The Quality
and Integrity of
Science Education

Most of us teach the way we were taught rather than the way we learn.

—David W. Kramer,
winner, Outstanding Biology Teacher Award

2.1 Introduction
How well biology gets taught is an important facet of the dissection debate. This section exposes some of the weaknesses inherent in the traditional animal dissection exercise and examines the oft-cited value of “hands-on” learning as it is applied to dissection. The relevant matter of alternatives and their effectiveness is addressed in chapters 4 and 5 of this monograph.

2.2 Scientific Literacy in America
In its book *Fulfilling the Promise: Biology Education in the Nation’s Schools*, the National Research Council (1990) is strongly critical of U.S. high school biology curricula and points to “an emphasis on naming structures” as contributing to the widespread failure of these curricula to adequately teach science (21). A 1988 survey of 12,000 American students found that the mean scores for those who had had a biology course were only slightly higher than those who had not, suggesting that, for most students, biology courses instilled little if any factual knowledge (Beardsley 1992).
It is, of course, impossible to say whether the current emphasis on animal dissection as part of the standard biology curriculum contributes to these findings. But dissection certainly has some pedagogical weaknesses, notwithstanding the teacher’s ability. Dissection as usually taught in the schools is weak on both concept learning and problem solving, yet the value of concept-driven teaching in the context of solving problems has been demonstrated (Jacobs and Moore 1998). Generally, dissection is also too focused on the acquisition of facts while failing to teach students to conceptualize and synthesize (Rollin 1981). The memorization of facts and terms is considered “boring” by most students, and most of what is learned is easily forgotten (Orlans 1991). Yet, according to Cole (1990), more new terms are introduced in a typical high school biology text than in the first two years of a foreign language.

An inherent shortcoming of dissection is that it is a destructive (rather than a constructive) process that destroys many of the specimen’s structures and their spatial relationships, precluding reexamination by the student (Rosse 1995). Many alternatives, such as computerized dissection simulations, allow the user to reverse and/or repeat the dissection process an unlimited number of times (Richter et al. 1994). The quality and handling properties of preserved tissues and organs also differ considerably from those of freshly killed specimens (Hancock 1995).

The moderately poor showing of American students in International Math and Science Study (IMSS) comparisons (Gibbs and Fox 1999) is doubtless attributable to many causes, but a good deal of the responsibility has to lie with teaching styles and curriculum content. As technological advances in science proliferate in such fields as genetics and biochemistry, there is an increasing need to educate students to grasp relevant concepts. In their new National Science Standards, the National Science Research Council in 1995 listed the following six areas of content for science instruction in the next century:

- cell biology
- molecular genetics
- evolution
- biochemistry
- environmental science
- animal behavior

As Texley (1996) observes, notably absent from this list is comparative vertebrate and invertebrate anatomy. Yet in the American biology curriculum, animal dissection continues to figure more prominently (Beardsley 1992) than in the curricula of many other countries with high student scientific literacy rates. In Sweden and Norway, for example, dissection is rarely practiced prior to the university level (Balcombe, Animal Use in Education, in press) and scientific literacy ranked highest in the most recent (1998) IMSS. If dissection occupies too much of the secondary school science curriculum, given the limited amount of classroom time, students may neglect other more important fields and concepts of study (Zierer 1992; Texley 1996). Perhaps there is a need to de-emphasize animal dissection and to redirect students’ limited time toward science topics that will have a greater impact on their lives.
2.3 “Hands-on” versus Active Learning

Criticisms of alternatives to dissection include failure to provide a comparable experience because of technological limitations (Schrock 1990; Snyder et al. 1992), the belief that alternatives are not the “real thing” (Schrock 1990; Wheeler 1993), and failure to convey individual variation (Morrison 1992; Wheeler 1993). Each of these criticisms springs from the belief that “you can’t replace the real animal” and provides the basis for what is probably the most common defense of dissection—that it is a hands-on learning activity.

The hands-on argument is not conclusive. Hands-on learning is not the exclusive domain of animal dissection. Many hands-on materials and approaches for learning animal biology do not require killing or harming animals. Of materials that mimic dissection specimens, three-dimensional plastic models, while less true-to-life than a preserved animal specimen, allow the user to explore the shape and dimensionality of organ structures (with the added advantages of greater durability, more realistic color, and already labeled parts). Plastination, a chemical process that transforms the tissues of a dead animal into plastic (see, for example, www.klimgras.ac.at/anawww/plast/pre.html), yields durable models with equal macroscopic detail to the original. Dissection of owl pellets is a popular activity, and many teachers have their students reconstruct the skeletons of small mammals from these regurgitated artifacts (Bealer 1980). Other models with particular applications to medical and veterinary medical training are discussed in chapter 5.

Even though a learning activity is hands-on, that does not automatically qualify it as the right way to teach or learn. Many hands-on activities could be carried out by students, but for safety, social, or moral reasons they are not; for example, constructing and detonating explosives in chemistry class. Michael (1993) observes that hands-on activities are only effective for learning if the students’ heads are being kept as busy as their hands. This point has particular relevance to animal dissection, where the behavior of poorly supervised students can degenerate to a point where little or no meaningful learning is taking place (Hertzfeldt 1994; Solot and Aruke 1997; Long 1997).

Although dissection may aid in the acquisition of manual skill (Wheeler 1993), this fact does not, by itself, necessarily justify killing and dissecting animals. Such skill can more conveniently and more ethically be gained by practicing on nonanimal training apparatus (section 5.4). Some nations recognize the weakness of this justification and have passed laws prohibiting the destruction of animal life merely for the acquisition of manual skill. The Cruelty to Animals Act passed in Britain in 1876 makes it illegal to practice surgery on animals. India’s 1960 Prevention of Cruelty to Animals Act (Section 17(2)(f)) states that “as far as possible, experiments are not performed merely for the purpose of acquiring manual skill.”

A more meaningful construct for learning with one’s hands versus not using one’s hands is that of active versus passive learning. Passive learning is epitomized by students sitting in a lecture hall attempting to transcribe what the lecturer is saying, and it says much for the need for educational reform that the lecture format still predominates in the undergraduate learning experience today. Active learning “occurs when students engage additional cognitive processes while con-
fronting the information being acquired (whether visually, orally or tactiley)” (Michael 1993, 37). Active learning is not something that is done for the learners, it is something they do for themselves (ibid.). It involves asking questions, not merely answering them, solving problems, and generating hypotheses. Sampson (1998) calls this “inquiry learning,” and it carries the added benefit of learning how to learn, rather than merely learning to become “knowers.” Active learning effects better retention, better retrieval, and better application of knowledge to other contexts (Heiman 1987).

One can discriminate between declarative (just the facts) and procedural (problem-solving) knowledge. Facts can be efficiently transmitted by passive learning, but problem-solving skills are learned most effectively by active, hands-on experience.

### 2.4 Conclusion

It is not known, nor is it easy to know, whether there is any relationship between the use of dissection as a teaching tool and the levels of scientific literacy of students who dissect. Hands-on learning methods are important and necessary, but they are abundantly available beyond dissecting animals. Furthermore, hands-on learning methods are only part of a solid learning environment for science; the learning should also be inquiry based, involving students in both forming hypotheses and solving problems. Animal dissection, as it is usually taught, does not do this, and allusions to the value of dissection as a hands-on exercise are not adequate justification for the destruction of animal life.

### 2.5 Recommendations

1. Biology teachers should emphasize active, inquiry-based learning, and engage their students in the “doing” of science.
2. Hands-on exercises should be pursued, but not at the expense of animal lives; countless ways exist for achieving exciting, engaging hands-on exercises for students (e.g., having students study themselves or conducting outdoor studies of animals and plants).
3. The time required to perform good-quality dissections should be used instead to make room for more pressing life science topics—such as cell biology, molecular genetics, evolution, biochemistry, environmental science, and animal behavior.