Sensitizing Introductory Biology Students to Bioethics Issue

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OUR PRESENT SOCIETY NEEDS educated citizens, including scientists, who are willing to become better informed and to take an active role in selecting the ways in which our society applies the discoveries of basic research. Yet, the professional training of biologists provides little opportunity for considering the ramifications of scientific research. We learned our values "by osmosis"; our attitudes were influenced, to a great extent, by the views of our mentors. Professional training fostered the appreciation of facts and theories over interaction with people and groups (Holton 1976).

In the past, we slowly applied the knowledge gained from basic research. Our present era is different. We rapidly put the discoveries made by basic researchers to practical, and sometimes questionable, use. For example, the observation of a mechanism to increase fruit and flowers in short-day plants led to the development of a devastating defoliant used in Viet Nam (Galston 1973). Where decisions about funding research and applying new knowledge should be made and who should make them are questions without clear answers.

We suspect that scientists themselves must have a voice in setting our value priorities and in fostering governmental and public understanding of science, but a suitable forum for conveying the complexity and subtlety of these issues in balanced fashion is not always accessible. The professional academies provide discourse on the appropriateness and implications of recent research techniques to scientists. The public, including the students in our colleges, may receive more information on social implication in the media than in an academic setting.

Consideration of the implications and applications of basic research should occur in the science classroom. The students we teach now, whether in science or in the humanities, will be expected to be informed on scientific issues. Those who enter the sciences will be expected to consider the implications of their work and to make sound value judgments. Biology teachers can offer their students opportunities to consider bioethical issues (Kieffer 1977); respondents to a recent survey that 45% of bioethics courses offered were taught through biology departments, and 31% through philosophy departments (Hendrix 1977).

I have described lecture, laboratory, and discussion exercises to awaken student consciousness of bioethical issues previously (Hoskins 1977). At that time, I did not present examples of their impact on students; the responses of my classes to laboratory questions are given here.

Laboratory Exercises and Queries

One way to help students develop sensitivity to ethical and social questions is to pose questions that permit them to probe into fundamental ethical issues. Who are we as individual human beings? Do we have inherent dignity, rights, obligations? What is our relationship to other inhabitants of the earth and to the earth itself? On what basis do we answer such questions? Is our value structure rational, coherent, and seasoned?

We included such questions as part of several exercises in our introductory life sciences course. LS 1001 at Worcester Polytechnic Institute is a seven-week survey of biological concepts, with emphasis on the departmental theme of "synthetic" biology. (Our understanding of the structure and function of life at all levels of organization is being extended and applied to the "creation" of unique, nonevolved, human-designed life forms. Of course, the enormous social questions of choice, crite-

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ria, and equity of distribution arising from this field of "synthetic" biology are just being delineated.) Satisfactory completion of six labs and of four essay assessments, as well as completion of the answers to the "Issues in Animal Experimentation" described in this article, are required to pass the course with a grade of "Acceptable." A "Distinction" grade may be attained by above-average performance on the labs and assessments or by increased breadth of knowledge demonstrated by completing more assessment topics.

Three of the six laboratories require the use of live organisms. The lab on energy conversion includes the classic demonstration of starch formation in shaded areas of the leaves of a light-deprived geranium. Cell behavior is studied by comparing rates of attachment to substrate in *Amoeba* under various conditions. Biological controls are demonstrated by recording the effects of acetyl choline, epinephrine, and atropine on the isolated frog heart. (The other three labs on are macromolecule properties, erythocyte membrane dynamics, and organelle visualization using paraffin sections of rat kidney.)

The frog experiment is particularly impressive to students. It is by far both the favorite lab in student evaluations and the most disturbing. The students or their teaching assistant must pith one frog for each group of four students and isolate the heart. Only hearts of larger frogs perform well for several hours, and frequently more than one animal must be "sacrificed" per group. The rest of the animal is discarded. On the page following the directions for the biological controls laboratory, the following information is given:

> *Issues in Animal Experimentation.* Clearly before a new drug or food additive is tested in humans, extensive animal trials are used to filter out potentially deleterious substances. Plant and tissue cultures may also be used. The number and conditions of trials are carefully designed and stipulated. However, the labs you have just performed on the frog heart and plant hormones have the justification of your own learning. We are not trying to discover new knowledge, or to cure disease, but to improve our own understanding of nature. Our obligations to the environment are just being sensed and formulated. Hand in your answers after you consider the following questions:
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> 1. Was there some way in which we might have made maximum use of these organisms?
> 2. Are we more justified in destroying microorganisms, algae, or lower invertebrates than vertebrates in our learning? Why or why not?
> 3. Are we justified in breeding frogs and rats for study? Why or why not?
> 4. Would we learn as much from a videotaped dissection? From a computer simulation? From a field trip?

Each student is required to hand in his/her responses to these questions in order to pass the course. We make it clear that the answers will not be graded, avoiding coercion toward adopting the instructor's values framework. Students who have not completed this exercise at the end of the term, along with those who lack a lab or assessment, are sent a note by the instructor and permitted to complete the requirement during the succeeding term. Responses to each question will be discussed in order.

Student Responses

Was there some way in which we might have made maximum use of these organisms? In discussing this question, students raised a series of basic issues. They perceived themselves as learners, with free will to choose their actions. They found it hard to kill in order to learn, but they saw their learning as a desirable goal. The means, killing animals, was justified by the end, their learning. The advance of medical knowledge and of medical training were also frequently cited as a rationale, although students recognized that they were not engaged in such situations at our school. The students seemed to be ecologically sensitive; they viewed humans as abusing nature and often creating needless waste. Some students proposed additional experiments with the animals; these suggestions indicated that had the students become more aware of this issue near the beginning of the course, they might have been more careful and thorough in their subsequent work.

Most students restricted their responses and reactions to the frog heart lab, their only experience with a live vertebrate. Of 42 respondents, 37 said more could have been done. They suggested a variety of possible improvements, such as larger lab groups, previewing of videotaped dissection procedures, more careful bathing of the heart with salt solution, increased observation of the rest of the frog, dissection of the reproductive system, spinal reflex studies, tissue preparation and so on.

Fewer students applied this question to other labs. Only one asked whether microbes and amoebae should be discarded down the sinks. Another noted that the use of food plants, such as oats and peas for the energy conversion lab, would not significantly affect food production.

The students who responded negatively to this question felt that more depth in laboratory study would detract from the time needed for their other studies and activities.

Are we more justified in destroying microorganisms, algae, or lower invertebrates than vertebrates in our learning? Many students felt more comfortable and could find justification for using plants and invertebrates in our labs. Approximately equal numbers answered yes and no to this question. Students identified with higher forms and presumed that higher forms of life felt pain and had consciousness.

One student commented:

> I can't come up with a real justification for using lower forms of life rather than higher forms. The only reason I can

think of for the feeling I have that this is true is probably because lower organisms do not show the resemblance to humans that higher vertebrates do, and certain types of experimentation (dissection, etc.) on humans are somewhat repulsive to most people (instinct to preserve one's own species?)

On the same question, another student observed that "..experimenting with *Amoebae* is much less emotionally painful than pithing frogs. We know frogs feel pain."

Students argued that higher forms of life may yield information pertinent to human studies: "Certain principles or properties can't be learned from invertebrate because only vertebrates contain them."

From an ecological viewpoint, students viewed organisms lower in the food chain as more abundant and more easily replaced. They assumed that lower forms are not only more plentiful, but also less expensive.

Are we justified in breeding frogs and rats for study? Students were in almost unanimous agreement that vertebrates could be bred for study so that humans can obtain knowledge without disturbing ecosystems. Some student comments follow:

It is probably more rational than depriving the natural ecological structure of massive numbers of some particular niche's inhabitants...When you breed (frogs), it's as if you are creating them. They really wouldn't have been alive if you hadn't bred them. I still don't like killing them, but it isn't as bad as capturing them from the wild...

Students made it quite clear in their comments that good ends must be served:

By breeding them for specific characteristics, we can learn from the results and be able to correct them in order to benefit mankind (sic)...As long as a particular organism is treated as something of value and efficiently used for a desirable end such as...advancement of knowledge, the expenditure of life is justified.

Would we learn as much from a videotaped dissection? From a computer simulation? From a field trip? The students were emphatic in their belief that learning proceeds by going from concrete to abstract. Only three students felt that they could have learned as much from a videotape of the experiment. All of the other students believed that the interaction with biological materials was essential: Comments included: "Hands-on is the best way." "The whole point of a lab is a concrete, tactile, active participation in a process which stimulates learning by greater personal implications."

Discussion

Experiments in a biology laboratory have several purposes. They are used to amplify the learning of biology, by repeating classic observations and by permitting students to experience the facts they memorize and conceptualize. They reproduce the experience of discovery. They sharpen professional skills. They drill students in the ability to observe accurately and encourage them to trust their own perceptions rather than the printed page. Such analytical ability to state and interpret one's observations is useful in many contexts, not only to the scientist and engineer but also to the humanities student.

However, laboratory exercises also raise implicit ethical questions. The experiments described touch on questions of human dignity and worth, on issues of obligation, and on perception of underlying reasons. I have previously suggested (Hoskins 1977) some general and specific objectives in the affective domain. The student responses reported in this article can help us to gauge our effectiveness in attaining those objectives.

1. *The teacher plans to raise questions about the responsibility and obligations of citizens, scientists and decision-makers for the environment, humans, and other organisms.* The students here report a sense of obligation to be humane, to at least "feel good" about their work:

Once the frog was dead I felt responsible to keep its life from being wasted, and proceeded more cautiously than with previous experiments.

They sense an obligation to treat the world well:

Man(*sic*) is slaying many organisms for the furthering of education and knowledge which is helping man (*sic*) to understand how to preserve the environment and those organisms within it.

At their present state of value development, students recognize their thought process as one of rationalization. They are aware of pragmatic and opportunistic causes for their actions. They accept a knowledge imperative: "I need to learn..." They sense, but barely articulate, other reasons such as better environmental management and medical advances.

2. *The teacher plans to provide examples of scientists behaving responsibly both personally and in their writings.* The simple fact of requiring this exercise permits one example of a biologist concerned with bioethical issues. There is, of course, not complete agreement or comfort at this approach; such exercises are not always included in the sections of this course taught by other faculty. Nevertheless, portions of the campus are sensitized to ethical considerations.

Much more ethical teaching is needed in professional education. It is our responsibility to convey explicitly the duty to be scrupulously truthful in reporting observations and in choosing data for analysis. Proper credit for contributions, in the highly competitive "marketplace of ideas" of rapidly moving fields, must also be taught to each generation.

3. *The teacher plans to encourage students to imitate such behavior, leading to increased use of valuing terms, increased position taking, the searching out of conflicting points of view, and the questioning of experimental procedures.* It can be seen that they have done so. The

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quotes reveal position taking, the use of such words as "I think..." "It's more rational" "It's important that..."

It may be felt that such exercises needlessly raise uncomfortable questions. A fear may arise that inadvertant support will be given to antivivisectionists. But it must be remembered that this is an era of rethinking "animal rights" (Singer 1975). It is an era of public suspicion that science and technology are not always beneficial, and that the cost in human dignity and ecosystem destruction may be greater than the gain in knowledge and social comfort. NIH deputy director Thomas E. Malone was reported in *Science* (1978) as saying:

> It behooves us to ask the same questions of ourselves—before they are asked of us. Does the potential good justify the use of an animal in an experiment? Will the research yield fruitful results which cannot be obtained by other means? Are we prepared to terminate an experiment when ever its continuation may result in unnecessary suffering to an animal? If the answers to these questions are "yes," then I for one have no difficulty in supporting the research.

Thus the preprofessional training of scientists and engineers appropriately offers the opportunity to think through and offer appropriate responses to these questions.

It is too soon to know if these students will become more significantly involved in bioethics projects, and environmental organizations. But that is one of the challenges of teaching—so often one never knows one's full impact on the life of students. That makes it all the more important that we carefully, and consciously consider our impact, particularly on their ethical development.

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