

# Genetics Education

## Innovations in Teaching and Learning Genetics

*Edited by Patricia J. Pukkila*

### **Instructors' Practices in and Attitudes Toward Teaching Ethics in the Genetics Classroom**

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#### ABSTRACT

There is strong consensus among educators that training in the ethical and social consequences of science is necessary for the development of students into the science professionals and well-rounded citizens needed in the future. However, this part of the curriculum is not a major focus of most science departments and it is not clear if, or how, students receive this training. To determine the current status of bioethics education of undergraduate biology students in the United States, we surveyed instructors of introductory genetics. We found that there was support for more ethics education both in the general curriculum and in the genetics classroom than is currently being given. Most instructors devote <5% of class time to ethical and social issues in their genetics courses. The majority feels that this is inadequate treatment of these topics and most cited lack of time as a major reason they were unable to give more attention to bioethics. We believe biology departments should take the responsibility to ensure that their students are receiving a balanced education. Undergraduate students should be adequately trained in ethics either within their science courses or in a specialized course elsewhere in the curriculum.

**T**HE content of undergraduate biology courses is constantly changing to keep up with new information and this is particularly true in rapidly developing areas like genetics. The rate of progress in genetics has been particularly apparent this past year as the 50th anniversary of the elucidation of the structure of DNA by Watson and Crick was celebrated. Commentators remarked on the pace of discovery of the molecular basis of life since 1953 in amazement, and it is unlikely that the rate of progress will decrease in the near future (DENNIS and CAMPBELL 2003; JASNY and ROBERTS 2003). Our developing understanding of the genome and how genetic information is manifest as a living cell has led to dramatic advances in all areas of biology, and these advances have been the basis of new technologies in medicine, agriculture, and industry. Most of this progress has been welcomed by our society; however, not all of the developments have been perceived as desirable by the public at large, and some remain highly contro-

versial, *e.g.*, GM food, germ-line gene therapy, preimplantation diagnosis (HUGHES and BRYANT 2002; TURNPENNY and BRYANT 2002; OWENS 2003). When there is disagreement among concerned parties as to the safety, usefulness, and/or desirability of a particular advance in biotechnology there is often confusion as to the appropriate contribution of experts and "interested" non-experts to the debate (JASANOFF 1999). To have the most democratic decision-making process, there is a strong consensus among science educators that we need a broad spectrum of educated people to contribute to these discussions about controversial scientific developments (JOHANSEN and HARRIS 2000; LUNDMARK 2002). Effective communication among the scientists developing these technologies, legislators who might regulate them, and members of the public affected by them is essential to ensure the democratic implementation of scientific advances (GARRETT and BIRD 2000).

To bridge the divide between the "experts" and the public, many different approaches are being tried to improve both the scientific literacy of the nonscientist public and the cultural and ethical awareness of the scientists (CUPPOLA and SMITH 1996). Professional organizations

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**Instructions:** *Please circle the appropriate response(s).*

**General**

1. Does your school offer courses in ethics to students?
  - a. Yes, including at least one course focusing on science/biology and ethics.
  - b. Yes, but not including any that focus on science/biology and ethics.
  - c. No, it does not offer any.
  
2. Does the school have core requirements that include some ethical component for all students?
  - a. No
  - b. Yes, the students are required to take a specific course(s) relating to ethics.
  - c. Yes, the students have a choice of specific courses related to ethics.
  - d. Yes, the students have a choice of many courses that fulfill a broad ethical requirement
  - e. Yes, the students are required to attend some non-classroom activity.
  - f. Other (please specify):
  
3. Is there any ethical component to the requirements for biology majors?
  - a. No
  - b. Yes, majors are required to take a course that specifically focuses on science/biology and ethics.
  - c. Yes, majors have a choice of many courses not all of which take a specific focus.
  - d. Other (please specify)

**Your Class**

4. How do you introduce the subject of ethics and policy issues to the class? (Circle all that apply)
  - a. Formal Lecture
  - b. Open informal discussion
  - c. Casual vocalization of thoughts on the subject
  - d. Included in assigned readings but not discussed
  - e. Included in optional reading but not discussed
  - f. Role-playing
  - g. Case study analysis
  - h. Assigned papers
  - i. Other (please specify):
  - j. I don't at all
  
5. Does the main assigned textbook(s) for your class include ethics and policy issues?
  - a. No, not at all.
  - b. Yes, in the main body of the text.
  - c. Yes, in special sections separated from the main body of the text.

FIGURE 1.—Main text of survey.

have taken a leading role in these efforts. For example, Project 2061 is a long-term initiative of the American Association for the Advancement of Science to improve public literacy in science, math, and technology; the ELSI program (Ethical, Legal and Social Implications) of the Human Genome Initiative has provided funds for scientists and physicians to explore the societal consequences of developments in genetics.

Although there appears to be agreement that science students should be broadly trained to be able to consider intelligently the consequences of science and technology in society, it is not clear if/how this laudable goal is being achieved. To address this question in our area of expertise, we surveyed instructors of introductory genetics courses in U.S. colleges and universities about the education received by their students. Do professors believe that their students in contemporary genetics courses are being adequately and effectively trained for their

future role as “expert” scientist and/or “educated” citizen? Are the students receiving sufficient training in the social and ethical consequences of science, somewhere in their undergraduate training, to assume their responsibilities as respected voices in these debates? Are professors of genetics comfortable with the amount of course time and resources available for discussion of these issues in their own course? If not, why not? We hope an understanding of the current state of genetics education and the instructors’ degree of satisfaction with it will lead to an open debate on how to improve our students’ preparation to be responsible scientists and citizens.

THE SURVEY

A four-page survey (Figure 1) was mailed to the “Chair of the Biology Department” at all American liberal arts colleges and research 1 universities listed in U.S. News

6. Do you incorporate extra materials into the lesson aside from the assigned textbook that specifically focus on ethics and policy issues? Yes / No
7. Do you cover any of the following issues in your class? (Circle all that apply)
- A variety of prominent ethical principles
  - General consequences of research on the individual or society
  - Consideration for diversity of values and beliefs
  - Awareness of the foundations for personal opinions (biases)
  - Defending one's personal stance on issues
  - Your own personal beliefs
  - Other (please specify):
  - None
8. Approximately what percentage of your class time is devoted to ethics and policy issues?
- None
  - < 1%
  - 1-5%
  - 6-20%
  - > 20%
9. Do ethics and policy components of the class count towards the students' grades? Yes / No
- 9y. If Yes, what is that grade based on (circle all that apply)?
- Papers
  - Exams
  - Participation in discussion
  - Other (please specify):

FIGURE 1.—Continued.

#### Your Opinion

10. Do you include as much ethics and science policy issues in your course as you think should be included? Yes / No
- 10n. If No, why do you think that is? (Circle all that apply)
- Lack of time
  - Lack of resources on the subject
  - Uncomfortable with the subject
  - Other (please specify)
11. Do you believe biology students should be exposed to ethical issues?
- No, not at all
  - Yes, in the science classroom
  - Yes, in a class with a specific science/biology and ethics focus
  - Yes, in unrelated ethics courses offered by the school
  - Yes, but in some other way (please specify):
12. Do you believe there should be an academic requirement of ethics for biology students?
- No, not at all
  - Yes, in the core curriculum requirements for all students
  - Yes, in the requirements for the major
  - Other (please specify):

and World Report (<http://www.usnews.com/usnews>). The survey was accompanied by an introductory letter requesting that it be forwarded to the instructor of the introductory genetics course at the institution. The main portion of the survey consisted of 12 questions designed to assess three areas of interest. These were the extent to which the school exposed students to ethics and policy issues, the extent to which the instructor introduced the subject in his or her class, and the instructor's opinions on the appropriate degree of expo-

sure a student should receive. An additional section of the survey contained basic questions about the participant, (age, sex, etc.) as well as two questions addressing the instructor's previous education in ethics and her or his effort to keep up with controversy in their field.

Of the ~500 surveys mailed, 151 replies relevant to our study were received (30% return rate). Some of the participants failed to fill out the demographic questions. Of those 120 who did respond, the demographics were typical of the U.S. biology professoriate. Sixty-six per-

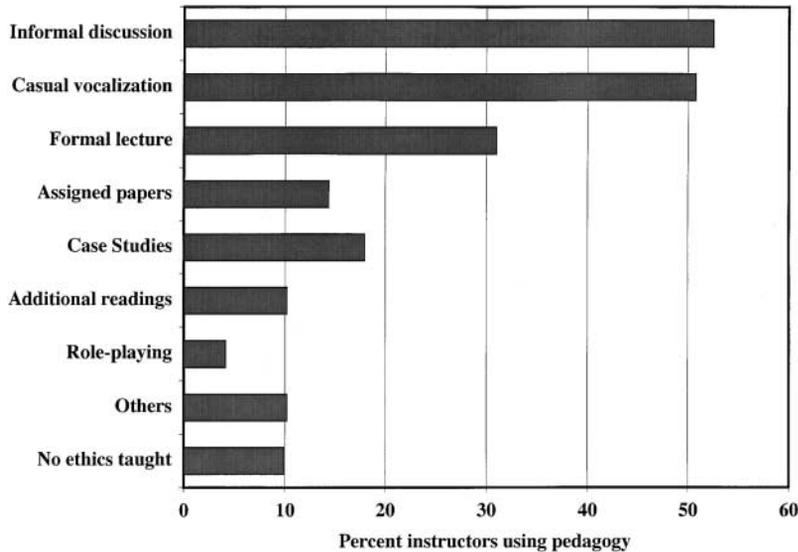


FIGURE 2.—Use of various pedagogical methods. In total, 90% of survey respondents indicated they do incorporate ethics and public policy into their genetics courses. The percentage using particular pedagogies is given.

cent were male, 95% were Caucasian, and 98% had a Ph.D. as a terminal degree. There was a wide spectrum of seniority among the respondents, 37% full professors, 36% associates, 23% assistants, and 4% instructors, and a majority (62%) were between 35 and 55 years old. One-half of the respondents taught classes of between 30 and 100 students, with 30% of the classes having <30 students and 20% having >100 students. When asked if they had previously had any formal education in ethics, 58% of instructors responded in the affirmative, 23% having had at least one class or workshop specifically addressing science and ethics. Ninety-three percent of all who responded did report that they try to keep up with ethical debates surrounding controversial advances in their field.

## RESULTS

Responses to the introductory questions in the survey asking about science and ethics education at the institu-

tion revealed that 95% of the schools employing the respondents do offer some courses in ethics to students, with 65% offering at least one class focusing on science and ethics. However, while courses in ethics are certainly available to students, only 37% of the schools have an ethical component to their core requirements. Of these, a majority (52%) simply give a choice of many courses to fulfill a broad ethical requirement. Thus there is little assurance that students are receiving any training relevant in the ethical or social consequences of science through their general education requirements. Furthermore, only 13% of the schools have biology departments with an ethical component to the requirements for majors. Of those that do, only 32% (4% of all of the respondents' schools) require a class that specifically focuses on science and ethics.

A vast majority (90%) of instructors who responded do attempt to introduce the subject of ethics and policy issues into their genetics courses in some way (Figure 2). The most widely used methods of introducing the

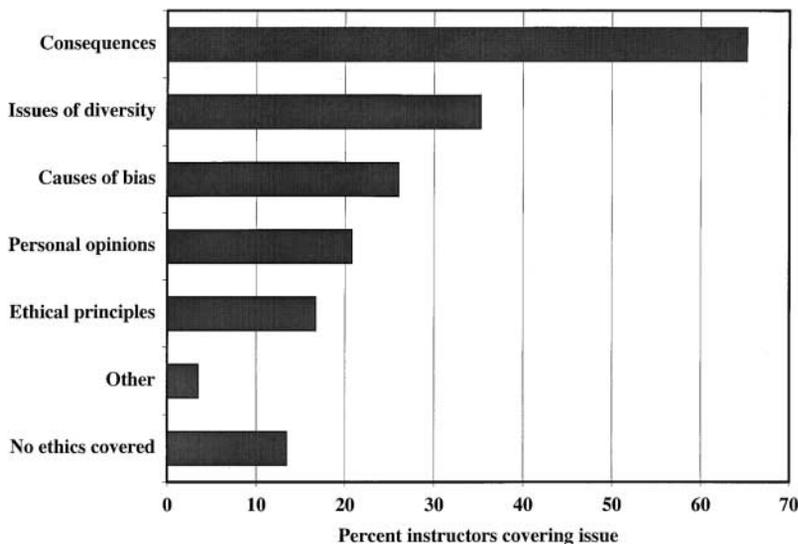


FIGURE 3.—Ethical issues raised. In this survey 87% of instructors reported covering at least one of these issues. The percentage responding positively to each issue is given.

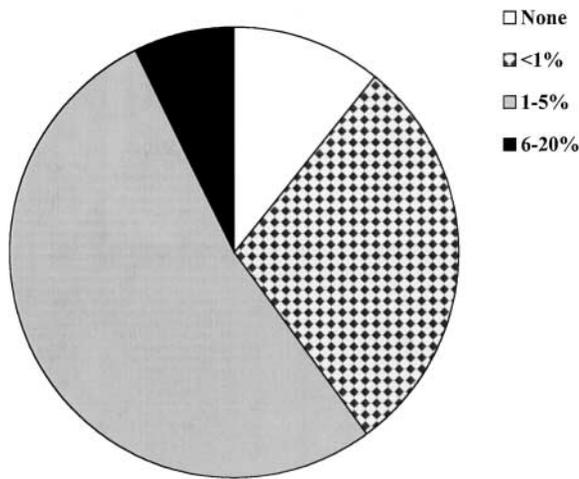


FIGURE 4.—Class time. The percentage of class time devoted to ethical and social issues in respondents' classes is given.

subject were through “open informal discussion” or “casual vocalization of thoughts” with 58 and 56% of the respondents claiming to utilize each. A “formal lecture” approach was also used by 34% of the respondents. Other, more varied pedagogies like debates or case studies were less common. When asked the topics that they covered in the ethics sections of their course, most instructors gave multiple responses to the choices given (Figure 3). The most prominent of these, with 75% of the instructors responding positively, was the “general consequences of research on the individual or society.” “Consideration for the diversity of values and beliefs” (41%) and “awareness of the foundations for personal opinions (biases)” (30%) followed in frequency.

Sixty-nine percent of the instructors surveyed use textbooks that do include ethics and policy issues in some way. However, of those textbooks that do so, only 35% include the topic in the main body of the text as opposed to special sections separated from the main body. Forty-

one percent of the survey respondents reported incorporating extra materials on ethics and public policy issues into the course to supplement course material.

Most instructors reported spending <5% of class time on ethical issues (Figure 4). Approximately 53% of the respondents devote between 1 and 5% of their class time to ethics and policy issues. Thirty percent allocate 0–1% of their time, and 11% devote none at all. Only 7% claimed to devote between 6 and 20% of their time and no one claimed to spend >20% of their class time on the subject. Another measure of the degree of integration of social and ethical issues into the course is whether that component is graded. Only 29% of the genetics professors that responded to our survey include assessment of the ethics components of their course in the students' grades. Exams, papers, and participation were all equally common bases for such grading with roughly 11% of the respondents reporting the use of each.

Our inquiry into the attitudes of the professors revealed strong support for student training in the ethics and policy issues arising from genetics. Almost all of those who responded (99%) indicated that they did feel students should be exposed to ethical issues in some way. Fifty-five percent felt this should take place within the science classroom, while 35% felt it should take place in a class specifically focused on science and ethics. When asked whether or not they believe biology students should have some ethical requirement, 67% felt they should and 24% of these respondents believed this requirement should be part of the biology major. However, the majority (57%) felt that the requirement should be in the school's core requirements. Another 20% of those who supported an ethical requirement for biology majors specified some other way in which students should be required to be exposed to ethics, the most common of which was the belief that ethics should be fully integrated into every course as an “ethics

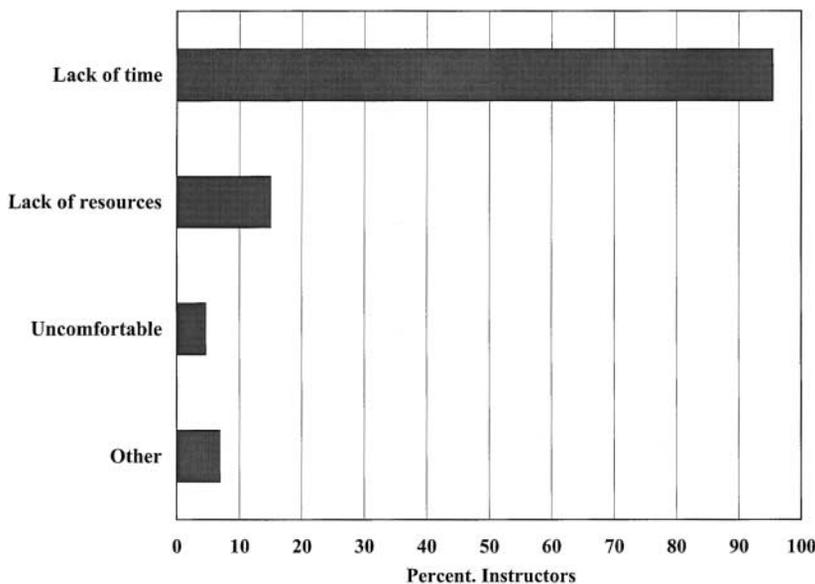


FIGURE 5.—Reasons why instructors give insufficient time to ethics in class. A total of 58% of instructors reported being dissatisfied with the amount of coverage of ethics and public policy in their classes. The percentage of those instructors citing particular reasons is given.

across the curriculum” policy rather than as an isolated requirement.

Forty-two percent of the instructors surveyed were satisfied with the amount of ethics and policy included in their courses. It is important to remember that this includes the 10% who do not agree that it is relevant anyway and therefore do not include it in their courses. However, 58% were not satisfied with the content in their own courses and the overwhelming majority of instructors (95%) cited lack of time as the reason for this situation (Figure 5). In contrast to our expectations we found little indication that faculty blamed lack of training or resources for their inability to expand their curriculum to include bioethics and policy.

We found no correlations between factors like age, sex, or status of instructor and their willingness to incorporate ethics and policy issues, spend more time on the subjects, or grade students on ethical components of their work. There were significant correlations between factors like instructor’s previous training in ethics and the amount of time they devoted to those topics and related variables. With an alpha level of 0.05, a Pearson correlation between this previous educational experience and the introduction of the subject into the course at hand was found to be statistically significant,  $r(123) = 0.193$ ,  $P = 0.031$ . Similarly an instructor’s previous training in ethics was also positively correlated with time devoted to the subject [ $r(122) = 0.225$ ,  $P = 0.012$ ], including extra materials in the lesson [ $r(123) = 0.199$ ,  $P = 0.026$ ], grading ethical components [ $r(123) = 0.188$ ,  $P = 0.035$ ], and feeling biology students should have an academic requirement involving ethics [ $r(123) = 0.263$ ,  $P = 0.003$ ]. Pearson correlations also indicated significant relationships at the 0.05 level between the instructors’ opinions and their actions. Those who believed biology students should be exposed to ethical issues were more likely to introduce the subject [ $r(147) = 0.349$ ,  $P = 0.000$ ] and to spend more class time on it [ $r(146) = 0.235$ ,  $P = 0.004$ ]. Likewise, those who felt that biology students should have some ethical academic requirement were more likely to introduce the subject [ $r(149) = 0.243$ ,  $P = 0.003$ ] and spend more time on it [ $r(148) = 0.353$ ,  $P = 0.000$ ], and they were also more likely to grade the students on it [ $r(149) = 0.164$ ,  $P = 0.044$ ]. Furthermore, these respondents were also significantly less likely to feel that they included enough of these issues in their course [ $r(148) = -0.243$ ,  $P = 0.003$ ].

## DISCUSSION

This survey illustrates a significant gulf between the ethics education instructors believe their students should receive and what is actually required by their undergraduate institutions. Not surprisingly, essentially all respondents supported students being exposed to the ethical consequences of scientific progress somewhere in the

curriculum although not everyone thought it should be formally required. As an approximation, we can divide our respondents into three groups. One-third believes there should be no requirements in this area; another one-third believes there should be a core curriculum general education requirement. The final group believes there should be a more rigorous requirement for biology students, either a required “science and society” course or integration of ethics throughout the science curriculum. In practice, the majority of institutions have no such requirement (59%), about one-third require a course in ethics as part of the general education requirement, and only 4% of biology majors are required to take a focused science and society course.

This disconnect would not be of concern if genetics students were receiving the necessary education in bioethics and policy within the science classroom. However, this is also not the case. Ninety-three percent of respondents devoted <5% of class time to these topics (Figure 4); this translates to 7.5 min of instruction or less per typical week of three 50-min lectures. In total, 55% of all instructors believe this is not sufficient and most of them (95%) cited lack of time as the reason for this shortfall (Figure 5). Unfortunately, it is not clear from our results whether the “lack of time” response refers to instructors believing they do not have time during their course to fit in more material in ethics because the course is already “full” of the science of genetics or whether the instructors lack the time for intensive preparation to teach in this new area, especially as ethics is not well covered in genetics textbooks. However, as few of the faculty surveyed reported being uncomfortable with their own preparation to teach “outside” their discipline (Figure 5), it seems likely that lack of class time for ethical issues is a serious concern.

Our finding that most respondents feel prepared to teach bioethical issues is inconsistent with results of a previous study (LINDELL and MICZAREK 1997). There are several possible explanations for our findings. The faculty responding to our survey may be particularly interested in ethical and social consequences of science and therefore better prepared than average to teach in this area: 58% reported some formal education in ethics. Alternatively, it is possible that they just have not yet devoted sufficient class time to these issues to become aware of their inadequate preparation for this subject matter.

The data from any survey are always suspect, as sample bias is a serious problem in an “opinion” poll such as this one. We obtained a response rate of slightly >30%, a good result considering we had no direct contact with participants and the fact that faculty are a heavily surveyed population. If there is bias in the sample, it is likely that faculty with strong opinions on the issues surveyed would respond. There was evidence (*e.g.*, from comments in margin) of a few respondents’ strong opposition to the “dilution” of scientific content in their

course through the inclusion of ethical and social issues. However, overall our data probably reflect an oversampling of genetics faculty with a broad vision of their role as science educators who favor ethics instruction. If this is true then, while there may be less support for the inclusion of these issues in the science classroom than we report, there is certainly also even less time devoted to these issues by the genetics professoriate as a whole than is evident from this survey. Another concern is how representative are the instructors surveyed of the biology professoriate as a whole? While we have surveyed the practices and attitudes of only genetics professors it is likely that similar results would be obtained for other areas of molecular biology, *e.g.*, developmental biology, neurobiology. There is evidence of increasing attention being devoted to ethical and social issues in biology courses by innovative instructors (LINDELL and MICZAREK 1997; GILBERT and FAUSTO-STERLING 2003), but our survey shows that this pedagogy is not yet adequately mainstreamed. However, additional surveys should be conducted to determine the situation in very different areas like ecology.

It is very clear from our results that it is quite easy for biology students to progress through their undergraduate education receiving minimal, if any, preparation for the controversies arising from developments in current biology. Any training they do receive in ethical decision-making in biological issues will be a result of their own interests and course choices as there is so little oversight of this area of the curriculum by the science faculty. It is also clear that most genetics professors believe that the current level of student preparation in ethics is inadequate. While it is our position that this training is best provided within the biology curriculum (ZAIKOWSKI and GARRETT 2004) the location of training is not as critical as the fact that it does occur somewhere

in the curriculum. The professoriate should take on its responsibility to ensure biology students are fully educated so that they can take part in the very important social debates on scientific issues of their time.

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