CHAPTER 4

Animal Dissection in Education

From the perspective of a physician involved in clinical practice, education, and research, I have come to the conclusion that killing and dissecting animals is not only unnecessary but also counterproductive in the training of physicians and scientists.

—David O. Wiebers, M.D.

4.1 Introduction

This section deals exclusively with the use of already-dead animals in education. The prevalence of animal dissection in education is discussed first, followed by an examination of humane issues and environmental concerns surrounding the procurement of animals for dissection. Then follows a critique of arguments made in defense of dissection, and finally, an exploration of the availability and effectiveness of alternatives to animal dissection. For humane, sociological, pedagogical and environmental reasons, The HSUS believes that animal dissection should be eliminated from the precollege curriculum and from university education except where absolutely necessary (e.g., veterinary training).

4.2 Prevalence of Dissection

The United States

The most common use of animals in education is for dissection (Mayer and Hinton 1990). Official figures for the numbers of animals dissected in American
schools are not available because there is no regulatory requirement to report dead animals either at supply houses or at educational facilities. Based on an estimate that about 75 percent of American high school students participate in animal dissections, Orlans (1993) estimated that close to six million vertebrate animals are dissected in U.S. high schools alone each year and that about three million of these animals are frogs. Orlans’s estimate seems accurate; a survey of 1,000 U.S. adults conducted in May 1999 by the National Anti–Vivisection Society found that 78 percent of respondents under the age of fifty-five reported that animal dissection was part of their education (ORC 1999).

The numbers of invertebrate animals used is probably greater (Orlans et al. 1998), especially if one includes the innumerable fruit flies killed in “morgues” (dishes of oil) in genetics courses. When animal use in postsecondary education, specialized training programs, and elementary and middle school is included, the annual educational toll on animals in the United States is probably close to ten million vertebrates and over ten million invertebrates.

In addition to frogs, other commonly dissected species include cats, fetal pigs, rats, minks, pigeons, turtles, snakes, salamanders, bony fish (usually perch), dogfish sharks, lampreys, crayfish, locusts, earthworms, roundworms, clams, starfish, and barnacles. An ISUS unpublished review of the “preserved specimens” section of a major biological supply company catalog (WARD’S catalog 1995) found 171 different species, 31 vertebrates and 140 invertebrates. In addition to animals available through biology supply companies, a relatively small number of teachers obtain animal parts from supermarkets or slaughterhouses, including chickens’ wings, cows’ eyes, hearts, and lungs, and sheep’s brains.

While reliable statistics are lacking, per capita dissection rates appear to be higher in the United States (and Canada) than anywhere else in the world. It is likely that the volume of animal use in education is proportional to that in research, and the United States easily ranks first in the latter category (Shapiro 1998). Orlans (1993) estimates that three out of four American students will dissect at least one animal by the time they graduate from high school. A BSCS survey in 1982 revealed that 65 percent of biology teachers reported spending at least five hours of the course with preserved specimens, and in many schools students perform dissections of a range of invertebrate and vertebrate specimens in ascending phylogenetic order (Russell 1987). When The Science Teacher, a magazine published by the NSTA, surveyed its readers in 1989, only 21 percent of the respondents (number not known) said they never dissected. Of the 79 percent who did dissect, 90 percent reported doing more than one dissection yearly, with some reporting up to fifteen dissections a year.

Dissection in the precollege curriculum is not limited to high school. At Algonquin Middle School, in Illinois, for example, seventh grade students in the life science class are required to dissect five animals: frog, crayfish, starfish, clam, and earthworm; a fetal pig dissection is offered for extra credit (Schmidt 1999). Middle school teachers who attend annual NABT and NSTA conventions frequently report that they or other teachers at their schools are conducting dissections of frogs and invertebrates, and there are reports of the spread of earthworm and insect dissection into elementary schools (Clifton 1992; Dun-
can 1999). Welch and Luginbill (1985) describe having their middle school students dissect, cook, and eat squid purchased from the supermarket.

There are signs of a growing trend toward having elementary-level children dissect animals. In 1997 The Smithsonian Institution presented a workshop on squids for four- to six-year-olds; among the activities was participation in “dissecting real specimens with scissors.” In the summer of 1999, the “College for Kids” program at Tulsa Community College ordered frogs, earthworms, cow eyes, and grasshoppers for four- to eight-year-olds to dissect. A “Blood and Guts” class at Discover Science Summer Camp, in Asheville, North Carolina, offers dissection of frogs, cow eyes, and sheep hearts. The HSUS relies on members and constituents to alert them of these announcements, and it is fairly certain that they represent only a small sample of the actual dissections being done across the country.

In secondary schools, however, there has been in recent years a gradual but steady trend toward teachers dropping dissection from their course requirements (Gilmore 1991b) and students requesting alternatives. According to the NABT, the number of students who dissect each year is declining as educational trends dictate removing dissection from science curricula. Solot (1995) interviewed several science teachers, who noted an increase in students’ awareness of animal rights arguments and a corresponding increase in the number of students who base their objections to dissection on these arguments. Kathy Frame, education project coordinator of the NABT, has attributed the decline of dissection to cost and accountability (Solot 1995).

**Europe**

Internationally there is a dearth of reliable figures on animal use in education, though some European nations keep better records than does the United States on animal use in research. In the United Kingdom, for example, extensive data on animal use are kept, but dissection of a dead animal is not defined a “procedure” by the British Home Office, so there are no official figures for the numbers of animals dissected there (Cochrane and Dockerty 1984). The only estimate of numbers of animals dissected in British schools was reported in a study by the Royal Society/Institute of Biology Working Party (RS/IOB 1975); based on numbers of preserved animals shipped to schools by a biology supply company, they estimated that 100,000 rats, 45,000 dogfish sharks, and 40,000 frogs were used in 1974. These numbers were thought to be higher by the early eighties, at which time more students were studying advanced level biology (Cochrane and Dockerty 1984). While the numbers for Britain provided by the RS/IOB 1975 study and by Cochrane and Dockerty (1984) do not include numbers of freshly killed specimens, they still pale compared with U.S. numbers, even when adjusting for population size.

Nevertheless, enough information exists in Europe to make broad comparisons. Animal dissection is still fairly common, but it doesn’t hold the prominent position it enjoys in North American schools. Rates of animal use in elementary through secondary levels of education are considerably lower in Europe (van der Valk et al. 1999), and several countries have passed legislation prohibiting dissection and invasive live-animal exercises at these levels (see section 6.5). In postsecondary education, where animal use is not prohibited, it is estimated that several hundred
thousand vertebrate animals are used yearly throughout Europe (ibid.).

International trends in overall laboratory animal use (in research, education, and testing) show significant declines during the past two decades. Shapiro (1998) summarizes these declines for six countries: Netherlands (40 percent decline from 1978 to 1990); Switzerland (eight consecutive years, 1984-1991 inclusive); West Germany (50 percent from 1981 to 1991); Italy (55 percent from 1978 to 1989); United Kingdom (58 percent from 1979 to 1993); and Canada (38 percent from 1977 to 1989). While these declines are probably most attributable to changes in animal testing and research, it is reasonable to assume that educational uses also contribute to these trends.

4.3 Procurement and Animal Suffering

The principal objections to the use of animals for classroom dissection are (1) concern for the way animals are treated before they arrive in the classroom, and (2) concern for the effect the exercise has on students’ values and attitudes toward life (see chapter 3). With an annual education demand for close to ten million vertebrate animals and a comparable number of invertebrates in the United States, supplying the bodies of dead animals (usually termed “preserved specimens”) is a large and thriving business. In the United States, at least twenty companies supply dead and/or living animals for use in education. Some of these companies (e.g., WARD’S, Nasco, Fisher Scientific) are large and successful, producing hefty, glossy color catalogs selling a broad range of educational materials in addition to preserved/live animals. The largest U.S. company, Carolina Biological Supply Company (CBSC), employs approximately 400 people, has annual sales of more than $25 million, and reportedly doubles in size every six years (Robinson 1996). CBSC was started in 1927 when its founder, Thomas Powell, began selling amoebae and frogs he collected. At the other end of the spectrum are small, family operations, such as Niles Biological and Hazen Farms, which deal strictly in the supply of animal specimens and have only a handful of full-time employees.

Information about the procurement of animals for use in dissection is notoriously hard to obtain in both the United States (King 1994; Solot 1995) and Canada (Zierer 1992). Nevertheless, some investigations have been made, and the remainder of this section summarizes what is known.

Frog Supply

Gibbs et al. (1971) conducted an in-depth study to document the conditions of the capture and warehousing of frogs bound primarily for dissection. The authors were concerned that supplies of frogs were dwindling; frogs caught up in the supply showed “a steady decline in the quality of life”; resulting shipments of frogs were routinely in “extremely poor health”; and scientific uses were compromised as a result.

Gibbs et al. (1971) found that crude handling methods and negligent transport conditions were the primary contributors to these problems. All of the frogs were captured in the wild, and the authors point out “the most basic misconception [that] the laboratory frog is . . . a domestic animal raised on ‘frog farms’” (1027).
The animals were taken from populations throughout North America, in a network extending thousands of miles into Canada and Mexico. Most were kept alive between the time of capture and the time of shipping to the classroom or laboratory. At the time of capture, frogs were kept in large sacks or cages. As many as 100 frogs were kept in each sack for up to a week or more, the only care being intermittent spraying with water. Eventually, the frogs were put into large tubs of water where they were kept for periods ranging from days to months depending on the season and the demand for shipments. During this period, the frogs were provided no food. Frogs shipped during the summer likely had gone without food for a week or more between capture and arrival at a school; in the early spring, frogs may not have eaten for more than six months. Live frogs were usually shipped 50 to a box lined with sphagnum moss. In the summer months, most frogs were “hot,” meaning that they were overheated and hyperactive often to the point of convulsion.

Gibbs et al. (1971) describe the high mortality rates that resulted from these conditions. Many of the frogs not initially crushed or “broken” during the rigors of capture, transport, and shipping in the sacks, died of starvation or disease in the unnatural and unsanitary holding tanks. On average, 15 percent of frogs were either dead or obviously injured following their initial transportation from collection site to the sorting depot. Gibbs et al. (1966) found that it was not uncommon for more than two-thirds of frogs being kept alive in the school or laboratory to be dead within the first week of their arrival. This article was not the result of antagonism towards the frog trade. One of the authors (Emmons) was an employee of a supply company dealing in frogs, and the authors expressed concern that experimental use of live frogs was declining at that time.

There is little to indicate that conditions of frog capture, transport, and storage have changed substantially since Gibbs and his colleagues published their study in 1971. Field investigations conducted between 1997 and 1999 by The HSUS suggest that the only significant change is that a much larger proportion of frogs is now killed before shipment to schools.

Rana Laboratories, a CBSC supplier located in Brownsville, Texas, is representative of The HSUS’s findings. A November 1997 interview with the plant manager revealed that Rana purchases well over 100,000 pounds of leopard frogs yearly and an unknown quantity of bullfrogs. The animals are taken from wild populations, primarily near the west coast of Mexico, and kept without food during the holding period prior to distribution. Live frogs are stored in trays inside coolers maintained at 50 degrees Fahrenheit and are shipped in boxes. Mortality rates during shipment can be high, particularly when held up at the U.S.–Mexico border during harsh weather conditions.

The frogs are killed at unpredictable intervals by dropping them into a solution of alcohol and water. The animals take fifteen to twenty minutes to die. An interview with the owner of another supply company, Cyr’s Biology, located in Ponchatoula, Louisiana, yielded similar information, with the additional note that live frogs are sometimes stored in the coolers for three months. In its report on euthanasia, the American Veterinary Medical Association makes no mention of immersion in alcohol as a means of killing amphibians (AVMA 1993).
PETA's Investigation of CBSC

With the launch of the modern animal rights movement a decade after Gibbs et al.’s article, the response of biological supply companies towards outside inquiries about the sources of animals sold for dissection became increasingly guarded. Consequently, the most detailed information regarding industry practices in recent years has been gleaned by animal protection organizations conducting undercover investigations. Their findings have tended to reinforce concerns that neglect and abuse pervade the procurement of animals for dissection.

In 1989 two employees of the organization People for the Ethical Treatment of Animals (PETA) worked for several months at CBSC headquarters in Burlington, North Carolina, following complaints of animal abuse at this facility. One of the investigators, Bill Dollinger, was able to secure employment in the section of the company that handles animals after they arrive at the facility. Using a hidden camera, he videotaped several disturbing scenes of live cats arriving at the facility in crowded wire cages.

The quality of Mr. Dollinger’s video is adequate to make some reliable assessments of conditions at CBSC. The behavior of the cats as they are poked with a long metal hook from one cage to another and then into the gas chambers (which used 100 percent carbon monoxide in bottled form), suggests high levels of stress in these animals. The handling is rough and noisy, and the cats’ movements are jumpy and skittish. Many of them have crouched postures and nervous, wide-eyed facial expressions. In his written log, Mr. Dollinger (PETA n.d.) describes the following related observations:

- up to twenty cats per cage (measuring approximately 4' x 1.5' x 1') in vehicles lacking ventilation
- a cat giving birth while being gassed
- a cat meowing after being gassed
- the movements of unborn kittens visible in the bellies of pregnant cats following gassing

These are violations of basic humane standards. Bottled carbon monoxide (CO) is accepted by the AVMA (1993) for euthanasia of cats, but The HSUS (1994), deems it “absolutely unacceptable” for use on cats who are old, young (under four months), sick, or injured. Gas chambers must never be overcrowded, and they should be designed to minimize stress and to allow for the appropriate separation of animals (ibid.). The random sourcing of cats killed at CBSC and the stressful, crowded conditions of gassing indicate that these caveats are not met.

Cats are not the only species observed being subjected to pain and/or distress at CBSC. Another videotaped scene shows a rat wriggling while being strapped into a restraining device and catheterized. During the initial stages of formaldehyde infusion, the vigorous, coordinated movements of the rat strongly suggest that the animal is at least partially conscious. Other excerpts from Mr. Dollinger’s written (PETA n.d.) and videotaped evidence includes:

- a live dog trying to crawl from beneath a pile of dead dogs in the back of a truck
- a rabbit, still breathing, being catheterized and embalmed
- shipments of live pigeons left on a loading dock for six and one-half hours in small cardboard boxes
- embalming of living frogs
- a large tray of apparently fully alive adult crabs being injected with a liquid thought to be formaldehyde preservative

The behavior of some of the CBSC employees is sometimes callous and sadistic, as evidenced by the following descriptions by the investigator (PETA n.d.):
- an employee spits on a rat after strapping the wriggling animal to a restraining device
- an employee laughs as a cat convulses after being hooked up to an embalming board
- a cat is bludgeoned to death by an employee after the cat bit him
- an employee deliberately prolongs the drowning of a rabbit by repeatedly pulling the animal from the water as he is about to drown
- employees play catch with a rat before drowning him

In a follow-up investigation by ABC News of CBSC practices aired in October 1990, Al Wise, one of CBSC’s major suppliers of cats at that time, is filmed while turning the bulldozer he is driving towards a reporter and charging him before ramming an ABC News van as it flees the scene. Two years after the ABC News report, the United States Department of Agriculture (USDA) charged Mr. Wise with obtaining cats illegally and falsifying his records. The charges were resolved on July 7, 1993, when Mr. Wise agreed to an order banning him from operating as an animal dealer for ten years (AWA Docket No. 93-118).

The question of whether or not some cats were still alive at the time of embalming following gassing was one of approximately ten charges of violations under the Animal Welfare Act (AWA) brought by the USDA against CBSC in 1991. During the hearing two USDA veterinarians testified that several cats were still alive, but two veterinarians retained by CBSC testified that all the cats were dead when embalmed. The USDA judge ruled in favor of CBSC on the basis of their experience with and knowledge of embalming animals. Movement of the cats on the embalming boards was attributed to muscular movements that occur during infusion with formalin and to the pressure (10-12 pounds per square inch) at which the embalming fluid entered the cats’ circulatory systems.

In the end, CBSC was held accountable for its failure to maintain complete records of the acquired animals, for failures in sanitation and maintenance of enclosures, for inadequate storage of animal food, and for failure to keep its premises clean and free of accumulations of trash. The company was assessed a civil penalty of $2,500.

**Other Investigations**

A 1989 study by Bonner et al. (1989) examined the supply of red-eared slider turtles for classroom experiments. Thirteen turtles ordered from Connecticut Valley Biological Supply Company (Southampton, Massachusetts), where they were observed being warehoused in crowded conditions, exhibited a range of maladies not found in a control group of eight wild-caught turtles. These included hemorrhaging from the shell; paralysis; swollen, inflamed eyes with purulent drainage; respiratory problems; diarrhea; marked weight loss; and overall lethargy and apathy. Three of the warehoused turtles died from illness during the ten-day acclimation period of this study.

In 1994 the World Society for the Protection of Animals (WSPA) sent two investi-
gators to Mexico following a report of a vehicle carrying two thousand preserved cat specimens in Mexicali. It was discovered that cats were being rounded up from the streets and killed by putting ten cats into a sack and drowning them or by affixing the sack opening to a car exhaust pipe. The bodies were embalmed and then shipped to the United States for school dissection (WSPA 1994). The man in charge of collecting the cats admitted that a large proportion of them were probably owned (WSPA 1994; WSPA n.d.). The company, Preparation of Animal Material for Scholarly Study (PARMEESA), was filling a shipment quota of 1,500 cats per month and had been in operation for approximately 20 years, supplying dead cats (as many as 3,000 per week) and other species to several American biological supply companies, including Fisher EMD, Delta, Frey Scientific, and Sargent Welch (WSPA n.d.).

In 1995 authorities raided a chicken farm near Monterrey, Mexico, and found 800 dead cats. Workers at this facility told health officials that the cats were killed by “sticking a piece of wood in their mouths to keep them still and cutting their throats” (Associated Press 1995). Television crews on the scene filmed 20 dehydrated live cats panting in what was described as a sweltering shack. The cats were being shipped to the United States for use in school dissections. The owner of the facility was not charged with animal cruelty but for possessing too many dead animals and for mishandling chemicals. In a previous raid of the same ranch earlier that year, 500 dead cats had been found, and similar operations were reported in other Mexican border states (ibid.).

It is not certain to what extent these findings are representative of procurement practices in the biological supply trade. The specific investigations cited above were spawned by complaints lodged by employees or witnesses, which could mean they were atypical cases where things had gone awry. On the other hand, many factors suggest that inhumane practices are commonplace and perhaps routine in the supply industry, including the lack of regulatory oversight, closed-door policies of the suppliers, and the potential for lack of humane care when living animals will be sold dead (Orlans et al. 1998). To date, the supply companies have not publicly broached the procurement issue other than to defend themselves when under attack (CBSC 1994).

**Animal Shelters**

While wild populations are numerically the largest source of dissected animals, there are several other sources of animals used in dissections. Some animal control facilities choose to sell euthanized cat and dog carcasses to biological supply houses for use in dissections. At one time pound seizure laws in more than a dozen states required shelters to relinquish un-adopted animals to research labs and schools when requested to do so. In the past few decades, however, most of these laws have been repealed, making it either illegal to transfer animals from shelters for laboratory use, or discretionary on the part of the shelter.\(^1\)

In light of the euthanasia of several million unwanted cats and dogs in U.S. shelters annually, it could reasonably be argued that these carcasses be put to educational use in our schools. This is no simple matter, however. The HSUS condones transfer of euthanized animals from shelters to research or educational institutions under only very limited circumstances. First, no transactions of live
animals should occur, and any animal involved must have been euthanized due to either mortal illness or injury, or because no suitable home could be found for the animal within a reasonable time. Second, animal cadavers may be transferred only when the animal's former owner has been informed of this policy and has given consent. Full public awareness of any animal transfer policy is vital to maintaining public trust in animal shelters. Regardless of owner consent, however, shelters not wishing to supply animal carcasses to institutions should not be compelled to do so.

Third, such transfers should not involve elementary, middle, or high schools. The HSUS opposes the practice of animal dissection in precollege classrooms for numerous reasons. At the college and graduate levels, the need for animal cadavers is obvious in veterinary training, for instance, but the cadavers should come only from euthanized animals and no animal should be raised or killed specifically for use in dissection. Fourth, transfer of animals from animal shelters should not involve the exchange of money. The existence of so-called “surplus” cats is a product of pet overpopulation, a problem needing resolution more than exploitation. Millions of cats are killed yearly in U.S. shelters because there are not enough homes for them all. When there is money to be made in dealing in their carcasses, there may be less incentive to address overpopulation. There is also the perception that the shelter would rather gain from this tragedy than invest their monetary resources toward resolving it.

**Farmed Animals**

Animals raised and killed in the meat industry are another source of dissection materials. Parts of animals, such as sheep brains and cow eyes, are sometimes used. Fetal pigs, removed from pregnant sows following slaughter, have become one of the most commonly used animals for school dissections. Viewed as by-products of the meat industry, these late-term fetuses have been called “the perfect specimen” (Nebraska Scientific n.d.). Nebraska Scientific alone processes more than 300,000 fetal pigs per year (ibid.), and annual school use of fetal pigs is estimated at half a million, though there are signs that declining availability may force this number down (Lewis 1999). Many teachers also use chicken wings and other animal parts that can be bought at local grocery stores (personal communications at science teacher conventions).

Certainly, the notion of using animals (or parts of animals) who are already dead and whose alternate destination may be an incinerator or rendering plant may seem sensible. As Nebraska Scientific (n.d.) points out in its brochure promoting the fetal pig as a dissection specimen: “The fetal pig was never born; it did not ‘die’ for dissection purposes. For those concerned about the use of live animals in scientific study, these fetal pigs are a viable alternative.”

However, there are serious humane concerns with this source of animals. The conditions in which a majority of animals raised for human consumption live on factory farms today have been widely criticized as inhumane (Mason and Singer 1990; Rifkin 1992). Conditions of transport from farm to slaughterhouse are routinely bad, causing significant numbers of animals to die in transit. Of 200,000 pigs deemed unfit for human consumption in the United States in 1994, 74,000 died during transport (Marbury 1994). And in the abattoir itself, an in-depth investigation by Eisnitz (1998)
documented routine abuse and some instances of sadistic cruelty.

When a school purchases fetal pigs from a biological supply company, or a teacher buys some chicken wings from the supermarket, the meat and slaughter industries profit from it. Should schools be helping to perpetuate the problems in the raising of animals for meat? Many of the students who conscientiously object to dissection do so on humane grounds. Many are vegetarians. Participation in the dissection of animals that come from the meat industry is not an acceptable option for them.

**Fur-Bearing Animals**

Classroom dissection of animals from fur farms, while less common, is no less problematic from a humane standpoint. Skinned mink, fox, and rabbit carcasses are available from biological supply company catalogs and the source is identified alongside them. The methods of trapping and killing wild animals for their pelts and methods of raising fur-bearing animals in captivity are inhumane (McKenna 1998). When schools buy these carcasses from supply companies, they provide income for the fur industry. Even if one feels that using these animals is morally acceptable, many students would not do so if they were fully aware of the conditions under which the animals were raised and killed. Many teachers are not aware of the relevant facts, so these issues are not usually discussed in the classroom.

Not only may animals destined for dissection suffer prior to death, their death in itself is harmful (Gilmore 1991a). Killing sentient beings involves a moral cost that needs to be addressed (Regan 1983; Cavalieri and Singer 1993).

### 4.4 Ecological Concerns

In this era of heightened environmental awareness, it is hard to find anyone who would openly disparage environmental protection and stewardship. Animal dissection runs counter to the aims of environmental protection by exploiting already vulnerable wild animal populations and by using hazardous chemicals.

**Frogs**

The frogs used for dissection in North American schools are almost always taken from the wild. At the time of their 1971 article on the supply of leopard frogs (*Rana pipiens*) and bullfrogs (*Rana catesbeiana*) for education and research, Gibbs et al. (1971) reported that U.S. suppliers were shipping approximately 9 million frogs (326.5 metric tons) annually for educational and research purposes alone. All of these frogs were being taken from the wild. The authors reported that frog populations had declined an estimated 50 percent in the prior decade, and concluded that “though frog-catching is probably not the major cause of the drop in the frog population, its influence certainly cannot be considered negligible.”(1028)

Declines in frog populations have apparently worsened since then, making these animals something of a cause celebre of global environmental concern (Phillips 1994; Blaustein and Wake 1995). While some frog populations continue to thrive, many are declining and some have recently gone extinct. Numerous factors are thought to be contributing to the demise of certain frog populations, including habi-
tat destruction, ultraviolet rays breaking through a dwindling ozone layer, fungal disease, air and water pollution, and human consumption (Blaustein and Wake 1995).

Theoretical arguments that frog populations can sustain themselves in the face of heavy human predation have proven false (Phillips 1994). Because frogs play such key roles in their ecosystems both as predators and prey, the detrimental effects of their overexploitation extend through the ecosystem. The taking of frogs from the wild for the frog leg trade was banned in India in 1987 in part because their declines were considered to be contributing to surging insect populations (Jayaraman 1987).

Along with dusky leopard frogs (*Rana berlandieri*), leopard frogs and bullfrogs are the most commonly used species in American schools, and both are in decline. According to Emmons (1980), Nasco’s collection of leopard frogs exceeded 30 tons in an average year prior to 1972 but dropped to only five tons in 1972 due to declining availability. Well-documented declines of these two species have been reported in both U.S. and Canadian populations (Hine et al. 1981; Vogt 1981; Kingsmill 1990; Klassan 1991), and Souder (1998) reports that the leopard frog may have disappeared completely from British Columbia. Collection for educational uses has been cited as contributing to bullfrog declines in both Canada (Kingsmill 1990) and the United States (Vogt 1981). Vogt (1981) points to the long time needed by bullfrogs to attain sexual maturity as hastening their declines and recommends a ban on all commercial collecting of the species.

Orlans (1993) estimated that 3 million frogs are dissected in U.S. high school classrooms each year. Additional frogs are used in postsecondary as well as middle school dissections. Efforts to turn the tide for frogs should involve both curbing human exploitation of wild populations and fostering appreciation and respect for their kind. Classroom frog dissection undermines the pursuit of these goals.

**Sharks**

The spiny dogfish shark (*Squalus acanthias*) is a small shark species (an individual weighing over five pounds is considered large) with populations off both the Atlantic and Pacific coasts of the United States. Exploitation for human consumption has gone up markedly in recent years, with average yearly landings of about 6,200 metric tons from 1977 to 1989, rising to 19,300 and 22,600 metric tons (about 20 million individuals) in 1992 and 1993, respectively (Rago 1994). *S. acanthias* is particularly vulnerable to exploitation because of its slow reproduction. The age at which females attain sexual maturity is higher than that of humans, and may be as old as twenty years (about eleven years for males). Gestation is also prolonged (two years), with litters ranging from two to fifteen pups.

Given the long period it takes for this species to mature, there would be an expected lag of a decade or more before population declines would be reflected in catch rates. Yet, the Ocean Wildlife Campaign, a consortium of environmental groups including the Natural Resources Defense Council, World Wildlife Fund, the National Coalition for Marine Conservation, and others, believes there is already sufficient fisheries data to demonstrate that the Atlantic population of *S. acanthias* is being threatened by overfishing (Wilmot et al. 1996). The National Marine Fisheries Service considers this species “fully exploited” (Rivlin 1996). Because the species is notably vulnerable, the Ocean Wildlife Campaign recom-
mended in 1996 that the U.S. Fish and Wildlife Service list *S. acanthias* as threatened under the U.S. Endangered Species Act.

Notwithstanding its ecological plight, *S. acanthias* has been and remains a popular species for school dissections. Biological supply companies pay fishermen for the dogfish sharks the companies market to schools for dissection (Robinson 1996). At least seven major U.S. biological supply companies sell *S. acanthias*. Bob Iveson (personal communication, 25 October, 1999), a scientist with WARD’S Biological, estimates the total number of these fish sold for dissection each year to be 100,000. Notwithstanding other arguments against animal dissection in schools, the tenuous ecological status of *S. acanthias* alone ought to discourage biology teachers from ordering this species in future.

### 4.5 Formaldehyde Exposure

Classroom dissection of preserved animals almost invariably involves a degree of exposure to formaldehyde. Used to embalm and preserve the dissected specimens, formaldehyde presents both immediate and potential long-term threats to the health of those participating in dissections. Formaldehyde (or formalin) is classified as a “toxic and hazardous substance” by the United States Occupational Safety and Health Administration (OSHA).

Formaldehyde is irritating to the upper respiratory tract and eyes. Concentrations of 25 to 30 parts per million (ppm) cause severe respiratory tract injury, and a concentration of 100 ppm is immediately dangerous to life and health. Deaths from accidental exposure to high concentrations of formaldehyde have been reported (OSHA n.d.). High concentrations can also cause permanent vision impairment if splashed on the eye, and prolonged exposure may result in respiratory impairment. Both OSHA and the American Conference of Government Industrial Hygienist standards place the human safety limit of formaldehyde at 1 part per million (ppm) (Young 1984). One part per million (ppm) is also the odor threshold for most people, so if one is using formaldehyde and can smell it, then its concentration exceeds the acceptable level prescribed by these standards (Young 1984).

No student who has ever dissected animals forgets the pungent odor of formaldehyde that accompanies the exercise. OSHA officials have acknowledged that use of formaldehyde as a tissue preservative for school dissections presents a health hazard and warrants the wearing of protective clothing, including gloves and goggles. A May 16, 1990, letter from then Assistant Secretary of Labor Gerard F. Scannell to the Association of American Medical Colleges states, in part: “In addition to the inhalation hazard, solutions of formaldehyde (such as the formalin used as a tissue preservative) can damage skin and eye tissue immediately upon contact. For this reason the standard requires effective protective equipment to prevent skin and eye contact, as well as eye-washes and showers if there is the possibility of splashes to eyes and body” (OSHA Web site www.osha.gov/).

Despite OSHA’s concern about formaldehyde’s hazards, students who dissect animals at schools are provided with little or no protection, and enforcement of OSHA standards is rare. One exception was Mt. Saint Mary College, New York, which was recently fined.
$20,000 for various violations of OSHA standards, including exposing employees to formaldehyde and infectious substances (Blumenstyk 1996).

4.6 Defenders of Dissection

In response to growing criticism of dissection and vivisection in education, several articles have appeared explicitly defending these practices.

Schrock (1990)
The main thrust of Schrock’s argument for dissection, and the basis for his disdain for alternatives, is that only the former provides the learner with “real material” and “real experience” (Schrock 1990). Schrock points out, correctly, that no model is complete, and that no simulation can replicate an actual organ or organism. Also, he adds, media such as pictures, models, and computer simulations fail to provide the full sensory experience—sound, taste, smell, and touch—that dissection provides (ibid.). For Schrock, dissection is “the only way to provide meaning to communications about anatomy, physiology, and health” (ibid., 15).

Schrock laments “the abysmal level of anatomical/medical understanding among American citizenry,” and calls for a doubling of time spent in anatomy labs to correct it. But there is no evidence that such understanding parallels the amount of time spent dissecting animals. In Sweden and Norway, for example, where dissection is almost nonexistent in the high school biology curriculum, students have attained significantly higher scores in scientific literacy tests (Gibbs and Fox 1999) than in America, where dissection is widespread. There is also no evidence that dissection is the only way to gain such understanding. To the contrary, studies of dissection alternatives find them to be at least as effective for imparting anatomical/medical knowledge (section 4.7).

The importance Schrock places on “real” experiences can also be rebutted. The “realness” of most preserved animal specimens is reduced by a number of factors related to death, embalming, and shipping in tightly packed containers. Simulations provide some level of realness (Schrock acknowledges this). Most importantly, Schrock provides no compelling case that realness is the measure of a learning tool’s effectiveness. Throughout science education, and education in other disciplines, we learn by using representations, symbols, and abstractions. Students learn about genes in genetics labs, atomic structures in organic chemistry, Cladism in systematics, and—to use one of Schrock’s examples—hydrostatic cells without ever seeing any of them in concrete form.

This is not to scoff at real experience. It is, of course, invaluable, and indispensable in many cases (e.g., surgical training—see section 5.4). But ultimately, Schrock’s appeal to realness is moot, for the principal objection to animal dissection is the harm inflicted on the animal during procurement (section 4.3), and not that the animal is real. Indeed, The HSUS and other animal protection organizations encourage the judicious and humane use of living animals in education. In a study by Bauhardt (1990) and reviewed by Killermann (1998), a group of 125 sixth grade students who
studied living invertebrates by handling them and not harming them showed significantly greater improvement in knowledge, attitude, and interest levels than did a group of 118 students who used preserved specimens and supplementary materials. Where real experience with animal tissues and organs is necessary, then ethical sources of animals can and should be found (see “ethical dissection,” section 4.7).

Perhaps most revealing in Schrock’s argument against alternatives to dissection is his reference to “Lysenkoism,” which he believes is analogous to philosophical objections to harming animals for education. Trofim Lysenko was a Russian scientist who rose to prominence during the Stalin era because his notions of inheritance appealed more to communist ideals than did Darwinian evolutionary principles. As a result, Russian scientists who championed reality-based Western genetics were banned from research, and Lysenko’s dogma cost Russia thirty years of progress in genetic research (Medvedev 1971). Schrock believes that replacement of animal dissections with computer simulations and other alternatives represents a similar abandonment of real science “to make our ‘science’ match with popular or expedient social and political views” (Schrock 1990, 13).

The underlying assumption of Schrock’s Lysenkoism theory is that alternatives to dissection are being adopted in response to pressures from the animal protection sector. He provides no evidence for this tenuous notion, nor does he acknowledge the cost savings and the strong educational performance achieved by many simulations, which seem more likely causes for their adoption than ideological pressure.

Pancoast (1991)
In an article published in Teacher Magazine, Pancoast (1991) offers several defenses for the use of animal dissection in the classroom. She alludes to the billions of animals killed for meat in the United States (approximately eight billion per year) and notes that the use of animals for research and education constitutes only about 0.3 percent (24 million) of animal consumption. Without stating it outright, Pancoast tries to convince readers that they need not be concerned about some twenty-four million animals because eight billion is such a greater number. If this logic were sound, then we would not try to prevent airline crashes because car accident rates are far higher. It is also tantamount to claiming that a 6'1" professional basketball player is short, because most other professional players are taller. Pancoast is not the only writer to use this argument (e.g., Hamm and Blum 1992).

Pancoast also tries to justify animal dissection by pointing out that fifty-four of seventy-six Nobel Prizes (71 percent) in medicine and physiology in this century were based on animal research. Even if animal use has played a vital role in breakthrough research, it is a considerable leap of faith to claim that its completion hinged on whether or not students dissected animals in high school class. Pancoast’s Nobel figure is contestable; Stephens’s (1987) analysis of Nobel Prizes determined that alternative methods played a key role in the research of fifty of the seventy-six (66 percent) laureates. Clearly there is subjectivity in estimating the role of animal experimentation in prize-winning research.

Pancoast is even more adamant that students not choosing careers in the life sciences should get exposure to animal dissection. Without any supporting data, she views the exercise as unforgettable, and that it may be these students’ only
chance to appreciate the complexity and intricacy of living creatures. There are two assumptions here: (1) that dissection is the only way to appreciate the complexity of the living organism and (2) that dissection invariably provides such an appreciation. Both assumptions are false.

Dissection is only one way that a willing student might be able to appreciate the complexity and intricacy of living animals. There are many others. The complexity that Pancoast refers to can only be the gross structural complexity of body systems, organs, and some tissues. One is not able to observe or appreciate either behavioral complexity or fine structural complexity from a dead, preserved animal. By comparison, computer simulations allow students to view many levels of complexity unavailable to the dissector. The CD-ROMs on the human body produced by ADAM (Animated Dissection of Anatomy for Medicine) software, for example, show not only gross structural anatomy in high detail, but also contain histology images, animations, and video clips of body processes unobservable during gross dissection of a living or dead organism. (For a more detailed discussion of dissection alternatives, see section 4.7).

Although some students may dissect a dozen different animal species during their biology schooling, they may not be struck by the complexity of the anatomy they observe. The bodies of preserved animals are often misshapen as a result of packing, the internal organs—through which living fluids have long since stopped flowing—tend toward a monochromatic gray cast, and the depth of study is almost invariably superficial, with attention given only to gross anatomy of the dissected specimen. Nevertheless, Pancoast may be right that dissection is unforgettable, but perhaps not for the reasons she hopes. When Shapiro (1992) asked Maine legislators what they recalled of their encounters with high school dissection, they tended to have vivid recollections only of the more visceral aspects of the exercise: the pungent smells and the ambivalence they felt about slicing into the bodies of once-living animals with scalpels and scissors. Solot (1995) made a similar observation from her qualitative study of dissection at a Rhode Island high school, noting that striking visual images of the exercise seemed to be more indelible than the anatomical relationships that formed the academic basis for the lesson.

Holden (1990)

Holden (1990), writing for the journal Science, likens efforts to make dissection optional for students to the efforts of religious fundamentalists to stifle the teaching of evolution. This is a weak analogy. Dissection opponents are unhappy with a particular method of teaching biology and are not interested in doing away with the study of life-science itself; creationists oppose the very subject of evolution regardless of how taught. While there is nothing unscientific about learning with computer technology, 3-D models, or videotape (or indeed, by studying animals noninvasively), the same cannot be said of the scientifically untestable notion of a divine creator (Mayr 1982). A substantial and growing body of published scientific literature shows that so-called alternatives are competitive with dissection for teaching life science; the same does not apply to replacing evolution with creationism, because it is not a parallel pursuit. Finally, while objections to evolution are based on such nebulous concepts as faith and soul—neither of which is accessi-
ble to scientific inquiry—objections to dissection rest on the very real issues of animal pain and suffering, and human and nonhuman violence (see chapter 3).

**Hamm and Blum (1992)**

Hamm and Blum (1992), of Stanford University Medical School’s Department of Comparative Medicine, make the common error of exempting dissection from regulatory concern because of the mistaken belief that it does not involve animal pain or distress (see also Marquardt 1993). As already discussed, animal dissection involves a great deal of animal pain and distress; it occurs usually before the animals reach the facility where they are dissected. The authors also point out that there are worse fates for animals consumed for other uses than for those harmed for education, where they are “generally handled with far greater solicitude and care.” Evidence from the biological supply trade suggests otherwise, but in any event, ethical conduct requires that we strive to avoid causing animal pain and distress, regardless of degree. Hamm and Blum (1992) do recommend that discussion of ethical and moral considerations for using animals in education be carefully integrated into every student’s course of study.

**Biological Variation**

The value of animal dissection as a way of demonstrating biological variation is frequently noted in support of dissection and as a way to devalue computer simulations, which tend to show only a single idealized specimen (Berman 1984; Morrison 1992). Biological variation could, of course, be illustrated using video, photographic, and/or computer-based learning materials. However, even in the absence of such resources, the students in a biology class present a ready source of interindividual biological variation, and there are numerous noninvasive ways to study and appreciate this variation (e.g., Orlans 1977; Russell 1978). Plants are another readily available source of subject material to study intraspecies variation (e.g., Dalby 1970; Keown 1994). Finally, it is not clear that dissection classes do, in fact, commonly use the specimens to demonstrate variation.

**Other Arguments**

Some writers have resorted to trivial arguments to try to justify harming animals for an education exercise. In an article titled “The Importance of Animal Dissection,” Lord (1990) asks: “Why does not the dissection of a flower or seed arouse the same sympathies in dissection opponents as the dissection of a frog or rabbit?”

In implying that animal dissection is the moral equivalent of plant dissection, Lord disregards the moral import of an organism’s having a nervous system and being able to experience pain and distress.

Howard (1993) goes so far as to claim that those who breed animals to kill them are promoting the interests of the animals: “None of these [dissected] animals would be born if not wanted, and they have a quality life and die humanely rather than live nature’s torturous life. From the standpoint of a quality life, the need for this resource produces an improvement of life for some individuals of these species.”

Howard is fond of the Victorian notion that nature is “red in tooth and claw,” that “carnage pervades the natural world” (McInerney 1993), and that suffering
is the wild creature’s lot. He has used it to defend a diversity of human exploita-
tions of animals (Howard 1990; Balcombe 1994). It is the same flawed logic of 
Pancoast (1991) and Hamm and Blum (1992) that one type of harm done to ani-
mals is acceptable because there are worse and greater harms that befall them. 

It appears as though there is a common misconception among dissection propo-
nents such as Howard (1993) and Hamm and Blum (1992) that most animals used 
for classroom dissections are raised in the laboratory. When Lord (1990) discusses 
the “four major ways” that supply houses procure dissection specimens, the capture 
of individuals from wild populations—the most common method of procurement 
and probably the most troublesome from a humane standpoint—is not even among 
them.

4.7 Alternatives to Dissection

The educational aim of dissection is primarily to impart knowledge on the 
anatomy and physiology of either the species of animal being dissected or 
animals (including humans) in general. Berman (1984) lists a number of 
other aims of animal dissection exercises, including understanding relationships 
between animals of different species, grasping the concept of individual variation, 
understanding the relationship of structure to function, gaining insight into the 
relationship between an organism and its environment, and teaching respect for 
life. Wheeler (1993) argues that dissection is a worthwhile skill in itself, and that 
the difficulty in performing dissections well helps to teach students that there are 
practical difficulties and limitations in the pursuit of scientific knowledge. Wheel-
er adds that dissection exposes students to a method that has played an important 
historical role in the acquisition of biological knowledge, and that it provides a 
concrete, nonabstract personal experience.

Dissecting animals has potential for imparting all of the above educational benefits 
to certain students, even teaching respect for life (see “ethical dissection,” below). 
However, if we are going to continue to include anatomy as a mainstay of basic biolo-
gy education, a key “value” question is not whether or not dissection can achieve these 
aims, but rather whether there are other methods—methods that do not carry the 
moral burden of destroying animal life—that can satisfy them as well or better. If there 
are, then moral concern should dictate that animal dissection be replaced in schools. 

There has been, in the past twenty years, a spectacular proliferation of new 
learning materials that can be used in place of animal dissection. These dissection 
alternatives are dominated by computer-based programs. A sampling of popular 
programs currently being used in the United States includes:

- ScienceWorks: DissectionWorks (earthworm, crayfish, fish, frog, pig, cat)
- Pierian Spring Software: BioLab series (pig, frog, invertebrate [earthworm, 
crayfish, sea star], fly [genetics])
- Tangent Scientific: DryLab series (frog, crayfish, perch, rat, fetal pig, earth-
worm)
- Digital Frog International: Digital Frog, Digital Frog 2
- NeoTek: CatLab
- Animated Dissection of Anatomy for Medicine: (ADAM) several programs,
including a series of five physiology modules.

Whereas all computer programs up to the early 1990s were stored on diskettes (or occasionally on videodiscs), practically all (including all of those listed above) are now available as CD-ROMs. Some of these programs simulate the actual step-by-step performance of a dissection, with the user making “cuts” along the specimen with the mouse-controlled cursor. Many of these programs also provide a variety of other information to supplement and enhance the lesson. Animated sections may comprise actual film or artists’ renderings of functioning systems at the organ, tissue, cellular, or molecular level. At least one program (3-D Body Adventure, by Knowledge Adventure) displays “fly-throughs” of the skeletal and circulatory systems of the human, in which the viewer tours these systems in three-dimensional space as if piloting a miniature airplane. On-line self-evaluation modules—some of which are randomly generated—are also available on many of these programs, allowing the user to evaluate his/her knowledge level and chart his/her learning progress.

Three-dimensional models, usually made of hard or soft plastic, provide tactile, textural, and spatial experiences not currently available with computer programs. Frogs are the most commonly modeled species, but fetal pigs, cats, sharks, rats, starfish, chickens, perch, and locusts are among the others. The human body is represented by an enormous range of sophisticated and life-size models. Denoyer-Geppert, a Chicago-based company, is notable for its range of hand-painted plastic models of the human. A recently developed process called “plastination,” in which a deceased animal’s tissues are chemically replaced by plastic, allows preservation of minute detail in gross anatomical features and produces a durable model for repeated use. Ohio State University is one of several universities that have begun to plastinate animal carcasses and to use them in their courses (Richard Tallman, personal communication, 1998).

Videotapes and charts provide moving and stationary images of animal dissections. The Cat Anatomy Instructional Videotape Series, contained on eight separate videotapes and distributed by Miron BioSystems, features an exhaustive, several-hour-long survey of cat anatomy. Other species available on videotape include the frog, fetal pig, crayfish, earthworm, perch, starfish, clam, and grasshopper. By using freshly killed animals, the Vertebrate Dissection Guides video series (rat, pigeon, frog, shark), produced in the United Kingdom, and the BioCam charts (pig, rat, frog, earthworm, crayfish, clam, perch, starfish, grasshopper, and pig heart/sheep brain) provide especially detailed and true-to-life images.

Not surprisingly, the advent of alternatives in education has been accompanied by studies to assess their effectiveness as learning tools. The general approach of these studies has been to compare them to traditional, animal-based methods, and to date, there are close to thirty such studies published in the scientific literature. Table 4.1 provides an annotated list of these studies.
### Table 4.1

**Published Studies Comparing the Performance of Alternatives with Traditional Animal-Based Learning Methods in Life Science Education**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Subjects</th>
<th>Principal Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen and Block</td>
<td>10 U.S. undergraduates</td>
<td>Students who studied feral pigeons in a city park scored equally well on evaluations as did students who studied operant conditioning with rats in a traditional lab.</td>
</tr>
<tr>
<td>Dewhurst and Meehan</td>
<td>65 U.K. undergraduates</td>
<td>Students using computer simulations performed equally well as students using traditional approaches in physiology and pharmacology laboratories.</td>
</tr>
<tr>
<td>Dewhurst et al. 1994</td>
<td>14 second-year U.K. undergraduates</td>
<td>Six students working independently with a computer program gained equal knowledge, at one-fifth the cost, to eight supervised students using freshly killed rats.</td>
</tr>
<tr>
<td>Downie and Meadows</td>
<td>2,913 first-year U.K. biology undergraduates</td>
<td>Cumulative examination results of 308 students who studied model rats were the same as those of 2,605 students who performed rat dissections.</td>
</tr>
<tr>
<td>Guy and Frisby</td>
<td>473 U.S. prenursing and premed students</td>
<td>Performance of students using interactive videodiscs was not significantly different from that of students in traditional cadaver-demonstration labs.</td>
</tr>
<tr>
<td>Jones et al. 1978</td>
<td>100 freshman U.S. medical students</td>
<td>Learning performances of students using films, computer-assisted instruction, and prosected human cadavers were the same as those of students taught by traditional lecture and dissection.</td>
</tr>
<tr>
<td>Kinzie et al. 1993</td>
<td>61 U.S. high school students</td>
<td>Findings suggest that an interactive videodisc was at least as effective as dissection in promoting student learning of frog anatomy and dissection procedures.</td>
</tr>
<tr>
<td>Leathard and Dewhurst</td>
<td>105 U.K. preclinical medical students</td>
<td>No significant difference was found in the performances of students who used a traditional live-animal laboratory and those who used a computer simulation on intestinal motility.</td>
</tr>
<tr>
<td>Leonard 1992</td>
<td>142 introductory U.S. biology undergraduates</td>
<td>In the use of videodisc or traditional laboratories, no significant difference was found for students’ laboratory grades. However, the videodisc group required one-half the time.</td>
</tr>
<tr>
<td>Lieb 1985</td>
<td>23 U.S. high school students</td>
<td>Posttest scores were equivalent for students who dissected earthworms and those who received a classroom lecture on earthworm anatomy.</td>
</tr>
<tr>
<td>Prentice et al. 1977</td>
<td>16 U.S. physician’s assistant students</td>
<td>Based on student learning performances, the authors concluded that use of labeled sequential slides of anatomical dissections provided a viable alternative to dissection.</td>
</tr>
<tr>
<td>Strauss and Kinzie</td>
<td>20 U.S. high school students</td>
<td>Two groups of high school students performed equally on a test following either animal dissection or interactive videodisc simulation.</td>
</tr>
<tr>
<td>Authors</td>
<td>Study Subjects</td>
<td>Principal Findings</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Dewhurst and Jenkinson 1995 | 20 U.K. undergraduate teaching institutions          | Use of computer packages saved teaching staff time, were less expensive, were an effective and enjoyable mode of student learning, and significantly reduced animal use.  
| Fowler and Brosius 1968     | 456 U.S. high school students                        | Students who watched films of animal dissections (earthworm, crayfish, frog, perch) demonstrated greater factual knowledge of these animals than did students who performed dissections on them.  
| Henman and Leach 1983      | U.K. undergraduate pharmacology students             | Students using biovideograph performed significantly better on post-laboratory tests than those participating in the organ-based laboratories.  
| Huang and Aloi 1991        | 150 introductory U.S. biology undergraduates         | Students using a computer-assisted interactive videodisc system that included dissection simulations performed significantly better than students who had not used the computer-aided instruction.  
| Lilienfield and Broering 1994 | 252 U.S. medical and graduate students               | Students who used computer simulation achieved a significantly higher grade in the cardiovascular section of the final exam than their classmates.  
| McCollum 1987             | 350 U.S. high school biology students                | Approximately 175 students taught frog structure, function, and adaptation via lecture performed better on a posttest than did approximately 175 students taught by doing a frog dissection.  
| More and Ralph 1992        | 184 U.S. biology undergraduates                      | Biology knowledge of about 92 students using computer courseware increased more than did that of approximately 92 students using traditional animal-based laboratories.  
| Phelps et al. 1992         | Undergraduate U.S. nursing students                  | Students who studied using an interactive video program on cardiac output principles performed better on a posttest than did students taught by lecture and live-animal physiology laboratory.  
| Samsel et al. 1994         | 110 U.S. medical students                            | Students used both computer demonstrations and animal (dog) demonstrations, and rated the former higher for learning cardiovascular physiology.  
| Matthews 1998a             | 20 U.S. biology undergraduates                       | Eight students who dissected fetal pigs scored significantly higher on an oral test with prossected fetal pigs than did twelve students who studied on a computerized pig (MacPig).  

\(^{a}\) Excluding veterinary schools (see table 5.2).  
\(^{b}\) equivalent performance  
\(^{c}\) statistical significance favoring alternatives  
\(^{d}\) statistical significance favoring traditional method
Studies comparing animal labs and nonanimal alternatives have found that both high school students (Lieb 1985; McCollum 1987; Kinzie et al. 1993; Strauss and Kinzie 1994) and college students (Leonard 1992; More and Ralph 1992; Phelps et al. 1992; Dewhurst and Meehan 1993; Dewhurst et al. 1994; Downie and Meadows 1995) learn just as well using alternatives as they do using traditional animal-consumptive methods. Similar results have been found for training in veterinary medicine (Fawver et al. 1990; Johnson et al. 1990; White et al. 1992; Holmberg et al. 1993; Greenfield et al. 1995), medicine (Jones et al, 1978; Lilienfield and Boering 1994; Samsel et al. 1994; Leathard and Dewhurst 1995); prenursing and premedicine (Guy and Frisby 1992), pharmacology (Hennman and Leach 1983), and physician assistant (Prentice et al. 1977). Several of the above studies showed statistical significance favoring alternatives (see table 4.1), while only one favored the animal laboratory.

Several additional studies, while not evaluating student learning performance directly, have nonetheless reported student preferences and time and cost savings for alternatives to traditional animal labs. In their study of 82 U.S. veterinary students, Erickson and Clegg (1993) found that students rated computer-based active learning the highest of fourteen learning methods for basic cardiac teaching and electrocardiograph interpretation. Use of computer packages by 20 British teaching institutions saved teaching staff time and money, were an effective and enjoyable mode of student learning, and significantly reduced animal use (Dewhurst and Jenkinson 1995). In a study involving 110 U.S. medical students who used both computer demonstrations and animal (dog) demonstrations, the students rated the former higher than the latter for learning cardiovascular physiology (Samsel et al. 1994).

A study by Pavletic et al. (1994) compared surgical abilities of 12 graduates from the Tufts University veterinary class of 1990 who had participated in an alternative small-animal medical and surgical procedures course with 36 of their counterparts. The subjects were rated for surgical competency by their employers at the time of their hiring and again twelve months later. No significant differences were found on either occasion for any of the measures, which included ability to perform common surgical, medical, and diagnostic procedures; attitudes toward performing orthopedic or soft tissue surgery; confidence in performing procedures; or ability to perform procedures without assistance.

These studies are far from flawless, and they do not cover the extensive range of alternatives applications now available for educational use. But collectively they provide a strong case that alternative learning methods are as effective pedagogically as are traditional methods that use animals, and they suggest that alternatives are in a number of ways better than animal-based exercises (Balcombe 1997b; Pope 1997).

The only study published to date that found a significantly higher performance from students (college undergraduates) using animal dissections over those using an alternative was reported by Matthews (1998a) (see table 4.1). However, the dissection alternative used in this study (the computer program MacPig) is too rudimentary for college-level biology classes (Balcombe 1998), despite apparent manufacturer’s claims to the contrary (Matthews 1999b). As such, it is not surprising that students using the computer program, who had not had any experience with preserved fetal pigs, scored worse (41 percent compared with 82 percent) on the oral exam—which used a preserved fetal pig—than did students who dissected fetal pigs (ibid.). The computer-using
students scored higher than the dissecting students on the computer quiz (75 percent compared with 66 percent), though the difference was not statistically significant.

### Computer-Assisted Learning

Today most alternatives to dissection are computer-based, and computer-assisted learning (CAL) is assuming an increasingly dominant role in education in general. One of the seven priorities of the U.S. Department of Education is that “every classroom will be connected to the Internet by the year 2000 and all students will be technologically literate” (U.S. Department of Education 1997).

Twenty years ago Kulik et al. (1980) conducted a meta-analysis of 54 published studies of CAL versus traditional teaching in postsecondary classrooms and found that students using CAL performed significantly better (by 3 percent) on examination scores. By 1996 Kulik had analyzed 250 such studies and reported that gains from CAL were generally enough to move an average student in the 50th percentile to the 64th percentile while simultaneously working at a 34 percent faster pace (Beyers 1996). A meta-analysis of 28 studies by Bosco (1986) of Interactive Videodiscs (a technology being rapidly replaced by CD-ROMs) rated their efficacy for learning as favorable overall. The Educational Testing Service recently released a report showing that learning improves when technology is used effectively to engage higher order thinking skills (Wenglinsky 1998).

The reported benefits of CAL in the life sciences include active involvement of students, even in large classes; less time needed to present information and for students to master it (Teyler and Voneida 1992; Dewhurst and Jenkinson 1995); greater cost-effectiveness (e.g., Dewhurst and Jenkinson 1995; Leathard and Dewhurst 1995); and self-paced learning that puts students in control of the learning resource (Nosek et al. 1993; Leathard and Dewhurst 1995; Erickson and Clegg 1993). Faculty members in veterinary medicine and in education at Kansas State University found that CAL increased opportunities for active learning, was less demanding of teacher resources, decreased live-animal use, and improved learner skills in problem solving and information handling. In a survey of eighty-two veterinary students, the subjects rated active learning experiences highest, with the computer labs receiving the highest scores. It should be noted that computer programs need not necessarily rely on static, synthetic data. Not only can random variation be built into the program (Nab 1989), but some programs (e.g., Pankiewicz 1995; Intelitool 1998) also use data from the students’ bodies.

### Cost of Alternatives

Teachers and school administrators often cite the cost of alternatives as a reason for their not being implemented (Balcombe 1997a). In fact, animal dissection is often more expensive. A cost analysis by The HSUS found that for a typical school’s needs, the cost of providing animal specimens for dissection was often greater than the cost of purchasing a range of reusable alternative materials (table 4.2). Depending on numbers needed, the initial cost of computer programs, videotapes, and three-dimensional models may or may not be higher than a shipment of preserved animal specimens, but the alternatives can be used repeatedly, while the specimens must be replaced after a single use. Providing a single class with bullfrogs for dissection
can cost a couple of hundred dollars (Griffith 1991). Recent shortages in the supply of fetal pigs to schools have raised prices to the point that a single fetal pig CD-ROM (featuring on-screen dissection, video clips, and built-in quizzes) may cost less (as low as $18.30 each) than a single fetal pig specimen (up to $23.74) (Lewis 1999). A comparison of costs for an instructor-based versus a computer-based physiology lab found that the live lab cost more than twice the amount (£860 and £320, respectively), without considering the cumulative savings from being able to re-use the computer-based modules in succeeding years (Leathard and Dewhurst 1995).

### Table 4.2
**Costs: Dissection Exercises versus Alternatives to Dissection for Commonly Dissected Animals**

<table>
<thead>
<tr>
<th>Animal</th>
<th>Alternatives</th>
<th>Cost</th>
<th>Dissection</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat</td>
<td>Anatomy model (x 2)</td>
<td>$800</td>
<td>High-cost animal ($48.45 x 135)</td>
<td>$6,541</td>
</tr>
<tr>
<td></td>
<td>Dissection video (39 minutes)</td>
<td>$70</td>
<td>Low-cost animal ($23.75 x 135)</td>
<td>$3,206</td>
</tr>
<tr>
<td></td>
<td>CatWorks (x4)</td>
<td>$360</td>
<td>64-page dissection manual (x30)</td>
<td>$285</td>
</tr>
<tr>
<td></td>
<td>CatLab (CD-ROM) (x 4)</td>
<td>$200</td>
<td>Supplies</td>
<td>$1,500</td>
</tr>
<tr>
<td></td>
<td>64-page dissection manual (x 30)</td>
<td>$285</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VCR</td>
<td>$150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL COST</strong></td>
<td><strong>$1,865</strong></td>
<td><strong>HIGH COST</strong></td>
<td><strong>$8,326</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>LOW COST</strong></td>
<td></td>
<td><strong>$4,991</strong></td>
</tr>
</tbody>
</table>

Alternatives can possibly save between $3,126 and $6,461

<table>
<thead>
<tr>
<th>Animal</th>
<th>Alternatives</th>
<th>Cost</th>
<th>Dissection</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bullfrog</td>
<td>Frog Inside Out video (67 minutes)</td>
<td>$159</td>
<td>High-cost animal ($11.25 x 135)</td>
<td>$1,519</td>
</tr>
<tr>
<td></td>
<td>Pictorial atlas (x 30)</td>
<td>$269</td>
<td>Low-cost animal ($5.97 x 135)</td>
<td>$806</td>
</tr>
<tr>
<td></td>
<td>Great American Bullfrog (x 2)</td>
<td>$1,310</td>
<td>Pictorial atlas (x30)</td>
<td>$269</td>
</tr>
<tr>
<td></td>
<td>The Digital Frog (CD-ROM) (x 4)</td>
<td>$600</td>
<td>Supplies</td>
<td>$1,500</td>
</tr>
<tr>
<td></td>
<td>DissectionWorks (CD-ROM) (x 4)</td>
<td>$240</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BioCam dissection chart (x 30)</td>
<td>$90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VCR</td>
<td>$150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL COST</strong></td>
<td><strong>$2,818</strong></td>
<td><strong>HIGH COST</strong></td>
<td><strong>$3,288</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>LOW COST</strong></td>
<td></td>
<td><strong>$2,575</strong></td>
</tr>
</tbody>
</table>

Alternatives can possibly save $470 and possibly cost $243
Table 4.2 (continued)

Fetal Pig

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Cost</th>
<th>Dissection</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetal pig model (x 2)</td>
<td>$590</td>
<td>High-cost animal ($14.85 x 135)</td>
<td>$2,005</td>
</tr>
<tr>
<td>BioCam dissection chart (x 8)</td>
<td>$90</td>
<td>Low-cost animal ($3.15 x 135)</td>
<td>$425</td>
</tr>
<tr>
<td>DissectionWorks (CD-ROM)(x 8)</td>
<td>$1,600</td>
<td>56-page dissection manual (x 30)</td>
<td>$285</td>
</tr>
<tr>
<td>Fetal pig anatomy (26 minutes)</td>
<td>$70</td>
<td>Supplies</td>
<td>$1,500</td>
</tr>
<tr>
<td>56-page dissection manual (x 30)</td>
<td>$285</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCR</td>
<td>$150</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td><strong>$2,785</strong></td>
<td><strong>HIGH COST</strong></td>
<td><strong>$3,790</strong></td>
</tr>
<tr>
<td><strong>LOW COST</strong></td>
<td><strong>$2,210</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Alternatives can possibly save $1,005 and possibly cost $575

Note: These figures are based on a hypothetical school’s needs for a three-year period. Reusable materials (dissection tools, trays, computer programs, models, charts, etc.) are treated as a one-time purchase. Costs are based on a ratio of two students per animal dissected (45 animals a year, 135 animals over three years). This comparison assumes that the school already has computers and CD-ROM players, but no VCRs. Because dissection manuals are needed for dissection but are also useful stand-alone study guides, they are included under both Alternatives and Dissection headings. Low and high prices of preserved animals were obtained from the Nasco Science 1999 Catalog and the alternatives (1999 prices) were selected from available lists, catalogs, and databases. Numbers of alternative materials were derived based on the assumption that students would not be using all alternatives at one time.

Availability of Alternatives

Alternatives to animal dissection, and relevant information about them, are readily available. They are conspicuously present in the exhibit halls of science teacher conventions, and most manufacturers have Web sites describing their products in some detail. Furthermore, resourceful teachers can gain access to dissection alternatives at little or no cost. There are at least four animal protection organizations in the United States that loan alternatives to dissection for temporary use with no cost to the borrower except return postage. The HSUS Humane Education Loan Program has more than 100 different CD-ROMs, videotapes, 3-D models, and charts for loan. The National Anti–Vivisection Society (NAVS), the American Anti–Vivisection Society (AAVS), and the Ethical Science and Education Coalition (ESEC) each have similar loan programs. Internationally, the European Network of Individuals and Campaigns for Humane Education (EuroNICHE) operates an alternatives loan program, as does the Australian office of Humane Society International. Both The HSUS and AAVS have recently launched programs that actually donate CD-ROMs to schools with a demonstrable commitment to using them. The manufacturers of many of these materials have “product preview” policies, allow-
ing the prospective buyer to order and try them out for a few weeks, with the option of returning them to the company at no cost.

There are several databases accessible through the Internet that provide descriptions, prices, and ordering information for thousands of alternative learning materials. Two excellent databases that focus specifically on alternatives in education are:

- NORINA (Norwegian Inventory of Audio-Visuals): [http://oslovet.veths.no/NORINA/search.html]
- AVAR (Association of Veterinarians for Animal Rights): [http://AVAR.org]

Collectively, these two databases contain information on close to five thousand alternatives, and they allow searching by scientific discipline, learning level, type of material being sought (e.g., videotape, computer simulation, 3-D model), and others. There are also two printed compendia of alternatives to animal use in education, EuroNICHE’s *From Guinea Pig to Computer Mouse: Alternative Methods for a Humane Education* (Zinko et al. 1997), and ESEC’s *Beyond Dissection: Innovative Tools for Biology Education* (Larson 1998).

In the face of available, cost-effective alternatives that measure up well against animal dissection, the persistence of dissection in the school curriculum is a curious phenomenon. A possible reason could be the cultural transmission of traditional learning methods, wherein a teacher simply uses the approaches with which he/she was taught. Another is that there is currently a lack of resources and materials to teach teachers to be comfortable with new computer-based technologies (Sampson 1998).

### Ethical Dissection

Animal dissection could be acceptable if the specimen is procured ethically. It is the deliberate harm inflicted on so many animals to make dissection available to students and the usual lack of any ethical context for the exercise that warrant criticism. Creative, concerned teachers can give their students experience with dissection and/or close contact with living anatomy without compromising a desire to do no harm to animals.

Ordering preserved animal specimens from biological supply houses will not usually suffice. When teachers ask representatives of biological supply companies about the source of the animals sold for dissection, they are apt to get blanket reassurances that the animals are handled legally and humanely. Teachers should not accept this, as the evidence from closer scrutiny of these operations indicates that there are significant costs in environmental harm and animal suffering (see section 4.3). Teachers should demand specific source information, with supporting evidence. By doing this, suppliers are made aware that teachers care about the humane and ethical aspects of procurement, and it may encourage supply companies to improve their record-keeping and record-sharing practices.

But even if the company can provide evidence that its animals are procured in legal and humane ways, that may not mean that the source is ethical. Instead of purchasing animals of unknown origin from biological supply companies, using animals who have died of natural causes is a preferred option (Morton 1987), provided sanitary sources can be found. An example is depicted on a video on alternatives in education by EuroNICHE (*Alternatives in Education* 1999), which documents Norwegian veterinary student Siri Martinson driving to a nearby farm to collect a sheep who died of natural causes, then returning to the lab to conduct...
a detailed anatomical study of the animal. In the United States, one teacher video-
taped her veterinarian’s necropsy of a horse who had died unexpectedly and now
uses this resource with students (Mayer and Hinton 1990). The use of compa-

dion animals who had died of natural causes resolved a dispute that arose at the
University of Pennsylvania school of veterinary medicine in the mid-eighties
when two students refused on moral grounds to participate in labs that harmed
healthy animals (Shapiro 1987).

More could be done to secure deceased companion animals as an ethical source
of dissection specimens. Approximately ten to fifteen million companion animals
are euthanized at shelters and veterinary hospitals every year (Patronek and
Rowan 1995). While the cadavers of some of these animals are cremated or buried
at the owners’ request, the majority are turned over to renderers or disposed of in
large-scale cremation. Similarly, at least tens of thousands of injured wild animals
die at veterinary clinics and wildlife rehabilitation centers each year. These ani-
mals might be made available, with appropriate disease control safeguards, to
schools. In all cases, students would be informed of the origins of the animals so
that they understand that the animal was procured in a caring, ethical manner.

Taking one’s students to observe surgeries at a local veterinary clinic is
another option (Balcombe 1997b). While this arrangement places limits on the
number of observers at any given time and would not normally allow students
to make physical contact with the animal, it has the advantage over dissection
that the animal is living, that the anatomy is fresh and in full color, not preserved,
and that the procedure is being done in the interests of the animal. It is also
increasingly possible to take one’s students to a hospital to observe live operations
in progress from an overhead observation gallery, which may also feature video
monitors. Similar galleries are used at some veterinary schools, such as the Uni-

versity of Florida, where students observe equine surgeries (Gretchen Yost, per-
sonal communication, August 1999).

Finally, human cadavers offer yet another ethical source of a dissection speci-
emen. Human cadavers are made available through consent of the individual in life.
While typically expensive, human cadavers play an important role in nursing and
medical education, and they have been used effectively in a variety of undergrad-
uate disciplines (Peterson 1993) as well as in high schools (Wharton 1996).

Outdoor Study of Animals
As an alternative to dissection, outdoor study provides limitless opportunities for
on-the-spot, hands-on learning (Heintzelman 1983; Russell 1987; Hancock 1991;
Harding 1992), and living organisms—particularly invertebrates—can be studied
noninvasively both in and out of the classroom (Hairston 1990; Ogilvie and Stin-
son 1992; Schwartz 1992a, b). The belief that observing animals in the wild helps
teach reverence for life is also widely held by humane educators (Russell 1996).
Animal studies conducted in natural settings have a number of advantages over
study in the classroom. First, and perhaps foremost, the organisms being studied
are observed in their full evolutionary context; not only are natural phenomena
not suppressed as they may be in captivity, but unnatural behaviors that may result
from captivity and confinement are avoided. Thus, students get the opportunity to
observe animals in the ecological setting to which they are adapted.

Another advantage is that students can learn firsthand that studying animals in the outdoors presents challenges to the scientist. They learn to appreciate that the animals are not ready and willing to cooperate in the studies they have designed and that the quest for information requires creativity and flexibility when it becomes apparent that the animals have not read one’s study proposal! Many educators will likely view this sort of challenge as a disadvantage, given the limited time they have to provide an education to their students, but the instructive power of such experiences can be great (see chapter 2). There are a number of good resources for relatively simple outdoor studies that overcome this obstacle (e.g., Heintzelman 1983; Hancock 1991; Harding 1992; Ogilvie and Stinson 1992).

In contrast to outside observation, keeping animals in-class has the advantage of providing students with ready access and direct contact with the living organism. There are many useful observational studies that can be conducted noninvasively in the school, such as simple genetics, behavior, maturation, learning, and food preference (Office of Technology Assessment 1986; Morton 1987). There are, of course, caveats to keeping animals in classrooms: these include welfare concerns for animals inadequately housed and cared for (Morton 1987), the potential for disease transmission or injury to students, and the potential to undermine the development of students’ respect for the special relationship between an animal and its environment. For these reasons, The HSUS (1993) recommends that only domestically bred animals with limited space and housing requirements be kept in classrooms and that keeping wild animals in the classroom is generally inappropriate. In rare cases, native wild vertebrates whose habitats can be easily simulated (e.g., toads, turtles) may be acceptable for short-term captivity in the classroom (ibid.).

4.8 Recommendations

For humane, sociological, pedagogical, and environmental reasons, The HSUS believes that animal dissection should be eliminated from the precollege curriculum and from university education except where absolutely necessary (e.g., veterinary training). However, realizing the pervasiveness of this activity, a realistic set of steps towards this goal follows:

1. Animal dissection should be eliminated from the precollege curriculum.
2. All procurement of animals for dissection should be from ethical sources, such as animal shelters, veterinary clinics, and wildlife rehabilitation facilities. Guardian consent programs should be established so that cats (and other companion animals) who have died or been euthanized for medical or humane reasons can be donated from shelters or veterinary clinics to schools for educational use. These cadavers should replace the supply of cats from random sources, fetal pigs from slaughterhouses, frogs from wetlands, etc.
3. The USDA, which is responsible for inspecting biological supply companies (classified by the USDA as “Class B Dealers”), should begin requiring biological supply companies to provide annual reports. These reports should include the numbers and species of animals killed or arriving dead at the facility, numbers sold...
to schools for educational use, and methods of capture, transport, handling, and killing of the animals.

4. Biological supply companies should be required to conduct environmental impact assessments prior to collecting from wild animal populations.

5. Students should be informed of the specifics regarding the sources of animals used in the classroom, including methods of capture, transport, handling, and killing of the animals.

6. Dissection of species whose populations are known to be over-exploited and/or in decline (e.g., leopard frogs, bullfrogs, spiny dogfish sharks) should be discontinued.

7. Students involved in dissections should be provided with gloves, masks, and safety instruction to minimize the hazards of exposure to formaldehyde.

8. Science teacher training should, without exception, include training in the use of computer simulations and other alternatives resources, including alternatives databases and loan programs.

---

1 Only two states (Minnesota and Utah) and a few smaller jurisdictions (e.g., the city of Houston, Texas) currently (1999) mandate pound seizure.

2 The author remembers vividly the size, color, texture, and the highly vascularized outer lining of the distended bladder of a domestic cat whose surgery to relieve a blocked urinary tract he observed in 1979. Equally memorable was the remarkable volume of fluid this organ held.