo, S., and Cyr, R J. (2005). Cat Dissection vs. sculpting human structures in clay: an analysis of two approaches to undergraduate human anatomy laboratory education. *Advances in Physiology Education, 29*, 27-34.



Guidelines for Student Experiments Involving Animals

ASPCA® HUMANE EDUCATION

This section provides guidelines for the appropriate study of animals by students. If carried out correctly, studying animals can be a rewarding educational experience. However, when experiments inflict pain or discomfort to the animals or if the animals are not well cared for, both animals and students suffer.

Students may be opposed to dissection for moral, religious or ethical reasons and can request alternatives. For more information on the right to refuse to dissect, see Dissection Alternatives at www.dissectionalternatives.org.

When students choose to engage in experimental studies involving other living organisms, ASPCA recommends the following:

- Observations of normal living patterns of wild animals in their natural habitat or at an American Zoological and Aquarium Association (AZA) accredited zoo. Students should be made aware that naturalistic observational studies do not involve any environmental manipulation or contact with the subject being observed.
- Observations of normal living patterns of pets or domestic animals.
- Studies of protozoa or plants are recommended as alternatives to experiments on more sentient forms of life. For more information, see the plant studies resource list on page xiv.

Some kinds of studies are not acceptable because of the pain and distress they cause to animals. These include:

- **Experiments that interfere with the animal's health**. These include depriving an animal of food or water, giving an animal an inappropriate diet (i.e. "junk food"), withholding necessary vitamins or minerals, or giving an animal an excessive amount of any food, vitamin or mineral.
- **Experiments that cause the animal pain or discomfort**. These would include experiments involving overcrowding and subjecting animals to extremes of heat, cold, noise and other stimuli. Though toxic substances will be covered below, students should also avoid designing experiments where animals are given excessive quantities of non-toxic substances (such as lemon juice, soda, etc.)
- **Experiments involving surgery on animals**.
- **Experiments involving electric shock, exercise to exhaustion or other distressing stimuli**.
- **Experiments involving any of the following**: microorganisms which can cause disease in humans or animals; ionizing radiation; cancer producing agents; drugs of any sort.
- **Behavioral studies involving punishment or any strongly aversive stimuli**.

For plant studies and activities, check out:

Just Do It! Page for Kids
www.cce.cornell.edu/

Ways to "Boss" a Plant Around
www.florence.ars.usda.gov/kidsonly/middle/mulch5.html

Educational Activities
www.usda.gov
(search: educational activities)

Plants and Our Environment
http://library.thinkquest.org/3715

Experiments and Projects with Duckweed
www.mobot.org/jwcross/duckweed/

Plant Parents
www.sciencenetlinks.com/
(search: plant parents)

Plant Science for Kids
/www.unl.edu/agnicpls/pskids.html

Plants in Action
http://biology.anu.edu.au/research-groups/Plantsc/pia.htm

Experiments with Plants
www.si.edu/nsrc/pubs/stc/eplovery.htm

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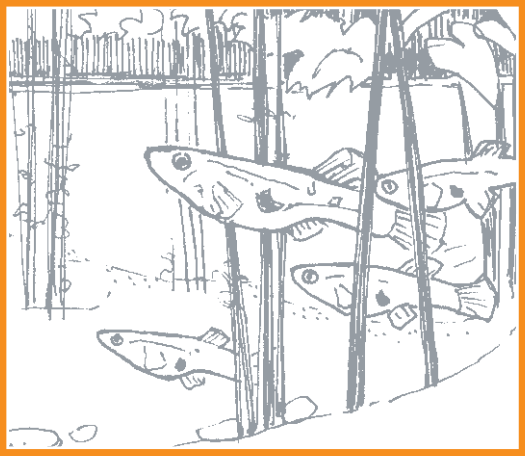

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"Until he extends the circle of compassion to all living things, man will not himself find peace."
~Albert Schweitzer

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