Ethics in the Science Classroom[1]

An Instructional Guide for Secondary School Science Teachers

With Model Lessons for Classroom Use

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INTRODUCTION[1]

The instructional material and lessons included in this volume had their origins in a National Science Foundation (NSF)-funded program in which one of the present authors was the director (TG) and the other the project consultant (MP).[2] That program, for Long Island, New York secondary school science teachers, included two-week summer institutes in 1994, '95 and '96 and school year follow-up sessions. The program was designed to encourage teachers to include ethics and values content in their classroom science lessons.

We became convinced of the need for that endeavor as a result of frustration experienced during efforts to teach research ethics to undergraduate science majors and beginning graduate students. Such instruction is currently mandated or encouraged by major science funding agencies including the National Institutes of Health and the NSF.[3] Although most senior undergraduate and graduate students can be persuaded of the need to learn about the ethical issues associated with scientific research, it is our experience that few, if any, of them have had any preparation for such learning in their prior science classroom experience. With the exception of biology, where some aspects of medical and bio-ethics have made inroads, considerations of ethics and values play almost no role in pre-college or college science instruction.[4] As a result, students tend to have a very narrow conception of the ways in which ethics and values enter into the practice or societal use of science. After years of instruction that either explicitly or implicitly reinforced the concepts of the total objectivity and value neutrality of science, students are resistant to parting with these idealizations. Our growing conviction that the ethics/science connection should be introduced and explored much earlier in a student's education was validated by the spontaneous suggestion to that effect in evaluations of our college- and graduate-level instructional efforts by our students.

One concern that is often raised by teachers is that national, state and local science curricula do not prescribe the inclusion of ethics and values in science instruction. While it is true that mandated or recommended subject matter content rarely makes explicit mention of ethics, many recent science education goals, objectives and standards documents include topics that intrinsically incorporate ethics and values issues. The *National Science Standards* recently published by the National Research Council[5]contains numerous recommendations in its Science Content Standards for subject matter that includes ethics and values components throughout the K-12 curriculum under such headings "Science as Inquiry," "Science in Personal and Social Perspectives," and "History and Nature of Science." The content standard for grades 9-12 in the "History and Nature of Science" category focuses on science as a human endeavor and the nature of scientific knowledge. Explicit reference is made to the ethical norms of scientific inquiry and to the values that influence scientists' judgments. Many state curriculum content guides include similar topics with ethics content. For example the student understandings of the nature of science prescribed in *Florida's Sunshine State Standards: Science, 1996*[(6)] include the influence of funding agencies on the areas of scientific inquiry; the constraints imposed by political, social, and ethic values on technological design; the need to seek out sources of bias and report data truthfully; and concerns about the ethical treatment of human and animal research subjects. Michigan's *Essential Goals and Objectives for Science Education (K-12)*[(7)] include understandings of the limitations of scientific knowledge; the influence of political, social and cultural factors on the development of science; and the risks and benefits of new technologies.

Almost all of the 76 high school, junior high and middle school science teachers who enrolled in one of our Summer institute programs began with the conviction that there was a need for their students to learn about ethics in science. Most often this was inspired by such common unethical behavior in their classrooms and laboratories as fudging experimental data and the reporting of anticipated rather than actual observations. Despite having received a set of pre-institute readings that introduced them to a wide variety of connections between science and ethics/values, most of the teachers entered the course with a narrow focus on such obvious issues as fraud, data manipulation and plagiarism. They were, however, generally receptive to broadening this perspective to include a much wider range of issues. Discussions of such topics as the influence of funding sources and competitive pressures on scientists, social responsibilities of scientists, and ethical issues related to biotechnology, the Human Genome Project, environmental protection, research on human subjects and animal rights took place with obvious interest and enthusiasm.

We were pleasantly surprised by the creativity displayed by the teachers in the key, lesson-planning phase of the program. Teachers worked both individually and in groups to produce classroom exercises incorporating some of the ethics/values issues that we had discussed. The expectation was that the teachers would make use of these lessons in their own courses during the following school year. This proved to be the case, as reported at the follow-up sessions held during December and April of the school year. Many teachers also introduced additional ethics/values lessons, which they had devised after the Summer institute, and some made use of lessons that had been created by other institute participants.

The level of enthusiasm in the descriptions of the success teachers experienced in the use of the lessons is encouragingly high. The overwhelming consensus is that students in all secondary school science courses find the science ethics lessons to be interesting and stimulating. An apparent, unanticipated benefit to infusing science curricula with ethics/values issues is that topics that students previously considered dull, tedious or dry are viewed more favorably when such topics are introduced along with related ethical considerations. The teachers attribute this increased student interest to the fact that material that was formerly viewed as unrelated to real life concerns has been "humanized." For example, one physics teacher found that he could greatly increase his students interest and involvement in learning about momentum by coupling it to a discussion of the ethical issues involved in requiring automobile passengers to wear seat belts. These types of teaching activities will focus students' attention on their own behavior. Although lessons that stress and illuminate the importance of honesty in recording and reporting scientific data certainly do not eliminate student dishonesty our teachers reported that they do result in more self-conscious, thoughtful behavior.

In the course of preparing this volume, we contacted the teachers one to three years after they had participated in the project. We were pleased to discover that most of them continue to use ethics and values lessons in their science teaching. Three of the teachers credit the institute experience with inspiring them to create year-long elective science courses containing a series of lessons designed to illustrate and teach many of the ethics/values in science issues we explored. Most of the teachers include at least one brief lesson early in the school year that is designed to introduce students to the relationships between science and ethics/values issues. This is followed later in the school year by additional lessons in which particular ethics issues related to the course subject matter are explored in some detail.. A significant minority of the teachers follow a much more ambitious program in which ethical considerations are incorporated in lessons throughout the year, sometimes on an almost daily basis. These teachers found that by taking advantage of the resulting enhanced student interest, they were able to design lessons that include ethics/values content without displacing other prescribed course content.

We are convinced that student understanding of science and the increasingly important role science plays in our society is enhanced by the infusion of ethics/values content. The success of our program inspired us to create the materials you now have in your hands. We hope to encourage other science teachers to enhance their classroom offerings in the same way that the Long Island teachers who participated in our institutes have found to be so fruitful.

Our plan is as follows: Section I of this book contains educational material derived from the introductory phase of our summer institute offerings, which developed and evolved over the three-year life-span of that program. The initial chapter is an analysis of science, which like all human activities, is infused with the values of its practitioners. We examine the many ways that science and ethics/values intersect, with regard to both the doing of science and in the societal uses of the results of scientific research. The second chapter is designed to provide an answer to the question "What is ethics?" We present an introduction to the current state of knowledge about moral development and to the different types of reasoning that are used in making ethical judgments. We show that students of all ages are capable of critical reflection and ethical reasoning. As an example of the practical application of the employment of ethical principles and concepts in a science context we explore the development of the guidelines that are used by institutional review boards that are charged with reviewing proposals for research involving human subjects or laboratory animals. Chapter 3 is devoted to the teaching of ethics. We begin with a set of objectives and the assumptions about students that they presume. Concern about whether ethics can or should be taught in the classroom is countered by the response that ethics can certainly be profitably studied with the vital goal of stimulating a student's moral imagination. Examples are given of how to help students recognize moral issues and to analyze key moral concepts and issues. In Chapter 4 we present a series of six cases studies, including five that our Long Island teachers found to be very illuminating. Each one of the cases is based on actual events and they are designed to probe ethics/values issues related to scientific fraud; the collection, manipulation and presentation of data; experiments on human subjects; genetics research and technology; competition among scientists; assignment of credit for scientific discoveries; and the effects of sexism and racism on science.

The second section of the book presents guidelines for, and examples of, classroom lessons incorporating ethics/values in secondary school science teaching. To aid this process, we begin with a presentation of suggestions and guidelines for the creation of such lessons. Next, we present 23 model lessons, which are edited or revised versions of lessons created by teachers in our institutes. These lessons cover a wide range of topics and levels of sophistication. We have assigned a category to each lesson that we think best describes its principal emphases - introduction to ethics/values, behavior of scientists, behavior of science students, social issues, research on humans and animals, or pedagogy. We also indicate the student academic level(s) and science course(s) for which we think each lesson is suitable. Our aim is to provide examples of ethics/values instructional materials that can be used by any teacher of a science class from middle school (sixth grade) through senior high school. We hope that science teachers will be encouraged to develop additional lessons that are tailored to their own unique teaching needs. A bibliography and listing of Internet and other non-print resources constitutes the final part of Section II.

SECTION I - A Guide To Teaching the Ethical Dimensions of Science

CHAPTER 1

How Ethics and Values Intersect With Science

The roles of ethics in science

A book devoted to advocating the infusion of ethics/values into the teaching of science rests on the assumption that ethics and values play a significant role in science and that ignoring this fact will diminish a student's comprehension of the true nature of the scientific enterprise. But this is not an assumption that is accepted and appreciated by most secondary school students, nor by all of their teachers. When asked about the connection between ethics and science, many science teachers will make reference to such issues as scientific fraud and plagiarism that have occasionally made dramatic headlines. They will generally view such behavior as the exception rather than the rule and profess a belief that science is for the most part an objective and value-free activity practiced by honest, moral individuals. Our point is not to deny that fraudulent behavior among scientists is unusual, but rather to emphasize the fact that science *is* the product of human activity, and as such it inevitably involves a wide variety of value-laden choices and judgements, many of which have ethical dimensions.

What is science? Professor John Ziman of the Imperial College of Science and Technology, London, one of the most influential writers on the practice of science, points out that definitions given by professional scientists, historians of science, philosophers of science, and representatives of other related disciplines tend to emphasize "different aspects of the subject, often with quite different policy implications."(8) Philosophers might emphasize the methodological aspects of science focusing on experimentation, observation and theorizing as elements of the means by which reliable information about the natural world is gleaned through the practice of science. Historians are prone to view science as the accumulation of knowledge, stressing its archival aspect as a significant historical process worthy of special study. Ziman concludes that: "...science is all these things and more. It is indeed the product of research; it does employ characteristic methods; it is an organized body of knowledge; it is a means of solving problems."(9)

The fact that the practice of science is a human social activity is a central theme of a booklet entitled "On Being a Scientist," initially published in 1989. This booklet was written by the Committee on the Conduct of Science under the auspices of the National Academy of Sciences as a description of the scientific enterprise for students who are about to begin to do scientific research. The reader is instructed that:

Scientists have a large body of knowledge that they can use in making decisions. Yet much of this knowledge is not the product of scientific investigation, but instead involves value-laden judgements, personal desires, and even a researcher's personality and style.[(10)]

Debunked is the notion of a rigid Baconian scientific method by which scientists derive truth about the universe by making observations with no preconceptions about what they may discover. Instead the authors claim that:

...research is as varied as the approaches of individual researchers. Some scientists postulate many hypotheses and systematically set about trying to weed out the weaker ones. Others describe their work as asking questions of nature: "What would happen if ...? Why is it that...?" Some researchers gather a great deal of data with only a vague idea about the problem they might be trying to solve. Others develop a specific hypothesis or conjecture that they then try to verify or refute with carefully structured observations. Rather than following a single scientific method, scientists use a body of methods particular to their work.[(11)]

The booklet includes several real-life stories that illustrate the fallibility of scientists, and the ways in which they can be influenced by personal or social values. Mentioned as examples of the values that can distort science are attitudes regarding religion, race and gender. Assurance is given that science has social structures and mechanisms that tend to limit and correct the influences of such biases. The peer review process, the requirement that experiments be replicable and the openness of communication are claimed to serve this purpose. The booklet ends with a strong appeal for scientists to exercise social responsibility. A second edition of this booklet, revised by a joint committee of the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine, was published in 1995 and retains much of the discussion of the role of values in science.

The claim that the peer review process and openness of communication significantly reduce the influences of bias in science assumes a set of historic norms for the behavior of scientists that are less descriptive of scientific behavior today than when they were codified by the eminent sociologist R. K. Merton in 1942. Merton's norms, as expressed by Ziman[(12)] include the principles of **communalism** (that science is public knowledge available to all), **universalism** (there are no privileged sources of scientific knowledge), and **disinterestedness** (science is done for its own sake). In today's world, where the vast majority of scientific research is funded by corporate or other private interests which often place rigid restrictions on the publication of scientific results and the exchange of scientific information, and where academic scientists find themselves in a highly competitive environment, these norms can no longer be viewed as generally applicable to the practice of science.

The tendency of many scientists and teachers of science to portray science and scientists in an idealistic and unrealistic manner is often motivated by belief that this will result in a greater willingness on the part of students and the public to accept scientific, rational thought as a powerful tool for learning about, and understanding, the world and the universe. There is no evidence to support this view. On the contrary, when students are taught that scientists are mere mortals who are subject to the same social pressures and temptations, in their work as well as in their private lives, that influence all human endeavor, they are more likely to identify with scientists. The powerful methods that science offers for seeking knowledge about the universe then become personally accessible rather then a set of exotic tools available only to the members of an elite priesthood.

Recent surveys have shown that despite a renewed interest in mysticism, and growing concern about the contribution of technological development to environmental degradation, public regard for science and technology remains very high. This is particularly true in the United States and other industrialized nations, but also in the developing world. While a high regard for science is certainly a desirable public attitude, it can be associated with an uncritical acceptance of any conclusion or opinion that is presented in the name of science. This is contrary to the essence of the scientific approach to knowledge, which seeks to engender a critical/skeptical attitude and recognizes that all of the results of science are to be viewed as subject to further verification and revision.

By presenting science to students as the product of the work of fallible human agents, rather than as a body of unassailable factual knowledge about the universe, gleaned by means of value-free observation and deduction, we can teach students proper respect for science, while nurturing an appropriate attitude of skepticism. Bringing scientists down from a pedestal is necessary if students are to recognize their own humble efforts in school science laboratories as requiring the same honesty in the reporting of observations and treatment of data that they assume was employed in the deduction of the scientific knowledge contained in their textbooks.

Examples of ethics and values issues in science

In an essay entitled "The Ethical Dimensions of Scientific Research"[(13)] the widely published logician and philosopher of science Nicholas Rescher attacks the view that science is value free, and shows how ethical considerations enter into many aspects of the practice of scientific research. Rescher describes ethical problems and issues in science under several headings. We will use Rescher's headings, describing the major ethical issues that he discusses, and adding a few that he doesn't mention:

- Choosing research goals.

Rescher states, "Perhaps the most basic and pervasive way in which ethical problems arise in connection with the prosecution of scientific research is in regard to the choice of research problems, the setting of research goals, and the allocation of resources (both human and material) to the prosecution of research efforts."[(14)] At the national level, he asks whether we are morally justified in committing such a large fraction of the federal research budget to space exploration at the expense of larger appropriations for the advancement of knowledge in medicine, agriculture and other fields of technology bearing directly on human welfare. Other major value-laden choices that he doesn't mention are the balance between the funding of military versus non-military research and between the funding of fossil fuel and nuclear energy investigations as opposed to those involving renewable energy sources. A recent issue that has divided the public, politicians and the scientific community is the extent to which "BIG SCIENCE" projects like the supercollider subatomic particle accelerator or the Human Genome Project should be funded as compared to funding a broader variety of more modest "small" science endeavors.

At the institutional level of the department, laboratory or research institute, Rescher mentions the issue of support for pure, or basic, versus applied, or practical, research. Today, with an increasing fraction of research being done by, or funded by, industry the constraints imposed by corporate interests on the choice of research projects, or on the direction of the research is becoming an increasingly significant ethical issue.

At the individual level Rescher cites difficult, and even painful, ethical decisions that often must be made. These include the choice between pure and, frequently more lucrative, applied research, and for those who choose applied science, such questions as whether to work on military projects. Recently the media have publicized the moral dilemma of whether former researchers for the tobacco industry should violate secrecy agreements by revealing that the industry knew more about the addictive nature of nicotine than was claimed in sworn testimony by company spokespeople.

- Staffing of research activities.

Rescher includes under this heading the ethical concerns that arise when scientists become administrators of large sums of public money that are needed to fund most forms of contemporary scientific research. As he points out, the increasing administrative responsibilities imposed on scientists is an ethical issue, in and of itself, because it impairs a scientist's ability to devote his or her energies to the practice of science. In research at universities, the employment of graduate students to do research raises issues about whether the assigned research is the optimal work in terms of the education and the training of the student. An additional ethical concern related to staffing a research group is the fact that women and minority members have historically been under-represented in scientific research. Making good on commitments to equal opportunity is a serious moral obligation of the scientist as research administrator.

- Research methods.

The ethical concerns related to the use of human subjects and animals in research are the focus of Rescher's remarks about issues related to the methods of research. We will discuss the topic of human subjects in some detail, both in the next chapter and in connection with the case study about the Tuskegee syphilis experiment in Chapter 4. The heightened public concern about animals as research subjects resulting from the animal rights movement is an issue familiar to most science teachers, particularly biology teachers. The deletion of experiments using animals in school science laboratories, due to moral objections by teachers, students, parents or the community, is becoming an increasingly common occurrence.

Other ethics and values issues related to research methods include such questions as whether a double-blind protocol is needed in cases where subjective interpretations of research data may influence experimental results. Additionally, there are issues related to the manipulation and presentation of data, many of which are discussed in connection with the Millikan case study in Chapter 4. The use of placebos in tests of the effectiveness of a new drug can raise ethical issues associated with the withholding of a potentially effective treatment of a serious illness.

- <u>Standards of proof and the dissemination of research findings</u>

Rescher discusses the issue of the amount of evidence a scientist must accumulate before announcing his or her findings. As he states, "This problem of standards of proof is ethical, and not merely theoretical or methodological in nature, because it bridges the gap between scientific understanding and action, between thinking and doing..." Personal factors, such as the need to publish in order to advance his or her career goals may tempt a scientist to exaggerate the certainty of scientific results. The fact that positive results are often rewarded by increased funding from research sponsors increases this temptation.

In most cases, the science establishment scorns the scientist who chooses to announce his or her findings via public media before they have been published in a peer-reviewed journal. As discussed by Rescher, there is good reason to be concerned about premature publicity about findings that have not been accepted as valid by the scientific community. Well known researchers or research institutions can use the sensationalism, which is as much a characteristic of science reporting as other types of journalism, to influence public opinion and governmental funding agencies. The media emphasis on such values as the novel and the spectacular which, if translated into more funds for this type of study, can distort the development of science.

Other types of ethical conflict, not mentioned by Rescher, may result from publication standards. A scientist may be convinced that the results of a study are valid, and may have significant, perhaps even urgent, social value, although they do not quite meet the often rigid standards set by his or her peers. One such standard is the generally accepted requirement that in order to be considered valid, a result derived from statistical analysis of data must have less than a 5% chance of being a result of chance. Suppose a scientist analyzes some geological data that show that some natural disaster is likely to occur at the 93% rather than the 95% statistical confidence level. No possibility exists of doing further studies that might increase the certainty of the result. Peer reviewers at the relevant scientific journal reject the report because it fails the 95% test. The scientist must make the decision whether to accept this judgment or risk the opprobrium of colleagues and make the results known by seeking the help of news-hungry science journalists.

- Control of scientific "misinformation"

Rescher affirms that scientists have a duty to control and suppress scientific misinformation. This obligation extends to preventing erroneous research findings from misleading their colleagues and, perhaps more urgently, to protect against the danger that false results may endanger the health or welfare of the public.

On the other hand, Rescher warns against misusing this need to censor misinformation in a way that stifles novelty and innovation. Too often in the history of science, scientists, particularly those who are young and not yet well-established, have found it very difficult to gain acceptance for revolutionary discoveries that do not fit within the prevailing disciplinary paradigm.

Rescher also raises the issue of science versus pseudo-science. Whereas the need to control misinformation would logically extend to pseudo-science, he points out that the distinction between what is accepted as science and what some members of the scientific community would label as pseudo-science is not always clear. As examples of contemporary problems in this area are the scientific standing of various forms of extra-sensory perception, herbal and other non-Western, "traditional" medicines, acupuncture and the recent controversy over the validity of "cold fusion." Rescher urges caution to those who would settle such disputes through censorship and suppression of views that they fear might damage the public image of science. He suggests, instead that scientists have faith that truth will "...win out in the market place of freely interchanged ideas..."

- Allocation of credit for scientific research achievements.

For obvious reasons, scientists are no less interested than those in any other field of endeavor in receiving appropriate credit for their work. Rescher mentions the bitter disputes that have arisen over the years with regard to decisions about who should receive credit for a particular discovery or invention. The agreement by the international scientific community to give such credit to the scientist(s) whose report of the discovery is first submitted to an appropriate journal has provided a means for resolving most, but not all such disputes. The recent controversy over the discovery of the virus that causes AIDS demonstrates that this procedure is not infallible, at least in cases where it may be difficult to determine if research reports from different laboratories are describing the same phenomenon. Furthermore since different laboratories frequently make nearly simultaneous, independent discoveries of the same scientific result or phenomenon, the question arises as to the ethical justification for giving all of the credit to the one who just happens to be first to submit the results for publication.

As Rescher points out, the fact that since scientific work is usually a collaborative effort, either within a single research facility, or involving several laboratories, the issue of allocating credit can be very complicated. This has become an even more problematic issue since Rescher first wrote his essay in 1965. In some fields, like high energy nuclear physics, the list of authors can exceed ten, or even twenty. Cases where junior colleagues or graduate students believe that a senior researcher has usurped credit that they deserve are not uncommon. Even issues like the order of the names on a published research article -- should they be listed alphabetically, in decreasing order of the contribution made, or in order of seniority -- can result in controversy.

A current ethical issue related to credit, and to authorship of research reports, is the extent to which a scientist whose name appears as an author should be held responsible for all the data and results reported in a published paper. This issue emerged from cases where data in a paper have been challenged as being wrong and perhaps fraudulently represented. If the work is a collaborative effort, involving researchers from different scientific disciplines, is it reasonable to expect all of them to vouch for the entire content of the paper? If not, should each author's contribution be clearly stated in the paper, or in a footnote?

One source of disputes concerning credit for research ideas and ownership of intellectual property is the peer review process. The National Science Foundation reports that accusations that a peer reviewer appropriated an experimental or theoretical idea or result from a research proposal or paper he or she was sent to evaluate, is the largest category of scientific misconduct complaints that it receives. Of course, the number of such serious accusations is only a very small fraction of all the proposals and papers that are reviewed.

This completes our discussion of ethical issues related to the practice of science under the headings in Rescher's essay. It is by no means an exhaustive list of issues of the types he discussed. There are also other important categories of ethical concerns not mentioned by Rescher. For example, there are ethical concerns related to the relative importance of cooperation and competition in scientific research, and the related issue of the extent to which scientists are obliged to share their data. (This issue is discussed in chapter 4 in connection with the case study on the discovery of the structure of DNA.)

Rescher explicitly states that he chose to ignore ethical issues related to societal uses of science as opposed to those associated with the practice of science. He claims that issues related to the exploitation of science "are not ethical choices that confront the scientist himself." This very assertion has been a continuing subject of dispute, both within the scientific community itself, as well as among philosophers, historians and sociologists of science. Not only is the obvious point made that scientists are members of society, and are therefore confronted by questions related to the social uses of science, a more controversial ethical claim is made by those who take issue with Rescher's disclaimer. They assert that scientists, because of their special knowledge, and because of the support they demand from society, have a social obligation to concern themselves with the uses that society makes of science, and to help the lay public make informed choices about technological issues.

Independent of this question concerning the social responsibility of the scientist, we believe that the introduction of ethical issues in the secondary school science curriculum should definitely include those related to the social uses, as well as the "doing" of science. Most students will not become scientists, but all students will need to participate, as citizens, in making informed choices about the uses of science.

We will mention two major contemporary developments in which numerous ethics and values issues related to the uses of science arise. The first is the rapidly developing field of bioengineering, including the application of the powerful techniques associated with modern genetics research. The results of the massive international Human Genome Project will further expand the need to confront a long list of extremely controversial social uses of this work. With increasing frequency, front page headlines and prime time TV news stories draw public attention to these controversies. Should society condone, or even encourage the cloning of animals, and perhaps human beings? Should prospective parents be able to buy embryos, with specific genetic pedigrees, for implantation into the woman's uterus? Should an individual's genetic code be kept on file by the government, and if so, to whom should it be available?

A second contemporary development that poses numerous ethics and values choices related to applied science is the worldwide concern about the potential conflict between industrial development and the ecological health of the planet. The growing list of serious local, regional and global environmental problems, including the pollution of air, water and land, acid precipitation, soil erosion, stratospheric ozone depletion and global warming, has spawned an increased sense of urgency among the world's people and their political leaders about the present and future health of the earth's ecosystems. Decisions concerning what to do about these problems involve an evaluation of the scientific facts in the context of many other value-laden social and political factors. Should the developing nations of the world be denied the benefits of the technologies that have resulted in serious pollution problems as a result of their widespread use by the developed nations? Is it appropriate to base environmental decisions on cost-benefit analysis when this requires measuring such human values as life, health and beauty in economic terms? Should the use of a chemical be banned when it is estimated to cause one death in a million, ten thousand or one thousand exposed people? What roles should scientists, political leaders and informed citizens play in making environmental decisions?

Further discussion of ethics and values issues related to the "doing" and "using" of science will be found in connection with the examples used in Chapters 2 and 3, and in more detail in association with the case studies presented in Chapter 4. We certainly make no claims to present, in this brief text, a comprehensive treatment of the vast terrain occupied by the intersection between science and ethic/values issues. Our purpose in this and succeeding chapters is to demonstrate the important and essential need to teach science in a manner that illuminates its ethical content. One reason for doing this is the practical result discovered by the teachers who attended our Summer Institutes: it heightens the interest of their students because of the "humanizing" effect of incorporating ethics into science teaching. But, we believe that a more important reason is our obligation as teachers to convey to our students the true nature of the human enterprise that we call science. As Rescher states in the final section of his essay, "It is a regrettable fact that too many persons, both scientists and students of the scientific method, have had their attention focused so sharply upon the abstracted 'logic' of an idealized 'scientific method' that this ethical dimension of science has completely escaped their notice. This circumstance seems to me particularly regrettable because it has fostered a harmful myth that finds strong support in both the scientific and the humanistic camps -- namely the view that science is antiseptically devoid of any involvement with human values."[(15)]

CHAPTER 2
What is Ethics?

Defining *ethics* and *morality*.

Ethics is concerned with what is right or wrong, good or bad, fair or unfair, responsible or irresponsible, obligatory or permissible, praiseworthy or blameworthy. It is associated with guilt, shame, indignation, resentment, empathy, compassion, and care. It is interested in character as well as conduct. It addresses matters of public policy as well as more personal matters. On the one hand, it draws strength from our social environment, established practices, law, religion, and individual conscience. On the other hand, it critically assesses each of these sources of strength. So, ethics is complex and often perplexing and controversial. It defies concise, clear definition. Yet, it is something with which all of us, including young children, have a working familiarity.

This makes ethics sound like morality. This is intentional on our part. Like most contemporary texts, ours will treat *ethics* and *morality* as roughly synonymous. This is in keeping with the etymology of the two words. *Moral* derives from the Latin word*moralis*. *Moralis* was a term that ancient Roman philosopher Cicero made up to translate the ancient Greek *ethikos* into Latin.[16] Both mean, roughly, "pertaining to character;" but today their English derivatives deal with much more than character.

It is tempting to seek a general definition of *ethics* before discussing any particular ethical topic. Although we have said a little bit about what we take ethics to be, we have not offered such a definition; and we will not do so. Demanding a definition at the outset can stifle discussion as easily as it can stimulate it. We offer one of Plato's dialogues as a case in point.

In the *Euthyphro* we find Socrates and Euthyphro meeting each other on the way to court. Socrates is being tried allegedly for corrupting the youth by encouraging them to believe in "false gods" and for making the better argument appear the worse.[17]Euthyphro is setting out to prosecute his father allegedly for murdering one of his servants. Socrates expresses surprise that Euthyphro would prosecute his own father, and he asks him for an explanation. Euthyphro appeals to the justice[18] of doing this. Socrates then asks him to define *justice*. Euthyphro offers some examples of justice and injustice. Socrates rejects them all on the grounds that they are only examples, whereas what he wants Euthyphro to tell him is what all just acts have in common that makes them just. That is, what Socrates demands is a definition that captures the *essence* of justice in all of its instances. Unfortunately, Euthyphro attempts to satisfy Socrates's demand rather than challenge its reasonableness. All of his efforts fail miserably, and the dialogue ends with Euthyphro indicating he must leave to get on with his business. The implication is that Euthyphro is going off to prosecute his father without the least grasp of the value in which name he is acting, justice.

As much as we might desire the sort of definition Socrates and Euthyphro were seeking, it seems an unreasonable demand. At best, this might come at the end of an inquiry rather than at its beginning. Morality, like science, should allow room for piecemeal exploration and discovery. It should not be necessary to provide a comprehensive definition of *justice* in order to be able to say with confidence that sometimes drawing lots is a just procedure, having the person who cuts the pie get the last piece is just, compensating people for the work they do is just, denying women the right to vote is unjust, punishing the innocent is unjust, and so on. Further reflection might reveal special features these examples all have in common, or at least special ways of grouping them. But having a solid starting point does not require having a well worked out definition of the concept under consideration.

18th century philosopher Thomas Reid has some useful advice for those interested in developing a systematic understanding of morality. He compares a system of morals to "laws of motion in the natural world, which, though few and simple, serve to regulate an infinite variety of operations throughout the universe."(19) However, he contrasts a system of morals with a system of geometry:(20)

A system of morals is not like a system of geometry, where the subsequent parts derive their evidence from the preceding, and one chain of reasoning is carried on from the beginning; so that, if the arrangement is changed, the chain is broken, and the evidence is lost. It resembles more a system of botany, or mineralogy, where the subsequent parts depend not for their evidence upon the preceding, and the arrangement is made to facilitate apprehension and memory, and not to give evidence.

Reid's view has important implications for how we should characterize moral development. On the botanical model, access to basic moral understanding need not be an all or nothing affair. Its range and complexity can be a matter of degree, and confusion in one area need not infect all others. Understanding how different, basic moral considerations are related to one another can be a matter for discovery (and dispute) without our having to say that those whose picture is incomplete, or somewhat confused have no understanding of basic moral concepts.

Ethics and childhood.

Children's introduction to ethics, or morality, comes rather early. They argue with siblings and playmates about what is fair or unfair. The praise and blame they receive from parents, teachers, and others encourages them to believe that they are capable of some degree of responsible behavior. They are both recipients and dispensers of resentment, indignation, and other morally reactive attitudes. There is also strong evidence that children, even as young as four, seem to have an intuitive understanding of the difference between what is merely conventional (e.g., wearing certain clothes to school) and what is morally important (e.g., not throwing paint in another child's face).[(21)] So, despite their limited experience, children typically have a fair degree of moral sophistication by the time they enter school.

What comes next is a gradual enlargement and refinement of basic moral concepts, a process that, nevertheless, preserves many of the central features of those concepts. All of us can probably recall examples from our childhood of clear instances of fairness, unfairness, honesty, dishonesty, courage, and cowardice that have retained their grip on us as paradigms, or clear cut illustrations, of basic moral ideas. As philosopher Gareth Matthews puts it:[(22)]

A young child is able to latch onto the moral kind, bravery, or lying, by grasping central paradigms of that kind, paradigms that even the most mature and sophisticated moral agents still count as paradigmatic. Moral development is ... enlarging the stock of paradigms for each moral kind; developing better and better definitions of whatever it is these paradigms exemplify; appreciating better the relation between straightforward instances of the kind and close relatives; and learning to adjudicate competing claims from different moral kinds (classically the sometimes competing claims of justice and compassion, but many other conflicts are possible).

This makes it clear that, although a child's moral start may be early and impressive, there is much conflict and confusion that needs to be sorted through. It means that there is a continual need for moral reflection, and this does not stop with adulthood, which merely adds new dimensions.

Nevertheless, some may think that morality is more a matter of subjective feelings than careful reflection. However, research by developmental psychologists such as Jean Piaget, Lawrence Kohlberg, Carol Gilligan, James Rest, and many others provides strong evidence that, important as feelings are, moral reasoning is a fundamental part of morality as well.[23] Piaget and Kohlberg, in particular, did pioneering work to show that there are significant parallels between the cognitive development of children and their moral development. Many of the details of their accounts have been hotly disputed, but a salient feature that survives is that moral *judgment* involves more than just feelings. Moral judgments (e.g., "Smith acted wrongly in fabricating the lab data") are amenable to being either supported or criticized by *good reasons*. ("By fabricating the data, Smith has misled other researchers and contributed to an atmosphere of distrust in the lab." "A thorough examination of Smith's notebooks shows that no fabrication has taken place.")

Kohlberg's account of moral development has attracted a very large following among educators, as well as a growing number of critics. He characterizes development in terms of an invariable sequence of six stages.[24] The first two stages are highly self-interested and self-centered. Stage one is dominated by the fear of punishment and the promise of reward. Stage two is based on reciprocal agreements ("You scratch my back, and I'll scratch yours"). The next two stages are what Kohlberg calls conventional morality. Stage three rests on the approval and disapproval of friends and peers. Stage four appeals to "law and order" as necessary for social cohesion and order. Only the last two stages embrace what Kohlberg calls critical, or post-conventional, morality. In these two stages one acts on self-chosen principles that can be used to evaluate the appropriateness of responses in the first four stages. Kohlberg has been criticized for holding that moral development proceeds in a rigidly sequential manner (no stage can be skipped, and there is no regression to earlier stages); for assuming that later stages are more adequate morally than earlier ones; for being male biased in overemphasizing the separateness of individuals, justice, rights, duties, and abstract principles at the expense of equally important notions of interdependence, care, and responsibility; for claiming that moral development follows basically the same patterns in all societies; for underestimating the moral abilities of younger children; and for underestimating the extent to which adults employ critical moral reasoning. We will not attempt to address these issues here.[25] Nevertheless, whatever its limitations, Kohlberg's theory makes some important contributions to our understanding of moral education. By describing many common types of moral reasoning, it invites us to be more reflective about how we and those around us typically do arrive at our moral judgments. It invites us to raise critical questions about how we*should* arrive at those judgments. It encourages us to be more autonomous, or critical, in our moral thinking rather than simply letting others set our moral values for us and allowing ourselves to accept without any questions the conventions that currently prevail. It brings vividly to mind our self-interested and egocentric tendencies and urges us to employ more perceptive and consistent habits of moral thinking. Finally, it emphasizes the importance of giving reasons in support of our judgments.

Descriptive and normative inquiry.

It is useful to think of *ethics*, or *morality*, as an umbrella term that covers a broad range of practical concerns, many of which are rather straightforwardly understood and dealt with, but some of which are not very clearly understood and are often quite controversial. This can help us see how the study of ethics differs from most other subjects of study, at least as they are traditionally understood.

Chemistry, for example, is typically viewed as *empirical*, or *descriptive*. We study chemistry to learn about how acids are different from bases, what the basic chemical properties of certain metals are, what the most basic principles are that explain chemical changes, and so on. Presumably, what we learn is based on careful, scientific observation. There is an attempt to describe what *is* the case, at least in the world of chemistry.

There is a descriptive aspect of morality, too. Psychologists, sociologists, and anthropologists might try to determine what particular values a certain group of people actually accept, how these values are related to people's behavior, their social and political institutions, or their religious beliefs. They can assemble information about the kinds of values people hold. Some of these values, although not moral values themselves (e.g., certain aesthetic values or value we attach to material goods), may nevertheless be regarded as important enough to be accorded moral (and even legal) protection. But social scientists can describe this without necessarily endorsing the values that people actually accept as values they *ought* to accept. To ask what values people *ought* to accept is to ask a *normative*, rather than simply a *descriptive* question. It is to ask what values are *worthy* of being accepted, rather than simply *whether* they are accepted; and it is the business of normative ethics to address these questions.

Philosophical ethics.

Traditionally, ethics has been taught at the college level mainly in departments of philosophy. (We will discuss how this has recently changed in Chapter 3.) In large part, philosophical ethics is normative in its focus. It examines basic questions about what our values should be, what, if any, fundamental grounding they can be given, and whether they can be organized into a comprehensive, coherent theory. Another part of philosophical ethics is called *metaethics*, which studies the nature of the language and logic we use when we are concerned about morality (as distinct from, say, law or social etiquette).

Although the study of philosophical ethics might make valuable contributions to our understanding of relationships between ethics and science, we do not regard it as a necessary preparation for bringing ethics into science classes. Thomas Reid wisely warns us not to make the mistake of thinking that "in order to understand [one's] duty, [one] must needs be a philosopher and a metaphysician."(26) This does not mean that careful reflection is not needed. Nor does it mean that philosophical reflection is not needed. But, just as we do not need to be logicians in order to think logically, mathematicians in order to think mathematically, or scientists in order to think scientifically, we do not have to be philosophers in order to think philosophically.

What Reid is telling us is that we do not need to be a Plato or Aristotle in order to know our way about morally. He is also telling philosophers that in framing their theories they need to respect the understanding that ordinary, thoughtful people have of morality even though they may never have opened a philosophy book. In fact, most moral philosophers do this. For example, Aristotle's account of the virtues, Immanuel Kant's categorical imperative ("Act only on those maxims that you could at the same time will to be a universal law"), and John Stuart Mill's utilitarian theories (promote the greatest good for the greatest number) all begin with what they take to be commonly accepted moral views; and they see their task as articulating, refining, and reworking these views where necessary. They do this in ways that, nevertheless, respect common, everyday morality. For example, Kant tries to show how his categorical imperative gives us an improved understanding of the moral insights provided by the Golden Rule. John Stuart Mill argues that his utilitarian theory both respects and provides a solid foundation for such basic, commonly accepted rules of morality as telling the truth and keeping promises, while at the same time providing a more fundamental principle for resolving conflicts among rules (e.g., when keeping a promise requires harming someone). Difficult to discern as their writings sometimes are, the constraints that common morality placed on them remain evident.

Common moral values.

Given the apparent moral differences found among people with different national, ethnic, or religious backgrounds, it may seem naive to talk, as we have, of common moral values. What moral values, if any, might be sharable across national, ethnic, religious, or other boundaries? This is the question philosopher Sissela Bok takes up in her recent book, *Common Values*.(27) She begins by listing a number of problems that cut across these boundaries: problems of the environment; war and hostility; epidemics; overpopulation; poverty; hunger; natural disasters (earthquakes, tornados, drought, floods); and even technological disasters (Chernobyl). The fact that we recognize these as common problems suggests that we share some basic values (e.g., health, safety, and the desire for at least minimal happiness).

However, our desire to "get to the bottom of things" often blocks gaining a clearer understanding of what we have in common. Bok nicely outlines this problem. She notes that we may feel we need a common base from which to proceed. But there are different ways in which we might express what we think we need. Bok mentions ten different ways. We may seek a set of moral values that are:

1. divinely ordained,

2. part of the natural order,

3. eternally valid,

4. valid without exception,

5. directly knowable by anyone who is rational,

6. perceivable by a "moral sense,"

7. independent of us, in the sense that they do not depend on us for their existence,

8. objective rather than subjective,

9. held in common by virtually all human beings,

10. such that they've had to be worked out by all human societies.

Although religious and philosophical traditions have concentrated on 1-8, Bok suggests we should start with 9 and 10. Given the inability of our religious and philosophical traditions to reach consensus thus far on 1-8, it seems unlikely, she says, that we will reach consensus on 1-8.

In regard to 9 and 10, Bok makes four basic claims. First, there is a *minimalist* set of values that every viable society has had to accept in order to survive collectively. This includes positive duties of mutual support, loyalty, and reciprocity; negative duties to refrain from harming others; and norms for basic procedures and standards for resolving issues of justice. Second, she says that these values are necessary (although not sufficient) for human coexistence at every level--in one's personal and working life, in one's family, community, and nation, and even in international relations. Third, these values can respect diversity while at the same time providing a general framework within which abuses can be criticized. Finally, Bok says, these values can provide a common basis for cross-cultural discussions about how to deal with problems that have global dimensions.

Bok's point about finding common values while respecting diversity is very important. It is fairly easy to see that the same general values might play themselves out quite differently from one locale to another. For example, although England and the United States drive on opposite sides of the road, they share the same basic values of safe and efficient travel. There is no reason to insist that one way is better than the other for these purposes. However, either is clearly preferable to, say, a rule that mandates driving on the left side on Monday, Wednesday, Friday and the right side on Tuesday, Thursday, and the weekend -- or no rule at all. The United States tends to use stop lights at intersections, while England favors roundabouts. They may work equally well, or one may be better than the other -- as judged by the same general values of safety and efficiency. It is also quite likely that both systems can be improved in ways yet to be discovered.

However, Bok is making another point as well. She is suggesting that, even in the absence of agreement at the most fundamental level, those with very different moral and religious backgrounds may find common ground. A good example of this is the consensus reached by the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. This commission was established by the United States Congress in 1974, and it issued what is known as the Belmont Report in 1978. This report contains the guidelines used by institutional review boards (IRBs) at colleges, universities, and other institutions that receive federal funding for research involving human subjects. The task of IRBs is to examine research protocols to make certain that the rights and welfare of human subjects are being protected.

Congress made a serious effort to make sure that different perspectives would be represented. Albert Jonsen and Stephen Toulmin describe the composition of the commission in this way:(28)

The eleven commissioners had varied backgrounds and interests. They included men and women; blacks and whites; Catholics and Protestants, Jews, and atheists; medical scientists and behaviorist psychologists; philosophers; lawyers; theologians; and public representatives. In all, five commissioners had scientific interests and six did not.

The commission got off to a slow start. Their deep religious and philosophical differences surfaced quickly and blocked their ability to move ahead. Then they decided to talk first about specific examples rather than more foundational concerns. As they discussed particular cases of research involving human subjects (like the Tuskegee case we will present later), they discovered substantial areas of agreement that enabled them eventually to formulate three basic areas of ethical concern: respect for persons, beneficence, and justice.

In articulating their concerns about respect for persons, the commission agreed with the Kantian idea that it is inappropriate to treat persons merely as means to the ends of research. They agreed that it is important to obtain the informed consent of subjects before including them in an experiment, thus respecting their ability and right to make an informed decision (respect for autonomy). In regard to beneficence, the commission accepted the utilitarian idea of trying to maximize benefits to human subjects while minimizing the risk of harm. Finally, in regard to justice, the commission agreed that discrimination in the selection of research subjects is inappropriate and that special attention needs to be given to especially vulnerable groups such as prisoners, children, and the elderly.

However, the commission also carefully avoided committing itself to a set of inflexible guidelines. The *Belmont Report* confidently, but modestly, comments:[(29)]

Three principles, or general prescriptive judgments, that are relevant to research involving human subjects are identified in this statement. Other principles may also be relevant. These three are comprehensive, however, and are stated at a level of generalization that should assist scientists, subjects, reviewers and interested citizens to understand the ethical issues inherent in research involving human subjects. These principles cannot always be applied so as to resolve beyond dispute particular ethical problems. The objective is to provide an analytical framework that will guide the resolution of ethical problems arising from research involving human subjects.

So, as a result of their willingness to reason with each other despite their differences, the commission succeeded in coming up with a workable document that is now reflected in the policies and practices of research institutions that receive federal funding for some of their research. Both the deliberate process and its results bear the marks of *reasonableness* that we might hope is obtainable in a democratic, but diverse, society. In fact, the work of the commission models many of the values that can be served by bringing ethics into the science classroom by making apparent how science and ethics are interrelated and how the challenges this poses might be thoughtfully addressed.

Reasonableness.

Insofar as we are concerned with *justifying* our moral judgments, as distinct from simply asserting our views, we are striving to be reasonable with others. Justification in morality is similar to justification in science in this respect. Justification in either realm is a public process. Convincing oneself privately, and only in one's own terms, is insufficient. A mark of unreasonableness is an unwillingness seriously to consider ideas unless they are cast in one's own terms and in ways congenial to one's preset views. W.H. Sibley puts the moral case rather well:[30]

If I desire that my conduct shall be deemed *reasonable* by someone taking the standpoint of moral judgment, I must exhibit something more than mere rationality or intelligence. To be reasonable here is to see the matter -- as commonly put it -- from the other person's point of view, to discover how each will be affected by the possible alternative actions; and moreover not merely to "see" this (for any merely prudent person would do as much) but also to be prepared to be disinterestedly *influenced*, in reaching a decision, by the estimate of these possible results. I must justify my conduct in terms of some principle capable of being appealed to by all parties concerned, some principle from which we can reason in common.

Coming up with principles from which we can reason in common may seem like quite a challenge. But there is a wide-reaching, long-standing principle that is useful in getting us started. Most moral systems and major religions subscribe to some form of the Golden Rule: Do unto others as you would have them do unto you. Although simple to state, interpreting this principle has proven more difficult.[31] We will discuss briefly a few of the difficulties and suggest how the Golden Rule might, nevertheless, prove useful in promoting the kind of reasonableness Sibley advocates.

Sometimes the Golden Rule is understood as a maxim of prudence: If you don't treat others as you want them to treat you, they may do likewise. Of course, we can take our chances that others will not do likewise, but this will usually require concealing from others that we are willing to take advantage of them, harm them, or cause them serious inconvenience in order to get what we want. This may work on special occasions, but it is difficult to sustain this on a regular basis, especially with those with whom one has a great deal of contact. So, it seems safer not to treat others in ways we don't want them to treat us -- for the most part.(32)

However, this rendering of the Golden Rule seems to fall short of capturing its moral intent, which is supposed to move us beyond thinking only of ourselves. If the prudential rendering is too centered on self-interest, there is another rendering that seems to go too far in the opposite direction, altruism. This rendering suggests that, since I would appreciate others making sacrifices to help me get what I want, I should do this for them. Taken to an extreme, each of us would give up much of what we want for ourselves in order that others will get what they want. Admirable as giving to others is, this seems to go too far in the direction of self-sacrifice.

That the Golden Rule might be given two such contrary renderings (self-interested and self-sacrificial) suggests that something has been lost in the translation. The Golden Rule was brought into this discussion in order to help clarify Sibley's notion of reasonableness. Yet, both renderings seem to end up with forms of unreasonableness. The self-interested version is unreasonable because it takes too much for oneself. The altruistic version is unreasonable because it does not leave enough for oneself. Either way there is a serious imbalance between the claims of oneself and others. The sort of reasonableness commended by Sibley urges us to employ a principle from which we can reason in common. This is really an appeal to fairness -- to be fair to others and to ourselves. Neither rendering of the Golden Rule discussed so far satisfies this.

We suggest that the Golden Rule be seen as embracing two basic moral concepts. The first is *universalizability*: Whatever is right (or wrong) in one situation is right (or wrong) in any relevantly similar situation.(33) This is a requirement of both consistency and fairness. If it is morally acceptable for Judy, a brilliant, young scientist, to alter data to make it look better, it is morally acceptable for others in relevantly similar circumstances to do likewise. This would have a rather general application--rendering morally acceptable the alteration of data by all scientists, engineers, and many others who may find themselves in similar circumstances. If Judy considers the likely consequences of all scientists altering data when it seems to be advantageous to do so, she will come up with a very different picture than if only the consequences of one alteration of data is imagined. This will make it much harder for her to justify altering data.

The second concept the Golden Rules embraces is *reversibility*. In treating others as I would have them treat me I need to ask what I would think if the roles were reversed. For example, in contemplating lying to someone in order to avoid a difficulty, I need to ask if I would object to the lie if I were being lied to in a similar circumstance. By subjecting our thinking to this reversibility test, we will often find it more difficult to justify lying than when we do not consider how we would feel about being on the receiving end of such a lie.

Of course, the Golden Rule cannot do everything by itself. Its successful use depends on other values we have. For example, if I place no value on human life, including my own, then universalizability and reversibility alone will not show that I should refrain from harming others (or myself). Fortunately, nearly everyone does value at least her own life, happiness, and well-being; nearly everyone objects to being lied to; and nearly everyone recognizes that her happiness and well-being depends to a large extent on cooperation and mutual trust with others. What the Golden Rule can help us see more clearly is what taking these values seriously requires of us morally.

Nevertheless, we should not assume that Golden Rule thinking is always easy, even for those with the best of intentions. Philosopher Sissela Bok notes the dizzying effect the demands of the Golden Rule can have on us:(34)

We need to shift back and forth between the two perspectives, and even to focus on both at once, as in straining to see both aspects of an optical illusion. In ethics, such a double focus leads to applying the Golden Rule: to strain to experience one's acts not only as subject and agent but as recipient, and sometimes victim. And while it is not always easy to put oneself in the place of someone affected by a fate one will never share, there is no such difficulty with lying. We all know what it is like to lie, to be told lies, to be correctly or falsely suspected of having lied. In principle, we can all readily share both perspectives.

In principle, Bok says, we can readily grasp both perspectives. However, *in practice* there are familiar and formidable obstacles. We are often psychologically predisposed against seeing things clearly. Thomas Reid observes:(35)

There is ... no branch of Science wherein Men would be more harmonious in their opinions than in Morals were they free from all Biass and Prejudice. But this is hardly the case with any Man. Mens private Interests, their Passions, and vicious inclinations & habits, do often blind their understandings, and biass their Judgments. And as Men are much disposed to take the Rules of Conduct from Fashion rather than from the Dictates of reason, so with Regard to Vices which are authorized by Fashion the Judgments of Men are apt to be blinded by the Authority of the Multitude especially when Interest or Appetite leads the same Way.

Bok and Reid make evident that there are serious obstacles to clear headed moral thinking, whether this is in the sciences or life in general. At the same time they hold out hope that there is something that we can do about this. Since science itself seeks to avoid "Biass and Prejudice" in its
inquiries, it seems like hospitable ground for hosting moral inquiry. At the same time, moral inquiry can help students of science understand their own liabilities even as they engage in scientific inquiry.

CHAPTER 3
Teaching Ethics

A set of objectives.

For the past several decades, colleges and universities have been wrestling with the question of the place of ethics in higher education. Traditionally, its proper place was thought to be in departments of philosophy or religion. However, beginning in the early 1970's courses in ethics began a rapid expansion into programs in medicine, law, business, education, engineering, journalism, communication, psychology, and so on. In the late 1970's a group of educators representing a broad range of disciplines gathered at the Hastings Center to explore the question of what the objectives in teaching ethics in higher education should be.[(36)] What is particularly striking is that, despite the differences among their respective academic disciplines, these educators developed a consensus statement of five basic objectives. Teaching ethics in higher education, they concluded, should:

- Stimulate the moral imagination of students.
- Help students recognize moral issues.
- Help students analyze key moral concepts and principles.
- Stimulate students' sense of responsibility.
- Help students deal effectively with moral ambiguity and disagreement.

Although intended for ethics in higher education, this set of objectives seems appropriate at the pre-college level as well, especially in junior and senior high school.

A set of assumptions.

We will discuss each of these objectives and suggest how they might be adapted to the schools. However, at the outset, it is important to notice some assumptions about students that underlie this list. The first objective assumes that students already have moral imagination -- the aim is to stimulate it, not to implant it. The second objective assumes that students are capable of recognizing moral issues but that, like all of us, they can be assisted in this. The third objective assumes students are capable of analyzing key moral concepts and principles--the aim being to help them sharpen and refine their abilities. The fourth objective assumes that students already have, to some extent at least, a sense of responsibility. The fifth objective assumes that students are already familiar with moral ambiguity and disagreement, but that they need help in dealing effectively with this. In sum, students are viewed as active learners who already have some aptitude for the study of ethics they will be undertaking.

We believe these are reasonable assumptions to make about junior and senior high school science students, too. Although their familiarity with the various contexts in which moral issues related to science arise is limited, students in their early teens have already had considerable moral experience -- in their family life, in interacting with friends and peers, and in dealing with major institutions such as schools, churches, and, for many, places of employment. Furthermore, they have been exposed to moral issues in the news and, quite dramatically, in popular movies and television programs. So, students are not moral neophytes. However, they may be neophytes as participants in science classrooms that explicitly examine moral issues.

Can ethics be taught?

The notion that ethics might be *taught* at the junior or senior high level is sometimes met with skepticism. The thought may be that if students haven't learned the difference between right and wrong yet, it is too late. The lessons should have begun in the nursery, in the family, the churches. If these lessons took, what is left to be taught? If they didn't, how could it happen now? In one respect, there is something to this concern. Morality does need to have an early beginning in our lives. How, by whom, or even whether, morality should be *taught* in the early years are important questions. At this level, issues about indoctrination and the role of families, churches, and public schools require careful attention. However, the story of moral development is anything but over once we move beyond these early years. Engineer and author Samuel Florman comments on what can be gained even at the college level and beyond:[37]

Skeptics -- both within academe and without--argue that moral character is formed in the home, the church, and the community, and cannot be modified in a college classroom or professional symposium. I cannot agree with the skeptics on this count. Most evil acts are committed not by villains but rather by decent human beings--in desperation, momentary weakness, or an inability to discern what is morally right amid the discordant claims of circumstances. The determination to be good may be molded at an early age, but we grapple all our lives with the definition of what is good, or at least acceptable.

If Florman is right (and we believe he is), early character formation and even the best of moral instruction is not enough.[38] Moral learning is a life-long process. If we change the question from "Can ethics be *taught*?" to "Can ethics be profitably *studied*?" what the Hastings Center group has in mind becomes more evident. *Studying* ethics, rather than trying to indoctrinate a set of moral prescriptions, is what the five objectives emphasize. Students are respected as active learners who bring with them considerable resources to undertake the study of ethics in this or that area -- and should not be subjected to misguided efforts to implant certain moral values in them. We are suggesting that this respect should be extended to junior and senior high school students as well. With this in mind, we now turn to a more detailed discussion of the five Hastings Center objectives.

Stimulating the moral imagination.

Consider a fictional case study, "The Falsified Data."[(39)] Jay is a young chemical engineer who specializes in catalysts to be used in chemical processes in his company. In preliminary research on catalysts, Jay has gathered some data suggesting that catalyst B might be best for a special chemical process. However, based on their experience, the senior chemical engineers in Jay's unit are still convinced catalyst A is best for that sort of process. Jay agrees that his data is inconclusive and that more research is needed. Meanwhile, the head of Jay's division tells the engineers that it is now time to recommend a catalyst for the company to use. Since there is no time for further research on catalyst B, the engineers recommend A. The division head tells Jay to write up the recommendation with supporting data. However, he tells him to "make the numbers look good" by doing the math backwards and leaving out Jay's data concerning catalyst B. What should Jay do?

Many are inclined to say that Jay simply should do what he is told. He is young, relatively inexperienced, and risks losing his job if he doesn't write up the report as requested; besides, his data are only preliminary and, for all he knows, the senior engineers may be right. In the fictional case, Jay does what he is told. However, the next case, "The Falsified Data Strike Back," introduces some complications. Jay's subsequent research shows rather decisively that catalyst B is preferable. Meanwhile, his company has invested a fair amount of money in catalyst A for the process. What should Jay do now? At this point we might want to reconsider the first case. What other options did Jay have? To ask this question is to begin exercising one's moral imagination.

Readers of the periodical *Chemical Engineering* were invited to respond to these two fictional cases. One of the more creative reader responses to "The Falsified Data" suggested that Jay try to convince his division head that the report should "tell it like it is" and include Jay's preliminary data about catalyst B. After all, if the senior engineers are convinced after analyzing all the data available to them that catalyst A is still preferable, why should it be necessary to "make the numbers look good" in order to persuade those at the next level that their recommendation is sound? Even if it later turns out that catalyst B is preferable, no one can complain that relevant data were deliberately withheld or that the math was done backwards. This may not actually convince Jay's division head, but it seems worth the effort.

A business manager interviewed in Barbara Toffler's *Tough Choices* points out the importance of imaginative thinking when facing moral challenges like Jay's:[40]

I first play out the scenario of what would happen if I did it one way and what would happen if I did it the other way. What would be the follow-up? What would be the next move? What would be the response back and what would be the consequences? That's the only way you can tell if you're going to make the right move or not because I think something that instinctively may feel right or wrong, if you analyze it, may not pan out that way.

The technique suggested by this business manager is one effective way of engaging one's moral imagination. The classroom itself provides another way. One of the advantages of discussing situations like Jay's in class is that, by thinking together, students are often able to come up with constructive alternatives that would not have occurred to them when thinking alone. Once again, we see students themselves as a powerful resource for generating new and useful ideas, rather than simply waiting for their teachers to provide them with answers.

Recognizing moral issues.

It is rather obvious that "The Falsified Data" raises moral issues. This is implied by the title, which suggests that, among other things, honesty and truthfulness are at stake. However, situations calling for moral reflection do not normally come with labels alerting us to this. In fact, all too often we find ourselves in the middle of moral difficulties without advance warning -- or without having noticed warning signals. If we are on the lookout for potential moral complications, it may be possible to prevent these problems from arising in the first place, or at least to lessen their severity.

For example, suppose Jay also represents his company in dealing with vendors who supply needed materials. Over time Jay may develop friendships with certain vendors. What if one of these vendors offers him free use of his vacation home for a week? Will it occur to Jay that accepting favors like this might compromise his judgment in his future dealings with vendors? Or will it occur to Jay that *others* might perceive this as compromising his judgment?

Routinely accepted practices can also have unnoticed objectionable features. Until fairly recently, the use of deception in designing experimental research was regarded as unproblematic. The infamous Tuskegee study of the long-term effects of untreated syphilis relied on deceiving subjects in the study about the true nature of their disease and the medical attention they were receiving.(41) The well-known Milgram studies on obedience had deception of volunteer subjects as an essential part of the experiment.(42) As we look back at these practices with questioning eyes, we need not see moral villains. Rather, we see a confirmation of Samuel Florman's view that even decent people can do things that, on more careful reflection, are morally inappropriate.

Analyzing key moral concepts and principles.

In examining examples like those just presented, key moral concepts and principles come to our attention and require clarification. For example, in "The Falsified Data" has Jay been asked to *lie*? What is a lie? Falsifying data seems to be lying, but what about withholding data, which in this case seems to be at least *deceptive*. What is wrong with lying or engaging in deceptive practices as a scientist or engineer? Is the offer of a free condo for a week simply an act of *friendship*, or could it be viewed as a*bribe*? What is a bribe, and what moral issues does bribery raise? If Jay accepts the offer (whether we understand it as an act of friendship or as a bribe), has he created a *conflict of interest* for himself in future dealings with vendors? What is a conflict of interest, and what moral issues does such a conflict raise?

Although junior and senior high school students have not had to face situations quite like Jay's, it is not difficult to make connections. In their science classes they prepare lab reports. If the data do not appear as they think it ought to (or as they think their teachers expect it to), they may wonder about "making the numbers look good." Or their lab partners might urge them to "clean up" the report. They may recognize that part of what is at stake is their honesty and truthfulness, or this may not occur to them until after their teachers question them. Or they may recognize that their honesty and truthfulness is at stake but not recognize what else is at stake -- viz., the importance *for others* that scientific experimentation and reporting be conducted competently and with honesty.(43)

Stimulating a sense of responsibility.

Discussions of situations like Jay's, as well as discussions of the societal impact of scientific practice, raise important questions about scientific responsibility. These questions may be about the individual responsibilities of scientists as practitioners, or they may be larger questions about the impact of science on society and a more collective responsibility for that impact (focusing, for example, on the responsibilities of educational institutions, professional societies, governmental agencies, and businesses). This, in turn, can stimulate students' sense of responsibility as future scientists or as participants in a democratic society that provides citizens with opportunities to participate in the shaping of its institutions, practices, and public policies, as well as to vote for or against individuals seeking public office. But it can also stimulate their sense of responsibility as students in the classroom.

Ethicist William F. May points out the need to pay particular attention to matters of moral character and virtue in our highly professionalized society. Most professionals, including scientists, work in large organizations and perform highly specialized functions that are understood by a relatively small number of people. As our growing knowledge in specialized areas increases, we are also becoming more and more dependent on those who have this knowledge to exercise it responsibly. May comments, "The knowledge explosion is also an ignorance explosion; if knowledge is power, then ignorance is powerlessness."[(44)] He then offers a test of professional character and virtue: "One test of character and virtue is what a person does when no one else is watching. A society that rests on expertise needs more people who can pass that test."[(45)] Scientists, for example, must depend on each other to do thorough, honest work in conducting and reporting their experiments. Scientists have neither the time or ability to check up on the reliability of all the work of other scientists -- not even of those with whom they work, who may have expertise in areas that only they understand well. So, they must trust each other; and the public must trust scientists. In short, to a large extent, "no one else is watching" when scientists do their work.

It is important to realize that our attitudes toward responsibility can vary quite widely. We might think of a spectrum, with irresponsibility at one end and going "above and beyond the call of duty" at the other. Much of the current literature on ethics in science focuses on wrongdoing (e.g., falsifying data, plagiarism, willful or negligent causing of harm, violation of regulations). Particularly when this is associated with potential litigation, unlawful behavior, or the violation of specific professional standards (as found, e.g., in a code of ethics), it is tempting to focus primarily on what must be done in order to avoid getting in trouble.

There is a *Calvin and Hobbes* comic strip in which six-year-old Calvin congratulates himself for staying out of trouble and for not doing bad things.[(46)] He suggest to his companion, Hobbes the stuffed tiger, that this shows he deserves lots of Christmas presents. Hobbes wryly replies, "Maybe good is more than the absence of bad." Calvin's view could be characterized as *minimalist* when it comes to responsibility. (Elsewhere, after Hobbes notes how impressed Calvin's mother is that Calvin has made his bed, Calvin replies that he likes people to be impressed when he fulfills the least of his obligations.) At the other end of the responsibility spectrum are instances of *exemplary* work. Presenting stories of exemplary scientific practice can also be an effective way of stimulating students' sense of responsibility by modeling responsibility at its best. A good illustration is the story of Fran Kelsey, a Food and Drug Administration official in the early 1960's.(47) Despite considerable industry pressure to approve a "morning sickness" pill for pregnant women, Kelsey insisted on further testing. She had seen reports of animal studies and human trials in England that raised questions for her about the drug's safety. Yet, if she had approved the drug, this would have been fully within standard regulatory practice. What was the drug in question? Thalidomide, whose use by pregnant women in England and Germany resulted in a large number of their babies being born with gross physical deformities. For her efforts Fran Kelsey received a Congressional Medal of Honor from President John F. Kennedy in 1962.

Dealing with moral ambiguity and disagreement.

Consideration of moral problems that arise in the sciences can be complicated in a variety of ways. First, there may be uncertainty or disagreement about what the relevant facts are. Second, there may be uncertainty or disagreement about the relative importance of facts that bear on the problems. Third, there may be uncertainty or disagreement at the level of basic moral principles or moral orientation. Fourth, there are some problems that seem to be genuine moral dilemmas. All of this becomes readily apparent in classroom discussions, and it raises important questions about what students and teachers should expect from discussions of moral issues.

One response to these complications is, "There are no right or wrong answers." However, uncertainty and disagreement themselves do not warrant this conclusion. Insofar as the uncertainty or disagreement pivots around factual matters such a conclusion would be premature. This means that one of the first tasks of analysis is to get as clear as possible about the relevant facts. Scientific inquiry itself is characterized by factual uncertainty and disagreement, but it is based on the assumption that further inquiry can help resolve this.

However, many people apparently believe that there is a fundamental difference between factual and value issues. This is often reinforced in the schools -- factual issues can be resolved, it may be said, whereas value issues are simply a "matter of opinion". But we need to realize that this way of putting the "fact/value" distinction is itself highly controversial and the subject of much philosophical discussion. Furthermore, it is not clear what the implications of making the distinction in this way are. Does something's being simply a "matter of opinion" imply that, when it comes to opinions, one opinion is as good (or bad) as another? If so, then we might wonder what the point is of trying to examine carefully moral issues in the sciences . Is it true that no matter what moral opinion one comes to, it is no better or worse than any other opinion (including one's previous or future opinions)? If so, we might ask, why bother?

At the same time, if teachers insist that there are right and wrong answers (and attempt to provide them to the students), they risk being accused of attempting to indoctrinate their students. Equally worrisome, they risk discouraging students from thinking for themselves about moral issues. In any case, whether or not they agree with their teacher's pronouncements, students may soon become more interested in their teacher's answers than in the reflective process itself; after all, they may think, to get a good grade one must satisfy the teacher's expectations -- which, in this case, is to come up with what the teacher thinks are the right answers.

Fortunately, there are ways around these difficulties. The first thing that needs to be borne in mind is something we have already noted: by the time students are in junior or senior high school science classes, they are capable of thinking on their own about ethics. A careful examination of a situation often results in general agreement about what the salient ethical dimensions are; and this is not something that teachers will have to force on their students. For example, the importance of acquiring the informed consent of people before exposing them to health risks in an experimental study is rather evident.(48) Or, falsifying data on the effectiveness and safety of an experimental drug to treat heart disease can easily be seen to be unethical.

It is worth pointing out that not all ethical problems in science are *dilemmas* (a much overused word in discussions of ethics). A dilemma is a special sort of problem that seems to have no good solution -- whether this involves having to decide between undesirable options or good, but mutually exclusive, options.(49) Most situations calling for ethical sensitivity and reflection are not dilemmas at all -- even though many might require good, hard thinking in order to come up with satisfactory answers. The danger of presenting students with an exclusive diet of dilemmas is that they may too easily generalize that all of ethics is a matter of unresolvable conflict.

Teachers can also indicate that students will not be graded on the "correctness" or "incorrectness" of their conclusions about the moral issues the class is considering. There might, indeed, be right or wrong answers; but that is not the point. The point, rather, is to encourage students to think about the issues carefully, to assemble and organize relevant facts as best they can, to support whatever conclusions they draw with the best reasons they can come up with, and to consider carefully alternative views suggested by others. If there are right or wrong answers, this seems like the most promising way of determining which is which. Even if, in the end, this is an unattainable goal, students will still have accepted the responsibility to think thoroughly and thoughtfully about moral issues related to science.

It is worth noting that there are many terms of evaluation other than 'right/wrong'. Our views can be carefully formulated/carelessly formulated, articulate/inarticulate, well informed/poorly informed, consistent/inconsistent, coherent/incoherent, and so on. Likewise, the vocabulary of ethics is much richer than 'right/wrong,' 'moral/immoral,' or 'ethical/unethical.' Each of these pairs admits of degrees. But, in addition, there are many other terms that admit of degrees, such as, fairness/unfairness, honesty/dishonesty, beneficence/maleficence, considerateness/inconsiderateness, and respectfulness/disrespectfulness. All of these, and many others as well, can be usefully employed in developing thoughtful, well-developed responses to moral issues.

Although it will sometimes happen that a class consensus will emerge when discussing a difficult issue, the failure to reach consensus does not mean that the discussion is a failure. Consensus on complex issues should be no more expected in morality than in science itself. Reaching consensus does not necessarily mean the discussion is a success, either. If one person can have an ill-formed or inadequately supported view, so can an entire class. Closure is better marked by the bell than a final vote. This may seem awkward, but it need be no more awkward than any group of people deciding it is time to go on to something else despite the differences that remain. Furthermore, those who engage in lively debates outside the classroom do not necessarily conclude that no one has a better view than anyone else since agreement has not been reached (especially if they still think that their view is right!).

Finally, differences should not be exaggerated. People may argue endlessly about who, for example, should win the Academy Awards in a given year. However, the list of serious candidates is not endless, and the vast majority of films, actors, directors, and producers will not qualify as serious candidates. Or consider "best player" arguments in various sports. Who should be ranked the current best in men or women's tennis may be hotly disputed, but the list of plausible candidates is short, while the list of those who clearly do not belong on that list is very long. A similar point can be made about moral issues. What makes something a difficult choice is that we can see rather clearly positive or negative points on either side, but it is difficult to give them a decisive weighting that clearly determines what should be done. However, it is not difficult to think of any number of clearly *un*satisfactory ways of dealing with the situation.

"Who's to say?"

However, one might ask, "Who's to say?" In moral matters, as in science, this is not really a useful question to ask. In one important respect *no one* is to say, if by this we mean that there are voices that, by their sheer "authority," can dictate answers. In another respect we might say *everyone* is to say, if by this we mean that anyone might have an important contribution to make. Most important is *what* is said, and how it is supported, rather than *who* says it. Of course, as already noted, it is necessary for scientists to rely on the work of each other and for the public to rely on the expertise of scientists. However, even here it is assumed that, if pressed, scientists can give good reasons for their views. In short, it is the *support that can be given a view* that should carry the day, not those individuals who happen to provide that support. Although we must rely on scientists to provide us with well supported scientific information, we also need to be careful not to project a "halo effect" onto scientists that puts them on an "authority" pedestal that extends well beyond their expertise. This is particularly true when that "authority" extends into the moral domain, where the notion of "moral expert" needs to be viewed with some care and suspicion.

There is an important pedagogical point that follows from the above discussion of authority figures. Teachers obviously wield considerable power and influence over students. Furthermore, students easily grow accustomed to being told what the answers are -- both by authoritative teachers and texts. To resist this, teachers need to encourage students to think for themselves, to respect one another as mutual inquirers -- without this resulting in an atmosphere of "anyone's opinions are as valid as anyone else's." This is not easy to do. Teachers need to resist the temptation always to have the last word -- whether this be to conclude a class session by pronouncing authoritatively that this or that has been established, or to conclude by pronouncing that nothing has been established (because, after all, these are moral issues). Teachers are best viewed here as facilitators. This requires leadership and guidance, but sometimes this is accomplished better by silence than speaking. The mark of success is students engaging in thoughtful, informed discussion that shows respect for both the subject at hand and the students' own reflections.

Although we are suggesting that teachers who bring ethics in the science classroom see themselves more as facilitators than dispensers of answers to ethical questions, there are some important ground rules that need to be observed. First, as we have already indicated, students need to realize that they will be expected to support their views with good reasons, which requires them to be as well informed about relevant factual information, social policies, laws, and possible ethical stances as they can. Second, although some disagreements among students are to be expected, an atmosphere of "put downs," impatient rejection of the ideas of others, and disrespectful behavior in general need to be discouraged. Third, as suggested in Chapter 2, teachers need to encourage an atmosphere of *reasonableness*, an atmosphere in which students are willing to listen to and reason *with* one another.

CHAPTER 4
Case Studies

The teaching of ethics is particularly suited to the use of illustrative case studies. Such narratives can be used to present examples of a range of significant ethical issues related to some human enterprise and many of the complexities associated with each of the issues. The cases can be either fictional or they can be based on actual events.

In our Summer Institute instructional program we used a series of real-life case studies to illustrate several of the key ethical issues related to science. The teachers found these cases helpful in enhancing their in-depth understanding of the issue and in suggesting practical topics for the development of classroom ethics lessons.

In this chapter we present six such case studies, including five that were used, to good effect, during our Summer Institute instructional program. Each is based on a real case. The cases and major associated ethics issues are: Overly Ambitious Researchers -- Fabricating Data (scientific misconduct); The Millkan Case (issues related to the collection, treatment and presentation of scientific data); The Tuskegee Syphilis Study (issues concerning research on human subjects and the influence of racial prejudice on science); The Search For the Structure of DNA (competition vs. cooperation, and sexism in science); The XYY Controversy (genetics and biotechnology research issues); and Love Canal (environmental protection issues).

Each case includes:

1- Introduction.. A discussion of the nature and significance of the types of moral issues raised in the case.

2- Background. Background discussion designed to place the case in an appropriate context.

3- Case Study. A narrative presentation of the particulars of the case.

4- Readings and Resources. A brief list of suggested readings (as well as videos and other educational material) that can be consulted to get a more thorough understanding of the case in question, related cases, and the associated ethics/values issue.

5- The Issues. Sets of questions designed to elicit thought and exploration concerning both the specific ethics/values issues raised by the case, as well as related issues.

CASE STUDY #1: OVERLY AMBITIOUS RESEARCHERS -- FABRICATING DATA

Categories of Ethics/Values Issues Illustrated by This Case: Issues related to fraud in scientific research and its consequences.

1. Introduction

In recent years the National Science Foundation (NSF), the National Institutes of Health (NIH), the Public Health Services (PHS), the Office of Scientific Integrity (OSI), and various scientific organizations such as the National Academy of Sciences (NAS) have spent considerable time and effort in trying to agree on a definition of *scientific misconduct*. A good definition is needed in developing and implementing policies and regulations concerning appropriate conduct in research, particularly when federal funding is involved. This is an important area of concern because, although serious scientific misconduct itself may be infrequent, the consequences of even a few instances can be widespread.

Those cases that reach the public's attention can cause considerable distrust among both scientists and the public, however infrequent their occurrence. Like lying in general, we may wonder *which* scientific reports are tainted by misconduct, even though we may be convinced that relatively few are. Furthermore, scientists depend on each other's work in advancing their own. Building one's work on the incorrect or unsubstantiated data of others infects one's own research; and the chain of consequences can be quite lengthy, as well as very serious. This is as true of honest or careless mistakes as it is of the intentional distortion of data, which is what *scientific misconduct* is usually restricted to. Finally, of course, the public depends on the reliable expertise of scientists in virtually every area of health, safety, and welfare.

Although exactly what the definition of *scientific misconduct* should include is a matter of some controversy, all proposed definitions include the fabrication and falsification of data and plagiarism. As an instance of fraud, the fabrication of data is a particularly blatant form of misconduct. It lacks the subtlety of questions about interpreting data that pivot around whether the data have been "fudged", or "manipulated." Fabricating data is making it up, or *faking* it. Thus, it is a clear instance of a lie, a deliberate attempt to deceive others.

However, this does not mean that fabrications are easy to detect or handle effectively once they are detected; and this adds considerably to the mischief and harm they can cause. Two well-known cases illustrate this, both of which feature ambitious, and apparently successful, young researchers.

2. Background

Dr. John Darsee was regarded a brilliant student and medical researcher at the University of Notre Dame (1966-70), Indiana University (1970-74), Emory University (1974-9), and Harvard University (1979-1981). He was regarded by faculty at all four institutions as a potential "all-star" with a great research future ahead of him. At Harvard he reportedly often worked more than 90 hours a week as a Research Fellow in the Cardiac Research Laboratory headed by Dr. Eugene Braunwald. In less than two years at Harvard he was first author of seven publications in very good scientific journals. His special area of research concerned the testing of heart drugs on dogs.

3. The Darsee case

All of this came to a sudden halt in May 1981, when three colleagues in the Cardiac Research Laboratory observed Darsee labeling data recordings "24 seconds," "72 hours," "one week," and "two weeks." In reality, only minutes had transpired. Confronted by his mentor Braunwald, Darsee admitted the fabrication; but he insisted that this was the only time he had done this, and that he had been under intense pressure to complete the study quickly. Shocked, Braunwald and Darsee's immediate supervisor, Dr. Robert Kroner, spent the next several months checking other research conducted by Darsee in their lab. Darsee's research fellowships were terminated, and an offer of a faculty position was withdrawn. However, he was allowed to continue his research projects at Harvard for the next several months (during which time Braunwald and Kroner observed his work very closely).

Hopeful that this was an isolated incident, Braunwald and Kroner were shocked again in October. A comparison of results from four different laboratories in a National Heart, Lung and Blood Institute (NHLBI) Models Study revealed an implausibly low degree of invariability in data provided by Darsee. In short, his data looked "too good." Since these data had been submitted in April, there was strong suspicion that Darsee had been fabricating or falsifying data for some time. Subsequent investigations seemed to indicate questionable research practices dating back as far as his undergraduate days.

What were the consequences of John Darsee's misconduct? Darsee, we have seen, lost his research position at Harvard, and his offer of a faculty position was withdrawn. The National Institutes of Health (NIH) barred him from NIH funding or serving on NIH committees for ten years. He left research and went into training as a critical care specialist. However, the cost to others was equally, if not more, severe. Harvard-affiliated Brigham and Women's Hospital became the first institution NIH ever required to return funds ($122,371) because of research involving fraudulent data. Braunwald and his colleagues had to spend several months investigating Darsee's research, rather than simply continuing the work of the Cardiac Research Laboratory. Furthermore, they were severely criticized for carrying on their own investigation without informing NIH of their concerns until several months later. The morale and productivity of the laboratory was damaged. A cloud of suspicion hung over all the work with which Darsee was associated. Not only was Darsee's own research discredited, but insofar as it formed an integral part of collaborative research, a cloud was thrown over published research bearing the names of authors whose work was linked with Darsee's.

The months of outside investigation also took others away from their main tasks and placed them under extreme pressure. Statistician David DeMets played a key role in the NIH investigation. Fifteen years later, he recalls the relief his team experienced when their work was completed:[50]

For the author and the junior statistician, there was relief that the episode was finally over and we could get on with our careers, without the pressures of a highly visible misconduct investigation. It was clear early on that we had no room for error, that any mistakes would destroy the case for improbable data and severely damage our careers. Even without mistakes, being able to convince lay reviewers such as a jury using statistical arguments could still be defeating. Playing the role of the prosecuting statisticians was very demanding of our technical skills but also of our own integrity and ethical standards. Nothing could have adequately prepared us for what we experienced.

Braunwald notes some positive things that have come from the Darsee case. In addition to alerting scientists to the need for providing closer supervision of trainees and taking authorship responsibilities more seriously, the Darsee incident contributed to the development of guidelines and standards concerning research misconduct by PHS, NIH, NSF, medical associations and institutes, and universities and medical schools. However, he cautions that no protective system is able to prevent all research misconduct. In fact, he doubts that current provisions could have prevented Darsee's misconduct, although they might have resulted in earlier detection. Further, he warns that good science does not thrive in an atmosphere of heavy "policing" of one another's work:[51]

The most creative minds will not thrive in such an environment and the most promising young people might actually be deterred from embarking on a scientific career in an atmosphere of suspicion. Second only to absolute truth, science requires an atmosphere of openness, trust, and collegiality.

Given this, it seems that William F. May is right in urging the need for a closer examination of character and virtue in professional life.[52] He says that an important test of character and virtue is what we do when no one is watching. The Darsee case and Brauwald's reflections seem to confirm this. If this is right, then it is important that attention be paid to these matters before college, by which time one's character is rather well set.

Many who are caught having engaged in scientific misconduct plead that they were under extreme pressure, needing to complete their research in order to meet the expectations of their lab supervisor, to meet a grant deadline, to get an article published, or to survive in the increasingly competitive world of scientific research. Although the immediate stakes are different, secondary school science students sometimes echo related concerns: "I knew how the experiment should have turned out, and I needed to support the right answer;" "I needed to get a good grade;" "I didn't have time to do it right; there's so much pressure." Often these thoughts are accompanied by another--namely, that this is only a classroom exercise and that, of course, one will not fabricate data when one becomes a scientist and these pressures are absent. What the Darsee case illustrates is that it is naive to assume such pressures will vanish. So, the time to begin dealing with the ethical challenges they pose is now, not later (when the stakes may be even higher).

4. The Bruening case

In December 1983, Dr. Robert Sprague wrote an eight page letter, with 44 pages of appendices, to the National Institute of Mental Health (NIMH) documenting the fraudulent research of Dr. Stephen Breuning.[53] Breuning fabricated data concerning the effects psychotropic medication have on mentally retarded patients. Despite Breuning's admission of fabricating data only three months after Sprague sent his letter, the case was not finally resolved until July 1989. (Sprague credits media attention with speeding things along!) During that five and one-half year interval, Sprague himself was a target of investigation (in fact, he was the first target of investigation), he had his own research endeavors severely curtailed, he was subjected to threats of lawsuits, and he had to testify before a United States House of Representatives Committee. Most painful of all, Sprague's wife died in 1986 after a lengthy bout with diabetes. In fact, his wife's serious illness was one of the major factors prompting his "whistleblowing" to NIH. Realizing how dependent his diabetic wife was on reliable research and medication, Sprague was particularly sensitive to the dependency the mentally retarded, clearly a vulnerable population, have on the trustworthiness of not only their care givers, but also those who use them in experimental drug research.

Writing nine years after the closing of the Bruening case, Sprague obviously has vivid memories of the painful experiences he endured and of the potential harms to participants in Bruening's studies. However, he closes the account of his own experiences by reminding us of other victims of Bruening's misconduct--namely, psychologists and other researchers who collaborated with Bruening, but without being aware that he had fabricated data.

Dr. Alan Poling, one of those psychologists, writes about the consequences of Bruening's misconduct for his collaborators in research. Strikingly, Poling points out that between 1979 and 1983, Bruening was a contributor to 34% of all published research on the psychopharmacology of mentally retarded people. For those not involved in the research, initial doubts may, however unfairly, be cast on all these publications. For those involved in the research, efforts need to be made in each case to determine to what extent, if any, the validity of the research was affected by Bruening's role in the study. Even though Bruening was the only researcher to fabricate data, his role could contaminate an entire study. In fact, however, not all of Bruening's research did involve fabrication. Yet, convincing others of this is a time-consuming, demanding task. Finally, those who cited Bruening's publications in their own work may also suffer "guilt by association." As Poling points out, this is especially unfair in those instances where Bruening collaborations with others involved no fraud at all.

5. Readings

For readings on scientific integrity, including sections on the fabrication of data and a definition of scientific misconduct, see: *Integrity and Misconduct in Research* (Washington, D.C.: U.S. Department of Health and Human Services, 1995); *On Being a Scientist*, 2nd ed. (Washington, D.C.: National Academy Press, 1995); and *Honor in Science* (Research Triangle Park, NC: Sigma Xi, The Scientific Research Society, 1991).

Sources for information on the Darsee case include: Sharen Begley, with Phyllis Malamud and Mary Hager, "A Case of Fraud at Harvard," *Newsweek*, February 4, 1982, pp. 89-92; Richard Knox, "The Harvard fraud case: where does the problem lie?", JAMA, Vol. 249, No. 14, April 3, 1983, pp. 1797-1807; Walter W. Stewart, "The integrity of the scientific literature," *Nature*, Vol. 325, January 15, 1987, pp. 207-214; Eugene Brunwald, "Analysing scientific fraud," *Nature*, Vol. 325, January 15, 1987, pp. 215-216; and Eugene Brunwald, "Cardiology: The John Darsee Experience," in David J. Miller and Michel Hersen, *Research Fraud in the Behavioral and Biomedical Sciences* (New York: John Wiley & Sons, Inc., 1992, pp. 55-79.

For readings on Bruening, see Sprague, Robert L., "The Voice of Experience," *Science and Engineering Ethics*, Vol. 4, Issue 1, 1998, p. 33, and Poling, Alan, "The Consequences of Fraud," in Miller and Hersen, pp. 140-157.

The Miller and Hersen book includes other good essays on misconduct in science.

6. The Issues

The Darsee and Bruening cases raise a host of ethical questions about the nature and consequences of scientific fraud:

- What kinds of reasons are offered for fabricating data?
- Which, if any, of those reasons are *good* reasons--i.e., reasons that might *justify* fabricating data?
- Who is likely to be harmed by fabricating data? Does actual harm have to occur in order for fabrication to be ethically wrong?
- What responsibilities does a scientist have for checking on the trustworthiness of the work of other scientists?
- What should a scientist do if he or she has reason to believe that another scientist has fabricated data?
- Why is honesty in scientific research important to the scientific community?
- Why is honesty in scientific research important for the public?
- What might be done to diminish the likelihood that research fraud occurs?
- What applications of the concerns raised in the above questions are there for teaching science classes in high school? Middle school? Elementary school?

CASE STUDY #2: THE MILLIKAN CASE -- DISCRIMINATION VERSUS MANIPULATION OF DATA

Categories of Ethics/Values Issues Illustrated by This Case: Issues related to the collection, treatment and presentation of scientific data.

1.Introduction

Of all the various types of "ethical dilemmas in science," the temptation to "fudge", or even invent data outright, is probably the one which high school science students will find most familiar. It happens all the time: their instruments give one result -- but they know that everybody else is getting some other result, or that something's wrong with the way they have done it, or that the result that people got last year is different, or that the result in the book is different.

What makes this an ethical issue, rather than just an issue of laboratory practice, is that the action that most promotes one's self-interest can be different from the "right" thing to do.

The Millikan case highlights a number of the important issues involved. But by itself, it is probably too complicated to use in helping students to navigate this issue. One can, however, set up simpler situations to illustrate the same points. As those historians who have analyzed the record of Millikan's treatment of his experimental data, and other similar cases, have pointed out, it is not always easy to distinguish between the "right" thing to do, inappropriate but inadvertent manipulation, and intentional fudging. Scientists agree that there are circumstances when some of the data collected in an experiment can be rejected or disregarded. In some cases statistical rules can

be used as guidance, but in many situations it is left to the judgement of the experimental scientist to decide if a problem with the equipment or some other consideration justifies discarding a datum or a set of data. An acceptable practice, but one that is rarely followed, is to decide in advance what specific observed circumstances in a particular experimental situation would justify data rejection.

2. Background

In the 1930s and 1940s, Robert A. Millikan was the most famous U.S. scientist of his time. He had won the Nobel Prize in 1924, largely due to his important and innovative measurement, carried out around 1910, of the charge on the electron -- one of the most central physical constants that scientists of that era had been seeking to determine.

In 1897, British experimenter J. J. Thomson had discovered the electron and measured the ratio of its charge to mass (the e/m ratio) -- an event which helped to usher in the electronic age. The e/m ratio of the electron was related to a number of other important quantities of interest to scientists. But without knowing either the charge e or the mass m of the electron, all one had was a set of relative values; it would be like knowing a set of values in units of a foreign currency -- that a house costs x times what a car costs, which in turn costs y times what a newspaper costs -- without knowing the value in your own currency of any one. Measuring the mass of an electron seemed out of the question; you couldn't put one on a scale and read a dial. But neither, it seemed, could you isolate an electron and measure its charge on an electrometer. Around the turn of the century, Thomson and several of his students at the Cavendish Laboratory tried various means of indirect measurement, with unconvincing results. Moreover, until one had a relatively direct way of measuring the charge on the electron, one couldn't really be sure that the electron was indeed an "atom of electricity." It was still at least possible that electrons came in a spectrum of charges.

Millikan's method involved watching the behavior of oil droplets in an electrically charged field. Tiny oil droplets are ionized by passage through an atomizer; they have an extra electron or electrons riding on them. A droplet is allowed to fall between two plates, and then an electric field is created which pulls the droplet upwards. The speed of the droplet depends on the charge riding on it. Thus the basic measurement is the rise time; how long it takes a particular drop to rise a certain distance. If electrons had a spectrum of charges, one would expect a corresponding continuous spectrum of rise times. If, on the other hand, all electrons had the same charge, the charge on each ion would be multiples of a single number, a fact which would be reflected by rise times that would also be simple multiples of each other.

Millikan published tables of his measured drops and their rise times. What these tables indicated was that the charges on the droplets were, indeed, multiples of the same number -- thus, the charge of the electron. He then wrote a series of papers on his experiments. He would win the Nobel Prize in Physics for this work; he was only the second American to be so honored.

Millikan considered the experiment to be such a direct and irrefutable demonstration of the atomicity of electric charge that he wrote in his autobiography that "he who has seen that experiment, and hundreds of observers have observed it, [has] in effect

SEEN the electron."

3. The Case

An examination of Millikan's own papers and notebooks reveals that he picked and chose among his drops. That is, he exercised discrimination with respect to which drops he would include in published accounts of the value of e, leaving many out. Sometimes he mentioned this fact, and sometimes he did not. Of particular concern is the fact that in his 1913 paper, presenting the most complete account of his measurements of the charge on the electron, Millikan states "*It is to be remarked that this is not a selected group of drops but represents all of the drops experimented upon during 60 consecutive days."* Millikan's notebook appears to contradict this assertion. Of 189 observations during the period in question, only 140 are presented in the paper.

Millikan's results were contested by Felix Ehrenhaft, of the University of Vienna, who claimed to have found "subelectrons." Moreover, Ehrenhaft claimed that his finding was in fact confirmed by some of Millikan's own data -- droplets that Millikan had mentioned but discounted in his published writings. The result was a decades-long controversy, the "Battle over the Electron," over whether or not there existed subelectrons, or electrons with charges of different values. This controversy makes an excellent case study because we are fortunate, thanks to Millikan's notebooks, to be able to see very specifically which drops he included and which he did not.

In retrospect, we know that Millikan was "right" and Ehrenhaft "wrong." Electrons, to the best of our present experimental and theoretical knowledge, have a specific, discrete charge.

Those scientists and other scholars who have carefully reviewed this case have failed to agree on whether Millikan was guilty of unethical behavior or "bad science" in the treatment and presentation of his data. One of the expressed opinions condemns Millikan on the simple basis of the fact that his published statement is at odds with what can be concluded from an uncritical examination of his laboratory notebooks. Others exonerate Millikan on the basis of a careful analysis and interpretation of comments on the data that appear in the notebooks. In the opinion of these Millikan defenders, the assertion that all drops were presented in the paper refers to all of the data taken under those conditions when the apparatus was working properly. Some of the scientists who have commented on this case appear to permit Millikan much discretion in the use of his "scientific intuition" to decide which data to include or exclude. This latter view seems to be guided by the principle that any scientist who consistently gets what turns out to be the correct answer is doing "good" science.

4. Readings

For biographical information about Robert A Millikan and the history of the oil-drop experiment that will provide the context for this case we suggest that you read:

"Robert A. Millikan," by Daniel J. Kevles, *Scientific American*, 240, pp 142-151 (January 1979).

"My Work With Millikan On the Oil-drop Experiment," by Harvey Fletcher, *Physics Today*, pp 43-47 (June 1982).

For a detailed analysis of the Millikan's work on the oil-drop experiment, including what he wrote in his laboratory notebooks see:

"Subelectrons, Presuppositions and the Millikan-Ehrenhaft Dispute" in *The Scientific Imagination*, by Gerald Holton (Cambridge, Mass: Cambridge Univ. Press, 1978).

For several perspectives on the Millikan case and on other controversies concerning the analysis and presentation of scientific data see:

Betrayers of Truth, by William Broad and Nicholas Wade (New York: Simon and Schuster, 1983).

"Forging, Cooking, Trimming, and Riding the Bandwagon," by Allan Franklin, *American Journal of Physics*, 52, pp 786-793 (1984).

"Moral Theory and Scientific Research," by Bernard Gert in *Ethics, Values and the Premise of Science Sigma Xi Forum, San Francisco 1993* (Research Park, NC: Sigma Xi Publishing Office, 1993).

"Scientific Fraud," by David Goodstein, *The American Scholar*, 60, (Autumn 1991).

False Prophets: Fraud and Error in Science and Medicine, by Alexander Kohn (New York: Basil Blackwell, 1986).

5. The Issues

Ethical questions specifically related to the Millikan case:

- Does the contradiction between Millikan's unqualified statement that he has published all

the oil-drop data and the evidence of unpublished oil-drop measurements in his notebooks prove that he is guilty of unethical scientific behavior?

- If Millikan had not claimed to have published all the data, would he still be guilty of questionable behavior?
- Should the fact that Millikan was a highly successful scientist, and that he got the right answer in the controversy about the charge on the electron be a consideration in judging his scientific ethics?

More general questions about the manipulation and presentation of data raised by this case:

- What criteria should be used in deciding whether data can be legitimately discarded?
- When a scientist uses his or her "intuition" as the basis for deciding whether to ignore certain data, is the question of the ethics of this action dependent on whether the conclusion reached by the scientist is later proven to be correct?
- Is the intentional manipulation and selection of data in order to falsely prove a scientific premise less of a violation of acceptable ethical standards than the outright fabrication of data?
- Does the need for an accurate record to determine whether data have been treated and presented appropriately imply certain universal standards for the recording of observations by scientists? If so, what are these standards?

CASE STUDY #3: THE TUSKEGEE SYPHILIS STUDY

Categories of Ethics/Values Issues Illustrated by This Case: Issues related to experimentation on human subjects.

1. Introduction

Although experimentation on human subjects has long been understood to be fraught with serious ethical concerns, little was done to develop national and international guidelines and regulations with regard to such research until the end of World War II. Populations that were frequently victimized by involuntary or coerced participation in potentially dangerous experiments included prisoners and insane asylum inmates. Due to popular recognition of the need to test new medical treatments, defenders of the rights of such powerless individuals found little political interest in outlawing these practices. However, the atrocities committed by Nazi doctors in the name of medical experimentation, as revealed during the Nuremberg war crimes trials, raised international consciousness about the need for an acceptable code for medical research.

The result was the promulgation in 1947 of the Nuremberg Code. This document was drafted by an international panel of experts on medical research, human rights, and ethics. It focused on the requirement for voluntary consent of the human subject and the weighing of the anticipated potential humanitarian benefits of a proposed experiment against the risks to the participant. The Code served as the initial model for those few public and private research and professional organizations that voluntary chose to adopt guidelines or rules for research involving human subjects.

In the ensuing years occasional media publicity called attention to continuing questionable biomedical and behavioral research practices. In 1972 the Tuskegee Syphilis Study, described in the case study below, became a cause célèbre due to the thorough and dramatic Associate Press story written by reporter Jean Heller. Congressional hearings took place in 1973 and the following year Congress passed legislation creating the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. The Commissioners included prominent experts and scholars in the fields of medicine, psychology, civil rights, the law, ethics and religion. In 1979 they published "Ethical Principles and Guidelines for the Protection of Human Subjects of Research," which is commonly referred to as "The Belmont Report." This document presents a well-developed ethical framework for the exploration of the issues associated with the use of human beings as the subjects of research. More comprehensive than the Nuremberg Code, it defined the boundary between accepted therapeutic practice and experimental research, and proposed the following three basic principles to guide in the evaluation of the ethics of research involving human subjects:

- **Respect for Persons** - This principle incorporates the convictions that individual research subjects should be treated as autonomous agents, and that persons with diminished autonomy (such as prisoners or inmates of mental institutions) are entitled to protection.
- **Beneficence** - Research involving human subjects should do no intentional harm, while maximizing possible benefits and minimizing possible harms, both to the individuals involved and to society at large.
- **Justice** - Attention needs to be paid to the equitable distribution within human society of benefits and burdens of research involving human subjects. In particular, those participants chosen for such research should not be inequitably selected from groups unlikely to benefit from the work.

The Belmont report has greatly influenced the codes and regulations regarding human subjects research that have since been established in the United States by federal and many state governments, universities, professional organizations and by private research institutions, as well as similar codes and regulations elsewhere in the world.

2. Background

Syphilis was a widespread but poorly-understood disease until shortly after the turn of the century. Two of the principal steps forward were the isolation of the bacterium associated with syphilis in 1905, and shortly thereafter, the development of the Wasserman reaction to detect the presence of syphilis through a blood test.

Still, much about the disease and its progress remained unknown. Due to this lack of understanding many cases were incorrectly diagnosed as syphilis, while in other cases patients who would now be recognized as victims of the disease were missed. As the etiology of the disease was better understood, it became increasingly urgent to understand its long-term effects. The early treatments that predated the discovery of penicillin involving the use of such poisons as arsenic and mercury were dangerous, and sometimes even fatal. Thus, it was vital to learn about the likelihood that the disease itself would result in serious physical or mental disability in order to make sure that the potential benefits of treatment exceeded the risks.

One long-term study had been carried out in Oslo, Norway. This had been a retrospective study, going over the past case histories of syphilis victims then undergoing treatment, and had been undertaken on an exclusively white population.

In the early 1930s, the U.S. Public Health Service (PHS) began a program aimed at controlling venereal disease in the rural South. The Julius Rosenwald Fund - a philanthropic organization that was interested in promoting the welfare of Afro-Americans ("Negroes") - provided the funds for a two-year demonstration study in Macon County, Alabama where 82% of the residents were Afro-Americans, most of whom lived in poverty and had never seen a doctor. A principal aim of this study was to determine the incidence of the disease in the local population, while training both white and Afro-American physicians and nurses in its treatment. When the results revealed that 36% of the Macon County Afro-Americans had syphilis, which was far higher than the national rate, the Rosenwald Fund, concerned about the racial implications of this finding, refused requests to support a follow-up project

The discovery of the fact that the incidence of the disease was higher among African-Americans than among whites was attributed by some to social and economic factors, but by others to a possible difference in susceptibility between whites and non-whites. Indeed one Public Health Service consultant, Dr Joseph E. Moore of Johns Hopkins University School of medicine proposed that " Syphylis in the negro is in many respects a different disease from syphilis in whites."

3. The Case

In 1932 the PHS decided to proceed with a follow-up study in Macon County. Unlike the project supported by the Rosenwald Fund, the specific goal of the new study was to examine the progression of *untreated* syphilis in Afro-Americans. Permission was obtained for the use of the excellent medical facilities at the teaching hospital of the Tuskegee Institute and human subjects were recruited by spreading the word among Black people in the county that volunteers would be given free tests for "bad blood," a term used locally to refer to a wide variety of ailments. Thus began what evolved into "The Tuskegee Study of Untreated Syphilis in the Negro Male," a project that would continue for forty years. The subject group was composed of 616 Afro-American men, 412 of whom had been diagnosed as having syphilis, and 204 controls.

The participants were never explained the true nature of the study. Not only were the syphilitics among them not treated for the disease -- a key aspect of the study design that was retained even after 1943 when penicillin became available as a safe, highly effective cure -- but those few who recognized their condition and attempted to seek help from PHS syphilis treament clinics were prevented from doing so.

Eunice Rivers, an Afro-American PHS nurse assigned to monitor the study, soon became a highly trusted authority figure within the subject community. She was largely responsible for assuring the cooperation of the participants throughout the duration of the study. She was aware of the goals and requirements of the study, including the failure to fully inform the participants of their condition and to deny treatment for syphilis. It was her firm conviction that the men in the study were better off because they received superior medical care for ailments other than syphilis than the vast majority of Afro-Americans in Macon County.

The nature of the Study was certainly not withheld from the nation's medical community. Many venereal disease experts were specifically contacted for advice and opinions. Most of them expressed support for the project. In 1965, 33 years after the Study's initiation, Dr. Irwin Schatz became the first medical professional to formally object to the Study on moral grounds. The PHS simply ignored his complaint. The following year, Peter Buxtin, a venereal disease investigator for the PHS began a prolonged questioning of the morality of the Study. A panel of prominent physicians was convened by the PHS in 1969 to review the Tuskegee study. The panel included neither Afro-Americans nor medical ethicists. Ignoring the fact that it clearly violated the human experimentation guidelines adopted by the PHS in 1966, the panel's recommendation that the Study continue without significant modification was accepted.

By 1972, Buxtin had resigned from the PHS and entered law school. Still bothered by the failure of the agency to take his objections seriously, he contacted the Associated Press, which assigned reporter Jean Heller to the story. On July 25, 1972 the results of her journalist investigation of the Tuskegee Study of Untreated Syphilis in the Negro Male were published. The response to Heller's revelations was broad-based public outrage, which finally brought the Study to an immediate end.

4. Readings and Resources

A good, detailed case study of the Tuskegee Syphilis Project, with background material and suggestions about teaching the case, written for undergraduate college students is:

"Bad Blood - A Case Study of the Tuskegee Syphilis Project," by Ann W. Fourtner, Charles R. Fourtner, and Clyde F. Herreid, *Journal of College Science Teaching*, March/April 1994, pp 277-285.

An excellent dramatization of the Tuskegee Syphilis Study story, available as a 60-minute video recording is:

"The Deadly Deception," a *Nova* video written, produced and directed by Denisce Di Anni, WGBH Boston, 1993 production. [This video is owned by many libraries and is currently distributed by Films for the Humanities and Sciences, P.O. Box 205, Princeton, NJ 08543-2053.]

For a medical report on the Study summarizing the first thirty years of subject observation see:

"The Tuskegee Study of Untreated Syphilis: the 30th year of observation," by D.H. Rockwell et al., *Arch. Intern. Med.*, 144, pp 792-798, 1964.

Recent books about the Tuskegee Study include:

The Tuskegee Syphilis Study, by Fred D. Gray (Montgomery, AL: Black Belt Press, 1998).

Bad Blood. The Tuskegee Experiment, by J. H. Jones (: Free Press, 1993).

For more information on the ethics of experimentation on human subjects read:

"The Belmont Report," by The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, OPPR Reports, NIH, PHS, HHS , April , 1979.

The Nazi Doctors and the Nuremberg Code, by G. Annas and M. Grodin, (New York: Oxford University Press, 1992).

For a report on recent revelations concerning unethical experiments that exposed many human subjects to nuclear radiation see:

"Radiation: Balancing the Record," by Charles C. Mann, *Science*, 263, pp 470-473, January 28, 1994.

For an excellent treatment of the history of syphilis, which raises many other interesting questions about the nature of scientific research see:

Genesis and Development of a Scientific Fact, by Ludwick Fleck, (Chicago: University of Chicago Press, !979).

5. The Issues

Significant questions of ethics and values raised by this case:

- An explicit requirement of the Tuskegee study was that the subjects not receive available treatment for a debilitating disease, a clear violation of normal medical practice. Would any study involving human subjects that violated normal medical practice necessarily be unethical?
- The Tuskegee victims were not informed -- in fact they were deliberately misinformed -- about the nature of the study in which they were participants. A basic guideline for human subject research, specified in both the Nuremberg Code and the Belmont Report is the requirement of informed consent. What would have constituted informed consent in the case of the Tuskegee Study? If such informed consent had been obtained from the subjects, would this remove all questions about whether the Study was ethical?
- In what sense were the premises and the practices of the Tuskegee study racist? An important question to explore when examining accusations of human rights violations or of prejudicial behavior is whether the standards being applied are those of the time the action took place, and if not, whether this should affect any judgement about the ethics of the situation. (Conforming to official social standards does not necessarily imply that you are behaving in an ethical manner. Most people would consider the medical experiments of the Nazi Doctors to be unethical even though they conformed to the principles spelled out in the Nazi ideology imposed on Germany by the Third Reich.)
- Eunice Rivers, the Afro-American nurse who played a vital role by befriending the Tuskegee Study participants and assuring their cooperation has justified her support for the project in terms of the fact that the attention that she and the other medical staff gave to the men was more than a non-enrolled, poor, Macon County resident was likely to receive. If you had been in her place, do you think you would have come to the same conclusion with regard to the ethical choices available to you.
- Ordinarily, one would not think of the media as the proper instrument for enforcing public morality. They had that role here, but should they have?
- The political reaction to the Tuskegee revelations was largely responsible for establishing the committee that wrote the Belmont report, which set guidelines for experimentation on human subjects. These guidelines have been the basis for regulations, usually enforced by human subjects research panels, at most public and private institutions that conduct such research. Is

this likely to assure that all future research on human subjects will be conducted in a manner that raises no ethical concerns?

- The Belmont Report proposes three criteria for the evaluation of human subjects research, *respect for persons*, *beneficence* and *justice*, as described above in the introductory section. In what ways does the Tuskegee Study fail to conform to each of these criteria.
- In experiments on infants, it is obviously impossible to obtain the informed consent of the subject. This is also true in experiments on senile individuals. Does this mean that ethical considerations preclude using such subjects in any experiment?

CASE STUDY #4: THE SEARCH FOR THE STRUCTURE OF DNA

Categories of Ethics/Values Issues Illustrated by This Case: Competition vs. cooperation, and sexism in science.

1. Introduction

In 1953, an article was published in the British science journal, *Nature,* by James Watson and Francis Crick on the structure of DNA. Like most important scientific discoveries, this result was based on the work done by a large number of investigators over many years. It has become known as the Watson-Crick model and has laid the foundation for the tremendous advances made in genetics and molecular biology in the ensuing decades. The double helix structure of DNA and the genetic code it incorporates is regarded as one of the most important scientific discoveries of the century. On the basis of this work, the 1962 Nobel Prize for Medicine and Physiology was awarded to Watson, Crick and Maurice Wilkins. High school and college biology students throughout the world learn about the Watson-Crick model.

In 1968 James Watson published a book entitled *The Double Helix* (New York: Atheneum, 1968) giving his own account of the events leading to the solution of the DNA structure. The Norton Critical Edition of this book edited by G.S. Stent in 1980 contains the six original published articles, as well as 13 reviews of the book that appeared in journals. These reviews express the viewpoints of other scientists regarding the discovery of the structure of DNA and Watson's account of the work. Watson's portrayal of the personal lives of the people involved and the events leading to the discovery proved to be highly controversial. Harvard University Press refused to publish this book, considering its style and content to be irreverent of the scientific research process. In 1975 Anne Sayre's book entitled *Rosalind Franklin and DNA* (Norton) appeared and presented a different perspective on the discovery by describing Rosalind Franklin's outstanding X-ray diffraction studies on DNA and making the case that the Watson-Crick model would not have been postulated by them without access to Franklin's data, which they obtained by rather devious means. Anne Sayre was a personal friend of Dr. Franklin and was unable to recognize the "Rosy" that Watson described as the Rosalind she knew. An amusing 1987 made-for-TV film, "The Race for the Double Helix,", is loosely based on Watson's book and illustrates the concerns raised by Ms. Sayre. (See Readings and Resources, below.)

2. Background

By the early 1940's it was known that genes were the chemical constituents of plant and animal cells that carried the hereditary information. What was not known was their chemical identity and structure. The many researchers who were avidly seeking the answer were divided among those who thought that genes were specific types of proteins and those who thought evidence made it more likely that they were nucleic acids (e.g., DNA). While some scientists thought it unreasonable to understand the complexities of genetics in terms of the structures of "lifeless" chemicals, others believed that the molecular structure of the genes carried by the chromosomes held the key to understanding how genetic information is inherited and expressed. It seemed logical to consider proteins as the carriers of genetic information due to their greater complexity than DNA, which contains only four different nucleotide bases. In the 1920's DNA was found by staining to be concentrated in the chromosomes, but was commonly thought to play an auxiliary role in hereditary.

Although DNA was isolated in 1869 by Miescher, there was not much interest in it for several decades. Levene subsequently determined correctly that each nitrogenous base was attached to a sugar molecule and phosphate group. However, he postulated that they existed as a tetranucleotide cluster which repeated over and over to form the DNA molecule. Such a simple, monotonous structure could not be envisioned to carry genetic information, and since Levene's theory was given great weight by his renown as a biochemist, scientists looked to proteins for many years. It wasn't until 1950 that Erwin Chargaff published results indicating that the bases were not present in equal proportions. He found a correlation between the amount of adenine to thymine and cytosine to guanine providing the important clue to the coupling of these pairs of bases in the DNA structure.

It was correctly anticipated that if DNA was the carrier of genetic information, determination of its three-dimensional structure would provide answers to how it functioned. X-ray crystal-lography is a technique uniquely suited to this task. However, by mid-twentieth century scientists had only just begun to apply it to large biological molecules. For many of these it was difficult to obtain suitable crystals. Although today macromolecular structures are routinely solved with the aid of fast computers, in the 1950s the determination was mathematically very tedious.

3. The Case

Rosalind Franklin was brought to Kings College, London in 1951 to set up and be in charge of an X-ray diffraction laboratory. She came with considerable experience, particulary in working with macromolecular materials that do not readily form crystals, and which give diffraction patterns that are difficult to interpret. She set to the task of determining the structure of DNA by X-ray diffraction of DNA fibers. In March of 1953 she presented a research report that included the following key results based on her experimental evidence: that DNA contained two polymeric strands arranged in a coaxial helical structure with a type of symmetry described as "C_2," and that the phosphates were on the outside of the helix. She had also determined the number of molecules of water per structural unit, the molecular diameter and repeat distance, and the number of nucleotides per turn of the helix. The important missing piece of information was precisely how the nucleotide bases fit into the structure.

Watson and Crick collaborated at Cambridge to work on determining the structure of DNA. Each of them had been assigned to work on another problem, but recognizing its key importance, they talked about and worked on the DNA problem extensively at the expense of their official responsibilities. They did not actually perform experiments, but based their theorizing on bits of information published in the literature, as well as on Dr. Franklin's results, which they obtained, without her knowledge, from an unpublished report she had written for her research director. They relied on the relatively new technique of using physical models incorporating approximate distances and angles of atomic groupings from known molecular structures.

By guessing the correct position and structural pairing of the nucleotide bases, they were able to construct a model that was consistent with the known facts and that could account for the biological role of DNA. This was the structure that Watson and Crick published in their famous 1953 paper, which resulted in their receiving worldwide recognition as the discoverers of the DNA structure, and ultimately led to the Nobel prize. No mention of Franklin's key contribution appears in their paper. Franklin's co-worker, physicist Maurice Wilkens, (whom Watson mistakenly refers to as Franklin's boss in his book) did share the Nobel Prize with Watson and Crick. Franklin died of cancer before the awarding of the Prize, which can not be received posthumously, so it cannot be assumed that the Nobel Committee considered Wilken's work more important than Franklin's. If she had lived, they could not both have been honored because Nobel stipulated that no more than three people can share the prize. What is unquestionably true is that little recognition is accorded to Franklin's important role in most descriptions of the quest for the DNA structure, and her name does not appear in most high school or college biology texts in association with the discovery.

Anne Sayre's book stresses the difficulties faced by a woman scientist in England during the period in question. The small female minority were not even allowed into the lounges in scientific research institutions, where many of the important discussions among male scientists took place. The influence that contemporary attitudes toward women had on Watson's (and subsequently on the scientific world's) evaluation of Franklin's contribution to the DNA work warrants serious consideration.

4. Readings and Resources

The two key books that should be read in connection with this case are:

The Double Helix, by James Watson (New York: Atheneum, 1968). [As noted above the 1980 Norton Critical Edition of this book, edited by G. S. Stent includes valuable reviews and other documents related to this case.]

Rosalind Franklin and DNA by Anne Sayre (New York: Norton, 1975).

An amusing feature-length video loosely based on Watson's narrative and illustrating many of the concerns raised by Sayre is:

"The Race for the Double Helix," a British Broadcasting Corporation (BBC) / Horizon Films / Arts & Entertainment Network (A&E) 1987 production. [This video is owned by many libraries and is currently distributed by Films for the Humanities and Sciences, P.O. Box 205, Princeton, NJ 08543-2053.]

Articles that discuss other cases involving questions regarding the assignment of credit for scientific discoveries include:

"Discovery of Pulsars: A Graduate Student's Story," by Nicholas Wade, *Science*, 189, pp 358-363, August 1, 1975.

"My Work with Millikan on the Oil-Drop Experiment," by Harvey Fletcher, *Physics Today*, June 1982, pp 43-47.

"Masters and Apprentices," (Chapter 8) in *Betrayers of Truth* by William Broad and Nicholas Wade (New York: Simon and Schuster,).

5. The Issues

Significant questions of ethics and values raised by this case:

- Many scientists objected to the very personal and irreverent nature of the style that Watson chose in relating the tale of his quest for the structure of DNA. This manner of describing a highly significant historical episode in scientific research was certainly unusual, if not unprecedented. Is it in any way unethical or morally questionable to adopt colloquial, perhaps even flippant reportorial approach to the description of historically important scientific events?
- Watson, and to a lesser extent Crick, displayed a highly competitive attitude toward other researchers during their collaboration on the DNA research. One of the norms traditionally associated with scientific work is that of cooperation

among researchers. Does Watson's description of his and Crick's competitiveness constitute such an extreme departure from this norm as to be viewed as unethical?

- Sir Lawrence Bragg, Director of the laboratory in which they were employed, did not want Watson and Crick "fishing in other people's ponds" by working on the structure of DNA.. To what extent is science territorial, and to what extent is such territoriality: beneficial or harmful; necessary or unnecessary; ethical or unethical?
- Watson and Crick clearly made use of the ideas and results of other scientists in pursuing their goal, including those of Linus Pauling, Erwin Chargaff and Rosalind Franklin. This is, of course, a commonly accepted practice. What was it, then, that led Ann Sayre to suggest that Franklin had been treated unethically as a result of the use of her findings in the construction of the Watson-Crick DNA model? Is Sayre correct in her assessment? If so, were Pauling's and Chargaff's scientific conclusions or predictions also appropriated improperly?
- Franklin's approach to the DNA problem was painstaking and methodical. She clearly eschewed guesswork. Watson and Crick, on the other hand, did no labor intensive experiments, ventured many guesses about the DNA structure based upon the results of other scientists, and finally triumphed because this informed speculation allowed them to build a model that uniquely conformed to all the known properties of the molecule. Is there anything inherently unethical or of questionable values in the less conventional approach of Watson and Crick?
- It is clear that in the 1950s Watson held the very chauvanistic and derogatory attitudes toward women that were common among male scientists in that era. Does Watson's narrative support Sayre's assertion that these attitudes resulted in his devaluing of Franklin's research?
- To what extent do the social values that Franklin had to confront justify her reticence to engage in discussions about her research progress with her male colleagues.?
- Do you agree that there is sufficient evidence to conclude that Franklin has not been given the credit she deserves for her role in the discovery of the DNA structure?

Additional ethics and values questions related to assigning credit for scientific discoveries, sharing of data and results, and prejudice in science.

- Credit for a scientific discovery is generally accorded to the person(s) who first publishes the finding in an accredited scientific journal. Do you see any ethical problems with this accepted practice?
- Can you think of any objective criteria for deciding how significant a scientist's contribution to a discovery or a result should have to be in order to merit receiving credit for it and/or being listed as one of the authors of the research paper that describes it?
- Frequently scientific papers or reports are authored by a several scientists, each of whom made a distinct contribution to the work. Sometimes the contributors include those with very different scientific expertise. In such cases, should all of the authors be held responsible for everything included in the publication?
- Frequently research directors have received all, or most, of the credit for work that has been actually carried out by their students. Is this ethical? Does it matter if the principal ideas for the research were those of the research director?
- Competition can frequently stimulate rapid progress an scientific research. On the other hand, competition can also impede the sharing of ideas and interim results, which are generally of great value for the healthy development of science. Can you think of any guidelines that might result in an appropriate balance between these opposing values?
- Under what circumstances should a scientist feel justified in refusing to share his/her results with a competing scientist?
- Racial, sexual and ethnic prejudices that impede an individual's full development as a scientist are clearly unethical in a just society. Aside from limiting the scientific development and career opportunities of individual scientists, what other negative scientific impacts can you think of that have resulted from such prejudice?

CASE STUDY #5: THE XYY CONTROVERSY

Categories of Ethics/Values Issues Illustrated by This Case: Issues related to genetic screening and other applications of genetics and biotechnology research.

1. Introduction

Efforts to make use of increasing knowledge about the genetic component of human development and behavior have been a frequent source of serious ethical controversies. Support among geneticists, other scientists and the educated public for the eugenics movement, which advocated efforts to improve the human race by controlling presumed heritable characteristics, resulted in such misguided governmental policies early in this century as the large-scale sterilization of "inferior" individuals. Legislation authorizing such forms of social engineering was met with increasing criticism from those who questioned the morality of such practices as well as those who doubted the validity of simplistic biologically determinist models of complex human social behavior.

The reaction to the extreme and horrific use of eugenics measures by the Nazis in their campaign to promote the superiority of a cleansed Aryan "race" resulted in a temporary hiatus in research and development in applied human genetics. By the 1960s, however, increasing understanding about the genetic causes of such specific conditions as Down's Syndrome and sickle cell anemia were again arousing support for efforts to seek genetic explanations - and perhaps improvements - for a wide range of human "deficiencies" from various sorts of socially deviant behavior to susceptibility to environmental hazards.

The explosive growth of facile genetic engineering technologies and, in particular, the potential applications of the information gained through the Human Genome Project is destined to greatly amplify both the quantity and the variety of ethical concerns related to attempts to screen, control, manipulate or modify people based on their genetic predispositions.

A frequent underlying theme in disputes over "progress" in applied human genetics is rooted in the nature-nurture controversy. Those who do research into the genetic factors related to complex human problems are seen by their opponents as diverting attention from and ultimately undermining attempts to ameliorate the socioeconomic conditions related to the problems. In the view of these opponents, genetic differences are likely to be less important than social inequalities in determining most human behavior. Furthermore, they argue that the end result of a biological determinist perspective is discrimination against, rather than help for, those who are deemed inferior or defective.

The XYY controversy offers a case study that dramatically illustrates many of the ethical issues that arise when efforts are made to explore the social implications of human genetic differences.

2. Background

In 1961, a paper was published in the medical journal *Lancet* reporting the first man to be discovered with an extra Y chromosome in his cells, in addition to the normal male complement of one X and one Y. Within the next few years research reports appeared that purported to show that

XYY males were predisposed to violent and criminal behavior. This claim was widely publicized in

the news media. By the mid-1960s XYY was being referred to as the "criminal chromosome." In 1968 lawyers in at least two cases succeeded in persuading juries that their clients were less culpable for their crimes because they were XYY males. If this was not sufficient to persuade the public that XYY individuals were potentially dangerous social misfits, the erroneous report that a vicious serial killer of eight student nurses in Chicago was an XYY male surely had that result.

As is often the case for sensationalized, premature publicity about unproven scientific findings, the subsequent research that debunked the connection between the XYY karyotype and any demonstrable link to anti-social behavior received very little publicity. Thus the myth persisted that males with an extra Y chromosome were likely to manifest excessive violence and other undesirable social traits. This fallacious association even made its way into biology textbooks.

Several research projects underway during the 1960s were aimed at examining the actual prevalence of the XYY karyotype in the general population and attempting to explore whether there were any phenotypic consequences, including predisposition to any form of abnormal social behavior. One such study was carried out by Harvard child psychiatrist Stanley Walzer and Harvard Medical School geneticist Park Gerald. By 1968 they were screening all newborn males at Boston Hospital for Women and following up by studying the development of those with abnormal karyotypes like XYY or XXY. The research was funded by a grant from the Centers for Studies of Crime and Delinquency of the National Institute for Mental Health.

3. The Case

In 1974 the Walzer and Gerald research project became the subject of sharp criticism orchestrated by a study group from the organization Science for the People and led by

Harvard microbiology professor Jonathan Beckwith and MIT molecular biology professor Jonathan King. Their criticism was based on claims that the research seriously stigmatized those infants found to be XYY, that efforts to obtain informed consent were flawed, that the research served no potentially useful purpose for either the subjects or society as a whole, that the research design could not produce any valid scientific conclusions, and that the only possible consequences of the work would be to undermine appropriate efforts to deal with social problems.

After failing in their attempt to have the research stopped by appealing to Harvard's internal institutional review boards, the Science for the People Group went to the press and successfully enlisted the help of other organizations concerned about the welfare of children. This tactic ultimately achieved their goal of getting Walzer and Gerald (as well as other researchers) to stop screening newborns for XYY. The victory was won at the expense of alienating many biomedical researchers who objected to the tactic of using public pressure to stop a research project.

4. Readings

To prepare yourself to consider the issues raised by this case you should read the following documents:

"The XYY Controversy: Researching Violence and Genetics," a Special Supplement to the *Hastings Center Report*, August 1980.

"Behavioral Implications of the XYY Genotype," by Ernest B. Cook, *Science*, 179, pp 139-150, January 12, 1973.

"Patients' Rights: Harvard Is Sight of Battle Over X and Y Chromosomes," by Barbara Culliton, *Science*, 186, pp 715-717, November 22,1974.

"XYY: Harvard Researcher Under Fire Stops Newborn Screening," by Barbara J. Culliton, *Science*, 188, pp 1284-1285, June 27, 1975.

Part III of *The Code of Codes*, edited by Daniel J. Kevles and Leroy Hood (Harvard University Press, Cambridge, 1992) contains several essays that discuss many of issues concerning ethical, legal and social implications of human genetics research and technology.

An excellent discussion of issues related specifically to genetic screening of workers is "Genetic Testing in the Workplace" by Paul Billings and Jon Beckwith, *Trends in Genetics*, 8, pp. 198-202, June 1992.

5. The Issues

Significant ethical questions raised by this case:

- How should the principle of informed consent be interpreted when the subject of a research project is newborn infants?
- What possible outcomes would justify a research project that will have the inevitable outcome of stigmatizing the subjects in a way that may result in serious restrictions on their personal freedom?
- Is it an inappropriate intrusion for a researcher to offer "anticipatory guidance" to subjects of a research study where no scientific basis exists for expecting the need for this help?
- Is it possible to design an ethical, valid research project aimed at establishing a genetic component for the predisposition to some socially unacceptable behavior?
- Is it ethical to ban or refuse to use public monies to support certain types of research because of their potential social consequences, even if the research may have scientific merit?
- Is it ethical for scientists (or anyone else) to organize public opposition, with the help of the press, to halt a research project that has won the approval of the public funding agency and all of the review procedures within the institutions where it is being carried out?
- To what extent should the principle of academic freedom be invoked to protect researchers from the scrutiny of the public?
- Under what circumstances is it ethical to deny human subjects of research projects information about the results of that research?
- To what extent should the public be represented on institutional review boards set up to approve research that may have serious social or political consequences?
- Should there be any limits to the genetic information that a pregnant women can use in deciding whether to interrupt a pregnancy.

Additional ethical questions related to applications of genetic research results not covered by this case study:

- What are the ethical issues related to such concerns as rights of privacy, pregnancy counseling, public education, equal access and public welfare that are raised by existing or proposed screening programs for debilitating or fatal diseases resulting from genetic defects, such as Down's syndrome, cystic fibrosis, Huntington's disease and Tay-Sach's disease?

- What are the ethical implications of using genetic screening in the workplace to exclude candidates from eligibility for jobs?
- Is it ethically permissible to use genetic susceptibility to various diseases as a basis for determining eligibility for health care coverage?
- Is the use of genetic information to increase the social categories to which people can be assigned likely to lead to various forms of discrimination, and to what has been referred to as a "genetic underclass?"
- Can the potential invasions of privacy that may result from the increased use of genetic screening in forensics be avoided?

CASE STUDY #6: LOVE CANAL

Categories of Ethics/Values Issues Illustrated by This Case: Issues related to individual, corporate and governmental responses to environmental and ecological concerns.

1.Introduction

Degradation of the environment resulting from human activity is certainly not a phenomenon of recent origin. As early as the 15th century, long before the beginning of the industrial revolution, London was already being plagued by noxious air pollution resulting from the burning of coal and wood. However the extent of the effect of environmental pollution was greatly increased following the end of World War II by the exponential expansion of industrial activity in developed nations, employing vast quantities of fossil fuels and synthetic chemicals. Today's environmental concerns are regional, national and global, as well as local.

The ongoing educational, social and political movement, which has raised the consciousness of people in the United States and throughout the world about environmental concerns, began in the early 1960s. Its initiation is often attributed to the popular response to *Silent Spring* the eloquent book by marine biologist Rachel Carson about the dire effects of the overuse of pesticides and other chemical poisons, which was published in 1962. The ensuing environmental movement has spawned numerous local, regional, national and international organizations, many rather militant, which have used numerous tactics to press their demands for the preservation of clean air, pure water and unspoiled land. In response to these demands, legislative bodies have enacted all manner of regulations and numerous agencies have been charged with the task of environmental protection.

This increase in environmental activity has been accompanied by much controversy. Entrepreneurs, property owners, industrial workers, politicians, scientists and people in all other walks of life differ with regard to the relative value they accord to the benefits and costs associated with restrictions on freedom of action designed to protect the environment. A wide variety of ethics and values issues arise in the course of attempting to balance such demands as property rights and the entrepreneurial freedom to pursue profits against the ecological need to curtail those rights and restrict that freedom.

One of the most contentious environmental issues has been how to respond to the discovery of many thousands of hazardous toxic dumps that have resulted from decades of virtually unrestricted disposal of toxic industrial waste. This issue was first widely publicized as a result of the health emergency declared by the New York State

Department of Health in 1978 in response to shocking revelations about the problems caused by improper waste disposal in the now infamous Love Canal dump site. The actions and reactions of the corporation that disposed of the waste in question, public officials, residents, the media and scientists involved in the Love Canal controversy serve as excellent illustrations of many of the ethics issues associated with efforts to protect the public from environmental pollution.

2. Background

Toward the end of the nineteenth century, numerous canals were built by entrepreneurs to unify waterways into efficient shipping systems. One such canal was begun was begun in 1894 by venture capitalist William Love in the Niagra Falls area of New York State. Within a few years, an economic depression undermined Love's financial plans and the partially completed project was abandoned.

Dubbed "Love Canal" by the local residents, it was used as a swimming hole and an ice rink. In 1942, faced with the need for a place to dispose of toxic waste from the manufacture of chlorinated hydrocarbons and caustics, the Hooker Electrochemical Corporation (presently Hooker Chemical and Plastics, a subsidiary of Occidental Petroleum Corporation) leased the canal as a waste dump. In 1947, Hooker bought the canal and the surrounding land. Between 1942 and 1950, more than 21,000 tons of chemicals, including such potent toxins as benzene, the pesticide Lindane, polychlorinated dioxins, PCBs and phosphorous were deposited in the canal, which Hooker had lined with cement. Having exhausted the canal's potential as a waste dump, Hooker then installed an impermeable cap that was supposed to prevent water from entering and promoting seepage of the toxins, and the former canal disappeared from view beneath a layer of fill..

In the early 1950s the local School Board was confronted with the need to build a new school to accommodate an increasing population of children. The Board knew that Hooker was anxious to get rid of the Love Canal property and began making inquiries. Hooker has claimed that it resisted and warned the Board of Education that the buried chemicals made the site inappropriate for school construction. The property sale was consummated for $1.00 in 1953 - but the company asserts that it gave in because the Board would otherwise have taken the land by eminent domain. Whether Hooker was as reluctant as it says it was and as assertive in cautioning the Board about the hazards is impossible to determine. Existing minutes of the meetings in question do not fully support Hooker's version of the proceedings and none of the Board members are still alive. What is clear is that the deed that was negotiated contains a clause exempting Hooker from any "claim, suit or action" due to future human exposure to the buried chemicals.

An elementary school was built in the middle of the property and the surrounding land was sold by the School Board to developers who built 98 homes along the former canal banks and about a thousand additional houses in the Love Canal neighborhood. The construction of the school, houses and associated utilities resulted in the breaching of parts of the canal's cap and its cement walls.

3. The Case

The first known case of exposure to the buried toxins occurred in 1958 when three children suffered chemical burns from wastes that had resurfaced at the former canal site. Both Hooker Chemical and city officials were officially informed, but neither the Niagra Falls Health Department nor any other public agency took any action in response to that event or to numerous other complaints during the next twenty years. Hooker's records reveal that they investigated the initial incident and several other reports and quickly became convinced that the very large reservoir of toxins was not likely to be contained. They did nothing to convey this knowledge to the Love Canal homeowners, who had never been informed about the nature of the potential hazard. In testimony two decades later, Hooker acknowledged that its failure to issue a warning was due to concern that this might be interpreted as liability for possible harm despite the clause in their property sales deed.

By 1978 occupants of the homes in the area had begun to organize what was to become the Love Canal Homeowners Association (LCHA), under the highly competent and aggressive leadership of Lois Gibbs. Investigative newspaper reporter Michael Brown helped publicize the plight of the many deeply concerned local residents who had encountered evidence of toxins resurfacing in or around their property. Chemicals had been observed in the form of viscous fluids seeping into both yards and basements, pervasive odors in homes and the stench emanating from storm sewer openings.

Love Canal soon became the first hazardous waste site to be featured in TV news reports and to get front page, headline billing in newspapers and magazines in New State and nationally. Embarrassed by the past failure of officials to respond to the clear indications of a serious problem, both the New York State Department of Health (NYSDH) and the U.S. Environmental Protection Agency (EPA) quickly became involved. Tests soon revealed a wide variety of noxious chemicals in the air in Love Canal homes and an excess frequency of miscarriages among women living in homes adjacent to the former canal site. A public health emergency was declared on August 2, 1978 by the New York State Commissioner of Health. A few days later Governor Hugh Carey announced that New York State would purchase the 239 homes nearest to the canal and assist the displaced families in relocating. These abandoned homes were fenced in and work was soon begun on a plan to construct an elaborate drainage system including trenches, wells and pumping stations to prevent further outward migration of the toxins.

The cost of these initial actions, which rapidly followed the emergence of Love Canal as a national "cause célèbre" ultimately cost the state and federal governments in excess of $42 million. Public officials quickly recognized that a continued preemptive response to potential health problems at Love Canal was likely to exceed available emergency funds in the states coffers. Furthermore it was known that thousands of other toxic waste sites existed throughout the country that might pose similar threats to numerous other communities. Thus it is not surprising that the concerns and demands of the owners of the 850 homes outside the inner evacuated circle were not to be satisfied by either state or federal officials in a similar fashion.

The NYSDH did conduct a survey study of the residents in the remaining homes, which led to an announcement in early fall that the rest of the neighborhood was safe, posing no increased health risk. As subsequently revealed, this assurance had been based on only one health issue examined by the survey. The Department had concluded that the miscarriage rate in the homes beyond the fence did not exceed normal rates -- a conclusion based on a methodology that was subsequently seriously questioned. The many other possible health effects of chemical exposure had not entered into the NYSDH evaluation.

Citing the fact that chemical seepage was evident beyond the evacuated area and that families living there appeared to be experiencing unusual health problems, members of the LCHA rejected the department's assurances. They demanded more definitive studies and, when they did not get a satisfactory response from either the NYSDH or the EPA, they sought scientific aid from outside the government's environmental health establishment.

Beverly Paigen a cancer research scientist who worked for the NYSHD Roswell Park Memorial Institute in nearby Buffalo agreed to volunteer her services in an unofficial capacity. Her professional interests included the variation among individuals in their responses to chemical toxins and she anticipated that, in addition to helping the Love Canal residents, her involvement might also result in identifying appropriate subjects for her research work. Dr. Paigen designed a survey aimed at investigating several potential effects of exposure to chemicals. She used a different set of assumptions about the mechanism and likely path of the flow of the dissolved toxins that seeped out of the canal. Based on her model Dr. Paigen found that miscarriages were significantly higher among women living in homes most likely to be in the path of the chemical plume. She also found much larger than normal rates of birth defects and evidence of serious nervous system toxicity as well as elevated incidences of asthma and urological problems for residents of these homes.

In early November 1978 Dr. Paigen presented the results of her "unofficial" research to her NYSDH superiors. After a delay of three months the new New York State Commissioner of Health publically announced that after reevaluating its own data it also found excess miscarriages and birth defects in homes in previously "wet" regions of the Love Canal neighborhood and promised additional studies of Dr. Paigen's other findings. However, the action taken in response to these results puzzled and dismayed both the residents and Dr Paigen. Families with children less than two years of age or with women who could prove they were pregnant were to be relocated at state expense but only until the youngest child reached the age of two. Women who were trying to become pregnant, or those who thought they were in the early stages of pregnancy when the fetus is most sensitive to toxins, but who could not yet prove they were pregnant with tests available at that time, were denied permission to join the group that was evacuated.

During the next year and a half the frustration and the militancy of the LCHA members increased as the additional studies promised by the commissioner failed to materialize. On the federal level EPA lawyers had become convinced by media reports and public appeals from Love Canal residents claiming a variety of toxin-related illnesses that hundreds of additional families should be moved away. They sought a court order from the Department of Justice requiring Hooker Chemical to pay for the relocations. When the Justice Department responded by demanding evidence that the inhabitants who remained in the Love Canal neighborhood were at risk the EPA commissioned a quick "pilot" study to determine whether residents had suffered chromosome damage that could be attributed to chemical exposure. This study, which was to subsequently receive much criticism from the scientific community both because of its specific design and because, at the time, chromosome studies were notoriously difficult to interpret, did provide the type of evidence EPA was seeking. On the basis of finding "rare chromosomal aberrations" in 11 out of 36 subjects tested, the scientist who performed the study concluded that inhabitants of the area were at increased risk for a variety of adverse health outcomes.

On May 19, 1980, when two EPA representatives went to the LCHA office in one of the evacuated homes to announce the results of the chromosome study they were greeted by irate homeowners who proceeded to lock them in the office for five hours until FBI agents showed up and demanded their release. This tactic, which received the anticipated media coverage, had the desired effect. With the intervention of high-ranking officials in the Executive Branch, and undoubtedly with the support of then-president Carter, funds were made available for the relocation of several hundred additional Love Canal families.

A conclusion that can clearly be drawn from this and many subsequent environmental controversies is that politics, public pressure and economic considerations all take precedence over scientific evidence in determining the outcome. Another aspect of the Love Canal case that is characteristic of such events is that the victims, although hostile to Hooker Chemical, directed most of their rage at an indecisive, aloof, often secretive and inconsistent public health establishment.

Lawsuits against Occidental Petroleum Corporation, which bought Hooker chemical in 1968, were initiated by both the State of New York and the U.S. Justice department to cover costs of the cleanup and the relocation programs and by over 2000 people who claimed to have been personally injured by the buried chemicals. In 1994 Occidental agreed to pay $94 million to New York in an out-of-court settlement and the following year the federal case was settled for $129 million. Individual victims have thus far won in excess of $20 million from the corporation.

In early 1994 it was announced that the cleanup of the condemned homes in Love Canal had been completed and it was safe to move back to the area. The real estate company offering the inexpensive refurbished homes for sale had chosen to rename the area "Sunrise City."

4. Readings and Resources

A wealth of written and audiovisual material is available on Love Canal and other environmental controversies. Searching the electronic catologue of any public or academic library or using an Internet search engine should prove very fruitful.

For a colorful discussion of the early events in the Love Canal case by the investigative reporter who initiated the media coverage of the issue, and for a personal version of the events by the woman who organized the Love Canal Homeowners Association and went on to become a national leader of citizen's toxic waste organizing, see:

Laying Waste, by Michael Brown (New York: Pantheon Books, 1979).

Love Canal: my story, by Lois Gibbs; as told to Murray Levine (Albany, NY: State Univ. Of New York Press, 1981).

For a thought-provoking article that focuses on the political and ethical dimensions of the case by the scientist who volunteered her services to the Love Canal residents see:

"Controversy at Love Canal," by Beverly Paigen, *The Hastings Center Report*, pp 29-37, June 1982.

For a report written by the public health, transportation and environmental agencies of New York State see:

"Love Canal, a special report to the governor and legislature," by New York State Department of Health, Office of Public Health; with assistance of NYS Dept.of Transportation and NYS Dept of Environmental Conservation, Albany: The Office, 1981.

For two additional perspectives on the controversy see:

Love Canal: science, politics and people, by Adeline Levine (Lexington Mass.: Lexington Books, 1982)

Citizen Participation in Government Decision Making: the toxic waste threat at Love Canal, Niagra Falls, New York, by L. Gardner Shaw (Albany, NY: Nelson A. Rockefeller Institute of Government, State University of New York, 1983).

For articles published in science news journals see:

"Continuing Confusion over Love canal," by Barbara j. Culliton, *Science*, 209, pp 1002-1003, August 19, 1980.

"Uncertain Science Pushes Love canal Solutions to Political, Legal Arenas, *Chem. & Eng. News*, pp 22-29, August 11, 1980.

For comments on the plan to rehabilitate, rename and repopulate the Love Canal neighborhood see:

Rachel's Hazardous Waste News, #133, June 13, 1989.

For an Internet WWW site that contains a summary discussion of the Love Canal case with links to additional Love Canal sites use this URL:

http://ethics.cwru.edu/CONTEST/Canal/love_canal.html

For a highly informative collection of essays, comments and analysis on a wide variety of issues in environmental ethics see:

The Environmental Ethics and Policy Book, by D. VanDeVeer and C. Pierce (California: Wadsworth Publishing Co., 1994).

5. The Issues

Significant questions of ethics and values raised by this case:

- Beverly Paigen, the research scientist who volunteered her services to the Love Canal Residents commented in reference to her differences with her superiors in the NYSDH; "...I thought our differences could be resolved in the traditional scientific manner by examining protocols, experimental design and statistical analysis. But I was to learn that actual facts made little difference in resolving our disagreements -- the Love Canal controversy was predominantly political in nature, and it raised a series of questions that had more to do with values than science." Consider the differences in the values that might be of greatest importance to: a Love Canal resident; the New York State Commissioner of Health; a scientist doing research sanctioned by either the New York State Department of Environmental Conservation or the EPA; an independent scientist (like Dr.Paigen) who was doing volunteer research for the residents; a typical citizen of the state of New York. In what respects might these value differences lead them to conflicting decisions about what should have been done in response to the Love Canal disaster and how to do it?
- Is it reasonable to demand that the ethical duty of public officials is to respond to an environmental problem by objectively examining the scientific facts and the potential hazards to local residents, independent of economic and political considerations?
- One of the charges raised against the NYSDH and the Health Commissioner was that the public health establishment would not divulge the details of the studies that led to its decisions, held many closed meetings and even refused to reveal the names of members who served on consultation panels it established. Do you think that there might be an ethical justification for such public agencies to refuse public access to such information? If so does this seem to apply to the Love Canal situation?
- Another accusation was that state employees sympathetic to the Love Canal residents were harassed and punished. For example: Dr. Paigen's ability to raise funds for her research work was curtailed by the Roswell Park Memorial Institute - causing the professional staff to charge the administration with scientific censorship - her mail arrived opened and taped shut, her office was searched and when she was subjected to a state income tax audit she discovered newspaper clippings about her Love Canal activities in the auditor's

file; and when William Friedman, who had been the Department of Environmental Conservation's Regional Director, pressed state officials to take a less conservative approach to protecting the health of Love Canal residents he was promptly demoted to staff engineer. This type of reaction by the political power structure seems morally indefensible, but it is by no means unique to the Love Canal case.

- Another values issue is the extent of evidence needed to justify action to protect public health. In order for the scientific community to accept as fact research showing that a specific health effect is caused by a particular agent, the statistical analysis of the data must indicate with more than 95% certainty that the observed effect could not occur by chance. This high, but clearly arbitrary standard, has been adopted to protect the integrity of the body of accepted scientific facts. But should public health officials demand, as they often do, the same standard before taking action? For example, if evidence shows that there is an 80% chance that exposure to some chemical in the environment may cause a serious adverse health effect, should the health officials refuse to inform the public of the risk or take action to prevent exposure until further studies -- which may take months, or even years -- raises the certainty of the causal relationship to 95%?
- It is common in environmental controversies for those who believe they are at risk to become distrustful of public officials in charge of investigating their concerns. This was certainly the case in the Love Canal controversy. It is unusual for a citizens group to be able to obtain the volunteer services of an independent expert with qualifications like those of Dr. Paigen and they are not likely to have the financial resources necessary to hire their own consultant. Furthermore, although Dr. Paigen was able to provide valuable scientific services, she was unable to gain access to and assess much of the evidence that the public officials used as the basis for their decisions. Dr. Paigen and others have suggested that the ethical solution to this problem is to provide public funds to groups like the LCHA with which they can hire their own experts, and which they can use to hire a qualified advocate who will be given access to all public data and a voice in the decision-making process.
- The Hooker Chemical Company did not violate any then-existing specific environmental regulations by disposing of toxic waste in Love Canal, or in selling the land to the School Board. However, the courts have found Hooker financially liable for the harm that was the ultimate result of their disposal practices. This decision was largely based on the judgement that Hooker possessed the scientific expertise to be able to anticipate that dumping waste chemicals in the canal was likely to result in a public health threat. It was also

argued that Hooker acted irresponsibly by not informing the public of the risks it discovered in 1958. Should corporations be required to use their knowledge to avoid activities that may cause public harm?

- In recent years the issues of environmental justice and equity have been raised within the environmental movement. Minority populations, and poor people in general, have produced persuasive data showing that they are far more likely to be exposed to environmental pollution from factories or waste disposal facilities than more affluent white people. In the Love Canal case, the initial population of the neighborhood was neither poor nor did it have a high percentage of minority members. Of course those who chose to live there were not aware of the pollution risk. It is likely, however, that the inexpensive houses now being offered to induce people to move back into the area after remediation is supposed to have made it safe will attract primarily the poor. One proposal that has been put forth in response to demand for environmental justice is to provide some form of reward to those who live in neighborhoods where exposure to environmental toxins is significantly higher than average. Would this be an ethical practice? What other steps might be taken to promote environmental equity in an ethical manner?
- In our society environmental risks are generally evaluated in economic terms. However, the assignment of economic value to human health, a pristine forest or a smog-free vista is surely not an objective exercise. What other means might be used to evaluate environmental risks and benefits?
- We generally assign value to things in anthropogenic terms. We consider how humans will be affected by an activity that will cause pollution or degrade an ecosystem. Some environmental ethicists have proposed that we should adopt a biocentric perspective in which living things and natural objects are assigned intrinsic value independent of human concerns. How do you respond to the assertion that nature does not exist solely for the purpose of being exploited by humans?

SECTION II - Incorporating Ethics in Classroom Science Lessons

PART 1

Creating Your Own Ethics-in-Science Lessons

Teaching Ethics and Values in *Your* Science Classroom

In Section II, Part 2 we will present twenty-three edited versions of model lessons originally developed by teachers who participated in our program. In principle, a teacher of any secondary school science course should be able to select from this set at least two or three lessons that can be used in her own classroom which serve to meet some, or all, of the basic objectives of any program of ethics and values instruction discussed in Section I, Chapter 4. In practice, however, each teacher's classroom needs are unique. This point was stressed by our institute teachers. Thus, although most of them did make use of lessons developed by other participants, almost all of them found it necessary to construct lessons specifically tailored to their own interests and the needs and abilities of their own students.

During the second and third summers of our program our institute staff included teachers who had been participants during one of the previous years. These participant-instructors, Ms. Phyllis Satz, Mr. David Flatley and Mr.Vincent Sydlansky were specifically charged with the task of aiding the teachers in the development of their ethics and values classroom lessons. Many of the suggestions and comments that we offer here are based upon the creative work of these three talented teachers.

Some Basic Observations and Suggestions

Teachers are accustomed to carefully considering the goals and objectives of their classroom

science lessons. This should apply equally to lessons designed to explore ethics and values in science. Many of the teachers who enrolled in our institutes began with a rather narrow conception of the purpose of ethics education. They mistakenly identified the study of ethics exclusively with the examination of dilemmas. A dilemma poses a choice among mutually exclusive options, none of which appears to be completely satisfactory. Whatever choice is made will result in some negative consequence, so the right or preferable choice is not clear. Ethics education was seen only as encouraging students to examine the ethics and underlying values associated with choosing among the possible courses of action in such "dilemma" cases.

In Part I, Chapter 3 we presented the following five goals of ethics education: Stimulating the moral imagination of students; Helping students recognize moral issues; Helping students analyze moral concepts and principles; Stimulating students' sense of responsibility; Helping students deal effectively with moral ambiguity and disagreement. Dilemma cases are specifically associated only with the last of these basic objectives. Although it is true that exploring dilemmas *can* involve the other four objectives it is important to make students aware that morality and values do not arise primarily in the face of a dilemma. Furthermore, cases involving moral ambiguity need not be dilemmas -- they can simply involve situations where making a good choice requires more thoughtful analysis. The universal goal of infusing ethics and values into science education is to reveal that as in all human endeavors, most of the actions of those that practice or use science involve choices with moral implications.

A second common mistaken notion is that the only way to avoid indoctrination when teaching ethics and values is to encourage the notion that all ethical choices are equally valid. The fact that few if any of us would want our students to become the kind of amoral agent who accepts the validity of that notion should be sufficient to discredit it. Indoctrination should indeed be avoided. Students should be encouraged to explore and express a wide range of ethics and values positions including those that may be viewed by other students (or the teacher) as socially or personally unacceptable. But students (and teachers) should also be expected to defend their positions and choices and to accept responsibility for their actions.

A problem commonly raised with regard to ethics education is that it may raise strong objections among the citizens, parents and school board members to whom teachers are ultimately beholden. Curiously, although this concern was voiced by many of our Long Island institute participants, few of them felt personally constrained by potential censorship. Most of them felt relatively free to introduce such sensitive issues as abortion and sexual preference in their classrooms. While this may be less true in other parts of the country, we suggest that teachers cautiously test the waters before assuming that an important issue related to ethics in science is indeed taboo.

Ethics and values education, like most other academic endeavors requires the use of terms with specific meaning. Although we do not propose that the science classroom is the proper venue for detailed introduction to the study of ethics it is necessary to begin with a lesson that presents some basic definitions and concepts Some initial attention should also be paid to persuading students of the validity of some of the connections between ethics and science discussed in Part I, Chapter 1.

Sources for Ethics in Science Lessons

A wide variety of sources are available to draw upon for the development of science classroom ethics lessons. These include:

- Books on ethics in science and scientific integrity.
- Articles on scientific ethics and case studies in journals like *The Science Teacher, The Biology Teacher, Journal of College Science Teaching,* and *The Hastings Center Report*..
- Science articles in newspapers and news magazines.
- Ethics lessons in existing science texts like the Biological Sciences Curriculum Study (BSCS) materials.
- Numerous education and science related ethics websites.
- The Woodrow Wilson Biology Institute website.
- Science fiction stories - books and videos.
- Ethics in science videos
- The case studies in Section I, Chapter 4

The resource listings in Part 3 of this Section contain references to specific examples of many of these materials. One particular resource that deserves attention because it is received by a large percentage of science teachers is the *National Science Teachers Publications Catalog* which includes a wide variety of educational materials distributed by the NSTA. Of the numerous publications and other resources listed in the most recent catalog, the one that science teachers are likely to find most useful in designing values and ethics lessons is *Real Science, Real Decisions.* It is a collection of "Thinking Activities" reprinted from *The Science Teacher* about ten different controversial issues associated with contemporary science. Many of the ethics/values questions are highlighted in a background piece on the subject designed for teachers and a briefer discussion of the topic with questions written for students.

Several of the other publications distributed by the NSTA are fruitful sources of materials for constructing ethics-in-science lessons -- but the lesson maker will have to draw attention to, and spell out the ethics issues, since the texts themselves make no mention of the related ethics/values questions. Such publications include a series of "event-based science modules," entitled *Oil Spill!*; *Earthquake!*; *Hurricane!*; *Toxic Leak!*; *Flood!*; *Asteroid!*; *Gold Rush!*; *Tornado!*; and *Volcano!* Each includes a student booklet and accompanying teacher's guide.

Another NSTA recent publication, *Decisions Based on Science*, despite its suggestive title, does not explore or clarify the values implicit in the making of scientific decisions. Instead it describes the use of risk-probability methodologies in making decisions. Unfortunately these methodologies are presented in a way that erroneously implies that they lend themselves to value-neutral decision making. With an appropriate supplement by the lesson maker this publication could serve as a useful resource for a lesson on the numerous ethics/values questions that actually arise when attempting to employ risk-benefit or cost-benefit analyses.

Techniques and Strategies for Ethics-in-Science Lessons

The twenty-three model classroom lessons we present in Part 2 illustrate several useful techniques or strategies that can be employed in the design of your own lessons. These include:

- The use of case studies. Students are given a brief scenario, or a set of brief scenarios, designed to illustrate specific ethical issues associated with science. These can be fictional or they can be based on actual events. After reading the scenario(s) students, either individually or in cooperative learning groups, are asked to respond questions designed to probe their ethics and values contents.
- The use of the "structured controversy." Students are divided into groups of two pairs. In each group the pairs are given one of two brief essays describing opposing views on a controversial issue related to science. After reading and discussing the issue among themselves the pairs engage in a brief debate in which they focus on the ethics and values differences that underlie the conflicting positions. The pairs then exchange essays and again debate, this time supporting the opposite position. The teacher rotates among the debating groups with the goal of keeping the debates focused on questions of ethics and values.
- Panel discussion. Students are given a description of a scientific dispute facing a community, as well as an outline of the positions likely to be taken by key parties to the dispute, governmental officials, and citizens groups. Students are then selected to represent the various parties and engage in a panel discussion, with the remainder of the class directing questions at the panelists. The entire class then engages in an analysis and discussion of the ethics and values issues raised by the panelists and questioners.
- Simulation. After reading a background essay on the some controversial new application of scientific research, students engage in a simulation of some real-life activity that requires them to make decisions with ethics and values

implications about the ways society may choose to make use of this new technology.

- Ethics and values from science fiction. Students read a science fiction story that illustrates real life ethics and values issues related to science and technology. Either individually or in cooperative learning groups students respond to a series of questions designed to engage them in an analysis of the ethics and values associated with the choices made by the characters in the story, and to consider the ethics of the range of alternative actions open to the characters.
- Maintaining an ethics and values journal. Students are instructed to make weekly entries in a journal concerning the ethics and values issues described in science articles appearing in newspapers or magazines. The teacher periodically collects these journals, comments on them and selects one each week or two for classroom discussion.
- The "moot court." Students are given details of a case involving an individual who is being accused of some form of scientific misconduct. Students are assigned to play the roles of defendant, prosecuting attorney, defense attorney, judge and a series of witnesses for the prosecution and the defense. A mock trial is held with the remainder of the class serving as the jury.

Creative teachers will surely be able to think of many additional classroom teaching strategies designed to meet the goals of ethics instruction. No matter what techniques are used, an ethics lesson will almost invariably benefit from the inclusion of a significant time period for discussion of the issues among students. Teachers should confine their roles in such discussions to keeping things moving and focused on the ethics and values issues at hand. The stimulation of the moral imagination and development of moral reasoning by students is generally promoted and enhanced by observing the differences and similarities in values and in modes of analysis employed by their peers.

A Few Words of Caution

The personal lives and experiences of students may be closer to some of these issues than we realize. Discussion of a debilitating hereditary condition may be painful for a student who has a family member or close friend who suffers from that condition. Children of scientists may be disturbed by suggestions that scientists aren't all scrupulously honest at all times. Discussing the ethics of various techniques used to enhance reproductive techniques may distress a student who has learned that he or she is some form of "test tube baby." This doesn't mean that such issues must not be discussed in class, but teachers should be sensitive to the potential personal impacts they may have on an individual student.

Finally, dogmatism has no place in ethics education. It is impossible and unwise for a teacher to try to hide personal feelings and thoughts on important ethical issues. Indeed, we should try to be good ethical role-models for our students. But at the same time we need to be scrupulous in encouraging open discussion of different moral perspectives among our students.

Suggestions for Analyzing Cases

Can an ethics discussion be more than a "free-for-all," especially if it is not the responsibility of teachers to provide students with the "correct" answers? We believe that it can--and that it should. A lesson plan typically will include a scenario (or case) to be discussed. As in any inquiry, it will be important to determine the facts that are given in this scenario as clearly as possible. It is also important to try to determine if there are possibly other facts (facts not presented in the scenario) that would be helpful in addressing the ethical questions.

So, one of the first things to do with students is to try to get as straight as possible about what the facts are that give rise to ethical questions, and to try to determine what other facts might be relevant to answering those questions. This may require hard, careful work -- for two reasons. First, the facts presented might be unclear or in need of further explanation; to understand some of them it might well be necessary to learn a fair amount about science. Second, not every fact that is mentioned may be*relevant* to the ethical questions raised. So, some attempt to sort out the relevant facts from irrelevant ones is necessary.

Let's look at an example to see how this sorting might work:

Kim is one of the most popular students in her school and one of the smartest, as well. She has had all A's every semester since the 10 grade. Now she is a senior in her last semester.. Both John and Mark have invited her to the prom next month, and she is having difficulty deciding which invitation to accept. She likes both of them and does not want to hurt their feelings.

Usually Kim concentrates very hard on what she is doing in her chemistry lab. She has been working on an important project for the past three weeks. It will count 25% of her grade. Until yesterday everything in the lab had gone quite well. Her project was nearly finished, and all the data she had collected pointed in the same direction. One more day in the lab would clinch it, she thought.

But receiving a second invitation to the prom yesterday morning took her by surprise. In the afternoon lab Kim seemed more concerned about what to do about John and Mark than in paying careful attention to her lab work. She finally resolved her problem that evening, but today presented her with a new one. Checking the results of yesterday's lab work, Kim found a set of results that did not fit very well with all the other data she had collected. Today was the day to write up her final report. She was worried that if she included yesterday's data her results would look a lot less impressive than if she simply excluded the data. She worried that this might result in her not receiving an A for the semester.

"I can't believe this," Kim thought to herself. "Almost three weeks of wonderful data, and now this -- on the last day of the project. I can't do it over, because the report is due tomorrow. Maybe I made a mistake in the lab yesterday; I could hardly think about anything other than John and Mark. So, maybe I should just leave out that data. After all, I have almost three weeks worth of good data -- and I *know* my conclusion is right.

Would it be all right for Kim to leave out the data from yesterday's lab work?

In reading this scenario we can understand why Kim is tempted to leave out the data. But we should not assume that the psychological factors at play here are relevant to the ethical question of whether she would be *justified* in leaving out the data. Whether or not Kim wears glasses, has blond or brown hair, or is tall or short clearly have no relevance to the ethical question. Even if Kim were self-conscious about wearing glasses, having dyed her hair, or being very short or tall, this would not seem to have any relevance to the question of whether leaving out the data is justified. So, we should ask, what relevance does the fact that she was distracted by thoughts about John and Mark have to the ethical question?

By now it may be clear that to ask whether certain facts are relevant requires us also to ask what ethical concepts, rules, principles, or considerations are relevant to the case. So, the discussion needs to begin with two questions at once: 1) What are the relevant facts? 2) What are the relevant ethical considerations? In some cases, the answers may be relatively straightforward. In others, matters may be less clear and call for more extended discussion. Some of that discussion may pivot largely around what the facts are (e.g., what *is* the data from the study?), and we might want more information than the case provides. But what facts (known or unknown) we need to consider will, again, depend on the ethical issues at stake. Certain key concepts might also need to be examined. In this case, for example, it will be important to discuss what it might mean to *misrepresent* data, and whether *omitting* data is a form of misrepresentation. Further, is misrepresentation of data a form of *cheating*? Finally, we can ask what is wrong with cheating in a science assignment.

To give the discussion some structure, it might be useful to provide students with a set of tasks to perform. After reading the scenario, address the following questions:

- What facts are presented? (We can call these the *known* facts.)
- What ethical concerns do they raise?
- What are the key ethical concepts or principles that need to be considered?
- Which of the known facts are *relevant* to resolving the ethical concerns?
- What additional facts might be relevant to the case? (We can call these the *unknown* facts.)
- How might these unknown facts affect what is ethically at stake?
- What options are available?
- Which of these options seem best from an ethical point of view? Explain.

It is not intended that each question be addressed sequentially. It is to be expected that the discussion will move back and forth among the questions. However, it is helpful always to keep them in mind and to remind students of the importance of getting as clear as possible about each of them.

PART 2
Model Classroom Lessons

Introduction to Part 2 --- Including a printable taxonomy which characterizes the focus of each lesson and the issues with which each is concerned. ***This is a very valuable tool. Check it out!***

The following 23 lessons are designed for classroom use. They are all edited or revised versions of lessons created by teachers in our institutes. These lessons cover a wide range of topics and grade-levels. At least one lesson is included that is designed for each of the science courses commonly offered in secondary schools, including middle schools, junior high schools and senior high schools. Some of the lessons are adaptable for use in several subjects and grade-levels.

Each lesson conforms to the following format:

1- Title of Lesson

2- The author(s) of the lesson.

3- Which science course(s) the lesson, as written, is designed for.

4- The kind of teaching activity employed in the lesson. (For example, a hands-on laboratory exercise, an organized student debate, a panel discussion, student responses to case studies, discussion of ethics issues involved in a science fiction story, etc.)

5- Which one, or more of the following categories of ethics-related issues best describes the lesson: Behavior of scientists, behavior of students, social issues, or honesty.

6- A listing of the principal ethics/values issues that are raised by the lesson.

7- A detailed lesson-plan, instructions for the teacher, and materials for the students.

8- A discussion of the appropriate use of the lesson, and the ethics/values issues that the lesson is designed to explore.

Listing of model lessons by science class for which they are appropriate.

Lessons for any secondary school science class.

(1) Alas, All Humans

(2) Student and Teacher Behaviors in Science Classrooms

(3) Keeping a Science Journal

(4) Honesty in Reporting Research

(5) What Kind of Research Should Our Government Support?

Lessons for middle and junior high school general science

(6) Low Birthweight Infants

(7) Fraud in Science: Circumstances and Consequences

(8) Recycling

Lessons for earth science classes

(9) Dune Road

(10) Summer Home

(11) The Landfill

(12) Pinebarrens

(13) The Automotive Plant

Lessons for biology classes

(12) Pinebarrens

(14) Ethics Issues From Science Fiction

(15) The Envelopes

(16) The Human Genome Project Structured Controversy

(17) Whose Life Is It?

(18) My Friend Linda

(19) The Race for the Double Helix

<u>Lessons for chemistry classes</u>

(10) Summer Home

(11) The Landfill

(13) The Automotive Plant

(20) Reporting Data

(21) Ethics in the Science Laboratory

<u>Lessons for physics classes</u>

(21) Ethics in the Science Laboratory

(22) The Law of Inertia

(23) Handling Discrepancies

Listing of model lessons by categories of ethics issues that they illustrate.

<u>Behavior of scientists</u>

(1) Alas, All Humans

(3) Keeping a Science Journal

(4) Honesty in Reporting Research

(7) Fraud in Science: Circumstances and Consequences

(13) The Automotive Plant

(14) Ethics Issues From Science Fiction

(19) The Race for the Double Helix

(20) Reporting Data

(22) The Law of Inertia

Behavior of students.

(2) Student and Teacher Behaviors in Science Classrooms

(3) Keeping a Science Journal

(4) Honesty in Reporting Research

(21) Ethics in the Science Laboratory

(23) Handling Discrepancies

Social issues.

(3) Keeping a Science Journal

(5) What Kind of Research Should Our Government Support?

(6) Low Birthweight Infants

(7) Fraud in Science: Circumstances and Consequences

(8) Recycling

(9) Dune Road

(10) Summer Home

(11) The Landfill

(12) Pinebarrens

(14) Ethics Issues From Science Fiction

(15) The Envelopes

(16) The Human Genome Project Structured Controversy

(17) Whose Life Is It?

(18) My Friend Linda

(22) The Law of Inertia

Honesty.

(1) Alas, All Humans

(2) Student and Teacher Behaviors in Science Classrooms

(3) Keeping a Science Journal

(4) Honesty in Reporting Research

(7) Fraud in Science: Circumstances and Consequences

(20) Reporting Data

(21) Ethics in the Science Laboratory

(23) Handling Discrepancies

LESSON 1

Alas, All Human

Author:

This is a revised version of a classroom lesson initially developed by:

Solomon Buchman, Elwood John H. Glenn High School, East Northport, Long Island, NY

Courses for Which the Lesson is Intended:

This lesson is suitable for use in any high school science class.

Types of Teaching/Learning Activities Employed in this Lesson:

Students are told to write a description of the traits of character and behavioral characteristics that they associate with someone who is a scientist. The teacher then lists on the board the characteristics that students thought of. This leads to a discussion about the stereotypical view of a scientist as honest and objective. For homework, students are required to read and answer questions about an essay by science fiction writer Isaac Asimov in which he gives many examples that show that scientists, being human, don't always live up to the stereotypical ideal. A classroom discussion is then conducted to explore and clarify the ethics and values issues in the examples given by Asimov.

Categories that Best Describe this Lesson:

The behavior of scientists.

Honesty.

Ethics/Values Issues Raised by this Lesson:

Issues related to credit for discoveries, citing of authority, excessive pride in one's own ideas, overeagerness, and various degrees of manipulation or fraudulent reporting of data.

Lesson Plan

Introduction

The idealized view of a scientist is of a scrupulously honest, objective, highly ethical individual. The point of this lesson is to emphasize that science is a human endeavor and as such it is unrealistic to expect its practitioners to be exempt from the influence of social and personal values that make all of us fallible. The lesson makes use of an essay by the very popular science fiction writer, Isaac Asimov. Asimov is well known as an ardent advocate of science. He wrote his persuasive essay in response to his own awakening to the reality that, no matter how hard the scientific community strives to live up to its idealistic stereotype, it is necessary to be mindful that scientists are mere mortals, not infallible icons.

As written, this lesson requires 1 1/2class periods and an intervening homework assignment.

1. During the latter half of a class period instruct students to spend ten minutes listing all of the characteristics and behaviors, which they would attribute to a professional scientist.

2. Invite students to read what they have written and compile on the chalk board a comprehensive list of the traits of character and behaviors the students associate with scientists.

3. From the traits that are mentioned most often, create the class's stereotypical view of the scientist. In all likelihood the stereotype will picture the scientist as a dedicated seeker of the truth who is honest, objective and who maintains high ethical standards.

4. At the end of the discussion students should be given for homework the assignment of reading the essay "Alas, All Human," by Isaac Asimov. [This essay is included in *A 30 Year Retrospective: 1959-1989*, by Isaac Asimov (Doubleday: New York, 1989). This book is available in many libraries.] Students should be instructed to bring to the next class session written responses to the following questions about the essays:

   a. What do you think Asimov meant by the title of the essay and what was the principal point he was trying to make?

b. Do you think that Asimov believes that most scientists are dishonest or unethical?

c. Why does Asimov claim that despite "misconceptions due to incomplete or erroneous data" the movement of science "is always from the less true to the more true"?

5. Begin the next class period by inviting students to read their answers to the homework questions. Make sure that during the discussion of the answers the following points are emphasized:
a. Asimov's title is intended to point out that scientists are human beings and can't be expected to always resist the pressures and temptations that result in less than completely ethical or honest behavior.

b. Asimov makes it clear that he is a strong supporter of science and that he considers the types of dishonest activity he describes as the exception and not the rule.

c. Asimov considers science -- as opposed to scientists -- to be "incorruptible." He makes this assertion on the basis of his claim that no scientific observation (or reported result) is accepted until it has been independently confirmed, presumably by another scientist or team of scientists. Unfortunately if this was ever true, it is becoming less so as scientific research becomes more expensive and sophisticated. Although it is true that all research reports are reviewed by other scientists before being accepted for publication, it is not uncommon for results to enter what Asimov refers to as "the account books of science" without actual independent experimental confirmation. In many cases such confirmation would require the expense of duplicating the original work to be supplied by some funding source. Few agencies that support expensive research are willing to pay to duplicate apparently successful research when the money could be used instead to support a new project. Since most important scientific work will ultimately be the basis for further research, it is likely that erroneous results will ultimately be discovered. But, until this happens a fraudulent report, especially by an established scientist, can cause considerable havoc.

6. Review each of the types of dishonest or improper behavior by scientists described by Asimov. In each case have the class discuss whether it is an example of: a) inappropriate, but not unethical behavior; b) a case of scientific misconduct, but not truly unethical because it is probably unintentional; or c) a clear case of serious scientific misconduct or fraud.

7. End the class session with a discussion about what, if anything, the students think should be done by either the scientific community, the government, or the public in response to the issue of occasional, but possibly serious scientific misconduct.

Discussion:

There is no need for concern that students will be turned away from science by a lesson that undermines the heroic model of a scientist as an invariably honest seeker of truth. In fact, those who have used this lesson, or who have otherwise made efforts to portray a more realistic view of scientists have found that students are more sympathetic to scientists when they learn that they are fallible human beings like themselves.

By describing a variety of questionable science behaviors that differ in the degree to which they involve intention on the part of the scientist as well as severity of possible consequences, Asimov provides the opportunity to teach two important lessons about ethics. The first is that judgements about whether an action or behavior is ethical or morally acceptable is not generally an all-or-nothing proposition. Most of us make such evaluations by applying a scale with clearly unethical on one end, highly ethical on the other, and many gradations in between. The second is that there are various obstacles that prevent even those with good intentions from satisfying the ethical demands of good science practice. This latter point is likely to be revealed during the class discussion of Asimov's categories of questionable scientific behavior.

LESSON 2

Student and Teacher Behaviors in Science Classrooms

Author:

A edited version of a classroom lesson initially authored by the following Long Island, NY science teachers:

Kenneth Abbott, and William Leacock, W.C. Mepham High School, Bellmore

Heidi Gross, Oyster Bay High School, Oyster Bay

Courses for Which the Lesson is Intended:

Intended for use at the beginning of the year in any science classroom. The teachers who developed this lesson teach physics and earth science and have described incidents that have occurred in their courses. Teachers of other disciplines can easily modify the cases so that they will be more familiar to their own students.

Types of Teaching/Learning Activities Employed in this Lesson:

Students working in cooperative learning groups respond to cases involving ethical choices by students and teachers in science classrooms. The teacher directs a classroom discussion of the conclusions reached by the groups. Students create and submit additional cases and questions for use throughout the school year.

Categories that Best Describe this Lesson:

Behavior of students.

Honesty.

Ethics/Values Issues Raised by this Lesson:

The cases presented raise questions about the ethics of "sharing" test and laboratory results, of manipulating data, of receiving credit for work done by others, of a teacher adjusting a student's grade and of a student taking action to prevent another student from cheating. The same format can be used to raise questions about other real life ethical issues encountered by science students and teachers.

Lesson Plan

Introduction

The social and academic pressures experienced by science students and teachers can sometimes induce them to engage in questionable behavior. Such pressures are frequently the result of conflicts between the performance expectations and the ethical expectations placed on the individuals by the school, the community and society. The activities in this lesson provide an opportunity to examine and discuss these types of conflicts. The students will benefit from being given the chance to consider their own actions prior to being confronted with similar ethical choices.

Students will be asked to consider nine case studies based on actual situations that have occurred in a science class setting. Questions are provided with each scenario to stimulate and initiate discussion. The lesson requires two normal length class periods.

Divide the class into six groups of 3-5 students. Assign one member in each group to each of the following roles:

- Leader/Taskmaster - responsible for keeping the group on task. Obtains the material for the group and moderates discussions.
- Reader - reads the case to the group and responds to factual questions about them.
- Scribe - records the groups responses during the discussions of each case.
- Presenter - describes and explains the groups conclusions to the other groups and to the class.

Group the case studies into three sets of three and assign each set to two of the groups. Allow twenty-five minutes for the groups to read, discuss and record their responses to their three assigned case studies.

During the remainder of the first class period the two groups that have been assigned the same set of case studies get together to exchange views and begin preparing a presentation for the class.

At the beginning of the second period the pairs of groups continue their preparation for the class presentation. The two presenters from the original groups agree on how they will divide the presentation.

The presenters describe and explain the points of agreement and any conflicting points of view that have emerged from the discussions. These conclusions are then discussed by the class. The teacher should intervene only to raise ethical choices or issues not considered in the presentations or discussion.

The students are given a homework assignment requiring each of them to create and submit an ethical case study - either imagined or based on experience - along with discussion questions.

After reviewing and giving the student authors a chance to improve their creations, the teacher should select the best of the student cases for brief discussions at the beginning of class periods during the school year.

Case # 1

Rachel has a crush on Don, who is a popular student and star of the school basketball team. Both Rachel and Don have the same physics teacher. Rachel is in Mr. Link's third period class and Don is in his sixth period class. Rachel works hard and is doing very well in physics. Don is not very interested in science, does little work, and is barely passing. Rachel and Don meet each other in the hall every day between fourth and fifth periods. Today there is a test in Mr. Link's class and Don did not study because he was very tired after basketball practice yesterday. Don asks Rachel to give him the test answers. She knows that if he doesn't pass the test he may fail the course.

1. What are Rachel's and Don's options?

2. If you were Rachel, what would you do? Why?

3. If you were Rachel's friend, would you recommend that she should do what you would do?

Case # 2

John is doing a research study for his earth science class. The object is to measure and make a plot of the altitude of the sun at noon over a four-month period. He collects data every third day. At the end of the four months John has six missing data points because cloudy weather on those days prevented him from making the necessary measurements. He decides to estimate the correct data points for the missing days and simply include them in both his table of data and his graph.

1. Did John's action violate any principle of scientific ethics?

2. What other options did John have?

3. If you were John, what would you have done?

<u>Case # 3</u>

Pete, Brooke and Lisa are laboratory partners in their chemistry class. Yesterday Lisa was absent. This required Pete and Brooke to work very diligently to complete the experiment during the lab period so they could hand in the report in class today. Today Lisa has returned to school after being ill. She meets her lab partners on the way into school in the morning and asks them for the data from yesterday's experiment so she can write it up during study period and hand it in. Pete is willing to give Lisa the data, but Brooke objects.

1. Was it right for Lisa to ask for the data?

2. What other options does Lisa have.

3. What should Brooke do if Pete gives Lisa the data, despite her objection?

4. What would you do if you were Pete or Brooke? If you were Lisa?

<u>Case # 4</u>

Joe is making electrical measurements in a physics laboratory. Joe is a good student and is confident that he has set up the circuit properly. When Joe tries to do the required calculations to verify the formulas in his physics book he finds that the data he took appears to be incorrect. He suspects that one of the electrical components he was given is not working properly. His teacher, Mr. Grim, is busy helping some of the weaker students so Joe decides not to report his problem. Instead he does the mathematical calculations to determine what a correct set of data would be and simply changes his own data to match what he has calculated.

1. Since Joe is bright enough to figure out the correct data is there anything wrong with what he did?

2. What other options were there for Joe.

3. If you were Joe, what would you have done?

<u>Case # 5</u>

Janet is putting a lot of effort into her final earth science report. She has neglected the course earlier in the year and has chosen a difficult topic to impress her teacher and get a good grade. Her friend Sarah, who is a very good student is working on the same topic. Janet asks whether she can work cooperatively with Sarah, as permitted by her teacher. Janet then puts in little further effort, knowing she can rely on Sarah to do a good job. Since she is Janet's friend, Sarah raises no objections to having Sarah simply put her name on the report and share the grade.

1. Since Sarah does not object, is there anything improper about Janet's action?

2. What other options are open to Sarah?

3. If you were Sarah, what would you have done?

4. How could the teacher change the assignment, without discouraging student cooperation, while preventing students from simply taking credit for work done by others?

Case # 6

Two years ago Central high hired new chemistry teachers, Mr. Young and Mr. Keen. Last year Mr. Young's students did not do as well on the statewide final exam as Mr. Keen's chemistry students. The number of chemistry students has been decreasing and the school is under pressure to reduce expenses. It is therefore very likely that the school administration will decide that only one chemistry teacher is needed. To improve his chances of being retained, it is important for Mr. Young's students to do well this year. He has just received a copy of this year's statewide exam. Mr. Young decides that during the last two weeks of class he will only review the particular material that is covered by questions on the exam and include many examples of problems that are almost identical to the exam questions.

1. Since he hasn't actually given his students the answers to the exam questions, is there anything wrong or unethical about Mr. Young's actions?

2. Can you think of any negative consequences of Mr. Young's strategy?

3. Is it a good idea for the state to give the teachers advance copies of the exam?

Case # 7

Andy is doing a physics lab in which he attaches different masses to the end of a spring and measures the increase in the length of the spring. The instructions are to express the results in the form of a simple graphical plot of the data. He quickly discovers that if he plots the mass versus the increase in the spring's length most of the points fall on a straight line. Two of the points are clearly off the line. Assuming that he must have made an error in measuring the spring's length in the case of these two points, Andy decides to erase them from his graph and data table when he hands in his lab report.

1. Was Andy justified in omitting the points that didn't fall on the line?

2. Is it ever permissible to ignore part of the data taken during an experiment? If so, under what circumstances.

3. If you were Andy, what would you have done?

Case # 8

Mr. King teaches earth science at Central High. Larry, one of his students, is learning disabled and has difficulty reading. Larry works hard and Mr. King likes him. Twice during the year Larry has become discouraged and talked to Mr. King about dropping the course. Both times Mr. King persuaded him to stick with it. The final exam has several problems based on reading a preceding detailed description of an experiment. Larry finds this kind of problem particularly difficult and fails the exam with a score of 52. He needed a score of 72 to pass the course. Mr. King feels guilty about having encouraged Larry and he simply changes his grade in his record book to a 72. He justifies this to himself on the basis of his speculation that Larry would have done much better if he wasn't learning disabled.

1. Is Mr. King's action justified?

2. Can you think of any negative consequences of this action?

3. What other options were available to Mr. King?

Case # 9

Steven has studied many hours for the chemistry midterm exam. He is confident that he will do well. He has lunch period just before the exam. He finishes quickly and gets to the chemistry classroom several minutes before the other students or the teacher. On his way to his desk he notices that his classmate George's desk has extensive notes related to the exam written on it. Since the desks are moveable he replaces the desk with the writing with one from the classroom next door. Steven is amused by the bewildered expression on George's face when he sits down and recognizes that his desk has been switched.

1. Was George justified in switching the desk? Why?

2 What other options were open to George?

3. If you were George, what would you have done?

Discussion:

The format of this lesson provides the science teacher with the opportunity to have the students consider a variety of classroom ethics issues that are based on his or her past teaching experience. The value of including cases that involve dubious behavior by teachers is that it reassures students that the teacher recognizes that all human beings, not only students, occasionally engage in questionable ethical behavior.

As specified in the lesson, the role of the teacher during the discussion should be to encourage the students to explore the various ethical choices related to each of the cases. In general teachers should refrain from presenting their own views about the ethical issues raised by the cases so as not to discourage students from making their own decisions. The authority associated with the position of teacher can undermine the intent to encourage students to examine all of the behavioral options and reach their own personal decisions on the issues. However, if a teacher has included a particular case because it illustrates an ethical choice by students that he or she considers unacceptable, then the teacher may wish to make this clear, if the student discussion of the issue reveals some ambiguity.

LESSON 3
Keeping a Science Journal

Author:

A revised version of an individual lesson plan developed by

Roseann Cirnigliaro, Northport High School, Northport, Long Island, NY

Courses for Which the Lesson is Intended:

Intended for use in any science class.

Types of Teaching/Learning Activities Employed in this Lesson:

Students keep a journal on current news coverage of science issues that have ethical dimensions.

Categories that Best Describe this Lesson:

All categories.

Ethics/Values Issues Raised by this Lesson:

Depends on the contents of the articles selected.

Lesson Plan

1. The teacher collects and copies articles in newspapers and magazines that deal with science related issues. These articles are distributed with appropriate questions for the students. The questions focus mainly on the ethical issues rather than on specific scientific facts (although getting clear about the ethical questions usually requires getting clear about some of the scientific facts).

2. Articles are distributed periodically over the entire school year. Students are invited to submit articles they find to the teacher for possible distribution to the entire class.

3. The level of sophistication of the articles depends on the grade level and the level of the class. Here is a possible format for a quarter:

Distribute approximately 10 articles for students to read and comment on. Each student keeps the articles and responses in a separate folder which will be graded. Each assignment will be graded on the basis of a possible 10 points:

3 points Brief summary of article

3 points Reaction to article

2 points Answer to a specific question

2 points Quality of writing (spelling, sentence structure, etc.)

4. Article topics will vary, depending on the course (e.g., biology, chemistry, earth sciences, physics). In 1995, for example, a controversy developed over a proposed Smithsonian Institution 50th commemorative exhibit of the 1945 dropping of the first atomic bomb on Hiroshima. Critics claimed that the proposed exhibit was biased, even "anti-American," since it seemed to show the United States as the aggressor and it placed more emphasis on Japanese losses than the United States's triumph. Articles detailing this controversy would be appropriate in physics or chemistry courses, since the development and use of the atomic bomb is a dramatic illustration of possible military uses of scientific knowledge; and important questions about the social responsibilities of scientists can be raised. Students could also read Albert Einstein's famous 1939 letter of warning to President Franklin D. Roosevelt that, in light of reports that Germany might be developing an atomic bomb, the United States needed to accelerate research in nuclear physics -- and Einstein's later regret when he said, "I made one mistake in my life when I signed the letter to President Roosevelt."

5. A journal entry consists of a summary of the main points of an article and some discussion of the ethical and value issues raised by the article. Teachers might assist the discussion of ethical and value issues by adding specific questions for students to answer. For example, "Why do you think Einstein thought he had made a mistake signing the letter to President Roosevelt?" "What kinds of questions should scientists ask about possible areas of research before they undertake them?" "Is science 'value-neutral'?" However, it would be useful to encourage students to develop their own questions, as well.

6. Journal entries can simply be turned in for teacher evaluation and grading; or they can provide the basis for class discussion, as well.

Discussion:

Journal assignments encourage students to connect their science studies with current events, as well as historically significant events that involve science. This is important both for students planning to undertake science careers and for the general student preparation for informed citizenship in a democratic society. Regular attention to science in the news helps students see the relevance of science studies to their lives outside the classroom.

Writing about ethical and value issues in science news not only places science in the context of our everyday lives, it also promises to deepen our understanding of those issues. As an individual activity, this can be quite valuable in its own right. However, these writing exercises can also prepare students for classroom discussion, which will further broaden and deepen their understanding of the social implications of science. Teachers might even want students to share journal entries with each other. However, if this is to be done, students should be told in advance that this will be done; and if the topics are particularly sensitive, this should be done only with their permission.

LESSON 4

Honesty in Reporting Research

Author:

A revised version of a lesson plan developed by

Kenneth Abbott, Mepham High School, Bellmore, Long Island, NY

Courses for Which the Lesson is Intended:

All science classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Students view and discuss a video on dishonesty. Then they have a homework assignment to apply this discussion to household products that have resulted from scientific research by asking what dangers these products might pose if the research behind them had been falsified or misrepresented.

Categories that Best Describe this Lesson:

Behavior of scientists.

Behavior of students.

Honesty.

Ethics/Values Issues Raised by this Lesson:

Importance of laboratory honesty, especially in research that has a direct impact on human health and welfare.

Lesson Plan

Designed for use at the beginning of science classes that include a laboratory component. The teacher outlines the requirements of laboratory work in the class. The teacher then asks the students what they think about the importance of not cheating or fudging when collecting data.

Following a brief discussion of their ideas, the teacher shows the first few minutes of the Nova video, *Do Scientists Cheat?*, which emphasizes the importance of honesty in data reporting. [Note: Like most Nova videos that are more than three years old, *Do Scientists Cheat?*, which was produced by WGBH, Boston in 1988, is no longer available for purchase or loan from the producer. It is, however in the collection of many libraries, academic institution and other video archives from which it may be borrowed. One such source is the Wisconsin Regional Primate Research Center, phone (608) 263-3512, fax to (608) 263-4031, e-mail to hamel@primate.wisc.edu, write to the Primate Center Library, 1220 Capitol Court, Madison, WI 53715, or request it (video #VT0113) through interlibrary loan at your local library.] Then the video is fast-forwarded to the segment in which 8^{th} graders are conducting a pond study. Before showing this segment, students are asked how honest they think the 8^{th} graders will be in reporting their data. Following the showing of that segment, students are invited to discuss their reactions.

The teacher highlights the idea that students, and researchers in general, should not anticipate what they think they will find and alter their observations to match their preconceived notions. The teacher indicates that student projects will not be graded on the basis of the conclusions reached so much as the quality of the process.

The last segment of the video is then shown. This features Robert Sprague, a researcher who reported the fabrication of data by someone who was doing research intended to benefit mental patients in a state hospital. Sprague stresses the importance of honesty in science research because of the risks dishonesty poses to the general population.

Students are then given a homework writing assignment: Find five things in their household that they think were developed from scientific research. For each item, they are asked describe the sorts of dangers these products might pose if the research behind them had been falsified or misrepresented. Time permitting, the student examples can be discussed during the next class period.

Discussion:

This is one of many ways to introduce the idea that honesty in conducting and reporting scientific research is fundamental both to good science and to the public interest. It is important to emphasize that what is at stake is not merely the reputation, and possibly the career, of scientists who get caught cheating, but the well-being of others.

It is not just the well-being of the general public that can be seriously affected by the fabrication, falsification, or misrepresentation of data. As the case of Robert Sprague shows, those who report scientific misconduct may go through hardships. Although his wife was dying of cancer at the time, Sprague was so concerned about the fabrication of data he discovered, that he took on the responsibilities of a whistleblower. In fact, it was partly because of the realization that his wife's well-being depended on honest, reliable research regarding drugs and treatment that Sprague was motivated to act on behalf of others who are similarly dependent. Sprague's article, "The Voice of Experience" (*Science and Engineering Ethics*, Vol. 4, Issue 1, 1998, pp. 33-44), chronicles some of his experiences and those of other whistleblowers. Often it is not only those on whom the whistle is blown who challenge whistleblowers, but also institutions within which those accused work. Institutions also wish to preserve their public reputation as reliable. They may also find it difficult to accept the idea that one of their researchers has cheated, and they may feel accused of themselves failing to monitor carefully the work of the accused. In Sprague's case, he found that, even though he had submitted lengthy documentation of data fabrication at another institution, *he* was the first to be investigated; and it took several years for the case to be resolved.

For a good account of another well-known fabrication case, see Case Study #1 in Chapter 4 of Section I. For an statements about the importance of integrity in science, see: Sigma Xi's booklet, *Honor in Science* (Research Triangle Park, NC, 1991); and the Commission on Research Integrity's report, *Integrity and Misconduct in Research*, 2nd ed. (U.S. Department of Health and Human Services, 1993).

LESSON 5

What Kind of Research Should Our Government Support?

Author:

A revised version of a classroom lesson initially authored by the following Long Island, NY science teachers:

Vincent Calabrese, Daniel M. Leccese and Rosemary McPartland, Glen Cove High School, Glen Cove

Michael Foley, Miller Place High School, Miller Place

Jennifer Visconti, Northport High School, Northport

Courses for Which the Lesson is Intended:

Intended as an introductory lesson, which can be adapted for use in any high school science course. As presented here, the research topics come from a variety of science disciplines. A teacher of a particular science course may choose instead to drop some of the topics and add others in order to make more - or perhaps all of them - specifically relevant to the subject matter of the course.

Types of Teaching/Learning Activities Employed in this Lesson:

Students are given a homework assignment requiring them to read descriptions of research proposals and to rate the proposals on the basis of a set of specific criteria. In class students are assigned to research review groups, which have to decide which of the proposals to fund. The teacher then leads a discussion focusing on the ethical issues raised in the reasons given for each group's decisions.

Category that Best Describes this Lesson:

Social Issues.

Ethics/Values Issues Raised by this Lesson:

General ethical issues associated with public funding of research include: Does publicly funded research need to promise material social benefits?; How can value be assigned to benefits in order to compare it to costs?; Should research be supported if it does not promise equal benefits to all members of society? Other ethical issues will depend on the specific nature of the research projects considered. Issues raised by projects described in the lesson as written include: What restrictions should there be on research involving human or animal subjects?; To what extent should environmental issues be considered in making funding decisions?; Should decisions on funding be based only on the opinions of the majority of scientists?; Should research be funded that could result in violating the civil rights of some group of individuals?

Lesson Plan

1. In preparation for the lesson the students are given a homework assignment requiring them to read brief descriptions of 12 research proposals, rate each one on the basis of a set of specific criteria and write reasons why they would or would not approve funding the proposal.

2. The class is divided into five "research evaluation panels." These panels are supposed to be advising a government agency that provides funds to support general scientific research. The agency has only enough funds to support eight of the research projects. Each evaluation panel is to use the ratings of the research projects by its members to produce a list of the eight projects it recommends supporting. Each panel should write down the reasons it chose to include or exclude each project from its list.

3. The teacher reads the selections of the five panels to the class and then leads a discussion focusing on the ethical principles that are reflected in the reasons that the panels have presented. (If this is the first lesson on ethics in science, the discussion should be preceded by a brief introduction to the subject of ethical reasoning. In this case at least 1? class periods should be devoted to this lesson.)

<u>Homework Assignment</u>

Pretend that you are a scientist who has been selected to advise a government agency that provides funds to support scientific research. You have been sent the following brief abstracts of 15 proposed research projects that have been submitted to the agency. Read the abstracts carefully and then rank each one on a scale of 1 to 10 -- where 10 is the highest possible score -- with respect to the listed criteria. Finally write reasons why you would or would not fund each of the proposals

Criteria:

a) Extent to which you think the research is important.

b) Extent to which the research may result in public benefit or harm.

c) Extent to which the research is necessary for the advancement of science.

d) Extent to which the research is likely to improve the country's economy.

e) Ways in which the research is likely to affect the environment.

f) Whether or not it is important for the *government* to support this research.

g) Whether or not the likely results justify the cost.

I would (would not) fund this research project because ....

RESEARCH PROPOSALS

1. Development of High Energy Rocket Fuel For Mission to Mars

The National Aeronautics and Space Administration (NASA) has proposed sending a series of manned rocket ships to Mars in order to establish a permanent space colony there within the next decade. This proposed research would examine the combustion properties of a newly discovered group of high energy chemicals that can be made from coal and other plentiful raw materials. The goal would be a more energetic rocket fuel that would allow the Mars spaceships to carry a larger payload

2. New Artificial Kidney

A new type of plastic shows promise of being used as a thin film in an artificial kidney that can filter and cleanse blood just as effectively as a real kidney. This proposed research would test the ability of this plastic film to filter all of the poisons out of human blood that are filtered out by a real kidney. Human volunteers who are waiting for kidney transplants will be used in this research. The plastic material is extremely expensive so, if the research is successful, the artificial kidneys will cost more than a kidney transplant, but those that can afford them won't have to wait for the availability of kidneys that matches their blood types

3. Use of Organ Transplants From Death Row Inmates

The ability to save and prolong human lives by transplanting organs has created an increasing shortage of available organs. A potential sources of such organs is death row inmates. This research would explore the potential for reducing the waiting time for human organs if the organs of those who are condemned to death were automatically available upon execution without requiring permission of the condemned person or next of kin.

4. Genetically Engineered Tobacco

A variety of tobacco has been developed by selective breeding techniques that has only half the nicotine and tar of the average tobacco plant. This new variety is very expensive to grow because it is not as resistant as other varieties of tobacco to several insect pests. This research is designed to perfect a technique of incorporating into the new low nicotine and tar variety the gene that makes other varieties resistant.

5. Migratory Behavior Of the Humpbacked Whale

Efforts to protect the humpbacked whale from pollution and from its predators has been made difficult by the fact that not enough is known about this species migratory behavior. This proposed research will use a small electronic device that can be attached to the whales' back with no ill effects to track the whales as they move between their Summer and Winter feeding areas and to determine where they go to mate and raise their young.

6. Protecting a Government DNA Data Bank

A small sample of blood or loose skin from any human being can be used to obtain a DNA "fingerprint" that is a virtually infallible way of identifying that individually from a future sample obtained from that same person. The government would be able to use a computer data bank of stored DNA information from all U.S. residents for many purposes such as tracking down criminal suspects, identifying missing persons, positively identifying people for income tax and social security purposes, etc. One problem with the scheme is that the data bank would need to be available only to those authorized by the government to use it. This research is aimed at finding ways of protecting such a data bank from access by unauthorized computer hackers.

7. Testing An Experimental AIDS Drug On Rhesus Monkeys

A potentially highly effective new drugs for the treating AIDS patients has been developed. There is concern however that this drug may have several severe side effects in humans that would not occur in the usual laboratory animals like mice and rats in which it has been already tested. Before it is tested on humans this research proposes to test it on Rhesus monkeys. These monkeys, although rare and expensive have been used in research in the past because they are often very similar to humans in their toxic responses to drugs.

8. Effects of Eating Fast Foods On Health

Fatty, high cholesterol, foods have been blamed by health scientists for increasing obesity and susceptibility to heart disease in the public. Scientists who disagree with this assertion propose to provide food from McDonalds, Burger King, Pizza Hut, KFC and other fast food restaurants to elementary school children in ten low income neighborhoods in New York, Chicago and Los Angeles. By following the health of these children over the following twenty years they hope to disprove the allegation that fast foods cause poor health.

9. Development of Disposable Business Clothing

One of the inconveniences for frequent business travelers is the need to constantly pack and unpack clothing. Textile scientists have proposed testing the use of a very cheap new fabric that they think can be adapted to the production of shirts, suits, underwear, dresses and virtually every other essential item of clothing. Their goal is to demonstrate that such clothing can be produced in such a cheap manner that a business traveler could simply purchase new clothes at his or her destination and throw them out when the trip is over.

10. Research On Differences In Mathematical Ability Between Asians and Afro-Americans

In the U.S. Asians tend to do better than average and Afro-American do worse than average in courses in mathematics in grade school and college. Among professions that require mathematics, there tend to be more Asians and fewer Afro-Americans than there are in the general population. The intent of this proposed research is to determine whether these differences are due to inherited, genetic differences between Asians and Afro-Americans or to social factors.

11. Scientific Validity of Astrological Predictions

Most scientists reject astrology as one of many forms of superstitions and mysticism that has no true predictive or interpretive value. An organization of scientists who believe in astrology proposes to do a scientific study to demonstrate its validity. They intend to test the ability of astrological predictions, based on the positions in the sky of the sun, moon, stars and planets to predict which days are most favorable for a person to buy a lottery ticket.

12. Looking For Life Elsewhere In the Universe

Although the possible existence of life on a planet circling a distant star is unlikely to have direct impact on life on Earth, scientists, as well as the general public continues to show interest in looking for signs of such life. An astrophysicist has developed a new mathematical theory on how to examine the numerous radiowave signals that arrive from space in order to determine whether they may have been produced by intelligent life. She seeks funding for the development and use of computer programs to test her theory.

Discussion:

Since scientists require funding for almost all the work they do, the fact that ethics and values questions play an important role in determining what research will receive funding is all the evidence needed to demonstrate a strong link between science and ethics.

The teacher may have to intervene to make sure that the discussion of the panels' selections focuses on the ethical principles connected to the reasoning presented. Some students may prefer to debate the technical merits or defects in the various proposals. The proposals presented here (and presumably alternate proposals created by teachers using this lesson) were included because they raise one or more ethics or values issue rather than because of their unique technical merits. Thus, the proposed ambitious mission to mars raises questions about the ethics of supporting a very expensive research project that appears to have little direct relevance to any of our many Earthly problems; the artificial kidney proposal raises issues about supporting research that will produce results that are only beneficial to affluent members of society; etc.

LESSON 6
<u>Low Birthweight Infants</u>

Authors:

A revised version of a lesson originally authored by the following Long Island NY science teachers:

Albert Coppola, Robert Frost Middle School, Deer Park

John Marr, West Hollow Middle School, Melville

Mary Kay Marr, Paul J. Gelinas Jr. High School, Setauket

Dennis O'Hara, Miller Place High School, Miller Place

John Piropato, William T. Rogers Middle School, Kings Park

Courses for Which the Lesson is Intended:

Intended for middle school and junior high general science classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Students are given a handout to read as a homework assignment, which contains factual information about low birthweight infants. In the following class period students are divided into cooperative learning groups. Each group reads and responds to questions about a case study involving the birth of a 14 ounce boy and the problems this presents to various characters in the story. The entire class then discusses the responses of each group. An additional set of questions is presented for an optional follow-up class discussion about the more general ethical problems presented by children who are born with birth defects or special needs.

Category that Best Describes this Lesson:

Social issues.

Ethics/Values Issues Raised by this Lesson:

Does society have the obligation to provide whatever medical care and other aid is technically feasible to treat a child born with a birth defect or other special needs, regardless of cost?

What are the ethical responsibilities of a family with regard to such a child?

What are the ethical responsibilities of other social agents, such as medical insurers and employers with regard to the birth of such a child?

Should parents be legally libel for actions they have taken, such as drinking, smoking or marital abuse that increased the probability of the birth of a defective child.

Should a handicapped child have the right to sue parents or institutions that failed to take actions to prevent or treat his/her condition

Lesson Plan

1. Students should be given the following fact sheet to study as a homework assignment in preparation for this ethics lesson. To increase the likelihood that students will take this assignment seriously, they can be told that a brief (five minute) written quiz based on the fact sheet will be given at the beginning of the lesson.
<u>Facts About Low Birthweight Infants</u>

a) A low birthweight infant is any baby born weighing less than 2500 grams (5.5 pounds).

b) Low birthweight is the most common cause of serious illness among newborn infants.

c) Even with extraordinary care, low birthweight infants live's are threatened by such problems as frequent brain bleeds, inadequately developed lungs, poor body temperature control and malfunctions of the liver.

d) If they survive, low birthweight infants have a higher than average likelihood of having such serious health problems as birth defects, heart disease, mental deficiencies, poor nervous system development and susceptibility to infections.

e) Smoking, drugs, poor nutrition and stress are all factors that significantly increase a pregnant woman's chances of having a low birthweight infant.

f) Intensive hospital care required by a low birthweight baby typically exceeds $50,000.

g) Care of the smallest babies, requiring the longest hospitalization, can cost as much as $150,000.

h) Low birthweight infants represent about 7% of the babies born in the U.S. each year.

i) Because they are likely to have disabilities children who were low birthweight infants require greater than normal community and school resources for their education.

j) The yearly federal budget for the education of disabled children is about $2 billion.

2. Students should be divided into cooperative learning groups of three of four students. These groups should each be given the case study to read and discuss, and questions to answer (see below).

3. The teacher should lead the entire class in a discussion of the answers recorded by the cooperative learning groups to each of the questions.

4. If time permits, all, or part of the following class period should be devoted to a teacher-led follow-up discussion of the optional questions. The value of this session can be enhanced by asking the students to prepare answers to some, or all of these questions in advance, as a homework assignment.

What To Do About Thomas? -- A Case Study

Cast of Characters:

Dr. Robert Fisher

Dr. Fischer, 46, is a pediatrician (children's doctor) and an expert in the care of the newborn at Public University Hospital. He has developed a new medical procedure that has an 80% survival rate for extremely low birthweight (under one pound) babies. Previously, using the normal intensive care given to low birthweight infants, there was almost no chance of survival for such tiny babies. Unfortunately this new method is extremely expensive, costing $450,000 per baby.

Joy Smith

Joy Smith, 30, is a clerk in the accounts receivable for the Community Waste Management Corp. She is the mother of one child (Susan, see below) and is and on March 9 she will complete the fifth month of her second pregnancy. This pregnancy, like her first one has been difficult. She would like to work until just before her due date, but back pains are making it increasingly difficult to do her job. She has ignored the advice of her obstetrician to give up smoking and social drinking during her preganancy because of the harm that these habits can cause to her fetus.

Michael Smith

Michael Smith, 32, is married to Joy. He is one of the most skilled machinists at Delta-Delta Electronics and earns a base salary of $58,000 per year. Three years ago he and his family moved into an attractive new four-bedroom home. With the new mortgage and a second child on the way, which means that his wife will not be working for at least two years after the baby is born, he has been taking all the overtime work that is available. He hopes that he and Joy will be able to afford the college educations for their children that they didn't have.

Susan Smith

Susan, 12, is in her first year at Middleville Middle School. She has made a good adjustment to the new school environment and has developed a large group of friends. She is excited about the prospect of having a brother or sister after years of wishing for a sibling. Susan is already in the school band and the drama club. She also serves one period each day as an assistant in the school library. This year she hopes to try out for the Cheer Leader Squad. At home she has a nice large room with her own TV, VCR and Stereo. She is trying to convince her parents that she also needs her own phone. She has begun thinking about college and would like to attend a good private university like Cornell.

Dennis Copa

Dennis Copa, 49, is the owner of Delta-Delta Electronics, a small sized, private company with 34 employees. Increased competition in the electronics field has recently reduced the company's profit. Sales of the company's most successful consumer products have leveled off. The company lost a recent bid for a government defense contract. Mr. Copa knows that if he doesn't reduce the amount of expensive overtime work he may have to lay off two or three of his employees. He is also looking into negotiating a reduction in health benefits with the employees union.

Joseph Sullivan

Joseph Sullivan, 58, has been the Chief Executive Officer (CEO) of Mega Insurance Corporation for four years. Mega has the contract to provide family health insurance coverage to the workers at Delta -Delta Electonics. Partly due to the increased cost of medical care, Mega's profits have been decreasing for two years. Mr. Sullivan knows that if he doesn't reverse this trend, the stockholders are not likely to retain his services as CEO. He has already down-sized the payroll as much as he can. One option he is looking into is declaring a larger number of new medical procedures to be "experimental" and therefore not eligible for coverage under the terms of the company's insurance policies.

The Action:
On February 27th Joy goes into premature labor and gives birth to a baby boy at Public University Hospital. Thomas weighs only 15 ounces. Joy had an easy delivery, is in excellent health, but she and Michael are faced with some very serious and troublesome decisions. They have been told about Dr. Fischer's new procedure for extremely low birthweight babies like Thomas. But they have also been informed that the hospital's policy on low birthweight babies is that "unusual" extreme care, such as that required by the Fischer procedure will only be employed if it is covered by medical insurance, or if the baby's parents agree to full financial responsibility. Otherwise, Thomas will be put in the normal intensive care unit for newborns, which means his chances of survival would be very small. Michael contacts Mega Insurance Corp. and is told that they consider Dr. Fischer's procedure to be experimental, and not covered under his policy. The hospital informs the Smiths that if Thomas is to receive the greatly enhanced survival prospect of the Fischer procedure they will have to agree to pay $300,000 -- the difference between the procedure's $450,000 cost and the maximum amount Mega will pay for intensive care for newborns.

Joy and Michael have less than 24 hours to make a most difficult decision. If they can somehow come up with $300,000 they can increase Thomas' chances of surviving for more than a few days, from nearly zero to 80%. They also are told that even if he does survive, the chances of him being a normal, healthy child are less than 50%. He would have an increased risk of having many serious ailments and a 25% chance of dying before the age of 10.

The Smith's total savings amount to $20,000. Fortunately, Joy has a rich uncle who she is sure would agree to help them get a bank loan for the remaining $280,000. But meeting the monthly payments will require a drastic reduction in the family's lifestyle. Joy and Michael decide to involve Susan in the decision. She is told that if they agree to the pay for the Fischer treatment the family will have to sell their new home and move into a much less expensive one in a less attractive neighborhood. Susan will have a smaller room and she will soon have to begin baby-sitting to pay for most of her entertainment expenses. When she is 13 Susan will have to take care of Thomas after school so that her mother can begin to work part time. She will surely have to abandon the idea of having her own phone and also of attending an expensive private college. Michael also knows that before making a decision he will need to confront

Mr. Copa and try to persuade him to make an exception and permit Michael to continue to earn at least as much overtime pay as he has in the recent past.

Questions:

1. Is it ethical for a hospital to provide a technically feasible treatment only to those who can pay for it?

2. Under the circumstances described, should Mega Insurance be required to pay for The Fischer procedure?

3. Does Dr. Fischer have any moral responsibility to try to make his procedure available to those with limited financial resources?

4. Should everyone have equal medical insurance, or should better policies be available to those who can afford them.

5. Is it fair for the Smiths to ask Susan's to help make a decision that will have negative impacts on her?

6. If you were the Smiths, what decision would you make?

7. If the Fischer treatment could provide a 100% guarantee of Thomas surviving and living a full life as a normal individual, would your answers to any of the preceding questions be different?

8. Should the Smith's take into account when making there decision how they would feel if they agreed to pay for the treatment and then Thomas either died, or became severely handicapped?

9. What moral responsibility should Susan feel for creating this predicament, since her drinking and smoking increased the chances that it would occur?

10. If Thomas survives, but is severely handicapped, should he have the right to either sue his mother for child abuse, or to sue the hospital or his parents for treating him, rather than letting him die?

Questions For Optional Follow-up Discussion:

1. Using intensive care procedures on children who would otherwise die results in larger numbers of retarded and handicapped children. What is your response to this ethical problem?

2. Should decisions about whether to use expensive medical techniques be based on some form of comparison of costs and benefits?

3. According to a U.S. Child Abuse law that went into effect in 1984, all infants with disabilities are to receive nutrition and other medically indicated treatment with three exceptions:

a) the infant is in an irreversible coma,

b) the treatment would only prolong dying and would not be effective in treating the infant's life-threatening condition.

c) the treatment would be futile in terms of survival and under such circumstances would be inhumane.

Do you agree with this law? Do you think that it would require a hospital to use an expensive "experimental" method like the Fischer procedure in the case study on all very low birthweight infants?

4. Some obstetricians will not make a great effort to resuscitate a severely handicapped newborn infant that experiences heart arrest. Do you think this is ethical?

5. Would it ever be ethical to withdraw treatment from an infant with a poor chance of survival in order to provide intensive care for an infant whose chances of surviving are greater?

6. Some medical policy makers have proposed that the public funds that are now made available to provide intensive care to infants with poor survival chances should be reduced in order to provide more funds for prenatal care for women who are at risk of giving birth to a low birthweight infant. What do you think about this proposal?

7. Wrongful life lawsuits brought against hospitals, doctors and even parents involve a claim that a severely handicapped child's life is worse than death or nonexistence. What is your opinion about such lawsuits?

8. Wrongful birth lawsuits involve claims against hospitals or doctors by parents that a severely handicapped child was born because of negligence on the part of the medical personnel in denying them the opportunity for an abortion. What is your opinion about such lawsuits?

Discussion:

Teachers report that the student complaint "That isn't fair" is becoming increasingly common. Frequently what the student means is that some personal expectation or desire is not being met. This lesson provides an excellent opportunity to get students to confront the difficulty of meeting individual needs within the constraints imposed by a society with limited resources.

As the students should learn from this lesson, the task of developing necessary policies for prioritizing the allocation of human, material or financial resources in an ethically fair manner is extremely difficult. The rub is that there are strongly held, sharp differences of opinion about what constitutes a fair policy. For example, wealthy people will generally favor a system that allows limited resources to be purchased by anyone who can afford them, whereas poor people will demand a system that distributes these resources in a manner that provides equal access to people in all economic strata.

These are issues that will become increasingly important as rapid advances in biomedical technology continues to make it feasible to devise healthcare options that can not possibly be made available to everyone. Government officials in the Oregon have already learned how divisive it can be to attempt to define a scheme for rationing healthcare. Questions like whether a kidney transplant should go first to the patient who needs it most desperately, or to the one whose life is likely to be prolonged the most, can not be answered in ways that will be agreed to by everyone. All of today's students will be choosing governmental officials who will be faced with the task of achieving a political consensus on these vital, value-laden questions.

LESSON 7

Fraud In Science: Circumstances and Consequences

Authors:

An edited version of an individual lesson plan developed by

David J. Flatley, Principal, Selden Middle School, Selden, Long Island, NY. (This lesson was developed when Mr. Flatley was Chair of Mathematics and Science at W.T. Clarke Middle School, Westbury, Long Island, NY.)

and

Jana Alferone, Woodland Middle School, East Meadow, Long Island, NY

Courses for Which the Lesson is Intended:

As written, the lesson is intended for middle school and junior high school science classes, but the teacher-authors suggest that with minimal changes it could be used in any secondary science classroom through high school.

Types of Teaching/Learning Activities Employed in this Lesson:

Students are given a fictitious case study to read in preparation for the class. The scenario involves a young industrial research scientist assigned to a research project, her supervisor and her research director. Brief sketches of the principal characters are included along with a description of the project and actions they take which include clear examples of scientific misconduct. Several questions are presented after the case study to prepare students for a classroom discussion of the case.

The teacher leads a class discussion loosely based on the written questions, but intended to explore any other relevant ethics and values issues raised by the students.

This case study can also be readily adapted for a role-playing classroom exercise.

Categories that Best Describe this Lesson:

Behaviorof scientists.

Social issues.

Honesty.

Ethics/Values Issues Raised by this Lesson:

The principal issue is the effect of dishonesty in interpreting and reporting research results, especially in matters related to health. This includes not only the potential effects with respect to the public, but

also effects on science -- such as undermining trust within the scientific community, misleading other researchers and damaging the public image of science.

Several other ethical issues related to this lesson that may be raised by students, or by the teacher

include:

- Distinguishing legitimate manipulation of data from "fudging"
- Assigning credit for a scientific discovery
- Age discrimination
- Gender discrimination
- Performing research to promote goals (like those of the tobacco industry) that may be interpreted as contrary to the public interest

Lesson Plan

1. At the end of the class period preceding the one during which this lesson is to be taught the teacher hands out the case study, "Fraud In Science: Circumstances and Consequences" (see below) and instructs students to read it carefully, and to prepare for the discussion of the case by writing responses to the questions at the end of the handout.

2. At the beginning of the next class period the teacher should invite questions from the students concerning any problems they may have had in understanding the details of the case study. Other students should be invited to help the teacher respond to these questions as a way of assuring that everyone begins the discussion with a common understanding of the facts of the case.

3. The teacher should then lead a discussion of the case, using the written questions as an outline, but not as a rigid format that would preclude exploring other relevant ethics or values issues that may be raised by the students.

4. After the students have had the opportunity to describe their views on the ethics of the actions of Jana A., Enrico F. and Marie C., invite them to respond to the question,

"Which of the three characters in the story behaved in a manner that you would consider to be the most unethical -- and why?" This question is likely to generate an interesting discussion and reveal both similarities and differences in the value systems that individual students use in making their ethical judgments.

5. The teacher should direct the discussion of the potential negative effects of the actions of the case study characters so as to focus on the ways in which *science* may be affected as well as on the more obvious human health effects that may be caused by the decision to use the new bacterial strain. It is important to discuss the evidence that unethical behavior of the sort described in this case study is not very common among research scientists.

Fictional Case Study

Fraud In Science: Circumstances and Consequences

Dr. Jana A. is a young research scientist working in the research and development department of Crick Biotech, Inc. For the past three years she has been a member of a team of scientists examining the properties of genetically altered strains of E. colibacteria. The aim of the research is to produce a strain that meets the following criteria:

1. The bacteria will not be pathogenic to any organism they may come in contact with.

2. The genetic alteration will allow these bacteria to live symbiotically with tobacco plants and to be capable of converting atmospheric nitrogen to a chemical form that can be used by the plants. (This process is called "fixing nitrogen.") The result would be healthier, more productive tobacco plants, requiring less fertilizer -- thus reducing costs for tobacco farmers.

Other members of Dr. Jana A.'s team include her Senior Associate, who is her immediate supervisor, and the Project Director, who is responsible for reporting the groups findings and making recommendations to corporation's Board of Directors.

Project Director:
Dr. Enrico F. is 68 years old. While he is well respected in the scientific community and in the corporation, he has been under recent pressure from the Board. He has not produced a money-making development in several years. Some of the younger Board members feel he no longer practices "cutting edge" science. He would very much like to prove them wrong before his anticipated retirement in two years.
Senior Associate:

Dr. Marie C. is 45 years old. She is widely considered to be next in line for the position of Project Director. She is responsible for the day-to-day operation of the team's research effort. Her principal duty is to oversee the work of several junior research scientists, including Dr. Jana A. In addition to her responsibilities at the lab, she is president of the local chapter of the national organization, Women Scientists in Industry.

Dr. Jana A. has been given the responsibility for a critical part of the investigation. She has isolated a strain of altered bacteria which has been shown to meet the second set of requirements. Dr. Jana A is conducting tests to make sure that it isn't pathogenic. Jana believes that the strain she has isolated is safe. Most of the data support this hypothesis. However, some data suggest potential problems. It is known that other mutant forms of <u>E.</u> <u>coli</u> can cause serious, sometimes fatal human infections. Jana is aware of this. She also knows that future funding for the research, and possibly her job, may be in doubt if her problematic data become known. She makes note of the data in her notebook, but does not include it in the positive research report that she writes on the results of her tests on the new bacterial strain.

Dr. Marie C. reviews the report and notices what appears to be some missing data and incon-sistencies. Like Jana, she is very anxious to see the team's positive results recognized. Therefore, despite her doubts she approves the report and sends it to the Project Director. A week later, still troubled she asks Jana about the inconsistencies. She reviews Jana's lab notes and observes that there are a small number of "weird" data that raise some questions about the safety of the new starin of bacteria. She decides to support Dana's decision to ignore this data and makes no further report to Dr. Enrico F.

Dr. Enrico F. meets with the Board of directors to announce the team's encouraging findings. He makes the following recommendations:

1. Crick Biotech should invest corporate funds in producing large quantities of the new strain of bacteria and make a public announcement of the forthcoming availability of the new product.

2. The new strain should be named <u>E</u>. <u>enrico,</u> in honor of its producer and developer.

3. He plans to publish the research results in a paper that will list only his and Dr. Marie C.'s names as authors.

QUESTIONS (Bring written responses to class tomorrow)

1. What actions of the three principal characters in this fictional case study would you consider unethical? Why?

2. What do you think motivated each of the unethical acts that you described in answering the first question. How do these likely motivations effect your judgement of the moral character of each of these individuals.?

3. Do you think that questionable behavior like that described in this case study is common among research scientists? What is the basis for your answer?

4. What negative consequences are likely to arise as a result of the unethical behaviors you have identified?

5. In addition to these specific examples of unethical behavior, can you think of any other ethics or values that are brought to mind by this case?

Discussion:

The stereotypic cultural image of a scientist among most members of our society, including secondary school students, incorporates the virtue of honesty. It is important to stress to students that this lesson is not designed to undermine the notion that most scientists do exhibit high levels of honesty in their professional work. However, as demonstrated by several recent cases that have received considerable media attention, scientists like all human beings can occasionally be expected to give in to the sorts of personal pressures that result in dishonest or fraudulent behavior.

A goal of this lesson is to heighten student awareness of the serious consequences that can be the result of scientific dishonesty. Students will generally be quick to recognize that the dishonest behavior depicted in the case study could be serious because it may subject the public to a serious health risk. In general students are likely to focus on danger to the public as an obvious serious consequence of dishonest behavior by scientists whose work relates to products related to human health or safety. It may be necessary for the teacher to direct the discussion toward the threat that dishonesty poses to the scientific enterprise itself. Scientific knowledge is cumulative and a scientist needs to have confidence that the facts and data he or she uses are the result of honest efforts by other scientists.

The particular case study included in this lesson is cleverly designed to raise a variety of possible ethical issues. By providing personal information about the scientists it puts a human face on the discussion. Students will differ in their assessment of the relative moral culpability of the various characters. The fact that the research is designed to aid farmers in the production of tobacco is likely to lead to an interesting discussion of the ethics of participating in research on a product, which though legal, poses a serious health threat to consumers.

LESSON 8
Recycling

Author:

A revised version of an individual lesson plan developed by

Harvey R. Rabinowitz, Oceanside High School, Oceanside, Long Island, NY.

Courses for Which the Lesson is Intended:

Middle school and junior high school general science classes.

Earth science classes

Types of Teaching/Learning Activities Employed in this Lesson:

Students are presented with a hypothetical scenario for discussion. Students work in cooperative groups of three. Each group strives to reach a consensus decision. Each group devises a skit in which members role-play the hypothetical scenario. Summary questions are provided for further group discussion and completion for homework.

Category that Best Describes this Lesson:

Social issues.

Ethics/Values Issues Raised by this Lesson:

Environmental values; relationships between law and ethics; personal responsibility; responsibility for the behavior of others; effective communication; negotiating consensus.

Lesson Plan

Students work in cooperative groups of three. They are presented with the hypothetical scenario described below, along with two questions for discussion. They are instructed to strive for a consensus decision in their responses to the questions. Then each group will be asked to devise a short skit in which members role-play the individuals and situations outlined in the scenario. Finally, summary questions are provided for further group discussion and completion for homework. Homework assignments can be for each student to prepare alone, or each group can be asked to prepare a consensus statement that represents decisions and responses arrived at by all members.

Hypothetical Scenario:

A student has just completed a short unit of study on recycling in her science class. As a part of this unit, she receives a copy of the official town policy on recycling, which recommends the placement of newspapers, scrap (non-glossy) paper, and all metallic and plastic objects in an official town container that is placed curbside each week. She has become convinced of the importance of and need for recycling. This student and her family are friendly with their next-door neighbor; she has done some minor chores and run errands for the neighbor. While walking to school, she has observed her neighbor setting out trash containers which, she notices, never contain any recyclables. In her own home she is careful to recycle all acceptable materials, but her parents only recycle a few items, sporadically, and sometimes not at all.

Questions for Study Group Discussion and Formation of a Consensus Decision:

- Should the student approach her parents about recycling? If so, why? How should she approach them? If not, why not?

- Should the student approach her neighbor about recycling? If so, why? How should she approach her neighbor? If not, why not?

Role-Playing

- Each group should prepare a skit using role-playing in which the student approaches the others with the intent of persuading them to recycle. The presentation should be limited to 3 minutes.

- List below each group member and the role he/she will assume; record all notes or comments to be used.

Group member	Role	Group Notes
____________	_______	
____________	_______	
____________	_______	

Summary Questions (to be completed after group discussion and presentation):

- What reasons might the parents and neighbor have for not recycling? Are these reasons *good* reasons? Explain.
- What reasons might the student have for not approaching her parents or neighbor? Are these reasons *good* reasons? Explain.
- What skills and qualities of character are most important in trying to persuade someone to take recycling more seriously? Explain.
- If the town policy *requires* recycling, rather than merely recommending it, does this change what the student should do? Explain.
- What other resources might the student have at her disposal in discussions with her parents or neighbor?

Discussion:

This lesson requires students to engage in shared reflection on their convictions concerning a significant issue in society today--recycling. It also requires them to connect what they learn in science class with their daily affairs. In the hypothetical scenario it is clear that the student believes that recycling is important, and she incorporates this in her own treatment of recyclable materials. However, the scenario raises another kind of question of responsibility. What responsibility, if any, does one have to attempt to persuade others to share, and act on, that same belief?

An interesting feature of the lesson as described here is that students work together in small groups, and they are expected to try to reach consensus. This is a valuable activity in its own right, since such cooperative undertakings are typical of much of what we must do in our everyday and work worlds. Furthermore, striving for consensus requires listening carefully to others and trying to negotiate differences in ways that extend respect for those whose views may be different. This often results in genuine changes in our ideas, since others may bring up important matters that we would not think of on our own. But it also exemplifies some of the features of democratic life, especially those that require cooperative action even when there is not full agreement among those who must act together.

At the same time, insisting on consensus, particularly in controversial areas, is not always desirable. A consensus view is not necessarily more likely to be more adequate than a dissenting view. So, students should not be encouraged to think that consensus necessarily determines what is best.

As described above, this lesson requires groups to role-play attempting to persuade others to recycle. It is quite possible, however, that some groups will reach a consensus that, while the student should try to approach a parent, she should not (or need not) approach the neighbor. Or a group might conclude that the neighbor should be approached, but not a parent. Or a group might conclude that neither should be, or need be, approached. For these groups, role-playing the student approaching neighbor or parent might be difficult (although still worth trying). A possible variation on the lesson would be to allow groups simply to role-play whatever consensus they obtain. For example, the student could be portrayed as discussing with her friends why she is reluctant to approach either a parent or the neighbor. The friends can be portrayed as trying to convince her that she should. Or she could be portrayed as discussing with a parent why she (or the parent) thinks it best not to approach the neighbor. And so on.

The final assignment, writing responses to the summary questions, is important because it requires students to put their thoughts on paper--after there has been much exchanging of ideas with others. This will encourage further reflection, and it will encourage students to refine their thoughts even further. This can be a group assignment, requiring an effort to formulate a group consensus statement (although it would be good to allow individual differences to be expressed as well). Or each student could be required individually to write responses to the questions.

LESSON 9

Dune Road

Author:

A revised version of an individual lesson plan developed by

Maryann Librizzi, Sayville High School, West Sayville, Long Island, NY

Courses for Which Lesson is Intended:

Earth science classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Role-playing and communicating concerns (in writing) to others.

Category that Best Describes this Lesson:

Social issues.

Ethics/Values Issues Raised by this Lesson:

Values in expenditure of public funds; fairness; individual rights; public good.

Lesson Plan

Students are given the following scenario to read:

Dune Road in the Hampton's on Long Island's South Shore has houses worth millions of dollars built along the water. During hurricanes and severe storms, Dune road is often destroyed. The local government provides funds for the rebuilding of the road. Only the wealthy can afford to live there. Many of the houses on Dune Road are used only during the summer or as a weekend retreat by the owners. Unfortunately, some of the houses eventually get swept into the ocean.

The situation is quite controversial. Most Hamptons taxpayers are tired of paying for the road to be rebuilt; and they believe there are other, more important priorities in the community that need tax dollar support. Dune Road homeowners are afraid of what will happen if the road is not rebuilt. Not only will they find it difficult to reach their homes, their property value will go way down; and they fear no one will want to buy their homes if they try to sell them. They would also like to get some government money to repair their storm damaged homes.

Students are then asked to write two letters to the editor of the local newspaper concerning this problem. In doing this, they are to assume a different perspective for each letter. In one letter they are to assume the role of someone *favoring* repairing the Dune Road (e.g., a Dune Road homeowner who has spent the family's last dime in making this dream house a reality; a movie star who owns a Dune Road home; or a 12 year old child who visits his or her estranged father for two months during the summer at his Dune Road home). In the other letter they are to assume the role of someone *opposed* to repairing Dune Road (e.g., a taxpayer tired of contributing tax money to repair the road; a year around resident of the Hamptons who lives in a modest home and who would rather see tax dollars used to improve recreational facilities for year around residents; an environmentalist who would rather "let nature take its course" in the Dunes area). Letters should be restricted to no more than one page.

Students should then be invited to share their letters with the rest of the class, with discussion following.

Next, each student should assume the role of editorial writer at the local newspaper. Having heard a variety of arguments both for and against repairing Dune Road, the editorial writer is to write an editorial viewpoint that addresses the issues, pointing out the important values at stake and recommending, with reasons, a resolution of the controversy. The editorial should be restricted to no more than two pages.

Discussion:

This lesson raises basic questions about the appropriate use of tax dollars. Parties on both sides of the issue may appeal to individual rights and fairness. Those opposing the repairs might appeal to the larger good of the community, which raises questions about how minority interests are to be respected. Opponents might appeal to certain environmental values (particularly if they believe that the Dune Road owners are harming the dunes area). This raises basic questions about the appropriate relationship between human habitation and the rest of the natural world. Those who favor the Dune Road development might point out that, in one sense, all human habitation "interferes with" the rest of nature. So, assuming human habitation is to continue, what criteria for appropriate human habitation and development should be used?

An important feature of this lesson is the form of reflection and communication it requires. The students's first task is to consider the issues from different, and conflicting, perspectives. In writing letters to the editor, two important factors are involved. First, students are required to try to understand perspectives different than their own. Second, they are required to try represent and support these perspectives in a public arena (the local newspaper). This raises important questions about citizen participation in public discussion.

The students's next task is to participate in a class discussion that is likely to expose them to a much larger range of considerations than occurred to them in the first part of their assignment. This sets the stage for the final task, that of writing an editorial that is responsive to this wider range of public concern. Again, the communication is in the context of a public forum, but this time from the vantage point of someone with the public responsibilities of a journalist.

Although much of this lesson pivots around issues of public policy in expending tax dollars, the full range of concerns should make apparent the importance of obtaining as sound an understanding of the relevant ecological considerations as possible. (E.g., to what extent should communities attempt to *anticipate* problems such as the Dune Road before permitting the development of certain areas for residential or commercial purposes?)

LESSON 10

<u>Summer Home</u>

Author:

An edited version of an individual lesson plan developed by

William Miller, East Northport Middle School, East Northport, Long Island, NY

Courses for Which the Lesson is Intended:

Earth science classes.

Chemistry classes.

Types of Teaching/Learning Activities Employed in this Lesson:

A thought experiment in which students imagine themselves facing a practical decision in building a summer home. Students are instructed to make a decision, articulating the most important factors leading to that decision.

Category that Best Describes this Lesson:

Social issues.

Ethics/Values Issues Raised by this Lesson:

Environmental responsibility; long vs. short term consequences; ethics and punishment.

Lesson Plan:

Students are asked to find definitions of the following terms (providing examples for each in order to make definitions more understandable):

pollution	eutrophication
organic	decomposition
biodegradable	organism

Students are asked to read the following and answer the accompanying questions. This can be a written assignment, a class discussion, or both.

You are having a small summer house built on a lake in upstate New York. You have chosen this spot because of its isolation and the beauty of the lake. The lake is active with plant and animal life and covers an area of about 1.5 square miles. On its north side many small streams enter the lake carrying runoff from the area, while on the south side many small streams carry away some of the lake's water. Because of poor drainage in the area, it is necessary to have a septic tank installed. In order to have the septic tank do its job for a longer period of time, it is suggested to you, by the builder, to let all waste water (showers, sinks, garbage disposal, etc.), with the exception of the toilet empty into the lake. Since only you and two or three other people will be using the house and the lake is fairly large, you decide to give it some thought.

Questions:

- Since environmental change is slow and gradual, should you be concerned with whether you might be contributing to the pollution of the lake? Why or why not?
- Suppose it is not illegal to follow the builder's advice. What is your decision?
- Which of the following influenced your decision? (Rate each of them 1 to 5, with 1 having the most influence and 5 the least.)

    1. The fact that it is legally permissible
    2. Environmental concerns
    3. What is best for you
    4. Advice of the builder
    5. Easiest way to solve the problem
    6. Cost
    7. Consideration of likely future use of other property around lake
    8. Other (be specific)

- Suppose it is illegal to follow the builder's advice, but because of the location of your house, the chance of getting caught is minimal. What effect might this have on your decision (and your ranking of 2.-7. above)?

Discussion:

This lesson invites students to apply basic concepts they have learned in Earth Science ('pollution,' 'eutrophication,' etc.) to contexts in which individuals make practical decisions. The questions following the scenario invite students to reflect on the values underlying the decision they recommend. Factor 7 (consideration of likely future use of other property around lake) deserves special attention. The scenario describes the present situation. However, it is important to ask whether it can be assumed that things will remain the same. (After all, how is it that you were able to acquire the land? Won't others want to do the same?)

Another question to invite students to consider is why they might consider the environmental effects of allowing their wastewater running into the lake to be negligible, while agreeing to install a septic tank for effluent from the toilet. Further, might there be other ways to' extend the septic tank's useful period of time? This is a good opportunity to discuss various alternative ways in which people might more efficiently take care of their refuse in environmentally friendly ways (e.g., composting).

LESSON 11

The Landfill

Author:
A revised version of an individual lesson plan developed by

Joyce Margolis, Oceanside High School, Oceanside, Long Island, NY

Courses for Which the Lesson is Intended:
Earth science classes.

Chemistry classes.

Types of Teaching/Learning Activities Employed in this Lesson:
Students discuss the risks a landfill may pose to a community. The setting is a school board faced with a decision about whether to close a school until the landfill is capped (a 3 year period). Students are asked to determine (and defend) how they would vote.

Category that Best Describes this Lesson:
Social issues.

Ethics/Values Issues Raised by this Lesson:
Prioritizing values--risking health vs. lowering property values**;** role of environmental experts in affecting public policy.

Lesson Plan:

The teacher distributes the following scenario to students:

An old landfill site in Lakeville borders an elementary school. From 1950 until 1965 it was an active landfill. During this time the landfill was used by several sanitation and chemical companies for disposal of their wastes. Assured that the landfill site posed no health hazards, the Lakeville community opened the elementary school in 1985. Children can be seen playing in the landfill's shadow. Although the landfill has existed since 1950, no problems with it were raised until quite recently. The two reasons the landfill is now an issue are:

1) Having determined that it contains large quantities of highly toxic chemicals the Environmental Protection Agency (EPA) has designated the landfill a "Superfund" site. The landfill will be capped to reduce the likelihood that toxins will leach out. Construction will disturb the materials in the landfill. The project will last approximately 3 years.

2) A new housing development of about 100 homes has been built 3 miles from the school. Although there is an elementary school one mile from the development, it is overcrowded. So, the school board decided to send children in the new development to the school next to the landfill.

The school principal's home is next to the school. The principal's view is that the landfill poses no danger to the health of the children. If she thought it did, she states, "I wouldn't be willing to live where I do." Others who live near the school would like to keep the school open. In addition to favoring sending their children to a nearby school, they are concerned that closing the school will affect the value of their homes.

However, residents in the new housing development are concerned about health risks to their children. They would like the school to be closed and have their children sent to another school over the next 3 years.

A special school board meeting is taking place as a result of the issue. The environmental engineer hired by the school board states, "Although the capping process is probably harmless, there always is some risk that some type of toxic exposure could result. Still, the risk isn't high enough to force the government to close the school or require residents to leave until the work is finished. It's really the board's decision." The EPA engineer states, "There is no danger to anyone near the landfill, and the capping procedure presents very little or no risk to the surrounding school and community."

The following discussion is very emotional. There is standing room only in the school auditorium, with speaker after speaker strongly expressing his or her views.

Now it is time for the board to make its decision. As a member of the board, how do you vote? Explain your decision, presenting the strongest reasons you can in support of your view.

The discussion can be conducted in various ways. For example, a portion of the class could play the role of school board members, with other students playing the roles of engineers and concerned citizens. Alternatively, the class could divide into several boards, each of which carries on its own deliberations and then reports its conclusions to the entire class. Or there could simply be a class discussion of the issues without role-playing. Finally, regardless of how the discussion is structured, students could be asked to write up their views of the situation (either before or after the discussion--or both before and after).

Discussion:

This lesson may seem to be more about public policy than science. However, science plays an important role. First, the landfill issue facing the community is the direct result of industrial developments connected with biology, chemistry, and the earth sciences. However, aside from questions about the role scientists may have in *creating* difficult issues related to public health and safety, it is clear that scientists (and, in this case, engineers) have some responsibility to provide public constituencies with reliable information that can be used to *resolve* those issues.

Although this is not emphasized in the scenario above, one of the most important tasks scientists and engineers have in situations like this is to present needed information in ways that can be understood and put to relevant use by concerned citizens, and especially those whose responsibility is to make decisions that affect public health and welfare. This is a good time for future scientists and engineers to begin thinking about the importance of being able to form bridges between the world of expertise they will enter and the general public.

At the same time, this scenario should help students who will never become scientists or engineers understand why it is important for them to acquire at least minimal scientific literacy so that they will be in a better position to interpret expert reports and testimony they may need in order to make responsible decisions--whether as public officials or private citizens.

Another feature of this lesson is that students are asked to imagine themselves having to make an important decision in the public eye in an emotionally intense setting. This adds high drama to an already complicated situation. In such circumstances it may be difficult to remain clear-headed and composed. Teachers may need to remind students that the *psychological* forces that lead us to decide in one way or another are not necessarily good reasons from the standpoint of *justification*. The psychological forces may explain why a particular decision *is* actually made. But justifications seek to determine how one *ought* to decide.

LESSON 12

Pine Barrens

Author:

An edited version of an individual lesson plan developed by

Richard Tunick, Massapequa High School, Massapequa, Long Island, NY

Courses for Which Lesson is Intended:

Earth science classes.

Biology classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Role-playing in policy-making setting.

Category the Best Describes this Lesson:

Social issues.

Ethics/Values Issues Raised by this Lesson:

Environmental values vs. economic development; public vs. private interest; democratic decision-making.

Lesson plan:

This lesson is based on an actual case, a dispute about the use of 100,000 acres in Suffolk County on Long Island, known as the Pine Barrens. The details in this case are not intended to be completely accurate (e.g., there is no Suffolk County Planning Commission, as each town controls its own development). The purpose of this lesson is to help students understand the complexities of environmental decisions, rather than to recreate the actual circumstances and outcome of the original case.

The class is divided into five groups. Each group is given time to discuss its particular role in the case. Then the Suffolk County Planning Commission group will conduct a public meeting at which the other groups make presentations, and the Planning Commission will make its decision. The five groups are:

- The Suffolk County Planning Commission, whose responsibility is to decide on the uses of land in Suffolk County.
- The Paradise Development Corporation/LIPA/LIRR, a combination of a corporate home builder, the Long Island Power Authority, and the Long Island Railroad.
- The Long Island Association, an organization of businesses.
- The Long Island Pine Barrens Society, an environmental group.
- Citizens

The following materials are distributed to each member of the class for initial review. Then each group is asked to prepare for its particular role.

Status of the Pine Barrens

Originally the Pine Barrens consisted of about 250,000 acres of undeveloped, forested land. It is situated above a relatively unpolluted section of the aquifer system that is the source of all potable water to Long Island residents. But more than half of this land has been used for housing developments, farms, roads, landfills, golf courses, and businesses. Most of the remaining 100,000 acres are undeveloped. What to do with this land is highly controversial, which is why the Suffolk County Planning Commission is holding this public meeting.

- ***Suffolk County Planning Commission***

As members of the Planning Commission, you are expected to study and make decisions regarding the use of community facilities. You oversee street maintenance, sewage treatment, library services, and other public services. You also issue building permits, and you review plans for new residential developments. You have been elected by the citizens to make decisions that serve their best interests.

Today, you are reviewing proposals for the use of the Pine Barrens, 100,000 acres of undeveloped land in Suffolk County. Different proposals will be presented by the Paradise Development Corporation, in collaboration with LIPA and the LIRR; the Long Island Association; and the Long Island Pine Barrens Society. Also, some citizens of the area are present at this public meeting and should be allowed to speak.

You should listen carefully to the proposals and discussions that follow. You may want to take notes. You may question the representatives of these organizations. When the presentations and discussions are finished, you are to decide what to do, providing reasons for your decision. A voice vote will be taken. Majority vote determines the decision. (You realize that, as elected representatives, your votes will be remembered if you stand for re-election.)

You can decide whatever you want. You can completely accept a proposal or only part of it. You can come up with any kind of compromise you think best. What to do with this land is in your hands.

- ***Paradise Development Corporation/LIPA/LIRR***

Paradise Development Corporation representative: As a representative of this corporation, your objective is to persuade the Planning commission to allow development of the land for a community of 20,00 without disturbing the natural beauty of the area. Some arguments:

1. A new community would attract business enterprises, such as food stores, department stores, restaurants, gas stations.

2. The area's natural beauty would be preserved, for only a minimum of trees need to be cut down.

3.The community would provide a market for nearby farms: potatoes, wine, corn, and other vegetables and fruits.

4.This planned community would be able to provide decent homes at an affordable price.

Remember: You represent a corporation that makes its profits by building and selling homes. Here you have an ideal setting for a model community. Housing sales should be quick and profitable in such a setting, and your company stands to gain both large profits and prestige. Additional points you can make: Houses will use solar heating and natural ventilation, making them more "environmentally friendly" than typical houses. Housing will also be concentrated that a minimum of land will be under construction.

Questions you may be asked:

2. How large a community do you plan?

3. How have you planned for sidewalks, street maintenance, police protection, fire protection, garbage collection, schools, libraries, businesses to support the community?

4. What steps have been taken to minimize environmental problems?

5. Is this development really needed? Isn't there adequate housing now?

6. Won't this project simply add to the growing congestion on Long Island?

7. Can the current roads take more traffic?

LIPA representative: As a representative of this electric utility, your objective is to persuade the Planning Commission to allow development of the Pine Barrens with housing developments and industry. LIPA wants more customers so that it can request that the closed Shoreham nuclear power plant be used for a natural gas-fired power plant. With more customers, LIPA claims it can keep down future rate increases for its customers (rate increases that have already been approved for the next 10 years).

Questions you may be asked:

1. If LIPA gets more customers, won't there be a need for more generators, thus increasing costs to everyone?

2. Won't the production of more electricity add to the pollution of the environment?

LIRR representative: As a representative of the railroad, your objective is to persuade the Planning Commission to allow development of the Pine Barrens. This will benefit the railroad in a number of ways:

1. The LIRR will build a station in the center of the new community.

2. The LIRR will make this line attractive by electrifying the railroad from Ronkonkoma to Riverhead. (When LIRR electrified from Hicksville to Ronkonkoma, Ronkonkoma station usage more than tripled.)

3. This project will give LIRR reason to upgrade its services to keep up with the times.

Questions you may be asked:

1. Won't building a station cost more money, while the LIRR should be trying to save money?

2. Won't electrifying the tracks be expensive, therefore costing riders more money?

3. Why not simply use the current station and its tracks?

- ***Long Island Association***

This is an organization representing the businesses of Long Island. Your objective is to persuade the Planning Commission to grant permission for the expansion of businesses on Long Island in general, and in the Pine Barrens area in particular. Two general points can be made:

1. Successful businesses provide a strong economic base and, therefore, a thriving community.

2. More businesses mean more jobs; and more jobs mean more support services (e.g., stores, gas stations).

3. Questions you should be prepared to answer:

4. Whenever there are more businesses, there is more pollution (air, land, groundwater). What will be done to prevent increased pollution?

5. Why do we need more people in this area? Isn't the population of Long Island, and Suffolk County in particular, large enough? Is bigger always better?

- ***Long Island Pine Barrens Society***

Your objective is to persuade the Planning Commission to protect the Pine Barrens as much as possible. The following arguments could be used:

1. There is a need to protect the huge quantity of clean groundwater under the Pine Barrens.

2. There is a need to prevent air pollution. Increased population means increased air pollution form home, business, and industrial heating units, and auto pollution.

3. The currently undeveloped land needs to be protected from increased use of fertilizers, sewage and solid waste materials, and oil and gas runoffs.

4. Land protection benefits everyone. An unlimited public access park can be created with access to ball fields, bridle paths for horses, hiking trails, camp grounds, and unmotorized boats. A limited public access park can be created for limited hiking, fishing and boating.

5. Designating the land as park land will ensure preservation because current laws prohibt building transportation and urban facilities on park land.

6. The Pine Barrens is the last large, undeveloped area on Long Island.

Questions you may be asked include:

1. Why should land be preserved--you can't stop progress.

2. Development means more jobs and an improved economy. Won't preventing development hurt the economy?

3. Won't a public access park scare away wildlife and increase pollution caused by both cars and people? What will you do to prevent vandalism, and how much will this cost?

4. Won't creating such a park attract people who might want to live in the area, thereby increasing pressure for more housing development?

5.Won't a public park destroy the environment (more cars, motorbikes, picnic areas, baseball fields, basketball courts, campfire sites, etc.)?

6.Who will be allowed to enter a limited access park? Only local residents? Long Island residents? State residents? Is it fair to allow access to only a select few?

- ***Citizens***

  As citizens, you are sitting in on the Planning Commission hearings, and you have a right to speak. Here are some comments some of you might want to make (but you may think of others):

  1. Won't our taxes be raised with more children moving into the area, requiring new schools, playgrounds, sewage treatment, and so on?

  2. Long Island's over development is a bonanza for builders and developers and a disaster for the rest of us.

  3. LILCO's electric rates are much too high. Let's do anything we can to lower them.

4. Why can't we have both development and the Pine Barrens? Can't we use some of the land for development and preserve the rest?

5. When will it stop? We've already developed 40% of the original Pine Barrens land. We've gone far enough.

6. We can use the jobs and new services. Besides, no one's going to cut down all the trees. It'll still be a beautiful area.

7. What right do we have to stop progress and keep others from developing the land; isn't that what we've always done anyway?

Discussion:

In order to reveal the complexities of issues like this, and to allow the students to engage their imagination more fully, this lesson may take several class periods. Although students will probably want more information than this lesson provides, there should be enough for them to see the sorts of questions a planning commission needs to consider. Even though students are right in thinking that more information is needed, they need to realize that, no matter how much information they have, at some point they will have to address some basic ethical and value questions about rights, the public interest, and the importance of the environment. However, perhaps the most important lesson here is that responsible treatment of those ethics and value questions requires being well informed in a variety of areas. Here the social sciences (such as economics and political science) as well as the natural sciences provide important perspectives.

LESSON 13

The Automotive Plant

Author:

A revised version of an individual lesson plan developed by

Donald Jermusyk, Hauppauge Middle School, Hauppauge, Long Island, NY

Courses for Which the Lesson is Intended:

Earth science classes.

Chemistry classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Students imagine they are a team of scientists advising a town council on pollutants seeping into the groundwater. They discuss issues among themselves and then report to the class their recommendations.

Category that Best Describes this Lesson:

Behavior of scientists.

Ethics/Values Issues Raised by this Lesson:

The civic responsibilities of scientists; the value implications of scientific consulting/advising.

Lesson Plan

Students are divided into small groups. Each group is to imagine itself to be a team of scientists with expertise in industrial water pollution. The teacher distributes the following scenario and instructions to the groups. Each group will report its recommendations to the class.

Clinton Automotive is a factory in the town of Plainsville and the principal employer of the town. Clinton is also a major tax payer for the town and the local school district. The local water company has discovered that the undercoating applied to the chassis of its cars has been seeping into the ground water and is now in the water supply of a small part of the town.

A public meeting has been called to address the concerns. Clinton has threatened to leave town if it incurs heavy expenses and lawsuits related to the plant effluent. Homeowners with affected drinking water are threatening a lawsuit unless Clinton stops using the undercoating and pays for cleaning up the pollutant. At the public meeting it can be expected that there will be:

- homeowners with polluted drinking water
- homeowners living near the polluted water but whose water is not yet affected
- union members representing those employed at Clinton
- top executives at Clinton
- school board representatives concerned about a lowered tax base if Clinton leaves
- environmentalists concerned about the quality of groundwater for the community

Your team of scientists has been hired by the town council to help it and members of the audience understand the significance of what has happened thus far to the groundwater and what will correct the problem (including cost estimates).

Although the groups of students will not be able to make actual estimates, they can discuss their obligations and strategies in serving as town council consultants. To whom do they have obligations in this case? The town council? The community? Clinton? How should this affect their scientific analysis and the report they will construct based on that analysis? Can the team remain value "neutral" and simply report the facts? Should they attempt to? Why or why not?

Discussion:

This case focuses on the responsibilities of scientists as consultants and as community participants in policy making. It may be thought that scientists simply try to determine the "facts," leaving all value questions to others. However, the very purpose of the study undertaken here is to assist the town council in meeting its responsibilities. So, in addition to understanding the town council's responsibilities, a scientific team of consultants also has to make judgments about what kinds of information will be most relevant for its deliberations and the public meeting. It also should take into consideration the needs and rights of the community in this matter--both in regard to questions of health, safety, and welfare and in regard to meaningful participation at a public meeting addressing the concerns of the community.

This does not mean that the scientific team itself makes the policy decisions. But it does mean that it has a responsibility to assist others in making those decisions. The question is whether that responsibility extends only to those who hired the team (the town council), or also to those to whom the town council is accountable (the larger public). Either way, it seems that "value neutrality" does not capture the role of the scientific team. But if this is right, it does not follow that the team is justified in being*partisan* to one faction or another. So, this raises another question: to what extent should a team of scientists, even as consultants, strive not to be partisan to the concerns of those for whom they provide consulting services? Should they be "partisan" to interests of the larger community that will be affected by what is decided? *Which* interests?

LESSON 14

Ethics Issues From Science Fiction

Authors:

A revised version of a classroom lesson initially authored by the following Long Island, NY science teachers:

Joyce Birnbaum, Sharon Borakove and Phyllis Satz, Syosset High School, Syosset

Antonia Martin and Theresa Soltiz, Cold Spring Harbor High School, Cold Spring Harbor

Courses for Which the Lesson is Intended:

The particular science fiction story that this lesson is based on (*Letter to Ellen* by Chan Davis) is intended for use in standard or advanced high school biology classes, during or following a following the study of genetics. (Other science fiction stories that illustrate interesting ethical issues can of course be chosen for use in other science courses)

Types of Teaching/Learning Activities Employed in this Lesson:

Students are given a science fiction story and questions to respond to as a two-day homework assignment. The class is divided into cooperative learning groups of three or four students each, which are given tasks based on the story. The entire class views the results of each group, which have been recorded on overhead transparency masters. The teacher leads a discussion designed to probe the ethical issues and student responses revealed in the work of the groups. The groups are given a follow-up exercise, the results of which are discussed in the following class session.

Note: This lesson works best if two or three class periods are devoted to it. It can readily accommodate a role-playing exercise based on either a dramatic presentation of the short story or some format involving questions by reporters directed at the characters in the story.

Category that Best Describes this Lesson:

Social issues.

Behavior of dcientists.

Ethics/Values Issues Raised by this Lesson:

Informed consent as a requirement for research involving human subjects; other issues related to research on human subjects; secrecy and deception in research; the sanctity of human life.

Lesson Plan

(The classroom activities described below will require two or three class periods. If only a single period is available the work of the cooperative learning groups in item {4} can be restricted to activity {c}, and the lesson can be terminated after item {6e}.)

Instructions for the Teacher:

Many students enjoy reading science fiction. There are many well-written science fiction stories that are based on technically sound scientific principles and incorporate vivid examples of ethics and values issues that are associated with the actual practice or use of science. One such story is "Letter to Ellen," by Chan Davis (This story first appeared in the June 1947 issue of *Astounding Science Fiction.* It has been include in several science fiction anthologies including *Golden Years of SF 5th Series,* Isaac Asimov, Ed., {Bonanza Books, 1985}). This tale is particularly relevant because what was futuristic speculation in 1947 is now not so far-fetched in view of the capabilities of modern biotechnology. Indeed, several of the ethical issues raised by the characters in Davis' story are those that society is currently grappling with. (Two other science fiction stories that the authors of this lesson suggest as being suitable for teaching ethics in biological science are "The Winnowing," by Isaac Asimov and "Samson and the Temple of Science," by Harry Harrison. Teachers of other science courses should have little trouble finding suitable stories.)

1. Two class meetings before the this lesson is to begin in class, give the students the first student assignment. (See below.)

2. The next session give students the second assignment. (It is strongly recommended that students be given at least two days to read and reread the story to allow time for them to absorb and understanding the issues presented.)

3. Divide the class into cooperative learning groups of three or four students each.

4. Working among themselves each group should:

a) construct an outline of the events that take place in the story,

b) share and discuss briefly the written answers of each group member to questions 2 and 3 of the assignment,

c) compile a list of questions they would like to ask the main characters in the story and record these on an overhead transparency master.

5. The entire class should then view and discuss each group's transparency.

6. The teacher should then lead a class discuss focused on the following questions:

a) What common concerns are revealed by the questions framed by the groups?

b) What ethical problems and other ethics and values issues do the questions raise?

c) What are the possible alternative responses to each of the ethical problems?

d) What are the ethical implications of each of these choices?

e) What regulations or other actions might be taken to safeguard against future unethical practices at Pierne Labs?

f) Scientific research benefits from a free exchange of information among research scientists. (Why?) Yet, in many cases government or corporate laboratories impose restrictions on such information exchange, often demanding the type of secrecy of scientists that Dr. Hartwell tried to maintain. Under what circumstances is secret research an ethically acceptable practice?

g.) Even after a scientist leaves a particular research group, he/she is often required to honor secrecy restrictions. This can mean that the scientist can no longer continue the type of research he/she had been doing. Are such restrictions on a scientist's professional freedom ethically justified?

7. Students should then reconvene in their cooperative learning groups to formulate a code of conduct for research involving human subjects, recording the result on an overhead transparency master.

8. After reviewing and discussing each group's proposed code of conduct, the class should come up with a code incorporating the best suggestions of the individual groups.

9. The teacher should then hand out the Belmont Report[(54)] and discuss how the recommendations of that committee differed from those that the class produced.

Student Assignments:

Assignment 1

Carefully read the science fiction story "Letter to Ellen," by Chan Davis. While reading this story (which was written in 1947), make written notes of the principal actions that occur and controversial issues that are confronted by the characters.

Assignment 2

Reread "Letter to Ellen," adding to your notes. Write a description of the emotions expressed by the main characters in response to their experiences. Write down your own reactions to the behavior of the scientists, the nature of the research they are doing and the possible consequences.

Discussion:

One potential problem with the use of science fiction as a vehicle for ethics education is that most readers of fantasy don't generally expect the characters to be guided by the same ethical principles that they would expect of characters in a work of non-fiction or in real life. It is easier to get students to apply real-world ethical considerations if the events and technology in the story are not so far out as to be inconceivable in the foreseeable future. For this reason a story like "Letter to Ellen," written many years ago when it was clearly futuristic, but which describes events that are no longer so far beyond the reach of present-day technology, is particularly suitable.

In this, as in other ethics lessons, it is important to get students to recognize that ethics issues raise questions about which reasonable people can have legitimate differences of opinion. Although there are a few ethical statements like "genocide is always immoral" with which there is almost universal agreement, this is the exception rather than the rule.

The task of trying to write a general code of conduct for research on human subjects should prove to be a good illustration of the difficulty in constructing ethical guidelines that will win wide approval. Most students will probably include some type of requirement that the subject should consent to the research he or she is a subject in. Framing this requirement in a way that assures that the subject truly understands the research and all of its potential ramifications is no easy task!

LESSON 15

The Envelopes

Author:

A revised version of an individual lesson plan developed by

David Flatley, Principal, Selden Middle School, Selden, Long Island, NY. (This lesson was developed when Mr. Flatley was Chair of Mathematics and Science at W.T. Clarke Middle School, Westbury, Long Island, NY)

Courses for Which Lesson is Intended:

Biology classes.

Category that Best Describes this Lesson:

Social issues.

Types of Teaching/Learning Activities Employed in this Lesson:

Simulation: students imagining that they have learned specific genetic information about themselves.

Ethics/Values Issues Raised by this Lesson:

Responsible use of genetic information, both by researchers and those who learn the information. Basic questions about just how much we want to know about our future health and behavioral prospects.

Lesson Plan

The specific objectives of this lesson include students being able to communicate clearly the notion that ethics and values issues are central to scientific research and being able to identify at least one ethical concern related to the human genome project.

For a class of 30, 30 envelopes, 30 index cards, and a chalkboard are needed. Before class begins, each index card must carry a "genetic code." "Genotypes" are assigned based on the following distribution:

message	**no. of cards**	**% of class**
genotype 1	3	10
genotype 2	3	10
genotype 3	3	10
genotype 4	21	70

[These percentages are not intended to represent the actual proportion of people who might eventually be determined to have such genotypes. They are used only for classroom purposes to make sure that each genotype has at least a few students wrestling with the problems they pose.]

The teacher should fold each card and seal it in a separate envelope so that the genotype is hidden. The following information should then be presented to the class:

Assume for the moment that, thanks to the human genome project, certain human genotypes can be identified for members of this class. For our simplified example, we will consider only four different possible genotypes, 1, 2, 3, and 4 (described below). Each of these genotypes is related to a different set of human traits. The genotypes, their associated traits and the frequency of the genotype in our class population is listed in the following chart:

genotype	**traits**	**frequency**
1	75% have tendencies toward extremely violent, perhaps even criminal, behavior.	10%
2	98% will die before 15 unless given treatment before age 5. Treatments currently cost approximately $3,000,000.	10%
3	75% have the sorts of mental and physical traits that are keys to becoming superstar athletes.	10%

4 No special tendencies have been identified. They all fall within 70%
the "normal" range in appearance, ability, and predicted behavior.

The teacher should randomly distribute one sealed envelope to each student and review the prepared information with the class. Then, without opening the envelopes, the following questions can be used to start discussion:

- Do you want to open your envelope? What advantages or disadvantages might there be?
- If you open your envelope, who should have access to the information? Who should not?
- If this information became available to the public, what might be the consequences?
- If this information were available before the birth of an individual, what consequences do you think this might have? Should it be made available? To whom?

After discussing these questions, students should open their envelopes. Now the teacher can ask: "Considering what your genotype is, would you like to re-think your responses to any of the previous questions?"

All of this could be done orally. Or students could be asked to write answers to one or more of the questions considered before opening envelopes. This might most effectively be done over two class periods, with written answers prepared before the second period.

Discussion:

This "futuristic" lesson can be used to raise students's curiosity about the genome project and some of the ethical, social, political, and legal questions it poses. Some time should be spent discussing the importance of knowing what percentage of those with certain genotypes will develop the traits in question, as well as what factors might contribute to or interfere with their development. This is important because, in most instances the human genome project information we are likely to discover will be in the form of the likelihood, rather than the certainty, that various traits will develop; and there may be much we can do to affect their development.

At the same time, it is important to discuss who should have access to whatever information is discovered. Should insurance companies have access to this information? Should our health care providers? The police? The schools? The children who have these genotypes, or only their parents? Are there limits to what science should be allowed to discover about us? Who should be allowed to conduct this research? Who should pay for it?

For further discussion of these issues refer to Case Study #5: The XYY Controversy, in Chapter 4 of Section I.

LESSON 16

The Human Genome Project Structured Controversy

Author:

This is an edited version of a classroom lesson initially developed by:

Nicole Hollings, W.C. Mepham High School, Bellemore, Long Island, NY

Courses for Which the Lesson is Intended:

Biology classes. (It should be preceded by at least one lesson in which the students are introduced to the topic of ethics and values in science.)

Types of Teaching/Learning Activities Employed in this Lesson:

This lesson employs the "structured controversy" in which pairs of students get to debate and discuss both sides of a controversial issue. It is best suited for a two-period laboratory session following the study of DNA, genes and the basic science of inheritence.

Category that Best Describes this Lesson:

Social issues.

Ethics/Values Issues Raised by this Lesson:

Is it ethical for the government to invest such a large fraction of its research budget in the Human Genome Project when the result is denial of funding for other worthy projects? Do such possibilities as finding the cause of many genetic diseases and identifying criminals outweigh such concerns as the possibility of using the genetic information to renew the types of eugenics programs practiced before and during World War II or to deny health insurance coverage? Given the huge investment of public funds in the Human Genome project, is the government responsible to assure that the benefits will be equally available to people of all socioeconomic levels and ethnic or racial backgrounds? Should genetic testing be made available to people who have not received the genetics counseling they need in order to fully understand and respond to the results?

Lesson Plan

Introduction

This lesson was designed to help students identify and understand some of the complexities associated with the Human Genome Project. It is vital for students to understand that the enormous range of scientific and technological possibilities that will result from the complete deciphering of the human genome will require all of us to confront numerous new thorny ethical questions.

The pedagogic technique employed in the lesson is the "structured controversy." Students are assigned to four-person discussion groups, each of which is composed of two pairs of student partners. The lesson begins with each of the pairs choosing to argue in favor one of the two opposing viewpoints. After reading a brief essay supporting its viewpoint the pairs engage in a twenty minute debate/discussion. The pairs then switch sides, reading the essay supporting the opposing view and engaging in a second twenty minute debate/discussion.

By requiring students to learn both sides of the issue and allowing them to construct their own arguments in support of both positions they will come to appreciate the difficulties in establishing a reasoned position about a controversy that does justice to all of the important facets of the questions being discussed. The goal is to have each student reach his or her own ethical position on the question after a careful examination of the facts and the options.

1. At the beginning of the lab period the teacher should familiarize the class with the Human Genome Project, it's goals, and how far the research has progressed to date. A brief, non-judgmental description of some of the likely scientific and technical applications of the research should also be presented. (Note: At the time this lesson is being written, the task of sequencing the DNA in the entire Human Genome is less than half completed. This lesson will still be appropriate after the project has been completed. At that time the question to be debated will be whether the project <u>should</u> have been supported.)

2. Divide the class into groups of four students each of which should be further divided into two pairs of partners.

3. Give each group one copy of the "Order of Events" and two copies of each of the opposing essays; "The Human Genome Project: Science At Its Best" and "The Human Genome Project: Super Science Or Super Problem?"

5. The teacher should then go over and clarify the "Order of Events."

6. During the debate/discussions the teacher should circulate among the groups. Only if the conversations seem to be stalled or moving in an unproductive direction, should the teacher interject questions or comments designed to get things back on track. Teachers should avoid making any remarks that reveal their own positions on the ethical issues. This is important because students often look to teachers for answers, but here it is desirable for them to think for themselves.

7. The laboratory should conclude with the groups sharing and discussing their opinions on the ethical issues associate with the genome project. If time runs out, this discussion can be held at the beginning of the next class.

The Order of Events

1. Each pair of partners in the group should choose and read one of the opposing essays.

2. The partners should then discuss the readings, helping each other understand the issues raised and arguments made and developing a strategy for presenting these argument to the opposing partners.

NOTE: *These first two activities should be completed in approximately ten minutes. Your teacher will announce when it is time to begin the first debate/discussion.*

3. Engage in a twenty minute debate/discussion with the other partners in your group. Note that in this debate you must argue in favor of the positions taken in the essay you have read, even if they do not represent your own ethical perspectives on the issues.

4. Each pair now repeats activities 1-3, but this time reading the other essay and arguing in favor of the opposite point of view.

5. After the second debate the four members of your group should take ten minutes to write a statement expressing your points of view on the issues discussed. If you can not reach a group consensus opinion on an issue, then include the differing ideas in the statement.

The Human Genome Project: Science At Its Best

The Human Genome Project involves thousands of scientists in a huge cooperative effort. The goal is to determine the sequence of the four chemical groups called bases in all of the strands of DNA contained in the chromosomes of every human cell. This sequence of bases contains the codes for all of the estimated 100,000 human genes.

The genes, in turn, determine all of the information that is passed on by inheritance during reproduction.

Although expensive and time-consuming, sequencing all of the human genes is definitely a worthwhile scientific project for the government to support. Once all of DNA has been sequenced it should be possible to find the genes responsible for all inherited human traits including numerous serious genetic diseases. Already we have found the genes responsible for causing several diseases including Huntington's disease and cystic fibrosis. People will be able to undergo genetic screening tests to determine all of their genetic diseases, and in cases of recessive genes a married couple will know which diseases they may pass on to their children. Knowing the genetic cause of a disease may make it easier to find a treatment or a cure. In cases, like heart disease, diabetes and certain types of cancer genes may not cause a disease but may make a person prone to get the disease under certain environmental conditions. In such cases those who know they have such genes may be able to take actions to reduce the chance of getting the disease. Eventually we may even learn how to cure genetic disease by gene therapy to correct or replace the defective gene. By treating or preventing genetic diseases, billions of dollars of medical costs could be saved each year.

There are many other valuable uses that can be made of the information from the Human Genome Project. A government data bank could be set up containing every person's cpmplete genetic code. This would make it easier to identify criminals and trace missing persons. Insurance companies could use the information to refuse insurance or charge high rates to a person with a high risk genetic make-up. Prospective parents might be able to use genetic information to select specific traits that they want in their children. Ultimately genetic informatiom might even be used to help perfect the human race.

The Human Genome Project: Super Science Or Super problem?

The Human Genome Project involves thousands of scientists in a huge cooperative effort. The goal is to determine the sequence of the four chemical groups called bases in all of the strands of DNA contained in the chromosomes of every human cell. This sequence of bases contains the codes for all of the estimated 100,000 human genes. The genes, in turn, determine all of the information that is passed on by inheritance during reproduction.

This expensive and time-consuming project was begun after much heated controversy. Opponents pointed out that the huge government research investment (many billions of dollars over at least ten years) would mean that hundreds of other worthwhile scientific projects could not be supported. Furthermore it can be argued that much of that money will be used to determine the sequence in parts of human DNA that does not contain any genes and is often referred to as "junk" DNA.

Although scientists hope that the genetic information can be used to cure diseases and save lives, it is not clear how likely this is. For example, although we have known the precise gene that causes Huntington's disease for several years we are no closer to finding a cure or even a treatment for this deadly condition. While it is true that a genetic test is available that enables a person to know early in life whether he or she will get this disease at about age forty, it is not clear that an individual is better off living with the knowledge that he or she is doomed.

The government and insurance companies may be anxious to gain access to each of our specific genetic codes, but is this a good thing? Shouldn't we worry that such information could be used to restrict our civil liberties? Do we want insurance companies to be able to deny medical insurance to exactly those people who may need it the most? Do we have any way of assuring that the potential beneficial uses of the genome information, paid for by everyone's tax dollars, will be as available to the poor as to the rich?

Earlier in this century the eugenics movement gained popularity. Many people who were thought to have "bad genes" were sterilized so they couldn't have children. The use of such measures by Nazi Germany gave eugenics movement a bad name. But now we once again are hearing talk about how the Human Genome Project will provide the needed information for a much more scientific effort to improve the human race. Is this any more ethically acceptable than a less scientific eugenics program?

Discussion:

The "structured controversy" technique, which requires students to defend both of the opposing positions in a debate is based on pedagogical evidence that a thorough understanding of any controversial issue requires a detailed examination of the arguments on both sides of the question. Students may initially claim that it isn't possible to make arguments that you don't personally believe in. The teacher can counter this by pointing out that lawyers are required to do this regularly as part of their jobs. Once students make the effort, most of them will stop complaining and find that this exercise is an enjoyable challenge.

Students should not be confined to using only the arguments presented in the pro and con essays. Although teachers should abide by the admonition against making remarks that reveal their own positions on the issue being debated, they should make an effort to correct any major incorrect or misleading statements made by the debaters. So as not to interfere with the debates in progress it is best to present these corrections to the entire class in a brief "clarification of the issue" session at the completion of the debate phase.

LESSON 17

Whose Life Is It?

Author:

This is an revised version of a classroom lesson initially developed by:

Patricia Hayes, Clarke High School, Westbury, Long Island, NY

Courses for Which the Lesson is Intended:

Biology classes. (It should be preceded, earlier in the school year, by a lesson that introduces the class to the general consideration of the roles of ethics and values in science.)

Types of Teaching/Learning Activities Employed in this Lesson:

Students are given a homework assignment requiring them to read a fictional story involving the future cloning of human beings and to answer questions about some of the key technical aspects of the story. The class begins with a teacher led discussion of the answers to the homework questions, designed to assure that the ethics lesson is based on a common understanding of the scientific aspects of the story. The class is then divided into cooperative learning groups. Each group is charged with responding to a common set of questions about some of the ethical issues raised by the story. The teacher then leads a classroom discussion focused on the variety of alternative values-based responses of the different groups to the questions, as well as other possibilities suggested by the teacher or by students during the discussion. Students are then given a follow-up homework assignment based on the lesson.

Category that Best Describes this Lesson:

Social issues.

Ethics/Values Issues Raised by this Lesson:

The ethics of cloning human beings as compared to plants or animals; the ethics of a parental agreement that imposes unusual involuntary obligations on a child; the ethics of imposing restrictions on scientific research; the rights of a child to know the details of her/his genetic heritage.

Lesson Plan

1. Students are given a homework assignment (see below) requiring them to read the futuristic, fictional story "Whose Life Is It?" and to answer questions about the important scientific/technical aspects of the story.

2. At the beginning of the next class the teacher invites students to present their answers to the homework questions and leads a brief discussion designed to provide all of the students with the correct information about the scientific/technical details of the story before beginning the ethics lesson.

3. The class is then divided into cooperative learning groups, each of which is given twenty minutes to formulate answers to a set of questions about the ethics and values issues related to the story.

4. The teacher then conducts a discussion about differences among the answers to the questions arrived at by the groups. An effort should be made to get the students to recognize some of the differences in values that underlie the responses to the questions and to consider other reasons for their specific responses.

5. The students are then given a homework assignment requiring each of them to write a letter to their representative in Congress concerning the student's views about federal support for research on human cloning and describing any restrictions or guidelines that Congress should impose on the scientists who do cloning research.

Whose Life Is It?

On June 23, 2018 Jean Trueblood celebrated her seventeenth birthday. Her summer activities include preparing for her freshman year at Central State University. Due to the influence of several inspiring high school science teachers, she is seriously considering biology as her major in college. She is fascinated by what she has learned so far about the amazing scientific and medical advances made possible by powerful new biotechnologies. For her final paper in her advanced "Current Issues in Biology" course she chose to write about the ethical implications of cloning, not knowing that this topic was about to have a direct impact on her own life.

Just one week after her birthday Jean's plans for a carefree summer were shattered by a letter received by her parents. The letter was from Dr. Cynthia Hayes who had won the Nobel Prize for groundbreaking research on the cloning of mammals. Dr. Hayes' successful research on the cloning of chimpanzees had been funded by a grant from the U.S. National Institutes of Health.

As Jean's parents knew, Dr. Hayes had secretly used some of the funds to apply her new technique to the cloning of a human being. That human being was Dr. Hayes, herself. She was motivated by the fact that she had developed a chronic infection in both of her kidneys that might eventually require a kidney transplant. She knew that she had some rare blood and cell characteristics that would make it hard for her to find a matching kidney donor. With the aid of a close friend who was medical technician in Central State Medical Center's Department of Obstetrics and Gynecology, Dr. Hayes was able to obtain 10 human eggs removed from the ovary of a research volunteer. Then, using her new method, she was able to get four of these eggs to begin to grow into clones of herself by removing the original eggs' nuclei and inserting nuclei from her own cells. All of the successful clones were then frozen in liquid nitrogen in the early blastula stage.

With the aid of another friend who worked for a clinic for women seeking assistance in becoming pregnant, Dr. Hayes was able to locate a woman who was seeking an embryo implant after she had failed to become pregnant by any other means. That woman was Jean's mother, Valerie Trueblood. Dr. Hayes offered Jean's parents a very financially attractive deal. They could save the usual $60,000 cost of an embryo implant if they agreed to accept one of Dr. Hayes' cloned embryos and signed an agreement. The terms of the agreement caused the Truebloods to hesitate. It required the clone of Dr. Hayes that would be born to Valerie Trueblood to agree to donate one of her kidneys to Dr. Hayes should she require a transplant any time during her life. To persuade the Truebloods to accept this unusual and troubling requirement, Dr. Hayes agreed to create a $100,000 trust fund that the Truebloods could use toward the expenses of raising and educating her clone. After Dr. Hayes assured them that there was less than a 50% chance that she would ever need a kidney transplant, the Trueboods signed the agreement. A little less than nine months later Jean was born.

As the reader will certainly have guessed by now, the letter the Truebloods received from Dr. Hayes informed them that she was now in desperate need of a kidney transplant and that they should have Jean immediately "volunteer" for the tests that would determine that her kidney exactly matched Dr. Hayes' unusual tissue-typing requirements. All of this came as quite a shock to Jean who had never been informed by her parents about her biological origins or the existence of the contract they had signed.

<u>Homework Questions</u>

1. Explain why a germanium plant grown from a leaf placed in water is an example of cloning.

2. Describe the technique used in 1961 by Dr. J.B. Gurdon to clone a frog.

3. Explain what a blastula is.

4. Explain why Jean and Dr. Hayes are the same sex and why Jean's kidneys are ideally suited for Dr Hayes transplant operation.

5. Since every human cell contains all of the information required to make an entire human being in its DNA, why isn't it possible to simply use any cell to clone an individual?

6. Explain why identical twins are the same as clones.

Ethics Questions For Classroom Lesson

1. Dr. Hayes did not reveal her decision to clone herself in addition to the chimpanzees because she knew that the National Institutes of Health would not approve. Give two reasons why the government agency might object to cloning humans, although it approved of cloning monkeys.

2. Do you approve of the cloning of (a) plants, (b) mice (c) monkeys (d) humans? Explain your answers.

3. Do you think that Dr Hayes' was justified in secretly cloning herself because of her kidney condition? Explain your answer.

4. Do you think that the Truebloods decision to accept Dr.Hayes' terms for the embryo implant was ethically justified? Explain your answer.

5. Should the Truebloods have told Jean about her biological heritage and about the terms of the agreement they signed? If so, at what age should she have learned these facts?

6. Is Jean obligated to honor the terms of the agreement? Explain your answer.

7. Does the fact that Jean's upbringing and education have been partly payed for by Dr. Hayes have any influence on your answer to question 5. Explain your answer.

8. If one identical twin needs a kidney transplant due to a condition not related to heredity, should the other twin feel obligated to donate one of his/her kidneys for a transplant operation? Explain your answer? Why would the situation be different if one of the twins needed a liver transplant?

Follow-up Homework Assignment

Write a letter that could be sent to your representative in Congress that (1) explains your views on the cloning of human beings and (2) proposes any restrictions or guidelines that you think Congress should impose on scientists who use federal funds to do cloning research.

Discussion:

Cloning of human beings and other mammals has long been a component of science fiction because of the numerous fascinating (or horrifying) possibilities it opens up. This fascination has been heightened by the recent success in cloning mammals and the likelihood that the cloning of humans could soon be technically feasible. Philosophers, politicians, religious leaders and many others have begun an intense debate about the ethics and possible consequences of these advances in the science of cloning.

Teachers may wish to modify the questions assigned for homework in accord with the content of the information about cloning that has been previously taught to the students.

The fictional story included in this lesson is designed to raise many ethical issues in addition to the controversies typically associated with the potential cloning of human beings. The fact that the central character is a seventeen-year-old should make it easy for students to identify with her. Although this lesson could be completed in one class period, doing justice to the many important contemporary ethical concerns that are likely to emerge during the discussion will probably require continuing into a second period. This additional time can also be profitably used to read and discuss some of the letters that students are assigned to write to their Congresspersons.

LESSON 18

My Friend Linda

Author:

This is an edited version of a classroom lesson initially developed by:

Sheila Matus, Oyster Bay High School, Oyster Bay, Long Island, NY

Courses for Which the Lesson is Intended:

This lesson is intended for use in any biology course - introductory or advanced - that includes a unit on genetics or reproduction.

Types of Teaching/Learning Activities Employed in this Lesson:

Students read a story about a girl who grows up in a family affected by the heritable, disabling and fatal medical condition called Huntington's Disease. They then meet in cooperative learning groups to define the meaning of several relevant terms and to answer questions about ethical issues related to the available genetic test for Huntington's Disease. A classroom discussion is then held to explore the differences among the group's responses to the questions

Category that Best Describes this Lesson:

Social Issues.

Ethics/Values Issues Raised by this Lesson:

General ethical issues related to modern biotechnology; specific ethical issues related to testing for genetic diseases; the ethical consequences of the disclosure of genetic information.

Lesson Plan

1. In preparation for the lesson the students are given a homework assignment requiring the written definition and explanation of a series of terms related to the lesson.

2. At the beginning of the class, students are given ten minutes to read the brief introductory story, "My Friend Linda."

3. The class is divided into cooperative learning groups of three or four students each.

4. Working among themselves each group:

a) discusses and attempts to formulate a set of definitions and descriptions for the terms in the homework assignment.

b) discusses and attempts to reach a consensus in response to the discussion questions

5. The teacher asks for volunteers among the reporters for the learning groups to present definitions of the assigned terms. With the help of other students the definitions are discussed and, if necessary modified, with the goal of producing a set of definitions that the teacher and class find acceptable.

6. The teacher then leads a class discussion based on the questions, which is designed to expose the students to the many unavoidable ethical issues that our society faces as a result of the development of biotechnology and its application to genetic testing.

<u>Student Homework Assignment:</u>

Define and explain each of the following terms:

1. amniocentesis

2. autosomal dominant inheritance

3. tri-nucleotide

4. ethical issue

5. genetic testing

6. allele

My Friend Linda

When I was ten years old, my best friend Linda's father died. We knew he had been very sick, but Linda told us nothing else about his illness. When you are ten, the death of someone close to you is usually too frightening to talk about. Linda's friends would never have dreamed of asking, "What did your daddy die of?"

Although she moved to another city when we were both 13, I kept in touch with Linda. When she was twenty she told me that her brother Peter was ill. Peter was 31, married, and had a two-year-old daughter. Over the next three years I learned from Linda that his condition had gotten much worse and he had been confined to a hospital. A year later Linda wrote to tell me that he had died and that her unmarried sister Hope, then 33, was showing early signs of the same disease that had taken the lives of her father and brother.

Linda disclosed in that letter that her father, Peter, and now Hope were victims of Huntington's Disease. She explained that it is a genetic disease caused by an autosomal dominant gene. Anyone who inherits the gene will suffer physical and mental deterioration, usually beginning about age forty. Symptoms from the most lethal form of the gene can sometimes begin several years earlier. The disease begins by causing a variety of physical symptoms. The victim loses muscular control, soon becoming unable to walk normally or do tasks requiring any coordinated motion. Speech becomes difficult and then impossible. Within a few years serious mental disturbance occurs followed inevitably by death. There is no cure, nor effective treatment for the disease.

One purpose of Linda's letter was to seek my advice. She faces a very difficult decision. Genetic research has identified the form of the gene that causes Huntington's disease. A test has been developed in which the gene is cloned and DNA analysis can be done to determine if a person is carrying the lethal allele. Linda is now 24 and she has fallen in love. She knows there is a 50% chance that she inherited the lethal gene from her father. The question she has asked me to help her with is should she have the test done to find out whether or not she is doomed to suffer the same fate as her father, brother and sister?

<u>Discussion Questions</u>

1. Why might Linda not wish to be tested for the Huntington's Disease gene?

2. Do you think that Linda should be tested? Why?

3. If Linda is tested and plans to be married, should she tell her boyfriend about the results?

4. If she decides not to be tested, should she explain to her boyfriend that she has a 50% chance of having the lethal gene, and that if she has it, any children she has will also have a 50% chance of inheriting it from her?

5. Should Linda's test results be available to health insurance companies; to a potential employer; to the government? Should anyone else be informed of the test results without Linda's permission?

6. Suppose Linda had an identical twin sister. Should that sister have the right to know Linda's test results? Suppose that sister does not want to be tested, and since it would be difficult for Linda to hide either negative or positive test results from her, should the sister have the right to prevent Linda from being tested?

7. Should being tested for the gene be a requirement for anyone with a family history of Huntington's Disease?

8. Suppose a cure, or effective treatment for Huntington's Disease was discovered. Would this affect your answers to any of the other questions?

9. As you have seen in responding to these questions, genetic testing involves decisions of an ethical nature that have complicated possible effects on the person being tested, family members and society. Since most people will not be aware of all these issues, should genetic counseling be required before an individual undergoes genetic testing? If so, who should pay for it?

Discussion:

There is no doubt that biotechnology and the Human Genome Project will continue to result in new technologies that will become available to medical practitioners and to the public. It is important that in addition to learning about the tremendous potential benefits of this biotechnological revolution, students become aware of the complex social and ethical issues that will accompany this development.

In this lesson students learn that it is now possible for an individual with a family history of Huntington's Disease, a lethal inherited disease resulting from a genetic defect, to have a test to find out if he or she has inherited the defect. Since the disease is incurable and always fatal, the obvious question is whether or not an individual is better off knowing if the defect has indeed been inherited. Knowledge would be helpful in many ways. If the results are negative it means the individual can live a normal life without fearing an early, horrible death. If the results are positive it can help an individual prepare for the inevitable. An individual with the inherited gene may decide not to have children, each of whom would have a 50-50 chance of inheriting the lethal defect. On the other hand an individual may prefer to live with the uncertainty of not knowing rather than risk having to live with the certainty that she or he is doomed. Question 6 points out that the decision to have the test results in information that can affect relatives as well as the individual in question. Parents and children of an individual being tested, as well as the more unusual case of an identical twin, could learn that they are either definite or possible carriers of the defect from the results obtained by a person who chooses to be tested. This can clearly present thorny ethical problems for someone who is considering being tested.

It is important to emphasize that serious ethical issues are by no means confined to the case of genetic testing for a fatal incurable disease. Genetic testing of any sort is associated with serious potential consequences that most people are not aware of. In many cases an individual is advised to see a genetic counselor before making a decision about whether to be tested. It has been suggested by some of the people who have studied this issue that such counseling should be made mandatory. Before any action could be taken on such a suggestion it would be necessary to define what constitutes adequate counseling. At present, genetic testing and counseling are expensive and are not financially feasible for the majority of people. This raises a general ethical concern about how a democratic society can assure fair access to present and future expensive biomedical technological procedures.

LESSON 19

<u>The Race for the Double Helix</u>

Authors:

An edited version of a classroom lesson initially authored by the following Long Island, NY science teachers:

Steven Angell and Marcia Brandeau, Longwood High School, Middle Island

James Baglivi and Mary Loesing, Shoreham-Wading River High School, Shoreham

Theresa Dana, Deer Park High School, Deer Park

Jack Waszmer, Paul Gelinas Junior High School, Setauket

Courses for Which the Lesson is Intended:

Intended for use in a college-preparatory or advanced high school biology course.

Types of Teaching/Learning Activities Employed in this Lesson:

Students work in collaborative groups.

Students are required to use knowledge from the course to solve a puzzle.

The class watches a video.

The teacher leads a student discussion of the ethics/values issues associated with the student activity and the events depicted in the video.

Category that Best Describes this Lesson:

Behavior of scientists.

Ethics/Values Issues Raised by this Lesson:

Cooperation versus competition in science; attitudes toward the sharing of unpublished data and results; assignment of credit for scientific discoveries; sexual bias in the scientific community.

Lesson Plan

Instructions for the Teacher:

This lesson is designed to explore several common ethics/values issues related to the behavior of research scientists, while reinforcing students' understanding of the relationship between the structure of the DNA molecule and the biology of protein synthesis. It was inspired by the video *The Race for the Double Helix*[(55)], which is a dramatization of the efforts of James Watson, Francis Crick, Rosalind Franklin, Maurice Wilkins and other scientists that led to the discovery of the structure of DNA. The video is, in turn, based on the book *The Double Helix*, by James Watson[(56)].

The complete activity requires a minimum of four forty-minute class periods. It should be used after students have learned about the structure of DNA, the relationship between DNA and messenger RNA (mRNA), and the mechanism of synthesis of proteins using mRNA.

At the beginning of the lesson, the class is divided into groups of four students each representing a "research team." The objective of these teams is to win a "bonus" by deciphering a coded message. This is achieved by first transcribing a DNA segment, given to the team, into mRNA, determining the amino acid sequence that is coded on the mRNA, and then using a code that assigns each amino acid to a letter or other element of sentence structure.

No single research team is given enough information to decipher the entire message. Each team is given instructions on how to interact with the other teams in an effort to win the bonus. Some of the teams are instructed to behave in a collaborative manner, sharing their information. A second set of teams is told to act in a highly competitive manner, keeping their own results to themselves while aggressively attempting to obtain data from the others. One team is instructed to work independently and methodically in an effort to solve the problem on its own.

The following instructions are based on an assumed class size of 24. The six four-person research teams will be labeled Groups A, B, C, D, E and F. Groups A, B, and C will be instructed to behave as "collaborator" teams. Groups D and E will be told to behave as aggressive "competitors." Group F will be the "independent," methodical research team. (In classes of larger or smaller size, some, or all of the groups can be increased to five or decreased to three students. Alternatively, the number of collaborator or competitor groups can be increased or decreased.)

The first group that brings the correct message to the teacher wins the bonus. That message is "CONGRATULATIONS! YOU ARE THE WINNER. THE BONUS IS YOURS!"

The segments of DNA given to each of the groups, when correctly decoded, will produce the following partial messages:

Group A: ___________________! YOU ___ ___ WINNER. THE ______ IS YOURS!

Group B: ___________________! YOU ARE THE ________. ___ BONUS __ ______!

Group C: ___________________! YOU ___ ___ WINNER. THE ______ IS ______!

Groups D&E: ___________________! YOU ARE THE WINNER. ___ ______ __ ______!

Group F: CONGRATULATIONS! YOU ARE THE WINNER. THE BONUS IS SCAT!

Note that by exchanging data, the collaborator groups can get the entire message, except for the first word, which they would have to guess. The independent group has a longer message, which includes the first word, which none of the other groups have. By working methodically on their own that group can get an entire message, but the last word is incorrect and they can get the bonus only by guessing the correct word. The competitor groups are given the shortest part of the message, but by following their instructions to be aggressive, they may be able to find a way to get the rest of the information. In fact, teachers who have used this exercise report that it is usually one of the competitor groups that wins the bonus.

After one of the groups correctly deciphers the message, the teacher should lead a discussion about the students' reaction to the activity and their thoughts about how the instructions given to the groups compare with what they imagine to be the behavior of real-life scientific researchers. The teacher should help the students identify ethics/values issues that are related to the points the students raise in the discussion. Some questions that the teacher might ask to stimulate and direct this discussion are:

What do you think about the instructions your research group was given and did you have any reaction to the behavior of the other groups?

Did you have any problem with the way the bonus was awarded?

Which of the groups was instructed to behave in a manner that you think resembles the way real-world scientists behave?

What is your opinion about the roles of competition, collaboration and independent work in scientific research?

Are the standards of behavior that you expect of scientists any different than those you set for other professional workers?

When the continuation of this discussion no longer appears to be fruitful, the students should be shown the video *The Race for the Double Helix.* After viewing the video, the teacher should lead another discussion.[(57)] Some suggested questions for this second discussion are:

- Which of the scientists depicted in the film behaved in a manner that resembles the way that your research group was instructed to behave?

- If you were going to be a scientist, which of the researchers in the film would you choose to be like? Why? (Note: If, as is likely, more girls than boys in the class identify with the Rosalind Franklin character, some questions might be asked to get the class to think about reasons why this is true.)
- What differences did you observe among the research goals of the various principal researchers - James Watson, Francis Crick, Rosalind Franklin and Maurice Wilkins?
- Which do you think should be the goal of a scientist: receiving credit for being the first one to make an important discovery, or sharing your results with others so that the discovery can be made as soon as possible, even if you don't get the credit for it?
- In what circumstances do you think scientists are justified in not sharing their results with others before their research is completed.
- This video is based on a book written by James Watson, in which he very openly described his memory of the effort leading to the discovery of the structure of DNA. The book proved to be very controversial, and Watson received much criticism from other scientists for revealing the personal side of this historic research effort. Why do you imagine that other scientists reacted in this way?
- Do you think that women scientists are still discriminated against the way Rosalind Franklin was in the 1950s?
- Aside from the direct effects of discrimination against women, can you think of any other possible consequences of the fact that science has historically been a profession that has been dominated by men, most of whom had above average incomes?

Instructions and Handouts for Students:

1. You will be assigned to a four-student "research group."

2. Your group will be given a sequence of nucleotide pairs carried by a piece of DNA. Using the left hand set of nucleotides as a template, and your knowledge of the base-pairing that occurs in RNA, transcribe the corresponding strand of mRNA.

3. As you have learned, each successive set of three mRNA nucleotides is a codon that codes for a particular amino acid. Using Table 1, determine the amino acid sequence that would be produced by the mRNA you transcribed.

4. Use table 2 to determine the sequence of characters (letters, spaces or punctuation marks) that correspond to your DNA sequence, and write them in the appropriate place on your data sheet.

Groups A, B and C:

5. Your group is collaborating with groups B and C (or A and C, or B and C). After deciphering the part of the message coded by your piece of DNA, you should share your results with these other two groups to complete missing sections of the message indicated by the numbers of spaces in parenthesis. You should then "publish" your results on the black board for the other groups to share. You may then try to complete any missing part of the message by guessing. When you think you have the entire correct message, report it to your teacher who will give a bonus to the first group that gets it right.

Groups D and E:

5. Your group is intent on being the first to decode the entire message. You find that After deciphering the part of the message coded by your piece of DNA, you are missing sections of the message indicated by the numbers of spaces in parenthesis. You should try to obtain the missing information from the other groups by any means you can devise, without sharing your results with them. When you think you have the entire correct message, report it to your teacher who will give a bonus to the first group that gets it right.

Group F.

5. Your group believes in methodical, independent work. You do not wish to publish your work until you are sure it is correct. Unfortunately, you find that after you

decipher the message corresponding to your piece of DNA, it contains an error. You may try to independently deduce (guess) the correct complete message. Only if you are sure that you know what it is should you report it to your teacher who will give a bonus to the first group that gets it right.

DNA Pieces

(51 SPACES)	(24 SPACES)			(18 SPACES)		
TA	AT	TA	TA	TA	CG	GC
AT	CG	AT	TA	GC	TA	TA
CG	AT	AT	GC	GC	TA	GC
CG	TA	TA	AT	GC	GC	
TA	GC	TA	GC	CG	TA	
TA	GC	TA	AT	GC	TA	
GC	CG	AT	TA	AT	TA	
TA	TA	TA	AT	TA	TA	
CG	GC	TA	GC	GC	CG	
AT	CG	AT	AT	TA	GC	
TA	TA	TA	TA	AT	CG	
GC	AT	GC	GC	CG	AT	

Group B

(51 SPACES)			(36 SPACES)	
T A	CG	TA	CG	GC
AT	CG	TA	GC	CG
CG	TA	CG	AT	AT
CG	TA	AT	CG	AT
TA	TA	GC	TA	TA
TA	CG	AT	TA	GC
GC	TA	TA	CG	(27 SPACES)
TA	AT	AT	TA	
CG	AT	GC	GC	
AT	AT	AT	GC	
TA	TA	TA	TA	
GC	AT	GC	TA	

Group C

(51 SPACES)	(24 SPACES)			(18 SPACES)
TA	AT	TA	TA	TA
AT	CG	AT	TA	GC
CG	AT	AT	GC	GC
CG	TA	TA	AT	GC
TA	GC	TA	GC	CG
TA	GC	TA	AT	GC
GC	CG	AT	TA	AT
TA	TA	TA	AT	TA
CG	GC	TA	GC	GC
AT	CG	AT	AT	(18 SPACES)
TA	TA	TA	TA	
GC	AT	GC	GC	

Groups D and E

(51 SPACES)				
TA	CG	TA	AT	TA
AT	CG	TA	CG	AT
CG	TA	CG	AT	AT
CG	TA	AT	TA	TA
TA	TA	GC	GC	TA
TA	CG	AT	GC	TA
GC	TA	TA	CG	AT
TA	AT	AT	TA	TA
CG	AT	GC	GC	TA
AT	AT	AT	CG	AT
TA	TA	TA	TA	TA
GC	AT	GC	AT	GC
				(57 SPACES)

Group F

CG	GC	AT	TA	AT	CG	GC
AT	AT	TA	TA	TA	TA	CG

AT	CG	AT	CG	TA	TA	AT
CG	CG	CG	AT	TA	CG	AT
TA	GC	CG	GC	AT	TA	CG
TA	TA	TA	AT	TA	GC	CG
CG	TA	TA	TA	TA	GC	AT
TA	GC	GC	AT	AT	TA	CG
AT	TA	TA	GC	TA	TA	TA
GC	GC	CG	AT	GC	CG	AT
AT	AT	AT	TA	TA	CG	GC
AT	CG	TA	GC	TA	AT	TA
TA	TA	GC	AT	GC	AT	AT
TA	CG	CG	CG	AT	TA	
TA	CG	CG	AT	GC	GC	
CG	TA	TA	TA	AT	TA	
CG	GC	TA	GC	TA	GC	
AT	GC	TA	GC	AT	GC	
TA	CG	CG	CG	GC	GC	
TA	GC	TA	TA	AT	CG	
AT	GC	AT	GC	TA	GC	
GC	TA	AT	CG	GC	AT	
TA	AT	AT	TA	CG	TA	
CG	AT	TA	AT	GC	GC	
GC	TA	AT	TA	AT	CG	

The Amino Acids

Abbreviation	**Name**	**Abbreviation**	**Name**
gly	glycine	ala	alanine
val	valine	ile	isoleucine
leu	leucine	ser	serine
thr	threonine	pro	proline
asp	aspartate	glu	glutamate
lys	lysine	arg	arginine
asn	asparagine	gln	glutamine
cys	cysteine	met	methionine
trp	tryptophan	phe	phenylalanine

tyr	tyrosine	his	histidine
term	termination		

Table 1: The Genetic Code: Codons and the Amino Acids They Code

First Two Nucleotides of the Codon	**Last Nucleotide of the Codon**			
	U	C	A	G
UU	phe	phe	leu	leu
UC	ser	ser	ser	ser
UA	tyr	tyr	term	term
UG	cys	cys	term	ttrp
CU	leu	leu	leu	leu
CC	pro	pro	pro	pro
CA	his	his	gln	gln
CG	arg	arg	arg	arg
AU	ile	ile	ile	ile
AC	thr	thr	thr	thr
AA	asn	asn	asn	asn
AG	ser	ser	arg	arg
GU	val	val	val	val
GC	ala	ala	ala	ala
GA	asp	asp	glu	glu
GG	gly	gly	gly	gly

Table 2 Amino Acid to Character Conversion

Amino Acid	Character	Amino Acid	Character	Amino Acid	Character
Glycine	A	Alanine	B	Valine	C
Isoleucine	E	Leucine	G	Serine	H
Threonine	I	Proline	L	Aspartate	N
Glutamate	O	Lysine	R	Arginine	S
Asparagine	T	Glutamine	U	Cysteine	W
Methionine	Y	Tryptophan	D	Phenylalanine	J
Tyrosine	Space	Histidine	!	Termination	.

RACE FOR THE DOUBLE HELIX -- DATA SHEET

Name ________________________ Group ______ Period ______ Teacher ________________________

DNA	mRNA	Amino Acid	Character	DNA	mRNA	Amino Acid	Character	DNA	mRNA	Amino Acid	Character
____	____			____	____			____	____		
____	____	________	_______	____	____	________	_______	____	____	________	_______
____	____			____	____			____	____		
____	____			____	____			____	____		
____	____	________	_______	____	____	________	_______	____	____	________	_______
____	____			____	____			____	____		
____	____			____	____			____	____		
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Discussion:

Although this lesson requires a substantial investment of classroom time, teachers who have used it with properly prepared students commented that it serves to concretize the mechanism by which DNA codes for protein synthesis, while stimulating very rich and rewarding student discussions of important ethical issues related to the behavior of scientists.

In the discussions, it is important to direct attention to the significance and generality of the issues, rather than the particular circumstances of the student exercise, or the specific personality traits of the characters in the video. These general issues include the common conflict between a scientist's personal values, such as the desire to achieve success or fame, and the ethical demands of the scientific profession. Students should be challenged to consider why collaboration, sharing of information and the fair assignment of credit for discoveries are important to the advancement of scientific knowledge, but may often be compromised due to the fact that scientists are human beings with competing personal needs and desires. An effort should be made to take the discussion arising from the constraints imposed on women in science beyond the obvious negative aspects of overt sexism or racism. A possible way to do this is to ask students to consider whether the ranking of the importance of research problems by women or minority members might be significantly different from the choices made by relatively affluent white males.

For those teachers who can not devote four classroom periods to this lesson, the required time can be cut in half by eliminating either the viewing of the video and related discussion, or the DNA coding exercise. While this significantly reduces the student experience that can be used to probe the issues, teachers report that worthwhile ethic/values education is still achieved.

LESSON 20

Reporting Data

Author:

A revised version of an individual lesson plan developed by

Karen M. Zopf, Oceanside High School, Oceanside, Long Island, NY

Courses for Which the Lesson is Intended:

Chemistry classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Group discussion of a fictional case study involving environmental concerns. Each group submits a short paper and reports its recommendations to the class.

Category that Best Describes this Lesson:

Behavior of scientists

Honesty

Ethics/Values Issues Raised by this Lesson:

Responsibilities of scientists in determining and communicating risks to public health and safety; honesty in reporting data; role of scientists in the framing of public policy.

Importance of honesty, especially in research that has a direct impact on human health and welfare.

Lesson plan:

The teacher divides the class into small groups and distributes the following hypothetical scenario to students. Each group is instructed to submit a short paper on their recommendations, with supporting rationale, and to be prepared to report their views to the rest of the class.

Mark Sidwell is working his way through college. A chemistry major, he has a summer job monitoring pollution for a chemical company located on Bedell Creek. (Bedell Creek is adjacent to the high school and eventually flows out to the ocean.) He is instructed to collect three 100 ml water samples at certain locations at set times each day. To each sample he is to add 5 ml of a chemical solution that reacts and changes its color in response to the amount of toxic heavy metals in the water. He then checks each sample with an instrument that detects color intensity and gives a quantitative measure of the amount of pollutant in each sample. If heavy metals are present, further analysis will be conducted to determine the specific type of and quantity.

Mark's supervisor, Jerry Elrod, has made it very clear that he will be very upset if any unfavorable results show up, pointing out to Mark how costly it may be for the company and the community if the test results show significant amounts of pollution. "Mark," he says, "if we get unfavorable data, we're due for heavy fines; and we might even have to shut down the company. That would be bad news for a couple hundred folks from the area who work here-- and their families."

Mark finds that, after a week on the job, 98% of the tests he has run are favorable, with no significant heavy metal pollution detected. However, in 2% of the tests the change in color intensity seems to warrant further analysis. On further analysis he finds that those two samples contain significant quantities of cadmium and methylmercury ions, both of which are highly toxic. When he shows this data to Jerry, he is instructed to omit the unfavorable data in his report. "We don't have to worry about anything," Jerry explains, "as long as 95% of the tests are negative. As far as I'm concerned, anything under 5% is an unreliable indicator of a problem. 2% certainly isn't enough to bother anyone about--just leave it out of the report."

Mark has one of the best paying summer jobs around, and he has no desire to cause the company any problems. But he wonders if leaving out the unfavorable data is appropriate. He mentions, in confidence, his concerns with you and other members of your group, asking for your advice. What advice do you give him?

In advising Mark, be sure to take into consideration the following questions:

- Does the fact that Jerry Elrod tells Mark that anything under 5% unfavorable results is insignificant relieve Mark of any further responsibility?
- Do you agree that cadmium and methylmercury showing up in only 2% of the tests is insignificant? Does it matter what the levels of concentration are?
- If Mark wonders whether Jerry's 5% standard for reporting data meets regulatory standards of acceptability, how might he go about finding out?
- If Mark finds out that Jerry's standard is not acceptable, what should he do?
- Under what conditions, if any, do you think it is ethical for scientists not to report all data in cases related to pollution? Explain.

- What ethical problems does this hypothetical scenario raise? (E.g., *to whom* does Mark have obligations? Why?)

Discussion:

This is a complicated case. In addition to the specific issues about Mark Sidwell's circumstance, it raises basic questions about how standards of acceptable risk are established. Even though students should not be expected to know what those standards are (e.g., how much vinyl chloride or benzene poses a danger and precisely how this can be determined from data), it is important for them to begin to think about standards of acceptable risk and how scientists might responsibly conduct and report studies of risk in circumstances like the one described.

However, this case is also complicated by questions of authority. Mark is a summer employee, accountable to his supervisor. To whom else is Mark accountable? To what extent is he justified in simply doing what he is told? If he has doubts about the appropriateness of what he has been instructed to do, how might he best go about answering those doubts?

Finally, Mark has reasons for not wanting to "rock the boat." To what extent, if any, is it justifiable to allow himself to be influenced by the desire to keep his job? Students might be asked to compare Mark's reasons for agreeing to leave out data with their reasons for not reporting all the data they collect in their laboratory work. This can lead to a good discussion of the differences between those reasons that are *justifications* (reasons that can stand up to public scrutiny) and those that are, at best, *excuses* or*rationalizations*.

LESSON 21

Ethics in the Science Laboratory

Author:

This is a revised version of a classroom lesson initially developed by:

Heidi Gross, Oyster Bay High School, Oyster Bay, Long Island, NY

Courses for Which the Lesson is Intended:

This lesson is designed for use in a high school physics class. It may also be suitable for a chemistry class, if calorimetry is included in the course syllabus. Similar lessons that describe the alteration of data by students in laboratory situations could easily be written for any other laboratory science class.

Types of Teaching/Learning Activities Employed in this Lesson:

Students are given a homework assignment requiring them to read a brief laboratory case study and to write their reactions to the described conduct of the students in the scenario. A classroom discussion is then conducted by the teacher using a structured set of questions.

Category that Best Describes this Lesson:

Behavior of students.

Honesty.

Ethics/Values Issues Raised by this Lesson:

Alteration of laboratory data - an example of scientific misconduct. Real world consequences of data falsification.

Lesson Plan

Introduction

In school science laboratories, students frequently will know what the expected "correct" result is before doing an experiment. In such cases, students who err in carrying out the experiment may realize that the data collected is not consistent with the expected result. This often leads students to alter their data, rather than report a result they know is wrong. This case study lesson is designed to teach students why altering data is not acceptable behavior on the part of scientists or science students.

1. Give students the homework assignment of reading the case study "Making the Data Fit the Result," and writing about their reactions to the behavior of Mike and Sarah.

2. In class the teacher should lead a discussion using the following questions as a guide:

d) Why did Mike and Sarah change their data?

e) Was this ethical behavior?

f) Would you have done the same thing?

g) Ms. Joule knew that the masses of the unknowns she had given out were all less than 15 grams. She noted that the mass that Mike and Sarah had recorded for their unknown was 18.2 grams. She also noted that Mike and Sarah, who had recorded their lab results in pencil, had erased and changed what they had recorded for the final temperature, but she realized she never taught the class not to do that. Since the object of the experiment was to identify the unknown metal on the basis of its specific heat and Mike and Sarah calculated exactly the right answer, she gave them a grade of 100%. Thus they were rewarded for unethical behavior. How could she have designed and graded the laboratory exercise to avoid this result?

h) What would have been the ethical thing for Mike and Sarah to do?

i) Although real world scientists usually don't know the "correct" answer when they do an experiment, they frequently know what they hope the result will be in order to confirm an hypothesis they may have. Thus, they may also be tempted to alter laboratory results to get the answers they predicted. What would be the consequences if scientists frequently altered data to conform to their expectations?

j) If a student in a high school laboratory alters his or her data it will not have the same affect as if a scientist were to act unethically. Why then, is it important for students to learn always to report the actual data they observe in laboratory experiments?

With the teacher's help the class should write a set of guidelines for proper behavior in conducting laboratory experiments and reporting the results.

CASE STUDY: Making the Data Fit the Result

Jon and Sarah are laboratory partners in Ms. Joule's physics course at Central High. The laboratory for the day is the determination of the identity of an unknown metal by measuring its specific heat. Ms. Joule has told the class that each pair of partners' unknown metal is either aluminum, lead or zinc. As instructed, Jon and Sarah use the top loading balance to weigh a styrofoam cup, which will serve as a simple calorimeter. They then fill the cup half-way with water and weigh it again, subtracting the weight of the cup to calculate the weight of the water added. In the meantime they have placed their unknown sample in a beaker of boiling water. They use a thermometer to verify that the temperature of their sample is now 100^0C. At this point, thinking that they have plenty of time they get into a conversation with another pair of students in the class about a school basketball game that they all attended last weekend. They then measure the temperature of the water in the styrofoam cup and find that it is 27^0C. Next they remove their metal sample from the boiling water and transfer it to the styrofoam cup and begin measuring the temperature of the water in the cup. After a few minutes the water temperature has stopped rising and they record this as the final temperature. Realizing that they forgot to measure the mass of their unknown sample and that they must now hurry to complete the lab before the end of the period they transfer the sample to the balance, but forget to dry it. Therefore the mass they record is significantly higher than the true mass of the sample. Not realizing their error, they proceed to calculate the specific heat. They note that Ms Joule has told them that they can ignore the very small amount of heat that will be absorbed by the styrofoam cup. They make use of the following formulas from their lab manual:

$$\text{Heat Lost} = \text{Heat Gained}$$

$$(mcT)_{unknown} = (mcT)_{water}$$

$$(mc)_{unknown}[212 - T_{final}] = (mc)_{water}[T_{final} - 27]$$

$$m = \text{mass};\ c = \text{specific heat};\ T = \text{temperature change};\ c_{water} = 1.00\ \text{kcal/kg}^0\text{C}$$

The value of the specific heat they calculate for their unknown is 0.14 kcal/kg^{0}C Using the *Handbook of Physics and Chemistry* they find the following values for the specific heats of aluminum, lead and zinc: $c_{aluminum}$=0.22, c_{lead}=0.035, c_{zinc}= 0.087. From the appearance of their unknown they are certain it must be aluminum. It seems to be a light weight (low density) metal like aluminum, but unlike lead or zinc. However their result is closer to the specific heat of zinc than that of aluminum.

Mike and Jon discuss what to do. They could acknowledge that they realize they must have made some error in measurement and explain why they think their unknown is actually aluminum. Instead they decide to alter their data. Substituting the true value of the specific heat of aluminum in the equation, they solve for the value of T_{final} that would give the correct result, and change the value of the final temperature in their lab data to that value. They then hand in their lab report to Ms. Joule.

Discussion:

In the context of an informal classroom discussion students will usually admit that the changing of lab data to fit an expected outcome is a type of student behavior they have observed. If they know that there will be no negative personal consequences, many of them will also admit to having changed data themselves in the past. Although most of them will agree that what Mike and Sarah did was "theoretically" unethical, many will acknowledge that they would probably do the same thing if the odds of getting caught are low. Students will frequently try to justify this behavior by distinguishing between what goes on in a school laboratory and "real science."

Convincing students that they should abide by the same ethical standards with regard to collecting and reporting data as is expected of professional scientists is not an easy task. Explaining that a key purpose of the classroom laboratory is for students to learn to model all aspects of proper experimental procedure becomes much more difficult if the laboratory exercise is structured in a way that focuses primarily on getting the correct result. For this reason considerable attention to question (d) is likely to be very profitable, particularly if the result is a restructuring of the laboratory lesson in a way that emphasizes good procedure, and removes the motivation to alter data by greatly decreasing the credit accorded to obtaining the correct result.

The final task of developing a set of class-generated guidelines for proper laboratory behavior will usually prove very valuable. Once having constructed their own guidelines, the students will tend to think of them as something they have ownership of rather than as a set rules externally imposed on them.

LESSON 22

The Law of Inertia

Author:

An edited version of an individual lesson plan developed by

Albert R: Palazzo, East Meadow High School, East Meadow, Long Island, NY

Courses for Which Lesson is Intended:

Physics classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Students are asked to explain the law of inertia and apply it to the use of seat belts and airbags in automobiles.

Category that Best Describes this Lesson:

Behavior of scientists.

Social issues.

Ethics/Values Issues Raised by this Lesson:

Risk assessment, persuading others not to expose themselves to excessive risk.

Lesson Plan

This lesson begins with a discussion of the law of inertia ("a body at rest remains at rest and a body in uniform motion continues moving uniformly unless acted on by a net force"). Next, the law of inertia is applied to a specific context, the use of seat belts and airbags in automobiles. It is well known that automobile accidents often cause serious injuries or deaths as a result of the momentum of cars crashing into other objects. Devices such as seat belts and airbags can help by restraining or cushioning forward motion and lessening impact forces during collisions or other sudden vehicle decelerations. In addition, head restraints can prevent injuries such as "whiplash" due to rear end collisions.

After discussing these ideas, students are invited to comment on the following scenario:

A physics teacher is a passenger in a car driven by a colleague. As they are about to set out on a lengthy trip, the physics teacher notices that the driver is not wearing his seat belt. Should the teacher say something to the driver about this? If so, what should he say?

Suppose the physics teacher reminds the driver about the seat belt, but the driver replies, "I just don't feel safe wearing a seat belt. I've heard about some accidents in which people were killed *because* they couldn't get out of their belts. Besides, I don't really see the point. If the car goes forward, I go with it; if it stops, I stop. What can a seat belt do about that? Nothing. Isn't this a free country? We should be able to choose--and I've made my choice." What, if anything, should the physics teacher say now?

Students are asked to write out responses to these questions and then to discuss their answers with the rest of the class.

Discussion:

Students are likely to have a number of different views on these matters. Although the law of inertia is a settled matter, the question of whether or not to wear seat belts is not. Here we have to make choices. The question is, on what basis should such choices be made? Physics can help us understand possible consequences of the choices we make. It cannot by itself settle the questions of responsibility the use of automobiles raises--questions about the responsibilities designers and manufacturers have in producing reasonably safe automobiles for consumer use, the responsibilities governments have to establish and enforce safety standards to protect consumers, responsibilities consumers have to protect themselves, and responsibilities we have to urge those with whom we travel to "buckle up".

An understanding of basic principles of physics can help all of the above parties wrestle with their responsibilities. Does this give physics teacher's special responsibilities to help others understand the likely consequences of choosing not to use seat belts and air bags?

LESSON 23

Handling Discrepancies

Authors:

A revised version of an individual lesson plan developed by

William Leacock, W.C. Mepham High School, Bellemore, Long Island, NY

Courses for Which the Lesson is Intended:

Physics classes.

Types of Teaching/Learning Activities Employed in this Lesson:

Working in groups of 2 or 3, students perform a simple laboratory experiment with resistors.

Equipment has been altered in a manner that is likely to induce students to report what they expect

to observe, rather than what they actually observe.

After performing the experiment, the teacher leads a class discussion of the ethical issues it raises.

Category that Best Describes this Lesson:

Behavior of students.

Honesty.

Ethics/Values Issues Raised by this Lesson:

Honesty in interpreting and reporting data acquired in experimental procedures.

Lesson Plan

1. The teacher hands out **Laboratory 26--Series Circuit** (attached) and explains the procedure to the students.

2. Students are divided into groups of 2 or 3, depending on available equipment and the total number of students.

3. The teacher passes out the materials. However, a 20 ohm resistor is altered to look like a 10 ohm resistor.

4. Students are allowed the remainder of the period to complete the lab, with lab reports turned in at the end of the period.

5. When the reports are collected, students are asked to place their cover sheets last so that their names are hidden.

6. Between the first period and the second the teacher makes two columns on the chalkboard, one entitled *altered*, the other *unaltered*.

7. Without looking at student names, the teacher reviews the lab reports and records on the chalkboard the number of students who altered their data to conform with what would be expected with a 10 ohm resistor and the number who did not.

8. As the next period begins, the teacher explains to the class that one resistor was incorrectly marked as 10 ohms when it really was a 20 ohm resistor. Then the *altered* and *unaltered* columns on the chalkboard are explained (including the fact that no names are recorded).

9. The teacher invites students to discuss what has happened and its possible ethical implications. Questions such as the following could be asked:

- There was a discrepancy in this experiment. Is it unethical to alter your data in order to accommodate a discrepancy like this? Why or why not?
- What about scientists engaged in large scale research projects? Is it unethical for them to alter their data in order to make the results match their expectations? Why or why not?
- What kinds of factors might lead science students and scientists to alter their original answers? Are these simply *excuses*, or *rationalizations*? Or do you think that sometimes they actually *justify* altering data?
- What do you think is most needed in order to minimize unjustified data alteration by science students? By scientists?

Discussion

This lesson clearly raises issues about honesty in interpreting and reporting data acquired in experimental procedures. Although there may be cases in which there is some uncertainty about how one's data can be reasonably and fairly presented, this is not such a case; and there should be little doubt in student's minds that altering the data to conform with what they would expect from a 10 ohm resistor is dishonest reporting. What may be less certain to them is whether it is ethically wrong for them to alter the data. Most students realize that cheating commonly occurs, and they may wonder why they shouldn't cheat if cheating is so common. Discussing what happens when scientists cheat can help stimulate a discussion of the seriousness of cheating in a science lab.

Some students may reply that scientists cheating is different than students cheating. The consequences of scientists cheating can be very serious for others (e.g., resulting in doctors and their patients assuming that prescription drugs are safe when the data supporting this has actually been altered). But, students might say, at most, students hurt only themselves when they cheat; besides there are special pressures to do well as students in order to get into good colleges: once the pressure is off, and when the stakes for others are higher, they won't cheat.

Time permitting, the class could be shown the NOVA program "Do Scientists Cheat?" or the PBS program "Why do People Cheat?" in order to cast some doubt on the idea that there will be a time when there will be little pressure to cheat--and to cast some doubt on the idea that there is no connection between how one behaves as a student and how one will behave as a scientist, professional, or ordinary citizen. For an excellent resource on the extent to which lying can directly and indirectly cause harms to liars, those to whom lies are told, third parties who are affected by lies, and social practices and institutions we value, teachers might consult Sissela Bok's *Lying: Moral Choice in Public and Private Life* (New York: Random House, 1978). A very useful resource for both teachers and students is *Honor in Science*, published by Sigma Xi, the Scientific Research Society (North Carolina: Research Triangle Park, 1991). This clearly written 41 page publication concentrates on the importance of honesty in scientific research.

Another ethical issue:

There is another ethical issue this lesson raises. This has to do with a deceptive feature of the lesson itself. It is the teacher who introduces the discrepancy between data and expectation by deliberately mislabeling the resistor. The irony of a teacher using deceptive tactics in order to make a point about honesty in scientific practice is not likely to be lost on thoughtful students. They may not bring this to the attention of the teacher, as they may feel uneasy about challenging the ethics of their teacher. However, this does not mean they won't be thinking about this (and discussing it outside of class). But if the ethics of the teacher's tactic is raised, how should the teacher respond? Not only has the teacher deceived the students, he or she used this deception in order to tempt students to engage in unethical behavior themselves (viz., to falsify data). This, too, is bound to be noticed by the students. In fact, since some of them have been "caught with their hands in he cookie jar," they might be highly motivated to point their fingers back at what they take to be equally culpable behavior on the part of their teacher.

So, there is a substantial risk that this lesson, as presently designed, will backfire. It could generate some distrust of the teacher--who, after all, has lied to the students in a way that they might perceive as manipulative. If students can say to their teacher, "See, you behave unethically, too," much of the force of the lesson may well be lost. In any case, the teacher risks losing ethical credibility with the students--a very heavy price to pay for an ethics lesson!

Is there any alternative way of getting students to deal effectively with the ethical issues this lesson is designed to raise? One way would be for the teacher to describe this lesson to the students without asking the students to conduct the experiment themselves. This puts matters in the third person (since they will be talking about what others have done rather than themselves). Shifting the focus in this way will take some of the dramatic excitement from the lesson, but it does not change the basic ethical issues, which are inherently interesting in any case. Furthermore, students can still draw on their own experience of witnessing or engaging in cheating themselves in order to enliven their discussion of the issues this lesson raises. Not having their backs against the wall (as they would if caught in the act), students might well be in a better position to deal with the ethical issues more fairly and dispassionately.

LABORATORY 26

Series Circuit

NYS Required Laboratory

Objective - To create a series circuit and to determine if the rules for a series circuit are valid:

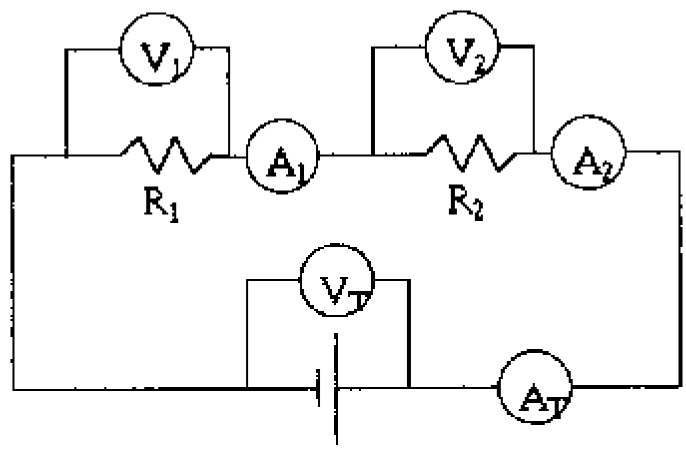
$$V_T = V_1 + V_2$$

$$I_T = I_1 = I_2$$

$$R_T = R_1 + R_2$$

Procedure:

1. Assemble the circuit below using a 10 ohm and 50 ohm resistor for $R_1$and R_2, respectively. Double check that the potential control is set to zero before you start assembling the circuit.



2. Turn the dial on the power supply until the V_T meter reads 10 V.

3. Log all the meter readings in your data table.

4. Turn the power off, remove the 10 ohm resistor, and replace it with the 5 ohm resistor. Repeat the above procedure.

5. Turn the power off. Remove the 50 ohm resistor, and replace it with the 10 ohm resistor. Repeat the above procedure.

6. Complete the data table for all three trials.

DATA TABLE

	V_T	V_1	V_2	I_T	I_1	I_2	$R_1=V_1/I_1$	$R_2=V_2/I_2$	$R_T=V_T/I_T$	$R_T=R_1+R_2$
5, 10										
5, 50										
10, 50										

Questions

1.You have two values for the resistors you used, a calculated value and the value printed on the resistor. Explain where any discrepancies between the two values may have come from.

2. Explain in detail whether the results of this experiment validate the three equations listed in the objective. Show equations to prove your point.

PART 3

Resources

In this section we list books, articles, videos, and websites that are useful resources for preparation for, or use, in classes that integrate ethics and values into the teaching of science. No doubt there are many other valuable resources that are readily available in this growing area of interest.

Books and Articles:

Annas, G. and M. Grodin, *The Nazi Doctors and the Nuremberg Code* (New York: Oxford University Press, 1992).

Bebeau, M., K. Pimple, K. Muskavitch, D. Smith, and S. Borden, *Moral Reasoning in Scientific Research: Cases for teaching and Assessment* (Bloomington, IN: Poynter Center for the Study of Ethics, 1995).

Belmont Report: Ethical Principles and Guidelines for Protection of Human Subjects of Biomedical and Behavioral Research, Publication no. OS 8-0012 (Washington, D.C.: DHEW, 1978).

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Korenman, S., and A. Schipp, *Teaching the Responsible Conduct of Research Through a Case Study Approach* (Washington, D.C.: American Association of Medical Colleges, 1994).

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National Academy of Science, *Responsible Science: Executive Summary* (Washington, D.C.: National Academy Press, 1992)

Nelkin, D. and M.S. Lindee, *The DNA Mystique: The Gene as a Culture Icon* (New York: Freeman, 1995).

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"Academic Integrity," produced at the Center for Applied Ethics, Duke University, 1995. Contact P. Aarne Vesilind: 919-660-5204. (4 vignettes in which college students are portrayed making decisions about fabricating data, cheating on tests, plagiarism, and whistleblowing.)

"Biomedical Research: Is It Really Necessary?," produced by Lockwood Films, London, Canada, 1993. Available from Partners in Research: 519-433-7866.

"The Deadly Deception," NOVA, written, produced and directed by D. Di Anni, WGBH Boston, 1993. Distributed by Films for the Humanities, P.O. Box 205, Princeton, NJ 08543-3053.

"Do Scientists Cheat?", produced by NOVA. No longer distributed, but written transcripts available from Journal Graphics: 1-800-825-5746. [The video is in the collection of many libraries, academic institution and other archives from which it may be borrowed. One such source is the Wisconsin Regional Primate Research Center, phone (608) 263-3512, fax to (608) 263-4031, e-mail to hamel@primate.wisc.edu, write to the Primate Center Library, 1220 Capitol Court, Madison, WI 53715, or request it (video #VT0113) through interlibrary loan at your local library.]

"Ethics and Scientific Research," in *Ethical Issues in Professional Life* series. Available from: GPN, P.O. Box 80669, Lincoln, Nebraska 68501-0669. Phone: 1-800-228-4630. Website for entire series: http://gpn.unl.edu. (Features Robert Sprague, whistleblower in the Bruening case.)

"Evolving Concerns: Protection of Human Subjects," produced for the National Institutes of Health (NIH) and the Food and Drug Administration (FDA) by the National Library of Medicine.

"Gilbane Gold," produced by and available from the National Society of Professional Engineers's Institute for Engineering Ethics: 703-684-2800. (Fictional dramatization of situation raising questions of whistleblowing, environmental protection, business ethics, and journalistic ethics.)

"Group Dynamics: Groupthink," CRM Films, 1995. Available from CRM Films, 249 South Highway 101, Suite 514, Solana Beach, California 92075. Or call CRM Films: 1-800-421-0833. (Application of Irving Janis's "symptoms of groupthink" to the Challenger disaster.)

"Moral Development," produced by McGraw-Hill, CRM films. Available from McGraw-Hill Films, 1221 Avenue of the Americas, New York, New York 10020. (A simulation of Stanley Milgram's obedience experiments, with an analysis in terms of Lawrence Kohlberg's theory of moral development.)

"Obedience," produced by Stanley Milgram. Available from Penn State Audio Visual Services, University Park, PA: 814-6314. (Original footage from Milgram's famous obedience experiments, which raised fundamental questions about deceiving research subjects.)

"The Race for the Double Helix," a BBC/Horizon Films/A&E 1987 production. Distributed by Films for the Humanities and Sciences, P.O. Box 205, Princeton, NJ 08543-2053.

"Scientific Research Integrity Video Series," directed by Mark S. Frankel and Albert H. Teich, sponsored by the American Association for the Advancement of Science (AAAS), 1996. Contact AAAS: 202-326-6600. (Five short vignettes portraying ethical issues in laboratory research.)

"Susceptibility to Kindness," produced by Larry I. Palmer. Available from Cornell University: 607-255-2090. (Excerpts from David Feldshuh's play, *Miss Evers' Boys*, dramatization of the 1932-1972 Tuskegee Syphilis Study, with commentary by governments officials, nurses, physicians, and James Jones, author of *Bad Blood*.)

Websites:

Here we list just a few websites that seem especially useful. Our exploration of the internet is by no means exhaustive, and the internet changes daily. Still, one thing leads to another. Websites typically contain links to other websites. So, try these and see where they take you.

http://bsuvc.bsu.edu/~d000tadl/index.html

This is the bioethical case studies site of Dr. J. R. Hendrix and University Computing Services

of Ball State University, Muncie, Indiana. Six case study scenarios are presented along with Dr.Hendrix' model for bioethical educational analysis.

http://ethics.cwru.edu/

This is the WWWeb Ethics Center for Science and Engineering. It contains a wide variety of useful resources and links on research ethics, moral leaders in science and engineering, women and minorities in science and engineering, and codes of ethics. Try the Education bullet for some good links.

http://k12s.phast.umass.edu/~ethics/index.html

The University of Massachusetts K-12 ethics education site. Contains a course syllabus and links to other ethics education sites.

http://www.awesomelibrary.org/cgi-bin/search-aw1.cgi

The Awesome Library site. Search under ethics and ethics center for useful sites and references on a variety of ethics topics and issues.

http://www.enc.org/rf/index.htm

This is the search page on the Eisenhower National Clearinghouse site. Search under ethics for a variety of useful resources.

http://www.ethics.ubc.ca/

This is the Home Page of the University of British Columbia's Centre for Applied Ethics. It contains numerous links to applied ethics sites including Health Care Ethics, Business Ethics, Professional Ethics, Science and Technology Ethics, Environmental Ethics, Animal Rights, Media Ethics, and Computer Ethics. From the Home Page click on the Applied Ethics Resources on World Wide Web button.

http://www.gene.com/ae/AE/AEPC/WWC/1992/research_ethics.html

Frank C. Jahn and Carol L. Mitch's grade 9-12 Biology and/or Student Research: essays and lesson plans. Woodrow Wilson biology Institute.

http://www.gene.com/ae/21st/TL/TBE/

Genevieve M. Nelson's bioethics teaching site. Good links to other sources.

http://www.gene.com/ae/AB/IE/

Biotech issues.

http://www.lbl.gov/Education/ELSI.html

Lawrence Berkeley National Laboratory's ELSI Project. Materials for middle and high school.

http://www.wmich.edu/ethics/

This is Western Michigan University's Center for the Study of Ethics in Society.

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2. National Science Foundation Grant No. SBR-9320255: "Workshops For High School Science Teachers: Ethics in the Classroom."

3. For example, since July 1990 the National Institutes of Health have required that all recipients of their research training grants receive a program of instruction in the responsible conduct of research.

4. A notable exception is the work of physics professor Marshall Thomsen, who has developed and taught an undergraduate course on ethics in physics, and organized workshops on ethical issues in physics in 1993 and 1996, the proceedings of which may be obtained by writing to him at: Dept. of Physics and Astronomy, Eastern Michigan University, Ypsilanti, MI 48197

5. National Research Council, *Science Education Standards* (Washington, D.C.: National Academy Press, 1996).

6. Florida Department of Education, *Florida Curriculum Framework: Science* (Tallahassee, FL: Florida Department of Education, 1996).

7. Michigan State Board of Education, *New Directions for Science Education in Michigan* (Lansing Michigan: Michigan Department of education, 1991).

8. John Ziman, *An Introduction to Science Studies: The Philosophical and Social Aspects of Science and Technology* (Cambridge, England: Cambridge Univ. Press, 1984), p. 1.

9. Ziman, p. 2.

10. Committee on the Conduct of Science of the National Academy of Sciences, *On Being a Scientist* (Washington: National Academy Press, 1989), p. 1.

11. Ibid, p. 2.

12. Ziman, p. 84

13. Nicholas Rescher, in *Philosophy and Science: the wide range of interaction*, Frederick E. Mosedale, editor (Englewood Cliffs, New Jersey: Prentice Hall, 1979)

14. Ibid, p. 317.

15. Rescher, in Mosedale, p. 325.

16. For this observation, we are indebted to Alasdair MacIntyre, *After Virtue*, 2nd Ed. (Notre Dame, IN: Notre Dame University Press, 1985), p. 38.

17. Plato, *The Trial and Death of Socrates*, G.M.A. Grube, trans. (Indianapolis, IN: Hackett, 1975).

18. English translations vary, including *piety*, *righteousness*, and *holiness* as possible renderings. The precise word does not matter here, as it is the nature of Socrates's demand that is under consideration.

19. Thomas Reid, *On the Active Powers of the Mind*, in *Philosophical Works*, Vol. II, with notes by Sir William Hamilton (Hildesheim: Gekorg Olms Verlagsbuchanlung, 1995), p. 642.

20. Ibid.

21. See, e.g., Richard A Shweder, Elliot Turiel, and Nancy C. Much, "The Moral Intuitions of the Child," *Social Cognitive Development: Frontiers and Possible Futures*, John H. Flavell and Lee Ross, eds. (Cambridge: Cambridge University Press, 1981), p. 288.

22. Gareth Matthews, "Concept Formation and Moral Development," in James Russell, ed., *Philosophical Perspectives on Developmental Psychology* (Oxford: Basil Blackwell, 1987), p. 185.

23. For balanced, accessible discussions of recent findings in moral development see, e.g., William Damon, *The Moral Child* (New York: Free Press, 1988) and Daniel K. Lapsley, *Moral Psychology*, (Boulder, CO: Westview Press, 1996).

24. See, for example, Lawrence Kohlberg, *The Philosophy of Moral Development: Essays on Moral Development*, Vol.1 (San Francisco: Harper & Row, 1981).

25. Michael Pritchard has written extensively on many of them elsewhere. See his *On Becoming Responsible* (Lawrence, KS: University Press of Kansas, 1991) and *Reasonable Children* (Lawrence, KS: University Press of Kansas, 1996).

26. Reid, p. 643.

27. Sissela Bok, *Common Values* (Columbia, MO: University of Missouri Press, 1995).

28. Albert R. Jonsen and Stephen Toulmin, *The Abuse of Casuistry*: *A History of Moral Reasoning* (Berkeley: University of California Press, 1988), p. 17. Jonsen was a member of the commission, Toulmin a consultant.

29. *The Belmont Report: Ethical Principles and Guidelines for Protection of Human Subjects of Biomedical and Behavioral Research*, Publication no. OS 78-0012 (Washington, D.C. DHEW, 1978), pp. 1-2.

30. W.H. Sibley, "The Rational and the Reasonable," *Philosophical Review,* 62 (1953), p. 557. Where Sibley refers to "conduct" and "behavior," we can substitute "judgment" without changing the essence of what he has in mind.

31. For discussions of some of these difficulties see, for example, see Richard Whately, "Critique of the Golden Rule," and Marcus G. Singer, "Defense of the Golden Rule," in Marcus G. Singer, ed., *Morals and Values* (New York: Scribners, 1977); Jeffrey Wattles, *The Golden Rule* (New York: Oxford, 1996); and James A. Jaksa and Michael S. Pritchard, *Communication Ethics: Methods of Analysis* (Belmont, CA: Wadsworth, 1994).

32. Here one is reminded of David Hume's sensible knave, who reasons: "That *honesty is the best policy*, may be a good general rule, but is liable to many exceptions; and he, it may perhaps be thought, conducts himself with mot wisdom, who observes the general rule, and takes advantage of all the exceptions." [David Hume, *Enquiries Concerning Human Understanding and Concerning the Principles of Morals*, 3rd ed., edited by P.H. Nidditch (New York: Oxford University Press, 1975), pp. 282-3.

33. Universalizability is widely discussed in philosophical ethics. See, for example, Kurt Baier, *The Moral Point of View* (Ithaca, NY: Cornell University Press, 1958), ch. 8; Marcus G. Singer, *Generalization in Ethics* (New York: Knopf, 1961), ch. 2; and any of the writings of R.M. Hare.

34. Sissela Bok, *Lying: Moral Choice in Public and Private Life* (New York: Random House, 1978), p. 28.

35. Thomas Reid, *Practical Ethics*, edited with commentary by Knud Haakonssen (Princeton, NJ: Princeton University Press, 1990), p. 110.

36. See Daniel Callahan and Sissela Bok, eds., *Ethics Teaching in Higher Education* (New York: Plenum, 1980). The Hastings Center, located in White Plains, New York, has been at the forefront of developments in biomedical ethics since its founding in 1969. It regularly publishes *The Hastings Center Report*, which contains timely articles not only on biomedical ethics, but many other areas of practical ethics as well.

37. Samuel Florman, "Moral Blueprints," *Harper's*, Oct. 1978, p. 31.

38. If it is going too far to say that the *moral character* of students is likely to be modified in the classroom, it is not going too far to say that their *moral judgment* may be modified.

39. This is based on two case studies presented and discussed by Roy V. Hughson and Philip M. Kohn in *Chemical Engineering*, May 5, 1980, pp. 100-107.

40. Barbara Toffler, *Tough Choices: Managers Talk Ethics* (New York: John Wiley, 1986), p. 288.

41. This study received federal government support for more than 40 years, until it was exposed in the press in the early 1970's. We will discuss this case in some detail in Chapter 4.

42. For an excellent discussion of how routinely social science students used to accept deception of human subjects in experimental research, see Thomas Murray, "Learning to Deceive," *Hastings Center Report*, Vol. 10, April 1980, pp. 11-14.

43. These others include not only other scientists who depend for their own work on the reliable work of their scientist colleagues, but also the public who take medications, undergo medical procedures recommended by physicians, drive over bridges, go up and down elevators, drive automobiles at high speeds, and so on -- all the while depending on the reliable work of scientists and engineers.

44. William F. May, "Professional Virtue and Self-Regulation," in Joan Callahan, ed., *Ethical Issues in Professional Life* (Oxford: Oxford University Press, 1988), p. 408.

45. Ibid.

46. Bill Watterson, *Calvin and Hobbes* in *The Kalamazoo Gazette*, December 23, 1990.

47. William Grigg, "The Thalidomide Tragedy -- 25 Years Ago, *FDA Consumer*, February 1987, pp.14-17.

48. This is true even though there are many instances in which researchers have failed to observe this basic form of respect for persons in their research.

49. Even here not everything is indeterminate. When we recognize something as a dilemma, this means that we see that some options really are undesirable. It is

precisely because we believe that several things really do matter that the choice is so difficult.

50. Demets, David, "Statistics and Ethics in Medical Research," forthcoming in *Science and Engineering Ethics.* (P. 29 of draft.) At the 1994 Teaching Research Ethics for Faculty Workshop at Indiana University's Poynter Center, DeMets recounted in great detail the severe challenges he and his team of statisticians faced in carrying out their investigation.

51. Eugene Braunwald, "Cardiology: The John Darsee Experience," in David J. Miller and Michel Hersen, *Research Fraud in the Behavioral and Biomedical Sciences* (New York: John Wiley & Sons, Inc., 1992, pp. 55-79.

52. May, William F., "Professional Virtue and Self-regulation," in Joan Callahan, ed., *Ethical Issues in Professional Life* (New York: Oxford University Press, 1988), p. 408.

53. Sprague, Robert L., "The Voice of Experience," *Science and Engineering Ethics*, Vol. 4, Issue 1, 1998, p. 33.

54. "The Belmont Report," by The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, OPPR Reports, NIH, PHS, HHS , April , 1979.

55. A British Broadcasting Corporation (BBC) / Horizon Films / Arts & Entertainment Network (A&E) 1987 production, owned by many libraries and currently distributed by Films for the Humanities and Sciences, P.O. Box 205, Princeton, NJ 08543 - 2053

56. *The Double Helix*, by James Watson (New York: Atheneum, 1968).

57. Case Study 4, "The Search For the Structure of DNA" in Chapter 4 of Part I is strongly recommended as preparation for teachers who plan to lead this discussion.