A Thousand Friends of Frogs

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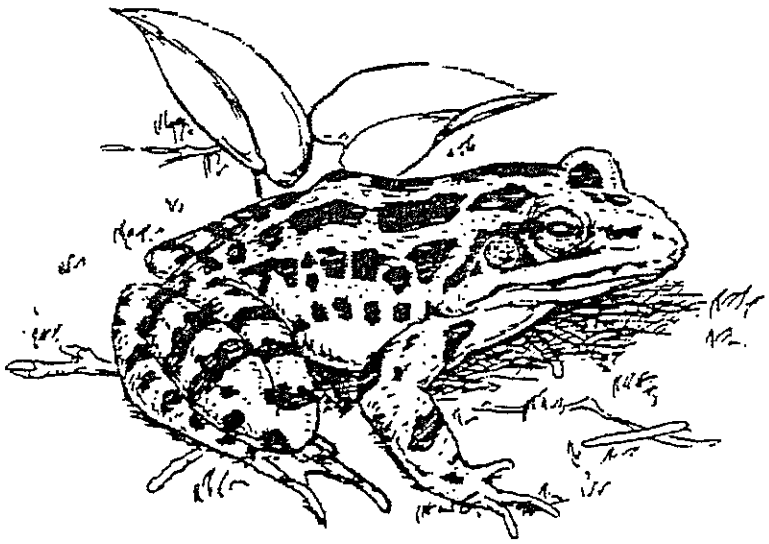

Center for Global Environmental Education

Educator Activity Guide

Student Activities for K–12 Classrooms

Second Edition, 1998

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A Thousand Friends of Frogs

Meeting Science Education Standards

A Thousand Friends of Frogs *Education Project has been developed with the following objectives in mind:*

- *to allow students to act and think like scientists*
- *to present science learning as an active process*
- *to allow all students to participate in real-life problem solving*

While focusing on observing and documenting the health of our state's frogs, the project contributes broadly to a K–12 science education program. Science should be something that students do. A good science program allows curious students to explore their world, to make discoveries that lead to theories and explanations. A good science program gives students a means to understand and act on personal and social issues. Educators looking to meet these goals and to infuse their existing curriculum with real-life problem solving will find an engaging hands-on project in A Thousand Friends of Frogs.

The frog project complements existing school curricula in fulfilling required science content standards for each grade level. For example, studying frogs fulfills the life science standard for K–4 students of understanding organisms and environments. Grades 5–8 are to understand populations and ecosystems and grades 9–12 are to understand the behavior of organisms—all accomplished through A Thousand Friends of Frogs *Project.*

Table of Contents

About This Guide

This study guide is designed to encourage an understanding of frogs, their habitat, and their role as bio-indicators for use with any grade level. This guide represents a combination of enhanced activities from the first guide and new original activities. Ideas for these new activities were generated at *A Thousand Friends of Frogs* Educator Institutes and Courses and at the first annual 'Frogs as Bio-indicators' National Education Summit. Use this guide to begin a working 3-ring binder to collect additional activities, newspaper clippings, and a record of your students' research and participation.

Contributors

I would like to thank all the people involved in the process of completing this educator guide. Contributors include members of the Project Frog Team and CGEE staff—Chris Bretz, Tracy Fallon, Tracy Fredin, Susan Goetz, Erika Halverson, Sehoya Harris, Judy Helgen, David Hoppe, John Moriarty, Tony Murphy, Cindy Reinitz, and Jessica Wiley. In addition, activities were edited and contributed by: Linda Baum, Jane Blumer, Mary Burmesch, Penny Eldridge, Deg Farrelly, Rosanne Fortner, Amy Hauge, Julie Niehaus, Cindy Schwie, Andy Weaver, Peter Weess, and Patricia Wendt.

Tony P. Murphy, Director, A Thousand Friends of Frogs Project

Hamline University's Center for Global Environmental Education

The Center for Global Environmental Education (CGEE) has pioneered distance learning and has become a resource for environmental education projects as they emerge around the world. CGEE is part of Hamline University Graduate School of Education, 1536 Hewitt Avenue, Saint Paul, Minnesota 55104-1284. Tracy Fredin, director. Phone: 651-523-3105; Fax: 651-523-2987; e-mail: tfredin@gw.hamline.edu

Funding for this project was approved by the Minnesota Legislature, 1997 Minnesota Laws, Chapter 216, Sec. 15, Subd. 13c. as recommended by the Legislative Commission on Minnesota Resources from the Minnesota Future Resources Fund.

Participate in International Frog Month

Get on-line to focus on frogs for a month! Classes logging onto CGEE's World Wide Web Frog Page at **http://cgee.hamline.edu/frogs/** can engage in exciting, informative, and creative activities. International Frog Month occurs twice every year, during April and October. Check the web site for full details of the activities for each month.

Ask the Expert

A chance for students and teachers to find out the answers to those intriguing questions whose answers can't be found in a book. Questions that have been posed by participants will be answered by one of four nationally recognized experts. Each day answers to students' and teachers' questions will be posted. To encourage student questions, try the activity, "Ask the Experts," on page 12.

Questions may be submitted by e-mail, fax, or snail mail anytime.

Challenge Questions

Stretch your thinking! Student and teacher answers to the following challenge questions will be posted each day. Students may submit answers to any or all of the questions!

1. Why is it fun to watch frogs?
2. Are there frogs where you live? Ask your parents/teachers if they remember frogs where they grew up. Do they remember more frogs now or when they were younger? Why?
3. Can you give any reasons why scientists believe that frogs are getting more difficult to locate around the world?
4. Would you like to be a frog for a day? Describe what you would do that day.
5. Deformed frogs have been found in Minnesota and in other places. Why do you think that deformed frogs are being found?
6. Why are frogs used as characters so much in books and on television?
7. Should we care about declining frog populations around the world? Why or Why not?
8. In recent years, some medicinal uses for frogs have been discovered. Research one of these and tell us what you find. Also answer this question: should we only maintain the frog populations that can be medicially useful? Defend your position?
9. Why are frogs found in some types of habitats and not in others? What are these areas and are they adequately protected?
10. How does a frog attract a mate?

Answers may be submitted by e-mail, fax, or snail mail during frog month (see page 2 of this guide for addresses and numbers).

Survey Results

Hundreds of Minnesota's concerned citizens, including teachers and students, have participated in surveying the health of the frogs in their communities. Explore the results of *A Thousand Friends of Frogs* observational survey on-line during International Frog Month and find answers to these key questions: Where have deformed frogs been found? What is the nature of their deformities? Which counties have been most affected?

Write About It

Throughout the world, frogs figure prominently in literature. Student poems, myths, origin tales, and even puns will be posted on-line. Check out the "Write Away" activity on page 20 to get students started. Writing may be submitted by e-mail, fax, or snail mail anytime (see page 2 of this guide for addresses and numbers).

Frog and Toad Art

Give your students an opportunity to have their artwork published on-line. Art work may be submitted by e-mail or snail mail anytime (see page 2 of this guide for addresses and numbers).

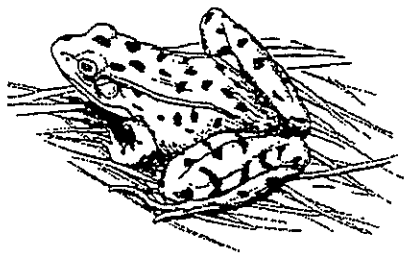
Frog Resources

Looking for more information about amphibians and their habitats? Teachers will find further classroom activities, trivia, and other information in this section.

Bio-indicators: What Are Frogs Telling Us?

Amphibians, because of their biological make-up and where they live, can serve as early warning indicators of problems in our environment. Tracking their decline or increase and monitoring their health can give us critical information about the wetlands in which they live, the surrounding environment, and our global environment as a whole. They act as bio-indicators of our environment. A bio-indicator is a living organism that conveys information on the state or health of the environment by their presence or absence in an area. Minnesota's deformed frogs are trying to tell us something—if we choose to listen.

Involvement in A Thousand Friends of Frogs will enable students and teachers to better understand how bio-indicators represent the health of our ecosystems and to expand their knowledge of both local amphibian species and the ecosystems in which they live. The project allows teachers to extend the school walls to the intriguing natural world beyond, to engage students in inquiry in partnership with their teachers and the larger science community. We invite you to enhance your students' understandings of the natural world and their skills of observation and scientific inquiry through A Thousand Friends of Frogs.



Take a Good Look: Guidelines for Fieldtrips and Reporting Data

When to Observe Frogs with Your Class

While spring is the best time to observe amphibians, frogs can still be seen as late as mid-October in southern Minnesota. Since frogs migrate during the autumn, it can be a good time to observe them, particularly on rainy days. Amphibians are most active when air temperatures are 16–28 degrees Celsius (60 to 80 degrees Fahrenheit) and particularly during rainy weather.

If outside Minnesota: amphibian activity varies based on temperature and atmospheric moisture conditions. So, frogs may be found over longer periods of time every year in your state. Check with your local wildlife managers for more details on the distribution of amphibians in your area and the times of the year they can be found.

Where to Observe Frogs

Northern Leopard Frogs live in all parts of Minnesota. They are sometimes called "Grass Frogs" because they are often found in grassy areas such as schoolyards, lawns, and parks, especially if there is water nearby. School nature areas may offer handy frog observation sites. Wildlife Management Areas are good public sites, but be sure they are easily accessible. Tall grasses and brushy trails can be very difficult to traverse with students. Swamps, marshes, streams, and sloughs are good areas because frogs can be seen leaping into the water as people approach. Using nets will help students take a closer look at the frogs.

Ethics

Always obtain permission from landowners if observing on or crossing private property. Treat the habitat kindly. Do not trample or destroy foliage. Don't litter. Leave the area better than you found it. Walk slowly and carefully so as not to step on any living creature.

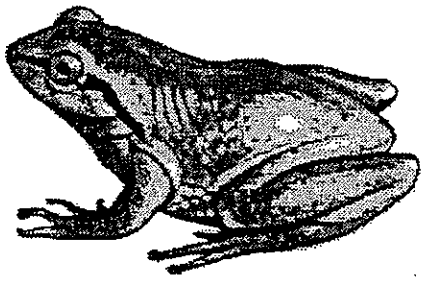
Do not remove frogs or any other creatures from their environment. Take care to prevent injury to the animal during capture and handling. Handle frogs gently, returning them to their habitat as soon as your observation is finished. (*A Thousand Friends of Frogs* does not encourage the collection of frogs or any other amphibian for use in the classroom.) At no time should egg masses be disturbed or handled.

Safety

1. Have plenty of adult supervisors when observing near water.
2. Make sure students use waders or boots before entering the water.
3. Use of rubber gloves is recommended if you don't know the quality of the water in which you're working.
4. Wade only in shallow water. Go slowly so you have sure footing.
5. Be aware of any allergies students may have, such as to ragweed or bees, and be prepared to handle such problems.
6. Be on the alert for deer ticks and other insect pests.
7. Know hunting seasons in your area and do not go to areas where hunting may be taking place.

Reporting Guidelines

Photograph any frogs you find that appear to be abnormal. Place a coin or a ruler alongside the frog in the photograph for perspective.



Measure the length of the frog, from the tip of its nose to the base of the spine where the tail once was (not including legs).

Take notes about the frog's color, gender (if known), type of frog, number of frogs observed, and the number of normal and abnormal frogs observed.

Take detailed notes about weather conditions including air and water temperatures, precipitation, etc.

Describe in as much detail as possible the area in which you observed the frogs (type of wetland, plant growth, wildlife, land use in the area). If your class does any water testing, include detailed notes of type of tests conducted and results.

Use the data reporting form available in *A Thousand Friends of Frogs Newsletter* (Summer, 1998) or visit the web site at http://cgee.hamline.edu/frogs

If you are from outside Minnesota and want to report deformities, visit the North American Reporting Center for Amphibian Malformations (NARCAM) web site at http://www.npwrc.usgs.gov/narcam/

Suggested Grades K–4

Hip Hop Habitat

Concepts
Habitat requirements for amphibians; food chains/webs

Time
50–90 minutes in class. Field trip to visit amphibian habitat

Catalyst Question
What kind of habitat do I need?

Background

NOTE: Some of this information is general for anurans (frogs and toads) around the country but life cycle dates are specific to Minnesota.

Minnesota wetlands are home to 14 species of anurans, the most common of which is the Northern Leopard Frog. These green or brown spotted creatures are also known as Grass Frogs because they are commonly found some distance from water in grassy places, such as lawns and parks.

Frogs are unique because they live both on land and in the water. They spend their winters in deeper bodies of water such as lakes where they are protected from the elements and there is plenty of dissolved oxygen to help them survive the winter. Sometimes frogs burrow down in the mud at lake bottoms, but they are not true hibernators. Rather, they tend to become inactive in winter. They may hang out at the bottom of the lake, swimming sluggishly under the ice.

In early spring, frogs will migrate as far as 1.5 km (1 mile) to their summer breeding ponds because these shallow bodies of water cannot support large fish that prey on frogs or their eggs. Egg masses are laid in water in early spring and complete metamorphosis to young frogs in three months. Tadpoles will feed on aquatic plants. In summer, juvenile and adult frogs can be found in grasses 15–30 cm (6–12 inches) tall because of the abundant supply of insects, their primary food source. They feed only on moving prey. Juveniles, however, will remain closer to the water than adults. From mid-September to mid-October, frogs begin their migration back to their wintering sites. When water temperatures are cold enough to cause their predators (fish) to become inactive, the frogs will enter the water for the winter. During winter, they take in dissolved oxygen through their permeable skin and do not need to come to the surface to breathe.

In the water, the frog's coloration camouflages it from predators. The green or brown spotted back makes it more difficult to be seen by predators such as herons, raccoons, snakes, and owls. The white belly helps protect it from predatorial fish. Tall grasses also provide protection from predators.

Objectives

Following the completion of this activity, the students will be able to:

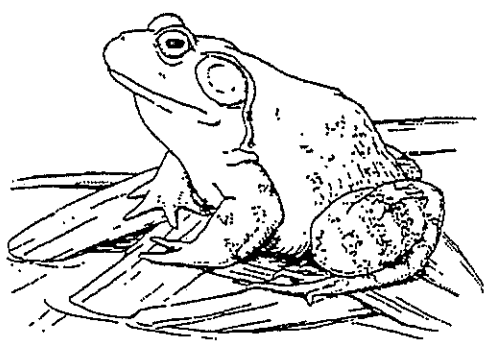
1. describe the characteristics of amphibian habitat.
2. construct a food chain/web with the correct linkages
3. list various frog species and their habitats.

Materials

The Salamander Room by Anne Mazer; information about state anurans. For the field trip, outside clothes and shoes/boots; (optional-shallow pan or white bucket (ice-cream pail); hand lenses); notepads, pencils.

Procedure

1. Take students on a frog watching hike. Good places to visit are grassy areas near ponds, streams, lakes, or rivers. Look for frogs in short grass with taller grass nearby. Frogs will hop into the tall grass for protection as you approach.
2. As you hike, question students about what they are observing. If possible, collect some pond water in a shallow pan and look at aquatic insects and larvae (young insects) with hand lenses. (If water is collected, return it to its sources with the aquatic insects/larvae.)
3. Ask students to sit and observe the frog habitat for a period of time, during which they are to sketch or write about everything seen in the area where frogs are found.
4. Back in the classroom, read the *The Salamander Room* by Anne Mazer, to introduce the concept of habitat. Have students reflect on the book and write or draw what they think it is about.
5. From this reflection, ask students what is needed to stay alive (food, water, shelter or protection, and space.) How are students' needs met?
6. Have students list the requirements and students should then make a web of habitat elements on chart paper which includes information from the field trip.
7. Students share their sketches and writings. As they share their contributions, add them to the appropriate category on the web (food-insects, plants; shelter/protection-water, tall grass, etc.). Display the habitat web in the classroom.



Hip Hop Habitat (continued)

8. In small groups or as individuals, have students create their own versions of *The Salamander Room*—"The Frog Room"—being sure to use their own room and incorporate all elements of a frog's habitat.
9. Older students could select an amphibian from around the world to research and write their book (for example, "The California Tree Frog Room"). Have each student share their book.

Evaluation/Review Questions

1. Would frogs make good pets? Why or why not? What problems might you encounter in raising a frog as a pet?
2. In what ways, both positively and negatively, might people affect a frog's habitat?
3. What difficulties might a three-legged frog encounter in finding food? In being protected?

Extensions

1. Students should take one aspect of the habitat web and create a concept map for it.
2. The space program is planning on colonizing a planet in the solar system. Select one of the planets in this solar system and determine its current status for life. If life were to survive on the planet, describe the components that would be required to encourage life and how the space program could facilitate this. You might want to check out the BioSphere2 Program in Arizona as an example of constructing habitats for humans to live in.
3. Develop a food chain/web for a deformed frog. How different is it to a food chain/web for a "normal" frog?

References and Resources

Behlet, J. L. and F. W. King. 1979. *Audubon Society Field Guide to North American Reptiles and Amphibians*. New York: Alfred A. Knopf.

Conant, R. and J. T. Collins. 1991. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America* (3rd Edition). Boston, MA: Houghton Mifflin.

Mazer, Anne and Steve Johnson (Illustrator). 1991. *The Salamander Room*. New York: Alfred A. Knopf.

Oldfield, B. and J. Moriarty. 1994. *Amphibians and Reptiles of Minnesota*. Minneapolis, MN: University of Minnesota Press.

Education Standards

Minnesota

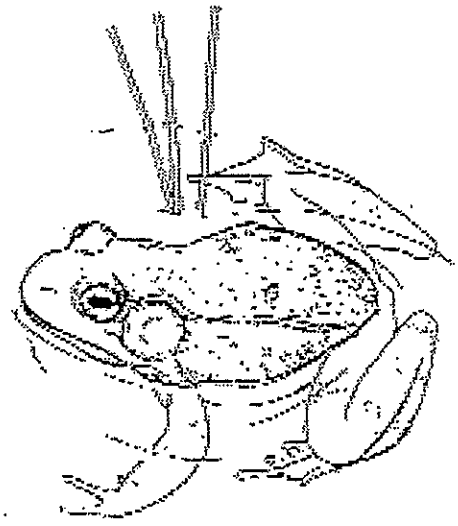
1 Read, View, and Listen (nonfiction)
2 Write and Speak (writing)
5 Inquiry (direct observation)
6 Science Application (living systems)

National

K–4:

Content Standard A Science as Inquiry (understanding about scientific inquiry)

Content Standard C Life Science (organisms and environments)



Suggested Grades K–4

Metamorphosis for a Change

Concepts
Habitat requirements for amphibians; food chains/webs

Time
50–90 minutes

Catalyst Question
Is this a change for the better?

Background

Development of frogs from egg to adult varies by species. The example here is for the Northern Leopard Frog in Minnesota.

The development of a frog begins in the early spring. Adult frogs migrate from their deeper wintering lakes, where predators become active as the water temperature warms. They find shallow breeding ponds safe from predators in which to lay their eggs. The male climbs on the female's back and uses his muscular front legs to squeeze her around the middle, causing her to lay as many as 6,500 eggs into the water. The male then fertilizes the eggs.

The jelly-like eggs can often be seen clinging to pond plants. The eggs separate and grow, hatching into tadpoles in 6 to 14 days. Tadpoles feed on algae. They have gills and breathe like fish. After about seven weeks, the tadpoles begin to change to froglets as hind legs appear. At about 12 weeks, the tadpole's tail shrinks, lungs develop, and jaws replace algae-feeding discs. By week 14, froglets can breathe air and leave the water. As fully developed frogs, they feed on moving insects such as earthworms, crickets, and grasshoppers. They have long, sticky tongues to catch their prey.

Objectives

At the end of this activity, students will be able to:

1. draw the various stages of the life cycle of a frog.
2. describe another animal that shows metamorphosis.
3. examine factors influencing survival of frogs at various stages of development.

Materials

"How The Frog Lost Its Tail"—A West African Folk Tale; *Life Story: Frog* by M. Chinery; depending on demonstration of metamorphosis selected: posterboards, pencils, paints, etc.

Procedure

1. Read the story in the sidebar "How The Frog Lost Its Tail"—A West African Folk Tale. Be sure that students understand that folk tales are not meant to be factual.
2. Use a book such as *Life Story: Frog* by M. Chinery or *The Tadpole* by Hidetomo Odo, to introduce, review, or reinforce the concept of metamorphosis.
3. Have students demonstrate their understanding of metamorphosis in one of the following ways:
   a. sequence pictures of a frog's development and write sentences to describe each stage.
   b. use the pictures or create hand puppets to tell other students or parents how metamorphosis in frogs occurs.
   c. research another creature that undergoes metamorphosis and illustrate the process.
   d. create a pond diorama including metamorphosis. Use movement to act out the metamorphosis of a frog. Add music such as "Jeremiah Was a Bullfrog" or other frog songs. Write a story from the perspective of a frog, describing what is happening during the change from an egg to a tadpole to a frog.

Evaluation/Review Questions

1. What did you like about the folk tale? In what other creative ways could we explain why Frog has no tail?
2. How is the development of frogs different from the development of humans? Why is human development not metamorphosis?
3. What might happen if a frog laid her eggs in a rain puddle?
4. What might happen to a frog egg if the water was suddenly polluted by a dangerous chemical such as bleach?

Extensions

1. Create a flip book of frog development. Illustrate each stage of development on 3 x 5 inch cards. Staple together and flip to see the action.
2. Examine the other types of amphibians (salamanders, cacaelians) and research their life cycle. How different are they from frogs?
3. In recent times, frogs have been found with deformities. Draw or describe the process of metamorphosis for a deformed frog.

References and Resources

Anonymous. "How The Frog Lost Its Tail"—A West African Folk Tale.

Chinery, M. 1991. *Life Story: Frog*. Mahway, NJ: Troll Publications.

Julivert, Marice. 1993. *The Facinating World of Frogs and Toads*. New York: Barens Education Series.

National Wildlife Federation. 1987. *Ranger Rick's Nature Scope: Let's Hear it for Herps.* Washington, DC: National Wildlife Federation.

Robbins, Robin. 1995. *Frogs Are Fantastic.* Hong Kong: Reader's Digest Young Families, Inc.

Media Resources

Various frog songs, such as "Jeremiah Was a Bullfrog" by Three Dog Night.

Suggested Grades K-4

Metamorphosis for a Change (continued)

Education Standards

Minnesota

1 Read, View, and Listen (nonfiction, fiction)

2 Write and Speak (writing)

3 Arts (artisitic creativity and performance)

National

Content Standard A Science as Inquiry (understanding about scientific inquiry)

Content Standard C Life Sciences (characteristics of organisms)

"How the Frog Lost Its Tail"—A West African Folk Tale

Long, long ago when the world was new, Frog became miserable because he was the only creature in the water hole that didn't have a tail. When all the other animals came to drink, they proudly showed off their tails and made fun of Frog.

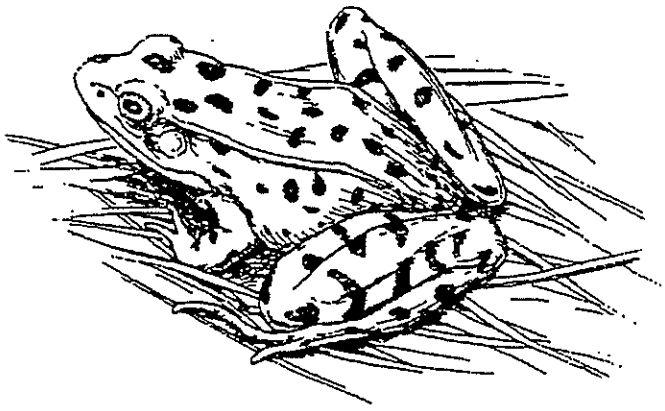
So Frog gathered up his courage and begged Nyame, the Sky God, to give him a tail. Nyame agreed, but in return she asked Frog to be the keeper of her own special well that never dried up. Frog promised to share the water with all the other animals.

It wasn't long before Frog became very conceited about his long, beautiful tail and got very bossy about who could share the water at the Sky God's well.

When the other wells dried up due to a drought, Frog was rude, shouting at the other animals, "Go away! There is no water here."

Nyame was very unhappy when she heard of Frog's behavior. She disguised herself and came to the well to drink. When Frog treated her very unkindly, Nyame became angry and decided Frog must be punished. She took away Frog's tail and banished him from the well.

From then on, Nyame gave all newborn frogs a beautiful tail, but caused their tails to gradually disappear as they grew. And that is how it is to this very day.



Suggested Grades K–12

Soak It Up

Concepts
Permeability; selectivity; amphibian respiration

Time
50 minutes (but egg/potato needs to soak for 24 hours prior to activity in classroom)

Catalyst Question
What does permeable mean?

Background

Since 1989, scientists worldwide have been alarmed by a dramatic decline in amphibian populations. Amphibians have a two-phased life cycle and permeable skin. They remain within relatively limited territories, being small and restricted to surface travel. Because of these factors, they are highly vulnerable to habitat changes. Exposed to pollutants and other environmental stresses on a daily basis, they can serve as early warning indicators of potentially drastic changes in ecosystems.

Researchers are trying to solve the mystery behind the deformities being found in Minnesota's frogs. Scientists think a frog's permeability is a factor. A membrane that lets molecules pass through it is called a permeable membrane. Cell membranes are selectively permeable because only certain molecules can pass through. What does it mean to have permeable skin?

Selective permeability is critical to frogs and toads. Living in moist woods, toads are able to draw the moisture out of the soil and into their bodies through their permeable skin. Just like the root hairs of plants, water moves out of the soil into the toad. Frogs can live underwater while they winter-over because they are able to draw oxygen from the water through their permeable skin.

Diffusion and osmosis are important in the movement of molcules in and out of a cell. Certain materials will either enter or leave cells by diffusion. The direction of diffusion within a cell will depend only on the difference in concentration of water on opposite sides of the cell membrane.

The diffusion of water across a semi-permeable membrane from a region of high concentration of water to a region of low concentration of water is called osmosis. (Semi-permeable membranes are selective for the substances which can pass through them, i.e. molecules of a certain size can pass through, molecules bigger than this cannot pass through the membrane.) When the molecules reach the point where they are moving in and out at the same rate, this is called equilibrium.

In this activity, three different experiments are used to show permeability. You can select to do one, two, or all three. Older students could perform these experiments in groups.

Objectives

After completion of this activity, students should be able to:

1. state what permeable means.
2. show how to test for permeability
3. understand the importance of permeable skins to amphibians.

Materials

Oranges; apples; microscope; water; peeled hardboiled egg or peeled potato; jar; measuring tape; orange juice with pulp; funnel, sieve or strainer; spoon; paper towel; plastic wrap; napkins; sponges; glass; paper; cardboard; cheesecloth.

Procedure

Experiment 1

1. Show students different kinds of skin—i.e., orange and apple peel, eggs, human skin, and some skin cells under a microscope.
2. Ask students what they think the functions of skin are for each of these plants/animals.
3. Peel a hardboiled egg or a potato. Measure its circumference and then place it in a jar of water for 24 hours.
4. Using an egg/potato you have already soaked for 24 hours, observe the egg or potato.
5. Students describe what is happening. Again, measure the circumference. Ask students to explain why they think the circumference has increased.

Experiment 2

6. Pour orange juice with pulp through a funnel. Have students describe what happened.
7. Then pour the orange juice through a sieve or strainer. Describe what happened.
8. How does the sieve demonstration show selective permeability?

Experiment 3

9. Pour a spoonful of water on a paper towel and a spoonful on plastic wrap. Ask students to identify which is impermeable.
10. Have students choose other materials to experiment with such as napkins, sponges, glass, paper, cardboard, cheesecloth, etc. Students should rank the materials from least permeable to most permeable.
12. Ask the students to compare the different types of skins again in light of the activity.

Evaluation/Review Questions:

1. How is a frog or toad like an egg or a potato?

Suggested Grades K–12

Soak It Up (continued)

2. Which materials are most permeable?
3. How are absorption and permeability different?
4. Why is permeability important to frogs and toads? How does it put them at risk?
5. Where do you normally find amphibians? Why do you think this is the case?
6. Do humans have the same skin as frogs? Why not?

Extensions

1. Imagine that you had the power to control how creatures develop in the future. Design a frog that will be better adapted to conditions 100 years from now, when the world may be warmer and drier and pollutants may abound in the air and water. What features would be important? Make a sketch of this modern frog.
2. Membranes can be permeable or semi-permeable. Students should develop an experiement to illustrate osmosis through a semi-permeable material. Which of the materials examined in the activity could fall into the semi-permeable category?

References and Resources:

National Wildlife Federation, Washington. 1987. *Ranger Rick's Nature Scope: Let's Hear it for Herps.* DC, Washington: National Wildlife Federation.

Carin, Arthur A. and Robert Sund. 1980. *Teaching Science Through Discovery.* Columbus, Ohio: Charles E. Merril Publishing Co.

Internet Resources

http://tqd.advanced.org/3542/experiments/osmosis.html

A web site with a definition of diffusion and osmosis and an experiment to show osmosis.

The web can be searched for other sites by using the following search words: osmosis, diffusion, water processes.

Education Standards

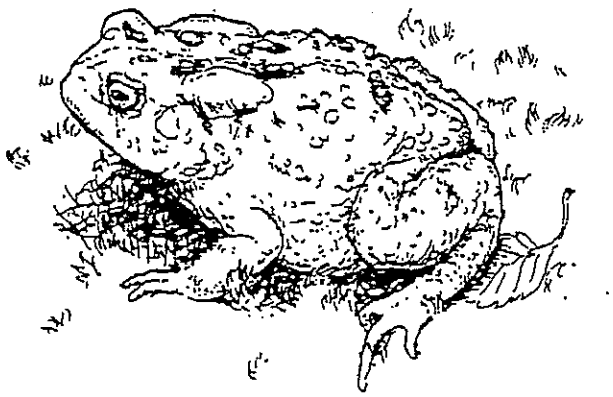
Minnesota

3 Arts (artistic creativity and performance)

5 Inquiry (direct observation)

National

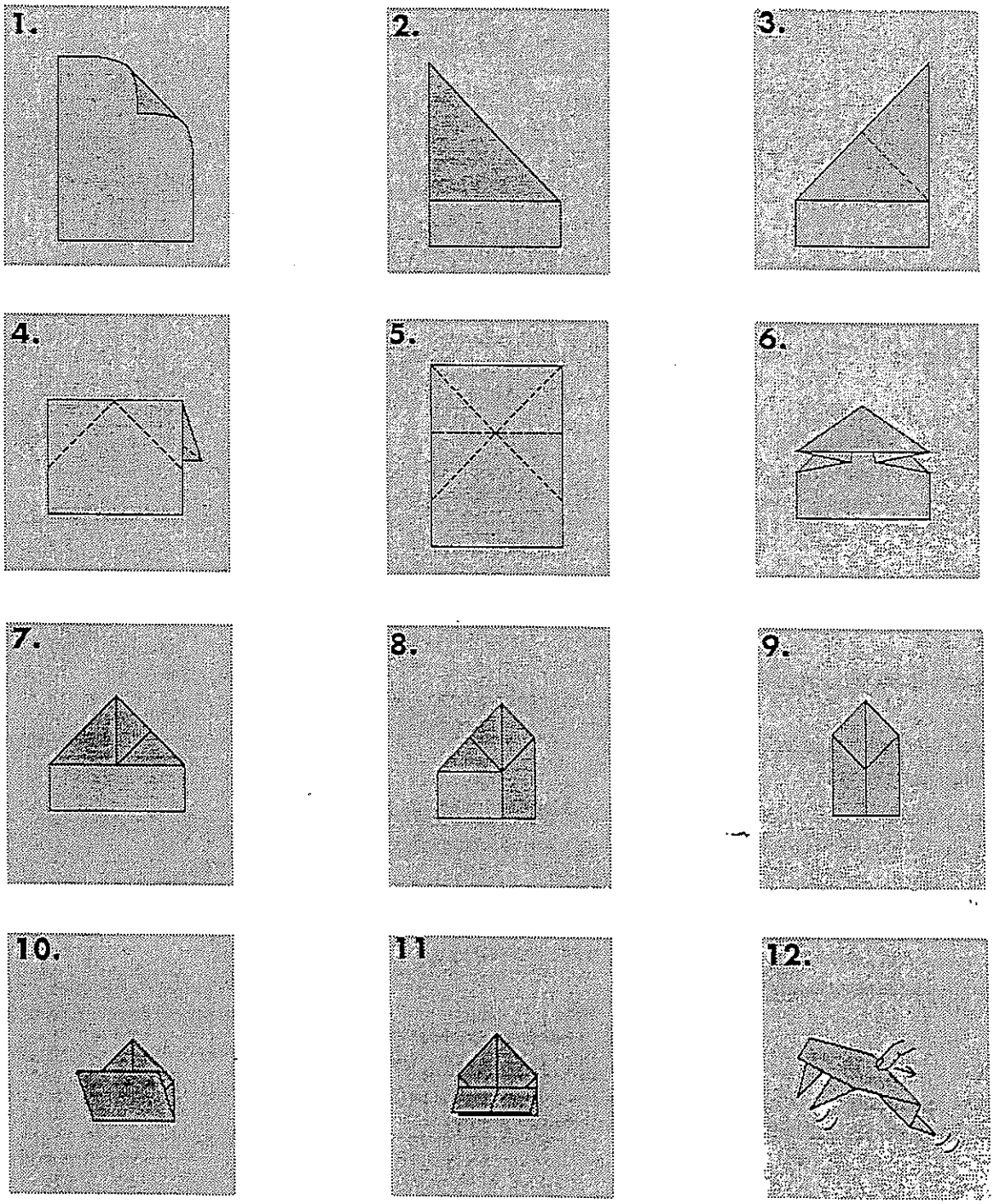
Content Standard C Life Science (characteristics of organisms)



Suggested Grades K–12

Origami Jumping Frog

Decorate your classroom with these fabulous folded frogs. And send some to *A Thousand Friends of Frogs* at the Center for Global Environmental Education. We'll use them in spreading the word to the public about frogs. (The darker color represents the back side of the sheet. Dotted lines represent creases from folds.)



Thanks to Deg Farrelly for the idea for this page.

Suggested Grades 2–12

Ask the Experts

Concepts
Questioning, research, amphibian information

Time
45 minutes

Catalyst Question
Got a question on frogs?

Background

Students often know a great deal about a topic, more than anyone realizes! This activity gives them a chance to explore what they already know and to develop and articulate questions that they have.

Then, during International Frog Month, students will have the opportunity to ask leading herpetologists and other scientists questions about the environment in general and frogs in particular.

Objectives

At the end of the activity, students should be able to:

1. locate information on different species of amphibians.
2. follow a systematic research method and create questions that are logical.
3. write answers to their questions which confirm or dispute what they know/assume.

Materials

Access to references with current amphibian content (*Frogs and Toads of the World*; or local, state, or regional books on amphibians); chart paper.

Procedure

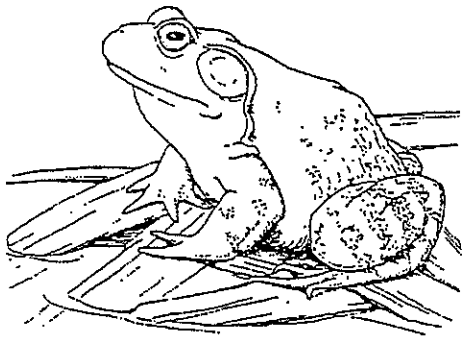
1. Divide students into groups. Give them chart paper with the words KNOW/ASSUME at the top.
2. Have the students list the things that they know or think are true about frogs and their habitat. After they've had time to complete their list, post the chart paper from each group and let them examine the class' knowledge base.
3. Using another piece of chart paper, have the class generate questions about frogs and their habitat. Some questions may arise from the KNOW/ASSUME lists.
4. Back in their small groups, have students decide which questions could be answered by using reference materials. For example, "What are the differences between frogs and toads?" could be found in reference materials. Students could choose questions of interest to answer and commit to finding the answers.
5. Have students identify questions that would best be asked of an expert. For example, "What would the major impact be to an ecosystem if frogs were to disappear?" This is an evaluative question and the answer might not be available in written materials. Make a list of the questions to be submitted to the experts.
6. Send questions either to local scientists(s) to answer or to A Thousand Friends of Frogs.

Evaluation/Review Questions

1. Were there any facts generated that surprised you?
2. Which questions most intrigued you?
3. What did you learn about frogs?

Extensions

1. Develop questions on other animals or other topics and check various references and resources to get the answers. Critically review the various answers.



2. Students should become experts in a plant or animal of their choice by examining various references and resources. List the various plants and animals chosen. Then, have students generate questions on the listed plants and animals chosen. Students then use the "experts" in the classroom to get answers to their questions.

References and Resources

Mattison, Chris. 1997. *Frogs and Toads of the World*. New York: Facts on FIle Publishers.

Nilsson, G. 1986. *The Endangered Species Handbook*. Washington, DC: The Animal Welfare Institute.

Internet Resources

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

Education Standards

Minnesota

2 Write and Speak (interpersonal communication)

National

Content Standard A Science as Inquiry (understanding about scientific inquiry)

Suggested Grades 2–4

A Frog Song

Concepts
Frog calls; frog characteristics; research skills

Time
50–90 minutes

Catalyst Question
What is that frog?

Background Information

"A Frog Song" project involves the Musical and Verbal-Linguistic intelligences. The two-part lesson uses critical thinking and research skills with a highly creative product.

The songs will teach important facts about frogs and toads—their characteristics and habitats. In this case, Minnesota species are used, but some of these species are found in various locations around the country. Other species can be substituted for Minnesota's frogs and toads. The songs serve as memory aids. The six songs are sung to the tune of "Ten Little Speckled Frogs."

For example:

- Ten little speckled frogs
- Sat on a speckled log
- Catching some most delicious bugs.
- Yum! Yum!

- One jumped into the pool
- Where it was nice and cool
- Then there were nine green speckled frogs.
- Yum! Yum!

Objectives

Following this activity, the students will be able to:

1. solve the mystery frog and toad songs.
2. write a song about frog or toad characteristics and habitat.

Materials

Pictures of scientists doing various types of work (in the laboratory, in the field, at a computer, in a library, etc.); pencil; paper; "Mystery Frogs and Toads Songs" sheet; "Frogs and Toads Research" sheet; reference books on frogs and toads (see References and Resources, page 14); frog poster (if available, i.e. *Toads and Frogs of Minnesota and Their Habitats* available from *A Thousand Friends of Frogs*; *A Thousand Friends of Frogs* web site (http://cgee.hamline.edu/frogs).

For educators outside Minnesota using this activity, contact your local Fish and Wildlife or Department of Natural Resources for resources.

Procedure

1. Show the students some pictures of scientists in various locations: in a laboratory, out doing fieldwork, at computers, and in libraries. Ask the students if they know what is happening in the pictures. Explain to students that the scientists are looking for answers to questions or mysteries. This is called research.
2. Students are going to do some research on frogs and toads to solve some mystery songs. The songs are sung to the tune of "Ten Little Speckled Frogs."
3. Students will receive a song that has clues about a specific frog or toad. They will sing the song together verse by verse. Students should listen carefully for clue words that describe the characteristics of a habitat of a frog or toad.
4. Pass out the "Mystery Frogs and Toads Songs" sheet. Sing the first verse of song #1 for the students, then sing the verse together. Ask students to share the clue words. Repeat with the second verse.
5. Do the same for all six songs.
6. Divide class into groups of 2 or 3 students.
7. Using the resource materials, have the groups try to identify the mystery Minnesota frog or toad and record the answer on the space provided on the sheet. Remind the students to look at the clue words in the song to help them in their research. (Optional: Have students document the resources used.)
8. Together as a class, share responses. Compare responses and discuss reasons why responses are correct or incorrect.

   Answers to the "Mystery Frogs and Toads Songs:"

   – Song #1: Northern Leopard Frog
   – Song #2: Northern Cricket Frog
   – Song #3: Western Chorus Frog
   – Song #4: Gray Tree Frog
   – Song #5: Canadian Toad
   – Song #6: Bullfrog
9. Once the mystery has been solved, then the students write their own mystery song about a selected frog or toad. Divide the class into groups of two or three students. The templates available in this activity can be used for this.
10. Give each group the "Frogs and Toads Research" sheet and the "Mystery Frogs and Toads Songs" sheet.
11. Groups collect important facts about the frog's or toad's characteristics and habitat. The groups must use at least 2 resources.
12. When the research is completed, students compose a new song for their mystery frog or toad, to the tune of "Ten Little Speckled Frogs." (Note: The lines in each verse should contain the following number of syllables—first line 6 syllables, second line 6, third line 8, fourth line is Yah Sure!)
13. Have partners share their songs with the class and have other students guess the mystery frog or toad. (Optional: display songs.)

Suggested Grades 2–4

A Frog Song (continued)

Evaluation

Teacher observation of student participation and discussion.

Students' ability to solve the mystery frog or toad.

Student research sheet and song of Minnesota frog or toad.

Extensions

1. Have the students investigate tropical frogs or amphibians not in their area/state. They could use the same template to compose a song about these animals.
2. Students create a diorama of the habitat for their mystery frog/toad. Perhaps the students could visit the type of habitat of their frog/toad with their family to have some "field" experience as scientists do. This experience could be used to enhance the diorama. Students should "show and tell" their diorama, their type of frog/toad, and talk about their "field" experience.

References and Resources

A Thousand Friends of Frogs/Minnesota Frog Watch/MN Department of Natural Resources. 1997. *Toads and Frogs of Minnesota and Their Habitats*. Poster available from the MN DNR, Non-Game Program, St. Paul, MN or A Thousand Friends of Frogs, Hamline University, St. Paul, MN.

Conant, R. and J. T. Collins. 1991. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America* (3rd Edition). Boston, MA: Houghton Mifflin. (More recent identification guide and good information.)

Oldfield, Barney and John J. Moriarty. 1994. *Amphibians and Reptiles Native to Minnesota*. Minneapolis, MN: University of Minnesota Press.

Audiotapes

Eliot, L. 1992. *The Call of Frogs and Toads*. Post Mills, VT: Chelsea Green Publishing.

Minnesota Frog Watch. 1998. *Calls of Minnesota's Frogs and Toads*. St. Paul, MN: Hamline University/MN Frog Watch.

Wiewandt, T. 1982. *Voices of the Night: The Calls of the Frogs and Toads of Eastern North America*. Ithaca, NY: Library of Natural Sounds, Cornell Laboratory of Ornithology.

Internet Resources

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

This web site has an extensive list of links in its Frog Resources section to other relevant state, regional, national, and global anuran and amphibian web sites. It also has a "Frogs as Bio-Indicators Science Corner," which examines many of the factors influencing declining populations.

Education Standards

Minnesota

Primary Level:

1 Read, View, and Listen (literal comprehension)

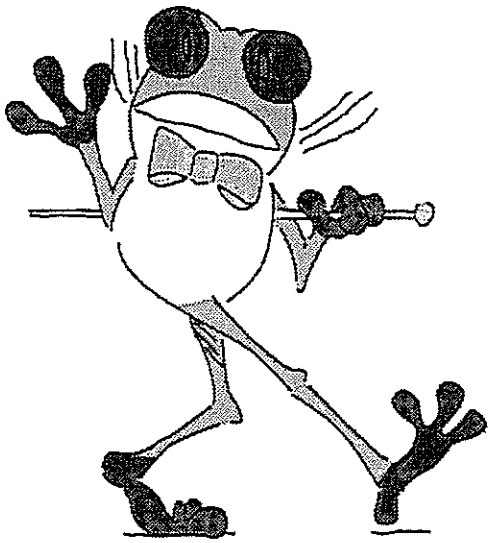
3 Arts (artistic creativity, performance, and expression)

5 Inquiry (data categorization, classification, and recording)

National

K–4:

Content Standard C Life Science (characteristics of organisms)



Name _____ Date _____

A Frog Song (continued)

Mystery Frogs and Toads Songs

Song #1:
These frogs are found statewide
in tall wet meadow grass
calls with a snore, grunt or a squeak.
Yah Sure!

Skin color brown or green
Dark rounded spots on back
Two to three and a half inches.
Yah Sure!

#1—What frog or toad am I?

Song #2:
This non-climbing tree frog
Likes muddy pond shorelines
Makes a sound like two hitting rocks
Yah Sure!

It comes in brown to gray
Green blotches and dark warts
Dark triangle spot between eyes.
Yah Sure!

#2—What frog or toad am I?

Song #3:
This tiny common frog
Is tan, red, green, or gray
With three long dark stripes on its back.
Yah Sure!

It is about one inch
Found in wet grass statewide
Call sounds like thumb scraped over comb.
Yah Sure!

#3—What frog or toad am I?

Song #4:
This frog's color can change
Even though it is gray
On vegetation it is green.
Yah Sure!

It likes forests and woods
Makes birdlike calls from high
Its skin is rough and blotchy gray.
Yah Sure!

#4—What frog or toad am I?

Song #5:
Found in the grassy lands
Of our state's northwest part
It's found in other countries too.
Yah Sure!

Brown, dry and lots of warts
With black and white markings
Has a raised bump between its eyes.
Yah Sure!

#5—What frog or toad am I?

Song #6:
It comes in shades of green
In rivers, ponds and lakes
Listen for the sound of "jug-a-rum."
Yah Sure!

It's the largest state frog
Tadpoles grow for two years
Females lay twenty thousand eggs.
Yah Sure!

#6—What frog or toad am I?

Name _____ Date _____

A Frog Song (continued)

Frogs and Toads Research

Choose one of the frogs or toads listed below to do research on.
You must use at least two resources.
Collect important facts about the characteristics and habitat of your frog or toad.

Frogs and Toads:

Green Frog	Spring Peeper	Mink Frog
Wood Frog	American Toad	Pickerel Frog
Great Plains Toad	Leopard Frog	Tree Frog

I will research the _____

Resource 1: _____

Important Facts: _____

_____

_____

_____

Resource 2: _____

Important Facts: _____

_____

_____

_____

Resource 3: _____

Important Facts: _____

_____

_____

_____

Name _____ Date _____

A Frog Song (continued)

Frogs and Toads Song

Use your "Frogs and Toads Research" sheet and compose a new song to the tune of "Ten Little Speckled Frogs" for the frog or toad you researched.

Include the important facts about your frog's or toad's characteristics and habitat.

Your song should teach the rest of the class the important things about the frog or toad you discovered.

Line One-6 syllables

_____

Line Two-6 syllables

_____

Line Three-8 syllables

_____

Line Four-Yah Sure!

Line Five-6 syllables

_____

Line Six-6 syllables

_____

Line Seven-8 syllables

_____

Line Eight-Yah Sure!

Name of your frog or toad: _____

Suggested Grades K–2, 3–5

Why Don't You Just Grow Up!!

Concepts
Life cycle, change or metaphorosis, stages of life

Time Required
45 minutes

Catalyst Question
What happens to a frog growing up?

Background

Anurans (frogs and toads) are a very special group of animals in many ways, but in one way in particular—their life cycle. They undergo incredible anatomical changes during their life cycle, progressing from an egg to a tadpole and finally to an adult frog. However, even within this change from egg to tadpole to adult there are numerous smaller stages where various events happen such as the loss of gills, the growth of legs, and the reabsorption of the tail into the body.

Jellied Eggs and Ham! Once the eggs have been laid by the female and fertilized by the male, the incredible journey begins. The eggs, or "frogspawn," are surrounded by jelly, which absorbs water, swells up, and floats to the surface of the pond where the sun warms it. One clump of eggs can contain any where from 4 to 40,000 eggs depending on the species or type of frog, yet only one or two survive to become adults! Why? (Because many of the eggs may not hatch, and if they do hatch, tadpoles are food for many creatures in water or aquatic habitats.)

Anurans may lay their egg in big masses, individually or in strings, some of which may attach themselves to vegetation in the water.

Am I a Tadpole or Polliwog? Well, actually, we are the same! After a few days a tadpole eats its way out of each egg and wiggles free. The tadpole uses the egg as its first food source. At first the tadpole breathes and moves like a fish, using its gills and long tail, but after several weeks the gills disappear and the tadpole develops lungs. It then has to swim to the surface of the water to gulp air. Depending on the species of frog, the tadpole may have fleshy lips with rows of teeth to eat water plants or suck in algae. Some species may eat other eggs. Tadpoles have even been known to nibble on each other in crowded conditions.

A Froglet I Am! After some more time, the back legs have formed and in a few more weeks the front legs have also appeared. Eventually the tail disappears (is resorbed) and the tiny froglet is ready to leave the water.

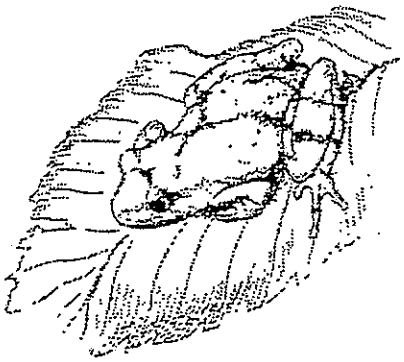
I Am an Adult Frog (well almost!) It may take a number of years before the froglet reaches maturity and is able to lay eggs so that the cycle can occur all over again.

Again, this is a very general time line of the changes, or *metamorphosis* (change in form), that occurs in the amphibian life cycle. Some species, such as Bullfrogs in Minnesota, may stay in the tadpole stage for up to three years because of the climate. Other species in Minnesota go through the whole transformation over one spring and summer.

Objectives

At the end of this activity, the students will be able to:

1. state the different stages in the life cycle of an amphibian.
2. dramatize correctly the life cycle of frogs (K–2).
3. draw the life cycle of a frog (3–5).
4. give two reasons why amphibians lay so many eggs.



Materials

Grades K–2
Diagrams of life cycle of an amphibian, i.e. frog.

Grades 3–5
Diagrams of life cycle of an amphibian, i.e. frog; modeling clay.

Procedure

Grades K–2

1. Ask students what they know about frogs and toads, especially the life cycle.
2. Show students pictures of the different stages of frog—egg, tadpole, and adult frog. Ask the students for words that describe the different stages of the frog, particularly in relation to movement.
3. Ask students to form body shapes and move in ways that reflect the life cycles: egg—ball up; tadpole—wiggle; adult—hop; death—keel over.
4. List the words that the students have stated in 2 above and create a story using these words. For example:

   See the egg in a big ball, see it float in the water—float, float, float
   There goes a tadpole, see it wiggle its tail—wiggle, wiggle, wiggle
   See it nibble on the algae—nibble, nibble, nibble

Why Don't You Just Grow Up!! (continued)

Here comes a frog, see it hop on by—hop, hop, hop.

5. Using these words, have the students dramatize the movements.

Grades 3–5

1. Ask students what they know about frogs and toads, especially the life cycle.
2. Show students pictures of the different stages of frog—egg, tadpole, and adult. Ask the students for words that describe the different stages of the frog particularly in relation to movement.
3. Teacher asks students to form body shapes and move in ways that reflect the life cycles: egg—ball up; tadpole—wiggle; adult—hop; death—keel over
4. Students draw the life cycle of the frog and create one part of the life cycle from some modeling clay.

Evaluation/Review Questions

Grades K–2

Photograph/videotape the students in their movements. (See Primary Science Performance Package, which asks students to dramatize life cycle of monarch butterfly... adapt to frog's life cycle)

Grades 3–5

Assess the life cycle stage constructed by the student.

1. Name the stages in the life cycle of a frog or toad.
2. Do all frogs lay large egg masses?
3. Why do some frogs and toads produce so many eggs?

Extensions

Grades K–2

Have students find out about other life cycles of plants and animals and have them dramatize these as well.

Grades 3–5

In recent years, a phenomenon has begun to affect amphibian populations more seriously than in the past. A group of students in Minnesota found large numbers of frogs with deformities—frogs/toads have been found with extra or missing eyes and limbs, extra webbing on their legs, etc. The students brought these observations to the attention of the world and scientists are trying to find an answer to this problem. Students should add this to the life cycle and predict how these deformities could impact it.

References and Resources

Chinery, M. 1991. *Life Story: Frog*. Mahway, NJ: Troll Publications.

Mattison, Chris. 1987. *Frogs and Toads of the World*. New York: Facts on File. Reprinted 1997.

National Wildlife Federation. 1987. *Ranger Rick's NatureScope. "Let's Hear It for Herps."* Washington, DC: National Wildlife Federation.

Education Standards

Minnesota

Primary Level:

1 Read, View, and Listen (literal comprehension, interpretation, and evaluation)

3 Arts (artisitic creativity, performance, and expression)

Middle Level:

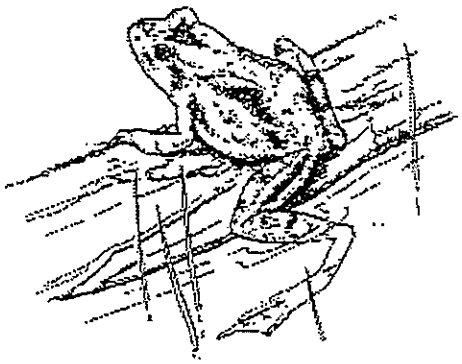
1 Read, View, Listen (literal comprehension, interpretation, and evaluation)

3 Arts (artisitic creativity, performance, and expression)

National

K–4:

Content Standard C Life Sciences (characteristics of an organism, life cycles of organisms)



Suggested Grades 3–5

Write Away

The Frog Prince, frog games, frog tales, Kermit the Frog ... these friendly amphibians have always held a special place in the lives and literature of American culture. During the months of April and October, students can participate in a poetry and prose celebration of frogs. Writing can be submitted on-line and selected pieces will be published. Submit via e-mail, fax, or snail mail. Any type of writing is welcomed. Help students get started by writing a cinquain, limerick, or a How to be. . . poem.

Cinquain

A cinquain poem follows a specific formula. It has 5 lines, each appealing to the emotions and the senses.

First line:	one word, giving the title
Second line:	two words, describing the title
Third line:	three words expressing an action
Fourth line:	four words expressing a feeling
Fifth line:	one word, a synonym the title

For each line, ask students to generate possible phrases and to choose the ones they like best.

Cinquain

wetland
mucky gucky
up and down
scared of monsters grabbing
squishy
Joe Heili, age 7

Limerick

Limericks, whimsical and humorous, also follow a set form; the first, second, and fifth lines rhyme; the third and fourth rhyme, too, and are shorter. Choose the name of the person, place, or thing your limerick is going to be about. The trick is to find a number of words that rhyme for lines one, two, and five. Experiment with word order and find synonyms to make the meter work out.

- Create your first line. You may follow the pattern

  There once was a_____named_____ or

  There once was a _____from _____.
- Lines three and four are short lines that rhyme which tell something about your topic.
- For the final line, you may want to repeat the pattern used for the first line.

Limerick

There was an old raccoon named Grog
Whose diet consisted of frog.
He lived near a pond
With the forest beyond
And grew fat on Mink Frog in the bog.
Jessica Cady, age 12

How to be...

Have students choose a topic. Give them time to cluster words around their topic, writing down any word associations that come to mind. Ask them to pretend they have the power to teach someone how to become the topic they have chosen. Have them list what one would need to know, what learning would be needed, or how one would act to become this thing. Students could begin each line with the word "learn," or "know," or "be."

How to be...

How to be water.
Learn to flow, slowly and swiftly.
Learn to splash and laugh going over rocks
Learn to gather drops of rain from the clouds.
Learn to love the fish who live in you.

Suggested Grades 5–8

Talk, Talk, Talk

Concepts
Environmental perspectives; various uses of habitats; civility in debates

Time
50 minutes for debate (research roles should be done over a number of days)

Catalyst Question
Why shouldn't we use this wetland?

Background

Wetlands provide a home for frogs and a habitat for a myriad of animals and birds. Bogs, swamps, marshes, flood plains, meadows, sloughs and ponds...all of these words describe a wetland. What makes all of these wetlands? They are all areas where water remains ponded or near the surface and saturates the soil, leaving little or no room for oxygen.

In addition to providing home and food for creatures, wetlands help prevent flooding, recharge groundwater, and soak up pollution. Unfortunately, wetland acreage has been shrinking rapidly over the past decades for a variety of reasons. Drainage for agricultural cultivation, drought, and industrial and housing developments have all contributed to the loss of wetlands. The United States has lost over 60% of its original wetlands and continues to lose this habitat at a rate of 60 acres per hour.

Western Chorus Frogs rely on a wetland habitat. They require temporary or permanent waters without fish populations. Located throughout Minnesota, Western Chorus Frogs co-exist easily within urban environments and can be found in wetlands surrounded by development.

Objectives

On completion of this activity, students will be able to:

1. use research as a means to learn more about an issue.
2. give reasons why wetlands are important.
3. state various perspectives on developing habitats.

Materials

Access to references and information on wetlands amphibian populations.

Procedure

1. Divide students into groups of four. Wetland loss can be viewed from a variety of perspectives. As a foursome, have students generate responses to wetland loss from the perspective of an environmentalist, a housing developer, a child, and a hunter.
2. Make two lists of the responses:

   – Wetland loss is okay because:
   – Wetland loss is not okay because:

   Add responses from as many perspectives as possible.
3. Divide each group of four into working partners. Have one pair take the position that wetland loss is necessary and natural. The other partners will take the position that wetland loss should be prevented.
4. Give partners time to prepare their assigned perspective.
5. Bring all the class together for a debate. Following the debate, ask each foursome to discuss the strengths and weaknesses of the arguments.

Evaluation/Review Questions

1. If you defended a position that was different from your personal opinion, how did that feel?
2. What were the strong arguments for each position?
3. What proposals might we make concerning wetland loss? To whom should they be directed?

Extensions:

1. Habitat destruction is one of the main causes for species loss. But what about habitat fragmentation? Try to learn more about this and how it can impact species.
2. Create a collage of the different types of habitats in your local area. Now, investigate what was in the area 10, 50, and 100 years ago and make a collage for each time period.

References and Resources

Beebee, T. J. C. 1996. *Ecology and Conservation of Amphibians.* New York: Chapman & Hall.

Langton, T. E. S. 1989. *Amphibians and Roads.* London, UK: ACO Polymer Products.

Lannoo, M. 1996. *Okoboji Wetlands.* Iowa City, IA: University of Iowa Press.

Phillips, K. 1994. *Tracking the Vanishing Frogs.* New York: Penguin Books.

Internet Resources

A Thousand Friends of Frogs Project
http://cgee.hamline.edu

Declining Amphibian Populations Task Force
http://www.open.ac.uk/OU/Academic/Biology/J_Baker/JBtxt.htm

Education Standards

Minnesota

2 Write and Speak (interpersonal communication)

National

Content Standard F Science in Personal and Social Perspectives (changes in environment)

Suggested Grades: 5–8

The Case of the Missing Anurans

Concepts
Requirements for survival; environmental change; influence of change on populations; declines in populations

Time
90 minutes to several days

Catalyst Question
Where have all the frogs gone?

Background

My name is Sheerluck Biomes. One Sunday afternoon, I was sitting in my favorite chair reading the newspaper. With me on this day was my assistant, Dr. Newt Watson. While reading the paper, I saw an article about the decline in amphibian populations, also known as frogs, toads, and salamanders. This article piqued my interest and I discussed this information with Dr. Watson. It seems that although there were no firm data on the actual numbers of amphibians past and present, herpetologists (scientists who study amphibians and reptiles) and other scientists noted that there were not as many of these creatures in ponds, marshes, forested areas, and along some streams where they used to be found. We decided that we wanted to know more about this problem.

It did not take long for Dr. Watson and me to discover that an investigation of this type was an enormous undertaking. So we decided to concentrate our investigation only on frogs and toads also called "anurans." We decided to call this "The Case of the Missing Anurans."

A proper inquiry into this situation would require the services of some top investigators. They would be responsible for delving into the different aspects of this case to form a complete picture for the solution of this mystery.

There are various clues available in "The Case of the Missing Anurans" otherwise known as declines in anuran populations. These include acid precipitation, predators, human consumption, habitat loss, climate change which may act on a local or global basis. These are outlined in greater detail in the clue sheets.

However, it is important when examining this issue to remember some additional points. For example, when discussing declines it should be remembered that there are two types of decline: declines in *size* of a population (affecting the *number of individuals* in a population) and declines in the *number* of populations (impacting *diversity* of species). In addition, declines can occur at a local and global level. So, when examining a decline, which angle are you investigating? Other points to be considered: population fluctuations do not necessarily indicate a decline and while local habitat destruction may be detrimental to some species other species could thrive. So, how do all these clues play out in this mystery? Let's investigate and see!

Life Cycle of Amphibians

Amphibians are cold-blooded vertebrates that lack scales. They usually begin their lives in the water (with gills) and live on land (with lungs) as adults. Most amphibians mate in water, where the females' eggs are deposited and fertilized by sperm from the males. The eggs of amphibians are covered with one or more gelatinous coatings that protect against shock and drying and make attacks by enemies more difficult. Frogs and toads are now more commonly grouped into "anurans"—tailless amphibians. It is these animals that we will concentrate on.

Frog and toad embryos form in eggs and then develop into tadpoles that remain in water, slowly changing into adults. During the tadpole period of their lives, they have some characteristics similar to fish—gills for breathing and tails for swimming. The larval stage may last from several weeks to even years for larger anurans, but the final metamorphosis from tadpole to juvenile frog usually occurs in a few days.

Habitats

The place in which an animal can be found is called its *habitat.* Anurans need two distinctly different habitats, within fairly close reach of one another, to complete their life cycle. The first is suitable dry land providing cover from predators and a supply of small-animal food; the other is a pond to lay their eggs in and allow their tadpoles to develop. During the winter, most anurans hibernate either on land or at the bottom of a pond.

Frogs and toads both need an aquatic environment to lay their eggs. However, in the rush to lay eggs, they may be laid in a puddle of water or in temporary pools/ponds of water. Aquatic habitats without fish are preferable, since fish will eat most of the tadpoles. Toad tadpoles are equipped early in life with poisons in their skin that quickly persuade fish to leave them alone. Frog and toad tadpoles require algae of some sort to feed on at an early stage in their development. However, as their development continues they also can eat meat. In overcrowded situations, they have been known to nibble on each other.

Pond Conditions

Ponds are very important in the life cycles of anurans. Anuran breeding ponds are generally small, with varying amounts of decaying plant and animal material (humus). As the humus

Suggested Grades: 5–8

The Case of the Missing Anurans (continued)

breaks down in the ponds, it produces acidic conditions in the water. The pH (measure of the acidity) may also be lowered (which means the water becomes more acidic) for short periods following snow melt or major rain storms. Because of the presence of humus, it is difficult to tell if the acidic conditions in the ponds are from atmospheric or natural sources.

Scientists are studying the acidic conditions in the ponds used by anurans. Most anurans can adapt to a slight change in the pH of the pond water; but if the pH becomes too low, serious problems arise. In a small pond, pH can be lowered rapidly, and anurans may be unable to adjust quickly enough for survival.

Anurans are most vulnerable when they are embryos and larvae. Some of the most significant effects of a lower pH on anurans occur because growth rates are slowed. Under laboratory conditions, tadpoles exposed to low pH grow much slower than those exposed to neutral conditions. The embryos and tadpoles of anurans are formed in the spring and must reach a certain size before the pond dries out in the summer. Size at metamorphosis (the change from tadpole to frog) affects survival in the land environment during the summer, and ultimately reproductive success in adulthood.

Scientists studying amphibian larvae in acidic ponds note:

1. increased need for food;
2. lower food quality available;
3. lower rates of food processing in the intestine;
4. behavioral changes, such as reduced attraction to food odors or reduced activity; and
5. larvae can withstand lower pH's than embryos.

Scientists state that pond acidity is currently having a major effect on the abundance of anurans. Continued monitoring is necessary to determine how natural processes and human activities affect the acidity of ponds.

Objectives

After completing this study, each student will be able to:

1. describe environmental changes that can affect anurans.
2. state a hypothesis about the cause of a large change in anuran population size.

Materials

Paper; pencil; copies of "clue" sheets for groups; presentation materials.

Procedure

1. Form a group of four to five investigator scientists. Give each investigator one of the "clue" sheets and background information so that all clues are available to the team. Alternatively, each team might receive only the clue title, ie. UV radiation, and do all the research on this topic. Teams should check the reference and resource list for additional sources of information on this topic. In addition, they should contact state or regional wildlife staff for information on local and state amphibian populations.
2. Each team writes a scenario describing why anurans may be declining in numbers. The team develops a hypothesis on the declines based on their information and should be able to present and defend this.
3. Each team then designs a controlled experiment which could be done by scientists in a laboratory or in the field to test the team's hypothesis. (A "hypothesis" is a credible idea to be tested by experimentation and a "theory" is a concept well established by much experimentation.)
4. Each team presents their findings and proposed experiment in the following possible scenarios.
5. Each team represents a group of herpetologists and other scientists who have gathered together for a meeting to discuss the declining frog and toad populations around the world. Each team presents their hypothesis and experiment designs to the entire group.

Presentations should be creative and can be of a multimedia nature or a final report to the group.

Perhaps team members could become the characters of Sheerluck Biomes and Dr. Newt Watson and give their report as these type of investigators do when they find the solution to a "mystery."

The students can compare their results with other class members to note similarities and differences. Is it possible to try any of the experiments? Why/why not?

Evaluation

There is no single solution to this problem. There is a need for more concrete data from field observers, but this activity gives clues as to some of the causes for the decrease in the numbers of anurans.

Evaluation should be performed on the following criteria:

1. the amount of research beyond that in the various clues and background information;
2. sources of additional information (i.e. books, journals, Internet—and assessment of the sources by the students); and
3. team presentations to the other students.

Extensions

1. Locate information on the amphibians in your local area/state/country. Check resources to determine how the populations

The Case of the Missing Anurans (continued)

are surviving in your area—are they steady, declining, increasing?

List the frogs, toads, and salamanders found in your local area. Ask your parents/grandparents if they see as many of these animals now as the did when they were growing up. If a change has/has not occurred, ask them if they know why.

How could you help the amphibian populations in your area? Some people go out during the spring when the frogs are migrating from the lakes, etc. where they spent winter to the breeding ponds and help the frogs get across obstacles such as roads. Could you organize a group of students to do this?

2. Using various resources find as many stories, anecdotes, folktales, and movies about amphibians. Why do you think they were used so much in art and literature? Were they portrayed in a positive or negative way? Were the characteristics given to these animals true? From what you have learned in this activity, write a short folktale about one or all types of amphibians.

References and Resources

Barinaga, Marcia. 1990. "Where Have All the Froggies Gone?" *Science* 247:1033–1034 (March 2).

Blaustein, A. R. and D. B. Wake. 1995. "The Puzzle of Declining Amphibian Populations." *Scientific American* 272(4):52–57.

Bratass, Anne. 1996. "A Croak of Alarm." *St. Paul Pioneer Press*, pp. 1D, 2D (May 9).

Freda, Joseph. 1986. "The Influence of Acidic Pond Water on Amphibians: A Review." *Water, Air and Soil Pollution* 30:439–450.*

Green David M. 1997. *Amphibians in Decline. Canadian Studies of a Global Problem.* St. Louis, MO: Society for the Study of Amphibians and Reptiles.*

Hurd, Dean, Myrna Silver, Angela B. Bacher, Charles W. McLaughlin. 1988. *Physical Science*. Englewood Cliffs, NJ: Prentice-Hall, pp. 615–616.

Lannoo, M. (Ed.). 1998. *Status and Conservation of Midwestern Amphibians.* IA: University of Iowa Press.

Lien, Dennis. 1996. "In Search of Frog and Toad." *St. Paul Pioneer Press*, pp. 1A, 5A (November 11).

Mattison, Chris. 1997. *Frogs and Toads of the World*. New York: Facts on File Publishers.

Minneapolis Star Tribune. 1998. "Frogs of Scarce Species Turn Up in Twin Cities Area," p. B3 (June 24).

Phillips, K. 1994. *Tracking the Vanishing Frogs*. NY: Penquin Books.

Phillips, Kathryn. 1990. "Frogs in Trouble." *International Wildlife* 20(6): 6–10.

Pierce, Benjamin A. and Jeffrey Montgomery. 1989. "Effects of Short-Term Acidification of Growth Rates of Tadpoles." *Journal of Herpetology* 23(2): 97–102.*

Tangley, Laura. 1998. "The Silence of the Frogs." *US News and World Report*, pp. 50–51 (August 3).

Media Resources

Cane Toads—An Unnatural History. New York: First Run Features.

An extremely interesting and humorous video presentation of an invasion of an alien species. This toad is also causing many problems in Florida.

The Frogs. ABC Nightline Program. September 30, 1997. To order, call 1-800-CALL ABC

This program is an excellent resource about the deformed amphibian issue and the scientific quest to determine what is causing this phenomenon. It examines the situation not only in Minnesota but in other states where deformed amphibians are being found. In addition, it discusses the various scientific hypotheses behind this issue.

Internet Resources

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

This web site has an extensive list of links in its Frog Resources section to other relevant state, regional, national, and global anuran and amphibian web sites. It also has a "Frogs as Bio-Indicators Science Corner," which examines many of the factors influencing declining populations.

Declining Amphibian Populations Task Force
http://acs-info.open.ac.uk/info/newsletters/FROGLOG.html

This is another organization with excellent information on the web. The organization's newsletter, FROGLOG, is also available on-line and has some interesting research reports from scientists around the world.

Education Standards

Minnesota

1 Write and Speak (writing, interpersonal communication)

5 Inquiry (direction observation; accessing information, controlled experiment)

National

Content Standard A Science as Inquiry

Grades 5–8:
Content Standard C Life Science (structure and function diversity and adaptation of organisms)

Grades 9–12:
Content Standard E Science and Technology (abilities of technological design)

*may only be available at a university/college library

Clues

Clue #1

Acid Precipitation (Rain, Snow, Sleet)

Acid precipitation, generally called acid rain, can fall in different forms but mainly as rain and snow. It is both a natural product and a product of today's industrialized world. Precipitation can become acidified or more acidic by combining with carbon dioxide and other gases in the air. Also, following volcanic eruptions precipitation can become more acidic through its combination with various sulfur oxides.

However, the biggest continuous source of acid precipitation is from burning fossil fuels. Coal, especially "soft" or high sulfur coal, and other fossil fuels contain sulfur impurities. When a fossil fuel is burned, sulfur combines with oxygen in the air to form various sulfur oxides. When sulfur oxides react with moisture in the air, droplets of weak sulfuric acid form in the atmosphere. The droplets eventually mix with rain water to form acid rain.

Although much air pollution comes from the industrial burning of coal and other fossil fuels, the most significant source of air pollution is motor vehicles. Gasoline and diesel fuels do not burn completely in the engines of cars, buses, and trucks. Unburned fuel vapors and carbon dioxide are released into the atmosphere.

Other pollutants contained in the exhaust of motor vehicles are nitrogen oxides. Nitrogen oxides are compounds in which nitrogen is combined with oxygen. In the atmosphere, nitrogen oxides may combine with water vapor to form droplets of weak nitric acid. The nitric acid may fall to the earth as acid precipitation in the same way sulfuric acid does.

When these droplets of sulfuric acid and nitric acid fall to the earth as acid rain or acid snow, they change the acidity, or pH level, of the waterways fed by the acid precipitation. Most aquatic organisms can survive in only a narrow range of water acidity. By increasing the water's acidity, acid precipitation kills many of the small organisms living there. Young organisms may be deformed, and adults may suffer if their food supply has been damaged. Aluminum and other metals may leach out of the soil and damage fragile gills.

Acid precipitation begins as air pollution. As precipitation falls to the earth the problem becomes water pollution. Then as the acid precipitation seeps into the soil, land pollution results. In the "pollution chain," all aspects of the environment are damaged. The acid precipitation affects the entire ecosystem of an area—the predators, the prey, and the vegetation.

What other sources of pollution may impact air and water quality?

Clues

Clue #2

Predators and Prey

The diet for tadpoles of toads and frogs is different than that of adults. Algae and protozoa are the main foods for the tadpoles. They also scavenge dead animals. In overcrowded conditions, they may even nibble on each other!!

Adult frogs and toads are hunters. Vegetables are not part of their diet. They stalk their prey among the insects that swarm about their habitats. They also eat worms and small mollusks. The bullfrog sometimes catches small fishes, birds, or mammals, and big anurans will devour smaller individuals of their own or other species.

Anurans have many enemies. Tadpoles are target prey for almost every carnivore in or around the ponds. Many tadpoles do not survive for more than a day. The list of predators is long: water beetles and their larvae, dragonfly nymphs, water boatmen, and water scorpions will eat all kinds of tadpoles. Other predators include newts, fish, water shrews, and birds.

As adults, frogs and toads are the staple foods of turtles, snakes, herons, certain hawks, raccoons, and large fishes.

Toad skin glands have secretions that make them unappetizing to most predators. Importantly, toads DO NOT cause warts. However, if you rub your eyes after handling toads, these skin secretions can irritate the eyes. Toads also have toxins located in parotoid glands behind the head, which can release these toxins when the toads are threatened.

But anurans are part of the chain of life and natural predation should not be a large factor in their declining populations in such a short period of time, otherwise amphibians would have died out millions of years ago. Yet they survived many global catastrophes for hundreds of millions of years.

What about unnatural predation (introduction of non-native species, etc.)?

Clues

Clue #3

Global Climate Changes

In the hydrologic cycle the earth circulates all the water there is on the planet through a system of storage sites, flow channels, and changes in state (solid, liquid, or gas). Storage sites include plants and animals using water to grow and conduct their body processes, rock layers porous enough to hold water, and ponds, lakes, and oceans (these are the most visible reservoirs). The amount of water available to an ecosystem is a result of the precipitation (bringing water from the atmosphere to the earth) and evapotranspiration (the combination of biological and physical processes that return water vapor to the atmosphere).

In the temperate zones of the earth, if there is more precipitation than evapotranspiration, the area will have dependable ponds for anuran habitat. If evapotranspiration exceeds precipitation, any ponds that form will probably be temporary. Temporary ponds create difficulties for anurans. If precipitation is acidic, the entire pond may immediately take on the same level of acidity, with resulting damage to the gills and bone development of tadpoles. With a high rate of evapotranspiration, the young anurans may not get to develop at all. Their pond may dry up before they are developed into their land-dwelling forms. Their deaths would mean an interruption in the anuran population of that year and would decrease the number of reproducing adults in the coming years.

Our global climate has changed over millions of years and has allowed life to evolve on this planet. With the aid of the "greenhouse effect" (which allows enough energy in to warm the planet and allows energy reflected by the planet to escape) life has evolved, adapted to planetary conditions and in many cases flourished. However, humans may be enhancing this greenhouse effect, causing more energy to be trapped in the atmosphere with the probability of raising global temperatures resulting in major climatic changes.

Scientists estimate that much of the northern latitudes' temperate zone will become increasingly warmer over the coming decades because of the enhanced greenhouse effect. Extremes of climate, such as droughts, El Niño events, blizzards and the like, may become more frequent. How will anurans respond to such circumstances, given their dependence on ponds and streams?

Clues

Clue #4

Habitat Fragmentation, Elimination, and Alteration

Anurans are locally based populations, they generally do not travel great distances. So, impacts on a local habitat can have detrimental results on local populations. As humans continue to push their way further into undeveloped or less developed areas—such as forests, swamps, and other habitats—thousands, if not millions, of species are displaced from their homes. This factor is still extremely important in population declines of most animals including anurans. In many cases, habitat may not be destroyed completely, but only fragmented, making it difficult for the anurans to get to breeding ponds.

For example, some species of frogs only go to ponds to lay eggs and breed, spending the remainder of their life in wooded or prairie areas. If a road is placed in between the ponds and the woods or prairie, the frogs may not be able to get to the breeding ponds. Or the young adults or metamorph can not make it from the pond to the habitat they require as adults. Faced with a new obstacle or a whole new environment, many of these organisms die off or become road-kill. But, some species are more tolerant of humans and do learn to live in this new habitat type, although their population numbers are greatly reduced. But, eventually this population may become too small to be sustainable.

Development of a local area may not always be the most direct influence on the anuran populations in that area. For example, at the 1998 Midwest Declining Amphibians Conference, Minnesota scientist Dr. David Hoppe from the University of Minnesota-Morris made a surprising and distressing statement about frog populations in some areas of Minnesota. He visited 14 sites which another herpetologist, David Merrell, has collected frogs from during the 1950s. In 1997, Dr. Hoppe found frogs only in five of the sites!!! Many of these sites had not been developed and were in a similar condition from the 1950s. Had other conditions altered in the area to impact these populations?

Overall, anurans in temperate areas are more fortunate than their tropical cousins. There may be a higher diversity of anurans in tropical regions but they have a small, limited geographic range while temperate amphibians have a larger range. This means that the destruction of tropical rainforests has a greater impact on animals and will lead to the extinction of a large number of anurans and other creatures.

Another example: by clear-cutting forests and filling in swamps to create farming areas, humans inadvertently introduce salts (minerals) into the soil. This salt can be transported by water from the soil to the anuran breeding sites which become saturated with salt. Eggs and tadpoles of anurans cannot handle this extra salinity and they die.

What other ways can habitats be changed?

Clues

Clue #5

Pathogens—Parasites and Fungi

Various pathogen theories have been put forward as playing a role in declining anuran populations. The pathogens may include some types of parasites or fungi. Researchers found that a fungus called *Saprolegnia* is infecting many amphibians in the lakes and ponds of Oregon.

In 1997, Dr. Karen Lips found dozens of dead and dying frogs in the Fortuna Forest Reserve, Panama, a protected area without any direct human disturbance. The same scene appeared in 1998 when she returned to the reserve. She and other scientists examined the dead and dying frogs and detected a previously unknown fungus on the body. As you know, frogs and toads have very permeable skin. This fungus grows on the outside of the frog, covering the skin of the animal and effectively suffocating it. According to a scientist from the National Institutes of Health, this fungus is causing an epidemic to sweep parts of Central America, Australia, and other areas in the world.

But how could this epidemic sweep different parts of the world, unconnected by any land? Could the fungus travel through the air or in the oceans...probably not and survive all that distance. Nothing else connects these areas...except research. How could the research be a factor in this? Could the scientists transport the fungus on their research equipment or even on their boots? Well, this is what the scientists now fear...that in their quest to find an answer to declining frog populations they have transported this fungus from infected to pristine areas. Do you think this is possible? Why/why not?

Many scientists now believe that ultraviolet rays have impaired the anuran immune system (which fights diseases), reducing the ability of anurans to resist fungal infections. What other factors could be involved in this lack of resistance to fungi/parasites?

Clues

Consumption

Consumption can come in many forms for anurans. They are an important part of the food chain, hunting and eating many insects, etc. and being hunted and eaten by various animals, including humans. For example, tadpoles are target prey for almost every carnivore in or around ponds. Many tadpoles do not survive for more than a day. The list of predators is long: water beetles and their larvae, dragonfly nymphs, water boatmen, and water scorpions will eat all kinds of tadpoles. Other predators include newts, fish, water shrews, and birds. As adults, frogs and toads are the staple foods of turtles, snakes, herons, certain hawks, raccoons, and large fishes. In Australia, feral pigs kill many frogs and in Switzerland, polecats destroy many frogs.

However, one of the largest consumers of anuran populations is us: humans. People typically eat only one part of the frog—its legs. In the late 1800s and early 1900s the hunger for frog legs decimated the wild red-legged frog populations of Oregon and California. Later in the 20th century, Midwestern states (Minnesota, Iowa, etc.) decimated the wild Northern Leopard Frog populations for human consumption. In France, average annual consumption of frog legs requires up to 60 million frogs. Even if these frogs are raised on farms and actual human consumption may be insignificant relative to the decline, it does affect the anuran populations.

In addition, humans consume anurans in other ways. They are used for fish bait and for biological work in laboratories and schools. Wild populations are still used as a source for these activities, although they may also be farmed for this purpose.

Examine frogs from birth to death and note all the points where and by what they are consumed. Can populations sustain these levels of consumption?

Clues

Clue #7

Deformities in Anurans

In recent years, a phenomenon has begun to affect amphibian populations more seriously than in the past.

In 1995, Minnesota students found a large number of deformed frogs in a pond. As anurans are good indicators of the quality and health of the environment, scientists and the media began to take notice of these reports. These deformities included extra or missing limbs, branching limbs, extra or missing eyes, and missing or deformed internal organs. Scientists feared that these deformities could impact the survival rate of affected organisms. Possible causes for these deformities include contaminated water sources, UV radiation, and parasites. However, following years of research by scientists, the cause of these deformities has not been pinpointed, but people are worried that whatever is causing the deformities in frogs could impact human health. Do you think this deformity phenomenon has an impact on declining populations? Why/why not? Are more deformed frogs being found because more people are looking for them?

Clues

Ultraviolet Radiation (UV-B)

When scientists began to notice the decline in anuran populations, another environmental phenomenon was also reported. A thinning in the ozone layer, that protective covering around the planet which shields life from harmful sun rays. Even though the chemicals which caused this problem have been banned, their impact will be felt for many decades to come. Most countries now broadcast warnings of UV during particular times of the year, so that we can protect ourselves from the harmful effects of these rays. We can wear long sleeves, hats, and sun block—all of which protect our skin from this radiation. Scientists began to speculate that perhaps there was a connection between these two incidents. However, while we can protect ourselves, anurans can not apply sun block to protect from radiation.

Anurans are extremely fragile in many stages of their life cycle, particularly in the egg stage. Many species lay egg masses in the water, eggs which do not have a strong protective covering. Eggs are exposed to a great deal of UV in this situation. Also, the ozone layer is generally at its weakest in spring, allowing more UV to pass through and cause damage to eggs.

In the 1980s, studies were performed to investigate the disappearance of anurans in the Cascade Mountains of Oregon. Researchers hypothesized that increasing UV was slowly decreasing anuran populations. Western toads were selected for the studies. Researchers believed that many fertilized eggs were dying. To prove this point, they conducted a laboratory experiment with fertilized western toad eggs. From the results, they stated that under UV, 40 percent of the fertilized eggs did not hatch. On the other hand, when protected from UV, only 10 percent of the eggs failed to mature. But this was performed in a laboratory, what about out in the field? What about factors such as water pollution or lake acidity which are encountered in ponds and lakes? These factors did not seem to alleviate the mortality rates and so the scientists deduced that ultraviolet light had a detrimental affect on anuran eggs.

Other studies showed similar results. In fact, this pattern continued. However, something else was noticed—species eggs that were high in an enzyme called *photolyase* had higher survival rates.

So, what role did this enzyme play? Enzymes are special types of protein which help in some chemical reactions. In this case, *photolyase* removes harmful, damaged DNA sections. From this knowledge, scientists speculated that the UV was destroying the DNA of anuran egg cells, killing them before they mature. In addition, if the UV light does not kill the cell, it may maim it by causing a deformity. If they reach maturity, adults from these cells will have suppressed immune systems, making them susceptible to attack from parasites and fungi. Scientists found that a fungus called *Saprolegnia* is infecting many anurans in the lakes and ponds of Oregon. What other impacts could UV radiation have on anurans?

Suggested Grades 5–8

Investigating Data

Concepts
Data collection procedures; data analysis and interpretation; environmental monitoring; environmental issues

Time
45–90 minutes

Catalyst Question
Data, data, just what is in those data?

Background

We hear science facts and data practically every day, whether in the news or in school. But what do we do with all these data? Well, many of the decisions we make can be based on data of different types from various places. Many policy decisions regarding the environment are made on data and the interpretation of these data. So, interpretation of data is extremely important, as this will have a great impact on decisions and their implementation. In this activity, students will examine some data from A *Thousand Friends of Frogs* 1997 deformity reports received from citizens. (Please note that this is only a selection of the data used for educational purposes and to illustrate to students data analysis techniques. These data were not necessarily verified by biologists doing extensive field surveys).

Objectives

At the end of this activity, students will be able to:

1. use a spreadsheet for examining data.
2. interpret/analyze data.
3. visualize data by creating bar graphs with the information.

Materials

Frog survey data (see pages 35–37); large roll of paper for bar graph; markers; pencil; notebook

Procedure

1. Students will form groups of four. Each group will be given a copy of the 1997 *A Thousand Friends of Frogs* survey data.
2. Students should examine the data sheets and generate some questions about the data. These questions should be listed on the board. Questions could consist of: Who collected the data? What were the local or pond conditions like when they were collected? How could the data be analyzed? What can the data tell us? How many counties had abnormal frogs? How many counties had more than one abnormal frog? How many counties had no abnormal frogs and what do you think this means? How many species showed abnormalities—for the county? For the state overall?

   Once the questions have been discussed, ask the students about analyzing data for one county.
3. Each group is assigned a specific Minnesota county whose data will be analyzed. Some counties may have sparse data. In this case, students could create a county plot plus a plot of the total reports from the state (by species, number of malformations for each species).
4. Each group will analyze the data and record the answers to the following questions:
   a. How many deformed frogs/toads (anurans) were reported in your county?
   b. How many normal frogs/toads (anurans) were reported in your county?
   c. What are the species (types) of anurans reported in your county?
   d. How many deformed frogs of each species were reported in your county?
   e. How many normal frogs of each species were reported in your county?
5. The class will gather as a large group and discuss how to label the parts of a bar graph. The following should be considered: title, horizontal axis, vertical axis, key (legend), and origin.

   Each group will then fill in their part of the graph.
6. Students will analyze the graph data to determine:
   a. County reporting highest rate of deformed anurans.
   b. County reporting highest rate of normal anurans.
7. Students should place push pins in the location of the deformities and normal reports in a map of Minnesota. Different colors should be used to represent the types of reports. With this map and the bar graphs students should be asked some of the following questions: What else would you want to know about the data, e.g. was the report confirmed by biologists going to the site? What time of year were the deformed frogs found? Would that make a difference? [Teacher note: It is known there are seasonal changes, most deformities are in young anurans, but scientists need to survey more than once to document the extent of deformities at individual sites. If anurans have delayed development as it appears in some sites, then the tadpoles may be metamorphosing late and not coming out of the wetland until September.] Could the deformities be injuries?

   Students should also develop their own questions. These could include: What is the distribution of the deformity reports around the state? How good (valid) are the data so

Investigating Data (continued)

far? How valid is the method of collecting this information? Were deformed anurans found again in 1998? Why were no deformed frogs reported from some counties? How would you go about verifying the reports? What would you need to do? (These types of questions should be asked of any data.)

8. Discuss the following with students: field surveys, collecting frogs, the need to do regular trips (in this case July, August, and September) to be sure there are or are not deformed frogs in an area/site. (Look at the What's The Big Idea? activity on page 45 as a possible extension.)

Evaluation

Each student will need to examine individually the data specific to a county and create a bar graph showing the specific types of anurans reported in their county and numbers of normal and deformed frogs/toads. This will reinforce the group activity and show who comprehends the lesson.

Extensions

1. Groups could produce a bar graph of reports for their own county. Each group may compare graphs to examine numbers of specific deformed and normal anurans in other counties of Minnesota. This could lead to discussion questions such as: Why do some areas have more deformed anurans than others? What is the role of seasonality in this? What about migration of deformed frogs from the breeding ponds to their overwintering pond in fall? Other issues such as reduced growth in malformed frogs and possible higher mortality rates in winter may come up.
2. Use this extension to examine the issues of fieldwork in science.

When the first deformed frogs were caught by students, they were caught in the weeds along the south shore of the pond. Other parts of the pond were more difficult to access. In addition, the pond has a soft, mud bottom several feet thick that slows wading. Frogs are well-adapted to escaping, even deformed ones can move somewhat quickly.

Because of these inherent problems, the question of accuracy of data immediately is a concern. How could these characteristics of the data collection influence the results of the field survey? Can you devise some ways for collecting to be more accurate? If you have to accept these errors, what are some ways that you can correct or compensate for these errors when you report the data?

References and Resources

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. A. C. Hayek, M. S. Foster (eds.). 1994. *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians.* Washington, DC: Smithsonian Press. *

Internet Resources

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

This web site has an extensive list of links in its Frog Resources section to other relevant state, regional, national, and global anuran and amphibian web sites. It also has a "Frogs as Bio-Indicators Science Corner," which examines many of the factors influencing declining populations.

This section also has a map of Minnesota showing the distribution of deformity reports for several years.

North American Reporting Center for Amphibian Malformations (NARCAM)
http://www.npwrc.usgs.gov/narcam/

This web site has deformity reports from all over North American and may be useful if you are located outside Minnesota or if you want to examine reports from other states.

Education Standards

Minnesota

2 Write and Speak (interpersonal communication)

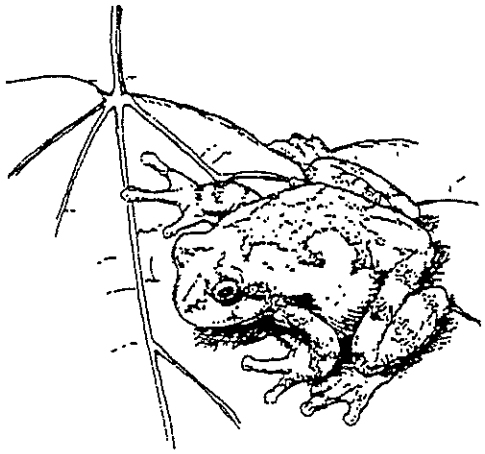
4 Math Application (chance and data handling)

6 Scientific Applications (living systems)

National

Content Standard C Life Science (structure and function in living systems, diversity and adaptation of organisms)

* may only be available at a university/college library



A Thousand Friends of Frogs 1997 Survey Data

STATE	COUNTY	NORMAL	No.	DATE M/D/Y	SPECIES	SIZE (cm)	HABITAT	ABNORMALITIES DESCRIPTION
MN	Hennepin	Yes	1	May/April 1997	Toad	10.16	park	
MN	Hennepin	Yes	1	May/April 1997	Northern Leopard Frog	12.7	park	
MN	Watonwan	Yes	15	May, 31 1997	Great Plains Toad	5.08-7.62	pond	
MN	Beltrami	Yes	1	May 15-June 1 1997	Wood Frog	5.3	pond	
MN	Beltrami	Yes	1	May 15-June 1 1997	Spring Peeper	1.9	pond	
MN	Beltrami	Yes	1	May 15-June 1 1997	Gray Tree Frog	3.2	pond	
MN	Beltrami	Yes	1	May 15-June 1 1997	Green Frog	7.2	pond	
MN	Beltrami	Yes	1	May 15-June 1 1997	American Toad	8.2	pond	
MN	Hennepin	NO	1	May 11, 1997	Northern Leopard Frog	1.4	lake	Has only one eye and three back legs.
MN	Hennepin	NO	1	May 11, 1997	Wood Frog	5	lake	Has only three back legs
MN	Goodhue	Yes	2	Fall 1996, Spring 1997	Green Tree Frog		pond	
MN	Goodhue	Yes	1	Fall 1996, Spring 1997	Wood Frog		pond	
MN	Goodhue	Yes	1	June 1997	Tadpole		pond	
MN	Cass	NO	1	July 4, 1997	Green Frog	5.08-7.62	lake	1 leg missing, appears cut off at joint.
MN	Cass	NO	1	July 4, 1997	Green Frog	5.08-7.62	lake	Missing one eye, looks full grown, but still has tadpole tail and it is black in color.
IL	Lake	Yes	4	May 5, 1997	Northern Leopard Frog	2.54	marsh	
IL	Lake	Yes	1	May 5, 1997	Northern Leopard Frog	7.62-10.16	marsh	
MN	Pine	NO	6	summer 1995-1996	frog		swamp	All missing a leg.
AZ	Maricopa	Yes	1	Feb. 4, 1997	Bullfrog	10	city	
KS	Trego	Yes	100's	1938-1941	Bullfrog		river	He remembers some with extra legs, and appearing to have a worm sticking out his side. Some were badly deformed, some only had an extra leg, some looked like turtles had chewed on their legs as tadpoles.
PA	Dauhpin	NO	1	Dec. 19, 1990	frog		stream	Frog with 5 legs, sticking out of its side.
MN	Benton	NO	1	July 17, 1997	Canadian Toad	1.25	pond	Missing a foot.
MN	Faribault	NO	1	July, 16 1997	frog	2.5	pond	Missing a foot - the right foot when facing the frog
MN	Sibley	NO	1	July 15, 1997	tadpole		pond	Tadpole with one eye
MN	Sibley	Yes	20	July 15, 1997	tadpole		pond	
MN	Sibley	Yes	20	July 15, 1997	frog		pond	
MN	Itasca	NO	1	August 5, 1997	Northern Leopard Frog	3.75	hill	Has only 1 leg
MN	Lake	Yes	1	July 28,29, 1997	American Toad	7.5	garden	
MN	Lake	Yes	1	July 28,29, 1997	American Toad	7.5	garden	
MN	Lake	Yes	1	July 28,29, 1997	American Toad	7.5	garden	

STATE	COUNTY	NORMAL	No.	DATE M/D/Y	SPECIES	SIZE (cm)	HABITAT	ABNORMALITIES DESCRIPTION
MN	Hennepin	NO	1	July 25, 1997	American Toad	3.75	creek	Missing half of one back leg. It is a stump.
MN	Hennepin	NO	1	July 26, 1997	Northern Leopard Frog	6.1	city	Right rear foot = 1.27 cm limb
MN	Dakota	NO	1	April 1997	frog	3.75	creek	Missing 1 back leg
MN	Dakota	NO	1	April 1997	frog	3.75	creek	Missing 1 back leg
MI	Gogebic	NO	1	August 3, 1997	frog	7.5	city	Missing right back leg.
MN	Anoka	NO	1	July 1996	frog	7.5	garden	2 legs coming out of the front socket on 1 side. No back leg on 1 side.
MN	Koochiching	NO	1	June 21, 1997	frog	2.5	lake/park	2 eyes on one side of the head. No eye on the other side.
MN	Redwood	NO	1	July 20, 1997	frog	7.5	farm	No leg on one side. Only a stump, not a complete leg.
MN	Douglas	Yes	1	July 27, 1997	Gray Tree Frog	4.1	woods	
MN	Douglas	Yes	1	July 27, 1997	Northern Leopard Frog	7.3	woods	
MN	Anoka	NO	1	July 21, 1997	Northern Leopard Frog	3.75	pond	Has no hind legs.
MN	Anoka	NO	1	July 21, 1997	Northern Leopard Frog	3.75	pond	Has only one back leg.
MN	Anoka	NO	1	July 21, 1997	Northern Leopard Frog	3.75	pond	Deformed leg - hip is sticking out.
MN	Anoka	NO	1	July 21, 1997	Northern Leopard Frog	3.75	pond	Has only one eye
MN	Isanti	NO	1	July 12, 1997	frog	5	garden	Front right foot has 3 fingers, front left has 4. Back left is webbed with another foot on top with a toe sticking out of the extra foot (2 feet grown together).
MN	Ottertail	Yes	1	June 26, 1997	Northern Leopard Frog	8	lake	
MN	Dakota	Yes	12	July 1-14, 1997	American Toad		city/pond	
OK	Canadian	NO	1	July 31, 1997	toad	5	city	Back 3rd leg that is quite long and is growing out of behind(has 5 legs total).
MN	Benton	Yes	1	July 24, 1997	Northern Leopard Frog	2.5	swamp	
MN	Benton	Yes	1	July 24, 1997	Northern Leopard Frog	2.5	swamp	
MN	Benton	Yes	1	July 24, 1997	Northern Leopard Frog	2.5	swamp	
MN	Benton	NO	1	July 24, 1997	Northern Leopard Frog	2.5	swamp	One deformed back leg (has 2 fingers where there should be only one).
MN	St. Louis	NO	1	July/August 1987	American Toad	5	woods	Has 5 legs - and extra front right leg growing out of the neck.
MN	Ottertail	NO	1	August 4, 1997	Northern Leopard Frog	5	swamp	Has only 1 eye on the left side, the right is smoother over like it never had an eye.
MN	Crow Wing	NO	1	July 26, 1997	Northern Leopard Frog	5.	wetland	Has only 3 legs, and there is a small nub where the back leg should have been.
MN	Crow Wing	NO	1	August, 1982	frog	7.5	lake	Had 2 heads.
MN	Rice	NO	1	June, 1997	tadpole	3.7	farmland	Only one eye(other side covered by skin)
MN	Dakota	NO	100	Summer 1994	Tree Frog		city/pond	Legs in triple length, extra leg coming out of head.
MN	Wright	Yes	1	July 31, 1997	Cope's Gray Tree Frog	4	lake	

STATE	COUNTY	NORMAL	No.	DATE M/D/Y	SPECIES	SIZE (cm)	HABITAT	ABNORMALITIES DESCRIPTION
MN	St. Louis	NO	50	Summer 1996			woods/ swamp	In duration of the 1996 summer about 50 frogs were caught, all with an extra leg coming out of their stomachs.
MN	Stearns	Yes	24	August 1-14, 1997	frog		river	
MN	Anoka	No	1	August 12, 1997	toad	6	wetland	Right rear limb - a stump, no full leg. Left rear limb - no webbed foot, slimy skin & nail where webbing should have been
WI	Burnett	NO	1	August 9, 1997	Green Frog	4	river	Left eye completely missing
WI	Burnett	Yes	1	August 9, 1997	Green Frog	4	river	
WI	Burnett	Yes	1	August 9, 1997	Green Frog	4	river	
WI	Burnett	Yes	1	August 9, 1997	Green Frog	4	river	
WI	Burnett	Yes	1	August 9, 1997	Green Frog	4	river	
MN	Aitkin	Yes	1	June 20, 1997	Wood Frog	3	lake	
MN	Aitkin	Yes	1	June 20, 1997	Northern Leopard Frog	4	lake	
MN	Aitkin	NO	1	June 20, 1997	Northern Leopard Frog	3.5	lake	Only 1 toe on left foot
MN	Isanti	NO	1	June 1997, late	Gray Tree Frog	2.5	swamp	Has an extra back leg, smaller than the other 2,coming out near the stomach, next to another leg.
MN	Winona	NO	1	August 25, 1997			garden	Front left leg is missing.
MN	Winona	NO	1	August 25, 1997				Right rear leg is missing. It is only a stump.
MN	Otterlail	NO	1	August 17, 1997	Northern Leopard Frog	5	lake	Right leg positioned in opposite direction.
MN	Winona	NO	1	September 9, 1997			city	Has only one eye.
ND	Cass	NO	1	September 4, 1997	Northern Leopard Frog	4	yard	Rear left leg stunted - bulge on side where hip would be.
MN	Stearns	NO	1	September 4, 1997	American Toad	2.5	yard	Missing front right limb & back right limb extremities.
MN	Otterlail	NO	1	Summer 1997	Northern Leopard Frog	3.75	lake	Missing right hind leg(foot missing to whole leg). Missing eye.
MN	Ramsey	NO	3	September 4, 1997	Copes Gray Tree Frog	1.8	yard	
WI	Burnett	NO	2	October 16, 1997	Green Frog	4.4	river	
WI	Burnett	NO	6	October 16, 1997	Green Frog	5	river	
WI	Burnett	NO	1	October 16, 1997	Green Frog	7	river	
WI	Burnett	NO	4	October 16, 1997	Green Frog	3.75	river	
WI	Burnett	NO	1	October 16, 1997	Green Frog	6.8	river	
WI	Burnett	NO	2	October 16, 1997	Northern Leopard Frog	5	river	
MN	Hennepin	Yes	1	September 22, 1997	Northern Leopard Frog	2.5	park	Missing left rear foot.
MN	Le Sueur	NO	10	July 31, 1997, August 8, 18, 28, 1997, September 2, 1997	Northern Leopard Frog			
MN	Winona	Yes	1	August 8, 1997	frog		garden	

Suggested Grades 6–8

If the Conditions Were Right

Concepts
Requirements for survival; communication of ideas

Time
100 minutes to several days

Catalyst Question
How far could an amphibian travel?

Background Information

Welcome to Costa de la Amphibia!! We all use some sort of information source when we want to buy something or travel somewhere, either catalogues or brochures. In the course of an animal's life cycle, they often travel or migrate to different places in response to natural changes in the environment—shortening of daylight, falling temperatures, vegetation losing leaves or dying totally. These indicate to some species that it is time to move on, to others it means an onset of hibernation. If animals do migrate, they do not use travel brochures to find out where they need to go!!

However, in this activity, students will develop a travel brochure for amphibians to attract them to a particular location/state. It should contain all the information that is published in such brochures such as food, accommodation, cost, hazards in the area, things to do, etc.

Objectives

At the end of this activity, students will be able to:

1. locate information on different species of amphibians.
2. describe five of the requirements for an amphibian species.
3. demonstrate how a "travel" brochure can be used to communicate some interesting facts about frogs or other amphibians.

Materials

Travel brochures; computer with desktop publishing or poster board; access to references with current amphibian content (*Frogs and Toads of the World*; or local, state regional books on amphibians); cooperation of local scientist(s) to review material if distributing this to the public.

Procedure

1. Students are members of teams that are designing a travel brochure for the Amphibian Adventures Agency.
2. Each team (2–3 students) should select an amphibian of choice. Make a class list so that duplication does not occur.
3. Each team should search the available resources and locate at least three references for information about the selected species. Be sure to locate the following information: the species' geographic region, possible travel destinations, a packing list to survive the conditions of the environment it is going to, food requirements, etc. A photograph or picture of the selected species should be included.
4. Collect some travel brochures for ideas on style and layout. The finished brochure will be two pages, maximum.
5. Once all the information about the species and environmental conditions of the area to be visited have been collected, write a draft of the brochure by hand so that it is ready when access to the computer is available. Choose the information to put on this wisely, remember that the brochure should be two pages maximum if you are making it on the computer.

   If a computer is not available, you can use posterboard: both sides should be available to use.

   In all cases, you can decide to fold the paper with single or multiple folds or not crease it at all.
6. Sketch how to design the brochure on the page or posterboard so that it is attractive to readers. It needs a headline, or catchy phrase, at least one picture (photocopy is fine), and some subheadings that help organize the information for the reader.

   Most editors agree that two or three columns on a page make the reading less tiring than if the words are typed or written all the way across the page without columns. Try various formats until the most suitable format is found.
7. If the school has computers with a publishing/word processing program available, use it to produce the brochure. If the school has a scanner, perhaps the photographs or illustrations can be scanned for the brochure. If a scanner is not available, paste the pictures or illustrations into the brochure by hand.

   If the school does not have a computer available, then use the posterboard to make your brochure, which will be oversized.

Procedure for the Teacher

1. Once all the groups have produced their brochures, create a database (either on computer or in a hand developed spreadsheet) so that all the species studied can be listed.

   If a computer is available, include various fields or categories, that will allow you to sort the amphibians by such characteristics as food requirements, temperature requirements, habitat requirements, etc.
2. With the various travel brochures finished, students should make presentations to the class on each of their species. Following all presentations, ask the following questions:

   a. which species of amphibians were

If the Conditions Were Right (continued)

selected the most (frogs, toads or salamanders, caecilians)?

b. what was one common requirement of all the amphibians?

c. what amphibians have actually "traveled" to different places and caused some problems for other animals?

d. what is the alternative for most amphibians to travel when conditions become unfavorable?

3. If the brochures are produced on computer, copy and bind the travel brochures. If the class is going to distribute these to the public, you may want to contact a local scientist or herpetologist to read the sheets and confirm the information.

   If the brochures are produced on posterboard, you could display them in the hallway or at some event.

Evaluation

Students should be able to present and discuss some interesting points about the ecology, behavior, and natural history of the selected species.(Including questions listed in the Procedure for the Teacher.)

Presentations and finished products can be graded on creativity, neatness, and organization—showing the effort level put into this project—use proper grammar, punctuation, and spelling, and amount of information included.

Extensions

1. Develop a travel video for amphibians. Critically review similar type media for people and then adapt it for amphibians. Remember for the amphibian video to cover similar content as for people and the topics outlined in the travel brochure.
2. Search through additional references for the mechanisms used by amphibians to tolerate changes in environmental conditions. What impact are humans having on these environmental conditions and how do you think amphibians will cope with these changes?

References and Resources

Behlet, J. L. and F. W. King. 1979. *Audubon Society Field Guide to North American Reptiles and Amphibians*. New York: Alfred A. Knopf.

Conant, R. and J. T. Collins. 1991. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America* (3rd Edition). Boston, MA: Houghton Mifflin.

Mattison, Chris. 1987. *Frogs and Toads of the World*. New York: Facts on File. Reprinted 1997.

National Wildlife Federation. 1987. *Ranger Rick's NatureScope*. "LET'S HEAR IT FOR HERPS." Washington, DC: National Wildlife Federation.

Nilsson, G. 1986. *The Endangered Species Handbook*. Washington, DC: The Animal Welfare Institute.

Oldfield, B. and J. Moriarty. 1994. *Amphibians and Reptiles of Minnesota*. Minneapolis, MN: University of Minnesota Press.

Smith, H. M. 1978. *A Guide to Field Identification: Amphibians of North America*. New York: Golden Press.

Stebbins, R. C. and N. W. Cohen. 1995. A *Natural History of Amphibians*. Princeton, NJ: Princeton University Press.

Internet Resource

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

This web site has an extensive list of links in its Frog Resources section to other relevant state, regional, national, and global anuran and amphibian web sites. It also has a "Frogs as Bio-Indicators Science Corner," which examines many of the factors influencing declining populations.

Education Standards

Minnesota

Middle Level:

1 Read, View, and Listen (nonfiction, technical reading)

2 Write and Speak (writing, interpersonal communication)

3 Arts (artistic creativity and performance)

6 Scientific Application (living systems)

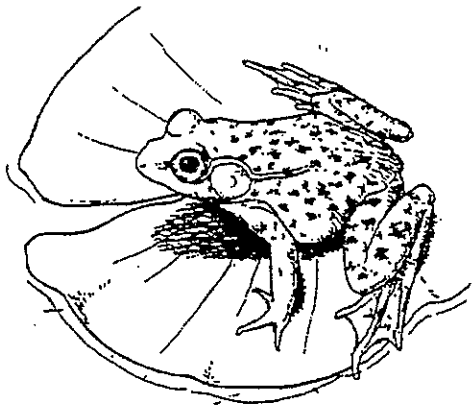
9 Resource Management (technology application)

National

Grades 5–8:

Content Standard C Life Science (regulation and behavior, diversity and adaptation of organisms

Content Standard E Science and Technology (abilities of technology design)



Safety Precautions
Watch out for:

1. **Predators:** snakes, birds, humans, automobiles, etc.

2. **Cold air:** the weather can get cold at any time!

3. **Parasites:** may be present

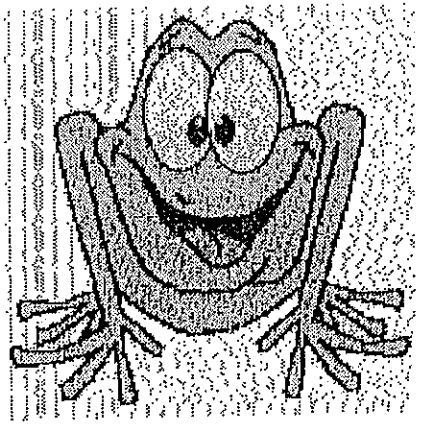
4. **Amplexus:** The MN Department of Herps (MNDH) warns against amplexus during your visit-may cause deformities.

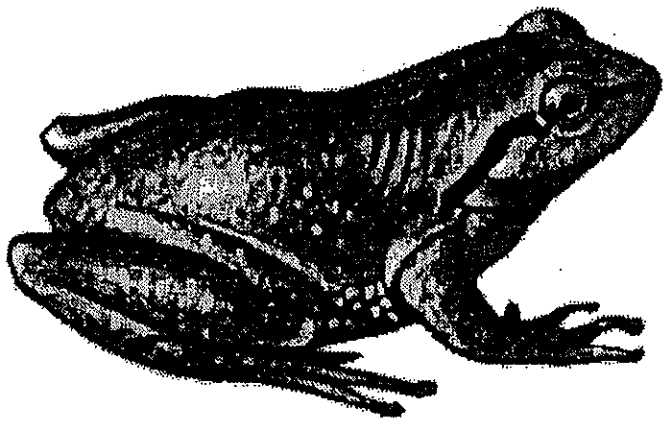
Practice safe amplexus!!

AAA
Amphibian Adventures Agency
3764 Lily Pad Lane
Ribbit, MN 55378

Discover Minnesota!

A Frog's Paradise





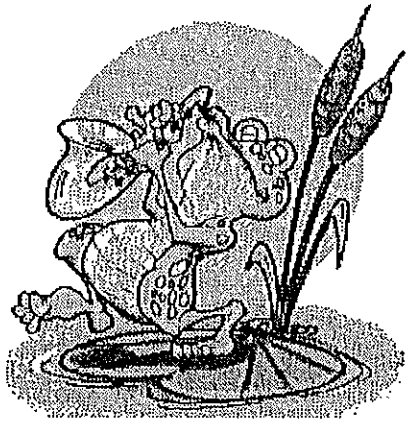
Amphibian Adventures found in Minnesota!

Leap into your own amphibian adventure and discover a frog's paradise in one of Minnesota's bountiful lakes, ponds, streams or rivers.

Things To Do

Minnesota, the "Land of 10,000 Lakes," is hopping with great features!

- **Lily Pads:** Get plenty of relaxation lounging on the green, green lily pads of Minnesota's refreshing lakes.
- **Insects:** Fatten up those anuran legs, with the excellent array of mouth-watering insects of Minnesota.
- **Concerts:** Enjoy the musical splendour of the finely practiced and world renowned "Minnesota Frog Choir." Concerts held nightly during the months of April-July.
- **Urban Adventure:** Create your own urban adventure with the diversity that Minnesota's landscape provides.



Climate

Spring: Lots of water, cool nights and warm days

Summer: Hot and humid

Fall: Cooler days and colder nights

Winter: Good for estivation!

Habitats

Lakes, ponds and rivers galore!

Grasslands

Wooded forests

Suggested Grades 7–12

Ribbit! Ribbit! Croak! Croak!

Concepts
different types of frog calls; different reasons for frog calls; visual representation of calls

Time
45–90 minutes to several days

Catalyst Question
What sounds do anurans make?

Background

Anurans (frogs and toads) make various types of calls or vocalizations for different purposes. These can include mating calls or defense calls. Anurans use *advertisement* calls in spring and summer to attract a mate. They squeeze their lungs with their nostrils and mouth shut. Air flows over their vocal chords and into their vocal sacs located on their throat, which then blow up like balloons. This is a physical act that you may have seen in nature documentaries. Some species can make noises without vocal sacs. Most frogs call at night and a number of different species can congregate around ponds and produce an incredibly loud chorus. Weather conditions can influence the intensity of the chorus. Depending on your state, frog choruses will differ in species composition and therefore intensity and duration.

Different frog species also produce *advertisement* calls at different times of the spring and summer. Some species will only call for a very short period of time, these are typically called *explosive breeders* because they congregate by a pond for a few days, breed, and then return to their adult habitat. *Prolonged breeders* are species that call for longer periods of time (several weeks). Other types of calls include:

1. *defense* calls when anurans are picked up by a predator or human.
2. *aggressive* calls made by a male when another male enters his breeding territory.
3. *rain* calls may be related to weather changes and made after the breeding season.

Because anurans are difficult to catch and monitor for population studies, many scientists use call surveys to estimate population levels of a species in a geographic region. These surveys can only be conducted at specific times of the years—when the frogs are calling to attract a mate.

In this activity, students will learn frog calls and that sound can be represented visually—such as from a musical score sheet or on a graphic equalizer in a music system.

Objectives

Following this activity, students will be able to:

1. identify four early calling frogs from a tape recording.
2. identify four early calling frogs from a visual representation of the call.
3. create a visual pattern to represent a frog call.

Materials

Frog call audio tape or CD; bird call tape or CD; audio tape/CD player (with a graphic equalizer would be perfect); sheet music; paper; pencil; posterboard; markers.

Procedure

1. Listen to some recent songs. Have the students brainstorm how these calls/sounds could be represented visually. Discuss some of these representations with them. Show and discuss sheet music as a visual representation of sound. In music systems you may have a graphic equalizer which shows the music levels as it plays.
2. Now listen to some bird calls. (Show the students how it is represented on the graphic equalizer.) Have the students practice drawing visuals of the bird calls.

3. Have students list other animals that use sounds in various ways. Ask the students about the purpose for animal calls. If frogs are not on the list, add them. Tell students that frogs will be studied in more detail. Students should study the mechanics involved in producing a frog call. List the four frogs to be studied on the board.
4. Students should divide a single sheet of paper into quarters.
5. Put one frog's name in each of the quarters.
6. Listen to the frog's call. Some calls are easily mimicked by people and on most audiotapes/CDs the narrator comments on what the frog call sounds like and may even give an example of it. Students should also discuss and decide if this makes it easier to represent the call.
7. Draw a visual of the frog call in the appropriate quarter.
8. Repeat #6 and #7 for each of the remaining three frogs.
9. Separate class into four groups.
10. Secretly assign each group one of the four frogs.
11. The group selects only one visual pattern for their frog and draws it on poster board.
12. Each group shows their call to the class and the class decides which frog made that call. The sound of that frog call is played so that the students can confirm that they

Ribbit! Ribbit! Croak! Croak! (continued)

were correct or incorrect. If incorrect, the group that produced the visual of the call is asked to select a more appropriate pattern. The group can also use written clues for the call so that other students can recognize and remember the call.

13. The next day, the teacher shows each visual call pattern to the class. Each student writes the name of the frog that produced this call pattern on a piece of paper.
14. Then the tape is played and the students identify the correct frog from its call. In addition, most tapes/CDs have examples of frog choruses with numerous species. One of these should be played so that the students can pinpoint the four species in this activity from other species.
15. This can be repeated for other frog species in the state.

(Optional: Students should learn more about the natural history of the frog/toad species whose calls they have studied.)

Evaluation/Review Questions

Students should be evaluated on their visual patterns for the four species of frogs. Were these correct and understandable by the students and teacher? Were the clues to remember these calls appropriate?

1. Why and how do frogs call? Do they call all year round?
2. There are many different amphibian species around the world, do they all call?
3. What are the mechanics involved in making a frog call?

Extensions

1. Frogs and other amphibians are disappearing at an alarming rate. What would spring be like if the frogs did not call? Write a perspective on the "silence of the frogs."
2. Are you concerned about disappearing frogs? Well then, get involved! In Minnesota, A Thousand Friends of Frogs and Minnesota Frog Watch are working with the DNR to monitor frog populations through a call survey: http://cgee.hamline.edu/frogs/

   Outside Minnesota, contact the North American Amphibian Monitoring Project (NAAMP), USGS Patuxent Wildlife Research Center, 12100 Beech Forest Road, Suite 4039, Laurel, MD 20708-4039, phone: 301-497-5500 or http://www.im.nbs.gov/amphibs.html
3. Most states do not have long term population data for frog species. In fact, population levels for many plants and animals are not well documented. However, bird populations have been studied for many years with the help of volunteers from various groups such as the Audubon Society. There are two main surveys: the Christmas Bird Count (CBC) and the Breeding Bird Survey (BBS). Locate information on these surveys (Audubon Society, *American Birds*) and compare the methodology of the survey to that of the frog call survey. http://www.audubon.org/bird/ cbc/index.html

References and Resources

A Thousand Friends of Frogs/Minnesota Frog Watch/MN Department of Natural Resources. 1997. *Toads and Frogs of Minnesota and Their Habitats*. Poster available from the MN DNR, Non-Game Program, St. Paul, MN or A Thousand Friends of Frogs, Hamline University, St. Paul, MN.

Conant, R. and J. T. Collins. 1991. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America* (3rd Edition). Boston, MA: Houghton Mifflin. (More recent identification guide and good information.)

Oldfield, Barney and John J. Moriarty. 1994. *Amphibians and Reptiles Native to Minnesota*. Minneapolis, MN: University of Minnesota Press.

Audiotapes

Eliot, L. 1992. *The Call of Frogs and Toads*. Post Mills, VT: Chelsea Green Publishing.

Minnesota Frog Watch. 1998. *Calls of Minnesota's Frogs and Toads*. St. Paul, MN: Hamline University/MN Frog Watch.

Wiewandt, T. 1982. *Voices of the Night: The Calls of the Frogs and Toads of Eastern North America*. Ithaca, NY: Library of Natural Sounds, Cornell Laboratory of Ornithology.

Internet Resources:

A Thousand Friends of Frogs Project · http://cgee.hamline.edu/frogs

This web site has an extensive list of links in its Frog Resources section to other relevant state, regional, national, and global anuran and amphibian web sites. It also has a "Frogs as Bio-Indicators Science Corner," which examines many of the factors influencing declining populations.

Education Standards

Minnesota

Middle Level:

1 Read, View, and Listen (nonfiction)
2 Write and Speak (interpersonal communications)
3 Arts (artistic creativity and performance)
4 Math Applications (patterns and functions)
5 Inquiry (accessing information)
6 Scientific Applications (living systems)

National

Grades 5–8

Content Standard A Inquiry

Content Standard B Physical Science (motions and forces)

Content Standard C Life Science (structure and function in living systems)

Suggested Grades 9–12

Get an Attitude

Concept
Survey techniques; data analysis

Time
90 minutes to develop and design survey, 90 minutes to compile and analyze results, 45 minutes for presentation of results

Catalyst Question
What kind of attitude is that?

Background

Since students began finding large numbers of deformed frogs in LeSueur County in August 1995, public awareness of the problem of amphibian decline and deformity has increased. Druing the 1990s, scientists became seriously concerned about the issue of gobal amphibian declines. They are examining possible causes such as pesticides and chemicals in the water, heavy metals in the soil, and parasite and genetic problems. Public awareness has now focused further attention on the troubling phenomenon of amphibian deformities, resulting in a major investigation on the part of the University of Minnesota and the Minnesota Pollution Control Agency. Elsewhere in North America and abroad, other scientists are involved in their own research related to this phenomenon.

Public awareness of an issue is important to maintaining support for scientific investigations. But how strong is public awareness and how do those concerned with an environmental threat keep attention focused on the issue? To measure this awareness, surveys are often performed. Terms such as reliability and validity of data should be used when creating the survey. A basic definition of *validity* is the ability to be able to generalize the results of the survey to other groups, places or times. *Reliability* has to do with the repeatability of the survey and obtaining similar results. Both validity and reliability are important in survey research and can be covered in a basic fashion, with the assistance of a math teacher. In addition, visit the web sites listed below for more detailed information.

Objectives

At the end of this activity, the students will be able to:

1. design a survey instrument to measure a person's opinions.
2. analyze data from a survey
3. present analysis in different forms.

Procedure

1. Divide students into working groups. Ask each group to choose an audience from whom they can generate opinions about the problem of frog deformity or the loss and pollution of wetlands. It might be students in the school, students from another school or part of the state, or a community group.
2. Have the groups design a survey that will measure the opinions of the selected group. In designing the survey, think about:

   What opinions do they want to know about?

   How many questions will there be?

   Will participants respond with narrative, or by checking terms like agree/disagree in response to given statements?

   How will the results be analyzed?

   How will the survey be distributed?
3. Create the survey.
4. Conduct the survey with the identified group.
5. Compile and analyze the results. Simple (such as percentages) or more advanced statistics might be used. Check with a math teacher to assist with the analysis.
6. Students should determine through research and possible interviews how those concerned with an environmental threat keep attention focused on the issue.
7. Each group produces a report, presents their results to the class and discusses the procedure followed for the research.

Evaluation/Review Quesitons

1. Were you surprised by any of the results?
2. Are there opinions that are difficult for you to accept?
3. What do you think should be done with the results?

Extensions

1. Perform survey research on other topics that are of interest to the students, or in your community.
2. Examine some research results in newspapers and magazine articles. What are the techniques used and how good are they?
3. Students should examine some past environmental issues and trace the development of the issue and how research and opinion polls were used in the issue.

References and Resources

Internet Resources

Survey Research Methods
http://www.ld.swin.edu.au/learning_guides/lsq201/contents.html

The Knowledge Base—An online Research Methods Textbook
http://trochim.human.cornell.edu/kb/kbhome.htm

Education Standards

Minnesota

2 Write and Speak (interpersonal communication)

5 Inquiry (controlled experiment)

National

Content Standard A Science as Inquiry (abilities necessary to do scientific inquiry)

Content Standard F Science in Personal and Social Perspectives (changes in environment)

Suggested Grades 9–12

What's the Big Idea?

Concepts
Environmental monitoring; data acquisition, validity, and reliability of data

Time
60 minutes (180 minutes if students research the problem)

Catalyst Question
What difficulties might you encounter in fieldwork?

Background

Monitoring and documenting the health of a state's amphibians is a complex process, as with any environmental issue. From the basic discussion over whether or not this is a critical problem to specifics about how to collect data, many conversations must take place before and during the launching of any investigation.

Objectives

Following the activity, students will be able to:

1. list the possible errors involved in fieldwork.
2. describe the characteristics of control sites in fieldwork.
3. trace some of the possible decisions involved in research.

Procedure

1. Propose one of the problems below to the class.
2. Divide students into pairs or small groups. Allow time to research, to discuss the problem, and to raise their own questions.
3. Have them share their conclusions and solutions with the class.
4. Repeat the process with the other two problems.

Problem I

Frogs live in an environment that is sometimes difficult for people to move through. Also frogs can be difficult to catch, even if they have deformed legs. Because of these types of problems in collecting field specimens, there are inherent errors in the accuracy of the sample. Develop a list of some errors you would expect to encounter in deformed frog field data. Try to determine and describe collecting methods that would eliminate some of these errors. How could you compensate for such sampling errors when reporting your results?

Problem II

Frogs' environment can be both similar and distinct from other areas depending on the environmental factor you are examining. Two ponds may have identical water sources but the depth may be different, or be the same size but have differing exposures to the sun. Given the wide range of environmental differences, it can be difficult to establish field control sites. What criteria would be important when choosing a control site? How would the criteria change if you thought that the problem was coming from atmospheric pollution? How about surface water or groundwater sources? Is it even possible to establish a field control?

Problem III

The monitoring of field sites can be expensive and time consuming. With apparent problems such as deformed frogs, who should pay for this monitoring? Who decides what sites or problems should be monitored? If government, what level of government should have primary control and what level final decision-making authority? What criteria should determine which sites or problems are addressed?

Evaluation/Review Questions

1. Were you and your partner or small group able to come to a consensus about these problems? Why or why not?
2. What were the strengths and weaknesses of the solutions and conclusions?
3. Taking this out of the classroom, what people or groups should be having these discussions?

Extensions

1. You and a team of scientists have to develop a research plan for the phenomenon of deformed frogs. Your team should recognize the subareas of the problem such as survey/monitoring work, analyses for specific causative hypotheses, etc., and come up with specific plans for each of these areas.
2. Examine the challenges facing researchers who are trying to track amphibian populations. Examine the methods used in both types of fieldwork and determine how volunteers can help in fieldwork situations.

References and Resources

Toepfer, Karen L. 1994. *Amphibians as Bio-Indicators.* Nebraska Department of Education.

Lannoo, M. (Ed.). 1998. *Status and Conservation of Midwestern Amphibians.* IA: University of Iowa Press.

Karns, D.R. 1986. *Field Herpetology: Methods for the Study of Amphibians and Reptiles in Minnesota.* Bell Museum of Natural History Occasional Paper 18.

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. A. C. Hayek, and M. S. Foster (eds.). 1994. *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians.* Washington, DC: Smithsonian Press.

Internet Resources

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

North American Amphibian Monitoring Program http://www.im.nbs.gov/amphibs.html

Education Standards

Minnesota

2 Write and Speak (interpersonal communication)

5 Inquiry (controlled experiment)

National

Content A Science as Inquiry (understanding about scentific inquiry)

Content Standard C Life Science (organisms and environments)

Content Standard F Science in Personal and Social Perspectives (changes in environment)

Suggested Grades 9–12

The Mystery of the Vanishing Frogs . . . and Other Amphibians

Concepts
Requirements for survival; environmental change; influence of change on populations; declines in populations

Time
90 minutes to several days

Catalyst Question
Did you see that frog disappear?

Background

Scientists believe amphibian populations (particularly frogs and toads) are declining. Declines in frog and toad populations around the world have been associated with a number of causes, including habitat loss and fragmentation, chemical pollution, ultraviolet radiation, acid precipitation, commercial harvest for food, and other causes. This is alarming to scientists (and should be a warning to you) because amphibians (frogs, toads, salamanders) are known to be bio-indicators—they are one of the first organisms to react to changes in the environment. Understanding what's happening with frogs and toads will help us understand how these problems affect humans. If the frogs and toads are being harmed, what's next for us? Your mission (should you choose to accept it!!) is to analyze why the frog populations are declining.

What is happening to the frog and other amphibian populations across the world? And is it really a mystery?

Over the last 50 years, many species of amphibians throughout the world have declined significantly in number. Some species have even become extinct. In many cases the declines are a direct response to the impact of human activities (such as habitat destruction or pollution) acting at a local level.

However, toward the late 1980s, scientists from many parts of the world reported declines in amphibian populations in relatively pristine areas, such as national parks and nature reserves, where habitat destruction and local pollution could not be implicated. Scientists began to ponder if impacts at a regional, national or global level could be influencing these species. This led to the suggestion that there may be one or more global factors that are adversely affecting amphibians. Can you list some of these possible impacts? (Air-borne contaminants, water-borne contaminants, global climate change.)

Also during this time period, another natural event was recognized for the first time. A thinning of the ozone layer, that protective layer which shields us from harmful ultra-violet radiation, was detected. Many scientists began to associate this increased UV radiation (in particular ionizing or UV-B radiation) penetrating to the earth's surface and the declining amphibian populations. But there were other possible candidates involved in this mystery.

Suspects involved in this mystery include:

1. habitat loss and fragmentation (breaking habitats into fragments);
2. chemical contamination: the effects of pesticides, acid precipitation, or the effects of fertilizers and herbicides;
3. introduction of exotic competitors and predators;
4. pathogens, including parasites and fungi.

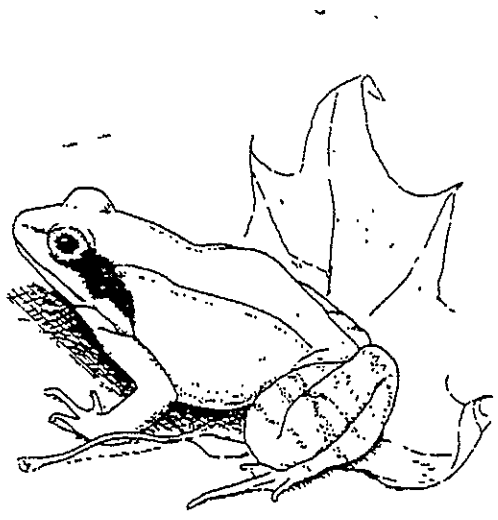
However, it is also important when examining this issue to remember some additional points. For example, when discussing declines it should be remembered that there are two types of decline: declines in size of a population (the demography—affecting the *number of individuals* in a population) and declines in the *number* of populations (impacting *diversity* of species). In addition, declines can occur at a local and global level. So, when examining a decline, which angle are you investigating? Other points to be considered: population fluctuations do not necessarily indicate a decline and while local habitat destruction may be detrimental to some species other species could thrive. So, how do all these clues play out in this mystery?

(For additional information, refer to the activity "The Case of the Missing Anurans?" on page 22.)

Objectives

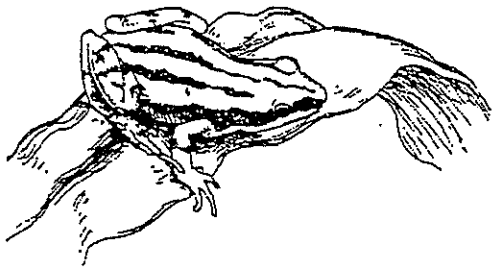
At the completion of this activity, students should be able to:

1. name and recognize some of the amphibian species that have become extinct or that are endangered on a local, regional, national or global level
2. list the main suspects involved in this mystery
3. give details and analyze the impacts of one suspect in this mystery
4. communicate the findings of the research to other students.



Suggested Grades 9–12

The Mystery of the Vanishing Frogs . . . and Other Amphibians (continued)



Materials

Paper; pencils; clue sheets from the activity "The Case of the Missing Anurans"

Procedure

1. Divide the class into groups of three or four students. Have them list the suspects that are involved in this mystery.
2. Groups should select a particular suspect that they are interested in and want to investigate on a deeper level.
3. From this, students will develop a hypothesis for their work. For example, the hypothesis could be "that _____ is the cause of the declining frog and toad populations."
4. Students should select the information from this activity which corresponds to their hypothesis and use this as a basis for their search. They should go beyond this information by using the references and resources in this activity.
5. From the information found students defend or refute the hypothesis. In other words, students must communicate whether they agree or disagree with the proposed hypothesis on frogs declines and why they agree or disagree with this.
6. Each group should present a final product in the form of a report which is presented to the other groups. The report should contain the chosen hypothesis plus research, and the conclusions. A written outline of the presentation to be delivered to the class is also a part of the final report. For example, who is involved in the report and the presentation, sequence of presentation, etc. This presentation can take the form of sharing the report orally with some visual elements—either a video presentation, a computer generated presentation, etc.

Evaluation

The presentation should meet the following criteria:

1. Clearly state the hypothesis researched by the group.
2. Clearly state the conclusion of the group and show this by referring to information found—written sources or Internet sources. Information from the Internet should be confirmed through multiple sources from the Internet or other written or expert sources. Be sure to cite the sources used in the report by author or the URL listing.
3. Neatness and organization—show the effort level put into this project—use proper grammar, punctuation, and spelling.
4. Extra credit will be awarded for creativity in the presentation.

Extensions

1. Read *Tracking the Vanishing Frogs* by Karen Phillips (New York: Penguin Books, 1994). The author follows this phenomenon when it was first discovered by scientists.

   You are a reporter with the environmental "beat" for your newspaper and have to write a story on what is happening to the frogs in the local area. Check out local resources (people and records) for clues and then analyze the issues and challenges facing frog populations in the area.
2. Amphibians have been around for an estimated 350 million years. The earliest known frog appeared about 190 million years ago, during what is known as the late Jurassic period. They have survived various natural events by being adaptive to their environment. You are a scientist working in the year 2050, and writing a report for a scientific journal. Describe the frog's environment and any changes which have occurred to it since the 1990s. Consider some of the following points in your discussion: the state of the environment—air and water quality, size of the human population, urban expansion, the frogs adaptations to these changes.

References and Resources

Barinaga, Marcia. 1990. "Where Have All the Froggies Gone?" *Science* 247:1033–1034 (March 2).

Blaustein, A. R. and D. B. Wake. 1995. "The Puzzle of Declining Amphibian Populations." *Scientific American* 272(4):52–57.

Bratass, Anne. 1996. "A Croak of Alarm." *St. Paul Pioneer Press*, pp. 1D, 2D (May 9).

Freda, Joseph. 1986. "The Influence of Acidic Pond Water on Amphibians: A Review." *Water, Air and Soil Pollution* 30:439–450.

Green David M. 1997. *Amphibians in Decline. Canadian Studies of a Global Problem.* St. Louis, MO: Society for the Study of Amphibians and Reptiles.

Hurd, Dean, Myrna Silver, Angela B. Bacher, Charles W. McLaughlin. 1988. *Physical Science.* Englewood Cliffs, NJ: Prentice-Hall, Inc. pp. 615–616.

Lien, Dennis. 1996. "In Search of Frog and Toad." *St. Paul Pioneer Press*, pp. 1A, 5A (November 11).

Suggested Grades 9–12

The Mystery of the Vanishing Frogs... and Others Amphibians (continued)

Mattison, Chris. 1997. *Frogs and Toads of the World.* New York: Facts on File Publishers.

Minneapolis Star Tribune. 1998. "Frogs of Scarce Species Turn Up in Twin Cities Area," pp. B3 (June 24).

Phillips, Karen. 1994. *Tracking the Vanishing Frogs.* New York: Penguin Books.

Phillips, Kathryn. 1990. "Frogs in Trouble." *International Wildlife* 20(6):6–10.

Pierce, Benjamin A. and Jeffrey Montgomery. 1989. "Effects of Short-Term Acidification of Growth Rates of Tadpoles." *Journal of Herpetology* 23(2):97–102.

Tangley, Laura. 1998. "The Silence of the Frogs." *US News and World Report,* pp. 50–51 (August 3).

Media Resources

Cane Toads—An Unnatural History. New York: First Run Features.

An extremely interesting and humurous video presentation of an invasion of an alien species. This toad is also causing many problems in Florida.

The Frogs. ABC Nightline Program. September 30, 1997. To order call 1-800-CALL ABC

This program is an excellent resource about the deformed amphibian issue and the scientific quest to determine what is causing this phenomenon. It examines the situation not only in Minnesota but in other states where deformed amphibians are being found. In addition, it discusses the various scientific theories behind this issue.

Internet Resources

A Thousand Friends of Frogs Project
http://cgee.hamline.edu/frogs

This web site has an extensive list of links in its Frog Resources section to other relevant state, regional, national, and global anuran and amphibian web sites. It also has a "Frogs as Bio-Indicators Science Corner," which examines many of the factors influencing declining populations.

Declining Amphibian Populations Task Force
http://acs-info.open.ac.uk/info/newsletters/FROGLOG.html

This is another organization with excellent information on the web. The organization's newsletter, FROGLOG, is also available on-line and has some interesting research reports from scientists around the world.

Education Standards

Minnesota

1 Read, View and Listen (nonfiction, technical reading)

2 Write and Speak (writing, interpersonal communication)

5 Inquiry (accessing information)

9 Resource Management (group resources, technology applications)

National

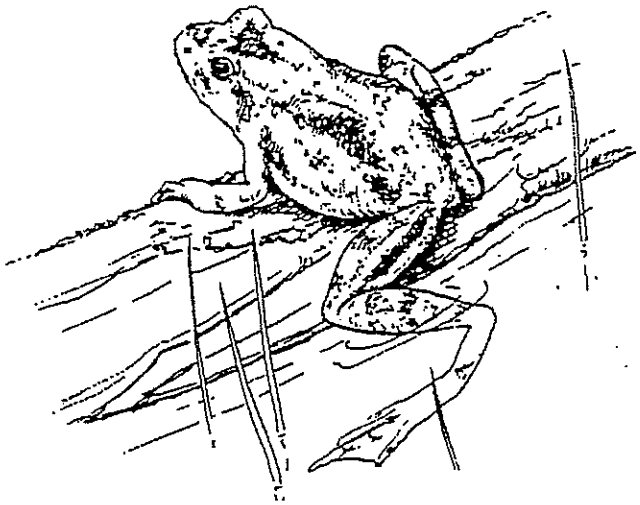
Grades 9–12:

Content Standard A: Science as Inquiry (activities necessary to do scientific inquiry, understandings about scientific inquiry)

Content Standard B Life Science (structure and function diversity and adaptation of organisms regulation and behavior)

Content Standard E Science and Technology (abilities of technological design)

Content Standard F Science in Personal and Social Perspectives (populations, resources, and environments, risks and benefits)



Suggested Resources

Additional resources accompany each activity.

Teacher Resources

A Thousand Friends of Frogs/Minnesota FrogWatch/MN Department of Natural Resources. 1997. *Toads and Frogs of Minnesota and Their Habitats*. Poster available from MN DNR, Non-Game Program, St. Paul, MN, or *A Thousand Friends of Frogs*, Hamline University, St. Paul, MN. Project web site: http://cgee. hamline, edu/frogs

A Thousand Friends of Frogs developed a Frog Trunk with lots of different resources for grades K–10. This is available from the Museum on the Move, Science Museum of Minnesota. Contact (651) 221-4748 for information about this resource.

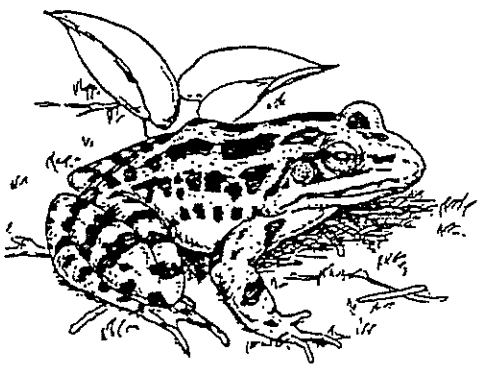
Braus, J. 1987. *Ranger Rick's Nature Scope: Let's Hear it for Herps*. Washington, DC: National Wildlife Federation.

Carin, Arthur A. and Robert Sund. 1980. *Teaching Science through Discovery*. Columbus, OH: Charles E. Merrill.

Kopp, J. 1992. *Frog Math*. Berkeley,. CA: Lawrence Hall.

Minnesota Volunteer. 1995. St. Paul, MN: Minnesota Department of Natural Resources, (May–June).

Minnesota Volunteer. 1996. St. Paul, MN: Minnesota Department of Natural Resources (May–June).



Oldfield, Barney and John J. Moriarty. 1994. *Amphibians and Reptiles Native to Minnesota*. Minneapolis, MN: University of Minnesota Press.

Toepfer, Karen L. 1994. *Amphibians as Bio-Indicators*. Topeka, KS: Nebraska Department of Education.

Frog Identification Resources

Books

Conant, R. and J. T. Collins. 1991. A Field Guide to *Reptiles and Amphibians of Eastern and Central North America* (3d Edition). Boston, MA: Houghton Mifflin.

Smith, H. M. 1978. *A Guide to Field Identification: Amphibians of North America*. New York: Golden Press.

Audiotapes

Elliot, L. 1992. *The Call of Frogs and Toads*. Post Mills, VT.: Chelsea Green Publishing.

Minnesota Frog Watch. 1998. *Calls of Minnesota's Frogs and Toads*. St. Paul, MN: Hamline University/MN Frog Watch.

Wiewandt, T. 1982. *Voices of the Night: The Calls of the Frogs and Toads of Eastern North America*. Ithaca, NY.: Library of Natural Sounds.

Student Resources

Caduto, Michael J. and Joseph Bruchac. 1991. *Keepers of the Animals*. Golden, CO: Fulcrum Publishing.

Chinery, M. 1991. *Life Story: Frog*. Mahway, NJ: Troll Publications.

Clarke, Barry. 1990. *Amazing Frogs and Toads*. New York: Alfred A. Knopf.

Clarke, Barry. 1993. *Amphibian*. New York: Alfred A. Knopf.

Julivert, Marice. 1993. *The Fascinating World of Frogs and Toads*. New York: Barens Education Series.

Robbins, Robin. 1995. *Frogs Are Fantastic*. Hong Kong: Reader's Digest Young Families, Inc.

Children's Story and Picture Books

A Frog Prince	Alix Berenzy
Those Fabulous Frogs	Melvin Berger
Seven Froggies Went to School	Kate Duke
A Chorus of Frogs	Joni Phelps Hunt
The Mysterious Tadpole	Steven Kellogg
It's Mine	Leo Lionni
Better Move on Frog	Ron Maris
The Salamander Room	Anne Mazer
Pig Pig Goes to Camp	David McPhail
The Prince of the Pond	Donna Jo Napoli
The Frog Prince	Jan Ormerod
The Frog Alphabet Book	Jerry Pallotta
Frog Medicine	Mark Teague
Hop, Jump	Ellen Stoll Walsh
I Toad You So–Riddles about Frogs & Toads	Rick & Ann Walton
Frog Went A-Courting	Wendy Watson

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