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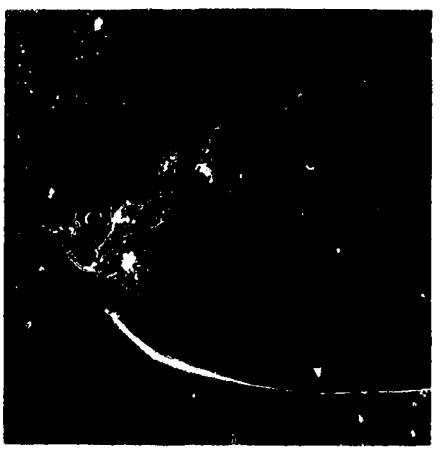
ABSTRACT

This monograph discusses the care and maintenance of animals, suggests some alternative teaching strategies, and affirms the value of teaching biology as the study of living organisms, rather than dead specimens. The lessons in this monograph are intended as guidelines that teachers should adapt for their own particular classroom needs. Chapter 1, "What Every Life Science Teacher Should Know About Using Vertebrate Animals in the Classroom and in Science Projects," discusses procurement and maintenance of animals, accidents involving animals, disposal of dead animals, and diseases that can be transmitted from animals to humans. Chapter 2, "The 3 R's: Reduction, Refinement, and Replacement," includes biology teaching objectives, alternatives that use the 3 R's, and lessons that use the 3 R's. Chapter 3, "Ethical Considerations," presents a field guide to the animal rights controversy and lessons that explore ethics. Chapter 4, "Resources," provides information on teaching materials, publishers and vendors, and selected organizations. Copies of the National Association of Biology Teachers (NABT) policy statement on animals in biology classrooms and the NABT guidelines for the use of live animals are included. Appendices include the following: (1) principles and guidelines for the use of animals from the National Academy of Science, the National Research Council, the Institute of Laboratory Animal Resources, and the Canadian Council on Animal Care; and (2) rules of the International Science and Engineering Fair, the Westinghouse Science Talent Search, the Animal Welfare Institute, and the Youth Science Foundation. Lists of 70 references and 50 curriculum guides consulted are provided. (KR)

The Responsible Use of

Animals in Biology Classrooms



Including Alternatives to Dissection

National Association of Biology Teachers

The Responsible Use of Animals in Biology Classrooms

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Monograph IV

A project of the
National Association of Biology Teachers

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About the Editor

Rosalina V. Hairston has been education director of NABT since 1987. Previously she taught at Bishop Ireton High School in Alexandria, Virginia. She brings to NABT more than 14 years of experience in science education in the areas of curriculum development, teacher education and research. Before coming to the United States, she was chairman of the Biology Workgroup of the Science Education Center at the University of the Philippines. In this capacity she organized and coordinated the Textbook Writing Committee for High School Biology and conducted teacher workshops and short-term laboratory technique courses for biology teachers. She also taught undergraduate biology courses and graduate courses in science education. Hairston worked on several occasions as a science educator with various UNESCO programs in Asia, Nepal and Paris. During a sabbatical at the University of Manitoba from 1980 to 1982, she taught courses in biology education, supervised student teachers and conducted workshops for teachers across Manitoba. She received her bachelor of science in zoology from the University of the Philippines in 1963. In 1973, she earned a Ph.D. in science education from the University of Texas at Austin. She has published numerous articles on curriculum development, concept formation, cognitive abilities of science students and science education in rural environments.

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Preface ■ About this Monograph

The National Association of Biology Teachers is dedicated to promoting quality life science education and encouraging its members to achieve the highest standards of instruction. We believe that developing in students a respect for life and an understanding of the fragile interrelationships and interdependence of all living things is one of the primary goals of life science education. With this in mind, NABT developed a policy on using animals in the classroom that includes a recommendation to use alternatives to dissection whenever possible. This monograph discusses the care and maintenance of animals and suggests some alternative teaching strategies.

NABT encourages teachers to reevaluate their use of dissection as they would any teaching technique to determine if it still satisfies the objectives of their biology course or if its disadvantages have begun to outweigh its advantages. If and when dissection is used, we want to insure that careful consideration has been given to the numbers and species used and to questions of safety, acquisition, use and disposal. NABT supports the prudent use of organisms and, through future workshops, hopes to continue to provide teachers with the knowledge and skills they need to adopt alternatives to dissection where and when possible.

The lessons in this monograph are intended as guidelines that teachers should adapt for their own particular classroom needs. The citing of specific products in the lessons should not be construed as an endorsement by NABT. Nor do the opinions expressed by various groups involved in the animal rights movement necessarily reflect the association's views. Some groups refer to the cutting apart of live or anesthesized animals as vivisection, but, for the purposes of this monograph, NABT defines dissection as the cutting apart of both live and preserved animals.

Patricia J. McWethy
Executive Director, NABT

Policy Statement

Animals in Biology Classrooms*

The National Association of Biology Teachers is actively committed to the support of quality biology education at the precollege and college level. The quality of biology teaching is determined in part by the classroom activities offered to students. Recently, dissection and vivisection have been the focus of criticism and growing dissent among students. Unfortunately, biology teachers may have little time or resources to cope with this concern.

As a service to its members, the National Association of Biology Teachers developed the following policy statement on the responsible use of animals in biology teaching, including alternatives to dissection. Recommendations for carrying out the policy are described in more detail in the monograph The Responsible Use of Animals in Biology Classrooms, Including Alternatives to Dissection.

The National Association of Biology Teachers believes that all biology teachers should foster a respect for life and should teach about the interrelationship and interdependency of all living things. Furthermore, they should teach that humans must care for the fragile web of life that exists on this planet.

In light of these principles, NABT supports alternatives to dissection and vivisection wherever possible in the biology curricula. These alternatives must satisfy the objectives of teaching scientific methodology and fundamental biological concepts. Implementing alternative methods in education does not mean excluding animals from the classroom. Certain teaching strategies allow for the continued, but modified use of animals, for example, observation in behavior studies and experimentation with invertebrates. Interactive instructional materials can be substituted that use state-of-the-art information technologies such as computer simulations, tutorials, videotapes and videodiscs on the biology of animals. Furthermore, NABT recommends the prudent and responsible use of animals in the life science classroom. This relates to a justification of the number and species of animals as well as proper husbandry practices. To assist in the implementation of this policy statement, NABT has provided further guidance in the above mentioned monograph. In addition, NABT will organize and conduct, across the country, teacher workshops that present alternatives to dissection and vivisection as well as the responsible use of animals in the life science classroom.

It is timely to reexamine the use of animals in precollege education. In many cases animals are present in the K-12 classroom so that students may learn about proper animal care and for them to observe social interaction. Using animals in teaching also provides opportunities to introduce ethical concerns and an ecological appreciation of animals.

The dissection of animals has a long and well established place in the teaching of life sciences. Well constructed dissection activities conducted by thoughtful instructors can illustrate important and enduring principles in biology. There has been increasing criticism recently of how and to what extent animals are used in biology classrooms and science projects at the middle school and secondary level. Students, parents and communities are becoming more outspoken in their objections to animal dissection. Faced with this controversy, teachers may have few resources and little time to deal with these

*Approved by NABT Board of Directors, October 1989

complex issues. Therefore, NABT is committed to providing teachers materials that offer alternatives to the more traditional practices involving dissection and vivisection.

The National Association of Biology Teachers recommends that teachers carefully consider alternative ways to achieve the objectives of teaching about the biology of organisms. These objectives should include the following:

- establishment of an understanding of the organism and its role in the environment,
- respect and appreciation for living things,
- humane treatment of animals,
- strict consideration for the safety and welfare of students and teachers,
- sensitivity to others' value conflicts.

The National Association of Biology Teachers is committed to providing information and teaching strategies for attaining these objectives. Furthermore, NABT supports the prudent use of organisms in the life science classroom and pledges to provide guidelines and direction for implementing this policy statement. NABT will disseminate information nationwide through its publications and teacher workshops.

Guidelines

NABT Guidelines for the Use of Live Animals *

Living things are the subject of biology, and their direct study is an appropriate and necessary part of biology teaching. Textbook instruction alone cannot provide students with a basic understanding of life and life processes. The National Association of Biology Teachers recognizes the importance of research in understanding life processes and providing information on health, disease, medical care and agriculture.

The abuse of any living organism for experimentation or any other purpose is intolerable in any segment of society. Because biology deals specifically with living things, professional biology educators must be especially cognizant of their responsibility to prevent the inhumane treatment of living organisms in the name of science and research. This responsibility should extend beyond the confines of the teacher's classroom to the rest of the school and community.

The National Association of Biology Teachers believes that students learn the value of living things, and the values of science, by the events they witness in the classroom. The care and concern for animals should be a paramount consideration when live animals are used in the classroom. Such teaching activities should develop in students and teachers a sense of respect and pleasure in studying the wonders of living things. NABT is committed to providing sound biological education and promoting humane attitudes toward animals. These guidelines should be followed when live animals are used in the classroom:

A. Biological experimentation should be consistent with a respect for life and all living things. Humane treatment and care of animals should be an integral part of any lesson that includes living animals.

B. Exercises and experiments with living things should be within the capabilities of the students involved. The biology teacher should be guided by the following conditions:
   1. The lab activity should not cause the loss of an animal's life. Bacteria, fungi, protozoans and invertebrates should be used in activities that may require use of harmful substances or loss of an organism's life. These activities should be clearly supported by an educational rationale and should not be used when alternatives are available.
   2. A student's refusal to participate in an activity (e.g., dissection or experiments involving live animals, particularly vertebrates) should be recognized and accommodated with alternative methods of learning. The teacher should work with the student to develop an alternative for obtaining the required knowledge or experience. The alternative activity should require the student to invest a comparable amount of time and effort.

C. Vertebrate animals can be used as experimental organisms in the following situations:
   1. Observations of normal living patterns of wild animals in their natural habitat or in zoological parks, gardens or aquaria.
   2. Observations of normal living functions such as feeding, growth, reproduction, activity cycles, etc.
   3. Observations of biological phenomenon among and between species such as communication, reproductive and life strategies behavior, interrelationships of organisms, etc.

Revised January 1990

D. If live vertebrates are to be kept in the classroom the teacher should be aware of the following responsibilities:
   1. The school, under the biology teacher's leadership, should develop a plan on the procurement and ultimate disposition of animals. Animals should not be captured from or released into the wild without the approval of both a responsible wildlife expert and a public health official. Domestic animals and "classroom pets" should be purchased from licensed animal suppliers. They should be healthy and free of diseases that can be transmitted to humans or to other animals.
   2. Animals should be provided with sufficient space for normal behavior and postural requirements. Their environment should be free from undue stress such as noise, overcrowding and disturbance caused by students.
   3. Appropriate care–including nutritious food, fresh water, clean housing and adequate temperature and lighting for the species–should be provided daily, including weekends, holidays and long school vacations.
   4. Teachers should be aware of any student allergies to animals.
   5. Students and teachers should immediately report to the school health nurse all scratches, bites and other injuries, including allergies or illnesses.
   6. There should always be supervised care by a teacher competent in caring for animals.

E. Animal studies should always be carried out under the direct supervision of a biology teacher competent in animal care procedures. It is the responsibility of the teacher to ensure that the student has the necessary comprehension for the study. Students and teachers should comply with the following:
   1. Students should not be allowed to perform surgery on living vertebrate animals. Hence, procedures requiring the administration of anesthesia and euthanasia should not be done in the classroom.
   2. Experimental procedures on vertebrates should not use pathogenic microorganisms, ionizing radiation, carcinogens, drugs or chemicals at toxic levels, drugs known to produce adverse or teratogenic effects, pain causing drugs, alcohol in any form, electric shock, exercise until exhaustion, or other distressing stimuli. No experimental procedures should be attempted that would subject vertebrate animals to pain or distinct discomfort, or interfere with their health in any way.
   3. Behavioral studies should use only positive reinforcement techniques.
   4. Egg embryos subjected to experimental manipulation should be destroyed 72 hours before normal hatching time.
   5. Exceptional original research in the biological or medical sciences involving live vertebrate animals should be carried out under the direct supervision of an animal scientist, e.g., an animal physiologist, or a veterinary or medical researcher, in an appropriate research facility. The research plan should be developed and approved by the animal scientist and reviewed by a humane society professional staff person prior to the start of the research. All professional standards of conduct should be applied as well as humane care and treatment, and concern for the safety of the animals involved in the project.
   6. Students should not be allowed to take animals home to carry out experimental studies.

F. Science fair projects and displays should comply with the following:
   1. The use of live animals in science fair projects shall be in accordance with the above guidelines. In addition, no live vertebrate animals shall be used in displays for science fair exhibitions.
   2. No animal or animal products from recognized endangered species should be kept and displayed.

Chapter 1. What Every Life Science Teacher Should Know About Using Vertebrate Animals in the Classroom & in Science Projects

An important objective of biology education is to foster respect for living things (Mayer 1973). This is done by introducing students to the complexity and diversity of organisms using both the traditional lecture format and direct contact with animals, whether preserved or living. Most biology classrooms feature living animals as classroom pets (referred to as "visitors" in the younger grades) and students are often asked to share in the responsibility of caring for these animals. It is thought that such daily contact with actual organisms helps young people learn about the conditions necessary for life as well as develop a respect for the intrinsic value of species other than our own.

At the middle school level, studying animal behavior through systematic and careful observation motivates students to learn more about animals. For some students, this classroom interaction may be their only contact with animals. Introducing secondary school students to animal studies through supervised research can reinforce early lessons and teach the procedures of scientific inquiry.

Whatever the reasons for using animals in the classroom, there are important guidelines that every life science teacher should follow. These will protect animals from needless pain and stress as well as safeguard the health of students. NABT recommends that a thorough understanding of the following guidelines, as well as those in the Preface, are necessary whenever animals are used in a classroom.

A. Procurement & Maintenance

Costs

1. The teacher should carefully examine the expenses involved in acquiring and keeping live or preserved animals. With live animals, consider the cost of housing, food, sanitary upkeep and health maintenance. Low food consumption and small physical size should be determining factors when selecting an appropriate species. The teacher should also consider which species is best suited to the learning environment and the instructional program. With

preserved animals, the cost ratio of animal per student should be examined. Students can team up to study an earthworm, a frog, or a fetal pig to reduce the number of animals purchased.

Buying

2. Animals to be used for genetic or behavioral experiments should come from biological supply houses so as to standardize their genetic background, age and health history. Animals meant only for classroom display (such as small rodents or fish) can be obtained from a local pet store, but be vigilant and avoid stores with poor reputations or unclean animal maintenance practices. Animals from shelters and the pound are not recommended as they have a high probability of carrying disease (Barnard 1989. p. 1).

   Preserved animals should be purchased only from a reputable supply house. Find out about the chemicals used for preservation and take appropriate precautions while handling the specimens. Many preserved animals should be soaked in water before allowing students to work with them so as to reduce toxic fumes. Check the label or call the supplier if you have questions.

Planning

3. Regardless of whether you buy live or preserved animals, the process should be well planned. Preserved animals must be ordered, and you should know where you will store them prior to use. Whenever you purchase live organisms do as much research as possible before they arrive to prevent costly or painful mistakes. Housing, food, temperature and other environmental requirements should all be carefully thought out. Consider whether this is a social species that requires companions to be comfortable and think carefully about allowing breeding to take place. Provisions should be made for separation of the sexes if frequent reproduction is not desirable.

   When purchasing an unfamiliar species, consider the following characteristics (Orlans 1977, p. 2). The species should:

   a. be hardy and able to thrive in captivity.
   b. have readily duplicated natural habitats.
   c. be fairly simple to care for and not present problems for weekend and vacation care.
   d. not require extensive housing space or have difficult food requirements.
   e. be tolerant of handling.

Never buy threatened/endangered species or those from a fragile habitat. Keeping wild animals in the classroom is a risky venture: in addition to safety and ethical considerations, you should be aware of any pertinent regulations. For more information at the federal level, consult your local branch of the U.S. Department of Interior, Land Enforcement Office. At the state level, seek advice from the department of game and fisheries' law enforcement office.

Housing

4. Housing is an extremely important consideration for classroom animals. The cage or aquarium should be designed for the animal's physical and mental comfort *first*, and for aesthetic reasons *second*. A good cage or aquarium does the following:
   - contains no sharp edges or broken wires
   - keeps food and water accessible and clean
   - allows sufficient space for normal activities, including exercise (see #5)
   - maintains optimum temperature and adequate light
   - allows for regular maintenance with minimal disturbance to the animals
   - provides privacy so that animals occasionally can withdraw from the bright lights and noise of a classroom

A schedule of sanitary maintenance is absolutely necessary. Small rodents must have their litter changed at least once a week. Problems with odor and insect pests can accumulate rapidly if cages are not cleaned regularly. Dirty aquariums make it difficult to see the fish and invite bacterial disease. Such conditions will not encourage students to respect or learn more about animals.

Avoid using pesticides for any insect problems in your classroom. Keeping cages clean should control pests; pesticides will harm invertebrates, amphibians and fish and pose a risk to vertebrates, including students and teachers!

Exercise

5. Exercise is of vital importance to the health and well-being of caged mammals (Orlans 1977, p. 263). Every few days, try to offer some new playthings to your rodents, such as walnuts, toy ladders, doll furniture, empty cans and wooden or plastic wheels. Check carefully for sharp edges or toxic substances; remember the animal might chew on the item. There are two types of exercise wheels–the ferris wheel and enclosed disks. The size of the ferris wheel should be three

times the length of the animal. Wheels with rungs should not be used with gerbils or other animals with long tails as they can cause injury to the tail.

Food & water

6. Maintaining a regular feeding schedule will help ensure that animals are not over- or underfed. This is especially important for fish, as aquariums can quickly become fouled by the presence of too much food. Keeping a feeding checklist by the aquarium or cage or assigning one student the task of feeding can be an effective way of controlling the amount of food given to classroom animals.

   Fresh water is more important than food to most animals. Water dishes should be cleaned and refilled daily; they can easily become contaminated. Use water bottles, not dishes, for rodents and be sure that litter, an absorbent, does not touch the spout; it quickly can absorb all the water in the bottle.

   Be sure to plan for adequate feeding and care over weekends and holidays. Most small animals and fish can manage two days without attention, but be prepared to see to their needs first thing on Monday morning. Don't wait until the last minute to arrange for a student to take an animal home over a holiday. Check with other teachers in the school who may have animals or plants that will require holiday care–sometimes you can pool resources.

Veterinary care

7. When animals are ill or injured, veterinary medical attention should be provided immediately. Veterinarians should be consulted about procedures for disease surveillance and containment. When euthanasia is called for, a veterinarian should perform the procedure in his office. No student should be allowed to witness the procedure.

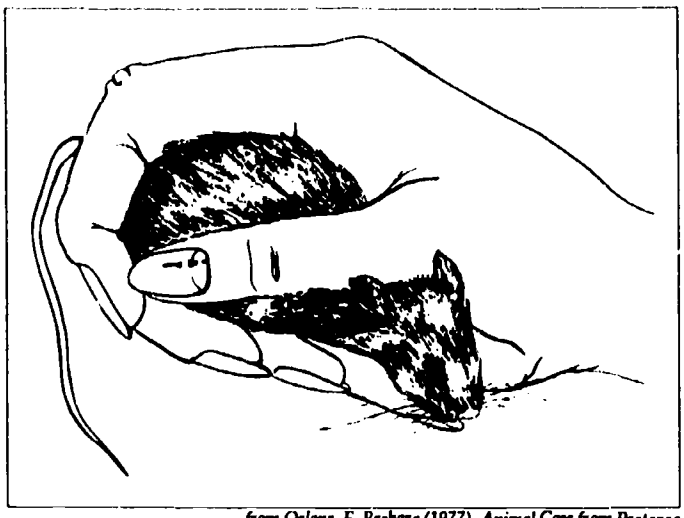
Handling

8. In general, animals should be handled slowly and carefully. Be certain that the water in an aquarium is the correct temperature before adding fish. The best way to do this is to float the closed bag containing the fish in the aquarium for 15 minutes to allow the water in the bag to slowly reach the temperature of the aquarium. Then open the bag and allow a small amount of aquarium water to enter. After another 15 minutes have passed, allow the fish to slip out of the bag into the aquarium. When you use a net, be sure to cup it gently in your hand so that the fish does not flip itself out onto the floor.

   Frogs and toads depend on moist, clean skin for respiration. Therefore, it is essential that they are handled as little

as possible and only when your hands are clean and wet. Be aware that many amphibians exude toxic substances as a defense against predators, so be sure to wash your hands thoroughly after touching them.

Small rodents should be handled gently to avoid hurting them and to prevent them from biting. Some people prefer to use gloves, but this is not a requirement if the following techniques are used.



from Orlans, F. Barbara (1977). Animal Care from Protozoa to Small Mammals. Addison-Wesley Publishing Co., Inc.

Figure 1.1. The proper way to hold a mouse.

Mice:

Mice are usually picked up by the tail. The tail should be grasped at the base. A preferred way of holding a mouse is to secure it in your cupped hand. See Figure 1.1 (Orlans 1977).

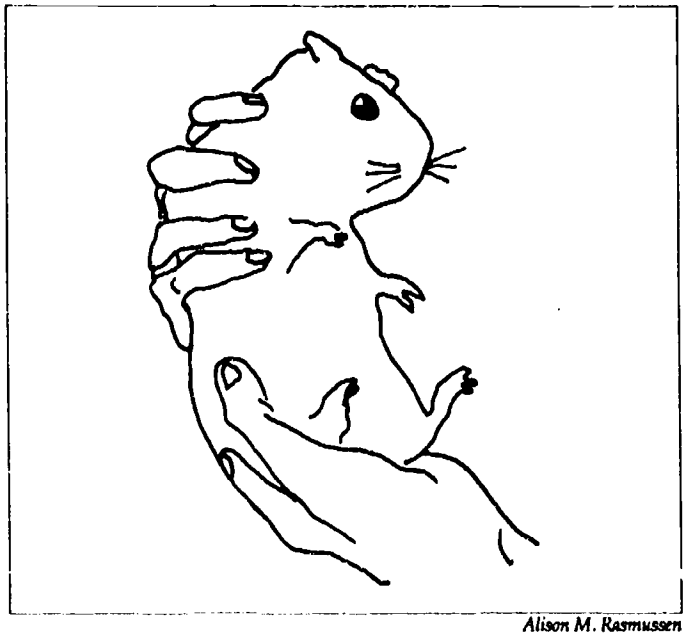


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Figure 1.2. How to hold and restrain a guinea pig.

Guinea Pigs:

Guinea pigs seldom bite, but they are easily frightened and usually make determined efforts to escape when held. It is best to hold them by placing your thumb and forefinger around the neck, with the palm of your hand over the back and your other fingers grasping the body. When lifting a guinea pig, use your other hand to support the lower part of its body (see Figure 1.2). You should always exercise special care when handling pregnant females since they may become very heavy.

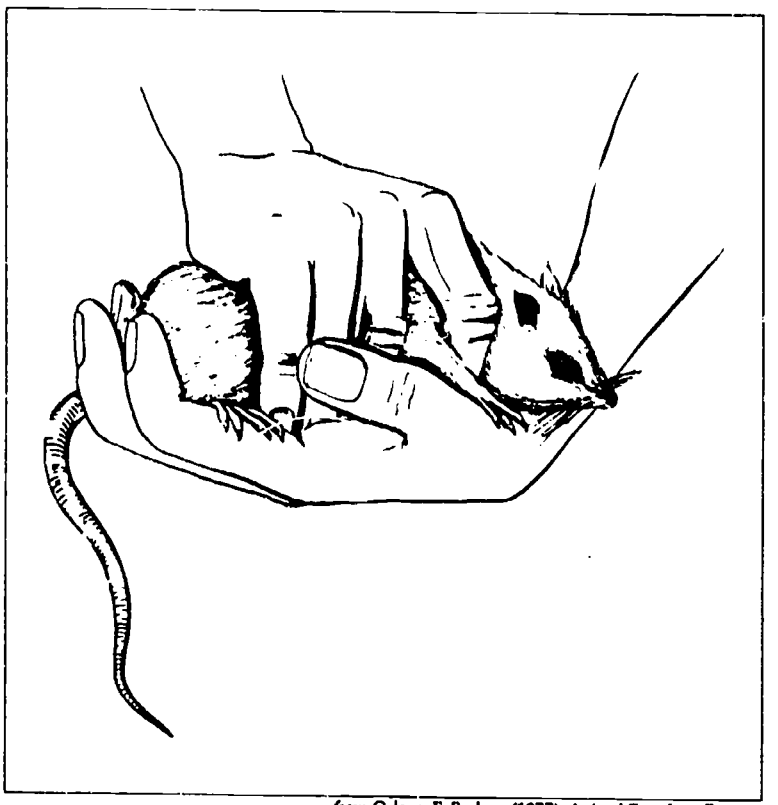

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Figure 1.3. The proper way to lift a rat.

Rats:

Rats normally are lifted by gently grasping the whole body. Initially, the rat may be caught by the base of the tail. See Figure 1.3 (Orlans 1977).

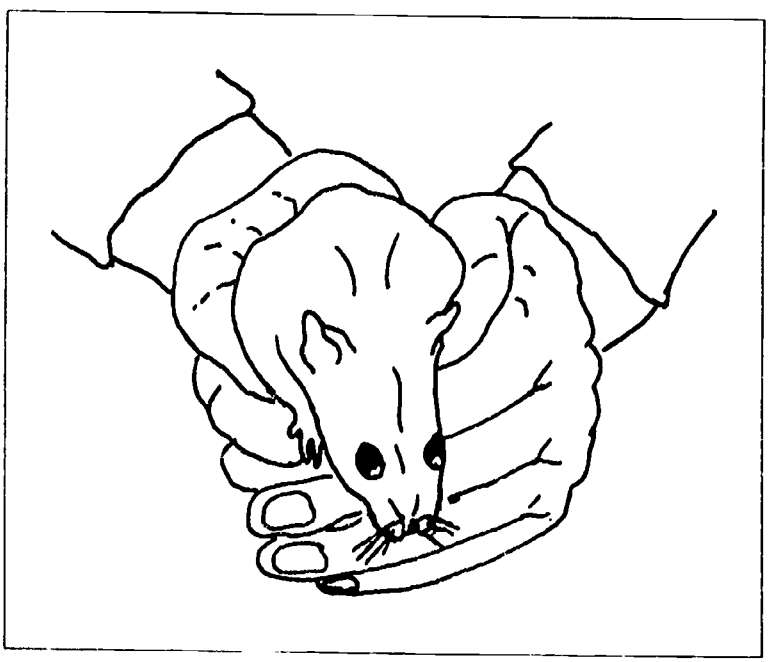

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Figure 1.4. Always use two hands when lifting hamsters.

Hamsters:

Hamsters will bite quickly and deeply when agitated. Several methods may be used in handling hamsters. One is to cup both hands to hold the hamster in your palms. Another is to pick them up in a method similar to that used for a rat. Putting your thumb under its chin and your forefinger around its neck affords good control. See Figure 1.4 for the proper way to pick up a hamster.

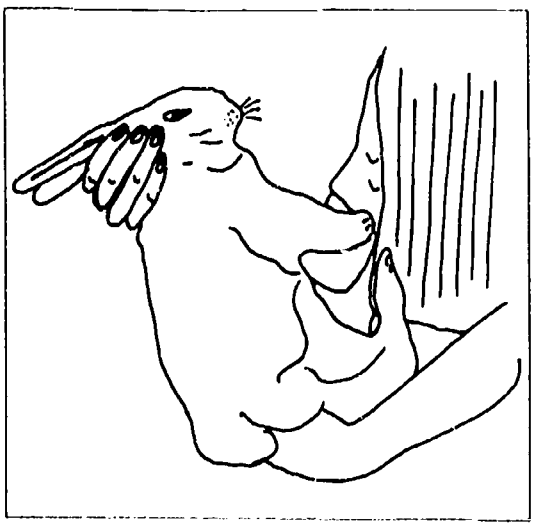

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Figure 1.5. Hold the scruff of fur and skin behind the rabbit's neck to provide control while using your other hand to support the rear legs. Use this method when lifting a rabbit from its cage.

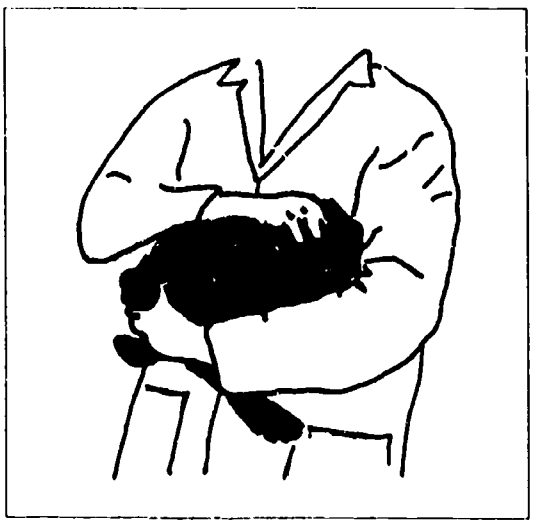

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Figure 1.6. A rabbit usually remains quiet when being carried if it is well supported and has a place to tuck its head. This should not be used in situations where the rabbit could become agitated.

Rabbits: Rabbits seldom bite, but can inflict painful scratch wounds, especially with their hind feet. Hold them in a way that allows direct control of their hind feet (see Figures 1.5, 1.6). Grasping the loose skin over the shoulder with the head directed away from the holder is the best method of initial restraint. When lifting, support the lower part of the rabbit's body with your other hand. Rabbits should never be lifted by their ears. If the rabbit begins to struggle violently and develops rotational movement with the hind quarters, it immediately should be placed on a solid surface and calmed. Continued violent struggling frequently leads to the fracture of one or more lumbar vertebrae and a fatal injury to the spinal cord. Rabbits can be placed in a state of hypnosis by gently rolling them on their back and slowly stroking the abdomen (American Association for Laboratory Animal Science 1989).

Gerbils: Gerbils respond to and are effectively handled by the general methods indicated for other small rodents. Avoid holding gerbils near the tip of the tail. Pregnant gerbils or females with young can be unexpectedly aggressive.

B. *Accidents Involving Animals*

Attempting to restrain an animal too tightly or picking up an animal in a way that scares it, causes it pain or poses a threat to an animal with babies can result in a bite or deep scratch. There is little chance that a student will become ill from such injury, but proper precautions should be taken immediately. Broken skin should be washed thoroughly with soap and water and then treated with an antiseptic. The teacher should report the incident to the school nurse. If an animal that has bitten a person becomes sick or dies within 14 days, it should be sent to the local health department so its brain can be examined for rabies.

Even if an animal has not inflicted injury, all persons handling it should wash their hands thoroughly before and after contact. This is to protect both animals and people and to avoid the transmission of bacteria such as *Salmonella* which can be found on some small animals, particularly turtles. In addition, some students may be allergic to animal dander and develop a reaction after touching or being near the animal. Any rash or irritation occurring after animal contact should be examined by a doctor.

C. *Disposal of Dead Animals*

As a general principle, animal bodies must not be disposed of by incineration or other methods until *rigor mortis* occurs and the animals are quite stiff. This is to ensure that the animal actually is dead and not comatose. The teacher should consult the school's safety officer or review the county's sanitation regulations for information on disposal of dead animals. Some counties prohibit burying animal carcasses. For advice, consult your local Humane Society office or the local animal shelter.

D. *Zoonoses*

Zoonoses are animal diseases that can be transmitted to humans. Such diseases may be transferred from animals to humans, sometimes through a vector (e.g., fleas, ticks), or from humans to animals. When live animals are kept in the classroom either as pets/visitors, for observation, or for dissection, the teacher should be aware of certain diseases that may be hazardous to humans.

The list that follows presents some of the more common zoonotic diseases. Note: For most of these, proper handling of waste and avoidance of wild animals will protect students and teachers. The list is arranged alphabetically.

Selected Zoonotic Diseases of Concern When Using Animals in Precollege Education*

Hymenolepis nana

Transmission ..... Ova shed in feces of infected rodents (unlike other trematodes and cestode, does not require an intermediate host)

Entry ..... Accidental ingestion/improper hygiene during cleaning of cages

Results ..... Diarrhea and vomiting

Lyme Disease

Transmission ..... Carried by deer tick

Entry ..... Tick bite

Results ..... Fever, headaches; risk arthritic, neurologic, cardiac complications

Murine typhus

Transmission ..... Rat fleas

Entry ..... Flea bites

Results ..... Fever

Pasteurellosis ("snuffles")

Transmission ..... Carried in oral cavity and upper respiratory tract, especially in rabbits

Entry ..... Bite or scratch from infected cat or dog; feces of infected rabbits

Results ..... Respiratory infection to acute septicemia of short duration

Psittacosis

Transmission ..... Dust from feces or feathers of parakeets, pigeons

Entry ..... Inhalation

Results ..... Respiratory problems

Rabies

Transmission ..... Rabid dogs, bats and wild mammals such as skunks, raccoons, foxes

Entry ..... Bites

Results ..... Death

Rat Bite Fever

Transmission ..... Rodents

Entry ..... Rodent bites

Results ..... Fever

*Listing compiled from: Gunnels Uniformed Services University of the Health Sciences, Merck Veterinary Manual and Dr. Margaret D. Snyder, Laboratory Animal Center, Ohio State University.

Rickettsial Pox

Transmission ..... Mice carrying infected mites

Entry ..... Bites from mites

Results ..... Rash

Ringworm

Transmission ..... Variety of domestic, farm and wild animals

Entry ..... Direct contact/contact with contaminated bedding

Results ..... Skin lesions

Rocky Mountain Spotted Fever

Transmission ..... Ticks carrying *R. rickettsia* found on field mice, meadow voles and dogs; most cases occur from May 1 to July 31

Entry ..... Bites from ticks; body fluid of infected tick coming in contact with broken skin

Results ..... Rash, extremely high fever, headaches

Salmonellosis

Transmission ..... Dogs, cats, wild mice, birds, reptiles (especially turtles) and amphibians

Entry ..... Ingestion/unhygienic handling of infected animal

Results ..... Diarrhea, nausea and fever

Tetanus

Transmission ..... Animal wastes infected with spore-forming bacteria called *Clostridium tetani*

Entry ..... Deep open wound

Results ..... Tetanus or lockjaw (a condition in which the jaws become firmly closed because of spasmodic muscular contraction)

Toxoplasmosis

Transmission ..... Ova shed in feces of infected cats

Entry ..... Accidental ingestion of litter dust; poor domestic hygiene

Results ..... Fever, flu-like symptoms

Note: *In pregnant women who have never been infected, the ova will cross the placenta and infect the fetus. The pathogen will cause neuromuscular damage to the fetus even if contracted in the third trimester.*

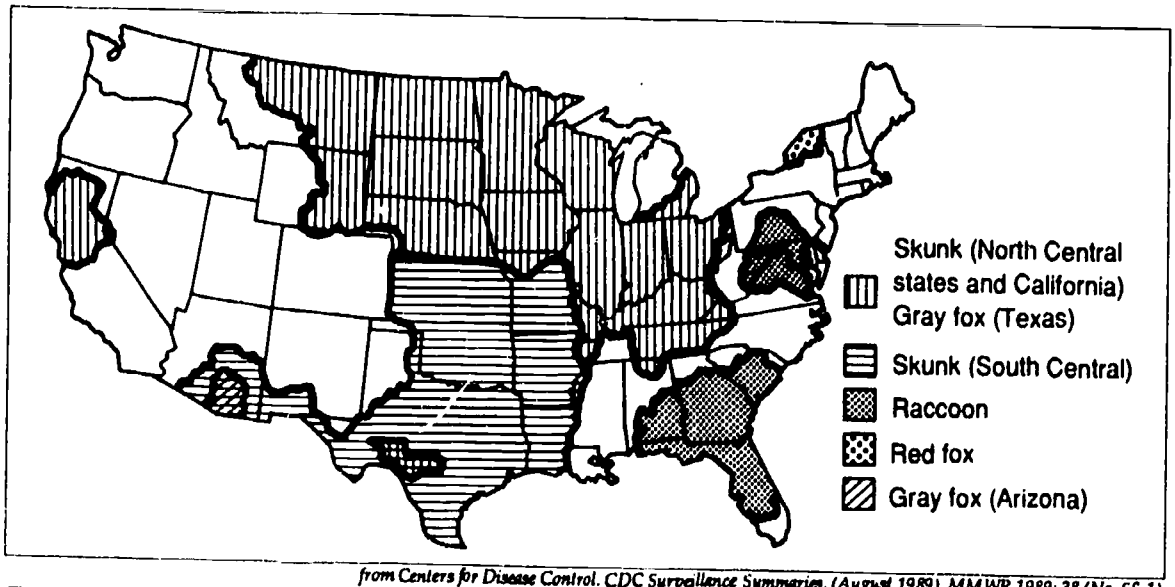
Rabies Update

Rabies is an acute infectious disease caused by a virus and transmitted by the saliva of a rabid animal. When a rabid animal bites, the infected saliva contaminates the wound and the virus gains entry into the body of a new host.

Immunization is the most effective way to control the spread of rabies. All dogs and cats kept as pets must be vaccinated against rabies at three months of age and revaccinated as indicated by a veterinarian. Stray dogs and cats should be removed from the community, especially in areas where rabies is prevalent.

There is no vaccine licensed for use in wild animals. The public is warned not to handle wild animals, including injured animals and roadkills. Wild, carnivorous mammals and bats (as well as the offspring of wild animals crossbred with domestic dogs and cats) that bite people should be killed and the brain submitted to a laboratory for rabies examination. A person bitten by any wild animal should immediately report the incident to a physician who can evaluate the need for anti-rabies treatment.

The Centers for Disease Control's 1988 rabies surveillance report says that 88 percent of reported rabies cases occurred in wild animals, 12 percent in domestic animals. Skunks, raccoons and bats accounted for 82 percent of all rabid animals. Foxes and mongooses are among wild animals that showed a low incidence of rabies. Among domestic species, cats were the most commonly reported carrier.



from Centers for Disease Control. CDC Surveillance Summaries. (August 1989). MMWR 1989; 38 (No. SS-1).

Figure 1.7. Distribution of five antigenically distinct rabies virus strains and the predominant wildlife species affected in the contiguous United States, 1988.

Chapter 2. The 3 R's: Reduction, Refinement & Replacement

The editor of *The Science Teacher* (September 1988, p. 8) reports, "We've received dozens of letters this year from readers who plan to abandon 'dead biology.'" The dissection controversy permeates the educational system from the biology teacher and student to the principal and, in some cases, up to the school board. The issues and controversy have prompted legislative bodies, including those in California and Florida, to create laws regulating the use of certain animals in classrooms.[1] Alternative teaching activities need to be identified or developed and a mechanism designed to make these alternatives available to teachers.

Dissection has not always been a part of biology instruction. It was not commonly used in high school classes

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[1]In California, Assembly Bill 2507(Speier) has passed and is now incorporated as Chapter 2.3 in Part 19 of the California Education Code, Section 32255. The main intent of the law is to give students in kindergarten through grade twelve the right to refuse or refrain from participation in activities that they feel would constitute the "harmful and destructive use of animals." Though agricultural programs are exempt from this mandate, the students' right extends to all other subject areas, including but not limited to, biology, physiology, home economics and outdoor biology programs. If the student chooses to refrain from participation, and if the teacher believes that an adequate alternative education project is possible, then the teacher may work to develop and agree upon an alternate avenue for helping the student obtain the knowledge, information, or experience (memo from California State Department of Education, Curriculum and Instructional Leadership Branch, April 10, 1989).

The Florida legislature has enacted a bill stating that no surgery or dissection shall be performed on any living mammalian vertebrate or bird. Dissection may be performed on nonliving mammals or birds secured from a recognized source of such specimens and under supervision of qualified instructors. Students may be excused upon written request of a parent or guardian. Lower orders of life and invertebrates may be used in such experiments. In addition, nonmammalian vertebrates, excluding birds, may be used in biological experiments, provided that physiological harm does not result from such experiments. Anatomical studies shall be conducted only on models that are anatomically correct for the animal being studied or on nonliving nonmammalian vertebrates secured from a recognized source of such specimens and under the supervision of qualified instructors. Students may be excused from such experiments upon written request of the parent or guardian. (Florida Statutes 233.0674 Biological experiments on living subjects 1988.)

until 1920 (Orlans 1988a) and did not become a pervasive part of the typical course until the establishment of the Biological Sciences Curriculum Study in the 1960s. At that time, crayfish, grasshoppers, mollusks, starfish, sharks, frogs, fetal pigs and cats all became regular candidates for dissection by high school students. The use of live animals in elementary grades was encouraged by the Science Curriculum Improvement Study, whose program involved large quantities of guppies, tadpoles, fruit flies, crickets and snails (Emmons 1980).

In 1987, Jenifer Graham received nationwide attention when she went to court after her grade was lowered because she refused to dissect a frog in biology class. This incident brought into focus the public and educators' changing attitudes toward dissection. As groups devoted to animal rights gain members and the media continues to address the ethical questions surrounding the use of animals in food production, fur manufacturing and medical research, the dissection controversy is not likely to disappear.

Among the arguments in favor of dissection are:

1. It's a hands-on experience that allows students to participate in a personal exploration (Updike 1989).
2. It allows students to see and learn the physical placement of organs, the appearance and texture of tissues and organs, and the relationship of structures with one another (Berman 1986).
3. It illustrates the idea that the animal body is a complex arrangement of functioning organs (Schrock 1990).
4. It develops manual dexterity in using dissection instruments (Delaware Association of Biology Teachers 1990).

The opponents of dissection use the following arguments:

1. It's a desensitizing experience for students (Leib 1985).
2. It can be perceived as condoning the desecration of a dead body (Santopoalo 1985).
3. Students might do a poor dissection; the activity becomes a "hack and slash" experience. The amount of information learned is often less than and inferior to that gained from a lesson without dissection (McCollum 1988).

4. It is not moral to harm animals when there is no compelling reason and when alternative activities can teach the same content and skills (Orlans 1988a).
5. High school biology should emphasize contemporary subjects such as genetics, cell biology, etc., with an emphasis on teaching thinking, not memorization (Waters 1990).
6. Dissection does not foster a reverence for life. This should be a part of the objectives of a biology course (Russell 1980).

There is a growing awareness among teachers and students that the wanton collection of animals brings about an imbalance in natural populations. A blend of ecological, ethical and moral concerns has provoked many students and teachers to question the justification of dissection as well as the use of animals in classroom experiments and science fair projects.

The following questions are intended to help teachers focus on various considerations when deciding whether to dissect and whether to keep and use live animals for instruction. The questions are classified into three categories: Dissection, Live animals and General.

Dissection

1. Is dissection necessary for all students in the elementary grades, in middle school and in high school?
2. Are the intended instructional outcomes significant enough to warrant the use of preserved or live animals?
3. Is it necessary for each student to have an animal to dissect or could one teacher-prepared demonstration be substituted?
4. Have I taken steps to ensure proper ventilation in the laboratory? Do students understand adequate safety precautions for the use and storage of instruments such as scalpels, razors, scissors and probes?
5. Have I made provisions for the proper and safe disposal of animals after dissection?
6. Can the procedures and skills be taught effectively using an alternative?
7. Are there alternate activities for students who object to dissection on a philosophical or moral basis?

Live animals

1. Am I aware of my responsibilities for the health and safety of students when I keep live animals in the classroom?
2. Have I thoroughly and objectively examined my reasons for using animals in the classroom?
3. Am I using animals in my classroom because of academic tradition?
4. Am I well trained to ensure that experimental procedures are done appropriately and humanely?
5. Am I aware of proper husbandry and handling techniques so I can give proper instruction to students?
6. Can I properly care for the animals in the classroom, even during holidays and summer vacations?

General

1. Have I considered students' feelings about living organisms when using them in my classroom?
2. Does the use of dead organisms or the killing of an animal provide students with an understanding of or respect for life?
3. Have I considered that collecting frogs and other animals from the wild contributes to a significant depletion of the population, resulting in an imbalance of an ecosystem?
4. Is it justified to conduct experiments that cause pain and harm to vertebrate animals?

Section A that follows presents research on the role dissection plays in state-mandated objectives of American school systems. Section B provides alternative lessons that can be used to replace or reduce the amount of dissection and live animal experimentation in biology classes.

Section A. Biology Teaching Objectives

NABT examined state curriculum frameworks and school systems' guidelines to determine which teaching objectives required dissection as the instructional method. These objectives were summarized and presented at various NABT workshops and validated by participants. The objectives were then classified according to the following domains: cognitive, affective, psychomotor and scientific inquiry. This classification is based on *Bloom's Taxonomy of Educational Objectives* (1956) and *Kloefer's Table of Specifications for Science Education* (Bloom, et al. 1971).

This list of objectives represents goals that any alternative to dissection must be able to achieve. Section B (following the list) presents lessons that reduce, replace or refine dissection while still meeting these objectives.

Cognitive objectives

1. To orient students to the gross anatomy and body plan of organisms.
2. To recognize major external structures.
3. To recognize major internal structures.
4. To locate organs of the different systems.
5. To determine the function of an organ.
6. To list structural characteristics of organisms belonging to specific phyla.
7. To label diagrams and illustrations of structures in an animal.
8. To recognize the structures of animals adapted for specialized functions.
9. To describe the organization and relationship between an organism's structure and function.
10. To demonstrate unique animal traits (e.g., regeneration).
11. To determine the interrelationships among tissues and organs.
12. To classify organisms in the major taxonomic categories (Kingdom, Phylum, Class, etc.) based on similarities in structure.

Affective objectives

1. To foster an awareness of the interrelationships that have existed among organisms through time.
2. To perceive the pattern of complexity of structure and function, as well as the beauty and economy of designs in different organisms.
3. To acknowledge the delicate balance between organisms and their environment.

4. To appreciate the elegant diversity in structures of organisms.
5. To appreciate the organism as a holistic entity rather than a collection of organ systems.
6. To teach responsible attitudes toward animals (e.g., care, breeding, etc.).
7. To instill an interest in pursuing a career that involves studying and caring about animals.

Psychomotor objectives

1. To use the senses to observe organ systems' structures.
2. To select tools for dissection and use them properly.
3. To examine histological sections of certain organs.
4. To measure certain structures (e.g. length of intestine, size of pig heart) accurately.
5. To demonstrate safety skills when using dissection instruments.
6. To sketch and locate the relationship between structure and function of organisms' structures.
7. To demonstrate proper handling of animals for specific procedures.
8. To maintain appropriate life-supporting environments for animals.

Scientific inquiry objectives

1. To observe animals and/or their structures as they relate to their functions.
2. To perceive proportion, shape, texture, location and detail of structures.
3. To use correct terminology to locate and identify the structures of animals.
4. To describe from observation the parts or organs of animals from different species.
5. To determine the best dissection procedure to study organs and/or structures of animals.
6. To formulate hypotheses concerning the evolution of adaptive structures for survival.
7. To explain the function of organs and structures of animals.
8. To design an experiment that tests a hypothesis.
9. To observe and interpret the effects of certain variables (e.g., substances, nutrition) on animals.
10. To explain how animals evolve various adaptive structures for survival.
11. To deduce from the design of the body plan how structures perform their functions efficiently.

Section B. Alternatives that Use the 3 R's

High school biology classes traditionally include the dissection of typical vertebrates such as the rat or fetal pig. Many biology classes "travel through the phyla" by dissecting earthworms, grasshoppers, clams and starfish, culminating with a frog or cat. Student research projects may use invasive procedures such as the injection of toxic substances and hormones and experiments that deprive an animal of food or disturb its normal physiological cycle.

Some biology teachers and curriculum specialists claim that students need these activities to better understand life processes and the role of organisms in their environment. Other teachers and students have raised concerns about the value and ethics of these teaching methods. In response to this debate, many teachers have begun to look for and make use of alternatives to dissection and live animal experimentation.

Alternatives to traditional dissection have met with a variety of criticisms. Proponents of dissection charge that alternatives are passive activities that do not involve students in "hands-on" learning. They claim that alternatives do not achieve the objectives of the curriculum and deprive students of an opportunity to see the natural appearance and orientation of organs in an animal's body.

Strauss (in progress) reviewed several studies that compared dissection to other teaching methods and reported results favoring the argument for alternatives. A study by McCollum (1988) revealed that student test scores improved significantly when the students were taught frog anatomy by lecture rather than by structured dissection. Prentice et al. (1977) compared the test results of medical school students who were taught by a slide-based auto-instructional unit and those who were taught by dissection. The results showed no significant differences between the test results of the two groups on the practical dissection questions and on the written questions. Another medical school study examined the use of silent film loops as substitutes for cadavers in the study of gross anatomy. Welser (1969) found that students who were taught with the silent film loop scored significantly higher than those who dissected the cadavers.

Good alternatives must teach both the techniques and the biological concepts intended for the lesson. They should require the student to invest a comparable amount of time and effort. The best alternatives foster self-motivated discovery and the development of critical thinking in students.

Russell and Burch (1959) defined "alternatives to the use of animals" as anything from **reduction** in the number of animals required to, whenever possible, the **replacement** of animals with alternative techniques to the **refinement** of existing procedures or techniques to minimize the level of stress induced on the animal.

This definition, which became known as "the three R's," was adopted by the U.S. Office of Technology Assessment in the document *Alternatives to Animal Use in Research, Testing and Education* (1986). In accordance with this view, NABT designed this monograph to provide teachers with materials and teaching strategies to help them apply the principle of the three R's in their search for alternatives.

This section first presents ideas as to how alternatives can be incorporated into the regular curriculum. It is followed by specific lessons that were contributed by teachers at NABT-sponsored workshops and were sent to NABT headquarters. Numerous suggestions of alternatives also were collated from publications relating to animal welfare and humane education. Hence, this section serves as a clearinghouse to enable biology teachers to locate resources and share with one another their ideas on alternatives to the use of animals.

Complete citations of the sources are included in the references. The names and addresses of contributors are included with the lessons. The presentation of alternatives to the use of animals is organized by major divisions in biology. These categories are:

- anatomy and physiology
- diversity of living things
- genetics and evolution
- ecology
- behavior

Anatomy & physiology

Knowledge of basic anatomy lays the groundwork for a broader understanding of organisms. Most educators who use traditional dissection and animal experiments claim they are necessary to satisfy the objectives of a unit on anatomy or physiology. However, there are a variety of ways to learn and teach anatomy and physiology.

A. *Reduction*

Using alternative techniques does not necessarily mean banishing animals from the classroom. There are several methods that allow for modified use of animals.

Demonstration

Demonstration of dissection by the teacher can combine direct student participation with a reduction in the number of animals sacrificed. When done professionally, demonstration avoids errors and the "hack and slash" method of dissection often done by inexperienced students. It is also significantly less expensive. Students should prepare for a demonstration by learning basic anatomy and something about the animal's habitat and niche. If the class is small enough, students can gather around the teacher to watch. If there are many students, more than one instructor should perform demonstrations simultaneously or equipment such as a videocamera and monitor should be used.

If a demonstration seems too awkward, consider providing groups of four or five students with one animal, rather than allowing students to work in pairs. This not only reduces the number of animals needed, it allows more time for the teacher to work with each group.

Preserved specimens

Biological mounts, skeletons and dissected specimens embedded in acrylic are effective, economical alternatives to the traditional formalin-preserved carcasses. Studies have shown that students who handle dried specimens such as horseshoe crabs and sea stars learn just as well as those who touch live animals (Sherwood, et al. 1989). Not only are such specimens more durable and appealing than animals in formaldehyde, they are reusable, reducing significantly the number of organisms sacrificed for classroom study.

Data

Rather than being required to conduct actual experiments on animals, students can be provided with the raw data from such experiments and asked to undertake their own analysis. Not only does this avoid inflicting pain on large numbers of animals, it saves a considerable amount of time and money.

Belzer (1989) has used this technique with students in introductory anatomy and physiology when studying the vagus nerve in rats. He finds that students focus more of their energy on problem solving and inquiry skills and less on the manipulation of animals, thereby achieving more of his educational objectives.

B. *Replacement*

Instructional models, charts, diagrams, transparencies and photographs are plentiful and have been used for many years as substitutes for real specimens. Many would complain, however, that these are static and uninteresting when compared with a real organism. There are several ways to avoid this problem without sacrificing or harming animals.

Audio visual media

Video technology has evolved to such a state of sophistication that the biological reality of living organisms can easily be demonstrated. Films and videotapes can present experiments that cannot be performed in the classroom and can be replayed as many times as needed for students to learn a particular concept or technique.

Computers

The lack of student interaction inherent in a film can be addressed with computer technology. Software is available that provides students with tutorials and simulations requiring them to make their own decisions while allowing them to work at their own pace. In some cases, students can construct mathematical models of quantifiable phenomena such as inheritance or predator-prey interactions which are difficult to study in natural populations.

Computer and video technology has been combined into Interactive Videodisc Technology (IVD) which stores a variety of photographic images on disk. Students can interact with a video by using prompts and by touching the

screen. IVD allows students to explore the body of an animal exactly as if they were performing a dissection, since actual photographs are used.

When HyperCard and HyperText software are involved, IVD is referred to as Hypermedia. Computer-assisted learning and interactive video programs offer excellent possibilities for replacing dissection and animal experimentation in the biology classroom.

Human subjects

Humans are a vertebrate worthy of study and can provide many hands-on activities that eliminate the need for animal subjects. (Teachers should always remember to ensure the safety, dignity and privacy of student participants.) Experiments dealing with nutrition, the leverage power of forearms, eye dominance, depth perception, localization of sound, the judging of weights, the mapping of sweat glands, muscle fatigue and reaction time all have been used with success at the middle and high school level (Orlans 1970, 1974; Chiapetta 1987). Human physiology investigations for advanced students have been written by Russell (1978), and Reed (1989) has edited a collection of simple human anatomy activities that can be used with students at all levels.

Dry labs

Higher order thinking skills can be emphasized by asking students to analyze the structure of organisms. For example, Brett (1989) designed an activity for grade 10 biology that teaches insect anatomy while avoiding rote memorization of terms. Students reconstruct the body plan of a typical insect by following a series of instructions based on geometry. Many teachers teach evolution by asking students to design their own life forms using principles of anatomy illustrated by existing organisms. Such innovative activities are inexpensive and can replace traditional examinations of dead specimens.

***In vitro* methods**

Many scientists work with cell cultures rather than live animals. The Center for Advanced Training in Cell and Molecular Biology at Catholic University has begun a project to make it feasible for high school teachers to introduce mammalian cell culture exercises in their biology labs. The project will provide fixed coverslip cultures of human and

mouse cells for cytological analysis, metaphase-blocked fixed cells for chromosome spreads and staining and fixed normal and tumor cell lines to show differences in growth patterns and cytology. Videotapes, protocols and supplies will be included. For more information, contact: High School Cell Program, CATCMB, Catholic University of America, Washington, DC 20064; (202) 635-5276.

C. *Refinement*

Existing procedures can be modified so as to reduce the amount of stress experienced by both the animal subjects and the students who must manipulate living or dead animals.

Substitution

Avoiding the more sentient creatures in favor of invertebrates such as worms or water fleas (*Daphnia*) is one way of refining one's use of animals in the classroom (Orlans 1977). Dissection of organisms such as fish or squid that are offered for sale as food can remove the stigma of killing animals merely for education, especially if students cook and eat them after the dissection is complete.

Observation

Whenever possible, students should observe animals engaged in their natural behaviors. Keeping animals in well constructed cages in the classroom and making regular trips into the field or even to a zoo or aquarium is an excellent way to increase students' respect for animals while teaching anatomy and physiology. Individual projects such as observing bird nesting habits or the flower preference of an insect can instill appreciation for the complexity and beauty of living things in many students. If dissection is still performed, students who have gained an appreciation for the living animal will be more likely to take it seriously and learn more than a disinterested student.

These strategies are not expensive or difficult, and they bring out students' natural inquisitiveness about nature which is the basis of scientific inquiry.

Diversity of living things

Biological diversity is often presented via dissection of the so-called representative organism of each phylum. Just as the use of animals can be reduced, replaced, or refined while studying anatomy and physiology, a survey of living things can be done without the usual parade of dissections. Attenborough's (1982, 1985) film series on organisms and biomes can serve as an excellent visual aid for diversity studies. Young children can be introduced to classification using their own pets (Reed 1989) and secondary school students can learn about the full range of life on this planet by engaging in classroom surveys that function more like mes than science labs (Purser 1989). Once again, visits to a oo, museum or wildlife park are often more positive experiences than traveling through the digestive systems of various dead specimens. (See the chapter on resources for additional references.)

Genetics & evolution

The study of inheritance often requires that organisms be alive to observe the characteristics in question. The evidence of evolution through adaptation is demonstrated by anatomical structures, physiological processes and behavior. Therefore, animals should be studied in their natural environment as much as possible. Here are some ideas:

Inheritance

1. Rodents
   A common class project in genetics is the study of simple Mendelian inheritance of coat color in generations of small rodents (*Alternatives to Animal Use in Research, Testing and Education* 1986, p. 209).
2. Fruit flies
   Drosophila, the common fruit fly, is an ideal organism for breeding studies because it is readily available and the inherited characteristics are easy to observe. *Drosophila* reproduces and develops rapidly and requires relatively simple maintenance.
3. DNA
   Another study of genetic variation in animals may be conducted using recombinant DNA technologies. The method is direct and noninvasive.

4. Shells & zebras
   A class project or activity for studying patterns of inheritance may use design and coloration in shells or stripe patterns in zebras.
5. Cells
   Human cells, such as skin cells, can be grown in tissue cultures for the study of human chromosomes. Tissue culture methods and karyotyping, using human cells grown in suitable nutrient media, can be performed by high school students. These methods can be modified to study the effects of pharmacological agents, food additives, radiation, etc. on cell growth and chromosome structure. Methods of this kind, which play a significant role in biomedical research, give students experience in laboratory research (Russell 1980).

Variation

6. Dog
   A worthwhile project is to have your class make a detailed study of one organism to see how representative it is of its class. For instance, students can study the major body parts and external characteristics of a certain species of animal–a dog, for example. Using various categories such as facial differences, body size, ear size, fur length and thickness, and so on, students can document the range of variation in appearance of dogs and then evaluate the biological significance of these natural variations.
7. Skulls
   The study of vertebrate skulls reveals adaptations for specific functions. Lawson (1988) has written a lesson that applies the learning cycle (exploration, concept introduction and application) to study vertebrate skulls.

Ecology

Using animals in the classroom to teach ecology is virtually impossible. Many teachers rely on descriptive lectures and films for this portion of the biology course. We suggest that many of the alternative techniques described earlier easily lend themselves to a discussion of ecology. By combining ecology with a study of anatomy, physiology and variation, students will receive a more complete and interesting picture of the natural world.

Field studies

Students from elementary through high school can benefit from a long term outdoor project. Reed's *KidScience* (1989) describes a simple exercise for young children and their parents that teaches them to become good observers. Another issue of the same publication discusses a "phenology book" that students and teachers can maintain to keep track of biological events occurring in their community.

Animal clues

Students who regularly go into the field often will find the remains of animals, if they are taught what to look for. An investigation of animal tracks and scat can reveal much about behavior and anatomy. One such exercise involving barn owl pellets has been written by Bealer (1980).

Behavior

An animal can be observed for a considerable length of time without doing it any harm. Painless experiments on learning ability and the responses of many organisms ranging from worms to fish to rodents serve as excellent ways to instill students with an appreciation for life.

Teachers can find a snail observation exercise for young children in Reed (1989). A study of bird behavior has been described by Weber, et al. (1990) and Marchioni (1989) has written a lesson that investigates the behavior of *Planaria*, the common flatworm. Marchioni (1987) has also published a set of curriculum materials that combine comparative psychology, neurobiology and animal behavior into a unit called *Biopsychology*. It includes activities such as a study of aggression in Siamese fighting fish as an example of instinct, drive and motivation.

The following sample lessons use the principle of the three R's. These lessons were contributed by NABT members who, on their own, searched for ways to offer a comparable learning experience to any students uncomfortable with dissection or the use of animals in their biology class.

Lessons That Use the 3 R's

This section consists of teacher-written lessons. The products mentioned in the lessons have not been endorsed by NABT. The lessons are grouped in the following categories:

A. Teaching Anatomy with Models
B. Films as Alternatives
C. Interactive Computer & Video Programs
D. Refinements of Dissection & Experimentation

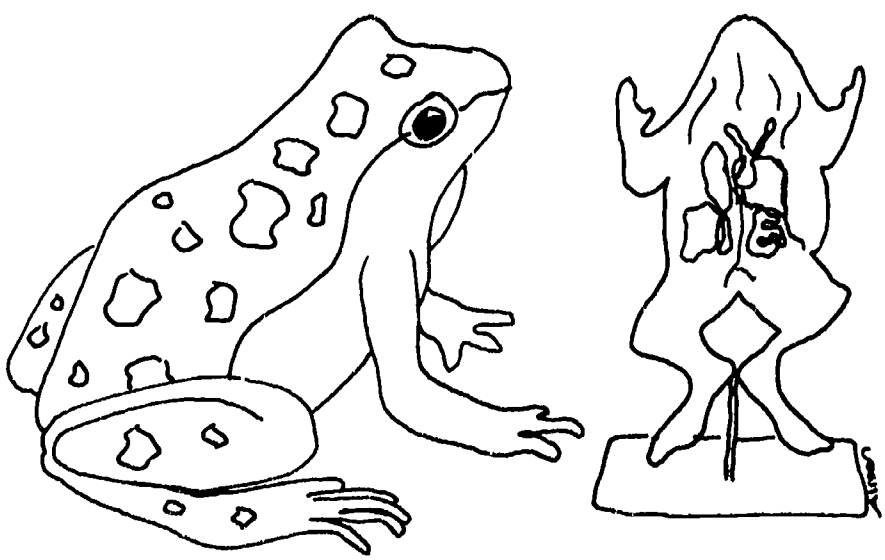
A Guide to the Lessons in this Chapter

A. *Teaching Anatomy with Models*

Models are effective teaching tools, especially those that can be taken apart and reassembled. This type of model can demonstrate the physical relationships and appearance of organs.

Models can be expensive to purchase, but are a one-time investment that can be used over many years. They save the annual purchase of preserved animals, the prices of which increase regularly. Models allow students to study the structures repeatedly without their being torn or accidentally cut. Moreover, millions of animals–e.g., frogs–could be saved and their niche in the environment maintained.

Teachers can use three-dimensional anatomical models, which can be taken apart and reconstructed, as substitutes for dissection and vivisection. There are also two-dimensional plastic models of parts of organisms which can be separated and reassembled. Sample lessons using these two types of models are presented in this section. The models can be ordered from suppliers listed under Resources.



Lesson title: **The Anatomy of the Frog**

By: **Rosalina V. Hairston**
National Association of Biology Teachers, 11250 Roger Bacon Drive #19, Reston, Virginia 22090; (703) 471-1134

This lesson is built around a large scale model of the frog's internal structure. It is designed to replace the dissection of preserved or freshly killed frogs. Groups of students are assigned various systems and act as "specialists," teaching the rest of the class about their organ system. The final activity described involves the entire class in reconstructing the frog from paper cut-outs.

Grade level Grade 7 life science; grade 10 biology.

Objectives At the end of this lesson students should be able to:

1. Describe the external anatomy of the frog.
2. Identify the various organ systems.
3. List and state the function of each of the structures that comprise the system.
4. Take apart and accurately reassemble the parts of the frog.

Materials

- model of the external and internal anatomy of the frog, e.g., Somso's frog model. Dissectable into five parts. Available from Carolina Biological Supply Company.
- overhead projector
- transparency master with outline of the organ system
- transparency pen set or erasable markers of assorted colors

Teaching tips Divide the class into five groups and assign each a topic:

Group 1 – external anatomy of frog
Group 2 – digestive system
Group 3 – respiratory system
Group 4 – circulatory system
Group 5 – urogenital system

Each group will be the "specialist" for its topic. Hand out assignments one week before the class activity to allow time for research. Appoint one member of each group as leader.

This lesson is suitable for the study of a typical vertebrate. Review the organization of cells, tissues, organs and systems before this lesson.

You can do this class activity using only one model. The entire lesson may take 90 minutes.

Instructional procedure

1. Conduct a brief discussion on the natural life habits of the frog–where it lives and its development from egg to tadpole up to adult stage. Describe appearance, size and habitat of different kinds of frogs. You may be able to discuss some reproductive behavior, for example the way males croak in a mating call. You may wish to use the videotape "The Frog Inside-Out (Part I)" to enrich the introduction to the lesson (see p. 45).
2. Start with group 1 (external anatomy) as the specialist. Call on one member of the group to describe the external structures found in the frog. Have a second group member point to the structures. Have a third member describe the specific functions of each structure. Any remaining members can help answer questions after the group presentations.
3. Do the same with groups 2, 3, 4 and 5. As each group from 2 to 5 finishes presenting its assigned organ system, one member will trace and color the system on the transparency. Each organ system will be a specific color. Have students decide the colors.

The teacher should serve as a facilitator/moderator. This is a lesson in which the students are responsible for their learning. It is also a good opportunity for cooperative learning.

Evaluation

To make sure students learn from one another, have them assemble cut out drawings of organ systems. Have the students tape or paste the pieces on an illustration board. Students label the organ and write the function on a strip of paper. When all the organs have been pasted on, the class will have constructed a collage of the internal anatomy of a frog. Make sure the group that worked on a specific organ system does not work on the same topic during the paper cut-out activity.

Lesson title: **Earthworm Anatomy**

By: **Kathleen Frame**
Bishop O'Connell High School,
6600 Little Falls Road, Arlington,
Virginia 22213; (703) 237-1400

This lesson is based on National Teaching Aids' earthworm model. This model is made of a series of vinyl overlays that can be removed and examined much as one would dissect a real earthworm. The lab involves presenting the model to students with an explanation of the functions of organs and systems. Some pre- and post-lab activities are described. This lesson can serve as an alternative to the dissection of preserved earthworms. This lesson may take 90 minutes.

Grade level Grade 7 life science; grade 10 biology.

Objectives At the end of this lesson students should be able to:

1. Describe the body plan of the earthworm.
2. Number the segments of the earthworm and use them as reference points for locating external and internal structures.
3. Locate and describe the function of the structures of the external anatomy and circulatory, digestive, excretory, nervous and reproductive systems.

Materials

- Model of the Earthworm (© 1970). Available from National Teaching Aids, Inc.
- live earthworms (1 for every 2 students) in covered petri dishes
- hand lens (same number as worms)

Teaching tips

The vinyl model is large, two-dimensional and consists of a series of overlays.

The plastic pieces are well packaged and easy to keep. If any pieces are lost, National Teaching Aids maintains an "organ bank" from which a replacement can be ordered.

Present the model of the earthworm to the class with parts correctly assembled. Copy portions of the manual for students to read before the activity.

This activity could be used for an entire class or with a team composed of 3 to 4 students.

Put an earthworm in each petri dish with moist soil. Cover the petri dish.

Instructional procedure

1. To prepare for this lesson ask students to read about the habitat of the earthworm and its role in the ecosystem. Whether you decide to work with teams of students or as a class, have them research the parts and function of structures for each organ system: nervous, circulatory, digestive, excretory and reproductive.
2. To motivate students for the lesson, pass around the earthworms in covered petri dishes. Tell students to use a hand lens to observe the movement and external structures of the earthworm. Ask them to determine the orientation points of the earthworm (i.e., dorsal, ventral, anterior, posterior). Allow enough time for observation, then collect the petri dishes and put the earthworms in a moist soil chamber or terrarium. Emphasize that it is important to return them to their natural habitat as soon as possible to prevent dehydration.
3. Now, conduct the activity using the vinyl model. Translate the orientation points of the live earthworm to the vinyl model. Locate the first 37 segments using the imprinted Roman numerals as a guide.
4. Using segment numbers when applicable, have students identify the external structures of the earthworm and their functions. Some of these structures are: grooves, mouth, prostomium, anus, setae, clitellum, dorsal pores, nephridiopores, sperm receptacle, opening to the oviduct, opening to the sperm duct and seminal groove.
5. Remove Overlay G. This section illustrates the nervous system. Have the students (or assigned team) locate the parts of the nervous system (brain, circumpharyngeal connectives, ventral nerve cord, segmental nerve, lateral nerves, sensory cell) and describe each.
6. Remove Overlay E. This cluster of segments is the circulatory system. Using the same procedure, have students locate some of the following: septa, dorsal vessel, ventral vessel, aortic arches, parietal vessels, dorsointestinal vessels, lateral vessels and segmental vessels.
7. Remove Overlay D. These segments show the digestive system. Have students locate the buccal region, pharnyx, esophagus, calciferous glands, crop, gizzard, intestine and anus.
8. Remove Overlays B and F. Structures in this cross-section are the typhlosome, intestinal epithelium,

chloragogen cells, peritoneum, longitudinal muscles, circular muscles, epidermis, cuticle, gland cell and coelom. Since this is a cross-section, the teacher may have to identify these structures and describe how a cross-section is made.

9. Locate the nephridiopore and trace the structures of the excretory system. These should include the nephrostome, tubules and nephridium.
10. As you begin to examine the reproductive system, introduce and define the word "hermaphroditic." Earthworms exemplify this condition: one organism possesses both male and female reproductive organs. Have students locate the following male reproductive structures and give the function of each: testes, sperm funnel, sperm duct and sperm sacs. Locate and describe the function of the structures of the female reproductive organs: ovary, ovarian funnel, ovisac and sperm receptacle.
11. Allow enough time for students to master the structures of each organ system by working with the vinyl model. If necessary, arrange for students to work individually during their free periods or after class.
12. Give students the responsibility of correctly reassembling the model.

Evaluation

Conduct a writing, poster drawing, comic-strip drawing, or three-dimensional diorama contest on the earthworm anatomy, its adaptation and its role in the environment.

Lesson title: **Build a Frog**

By: **Alison M. Rasmussen**
National Association of Biology Teachers, 11250 Roger Bacon Drive #19, Reston, Virginia 22090; (703) 471-1134

This lesson is based on National Teaching Aids' model of a frog. The model is made of a series of vinyl overlays that can be removed and examined in the sequence in which they would appear in a real frog. The lesson requires that students select a part to research. They then reassemble the frog in class while teaching each other about their part's main function and comparing it to the same part in a human. A post-lab quiz is recommended. This activity can serve as an alternative to dissection of preserved or freshly killed frogs.

Grade level Grade 7 life science, grade 10 biology.

Time required Two class periods: At least one class period for assignment and student research (research also can be done as homework); one class period for reconstruction of frog model.

Objectives In this lesson students should:

1. Learn the arrangement and function of parts in the frog.
2. Compare frog anatomy to human anatomy.

Materials

- Anatomical Model of a Frog. Available from National Teaching Aids, Inc.
- reference materials for student research on frog anatomy

Instructional procedure

1. Condense and simplify the list of parts included with the model to make a list for the students. By lottery or other means, assign each student or pair of students their own part from that list.
2. Have students research their assigned part and write down the answers to these research questions:
   a) Where can the part be found in a frog?
   b) What is the main function of the part?
   c) Are there any major differences between this part in a frog and a human (if human anatomy has been studied)?

3. Reconstruction:
The teacher lists the parts on a blackboard or overhead projector; students have their plastic part at their desks. The plastic board for the frog is set up so that everyone can see it. The teacher asks the students to decide which of them has the part that will go into the frog first. (Students make all the decisions in this exercise; the teacher simply provides guidance. If the students make a mistake, they have to remove the parts and begin again.)

As each part is placed on the board, the student who researched it explains to the class the answers to research questions 2b and 2c. The class should take notes.

4. When the frog has been reconstructed and all research questions have been answered, the students can take a Frog Quiz, consisting of the research questions. Students should be allowed to use the notes they took in class.

Additional activities

1. Divide the class into two (or more) teams. After some practice, use a stopwatch to determine which team can put the frog together faster. Accuracy is important: add a penalty of extra seconds for each mistake in reconstruction.
2. The teacher should secretly remove parts and then ask each team of students to determine which ones are missing. Give extra points to the team that can explain what will happen to the frog without those parts.

Teacher information

The frog model can be ordered from National Teaching Aids.

The pieces are easy to care for and can be replaced on an individual basis from NTA's "organ bank."

The information sheets that come with the frog provide a brief description of each part's function and explain exactly how to reassemble the frog.

Lesson title: **The Perch: Model Dissection & Imitation**

By: **Realista Rodriguez**
Fairfax County Public Schools, 6525 Montrose Street, Fairfax, Virginia 22312; (703) 941-8404

This activity is based on the Biosmount preparation of the perch. This model is an actual perch dissected to show its internal organs. The lesson teaches the external and internal anatomy of a perch. Students will use an organ puzzle to apply their knowledge about the anatomy of perch.

Grade level Grade 7 life science, grade 10 biology.

Objectives At the end of this lesson, students should be able to:

1. Examine and identify the external features of a representative of the bony fish, Class Osteichthyes.
2. Describe the functions of bony fish body structures.
3. Describe the adaptations the perch possesses that allow it to live in an aquatic environment.
4. Trace the pathway of food, blood and air through the perch.
5. Graphically and creatively represent perch anatomy using the organ puzzle. (Directions to make the organ puzzle are listed in teaching tips).
6. Summarize facts learned about the perch through graphic organizers (diagrams, concept maps), drawings, poetry, music and other means.
7. Investigate the structural and functional interactions of the different organ systems.

Materials

- Biosmount preparation of perch injected with two colors to show afferent and efferent arteries. Available from Carolina Biological Supply Company. (1 Biosmount may be adequate for a class)
- teacher-made organ puzzle

Teaching tips This lesson may take two class periods: the first for using the Biosmount, the second for assembling the organ puzzle and reporting observations made at a pet store or fish market.

To prepare the organ puzzle:

Using a textbook diagram(s) showing the perch's organs, draw the organs on a sheet of unlined paper.

Outline the drawings with a thick black marker and label each organ. Duplicate the original sheet(s) as needed and cut each one out. Label each set with a number or letter. Put this label on the outside of an envelope in bold print; put a complete set of organs for a system inside. Give each team an envelope.

Instructional procedure

1. Have students examine the Biosmount preparation of the perch. Two colors identify the afferent and efferent arteries of the gills. Identify the external and internal parts shown.
2. Discuss the functions of the following perch parts:

   External parts: dorsal fins, caudal fin, pelvic fin, anal fin, lateral surface, operculum, urogenital opening.

   Internal parts: swim bladder, mouth, esophagus, stomach, intestine, rectum, gall bladder, liver, pyloric caeca, heart, atrium, ventricle, kidney, urinary bladder, ovary, testes. (A textbook is a good source of information.)
3. Using the organ puzzle provided for each group of students, ask them to position in sequence the circulatory, digestive, excretory and respiratory systems as directed.
4. Students should confer with their lab partners as to the composition and arrangement of each of the systems. Use the Biosmount perch and the textbook as references.
5. Outside class activity: Do an observation-comparison study of different types of fish by visiting a fish/pet store with a variety of aquaria. Compare the behavior and body structure of two or three types of fish. A supermarket's fish section could also serve as a place of observation. Write down your observations for your report in class.

Evaluation

1. After the students work on their organ puzzle individually and in groups, synthesize facts and information. Request students' assistance in projecting colored transparency organs (cut out according to their shapes) in the correct sequence.
2. If a Biosmount of a dogfish is available, ask students to view both preparations, then list characteristics of each. Draw a Venn diagram (two identical geometric shapes that partially overlap; the overlapping area should be shaded–see Figure 2.1) or a different type of

graphic organizer to list the similarities and differences between Class Chondrichthyes and Class Osteichthyes. Have students list the characteristics the two fish have in common in the shaded area and the differing characteristics in the outer areas. This could be expanded to include three or more circles for more animal comparisons.

Extension/enrichment activities for students

1. Collect different types of fish scales from your local fish market and affix labels to baby food jars to identify the fish from which the scales came. Preserve them in the jars with water for about a week. Using a stereomicroscope, ask the class to examine the scales and hypothesize as much information as possible about the anatomy, physiology and environment of the fish.
2. Make models to represent the parts of the fish. Use commercial Plaster of Paris, clay, or make a three-dimensional paper sculpture.
3. Com[illegible] poem or informational rap song. This can be done by listing all the important terms that refer to the anatomy of the perch, then writing sentences that rhyme. Some type of beat/rhythm could be threaded into them. Tape (either audio or video) your rendition or perform it live before the class, then share it with other classes.

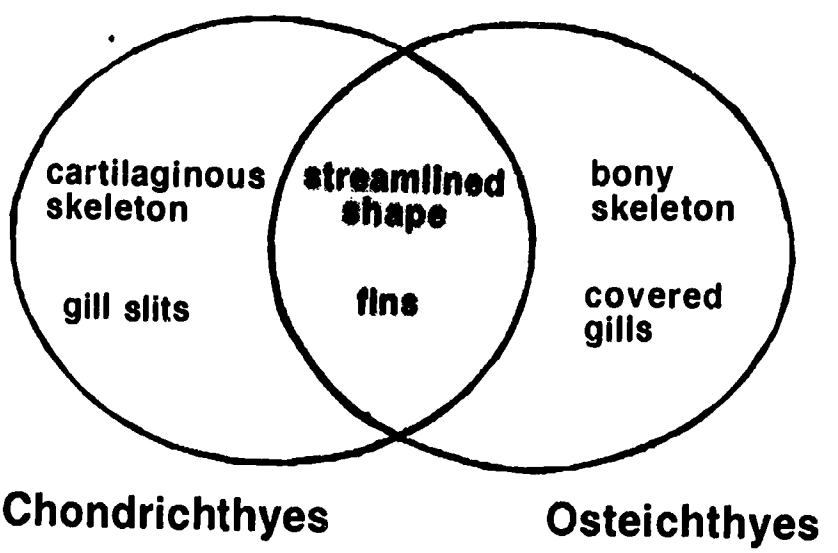


Figure 2.1. Venn diagram showing some similarities and differences between Class Chondrichthyes and Class Osteichthyes.

Lesson title: **Studying Human Anatomy Using Student-Made Models**

By: **Alton Biggs**
Felicia Perry
Allen High School, P.O. Box 1017, 601 East Main Street, Allen, Texas 75002; (214) 727-0400

This activity requires that students spend four weeks researching and constructing their assigned organ or organ system model. These models are then described before the class. A term paper can also be assigned. The teacher should provide a summary bringing together the models of systems done by students. This activity can be used as an alternative to dissection of rats or fetal pigs.

Grade level Grade 10 biology.

Objectives

1. To manipulate materials to enhance perceptual and spatial learning.
2. To simulate the anatomy of a human organ or system.
3. To relate the anatomy of a human organ or system to its function.
4. To relate the anatomy of a human organ or system to other organ systems in the human body.

Materials

- commercially prepared classroom models
- student-prepared classroom models
- drawings, photographs
- audiovisual material such as 16 mm films, VHS tapes and slides
- other materials supplied by students to complete project

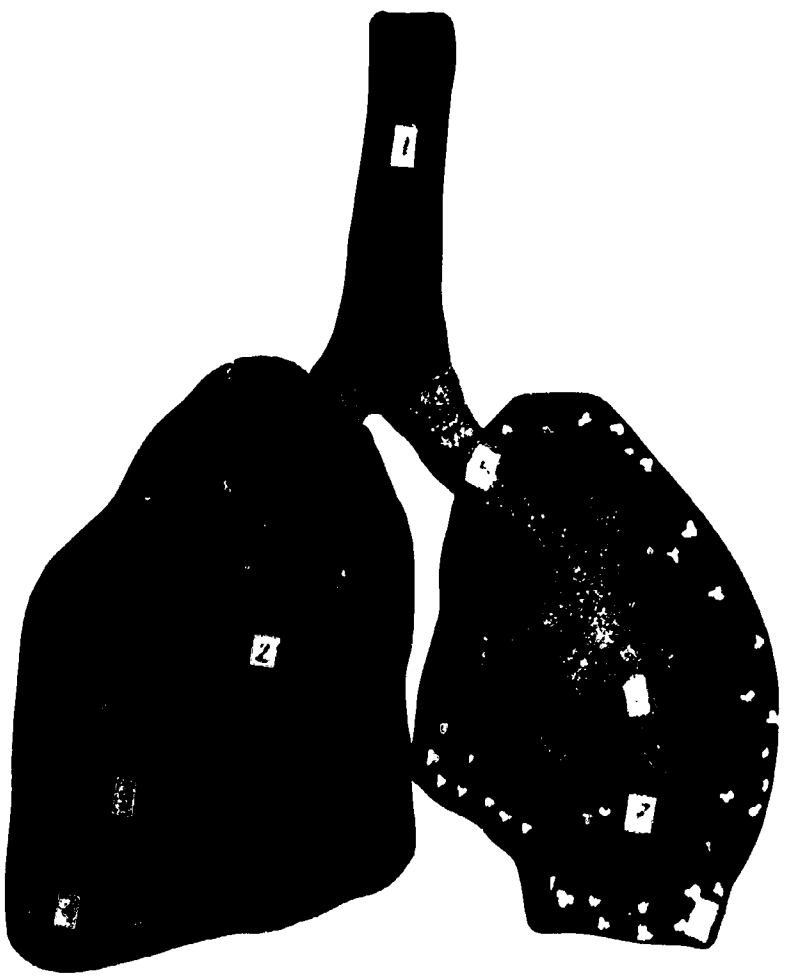
Instructional procedure

1. This is a research project, so class activities will proceed as usual while students work on their models.
2. Students will be given four weeks to research and prepare their models.
3. During the first week students decide which organ or system they will construct. Students may form groups of not more than three to work on a single model. They may also use any material available and suitable for the model.
4. Before beginning the production phase, students should do as much outside research as possible by referring to commercially prepared classroom models, drawings, photographs, films, charts and diagrams.

5. Students will complete a summary paper to go with their model and will make an oral presentation. Models must be sturdy enough to use in the classroom. If the model is made of a material that will degrade biologically, the student should find ways to preserve the model.

Summary & evaluation

After students have discussed and viewed all models, a summary lecture will be given by the teacher emphasizing the complementary relationship of structure and function. Students will also be given an opportunity to rate the projects' merits and suggest alternatives and changes.



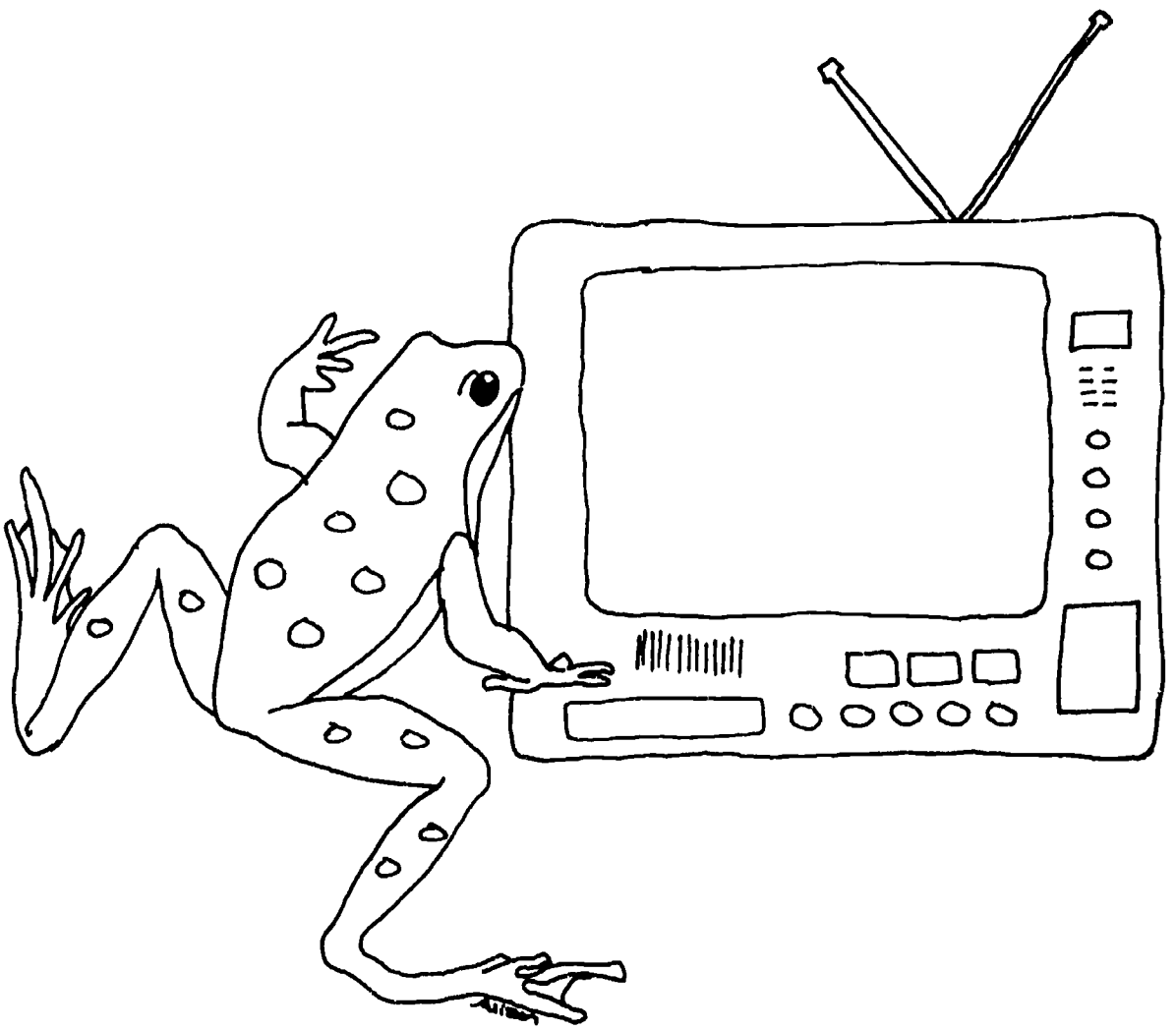
Lungs

1. Trachea
2. Upper Lobe
3. Middle Lobe
4. Lower Lobe
5. Bronchus
6. Bronchial Tubes
7. Terminal Bronchiole
8. Alveoli

Figure 2.2. Student-made model of lungs.

B. *Films as Alternatives*

Filmstrips, films and videotapes can be used to teach anatomy and physiology. They can be replayed many times, making them preferable to animal experimentation which would require the use of additional animals in order to repeat a procedure (Russell & Burch 1959, p. 65). Many subjects such as ecology and animal behavior virtually demand the use of a film since classroom and field experiences are necessarily limited. The following lessons are examples of how films can be incorporated into lessons that emphasize critical thinking as well as factual knowledge.



Lesson title: **A Study of the Relationship Between Structure & Function of the Human Organism Using the Videotape "The Incredible Machine"**

By: **Kathleen Frame**
Bishop O'Connell High School,
6600 Little Falls Road, Arlington,
Virginia 22213; (703) 237-1400

This lesson is built around the videotape "The Incredible Machine," a National Geographic Society film. Rather than dissecting a rat or fetal pig, teachers can use this video to explore mammalian systems. The lesson provides a list of topics and where they can be found in the video and suggests a number of activities for students to do before and after viewing the film.

Grade level Grade 10 biology.

Objectives

1. To view the structures of the integumentary, sensory, respiratory, circulatory, digestive, muscle, skeletal and reproductive systems.
2. To relate the structure to the function of the above systems.
3. To appreciate the relationship between structure and function within the human body.

Materials

- VHS machine
- 26-inch video monitor
- videotape "The Incredible Machine," produced by the National Geographic Society and Wolper Productions (1975).
- human torso (optional)
- human skeleton (optional)

Teaching tips

1. Allow 60 minutes for yourself to preview this program.
2. Structures and organ systems described in the video:

external anatomy	thermoregulation
skin	digestive system
skeletal system	sensory system
vision	bipedal locomotion
hearing	reproductive system
voice box	development
respiratory system	cell-tissue study
circulatory system	brain biofeedback
immune system	

3. The photography is beautiful and the explanations are brief and interesting.
4. The video may be shown in its entirety or in small sections to introduce or reinforce material learned about human systems.
5. Assign students to read about one or two organ systems (corresponding to the sequence of the tape) for each class meeting.
6. You might need to use seven days to teach with the film. With considerable depth and allowing for student participation, you may reasonably finish two organ systems per class period.

Instructional procedure

1. Using the model of the human torso and the skeleton, describe to students the body design of the skeletal and visceral systems. If the models are not available, you may use a chart or the diagram in their textbook.
2. Outline on the board the following organ systems: integumentary, sensory, respiratory, circulatory, immune, thermoregulatory, excretory, digestive, muscular, skeletal, reproductive and nervous. Special topics such as tissue and organ development, brain biofeedback, cell tissue study and physical strain in body building can be discussed as they relate to the organ system.
3. Begin by reviewing the homework on the organ system. Have students write on the board the structures included in that day's organ system. This will serve as a checklist.
4. Show the film and pause whenever a structure is shown or defined. Reinforce by repeating the ideas in the film or asking a question.
5. Proceed with the film using adequate pauses and prompts as needed. Stop the film when students have questions on a certain statement.
6. After studying each organ system have students write a short paragraph explaining how this particular organ system or structure(s) helps one survive.
7. In addition to #6, assign students to read about the organ system that will be shown during the next class.
8. After all the segments of the film have been shown, conduct a discussion on the beauty of design and the complementarity of structure and function found in the human body.

Evaluation

Depending upon their learning style, have students choose one of the following:

1. Write a fictional short story about a technological breakthrough that will make the human body more efficient and invincible to pathogenic microbes.
2. Choose the best organ system in your body in terms of helping you adapt and survive. Describe why.
3. Construct a model of the muscles and the skeletal system that demonstrates how they coordinate movement.
4. Create a skit/dramatization depicting the following ideas (this should be done in a group):
   a) Importance of the immune system.
   b) Harmful substances and their effects on the nervous system.
   c) Bio-feedback system in the human body.
   d) Tissue–organ development.

Lesson title: **"The Frog Inside-Out (Parts I & II)"**

By: **Realista Rodriguez**
Fairfax County Public Schools,
6525 Montrose Street, Fairfax, Virginia 22312; (703) 941-8404

This lesson is based on a two-part videotape intended as a predissection lesson or an alternative to dissection. When used before dissection it will ensure that students perform accurate and complete dissections.

Grade level: Grade 10 biology.

Objectives: The students should:

In Part I:

1. Observe and interpret the behavior of two different types of living frogs.
2. Observe the two species' responses to their environment.
3. Compare and contrast the frogs' external structures and their functions.
4. List adaptations that enable the frog to live both in water and on land.
5. Identify the major characteristics of a typical amphibian.
6. Trace a frog's life cycle.
7. Compare and contrast a frog with a toad.

In Part II:

1. Locate and describe the frog's external and internal anatomy.
2. Demonstrate the interconnections among organs that make up each of the systems.
3. Interrelate the structure and function of organs.
4. Examine certain cells and tissues under microscopes.
5. Probe the length, muscular composition and movement of the frog's legs and relate them to their functions.
6. Make a list of the many interesting species of frogs, their habitats and their uniqueness.

Materials

- videotape of "The Frog Inside-Out (Parts I and II)," by Instructivision. The videotape can be ordered from Carolina Biological Supply Company.
- VHS machine
- 26-inch video monitor
- model of frog or Biosmount (optional)
- terrarium with live frogs (some suggestions are tree frogs, bullfrogs and the African clawed frog)
- aquarium with tadpoles

Teaching tips

1. The videotapes are quite detailed and time-consuming, especially Part II. You may want to divide each part into two showings.
2. Introduce an activity after each half of Part I by doing a concept map and a Venn diagram.
3. The videotape (Parts I and II) may require four or five class periods.

Instructional procedure

Part I:

1. Have students examine frogs' behavior by observing them in an aquarium/terrarium setting for one week. In a journal, record their breathing rates, eye movements, feeding habits, locomotion and other behaviors. Divide the class into groups of five students to interpret observations. Exchange information with one another regarding the specific frog's behavior. Discuss general observations with the whole class.
2. Students should watch the videotape. Afterward, have the class examine a Biosmount prepared frog or a model. Students should identify the major organs.
3. Ask students to make a concept map of the frog's external and internal features. The teacher could present an incomplete one for students to complete in class or as a homework assignment (Figure 2.3).

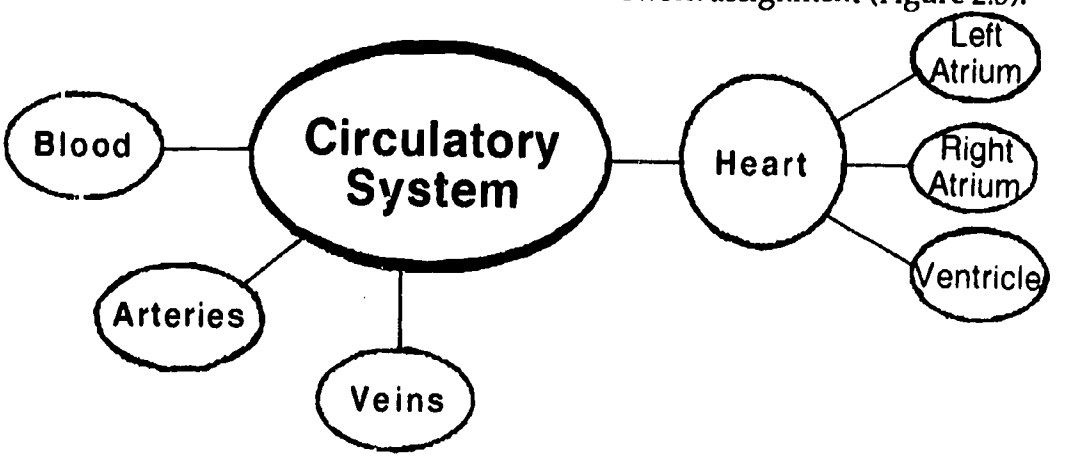


Figure 2.3. Example of a concept map.

4. Ask students to construct a Venn diagram (with two circles) to demonstrate features that allow frogs to adapt to live in water, on land and in both areas. A similar diagram could be used to compare a frog and a toad (Figure 2.4).

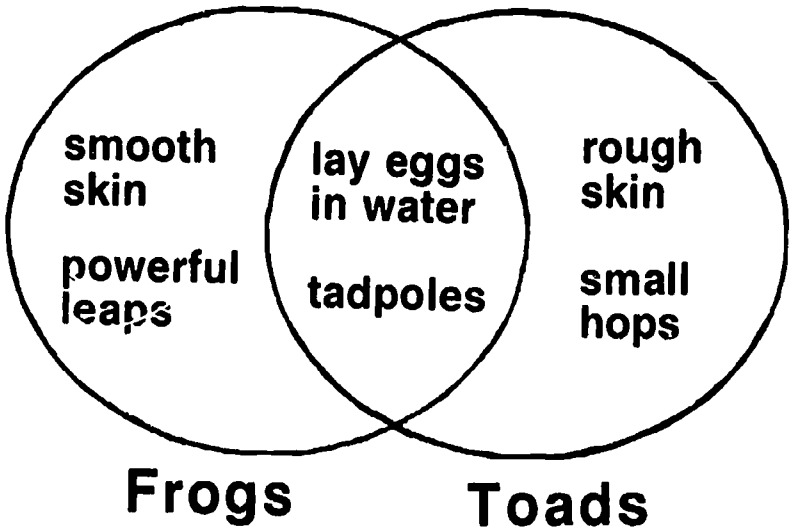


Figure 2.4. Example of a Venn diagram for frogs and toads.

Note: Be sure provisions are made for the proper care of live frogs after observation or release them into a proper environment.

Part II:

1. Give one preserved frog to each team of two students. Have them examine the external structures and measure the length of the frog's body and its legs. Record data on a chart. Discuss how the structure of the frog's hind legs helps it escape predators.
2. Students should open the preserved frog's mouth and draw the parts found. With your partner imagine how a frog eats and how the mouth parts are used. Share your hypothesis with the group to your right.
3. After viewing "The Frog Inside-Out (Part II)," divide the class into eight groups of three to four students each. Write down the names of the following eight systems, one per page:

external anatomy	circulatory system
skeletal system	excretory system
digestive system	nervous system
respiratory system	reproductive system

Have one student from each group pick a piece of paper; the system written on the paper becomes their group assignment. Using the cooperative learning strategy, students prepare to present an oral report on their assigned topic. Visual aids and creative delivery of information should be encouraged. Drawings, simulations, rhymes or cartoons could be used. Student presentations may be evaluated based on: accuracy of information, creativity of instruction and cooperation of all group members. Preserved frogs for this exercise should be reused year after year.

4. Discuss with the class a frog's anatomy compared to that of a human.

Evaluation

Prepare a report, a mobile, or a stabile on the life cycle of a frog.

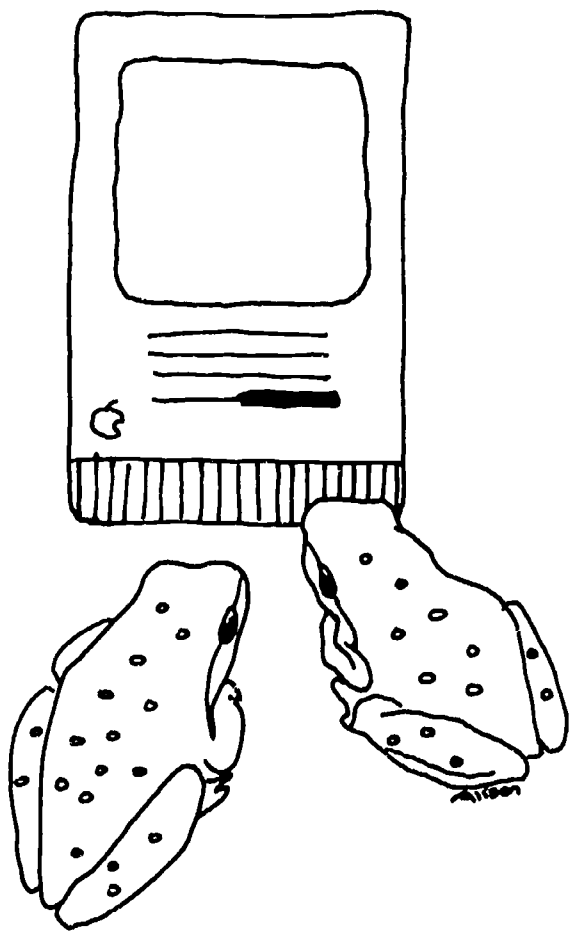
Enhancement/ enrichment activities

1. Raise tadpoles in the classroom. Prepare a 20-gallon tank for tadpoles and a 20-gallon tank to be used later when the frogs have metamorphosed. Assign a student to record brief observations (for example: "the tails have disappeared") daily on a blackboard. The rest of the class makes individual detailed observations and records them in their journals.
2. A fabric sculpture of a frog with internal and external features could be fashioned out of cloth, some type of fasteners and pillow stuffing. The ventral area could be made "dissectable" by using Velcro, snaps or buttons. The internal organs could be made movable by putting bits of Velcro on strategic areas where other organs would be attached in a true-to-life arrangement. (A commercial model, Ribbit, is available from SCIDEAS.)

C. *Interactive Computer & Video Programs*

Computer-assisted learning and interactive video programs offer great possibilities for reducing, replacing and refining the use of animals in education (Dewhurst, et al. 1988). These programs also have advantages from a pedagogical point of view, as many of them encourage critical thinking, allow students to work at their own pace and remove student passivity associated with many traditional teaching methods.

Computer programs usually are designed as tutorials on a particular subject or as simulations of a procedure such as dissection. When computers are combined with video (as in Interactive Video Technology), the range of programs becomes endlessly varied. The following lessons illustrate the variety of software available to teachers and the versatility of Interactive Video Technology.



Lesson title: **Tutorial Using the Computer Program "Anatomy of a Shark"**

By: **Kathleen Frame**
Bishop O'Connell High School,
6600 Little Falls Road, Arlington,
Virginia 22213 (703) 237-1400

This lesson is bas d on a computer program that demonstrates the external anatomy and the skeletal, circulatory and nervous systems of a shark. Each system can be studied using a lesson, probe, game or quiz format. Worksheets are included with the disk. It requires about 20 minutes of teacher pre-lab and 45 minutes of students' time. The accompanying teacher guide suggests some additional activities that would reinforce the program.

Grade level Grade 10 biology.

Objectives This tutorial will help students to:

1. Locate the structures of the shark.
2. Access information on the function of the structures of the shark.
3. Reinforce the knowledge of structures and functions via an information bank of their descriptions and a game format.
4. Evaluate understanding of structures and functions through a quiz format.

Materials

- Apple IIe computer 48K, 1 disk drive. One to two students per computer.
- "Marine Life: Anatomy of a Shark" (© 1986). Available from Ventura Educational Systems.
- worksheets from lessons #1-#4 in the user's manual. These are found after page 14 in the manual.

Teaching tips

1. The external anatomy and the skeletal, circulatory and nervous systems of the shark are included in this program. Each system may be studied by one of the following four formats: lesson, probe, game or quiz. Portions of the program take a while to load. The lesson section gives a tutorial of structures, while the probe section gives a detailed description of structure and function. The games section has three modes–"Identify," "Scramble" and "Wordsearch." In the "Identify" mode the student can choose whether to receive clues, decide the order of questions and select

an ability level (rookie, apprentice, or expert). "Scramble" gives an option of 10, 20, or 30 terms and is a timed exercise. In "Wordsearch" students may use a word list to solve the puzzle. In the quiz mode the student is given a percentage score and may retake the quiz if necessary.

2. The program may not be copied and is to be used on a single machine. Lab packs with multiple copies are available from Ventura Educational Systems.
3. This lesson could be used individually or in teams of two students. It may also be used as a reinforcement after a lesson on shark anatomy using models, charts and a film.

Instructional procedure

1. Assign students to research the shark's evolutionary advantages as illustrated by its structures and physiological adaptations.
2. Conduct a class discussion on the anatomy of the shark: how it is similar and different from the anatomy of other vertebrates.
3. Allow the students enough time to work through the lesson and probe portions individually.
4. Have them reinforce the information they have learned through the game formats and evaluate their understanding of the shark's anatomy with the quiz portion of the program.
5. When they feel they have mastered the material, have them evaluate their understanding by completing the worksheets for Lessons #1-#4.

Evaluation

1. Discuss the shark's advantages for evolutionary survival as compared to other vertebrates.
2. Conduct a discussion of accuracy in the portrayal of sharks in the movie "Jaws."

Lesson title: **"Visifrog: Vertebrate Anatomy": Structure & Function of a Typical Vertebrate**

By: **Kathleen Frame**
Bishop O'Connell High School,
6600 Little Falls Road, Arlington,
Virginia 22213; (703) 237-1400

This lesson is based on a computer program that takes students through the structures of a frog. It includes several different activities such as "Identification Game," "Slide Show" and "Data Retrieval," in addition to a "Quiz Machine" that students take to see how they are doing in the program. Activity sheets come with the disk and can be used alone or with a live frog (for observation, not dissection). The program has some flaws and requires about 90 minutes of teacher preview before assigning it to students.

Grade level Grade 10 biology.

Objectives At the end of this program students will be able to:

1. Identify structures of the musculature, digestive, nervous, cardiovascular, urogenital and skeletal systems of a typical vertebrate using a game format.
2. Describe the function of the structures of the listed organ systems.

Materials

- Apple II Plus, IIe, IIc, 64K or Commodore 64 computer
- "Visifrog: Vertebrate Anatomy." Available from Ventura Educational Systems (1984, 1986, 1988)
- Handouts:
  1. List of structures and associated functions that students will need to know
  2. Activity sheets #1-#6 and #14 (included with disk)
  3. Operation instructions

Teaching tips

1. Notes about the computer program:
   a) In the musculature system section it takes a while to access data.
   b) In the digestive, nervous, urogenital and cardiovascular systems, the graphics are blurry and the structures are difficult to see (e.g., the cutaneous arteries in the skin). A handout would be useful to students.
   c) Structures in the skeletal system are seen clearly.

2. A list of the structures and associated functions that students should know would be productive. Some material is much too detailed for a seventh grader or even a Biology I student.
3. The program itself does not contain directions as to what keys are used to ask for help, quit, etc. This information is found only in the manual. To be most beneficial to students, a short typed list of commands should be included with the program.
4. The "Data Retrieval" portion is a good tutorial.
5. If students are to use the quiz portion, include a handout with directions on how it operates.
6. In the "Quiz Machine" a % score is kept at the lower portion of the screen. Students are always aware of where they stand and are competing only against themselves. When a wrong answer is given, students go to a diagram and then onto an explanation if desired. If students are unsure about an answer, they may use the H key for *help* for additional information. **Again, this is not given in the program, only in the manual.**
7. Activity sheets are included with the program. One includes observations of a real frog.
8. The disk may not be copied, but extra disks may be purchased.
9. One to two students per screen may work on the "Identification Game," "Slide Show" and "Data Retrieval" portions. However, for the "Quiz Machine" there should be only one student per screen. The students may work cooperatively in answering the "Identification Game."
10. This is an involved computer program. The teacher should preview the different parts of the program before it is used.
11. The program may require two to three class periods to finish.

Instructional procedure

1. Assign specific structures for students to research using several references. Have them write a description of the structure and its function. This will be very useful as they work through the computer program.
2. Review with students the commands for the program.
3. Allow time for students to read the photocopied activity #14 from the *Visifrog* teacher's guide. In the interest of time, this may be assigned as homework.

4. Allow students to work in pairs to complete the "Identification Game" portion of the computer program.
5. After the students have identified the structures on their activity sheets to their satisfaction, they may continue with the "Data Retrieval" portion of the program.
6. As a review, students may wish to individually view the "Slide Show" portion of the program which shows all six systems.

Evaluation

1. Students may evaluate their understanding of the parts of a frog using the "Parts Identification" section of the program independently. Any student that receives a low score after going through this should review the material and do this section of the program again.
2. Students may evaluate their understanding of the functions of the frog's structures by doing the "Quiz Machine" portion of the program. When an incorrect answer is given, the student checks the computer diagram and, if desired, the explanation.

Lesson title: **Using the Computer Simulation "Operation: Frog" as an Alternative to Dissection**

By: **Kathleen Frame**
Bishop O'Connell High School,
6600 Little Falls Road, Arlington,
Virginia 22213; (703) 237-1400

This lesson is built around the computer program "Operation Frog." It requires at least an hour of teacher preview and preparation of explanatory handouts for students. It is intended to simulate dissection with the proper dissection tools. It will require at least three days of students at the computer plus time for pre- and post-lab activities.

Grade level Grade 10 biology.

Objectives With this simulation students should be able to:

1. Learn the proper use of dissection instruments.
2. Know the function of organs in the frog.
3. Orient organs to their original positions in the frog as part of the simulation activity.

Materials

- Apple II Plus, IIe, IIc, 64K or Commodore 64 computer (ideal number is one to two students per computer)
- "Operation: Frog." Available from Scholastic Software, Inc. (1984)
- instrument use instruction sheet (made by the teacher)
- "frog fact" sheet (included in teacher's manual)
- live frog with proper habitat
- *How to Dissect* (Berman 1986, p. 134)

Optional: 26-inch monitor if used as a demonstration

Teaching tips

1. The teacher must review this program beforehand. There are no instructions included in the program itself. Instructions are included in the teacher's manual. Be certain to reserve at least an hour to review this program.
2. The instrument functions must be explained first. Refer students to page 21 of the teacher's manual or prepare a handout on how to use the "instruments."
3. Once dissection begins, students cannot go on to another part of the program. It takes approximately one hour to dissect and study the accompanying explanations.

4. The operation of the keys, mouse and jockey stick require a certain amount of dexterity. Be certain that students do not become involved with the operation of the computer and overlook the objectives of the lesson.
5. Since the heart simulation does not include an explanation, the teacher should be prepared to explain what is occurring.
6. The heart simulation may be used as a separate demonstration by the teacher to show circulation.
7. Recognize the limitations of the software and the computer. Read notes regarding this on page 7 of the teacher's manual.
8. One or two students per screen allows each student a reasonable amount of involvement.

Instructional procedure

Pre-lab activity:

1. Show a film on how to dissect a frog. You may use "Frog Inside Out (Part II)."
2. Distribute frog facts sheet from "Operation Frog" teacher's manual.

Day 1

1. Ask students which fact they found to be the most interesting on the "Frog Fact" sheet. Discuss why.
2. List the instruments used in a dissection. Describe how each is used and have students list them in the proper sequence.
3. Discuss the steps involved in an actual frog dissection.
4. Discuss how a computer simulation of dissection would be different from an actual dissection. Include pros and cons.
5. Have students practice picking up and using the instruments in the computer program (some will be more adept than others, but allow all sufficient time).
6. Once students are able to use the instruments, have them practice for a few minutes how to find demonstrations and text in the computer program.

Day 2

7. Have students begin the computer dissection. Ask them to use the computer text, simulations and drawings to make their own notes about organ function and orientation.
8. Show students how to save their program if they do not complete it that day.
9. Students should save program before the period ends.

Day 3

10. Have students retrieve their programs and complete their dissections.
11. Upon completion of their dissections, have students reconstruct their frogs. A quiz score will be given by the computer to evaluate the student's performance.

Post-lab activity

1. Compare/contrast the computer dissection to an actual dissection performed on videotape.
2. Have students construct a model of a frog and its internal organs.

Evaluation Give students a quiz based on frog anatomy.

Lesson title: **"Frog Dissection": An Alternative to Dissection**

By: **Kathleen Frame**
Bishop O'Connell High School,
6600 Little Falls Road, Arlington,
Virginia 22213; (703) 237-1400

This lesson can serve as an enhancement to a dissection or as an alternative. It is based on a computer tutorial consisting of parts identification and student-controlled dissection. The lesson provides some pre- and post-lab activities and the students can quiz themselves as they proceed through the program.

Grade level Grade 7 life science; grade 10 biology.

Objectives

1. To describe the orientation points of an organism (dorsal, ventral, etc.).
2. To define the vocabulary words associated with frog dissection.
3. To locate and describe the mouth structures of a frog.
4. To locate and describe the internal structures of the frog.
5. To become familiar with the guidelines of a frog dissection.
6. To evaluate knowledge gained from the computer activity through the use of computer-generated self tests.

Materials

- labeled drawing of frog anatomy from textbooks
- Apple II Plus, IIe, IIc, 64K or Commodore 64 computer
- "Frog Dissection" by Larry Newby. Available from Cross Educational Software (© 1984).
- handouts:
  1. Vocabulary words in user's manual (p. 3).
  2. List of mouth and internal structures in user's manual (pp. 4-5).
- model of a frog
- *How to Dissect* (Berman 1986, p.134)

Teaching tips

1. Allow at least 20 minutes to preview this program.
2. This program could be a strong reinforcement to a demonstration of a dissection or could serve as an alternative when used with the instructional materials. A suggestion: Use a model frog that can be taken apart. Diagrams showing internal organs may be used along with the tutorial.

3. The program is well written, user friendly and does not require memorization of extensive directions.
4. One or two students per screen works best.
5. It takes about 20 minutes to preview this program and 90 minutes of student time to complete it.

Instructional procedure

1. Assign students to define the vocabulary listed on page 3 of the user's manual.
2. Review vocabulary and the list of structures found in the tutorial. When students sufficiently understand the vocabulary, allow them to progress through the program "Frog Dissection" in the following manner.
3. Have the students execute #1 from the Main Menu, using their own bodies to verify the orientation points.
4. Give students time to quiz themselves on the vocabulary list on the screen. Tell them to refer back to the homework list only when unsure of a definition.
5. When finished with #1 from the Main Menu, have students select #2 from the Main Menu.
6. As students are working on the Main Menu, instruct them to locate the structures on the model before them.
7. After locating the structures, have students recall each one's function. If students have difficulty recalling any functions, refer them to the listing of functions in the program. The students can follow this procedure for both the mouth and the internal structures.
8. When #2 from the Main Menu is completed, students return to the Main Menu and select #3.
9. When the students go through the student-controlled dissection, the following instructions may be given:
   a) Note the description of the dissection process and the precautions given.
   b) If at any time during the "dissection" you do not learn the function of the organ, refer back to the diagram to "see" the organ being described.
   c) In the last section, note the detail of the male and female reproductive systems.
10. Upon completion of #3 from the Main Menu, if students feel able to take a quiz on the material from the program, have them go back to the Main Menu and select #4.

Post-Activity/discussion

1. Have students review with their lab partner the orientation, vocabulary and function of parts of the mouth and internal structures, location of mouth and internal structures, and steps and precautions in dissection.

2. Compare the computer dissection to an actual dissection performed on videotape or film.

Evaluation

1. Students may evaluate their understanding of the parts of a frog dissection with the first test, Parts Identification. If any students receive a low score after going through this, they should return to #2 on the Main Menu and review.
2. Students may evaluate their understanding of the functions of the frog's internal and mouth structures from the multiple choice and true/false self-tests.
3. Students may evaluate their understanding of the process of dissection and related precautions by listing the steps of an actual dissection.

Lesson title: **"Interactive Frog Dissection"**

By: **Richard Strauss**
Mabel B. Kinzie
Curry School of Education, University of Virginia, Charlottesville, Virginia 22903; (804) 924-0835

The IBM InfoWindow system uses an IBM computer or IBM videodisc player that sends moving and still video to the InfoWindow Display. Computer-generated images can be superimposed on the video or displayed by themselves on the same InfoWindow touch screen. A mouse and keyboard also may be used. The user determines the selection, sequence and pace of audio and video messages. The "Interactive Frog Dissection" videodisc demonstrates dissection, allows students to practice and takes them through a frog layer by layer for an in-depth look at organ function.

Grade level Grade 10 biology.

Objectives

1. To learn and practice the techniques of dissection
2. To locate the organs within the frog.
3. To explain the function of each organ in the frog.

Materials

- IBM computer and videodisc player
- InfoWindow software
- Strauss's "Interactive Frog Dissection" videodisc

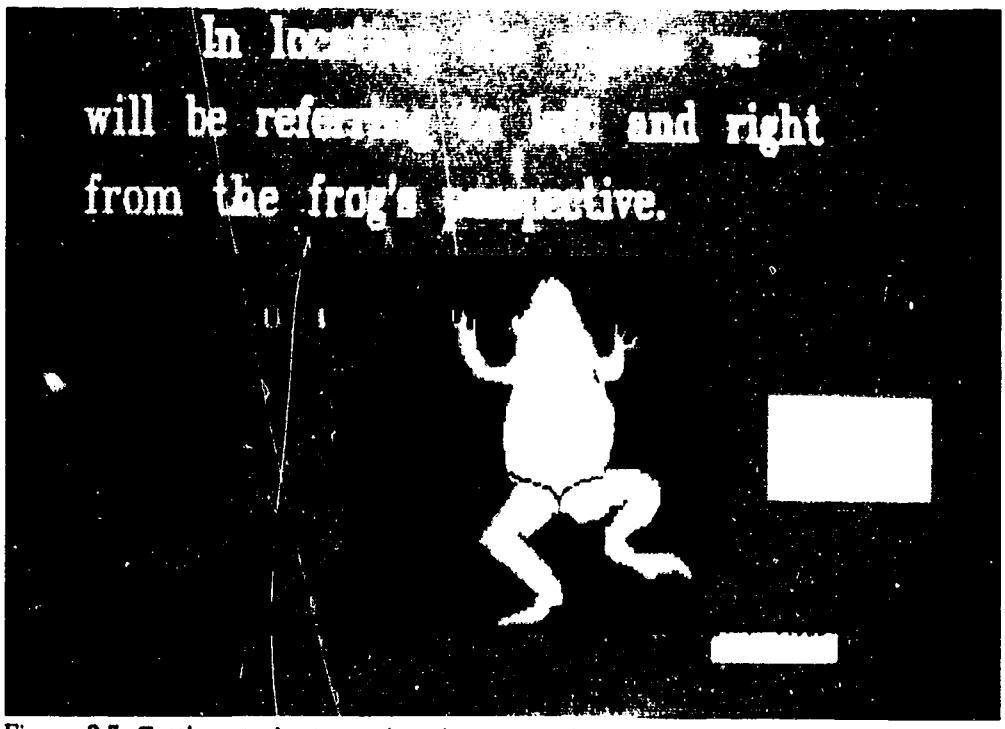


Figure 2.5. Getting students used to the terminology used.

Instructional procedure

1. Students should watch the first part of the videodisc, a narrated overview of the simulation that shows a high school student preparing for a dissection. The lesson continues with a demonstration of the actual dissection followed by a brief review.
2. Students can practice each of the dissection steps by selecting them in the correct order and touching the appropriate places on the computer monitor to indicate where a particular action (such as pinning and cutting the frog) should be performed.
3. Students should watch the second part of the videodisc which demonstrates how to locate each of the major organs by going layer by layer through the body cavity of a male and female frog. It begins with a view of the undisturbed organs, called "layer one." Organs then are shifted and removed to gradually reveal all the major organs at layers two through four, as far down as the dorsal wall of the body cavity. During the demonstration it is possible to request information about each organ's function or repeat the portion that illustrates its location.

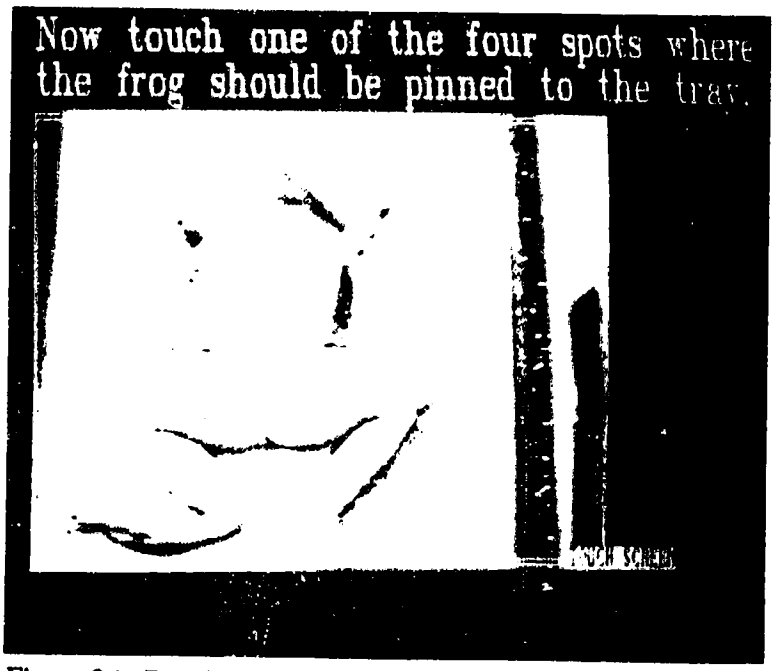


Figure 2.6. Practice in dissection procedure.

4. Students can practice locating organs on their own. Students first must identify the proper layer for randomly selected organs, then find particular organs at each layer by touching them on the videodisc display. In the last step, students select the proper layer number for specified organs. When a video image of that layer appears, students touch the correct organ.

Notes to teacher

Develop an evaluation based on material students are to have learned.

Lesson title: **A Hypermedia Program of the Frog: A Laboratory Dissection of *Rana pipiens***

By: **Jean Foss**
Western Albemarle High School, Route 1, Box 425, Crozet, Virginia 22932; (804) 823-4314

Using technologies such as a laser disc and player, and a Apple Macintosh computer with HyperCard and HyperCard Stack, teachers can create a lifelike simulation of dissection called the Hypermedia program. A Hypermedia simulation on frog dissection has pedogogical advantages, including:

1. students can see the dissection exactly as they would if they were actually performing it,
2. students can review the lesson any number of times,
3. the teacher can be sure that the whole class sees the same thing,
4. students who object to dissection can also participate using the same lesson. This alternative requires that students who object to the dissection devote time and effort comparable to that spent by those doing the dissection.

The laserdisc stack begins with a card that the teacher may use as a pre-lab on how to dissect. The lesson is divided into eight short segments, allowing the teacher to determine the rate at which the lesson is taught. The five cards are diagrams of the:

1. digestive system
2. heart
3. male reproductive and urinary systems
4. female reproductive and urinary systems
5. respiratory system and oral cavity.

These cards may be used with or without the laserdisc attached. The names of the organs are hidden until the student clicks on the organ with the pointer. The videodisc simultaneously shows the organ, clearly identified in the dissected frog and, optionally, the organ's function. For example, the card on the heart shows the heart beating; the lungs are filled and emptied slowly when the button of the respiratory system card is clicked.

The videodisc footage in this lesson was taken from a dissected preserved frog and a pithed frog. This program applies both the reduction *and* ultimately the replacement goals of alternatives to the use of animals.

Grade level Grade 10 biology.

Objectives Since this program can be used as a dissection pre-lab and guide or as a complete alternative to dissection, the students should be able to:

1. Learn the proper way to dissect through the demonstration shown in the videodisc.
2. Exercise more care and skill in dissection (for those who choose to dissect).
3. Visualize the location and appearance of the organs in vertebrates.

Materials

- laserdisc player
- Apple Macintosh computer with HyperCard
- cables to connect laserdisc player to Macintosh
- HyperCard stack
- large monitor
- "Interactive Frog Dissection" laserdisc (Strauss & Kinzie)

For students who opt to perform dissection, the following equipment should be available:

dissecting kit with scalpel	probes
forceps	dissecting pan
scissors	dissecting pins/needles

Teaching tips This lesson may be used as a demonstration and guide for students who choose to dissect and as a complete alternate lesson for those who object to dissection.

1. As a pre-lab demonstration, this lesson can show the whole class how to do the dissection using the videodisc. The students will clearly see the safety precautions, equipment and proper procedure to dissect.
2. During the lab period the program can help locate organs in the dissected frogs. Students who are not doing the dissection will use the laserdisc to identify the same organs and complete the same lab assignment as the rest of the class. This way, all students feel they receive the same treatment.
3. The post-lab activity for both groups of students provides a review and drill on the location and appearance of organs.
4. The time required for the complete program may vary from three to four class periods, depending on the students' pace.

Instructional procedure

1. Set up the laserdisc player, Macintosh computer and monitor. Set up the traditional frog dissection lab.
2. Demonstrate dissection process using the laserdisc.
3. Do the dissection and set up the Hypermedia as a Learning Station for those students not doing the traditional dissection.
4. The next day, review the dissection using the laserdisc. Allow students to continue their dissection or work with the Hypermedia programs at the Learning Station until students from both groups have finished the dissection and the program.

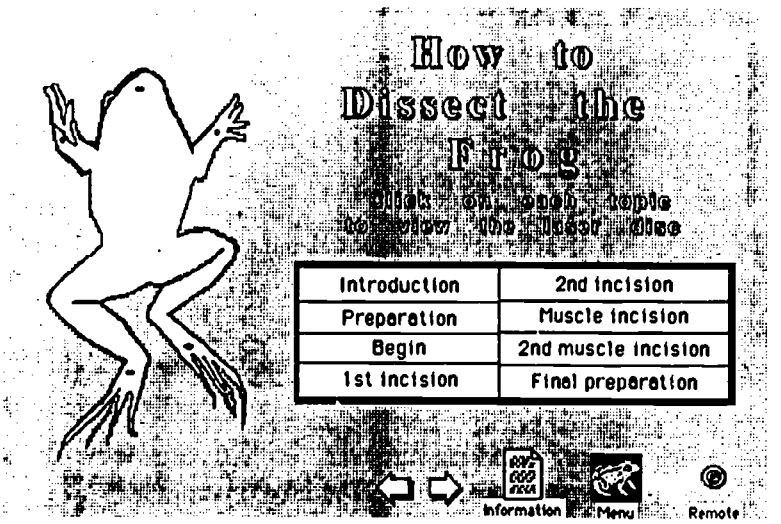


Figure 2.7. Main menu of the Hypermedia program.

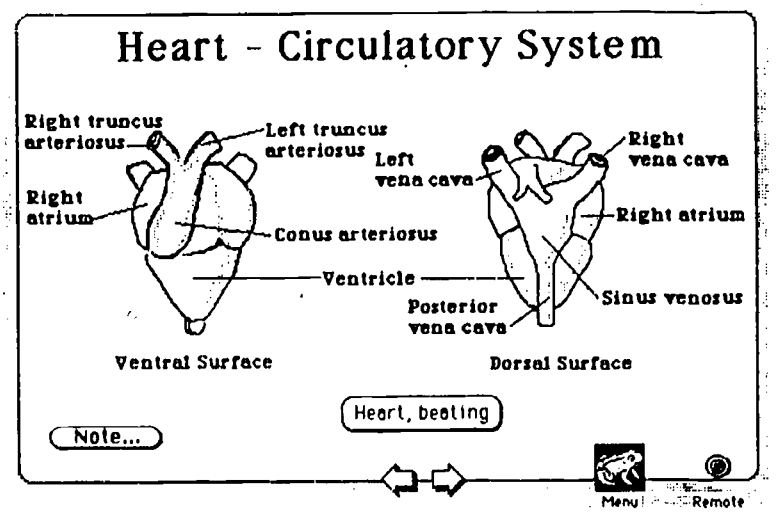


Figure 2.8. HyperCard shows the parts of the frog's heart.

Evaluation

Use the laserdisc, stack and large [illegible]or to present a lab pra[illegible]cum that can be seen by all students. Its advantages are:

1. It doesn't require an hour before school to set up,
2. There is no smell or drying out of specimens,
3. The videodisc program can be seen by all students at the same time.

Acknowledgments

The laserdisc program includes lab preparation, dissection procedures and organ identification. It was produced by the collaborative efforts of Mabel Kinzie, Richard Strauss and Wayne Connors of the University of Virginia and Jean Foss of Western Albemarle High School, Virginia.

Those interested in learning how to produce Hypermedia programs can write:
Alternatives to Animals
P. O. Box 7177
San Jose, CA 95150

Lesson title: **The Effects of Adrenalin on the Heart**

By: **Kathleen Frame**
Bishop O'Connell High School,
6600 Little Falls Road, Arlington,
Virginia 22213; (703) 237-1400

This lesson attempts to simulate the research experience by showing students a film that is stopped at designated points so they can discuss hypotheses and design experiments. The film investigates the effect adrenalin has on a frog's heart. After viewing the film students should gather research from the school or public library to construct a chart of pharmacological chemicals.

Not only does this technology reduce or eliminate the need for animals in the classroom, it also encourages cooperative learning which has been shown to have positive effects on both high and low ability learners. The high achievers from cooperative groups use a higher quality of reasoning strategies and are more likely to develop skills in leadership, communication, decision making and conflict management needed for future success in school and in a career (*BSCS Newsletter* September 1989, p.1).

Grade level

Grade 10 biology; advanced course in biology.

Objectives

1. To review how hormones control body functions.
2. To review the factors that control the beating of the heart.
3. To list the functions of adrenalin.
4. To design an experiment that shows adrenalin's effects on the heart in an emergency, in this case the capture of a frog from a pond.

Materials

- monitor, 26-inch if possible
- laserdisc player
- videodisc "The Frog," Optical Data Corporation (1989)

Teaching tips

Allow 20 minutes to preview Chapters 14 and 25 on Side 5 and Chapter 21 on Side 6.

The lesson may take 45 minutes.

Instructional procedure

1. Review how hormones control the coloration of frogs' skin. Show Frame 16835, Side 5 (Skin). Stop after "the skin becomes lighter in color" (Frame 19245).
2. Discuss how the heart beats. Start Frame 50352, Side 5 (Beating heart, pacemaker).

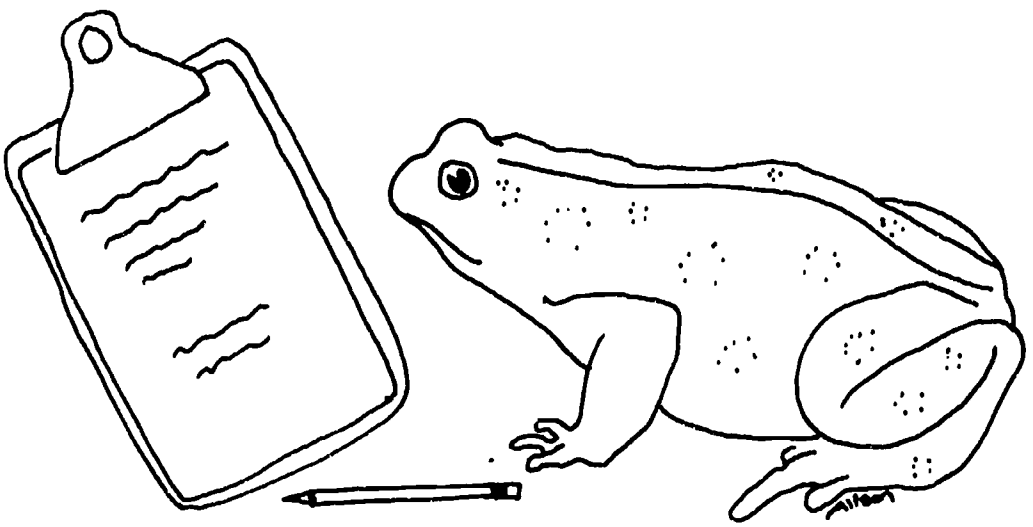
3. Summarize how hormones control bodily functions.
4. Ask students why adrenalin is classified as a hormone.
5. Have students share the information they found on adrenalin, listing its major functions. Have them distinguish between its role in an emergency and its role in regulating normal body functions.
6. Have students hypothesize how and why adrenalin would affect the heart rate and other bodily functions of a frog being captured.
7. Show Chapter 21, Side 6. Stop after "less-immediately necessary functions like digestion."
8. Have students design experiments and make predictions as to how and why adrenalin affects the heart. Consider variables such as concentration of adrenalin and method of delivery of adrenalin.
9. Discuss designs of student experiments.
10. Observe the effects of adrenalin on the beating heart. Show the remainder of Chapter 21, Side 6.
11. Refer to your students' hypotheses of adrenalin's effect on the heart. Develop generalizations about adrenalin based on what they learned from the videodisc.

Post activity & discussion Discuss the advantages and disadvantages of observing these functions in living organisms.

Evaluation Have students research various chemicals that are used to regulate heart activity. Design a chart showing the effect of chemicals on the body, pros and cons for their use and their interaction with other body systems or drugs. Have students verify their chart with a pharmacist or doctor.

D. *Refinements of Dissection & Experimentation*

After reevaluating the use of animals in biology class, some teachers may conclude that there is no substitute for the presence of actual specimens in the classroom. Instead, they may wish to refine their existing procedures to better reflect the view that all living organisms are worthy of appreciation and respect. The following lessons are examples of traditional techniques that have been updated so as to inculcate humane attitudes toward animals.



Lesson title: **Squid: An Illustration of Adaptation**

By: **Lois Glasscock**
North Garland High School, 2109 Buckingham Road, Garland, Texas 75042; (214) 494-8451

The squid makes a good alternative to conventional dissection because it is simple in structure, easy to obtain and can easily be cooked and eaten. By using fresh or frozen squid, you avoid the formaldehyde in preserved specimens. This lesson takes the student through an examination of the squid and provides a recipe for "squid strips" that can be prepared in the classroom.

Grade level Grade 10 biology.

Objectives The student will be able to:

1. Examine a squid, noting characteristics of both external and internal anatomy.
2. Formulate hypotheses about squid niche and habitat, relating a particular structure to a survival strategy.
3. Clean the mantle of the squid, which will be cooked for the student to taste.

Materials

- frozen or fresh squid from a supermarket/fish market/bait shop (keep refrigerated until ready to use; 4 lb. frozen block contains approximately 15 squid)
- squid diagram
- paper plates
- clean razor blades
- soap, paper towels
- deep fat fryer or electric frying pan
- oil
- batter ingredients:

a few lemons and limes	cornmeal (optional)
1 egg	1 T. baking powder
1 c. flour	1 T. water

Teaching tips It is helpful to have a student assist in frying the strips. You also can ask students to bring in lemons and limes to go with the strips.

It is easier to make the batter ahead of time rather than while students are dissecting. For the batter, mix together one egg, one cup flour (cornmeal mixed with flour also works well) and one tablespoon each of baking powder and water.

Instructional procedure

1. Have students first wash their hands. Remind them the squid will be cooked when the observations are completed.
2. Have students cover their lab station with newspaper. Make sure they work on a clean paper plate with a clean razor blade.
3. Tell students to rinse the squid in running water and examine it. Each lab group should generate a list of characteristics.
4. Explain that organisms must perform certain tasks in order to live. These tasks include eating and avoiding being eaten. Begin to relate squid characteristics to these tasks. Have students write the squid characteristics on the board.
5. Tell students to position the squid on the plate as they think it would be positioned if it were moving through the water. Notice the coloration and shape of the squid and the position of its fins.
6. Have students turn their animal over and find the siphon below the tentacles protruding from the collar. Using a razor, students should open the mantle below the siphon to expose the internal organs. The ink sac often has a metallic sheen. It secretes ink to hide the squid from predators and is used as an escape mechanism. The gills look like feathers and are centrally located. In mature individuals, most of the remainder of the cavity is filled with gonads. After comparing several squid you can begin to identify the mature females by the presence of eggs.
7. The shell of the mollusk is reduced and incorporated in the upper mantle. In the mantle collar opposite the siphon find the point that is the end of this shell or "pen." This is a stiff structure. Make a shallow 1 cm incision parallel to the pen. Carefully pull the pen from the mantle. You will see that it runs the length of the animal's body, giving it the advantage of a flexible internal skeleton.
8. Use the pen to write your name with the ink from the ink sac.
9. Have students examine the mantle carefully. Notice the grooves and knobs that hold the mantle tightly in place in the living animal. Realize that the squid takes water into the mantle cavity to oxygenate the gills. The squid is also able to direct water from the mantle cavity in a powerful stream through the funnel to the outside (similar to the flight of an inflated balloon once air is

released). The squid is able to control the direction the siphon points and consequently control its movement through the water. Note the position of the external fins.

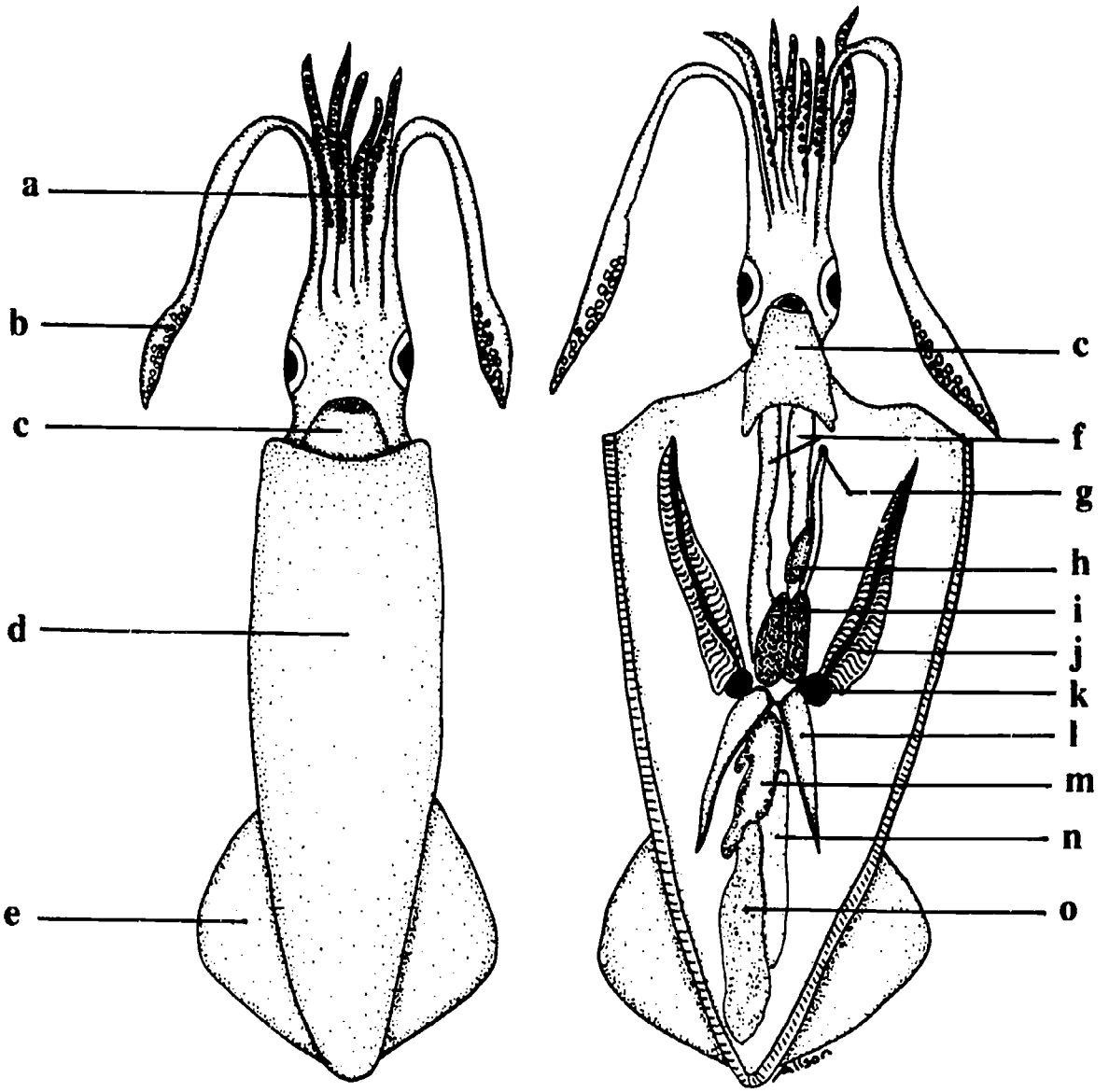
10. Another point of interest is the complex eye, similar in structure to the vertebrate eye. It can be dissected to find the lens. Ask students why a mollusk would need such an eye?
11. Collect the cleaned mantles and cut them into strips to be dipped into batter and fried. Fresh squid is delicious with lemon or lime and salt. Make sure students clean lab stations and wash tables.

Post-lab discussion

List the vital functions that an organism must perform to survive. How is the squid unique to perform each task? Why is that adaptation necessary for survival in that habitat? One way to discuss this is to draw a table with three columns:

1. adaptation
2. description
3. survival advantage.

Another way to answer these questions is to draw the animal in its habitat and illustrate its unique adaptations to its environment. Some might prefer to write a story about the life of a squid.



Key to the Squid

a.	arm	f.	siphon retractor	k.	branchial heart
b.	tentacle	g.	anus	l.	vena cava
c.	siphon	h.	ink sac	m.	stomach
d.	mantle	i.	kidneys	n.	gonads
e.	fin	j.	gill	o.	caecum

2.9. Internal and external anatomy of the squid.

Lesson title: **Look at My Muscles . . . Who's A Chicken?**

By: Peter DeDecker
Hastings High School, 520 W. South St.,Hastings, Michigan 49058; (616) 945-9591

Your neighborhood supermarket may be your best source of animal parts for a lesson in anatomy. The purpose of this investigation is to compare your arm to a chicken wing. How are your muscles and bones like those of a chicken wing? How do they differ? How do muscles and bones work together to bring about movement?

Grade level Grade 10 biology.

Objectives

1. Recognize the differences and the similarities between your arm and the wing of a chicken.
2. Infer how structure relates to function.
3. Recognize the interrelationship between the muscles and skeleton.

Materials

- a package of chicken wings from the supermarket
- scalpel
- forceps
- vinegar
- stopwatch

Instructional procedure

For introduction and motivation, begin with these brief statements at the beginning of the activity:

1. First, let's recognize how your arm works and realize some things about muscle function. Muscles are attached to your bones by tough, non-stretching white cord-like structures called **tendons**. **Ligaments** are very much like tendons in their structure but they function to hold one bone to another. Muscles do their work by getting shorter or **contracting**.
2. When you bend your arm to "make a muscle," that is called flexing your arm; the muscles used to bend your arm are called **flexors**. The name of this flexor muscle is the **biceps**. When you straighten out your bent arm, the muscles you use are called **extensors**. The name of this extensor muscle is the **triceps**.
3. A muscle will get tired or become **fatigued** if you contract it too many times without resting it.

A. Your muscles

1. Have the students work in groups of two. One person puts an arm on the table and the second places his/her arm so that the hand is on top of the first person's hand and wrist. Both place their other hand around their upper arm.

   Ask students to describe what happens to their upper arm muscles (biceps and triceps) as the first person tries to bend his/her arm and the partner tries to prevent that from happening.

   Have students switch roles. Ask them to describe the differences they notice.

2. In this part of the exercise, time students' activity for 30 seconds. Have them make a tight fist, then extend their fingers as far as they can. They should do this as fast as possible for 30 seconds. Ask students to:
   a) describe what they feel.
   b) point out where they feel muscle fatigue.
   c) explain why the muscles fatigued where they did.

B. Chicken wing

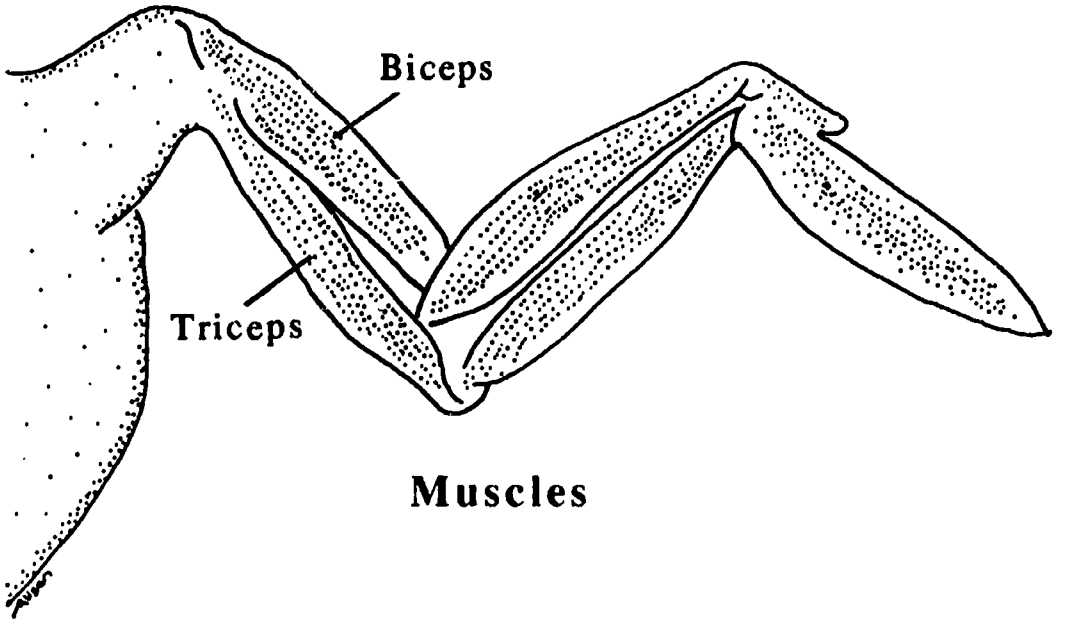
1. Instruct students to remove the skin from a chicken wing. Do not cut the muscles or destroy them in any way.
2. The biceps muscle is on the front part of the upper wing; the triceps is located on the back part of the upper wing. Ask students to identify the muscles in the upper part of the wing. Can they identify the biceps muscle and triceps muscle? (You should help those who cannot.)
3. Have students hold the biceps muscle between their thumb and forefinger on one hand and do the same with the triceps muscle with their other hand. Instruct students to pull on the triceps muscle and then on the biceps muscle. Have them describe what happens when each muscle is pulled.
4. Ask students to locate and describe the function of the "white cords" attached to the end of these muscles. Guide students to infer to what–in addition to the muscle–the "cords" are attached.

5. Give students these instructions:
   Starting at the middle of the biceps, remove the muscle from the humerus bone, but do not remove it where it attaches to the bones with the "white cords." Try to locate where the biceps muscle attaches to the bones. Have students again pull on the muscle and try to recognize what is happening to the bones. (The origin is the muscle attachment to a bone that does not move when the muscle contracts and the insertion is the attached point to the movable bone). Ask students on which bone the biceps is attached.
6. Help students locate the nerve and blood vessels along the biceps muscle.
7. Remove all the muscles from the bones. Observe the hinge joint after the muscles have been removed. Observe how is it held together. Have students identify what the "white cords" are attached to on both ends.
8. Have students cut the white cords at the back of the joint until the joint is open from the back. Have them describe the ends of the bones. Put the bones together and move the joint. Ask students to explain why this joint cannot straighten out more than approximately 180 degrees and therefore is classified as a hinge joint. Ask them how this joint differs from a ball and socket joint.
9. Ask students to observe the ends of the bones and notice a gray-white covering. Make a cut in this covering and remove a small piece for closer examination. Ask students to name this material and explain how it differs from bone.
10. Have students remove most of the skin and muscle from the remaining parts of the wing. Ask if they recognize the "wrist," "thumb" and "hand" portions of the wing.

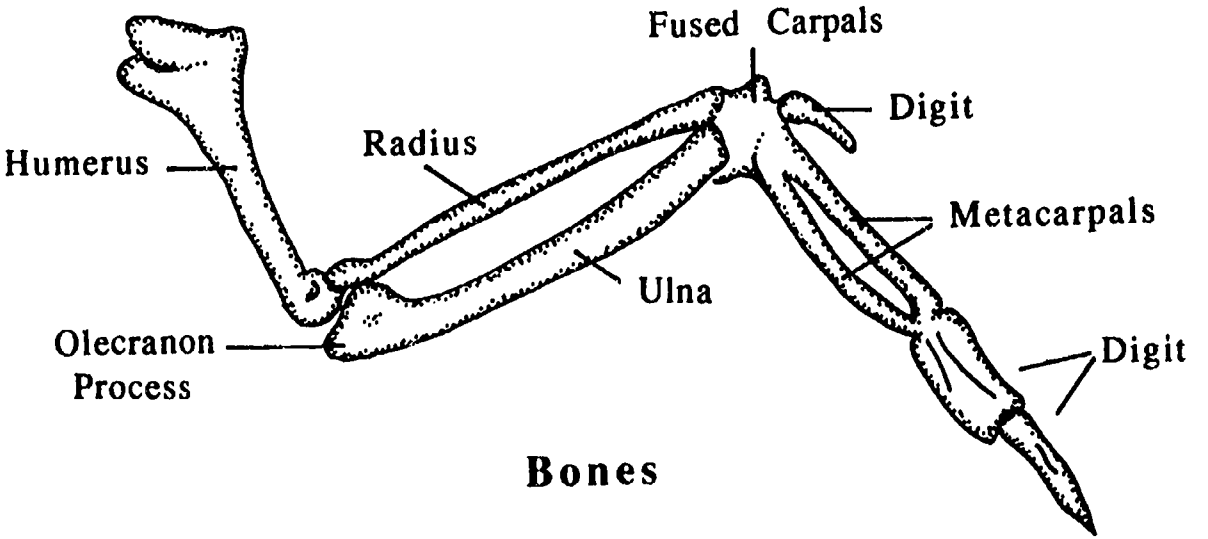
Evaluation Have students write a brief comparison of the muscles and bones of a chicken wing and the human arm. Have them include how they are the same, yet different.

Further study Place one of the wing bones in a weak acid or vinegar solution for five days. Explain what has happened to the bone. (Hint: Vinegar dissolves minerals).

Chicken Wing



Muscles



Bones

2.10. Anatomy of a chicken wing (adapted from DeDecker).

Lesson title: **Structural & Behavioral Adaptations of Felines**

By: **David Gilmore**
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The domestic cat is a classic example of semi-manipulated evolution. The companion animal we know today as the cat is descended from wild varieties of felines that originated probably in the Euro-African supercontinent. As it exists in its present form (*Felis cattus*), the domestic cat demonstrates anatomical, physiological and behavioral features that can be enlightening to a beginning student of biology. This activity is intended as a weekend assignment with a follow-up discussion the next class day. Students who don't have a cat can team up with those who do.

Grade level Grade 7 life science; grade 10 biology.

Objectives The students should be able to:

1. Become familiar with feline physiological responses to various stimuli.
2. Explain anatomical features in terms of what they enable the cat to do.
3. Compare physical parameters of cats' bodies.
4. Examine evidence of eating preferences.
5. Obtain experience measuring and recording physical characteristics of a living higher order vertebrate.

Materials

- live cat
- catnip
- cat muscular diagram
- cat skeleton diagram
- student chart
- ruler or meter stick
- penlight
- cat food–wet, dry, treat
- sound stimulus
- chase stimulus

NOTE: In any experiment with a living animal, be certain to follow humane laboratory guidelines (see Appendix).

Instructional procedure

1. Record your cat's name.
2. Spend a few minutes with your cat. Decide if it is in the mood to be picked up and held.

3. Place the cat on a table. Carefully examine major features of its external anatomy. Does your cat have any unusual features?
4. Describe coat color(s).
5. Record eye color(s).
6. Gently examine your cat's feet. Does it have more than five toes on its forelimbs? On its hindlimbs?
7. Record the number of major right eyebrow whiskers (vibrissae).
   Record the number of left eyebrow whiskers.
   Record the number of right maxillary whiskers.
   Record the number of left maxillary whiskers.
   What is the adaptational advantage of whiskers?
8. Does the set of your cat's eyes cause it to gaze forward or sideways?
   What is the adaptational advantage of this?
9. Does your cat seem to have a relatively elongated face or a relatively pug face?
   Consult the skeletal diagram and record what skull bones contribute to this facial characteristic.
10. Carefully feel and check off the following bones on your cat's body:
    a. sagittal crest of skull*
    b. scapula*
    c. elbow
    d. cervical, thoracic, lumbar, sacral and caudal vertebrae*
    e. pelvic ilium*
    f. knee

    Does it appear that any bones support the cat's ears?
    What is the upper bone of the forelimb?*
    What is the upper bone of the hindlimb?*
11. What bones does the cat walk on?
12. Gently measure and record the length of your cat's tail.
    What is the length of its vertebral column from first cervical to last sacral vertebra (neck and torso spine)?
    What is the ratio of the cat's tail length to its body length?
13. Is your cat clawed on all four feet?
    Carefully extend a claw. What is the adaptational advantage of claws?
    To what foot bones is the claw attached?

*Ask these questions to grade 10 students after a lesson on the names of the bones.

14. Allow the cat to perform the following movements. Look up and record the names of the major muscles used to complete these movements:.
    a. turn head
    b. jump up onto counter
    c. lift forelimb to paw at object
    d. jump down to floor
    e. any others that you notice
15. While someone else holds the cat relatively still, shine the penlight very briefly in its eye. What effect does this have?
    Compare the shape of a cat's pupil to a human pupil. What adaptational advantage is there to this reflex?
16. Analyze the forefoot and hindfoot bones on the diagram. Gently palpate (feel) your cat's hindfoot and forefoot, identifying the locations of these bones. Compare the drawing of the cat's foot to the way your cat's foot feels. Compare the length of the carpal, metacarpal, tarsal and metatarsal bones.
17. Carefully examine your cat's foot pads (tori). How many are on an anterior limb? Posterior limb?
    What are foot pads an adaptation for?
    What, if anything, can you tell of your cat's past by examining the foot pads?
18. If possible, obtain a shedding hair from the darker portion of the cat's body and put it in a plastic bag. Bring it to class to examine under a compound microscope for evidence of flea dust.
19. Have your partner make a clicking sound. Ascertain the furthest distance that your cat will respond in some way to a click. Trials at several distances will be needed. Responses may take the form of approach, avoidance, turning the head toward the sound, cocking an ear toward the sound, etc. Record distance.
20. Using your chase stimulus, determine the farthest distance at which your cat will respond to the toy by pursuing it. Several trials at each distance will be necessary for reliable data. Record the distance on your chart.
21. Place a small amount of dry cat food, a treat (not catnip) and a teaspoon of wet canned cat food about 15 cm apart on a paper towel, keeping your cat away from it as you set up. Place your cat about 50 cm from the foods, away from distractions, and restrain it.

Make sure tne cat is aware of the presence of the food, then release it. Note carefully which food item the cat sniffs first, second and third and which it eats first, second and third.

22. Sprinkle a little catnip directly under the cat's nose. Allow it to interact with the catnip fc . minutes. Compare the cat's behaviors now to its behaviors prior to the exposure. Try some of the previous procedures and record how the cat responds to them now.

23. **This is an optional activity:**
Carefully examine your cat's teeth and tongue. For what type of behavior are these kinds of teeth an adaptation?
Count the number of teeth in your cat's upper and lower jaw.
What is the texture of your cat's tongue?
What does this texture enable the cat to do?

Analysis / class discussion

1. a. Compare the class data for tail/torso ratios. List the cats' names in order from largest ratio to smallest.
   b. Does the cat with the largest ratio necessarily have the longest tail? Explain.
2. According to the class data, which cat pursues the chase toy from the farthest distance?
3. According to the class data, which cat takes notice of sounds at the farthest distance?
4. Why is there variation in the data related to question 2?
5. Discuss specific behaviors that you:
   a. Expected to see but didn't.
   b. Didn't expect to see but did.

Refer to specific parts of the procedure for each statement you make.

6. What could have been influencing your cat's behaviors?

Cat Observation Chart

Cat's name _____

Unusual features _____

_____

_____

right vibrissae _____

left vibrissae _____

right maxillary whiskers _____

left maxillary whiskers _____

Coat color _____

Eye color _____

toes on paws _____

Gazes forward / sideways

Elongated / pug face

Skull bones: _____

_____

Check off bones:

a. saggital crest of skull _____

b. scapula _____

c. elbow _____

d. cervical, thoracic, lumbar, sacral and caudal vertebrae _____

e. pelvic ilium _____

f. knee (patella) _____

g. ear bones _____

h. forelimb bone _____

i. hindlimb bone _____

Bones that cat walks on _____

_____

Claws on all 4 feet? _____

Adaptive value of claws _____

_____

_____

_____

Tail length _____

Vertebral column _____

Ratio: tail length to body length _____

Claws attached to _____ bones

Muscles required to:

a. turn head _____

b. jump up _____

c. lift forelimb _____

d. jump down _____

e. other movements (describe) _____

_____

Effect of light _____

_____

Comparative length of foot bones _____

_____

foot pads–front limbs _____

foot pads–back limbs _____

Adaptation of foot pads _____

_____

History of foot pads _____

_____

Furthest distance–hearing response _____

Furthest distance–chase response _____

Optional:

teeth–upper jaw _____

#teeth–lower jaw _____

Adaptations of teeth _____

_____

Tongue texture _____

Adaptation of texture _____

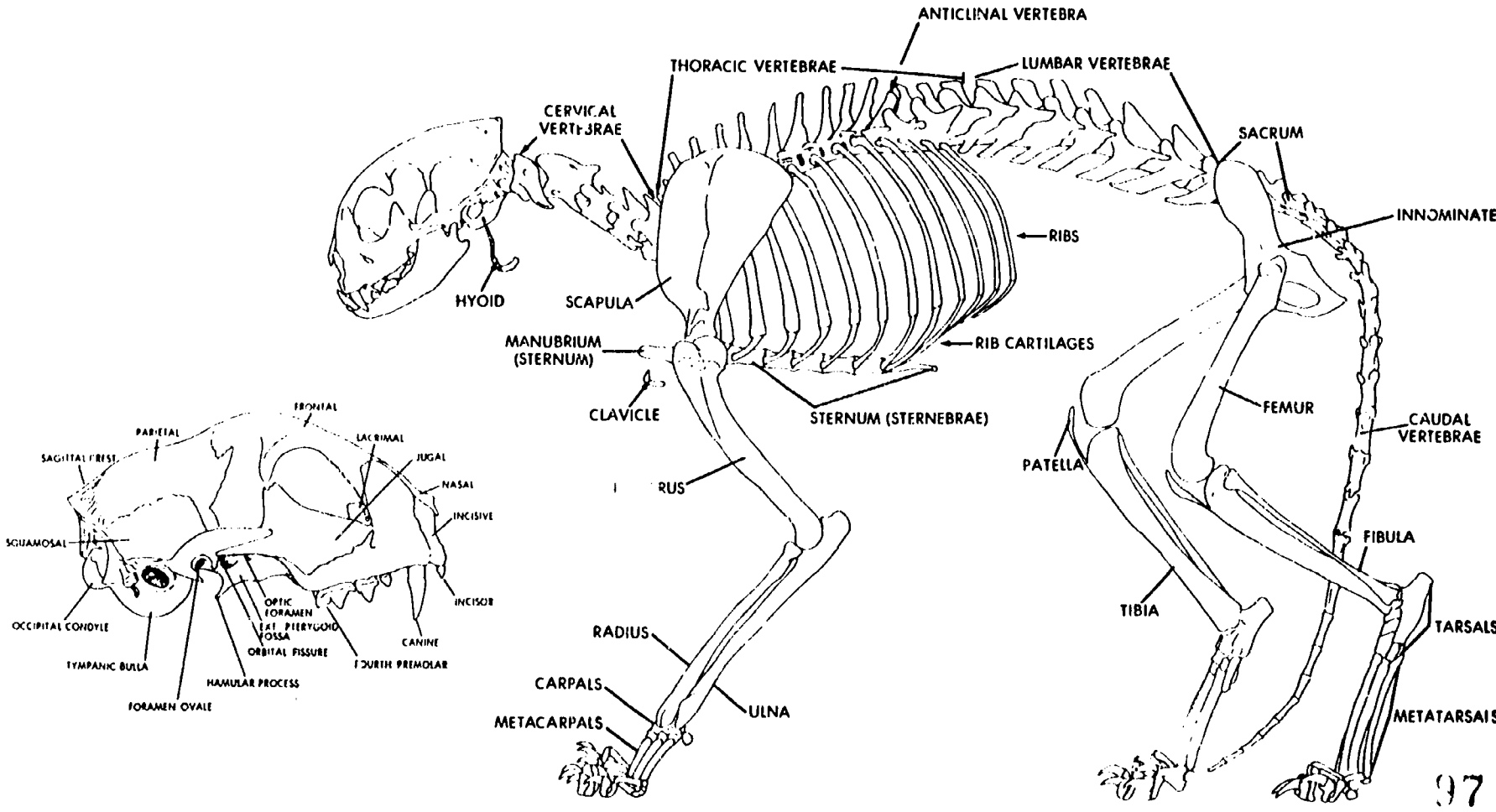
_____

Food preference _____

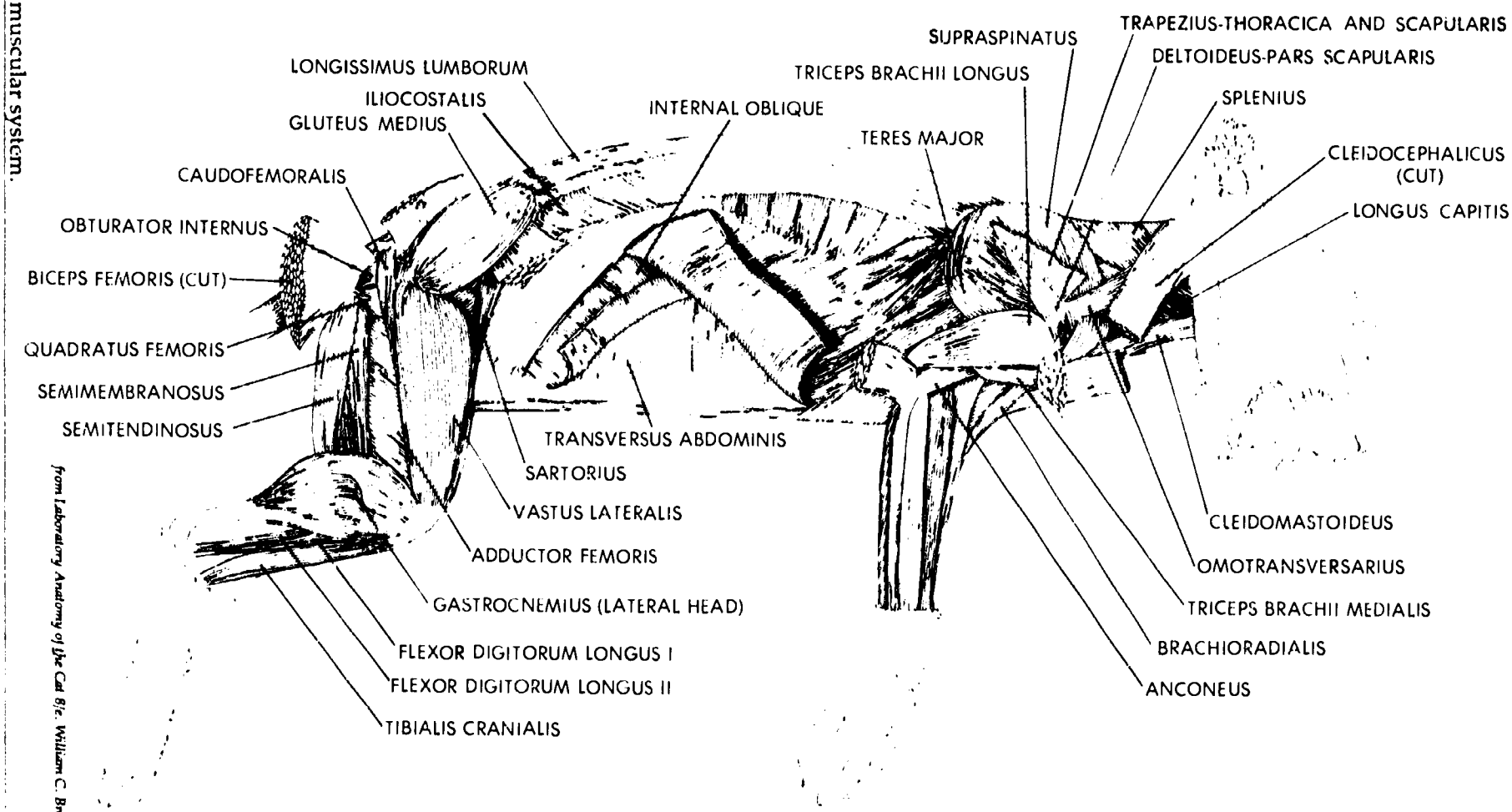
Catnip behavior _____

_____

2.11. Cat skeleton.



from Laboratory Anatomy of the Cat 8/e. William C. Brown Publishers.



2.12. Cat muscular system.

from Laboratory Anatomy of the Cat 8/e. William C. Brown Publishers.

Lesson title: **The Snail**

By: **Stanley L. Weinberg***
Iowa Committee of Correspondence, 156 E. Alta Vista, Ottumwa, Iowa 52501; (525) 682-7321

This is a straightforward exercise based on observation of a living animal, and it is unfailingly interesting to students. It is excellent for beginning the year's work, as it provides a lively introduction to laboratory work. While it is simple enough for even the slowest student, many of the questions are stimulating enough for bright youngsters.

Preparation

The white, edible Burgundy snail, *Helix pomatia*, works well in this exercise. Another edible snail, *Otala lactea*, or *Petit gris*, is less active and, therefore, less useful. These imported snails are sometimes available in fish markets in major cities. The common garden pest, *Helix aspersa*, is quite active; it can be collected at night or on rainy days. These and other snails are available from biological supply houses.

Other gastropods may be substituted for *Helix*, including local land and pond snails, aquarium snails, slugs and marine forms such as periwinkles or whelks. These are available in pet stores. You should obtain enough snails so that each student will have at least one to observe (students can also work in pairs). Snails can be used over again from one class to the next. Dispose of any dead snails quickly as they soon become odorous.

Snails purchased from supply houses will arrive dry, with the aperture of each shell closed by a mucous membrane. Distribute the snails in several covered Mason jars that have a little water and a few lettuce leaves in the bottom of each. Within half an hour many of the snails will emerge from their shells and crawl up the glass. Pick them up gently, one at a time, and place each on a glass plate. If a snail withdraws into its shell, have a student return it to the jar and take another. Temporarily inactive snails often can be reactivated by rinsing them in running water.

You can learn much about snails from careful observation. **Remember:** the snail is a living creature and can be hurt. Handle it gently. These directions are prepared for use with land snails. They can be modified slightly if only water snails are available.

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*Stanley L. Weinberg, a retired teacher, received NABT's Honorary Member award in 1985. "The Snail" and "The Frog" are from *Biology Laboratory Manual* authored by Weinberg and published by Allyn and Bacon.

Grade level Grade 7 life science; grade 10 biology.

Objectives

1. To become familiar with the anatomy and physiology of a common mollusk.
2. To determine how the structure of a snail helps it survive.
3. To learn proper techniques of animal observation.
4. To engage in humane animal experimentation.

Materials

snail	glass plate, 6" square
lettuce	sandpaper, 6" square
hand lens	compass
watch	ruler

Instructional procedure

1. Have each student (or pair of students) put a snail on a glass plate and watch it for a few minutes. How does it move? If the snail does not emerge from its shell and become active within three minutes, have students return it to the jar and take another which has emerged.
2. Tell students to time the rate of movement. A sheet of paper placed under the glass plate and marked with concentric circles equal distances apart will be helpful. Have students take the average of several trials; explain why several are needed. Tell them to give the results in table form.
3. Next have students place their snail on sandpaper and time its motion. Compare this with the results from Step 2.
4. Have students put their snail on the glass plate and turn the plate on edge. Have them observe what the snail does and try to explain its action.
5. Explain that the part of the body on which the snail moves is called the *foot*. Have students pick the plate up and look through the glass at the underside of the foot. What do they see happening that explains the method of movement?
6. Have students put a small piece of lettuce directly in front of their snail and notice how it eats. Tell them to use a hand lens to help them see what is happening.
7. Explain that at the front of the foot are four *tentacles*. Have students explain what they do. What do they do when students touch them gently with a pencil, one at a time?

8. Have students devise a means of blocking the snail from the light. Ask them to explain the function of the tentacles and use the lens to try to find eyes.
9. Tell students to look at their snail's shell and at some of the other shells. Do they all curl the same way or in different ways? Have them explain their observations.
10. Have students poke the foot gently with a pencil until the snail draws into its shell. How does it do this? How is it now protected? (Explain that the structure they have just seen is called the *operculum*.)
11. Have students wait very quietly for three or four minutes to see if the snail emerges from its shell. Ask them to explain how it does this.
12. Tell students to examine the jar in which the snails are kept. See if they can explain how the jar is arranged to keep the animals alive and active. After the exercise, keep the snails in a pond aquarium in the classroom or release them in a field or garden. For more information about snail care, see *Animal Care from Protozoa to Small Mammals* (Orlans 1977).

Results Students should give their numerical results from steps 2 and 3 in table form. Briefly record other results and explanations.

Analysis/discussion

1. What activities and traits did students see in their snail that are characteristic of living things in general?
2. What characteristics of living things did they not see?
3. Have them explain how the snail is markedly different from other animals with which they are familiar.

Lesson title: **The Frog**

By: **Stanley L. Weinberg**
Iowa Committee of Correspondence, 156 E. Alta Vista, Ottumwa, Iowa 52501; (525) 682-7321

Dissection and experimentation are not the only ways of studying animals. Intelligent observation of the living animal can tell you a great deal. In observing the frog's structure and behavior, look for characteristics that function in helping the animal survive. Teach students that through this exercise they can learn some things of value to them personally: that an animal such as a frog can be handled safely and easily and that small living animals are neither frightening nor disgusting. Your class probably will not be able to do all parts of this exercise, but have them work in groups and do as many as they can.

Grade level Grade 10 biology.

Objectives

1. To become familiar with the external structure of the frog.
2. To determine how the adaptations of a frog help it to survive.
3. To compare some of the frog's functions with those of a human.
4. To learn proper techniques of animal observation.

Materials

For each group:
- Leopard, green or pickerel frog in covered Mason jar
- mealworms
- net

For entire class:
- large dry, covered aquarium
- water-filled aquarium
- dry leaves
- colored glass jars

Teaching tips If you get your frogs from a biological supply house, rinse them in cold running water when they first arrive. Always have students wash their hands both before and after touching frogs.

Procedure

1. Have students wet their hands, then catch a frog by putting their hand over its head from the back and getting a firm grip on its body. Straighten out the hind legs with one hand and wrap this hand firmly around the body just behind the forelegs. Have students practice catching the frog. Make sure they notice how the frog swells as they hold it. Have them try to figure out how it does this. Ask them the value of this adaptation.
2. Have students rub the skin on the ventral surface between the forelegs and notice the clasping reflex. Can they see any value in this response?
3. Ask them how the skin feels. The frog does some breathing through its skin. Have students compare the frog's temperature with theirs.
4. Point out the nostrils, eardrums, eyes and eyelids. Explain that each eye has three eyelids–the third is the nictitating membrane attached to the lower lid. Have students hold their finger close to the frog's eye and observe the effect on the eye. On the third eyelid?
5. Ask students to compare and describe the color of the skin on the frog's back and belly. Have them place their frog on a pile of leaves in a Mason jar. What happens to its color after a few minutes? Pair up groups and have them put one of their frogs in a colored jar for five minutes, then describe the color. Ask what they've learned about the value of skin coloration to a frog.
6. Next, have students place their frog back in the Mason jar. Instruct them to slowly rotate the jar, then tilt it; combine both motions. The frog's responses are called compensatory movements. Ask students why they are necessary.
7. Students should put their frog in the dry aquarium, replace the cover and watch the frog jump. Tell them to catch it and examine its legs and feet. Explain how they are built to help it jump. Instruct students to look for hardened places at the joints of the toes and explain how they help. Can the students find suction cups anywhere on the feet?
8. Have students put their frog in the water and explain how it rests there. Have them tap the aquarium to make the frog dive. See if they can explain how it dives and swims. Students should repeat this last step several times to make sure they see everything that happens.

9. Next, have students catch the frog with a net and reexamine its legs and touch its nostrils. Ask what adaptations they have seen for life in the water.
10. Students should return their frog to the jar and put in mealworms one at a time to watch the frog feed. Point out that they will have to be very quiet to see this response. Ask how the frog eats. Swallows?
11. Have students gently spray the frog with water from the faucet or gently stroke its sides or back to make it croak. Ask them how the frog croaks and explain that they have just seen the sound sacs functioning.
12. Have students watch their frog breathe, then ask them to describe its rather complicated breathing movements.
13. Tell students to place their frog on its back and "hypnotize" it by stroking its belly. Rolling it over will make it recover.
14. Make sure students wash their hands thoroughly at the end of the experiment.

Analysis/discussion

1. Have students compare the frog's methods of breathing and swallowing with theirs.
2. Tell them to summarize the adaptations they have seen that seem to be useful for a frog's survival.

Additional activities

After the exercise, keep the frogs in a pond aquarium in the classroom or release them to a nearby pond. For more information about frog care, see *Animal Care from Protozoa to Small Mammals* (Orlans 1977).

Chapter 3. Ethical Considerations

The preceding chapter focused on ways that teachers could incorporate the principles of reduction, replacement and refinement in their existing procedures involving animals. The objective was to help eliminate waste of animals and time by suggesting ways that animals could be used more effectively. The sample lessons in Chapter 2 are designed to teach students more about organisms while fostering in them an appreciation and respect for life that they may not have developed with traditional teaching methods. Chapter 3 goes one step further to address the ethics of animal use by providing teachers with a guide to the current controversy and some sample lessons that illustrate how the issue can be brought into the classroom.

Because biology is the study of life, many of the subjects that arouse emotions outside of school also appear in biology class. Traditionally, the topics of sex education and evolution have been sensitive areas for biology teachers, but the ethics of animal use increasingly has emerged as a new source of controversy between students, teachers and administrators. Most people point to the 1987 case of Jenifer Graham (who went to court over her objection to dissection on moral grounds) as the beginning of a national debate about the ethics of dissection and animal experimentation in schools. Since then, California has adopted legislation making animal dissection optional for students, and several national organizations, including NABT, have adopted policy statements on the use of animals in education.

Values clearly have changed since teachers first brought animals into the classroom. It is no longer written in textbooks that man is superior to all species and therefore should control all aspects of the natural world. Ecology is now taught as a set of principles that govern *all* living things, including humans, and humans are seen by most scientists as developing directly from other animals. The environmental movement has made students, teachers and the public more aware of what humans have done to wild animals and their habitats. Today there is global concern about changes in climate, dwindling resources and loss of species. This awareness of the connection between humans and other organisms has made people more open to the concept of animal rights. There is a growing realization that

"we are living phenomena and we depend on our natural environment" (Kelly 1980, p. 56).

Animal rights issues are covered frequently by the media and opinions on both sides–some of them quite extreme–are voiced regularly. As with all complex questions facing society, it is important that citizens be well informed. Dr. Michael W. Fox of the Humane Society of the United States has said, "Education, in its fullest sense, entails the development of the whole person and human nature, involving ethics and sentiments as well as intellect" (Pringle 1989, p. 52). Teachers need not–indeed, should not–decide how they feel and then impose that opinion on their students. Instead, students should be given the opportunity to explore the issue themselves and come to their own conclusions. Class discussions of such controversial topics are often good strategies for teaching content as well as changing attitudes. Facts about vertebrate biology and evolution can be an important part of any debate or project concerning animal rights. Making students aware of differing viewpoints will encourage them to see science as a complex and sometimes emotional subject pursued by humans with feelings rather than as a refuge for cold, unfeeling intellectuals.

A Guide to the Lessons in this Chapter

A Field Guide to the Animal Rights Controversy

There are many books and pamphlets available that can help a teacher or student become better informed about the ethics issues surrounding the use of animals (see Resources and References). Below is a brief description of the major organizations and philosophies that make up the animal welfare movement. This guide is based on previously published statements and is intended only as a tool for further research, not as an exhaustive analysis of complex positions.

Organizations (listed alphabetically)

The American Society for the Prevention of Cruelty to Animals (ASPCA)

"Hands-on" experience is not necessary; in fact, early exposure to animal experimentation and dissection may have a negative effect both on those who dislike science and those who plan to pursue it as a career.

Animal Welfare Institute (AWI)

Dedicated to providing the public with information about the treatment of animals in laboratories, commercial trade, factory farms and traplines. Extensive publications and materials available to teachers.

Focus on Animals

A clearinghouse for audiovisual resources about human interrelationships with animals. Produces a newsletter as a link for educators who wish to share their ideas on curriculum improvement involving animals.

Foundation for Biomedical Research (FBR)

Established to serve as a resource for information on the use of animals in biomedical research. Educational materials developed by FBR address how animals are used in research, the regulations governing animal research and the importance of humane and responsible animal research for advances in human and animal health.

The Humane Society of the United States (HSUS)

Believes that the evaluation of proposed plans for research and testing should carefully address the following questions: Can the proposed use of animals be *replaced* by nonanimal methods that would yield comparable or superior results? If not, can the proposed number of animals be reduced to a minimum without compromising the results? Can the proposed procedure be *refined* so that any pain, suffering, or deprivation experienced by the animals be minimized without compromising the results?

Also believes that safeguards should prevent certain experiments from being conducted on animals, regardless of the state of alternatives. These include experiments that are unnecessarily duplicative of other studies; scientifically or medically trivial,

	dubious, or otherwise unnecessary; extremely painful or stressful; or otherwise fail to balance scientific aims and the public's concern for animals. (Policy statement 1989).
National Anti-Vivisection Society (NAVS)	Supports the abolition of all animal experimentation. Publishes a compendium of alternatives (Diner 1986).
National Association for Humane and Environmental Education (NAHEE)	A division of HSUS. Biology programs have a responsibility to help students develop an appreciation for the uniqueness of each organism, the connection between living things and the relationship of each individual to its environment. Dissection and animal experimentation do little to achieve this objective and therefore have no place in the classroom. Living animals should be used only for naturalistic observation and strict guidelines as to their care should be followed (Guidelines 1984).
People for the Ethical Treatment of Animals (PETA)	"When it comes to having a central nervous system and the ability to experience pain, hunger and thirst, a rat is a pig is a dog is a boy." Humans have no right to eat, wear, experiment on any animal. Works toward the abolition of all exploitation of animals by humans.
Physicians Committee for Responsible Medicine (PCRM)	Working toward increased consideration of ethics, alternatives and clinical applicability in research funding, increased awareness among medical students and doctors of the ethical foundation of medicine: "First, do no harm." Since most medical schools no longer require participation in animal labs, then such labs certainly have no place in a high school education.
Scientists Center for Animal Welfare	Holds that experiments on animals are justified and seeks to help institutions maintain high standards of animal welfare. Dedicated to the belief that high standards of animal welfare complement the quality of scientific results.
Student Action Corps for Animals	Runs a "Say No to Dissection" campaign that provides students who object to dissection with guidance and alternatives that they may suggest to their teachers. Opposed to any labs that rely on the deaths of animals, including films of dissection or dissection using animals or animal by-products from the supermarket.

People (listed alphabetically)

Michael W. Fox

Veterinarian; author of *Returning to Eden: Animal Rights and Human Responsibility*
Humans need to adopt a "new natural philosophy of eco-ethics in which we adopt an ecologically-based moral framework that would allow for a better world for both humans and animals. To be truly civilized is to minimize suffering by any living being whenever possible" (Pringle 1989).

Tom Regan

Author of *The Case for Animal Rights*
"The ultimate objective of the rights view is the total dissolution of the animal industry as we know it. . . We don't want larger cages, we want empty cages." Slaughtering animals humanely or killing an experimental animal painlessly while it is still unconscious is as immoral as euthanizing a healthy human (Pringle 1989).

Peter Singer

Author of *Animal Liberation* and *In Defense of Animals*
"Animals have the right to equal consideration and animals' interests ought to be given equal consideration with the like interests of humans. Pain and suffering are bad and should be minimized, irrespective of the race, sex or species of the being that suffers" (Pringle 1989).

The areas in which animals are used are food, research, clothing, entertainment and education. In each of these areas the question boils down to whether animal use should be abolished altogether, made more humane or left as is. Students can attempt to answer this question with research reports, oral presentations, role playing or classroom debates. The teacher can serve the class best by providing resources, guiding research and asking questions that stimulate discussion. Several of the resources listed in Chapter 4 may be consulted. Also review the Appendix.

Lessons that Explore Ethics

Lesson title: **The Dissection Dilemma: A Method for an Ethical Decision**

By: Peter F. DeDecker
Hastings High School, 520 South Street, Hastings, MI 49058; (616) 948-4409

Scientific objectivity rarely provides a consensus in subjective matters. To provide a method for considering such questions, I have devised a short lesson plan to be used either by the teacher(s) (such as a curriculum review committee) or with students (DeDecker 1987).

Grade level Grade 10 biology.

Objectives

1. Sensitize students to the issue of animal welfare.
2. Help students identify personal values related to living things.
3. Introduce a procedure for decision making.
4. Help students develop a way to justify a decision.

Materials

- questionnaire on dissection
- "Continuum"
- "Decision Making Model"
- "Decision Making Model" Worksheet

Instructional procedure

Day 1:

1. The day before you plan to discuss the issue, give students a written questionnaire consisting of the following:
   a. Would you benefit from the dissection of an organism? Why or why not?
   b. Would you have trouble learning about the anatomy of an organism without dissection? Explain.
   c. Can you think of some alternatives to dissection that would help you learn about the anatomy of an organism? Describe.
2. Collect the surveys and study them before the next class. Summarize the results to students and initiate a class discussion on the role that animals play in education and whether it is justified. How do the students feel about animals in cosmetic research? Biomedical research? Factory farming? Zoos and Rodeos? Attempt to clarify the pros and cons for each question.

3. Conduct the "Hammer Exercise" (described below). (This is optional. You may want to try it on a few students first. If not appropriate for your class, consider the alternative Decision Making Exercise on page 103.) Set out a row of small paper bags, each labeled with the name of an organism written large enough for students to see. There should be a bag for each of the following "pretend" organisms from the five Kingdoms:

   Bacteria, amoeba, bread mold, moss, grass, earthworm, mosquito, spider, frog, snake, sparrow, bat, rabbit, pig, cow, dog, human zygote, human fetus and post-natal human.

4. Hold up each "organism" and instruct students to write its name on their paper. Hit the bag ("organism") with a hammer and "kill" it. Students then write "OK" or "not OK" next to the organism's name to reflect their personal feelings about "hammering" each organism. Afterward, ask for the class's responses as you read through the list of organisms. Point out to students that value systems differ as shown by the variety of responses.
5. Repeat the exercise, but ask students to pretend there is a non-living object that they may have without cost (a stereo system, a car, etc.) in another bag. Give them a choice between hammering the organism and hammering the non-living object. They again should note "OK" or "not OK" in a second column next to the name of each organism. Comparing the two responses usually reflects a person's underlying values. At varying points students will begin to recognize that their respect for life supersedes material desires.
6. Break the class into groups of three to five students to discuss their individual choices and see whether a consensus opinion can be reached. Students should not be forced or even encouraged to compromise their values. Each student should record the group responses and comments on their paper and keep it for future reference.
7. Pass out the "Continuum" for students to complete. Ask them to compare their results with their answers to the initial questions. Have they changed their minds in the course of discussion?

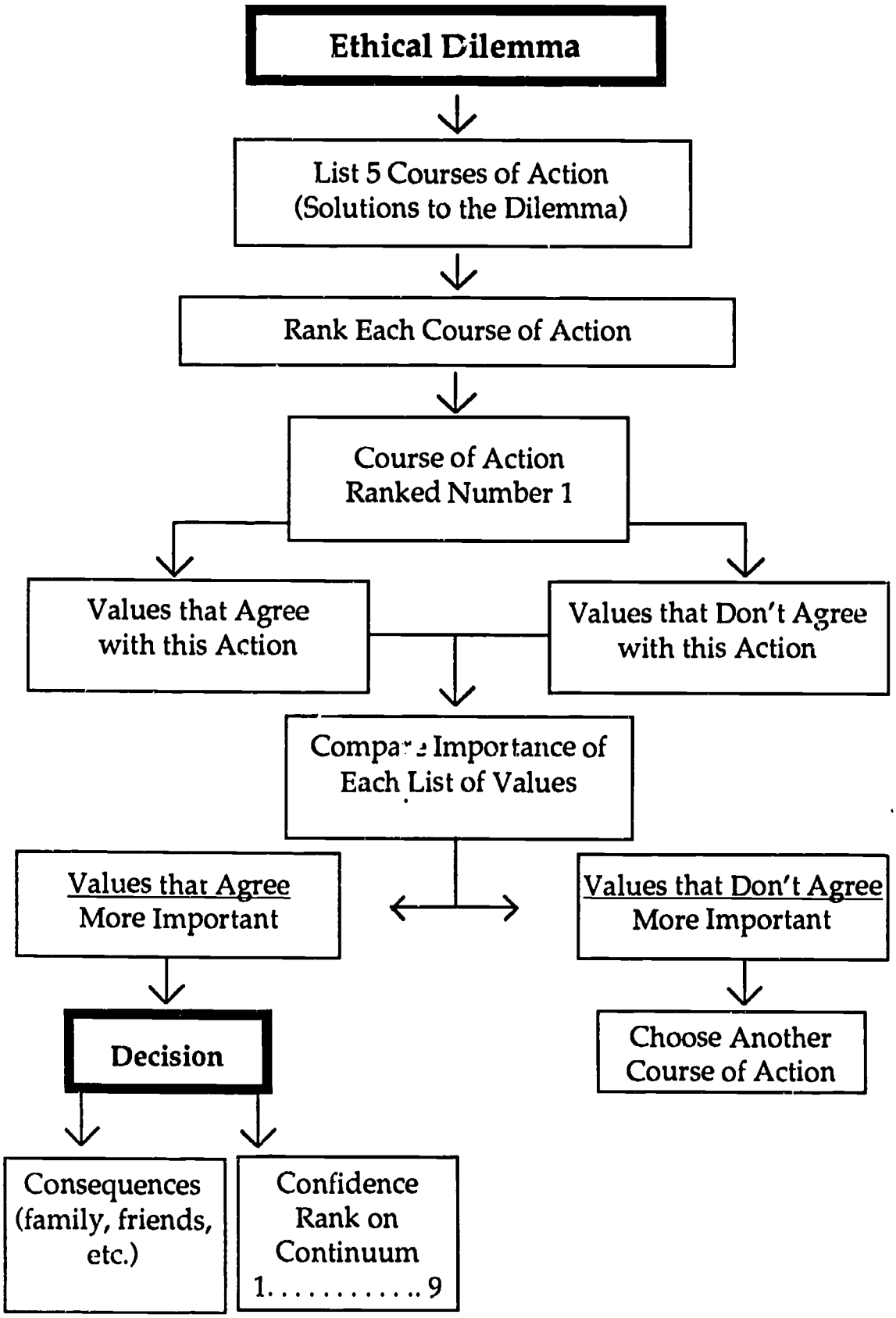
Day 2:

1. Present the "Decision-Making Model" and provide students with the worksheet, which you may wish to assign as homework.
2. In this step-by-step process, teachers (and/or students) begin by defining the dilemma or position and listing at least five different courses of action that may be followed. The pros and cons of each are listed and a preference ranking assigned to it. Evaluate the top-ranking action by correlating previously identified personal values with that action. If the supporting values outweigh the conflicting values this would be the decision of choice. If not, the procedure is repeated for the second-ranked course of action. After choosing a course of action, a confidence ranking is produced along with a list of anticipated long-term consequences of the decision.
3. Conduct a class discussion using the Bioethical Decision-Making Model. Students will have used their values to justify a decision. You will more clearly recognize their attitudes toward dissection.

The Continuum

	Agree 1	2	3	4	5 Disagree
Dissection:					
teaches the scientific technique of observation					
deals with reality, which is important					
is more real than pictures					
is fun					
allows me to take things apart to see how they work					
provides real experience of texture/feel					
is important to teach unity yet diversity					
is important to show variation among organisms					
is wrong, but necessary					
helps to conquer fears/inadequacies of new experiences					
makes "good" use of animals killed in shelters					
is an educational focal point of anatomy studies					
researches valuable information					
is cheaper than expensive models/alternatives					
can be learned from computer simulations					
is unnecessary–most scientific work has shifted from live animal work to *in vitro* tissue cultures					
just cuts up things and is not educational					
is OK if research using that one life saves several others					
cheapens student perception of the value of life					
offends me–I am against killing for study					
is cruel					
is smelly and unpleasant					
is the only way to experience the texture of organs					
is not necessary/important for elementary students					
is not necessary/important for middle school students					
is not necessary/important for high school students					
is not necessary/important for college students					
should only be done as a demonstration					
is the focal point of zoology					
is wrong, because animals are just as valuable as humans					

Decision Making Model



Bioethical Decision-Making Model Worksheet

A) Ethical Dilemma (What should I do?)
Write a short paragraph explaining the nature of your dilemma.

B) List 5 possible courses of action. Then, list reasons both for and against each.

1. Course of Action:

For	Against	*Rank*

2. Course of Action:

For	Against	*Rank*

3. Course of Action:

For	Against	*Rank*

4. Course of Action:

For	Against	*Rank*

5. Course of Action:

For	Against	*Rank*

C) Next, rank each action from 1 to 5 as to which you feel is best (1) and which you feel is worst (5).

D) List and explain those values that are in accordance with the course of action (decision) that you ranked number 1.

E) List and explain those values that are not in accordance with the decision that you ranked number 1.

F) Are you comfortable with this decision? Why or why not?

G) How much confidence do you have in this decision? Rank your confidence by marking a number on the continuum below:

Confident 1...2...3...4...5...6...7...8...9 Not Confident

H) List the long-term consequences of your decision. If applicable, explain how your decision will affect family and friends. What would happen if everyone made the same decision?

Lesson title: **Ethical Considerations of Dissection**

By: **David Gilmore**
Rocky Hill High School, Rocky Hill, Connecticut 06067; (203) 529-2583

Grade level Grade 7 life science; grade 10 biology.

Objectives Students will:

1. Be aware of the pros, cons and implications of dissection.
2. Identify their personal motivation regarding dissection.
3. Allow the expression of differing opinions from classmates, free from judgmental consideration.
4. Express in writing the ways in which their value systems affect their attitudes toward all organisms.

Instructional procedure

1. The teacher should lead students in a discussion identifying differing opinions within the class concerning dissection.
2. Instruct students to put into writing their position on dissection. Assure them that all opinions are valid and that their positions will remain confidential. Collect the papers and share three samples with the class, maintaining the anonymity of the writers.
3. Discuss the concepts of value systems and ideology. Invite students to share examples of their own ideologies.
4. Conduct the Hammer Exercise (see pp. 96) using the following organisms:

   Bacteria, amoeba, mold, moss, grass, spider, mosquito, frog, snake, sparrow, bat, rabbit, pig, cow, dog, zygote, fetus, human.

   You may wish to try the Hammer Exercise on a few students before deciding whether to use it. If it seems inappropriate for your class, consider using the alternative Decision Making Exercise (p. 103).
5. Discuss the results of the exercise with respect to the position of animals in people's value systems.
6. Briefly discuss the implications of our treatment of animals in food production, clothing, biomedical research, education, sports, entertainment and compan-

ionship. Try to enlist the support of guest speakers.

7. Present the students with alternatives to dissection.
8. Provide students with the opportunity to revise their written position on dissection. Encourage students to make their decisions consistent with how they treat animals outside the classroom.
9. Provide specimens, instruction and time for those who still choose to dissect. Provide equally challenging activities for those who decide not to dissect.
10. Solicit from the students an evaluation of the manner in which this issue was handled.

Decision Making Exercise

1. Write the following list on the board:
   Bacteria, amoeba, mold, moss, grass, spider, mosquito, frog, snake, sparrow, bat, rabbit, pig, cow, dog, zygote, fetus, human.
2. Group students into teams of at least two and assign each team an organism from the list.
3. Have each team think of two reasons why the organism should not be used by humans and two reasons why it is necessary for humans to use this organism.
4. When all the teams are ready, ask each to present their pros and cons to the class.
5. After each team finishes, ask the class to vote whether to use the animal or not, based on the presentation of the team. Keep a running tally of the voting results on the board.
6. When all the voting is complete, ask the students to write a brief summary of the day's conclusions about the use of animals.

Chapter 4. Resources

A. *Teaching Materials*

This chapter on resources lists selected instructional materials in various forms: printed materials (books, magazines), kits, models, films, videotapes, computer software and videodiscs. Complete addresses and phone numbers can be found in the Publishers/Vendors listing following this section.

Printed materials

Alternatives in Biology Education (1990). The Biology Methods Review Project. The guidebook contains listings of kits, computer programs, books, 35mm slides, videotapes, filmstrips, models, transparencies and charts. Each item listed is accompanied by a brief annotation and the name and address of the supplier, cost and recommended grade level for the material. The intention of the guidebook is to inform students and educators about these products and to serve as a reference for those who are assessing educational materials. The guidebook may be ordered from The Biology Methods Review Project or Physicians Committee for Responsible Medicine.

Alternatives to Animal Experiments (1985). Fund for the Replacement of Animals in Medical Experiments (FRAME). Seven main types of alternatives are discussed in two pages: (1) Mathematical Modeling of the Structure–Activity Relationships and Computer Graphics, (2) Mathematical Modeling of Biochemical and Physiological Processes, (3) Human Studies, (4) The Use of Lower Organisms, (5) In-vitro Techniques, (6) Improved Storage, Exchange and Use of Information and (7) Improved Design of Experiments. The beginning paragraph defines alternatives in light of reduction, refinement and replacement alternatives. The last section deals with recommendations on how a combination of alternatives may be used.

Alternatives to Animal Use in Research, Testing and Education (1986). Office of Technology Assessment. A thick document packed with information. Includes chapters on ethical considerations and animal use in the classroom. Extensive description of alternatives and resources.

Alternatives to Dissection (1990). National Association for Humane and Environmental Education. A methodical listing of traditional objectives of dissection and of animal study. The list of objectives is followed by ideas for alternative biology projects, all designed to meet at least one of the listed objectives. Several of the alternative project ideas have been ex-

panded into student activity sheets, written for students complete with step-by-step instructions for completing the activity. A list of resources is also provided.

The Anatomy Coloring Book, by Wynn Kapit and Laurence M. Elson (1977). Barnes and Noble. This book contains detailed plates that encourage active learning about human systems and anatomy. Appropriate for high school and undergraduate classes.

Animal Care from Protozoa to Small Mammals, by F. Barbara Orlans (1977). Addison-Wesley Publishing Co. A detailed book describing humane care and maintenance of classroom animals. Each chapter focuses on a different group of organisms. Includes two chapters on humane experiments that students can do in school. Lists many references.

Animal Films for Humane Education, by Dallas Pratt (1986). Argus Archives. A book useful as a reference. It has descriptions and reviews of the 139 best films, videotapes and filmstrips for humane education. The book also includes: (1) reactions of audiences and selected groups of children to the films, (2) discussion guide for each film, and (3) an index.

The Animal Rights Controversy, by Laurence Pringle (1989). Harcourt Brace Jovanovich Publishers. A brief, readable treatment of the arguments and philosophies behind the animal rights movement. A short section deals with animal rights in classrooms. Alternatives are described in a general way.

Animal Rites: A Research Perspective, by Jeff Diner (1986). The National Anti-Vivisection Society. A pamphlet briefly reviewing research from 1980-1984 that represents the most severe mistreatment of animals. Very graphic and disturbing descriptions. Does not describe alternatives.

Animals and Their Legal Rights: A Survey of American Laws from 1641-1978, by Emily Stewart Leavitt (1978). The Animal Welfare Institute. A detailed book made up of chapters written by different authors. Each chapter examines the laws concerning a particular species or situation (such as factory farms). Includes a chapter on humane education in public schools. Does not describe alternatives.

Animals in Education: The Use of Animals in High School Biology Classes and Science Fairs, edited by Heather McGiffin and Nancie Brownley (1980). Published by the Institute for the Study of Animal Problems. A compilation of sessions from the conference "The Use of Animals in High School Biology Classes and Science Fairs." The conference took place in 1979

and was sponsored by the Institute for the Study of Animal Problems (ISAP) and the Myrin Institute for Adult Education. Each session is presented as an article with an abstract and references. Numerous alternatives to dissection and inhumane use of animals in experiments are included, along with current regulations on the humane use of animals.

Classroom Creature Culture, by Carolyn Hampton, et al. (1986). National Science Teachers Association. A collection of articles from the journal *Science and Children*. Each article addresses a specific organism. The book focuses on insects, amphibians and reptiles. Presents many humane activities that can be done with living animals as an alternative to dissection.

A Compendium of Alternatives to the Use of Live Animals in Research and Testing, by Jeff Diner (1983). The National Anti-Vivisection Society. Booklet describes current animal testing procedures, their history, their flaws and the available alternatives. Extensive bibliography.

Dissection: You Can Study Life Without Killing Animals, Physicians Committee for Responsible Medicine (1987). Publication appropriate for grade school and junior high school students. Available free from PCRM.

Does the Idea of Dissection or Experimenting on Animals in Biology Class Disturb You? National Association for Humane and Environmental Education. Brochure for high school students.

The Endangered Species Handbook, by Greta Nilsson (1986), Animal Welfare Institute. A readable book that provides extensive information on which species are endangered and why. Includes projects for the classroom as well as guidelines for science fairs. Describes alternatives and lists many resources.

First Aid and Care of Small Animals, by Ernest P. Walker (1955). National Zoological Park, Smithsonian Institution and Animal Welfare Institute. A thoughtful and well written description of how to care for small wild animals in the home or classroom. The author emphasizes that when students know how to care for animals a knowledge of physiology as well as a respect for life will follow. He discusses proper housing, feeding, medical care and retraining for release into the wild. Includes mammals, reptiles, amphibians, fish and invertebrates.

How to Dissect: Exploring with Probe and Scalpel, by William Berman (1986). Prentice Hall Press. A detailed manual that

describes the basic equipment and techniques of dissection. Includes a chapter-by-chapter exploration of commonly dissected organisms. Describes one alternative to dissection of the earthworm: a noninvasive method for observing the heart.

The Living Science: A Humane Approach to the Study of Animals in Elementary and Secondary School Biology. National Association for Humane and Environmental Education. This folded brochure for teachers focuses on the "Guidelines for the Study of Animals in Elementary and Secondary School Biology" formulated by NAHEE. The brochure opens to a poster with information on (1) prerequisites to the use of animals in the classroom, (2) appropriate and inappropriate animals and sources, (3) breeding and disposition of animals after use, (4) care and handling, (5) experimental procedures, (6) independent study and science fair projects, and (7) non-educational use of animals. One side of the poster defines the role of biology in education, what young people really learn in animal experimentation and dissection, ethics of the classroom laboratory, the human cost and what teachers can do to promote responsible use of animals in the classroom. A short list of resources for alternate lessons and teaching materials is included.

Kind News, National Association for Humane and Environmental Education. A newspaper for elementary-level children published nine times each year. Contains lessons, activities, worksheets, puzzles and games focusing on respect for animals.

Nature With Children of All Ages, by Edith Sisson (1990). Published by Prentice Hall Press. This book contains dozens of activities for studying animals and plants in their natural settings. The purpose of the book is to show how easy sharing can be and help readers feel confident about teaching outdoors.

Objecting to Dissection: A Student Handbook. Published by the Animal Legal Defense Fund. A small booklet explaining students' legal rights when choosing to refrain from dissection. Provides a ten-step guide for students who decide to refuse to dissect and lists the Dissection Hotline: (800) 922-3764. Includes a list of alternatives.

People & Animals: A Humane Education Curriculum Guide. Published by the National Association for Humane and Environmental Education. Four books containing more than 400 activities designed to interpret and explore relationships between humans and other living creatures. Activities are divided into subjects; a curriculum index is included.

Proceedings of the First International Foundation for Ethical Research Workshop: Alternatives to Live Animals in Veterinary Medical Education. (1989). International Foundation for Ethical Research. Small collection of presentations describing the philosophical difficulties of using live animals in veterinary science classrooms. Describes some alternatives.

Proceedings on the Educational Use of Animals. (1980). Published by the Institute for the Study of Animal Problems, Proceedings Number 36. Available from the Myrin Institute for Adult Education. Essays by animal rights experts on the need to balance the teaching of animal structure and function with moral education about the rights and intrinsic value of animals. Discusses some alternatives.

Reverence for Life: An Ethic for High School Biology Curricula, by George K. Russell. Published by the National Anti-Vivisection Society. This pamphlet contains the text of a 1979 speech to the Conference on the Use of Animals in High School Biology Classes and Science Fairs. Ethical and pedogogical arguments against the use of animals in high schools are outlined. Provides a description of alternatives and a list of references.

Reviews of Software for Teaching Anatomy, Physiology and General Biology (1988). Physicians Committee for Responsible Medicine. A listing of computer software for teaching anatomy and physiology. The brief annotations include a description of the program–i.e., if it is a tutorial, program or simulation. The computer hardware and the name and address of the supplier also are indicated.

Selected Software Related to Dissection, Anatomy and Physiology compiled by Randall Lockwood (1989). The Humane Society of the United States. A typewritten list of computer software to teach about dissection. A short description along with information on hardware, and name and address of supplier are included.

Models/Kits

Plastic models and kits are available from:

Armstrong Medical Industry

NASCO

Carolina Biological Supply Company

Connecticut Valley Biological Supply Co. Inc.

Fisher Scientific–Education Materials Division

National Teaching Aids

Nystrom Division of Herff Jones, Inc.

Phipps and Bird, Inc. (The BIO-MONITOR)

Sargent-Welch Scientific Co.

SCIDEAS (Ribbit, a fabric frog model)

Science Kit and Boreal Laboratories

Ward's Natural Science Establishment

16mm sound films

Adaptations Of Insects (1982, 2nd ed.)
14 min. Color. Using new cinephotomacrography techniques, explores six ways insects are adapted to the environment. Develops broader concepts of adaptations in other life forms.
Stanton Films

Adventures of Bunny Rabbits (1984, 2nd ed.)
11 min. Color. Rabbits are shown in their natural environment; habits and characteristics are pictured. Replaces film produced in 1937.
Encyclopedia Britannica Films.

Bacteria (1985)
23 min. Color. This film examines the principal forms in which bacteria occur, explores the structure of a typical bacteria cell, and explains the cell's reproductive processes. Students learn that bacteria can kill us, and that we can kill them. The film also shows how bacteria can cause food to spoil, make nitrogen in the air available to plants and cause spoiled or dead organic matter to decompose, as well as how bacteria can aid in other processes (also available on videocassette).
National Geographic Society

Kakapo: The Night Parrot (1984)
30 min. Color. A true-life nature story about a nearly extinct parrot family living in the rain forests of New Zealand. It won the Best Film in Festival Award at the 1984 International Wildlife Film Festival.
New Dimension Films

Meet The Grebes (1987)
20 min. Color. Some of nature's most spectacular secrets are revealed in this film about grebes. Through vivid color photography, shows the world of the grebe, including egg incubation, hatching and mating rituals.
Berlet Films

Pandas (1983)

25 min. Color. Shows American and Chinese researchers as they work together to save one of the world's most engaging and elusive animals. Students will learn how research scientists work in the field to collect and analyze data in the process of investigating a problem.
National Geographic Society

Snakes, Scorpions, and Spiders (1981)

15 min. Color. This film reinforces the concept of predator–prey relationships that are studied in a seventh grade environmental life science and biology program. Shows the habitats, movement and reproduction of snakes, scorpions and spiders. The photography is excellent.
Learning Corporation of America

Videocassettes

Adapting To Changes In Nature (1985, revised)

12 min. Color. Vivid photography and appropriate text demonstrate how plants and animals adapt to changes in order to survive and flourish.
Journal Films, Inc.

Beaver (1985)

25 min. Color. Excellent photography taken over a seven-year period provides fascinating views of beaver life inside and outside the beaver lodge.
Phoenix/BFA Films and Video, Inc.

BSCS Classic Inquiries Series: The Kidney And Homeostasis

12 min. Color. What are the functions of the kidney? Based on the data presented, describes the kidney as a homeostatic organ.
Media Design

BSCS Classic Inquiries Series: Mating Behavior In The Cockroach (1986)

11 min. Color. After observing mating behavior in the tropical cockroach, the student may raise questions about the stimuli that evoke mating responses.
Media Design

The Crab

11 min. Color. Shows a variety of crabs and how they eat and move. Music and close-up photography make an interesting and informative video.
Barr Films

Digestive System (1980, 2nd ed.)

16 min. Color. A detailed analysis of the digestive system.

Emphasizes the role of each organ in nutrient absorption.
Media Design

Swallowtail Butterfly (1986)
11 min. Color. Visually stunning video that follows the development of a swallowtail butterfly. From egg to adult, explains terms caterpillar, insect, molting, chrysalis, metamorphosis, antennae and compound eyes.
Barr Films

Year Of The Wildebeast (1985)
30 min. Color. Depicts the 2,000-mile migration of wildebeast in Tanzania.
Benchmark Films

Filmloops/Filmstrips

Filmloops:

Inquiry into Nerves and Heartbeat Rate [single-topic filmloops]
BSCS

Filmstrips:

Alike and Different, All Kinds of Animals, All Kinds of Plants (K-2)
National Geographic Society

Biological Dissection
Contains: An Introduction to Dissection, The Earthworm, The Crayfish, The Fish, The Frog Parts I & II.
Discover Science Opportunities for Learning, Inc

Filmstrip Set Dissection of Fetal Pig
Science Kit and Boreal Laboratories

Dissection of Fetal Pig
Part 1. External Anatomy and Skeletal Structure
Part 2. Musculature
Part 3. Digestive and Urogenital Systems
Part 4 Circulatory, Respiratory and Nervous Systems
Schoolmaster Science

Dissection of a Frog
Part 1. Techniques Skin, Digestive and Circulatory
Part 2. Excretory, Respiratory, Reproductive and Skeletal
Schoolmaster Science

Frog Anatomy Collection
Carolina Biological Supply Company

Human Body Systems [18 filmstrips]
Discover Science Opportunities for Learning, Inc.

The Life of Animals (K-4)

Ways Animals Get Food; Animal Homes; Ways Animals Move About; Ways Animals Protect Themselves; Animals and Their Families

National Geographic Society

The Structure of Animal Series, 1987 (5-9)

Part I: Invertebrates, An Introduction to Invertebrates, Insects and Other Arthropods

Part II: Vertebrates, Fish, Reptiles and Amphibians, Birds, Mammals

National Geographic Society

Your Bones and Muscles (K-2)

National Geographic Society

Computer software

Anatomy of a Fish

Apple II, 48K; Level 7 and up. Presents information on the external, internal and skeletal structures of a bony fish.

Queue

Anatomy of a Shark

Apple II, 48 K; Level 7 and up. Presents information on the external, internal and skeletal structures of a shark.

Queue

Biology Volume I (1986)

5-inch disk; Level 7-10. Useful for Biology I, biology labs. Reviews digestion and nutrition with good graphics. Requires 64K Apple IIe computer.

Webster/McGraw-Hill

dbreed (1983)

-inch disk. Level 11-12. Designed for the exploration of netic principles using 16 breeding groups of birds of defined enotypes. The student may accumulate up to 100 birds for the analysis of genotypes and patterns of inheritance. Clutch sizes vary from 4 to 8 fledglings; incorporates the variations observed in small populations in nature. Requires 48K Apple computer.

EduTech, Inc.

Body Language: A Review of Anatomical Terms

Apple II, 64K

A computer-based drill designed to aid students in identifying and naming anatomical structures. Employs two complementary drill techniques–matching and recall. Both drills encourage students to pronounce the terms with phonetically spelled assistance. Each package consists of four program

disks with backups.

Body Language I–This program represents the skeletal system with more than 45 diagrams.

Body Language II–This program covers the muscular and respiratory systems. The section on the muscular system contains over 40 diagrams.

Body Language III–The cardiovascular and nervous systems with more than 45 total diagrams are presented on two disks.

Body Language IV–Using more than 40 diagrams, this program presents the digestive, urinary and reproductive systems.

Carolina Biological Supply Company

Cardiac Muscle Mechanics by COMPress

IBM PC 256K. The computer simulations and accompanying slides in this package are designed to assist in the teaching of heart muscle mechanics. Using high resolution graphics and color, the simulations show how the heart muscle behaves under a variety of conditions. There is enough flexibility in the simulations to allow for individuals or small groups. IBM versions require color graphics adapter and graphics monitor.

Queue

Catlab, Second Edition (1982)

Skills practice simulation; Level 9-college. Allows students to mate domestic cats selected by coat color and patterns.The program then produces genetically valid litters of kittens based on these matings. Students learn the principles behind transmission of genes, define research problems, control variables and analyze data. Network version available.

Apple II+/IIe/IIc/IIgs, 48K, 5-inch disk drive, Applesoft, DOS 3.3

IBM PC/PC-XT/PCjr, 128K, 5-inch disk drive, color graphics option, PC-DOS

Conduit

Cells and Tissues (1986)

5-inch disk. Level 7-10. Tutorial with animated graphic presentation of cell organisms,and simulation of materials passing through the cell membrane. Included are cell theory and structure, single-celled organisms, and plant and animal cells. Second tutorial has a simulation of mitosis and cell division. Sections followed by drill and practice. Requires Apple IIe.

Educational Activities

The Digestion Simulator (1986)

5-inch disk; Level 10. Full graphics of ingestion of food, peristalsis, digestion in the stomach, movement of food through large and small intestine. Requires 64K Apple II or IIe.

Focus Media, Inc.

Exploring Your Brain (1983)

5-inch disk; Level 7-12. Focuses mainly on brain structure and neuronal communication, helps students understand that epileptic seizure is a result of neuronal malfunction and teaches appropriate social response. Helps banish old myths and improve the social acceptance of epilepsy. Four units use color graphics and animation and include mastery tests. Requires 48K Apple II, IIe or IIc.
Epilepsy Foundation of America

Heart Abnormalities and EKG's (1985)

5-inch disk; Level 10-12. Shows the relationship between EKG's and heart abnormalities. Two modes of operation–Demonstration and Tutorial–allows for flexible use in classroom. Abnormalities illustrated include coronary artery disease, atrical or ventricular fibrillation, premature beats, brachycardia and tachycardia. Requires Apple IIe.
Focus Media, Inc.

Heart Lab (1981)

5-inch disk; Level 7-12. Animated graphics produce simulation mode of functioning human heart. Network version available. Program cannot be used as a sole source of information. Pulse simulation is worthwhile but heart diagram is poor. Useful in biology labs. Requires 48K Apple II or IIe.
Focus Media, Inc.

The Heart Simulator (1986)

5-inch disk; Level 10. Allows you to demonstrate, before an entire class, a beating heart together with blood flow, a timing exercise for the heart, heart-to-lung blood flow, and parts of the heart. Requires 64K Apple II or IIe.
Focus Media, Inc.

Human Anatomy (1983)

5-inch disk; Level 7-12. Explores the body machine, its structure and functions. Clarifies the interrelationships of tissues, organs and systems. With back-up diskettes. Requires 48K Apple.
Encyclopedia Britannica

Human Systems Series 1, 2, & 3 (1986)

5-inch disk; Level 9-12. Contains complete set of Human Series disks. Human Systems Series 1: Human Organisms, The Digestive System, Blood, The Circulatory System. Human Series 2: The Muscular System, The Skeletal System, The Nervous System, The Endocrine System. Human Series 3: The Respiratory System, The Excretory System, The Reproductive System and Human Genetics. Requires Apple IIe.
Focus Media, Inc.

Insect Identification (1986)

5-inch disk; Level 7-12. Game with beginner and advanced levels. More than 1,000 insect characteristics help students learn to identify 75 common species. Students also practice deductive reasoning in solving biology puzzles. Requires 48K Apple II, IIe, or IIc.
Focus Media, Inc.

Mendelbugs (1986)

5-inch disk; Level 5-10. Lets the students select parent Mendelbugs and trace traits through monohybrid and dihybrid crosses. They can predict the types of offspring that should be produced and compare these predictions with the actual outcomes as generations of Mendelbugs "hatch" before their eyes. Requires Apple II.
Focus Media, Inc.

The Microorganism Simulator

5 inch disk; Level 9-10. Provides students with a method of understanding the ways in which common microorganisms carry out life processes. Students can view full-screen simulations involving the structure, locomotion, digestion, and reproductive behavior among the amoeba, paramecium and euglena. Created to supplement use of the microscope. Requires Apple IIe.
Focus Media, Inc.

Oh, Deer!

Skills practice, simulation; Level 5-9. Based on real-life model. Challenges students to manage herd of white-tailed deer. During a five-year period, students make series of decisions necessary to maintain a herd size which is in balance with the natural environment and human tolerance. Allows students to experience social pressures of this situation, as well as effects of control measures on deer herd. Copy protected. Network version available. Apple KK+/IIe/IIc/IIgs, 48K, 5-inch disk drive, Applesoft, DOS 3.3
Conduit

Special Senses I: The Eye (1985)

5-inch disk; Level 10-12. Comprehensive introduction to the eye. Excellent graphics and animation on the anatomy of the eye and basic principles of optics mechanism of human vision and the function of rods and cones. Pop quizzes and a testing system are built into software Lab Pack. Requires 48K Apple II computer.
ComPress

Taxonomy Game

Apple II, 48K, Disk; Level 9-12. Students must teach the computer to recognize and differentiate among protists, animals and plants by phyla and characteristics. Program prompts students to provide questions the computer must ask to identify the protists, plants, or animals. Students sharpen their own ability to write questions and identify living things by biological classifications. The teacher can examine the questions for indications of pupil misconceptions.
Queue

Computer interfaces/ Data acquisition

The Body Electric

Apple II, 64K, Disk; Level 8-college. This sophisticated yet asy-to-use computer-based tool enables teachers and students to engage in investigations that up until now required more expensive equipment. Students monitor and measure brain waves, electrocardiograms and the electrical activity of muscles. The package comes with 3 gold-plated electrodes, an interface that connects the sensor to the microcomputer and an extensive Teaching Guide with activities and worksheets.
Queue

Cardidcomp

Apple II, PC 256K. Measures various indices of human heart performance; includes transducer, interface and board.

Flexicomp

Apple II, PC 256K. Measures reflex arc of different muscle systems; includes tranducer, interface and board.

Physiogrip

Apple II, PC 256K; Requires stimulator. Measures muscle response to point stimulation; includes transducer, interface and board.

Spirocomp

Apple II, PC 256K. Measures human lung volume and capacity; includes transducer, interface and board.
Ward's Natural Science Establishment

Videodisc

Bio Sci Videodisc; Bio Sci II. Videodisc and HyperCard Stack for Macintosh

Used with the Bio Sci Stacks produced by Videodiscovery, Inc. Bio Sci II offer expanded photos, movie sequences and computer graphics.
Videodiscovery, Inc.

Community of Living Things: Relationships–An Investigation of Biological Relationships

Stack allows teachers to redesign the disk by showing examples of particular organisms, for instance protozoans, insects or plants. A lesson could be done on types of animal

movement, classification or cell diversity.
Produced by WHRO and the SYSCON Corp.

The Frog (1989)

Two-sided 12-inch audiovisual learning device covering the internal and external anatomy and physiology of the grass frog *Rana pipiens*. Footage includes the live animals in their natural setting, laboratory dissection of preserved animals, histological slides of various tissue sections, diagrams of anatomy, diagrams of analogous human body parts and physiology, instructions on use of dissection instruments and techniques, and warnings not to perform various procedures on unanaesthetized specimens.
Optical Data Corp.

The Voyager VideoStack

A HyperCard Stack containing a collection of buttons that, once "pasted" into your own stacks, allows it to control the laser disk player. Can be used as a remote control to control any laser disk or as an authoring aid to develop a HyperCard stack to go with any laser disk.
The Voyager Company

B. *Publishers & Vendors*

Publishers and suppliers of products cited in this monograph are listed below in alphabetical order. The addresses and phone numbers when available were extracted from various catalogs, brochures and other sources. Send inquiry to specific supplier before sending order or monies. A list of additional organizations and institutions with programs and materials on alternatives to the use of animals begins on page 122. This listing should not be construed as an endorsement of any product by NABT.

Addison-Wesley Publishing Company
2725 Sand Hill Road, Menlo Park, CA 94025; (415) 854-0300.

Argus Archives
Dept. AF-2, 228 East 49th St., New York, NY 10017; (212) 355-6140

Armstrong Medical Industry
P.O. Box 700, Lincolnshire, IL 60069; (800) 323-4220

Barnes and Noble
(201) 767-7079

Barr Films
12801 Schabarum, P.O. Box 7878, Irwindale, CA 91706-7878; (818) 338-7878

Benchmark Films
145 Scarborough, Briar Cliff Manor, NY 10510; (914) 762-3838

Berlet Films
1646 W. Kimmell Rd., Jackson, MI 49201; (517) 784-6969

Biological Sciences Curriculum Study
P.O. Box 930, Boulder, CO 80302; (719) 578-1136

Carolina Biological Supply Company
1308 Rainey St., Burlington, NC 27216; (919) 226-6000/East: (800) 334-5551/West: (800) 547-1733

COMPress (division of Wadsworth, Inc.)
P.O. Box 102, Wentworth, NH 03282

CONDUIT (division of University of Iowa)
University of Iowa, Oakdale Campus, Iowa City, IA 52242; (319) 335-4100

Connecticut Valley Biological
82 Valley Rd., P.O. Box 326, Southampton, MA 01073; (413) 527-4030

Cross Educational Software
504 E. Kentucky Ave., P.O. Box 1536, Ruston, LA 71270; (318) 255-8921

Discover Science Opportunities for Learning, Inc.
20417 Nordhof St., Dept. R986, Chatsworth, CA 91311

Educational Activities, Inc.
1937 Grand Avenue, Baldwin, NY 11510; (516) 223-4666/(800) 645-3739

EduTech, Inc.
1927 Culver Rd., Rochester, NY 14609; (716) 482-3151

Encyclopaedia Britannica Educational Corp.
310 S. Michigan Ave., Chicago, IL 60605; (312) 347-7000/ (800) 554-9862

Epilepsy Foundation of America
4351 Garden City Dr., Ste. 406, Landover, MD 20785; (301) 459-3700

Fisher Scientific–Educational Materials Division
4901 West LeMoyne St., Chicago, IL 60077; (312) 378-7770/(800) 621-4769

Focus Media, Inc.
839 Steward Ave., Garden City, NY 11530; (516) 764-8900/(800) 645-8989

Harcourt Brace Jovanovich Publishers
Orlando, FL 32887; (407) 345-2000

Journal Films, Inc.
930 Pitner Ave., Evanston, IL 60202; (800) 323-5448

Learning Corporation of America
c/o Coronet Film and Video, 108 Wilmot Rd., Deerfield, IL 60015; (800) 621-2131

Media Design
P.O. Box 3189, Boulder, CO 80307; (303) 443-2800

The Myrin Institute, Inc. for Adult Education
521 Park Ave., New York, NY 10021; (212) 758-6475

National Teaching Aids
1845 Highland Ave., New Hyde Park, NY 11040; (718) 895-0898

NASCO
901 Janesville Ave., P.O. Box 901, Fort Atkinson, WI 53538-0901; (800) 558-9595

National Geographic Society
Educational Services, Departmen 89, 17th & M Sts., NW, Washington, DC 20036; (202) 857-7000/(800) 638-4077

New Dimension Films
85895 Lorane Highway, Eugene, OR 97405; (503) 484-7125

Nystrom, division of Herff Jones, Inc.
3333 Elston Ave., Chicago, IL 60618; (800) 621-8086

Optical Data Corp.
20 Technology Dr., Box 4919, Warren, NJ 07060; (800) 524-2481

Phipps and Bird, Inc.
8741 Landmark Rd., P.O. Box 27342, Richmond, VA 23261; (804) 264-7590

Phoenix/BFA Films and Video, Inc.
102 Dawn Heights, Scottdepot, NV 25560; (304) 757-7688

Prentice Hall Media
Rt. 59 at Brook Hill Drive, W. Nyack, NY 10994; (914) 358-8800

Prentice Hall, Inc.
200 Old Tappan Rd, Old Tappan, NJ 07685; (800) 852-8024 or (617) 455-1200

Queue, Inc.
562 Boston Ave., Bridgeport, CT 06610; (203) 335-0908/(800) 232-2224

Sargent-Welch Scientific Co.–Central Regional Office
7400 N. Linder Ave., P.O. Box 1026, Skokie, IL 60077; (312) 676-0172/(800) 727-4368

Scholastic Software, Inc.
730 Broadway, New York, NY 10003; (212) 505-3000 or (800) 392-2179
Orders to: P.O. Box 7502, 2931 E. McCarty St., Jefferson City, MO 65102; (800) 325-6149

Schoolmaster Science
745 State Circle, P.O. Box 1941, Ann Arbor, MI 48106; (800) 521-2832

SCIDEAS
516 Ridgeway St., Warrenton, NC 27589

Science Kit and Boreal Laboratories
777 E. Park Dr., Tonowanda, NY 14150-6782/P.O. Box 2726, Sante Fe Springs, CA 90670-4490; (800) 828-7777

Stanton Films
2417 Artesia Blvd., Redondo Beach, CA 90278; (213) 542-6573

Ventura Educational Systems
3440 Brokenhill St., Newbury Park, CA 913210; (805) 499-1407

Videodiscovery, Inc.
1515 Dexter Ave. N. Ste. 400, Seattle, WA; 98109-3017; (206) 285-5400/(800) 548-3472

The Voyager Company
2139 Manning Ave., Los Angeles, CA 90025; (213) 474-0032

Ward's Natural Science Establishment, Inc.
5100 W. Henrietta Rd., P.O. Box 92912, Rochester, NY 17692-9012; (716) 359-2502

Webster/McGraw-Hill
1221 Avenue of the Americas, New York, NY 10020; (212) 512-4100

WHRO Public Television and Radio
Consortium for Interactive Instruction, 5200 Hampton Blvd., Norfolk ,VA 23508; (804) 489-9476

C. *Selected Organizations*

Selected organizations and institutions with programs and materials on alternatives to the use of animals.

Alternatives To Animals (ATA)
P.O. Box 7177, San Jose, CA 95150; (408) 996-1405

American Anti-Vivisection Society
801 Old York Road, Ste. 204, Jenkintown, PA 19046; (215) 887-0816

American Association for Laboratory Animal Science (AALAS)
70 Timber Creek Dr., Ste. 5, Cordova, TN 38018; (901) 754-8620

The American Fund for Alternatives to Animal Research
175 W. 12th St., No. 16G, New York, NY 10011-8275; (212) 989-8073

American Humane Association
P.O. Box 1266, Denver, CO 80201-1266; (800) 842-4637

American Society for the Prevention of Cruelty to Animals (ASPCA)
441 E. 92nd St., New York, NY 10128; (212) 876-7700

American Veterinary Medical Association
1023 15th St., NW, Ste. 300, Washington, DC 20005; (202) 659-2040

Animal Legal Defense Fund
1363 Lincoln Ave Ste. 7, San Rafael, CA 94901; (415) 459-0885/(800) 922-FROG

Animal Welfare Institute
P.O. Box 3650, Washington, DC 20007; (202) 337-2333

Association of Veterinarians for Animal Rights
22 Bradford Dr., Old Bridge, NJ 08857; (201) 679-5139

Canadian Council on Animal Care
1105-151 Slater, Ottawa, Canada K1P 5H3

Center for Alternatives to Animal Testing
John Hopkins University, 615 N. Wolfe St., Baltimore, MD 21205; (301) 955-3343

Focus on Animals
P.O. Box 150, Trumbull, CT 06611; (203) 377-1116

Foundation for Biomedical Research
818 Connecticut Ave. NW, Third Floor, Washington, DC 20006; (202) 457-0654

Fund for the Replacement of Animals in Medical Experiments (FRAME)
Eastgate House, 34 Stoney St., N. Hinghen, NG1, NB, U.K.

The Humane Society of the United States
2100 L St., NW, Washington, DC 20037; (202) 452-1100

Institute of Laboratory Animal Resources
National Research Council, National Academy of Sciences, 2101 Constitution Ave., NW, Washington, DC 20418; (202) 334-2000

International Foundation for Ethical Research
53 W. Jackson Blvd., Chicago, IL 60604; (312) 419-6990

Medical Research Modernization Committee
P.O. Box 6036, Grand Central Station, New York, NY 10163-6018; (212) 876-1368

National Anti-Vivisection Society (NAVS)
53 W. Jackson Blvd. #1552, Chicago, IL 60604; (312) 427-6065

National Association for Humane and Environmental Education
67 Salem Road, East Haddam, CT 06423; (203) 434-8666

National Science Teachers Association
1742 Connecticut Ave., NW, Washington, DC 20009; (202) 328-5800

National Wildlife Federation
1412 16th St., NW, Washington, DC 20036-2266; (202) 797-6800

National Zoological Park (part of the Smithsonian Institution)
3001 Connecticut Ave. NW, Washington, DC; (202) 673-4800

Ohio State University and Ohio Academy of Science
University Laboratory Animal Resources, 6089 Godown Rd.
Columbus, OH 43220; (614) 292-6446

People for the Ethical Treatment of Animals (PETA)
P.O. Box 42516, Washington, DC 20015-0516; (301) 770-7444

Psychologists for the Ethical Treatment of Animals
P.O. Box 87, New Gloucester, MA 04260

Physicians' Committee for Responsible Medicine
P.O. Box 6322, Washington, DC 20015; (202) 483-1312

Scientists Center for Animal Welfare
4805 St. Elmo, Bethesda, MD 20814; (301) 654-6390

Student Action Corps for Animals
P.O. Box 15588, Washington, DC 20003-0588; (202) 543-8983

Western Humane Education Association
c/o Mickey Zeldef, 171 Bell Marin Keys Blvd., Novato, CA 94949

Epilogue ■ Some Final Thoughts

This monograph affirms the value of teaching biology as the study of living organisms, rather than dead specimens. Biology teachers can stand firm in their conviction that living organisms can be used in the classroom as long as appropriate care is given and that reasonable humane experimentation can be done.

It has been reported that the number of biology teachers completely rejecting dissection increases every year (*The Science Teacher* 1987). Many have found that dissection simply does not meet their objectives and some just do not have the time. Still others believe they can better prepare their students for college with more concept-oriented experiences.

A shortcoming in the practice of keeping animals in the classroom is the lack of knowledge among many teachers about the proper handling of living organisms. In addition, many teachers are unfamiliar with the diseases that can be transmitted from animals to man or vice versa. Teacher education classes need to provide inservice training on these subjects and information on the care and maintenance of animals.

It has come to our attention that most teachers have little or no background in the issue of animal welfare. When an incident occurs it is too late to study the issue–there is no time for a teacher to re-examine animal use in light of animal welfare. The growing controversy over dissection and the use of animals in the biology classroom can be used positively to infuse new ideas and changes in the traditional curriculum. The ethics of animal use should be discussed and decision making lessons related to the use of animals should be introduced. The inclusion of lessons reflecting respect for animal life is emerging as an important consideration.

A fourth "R" may be added to the principles of alternatives to the use of animals. This is to **re-examine** seriously the need for dissection and invasive experimental procedures such as injection of known toxic substances, deprivation of food or nutrients and the infliction of stress on the animal. A careful re-examination of dissection and the curriculum objectives it achieves may well reveal a need to replace it with learning activities that are more relevant to the students' educational requirements. An alternative teaching method may also be a better representation of current biological information.

This monograph is part of our commitment to provide direction and guidance to teachers preparing for the curriculum changes that alternatives to dissection may require. It is not NABT's intention to mandate the prohibition of the use of animals in biology teaching but rather to provide teachers with sufficient information to determine for themselves which

teaching activities are appropriate. NABT makes no claims that the alternatives discussed in the monograph are the best and most comprehensive.

Instead, NABT's goal in this project is to encourage members to maintain an open mind about alternatives to dissection. To foster this attitude, teacher workshops are being considered for conventions and summer update programs. They will familiarize teachers with alternative lessons and methods for teaching ethics and values clarification relating to animal use. Teachers are encouraged to submit lessons or labs that provide alternatives to dissection to NABT's journal, *The American Biology Teacher*. *ABT* submissions must follow specific guidelines. See *ABT* (November/December 1989) or request a copy from NABT.

In summary, biology teachers should interpret the introduction of alternatives to the use of animals as a professional growth experience. In the words of Christine Stevens, president of Animal Welfare Institute, "We have the opportunity in the training of young future scientists to encourage them in paths of symphathy and consideration for fellow animals. We should avoid developing a harsh and unfeeling attitude, both for the benefit of animals and for the benefit of young people and their intellectual and emotional development" (1980, p. 74).

The value systems of students and society as a whole are changing. The true measure of a *good* biology teacher is one who can adapt to these changes and make use of a variety of teaching methods. This way, a high school biology course can evolve into a dynamic science curriculum.

Acknowledgments

NABT wishes to thank the Geraldine R. Dodge Foundation for its generous support which made possible both this monograph and the symposium and teacher workshops that led up to it.

Other institutions and individuals have helped enrich the project staff and the Task Force's knowledge on the issues involved in dissection and vivisection. Christine Stevens of the Animal Welfare Institute pointed out the need to revise NABT's Guidelines for the Use of Live Animals. AWI also donated funds toward the project and allowed NABT the use of resources unavailable elsewhere.

Ohio State University, Laboratory Animal Resources and the Ohio Academy of Science invited NABT's Task Force to participate in a workshop conducted as part of its project. Margaret Duber Snyder, D.V.M., and her staff introduced us to new and broad perspectives in the "Workshop for Teachers on the Humane Care and Use of Vertebrates in Education and Student Research." A special thanks to Crowe Ward, D.V.M., of the University of Kentucky for allowing workshop space for three Task Force members to attend the above-mentioned workshop on its campus in Lexington, Kentucky.

Terri Champney, D.V.M., of Northern Virginia Community College-Loudoun Campus, generously made available resources on the topic of zoonoses.

Last but not least, my heartfelt thanks to those teachers who expressed opinions on NABT's position on alternatives to dissection. Their comments guided the direction of this project.

To Michelle and Alison, my thanks for helping me edit the draft manuscript and to one and all, my sincere appreciation for your support and commitment to this most important project.

Rosalina V. Hairston
Project Director

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Appendix

A. Principles and Guidelines for the Use of Animals

National Academy of Science
National Research Council
Institute of Laboratory Animal Resources

The humane study of animals in precollege education can provide important learning experiences in science and ethics and should be encouraged. Maintaining classroom pets in preschool and grade school can teach respect for other species, as well as proper animal husbandry practices. Introduction of secondary school students to animal studies in closely supervised settings can reinforce those early lessons and teach the principles of humane care and use of animals in scientific inquiry. The National Research Council recommends compliance with the following principles whenever animals are used in precollege education or in science fair projects.

Principle 1. Observational and natural history studies that are not intrusive (that is, do not interfere with an animal's health or well-being or cause it discomfort) are encouraged for all classes or organisms. When an intrusive study of a living organism is deemed appropriate, consideration should be given first to using plants (including lower plants such as yeast and fungi) and invertebrates with no nervous systems or with primitive ones (including protozoa, planaria, and insects). Intrusive studies of invertebrates with advanced nervous systems (such as octopi) and vertebrates should be used only when lower invertebrates are not suitable and only under the conditions stated below in Principle 10.

Principle 2. Supervision shall be provided by individuals who are knowledgeable about and experienced with the health, husbandry, care, and handling of the animal species used and who understand applicable laws, regulations and policies.

Principle 3. Appropriate care for animals must be provided daily, including weekends, holidays, and other times when school is not is session. This care must include:

a. nutritious food and clean, fresh water;
b. clean housing with space and enrichment suitable for normal species behaviors; and
c. temperature and lighting appropriate for the species.

Principle 4. Animals should be healthy and free of diseases that can be transmitted to humans or to other animals. Veterinary care must be provided as needed.

Principle 5. Students and teachers should report immediately to the school health authority all scratches, bites, and other injuries; allergies; or illnesses.

Principle 6. Prior to obtaining animals for educational purposes, it is imperative that the school develop a plan for their procurement and ultimate disposition. Animals must not be captured from or released into the wild without the approval of the responsible wildlife and public health officials. When euthanasia is necessary, it should be performed in accordance with the

most recent recommendations of the American Veterinary Medical Association's Panel Report on Euthanasia (Journal of the American Veterinary Medical Association, 188 [3]: 252-268, 1986, et seq.). It should be performed only by someone trained in the appropriate technique.

Principle 7. Students shall not conduct experimental procedures on animals that:

a. are likely to cause pain or discomfort or interfere with an animal's health or well-being;

b. induce nutritional deficiencies or toxicities; or

c. expose animals to microorganisms, ionizing radiation, cancer-producing agents, or any other harmful drugs or chemicals capable of causing disease, injury, or birth defects in humans or animals.

In general, procedures that cause pain in humans are considered to cause pain in other vertebrates.

Principle 8. Experiments on avian embryos that might result in abnormal chicks or in chicks that might experience pain or discomfort shall be terminated 72 hours prior to the expected date of hatching. The eggs shall be destroyed to prevent inadvertent hatching.

Principle 9. Behavioral conditioning studies shall not involve aversive stimuli. In studies using positive reinforcement, animals should not be deprived of water; food deprivation intervals should be appropriate for the species but should not continue longer than 24 hours.

Principle 10. A plan for conducting an experiment with living animals must be prepared in writing and approved prior to initiating the experiment or to obtaining the animals. Proper experimental design of projects and concern for animal welfare are important learning experiences and contribute to respect for and appropriate care of animals. The plan shall be reviewed by a committee composed of individuals who have the knowledge to understand and evaluate it and who have the authority to approve or disapprove it. The written plan should include the following:

a. a statement of the specific hypotheses or principles to be tested, illustrated, or taught;

b. a summary of what is known about the subject under study, including references;

c. a justification for the use of the species selected and consideration of why a lower vertebrate or invertebrate cannot be used; and

d. a detailed description of the methods and procedures to be used, including experimental design; data analysis; and all aspects of animal procurement, care, housing, use and disposal.

Exceptions Exceptions to principles 7-10 may be granted under special circumstances by a panel appointed by the school principal or his or her designee. This panel should consist of at least three individuals including a science teacher, a teacher of a nonscience subject, and a scientist or veterinarian who has expertise in the subject matter involved.[1] At least one panel member should not be affiliated with the school or science fair, and none should be a member of the student's family.

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[1] In situations where an appropriate scientist is not available to assist the student, the Institute of Laboratory Animal Resources (ILAR) might be able to provide referrals.

B. Science Service: Rules of the International Science and Engineering Fair

Rules

The booklet contains the rules for participation in the International Science and Engineering Fair (ISEF). The directors of all regional fairs which will be affiliated and participating in the ISEF must conduct the regional fair according to these rules. Copies of the booklet are available from Science Service, 1719 N Street, N.W., Washington, DC 20036. Permission to reprint with credit is granted. Rules may be updated yearly.

Before beginning any experimental work with vertebrate animals or humans, carefully read the rules in order to ensure compliance by the student experimenter. The following areas are the most critical in terms of compliance:

1. The use, misuse, and sacrifice of animals
2. The use of toxic substances by the high school experimenter
3. Nutritional deficiency experiments
4. The use of humans in any way

Failure to comply with the rules regardless of the institutional rules, will result in disqualification of the student from participation in competition in all ISEF affiliated fairs.

Recommendations

The ec . value of the selected student research topics should be the primary consideration of both the teachers and the fair directors. Science Service is proud to be associated in this important activity which provides incentives for the development of talent in scientific and technological fields among creative young people. We urge an increase i. the efforts of all persons involved to extend and expand the influence and effectiveness of science and engineering fairs and we offer our continued assistance and counsel to help assure success.

The development of the scientific method can be enhanced when teachers or supervisors insist that research has clearly defined objectives. Research should demonstrate scientific principles or answer propositions. It is suggested that this be completed before the student begins any research.

A paper describing the research, notebooks, computer programs, or other relevant written materials are encouraged and may be displayed.

C. Science Service: Westinghouse Science Talent Search

The rules for the Westinghouse Science Talent Search state in part: "No projects involving live vertebrate animal experimentation will be eligible. Projects involving behavioral observations of animals in their natural habitat and human subjects are excluded from this ruling and are eligible."

D. Animal Welfare Institute: Rules Governing Treatment of Animals by High School Biology Students

1. Animals being observed by students must always be maintained in the maximum possible condition of health, comfort and well-being.

2. No vertebrate animal used for primary or secondary school teaching may be subjected to any experiment or procedure which interferes with its normal health or causes it pain or distress.

REASONS WHY ANIMAL EXPERIMENTS BY
HIGH SCHOOL STUDENTS SHOULD BE PAINLESS

1. MORALLY, it is indefensible to hurt or kill animals unless original contributions which will advance human health and welfare can be expected. Elementary and secondary school studies do not meet this test.

2. PSYCHOLOGICALLY, it can be emotionally upsetting for youngsters to participate in harming or killing animals, or even worse, it may be emotionally desensitizing or hardening to immature minds.

3. SOCIALLY, in these days of widespread violence fostering personal acquaintance with inflicting pain on lesser creatures should be avoided.

4. EDUCATIONALLY, teaching about abnormal states before the student has a sound grasp of normal physiology is against common sense and does not advance scientific education.

5. SCIENTIFICALLY, promoting teenage animal surgery or induction of painful pathological conditions (which are very often poorly done in the unsanitary conditions of a student's home and have no scientific value) fosters an improper regard for animal life and an unbalanced view of biology which will rebound adversely when the next generation of scientists comes of age.

E. Canadian Council on Animal Care: Guiding Principles Governing the Use of Animals in the Classroom at the Pre-University Level

I. Purpose

These guiding principles have been prepared by the Canadian Council on Animal Care. They are recommended for use by Departments of Education and Boards of Education across Canada in order to ensure adequate safeguards exist for the proper care and use of animals in experimentation in the classroom, in the schools, in their jurisdiction.

These guidelines are not for use by students preparing projects for exhibit in Science Fairs. Students preparing projects for Science Fairs must adhere to the Youth Science Fair Regulations for Animal Experimentation, as prepared and distributed, by the Youth Science Foundation, Suite 302, 151 Slater St., Ottawa, Ontario K1P 5H3.

II. Philosophical considerations

Biological experimentation involving animals in the classroom is essential for an understanding of living processes. Such studies should lead to a respect for all living things. All aspects of the study must be within the comprehensions and capabilities of the student undertaking the study.

Lower orders of life are preferable subjects for experimentation at the pre-university level. Such lower orders as bacteria, fungi, protozoa, and insects can reveal much basic biological information; they should be used for experimentation, wherever and whenever possible.

III. Care of experimental animals

The care of experimental animals in the school should embody the principles laid down in the Guide to the Care and Use of Experimental Animals, as prepared and distributed by the Canadian Council on Animal Care. (address below)

The following principles are necessary in order to provide optimal animal care:

a. The maintenance of animals in a classroom shared by students on a long term basis, is not recommended. Therefore, animal quarters specifically for housing of animals should be provided.
b. All experimental animals used in teaching programs must be properly cared for. Animal quarters should be made comfortable by provisions for sanitation, protection from the elements and have sufficient space for normal behavioural and postural requirements of the species. The living quarters shall have surfaces that may be easily cleaned, good ventilation and lighting, well regulated temperatures and cages of sufficient size to prevent overcrowding. Animals must be protected from direct sunlight or other environmental factors which may disturb the well-being of the animal.
c. Food should be palatable, of sufficient quantity and balanced to maintain a good standard of nutrition. Animals shall not be allowed to go below the maintenance level of nutrition. *Clean drinking water shall be available at all times.* Containers for food and water should be of a design, made specifically for that purpose.
d. Colonies and animal quarters shall be supervised by a science

teacher experienced in animal care. The students and other animal care staff shall be trained and required to handle the animals gently and humanely.

e. All animals must be disposed of in a humane manner. If euthanasia has to be carried out an approved humane method must be used and carried out by an adult experienced in the use of such procedures.

f. The use of animals must comply with existing local, provincial or federal legislation.

g. The procurement and use of wild animals and birds must comply with the Migratory Birds Convention Act of Canada, the Convention on International Trade on Endangered Species of Wild Fauna & Flora (ratified by Order in Council July 3, 1975) as well as any existing legislation at the Provincial level concerned with wild animals and exotic species.

IV. Experimental studies

1. All experiments should be carried out under the supervision of a competent science teacher. It is the responsibility of the qualified science teacher to ensure the student has the necessary comprehension for the study to be undertaken.
2. Students should not be allowed to take animals home to carry out experimental studies. All studies involving animals must be carried out in a suitable area in the school.
3. All students carrying out projects involving vertebrate animals must adhere to the following guidelines:
   A. No experimental procedures shall be attempted on a vertebrate animal that should subject it to pain or distinct discomfort, or interfere with its health.
   B. Students shall not perform surgery on vertebrate animals.
   C. Experimental procedures shall not involve the use of:
      a. microorganisms which can cause diseases in man or animals.
      b. ionizing radiation.
      c. cancer producing agents.
      d. drugs or chemicals at toxic levels.
      e. alcohol in any form.
      f. drugs that may produce pain.
      g. drugs known to produce adverse reactions, side effects, or capable of producing birth deformities.
   D. Experimental treatments should not include electric shock, exercise until exhaustion, or other distressing stimuli.
   E. Behavioural studies should use only reward (positive reinforcement) and not punishment in training programs.
   F. If egg embryos are subjected to experimental manipulations, the embryo must be destroyed humanely 2 days prior to hatching. If normal egg embryos are to be hatched, satisfactory humane considerations must be made for disposal of the young birds.
4. The use of anaesthetic agents, by students, is not recommended and in the case of some anaesthetics not permitted by law.
5. Information on the care, housing and management for individual species, as well suitable experiments for use at the pre-university level, may be obtained from the Canadian Council on Animal Care, 151 Slater St., Suite 1105, Ottawa, Ontario K1P 5H3.

F. Youth Science Foundation: Humane Rules for Canadian Science Fairs

Regional Representatives of the Canada-Wide Science Fair approved new regulations May 23, 1975 which eliminate the use of vertebrate animals for science fair projects unless these projects are purely observations of normal living patterns of animals in the wild or in zoos or of normal activities of pets or other domestic animals.

The decision followed several years' attempts to control cruel experiments for science fairs by rules against those which caused harm to living vertebrates. Despite such rules, some students continued to conduct projects that caused animal suffering. The Regional Representatives, therefore, drew up the following regulations which are now in effect in Canada.

Regulations for Animal Experimentation in Science Fairs

1. Biological experimentation is essential for an understanding of living processes; such as studies should lead to a respect for all living things. Capable students, anxious to pursue a career in biological sciences must receive the necessary encouragement and direction. All aspects of the project must be within the comprehensions and capabilities of the student undertaking the study.

   Biological experimentation is subject to legal restrictions, including amongst others:
   Criminal Code of Canada, section 402 - Cruelty to Animals;
   Animal Disease and Protection Act;
   Animals for Research Act (Ontario);
   Regulations for Housing, Care and Treatment of Animals Used for Biological or Medical Purposes (Alberta).
   YSF regulations are more restrictive in view of:
   a) the need to maintain a positive public image towards the Foundation and its programmes;
   b) the lack of expertise of student investigators and many of their immediate supervisors.
   All animal experimentation must conform to the guidelines laid down by the Canadian Council on Animal Care.

2. It must be stressed that lower orders such as bacteria, fungi, protozoa and insects can reveal much basic biological information. If experiments are to be conducted on living subjects for Science Fair projects then only lower orders of life may be used.

3. Vertebrate animals (birds, fish, mammals, amphibians, reptiles) are not to be used in any active experiments which may be deleterious to the health or physical integrity of the animals. This permits:
   a) observations of normal living patterns of wild animals in the free living state or in zoological parks, gardens or aquaria;
   b) observations of normal living patterns of pets, fish or domestic animals;
   c) behavioral experiments with positive reinforcement (rewards).

4. No living vertebrate animals shall be displayed in exhibits in science fairs.

5. Cells such as red blood cells, other tissue cells, plasma or serum purchased or acquired from biological supply houses or research facilities may be used in Science Fair projects.

6. Chick embryos studies (domestic chicken–*Gallus domesticus*) only observational studies on normal embryos are permitted. No external interventions (e.g. drugs, chemicals) may be made. If eggs are to be hatched, then the chicks must be transferred to appropriate care (e.g. farm rearing). Otherwise all embryos must be destroyed, preferably by the 12th day of incubation and definitely by the 19th day. An acceptable method is storage in a domestic freezer for at least 48 hours. No eggs capable of hatching may be exhibited in science fair.

7. Experiments involving the human animal shall conform with these regulations as they apply to animals:
   a) evidence of informed consent must be provided.
   b) any stress should be limited to levels which the person concerned would voluntarily undertake in normal physical or mental activity;
   c) any invasive procedures, especially blood sampling, must be performed under the supervision of a qualified health care professional.

8. All experiments shall be carried out under the supervision of a competent science teacher. It shall be the responsibility of the qualified science teacher to ensure the student has the necessary comprehension for the study to be undertaken. Whenever possible specifically qualified experts* in the field shall be consulted.

*For information and names of qualified experts write to:
Canadian Council on Animal Care, 1105-151 Slater St., Ottawa, Ontario K1P 5H3
Youth Science Foundation, 805-151 Slater St., Ottawa, Ontario K1P 5H3

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