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**RETHINKING TEACHING
METHODS OF HIGH SCHOOL
GENETICS**

by Suzy Armstrong

The acquisition of knowledge in the field of genetics is accumulating at an exponential rate. However, the way genetics is taught to high school students is virtually the same as it was twenty years ago. This fact-based mode of teaching is becoming increasingly unacceptable. Not only are the vast majority of students uninterested in genetics, but also they are unprepared to deal with the new problems that will impact their lives. According to Dr. Robert Blank, chairman of the Department of Political Science at the University of Idaho, biomedical issues are becoming more and more issues of public concern. Blank calls for greater public participation to solve questions that involve human values, and states that we must rely upon the average person--not the experts--to make the complex moral decisions that are becoming increasingly common to genetics. He argues that a well educated public can be counted on to make the best decisions.¹

However, I would suggest that, as far as genetics goes, our students are not so well-educated and are unprepared to tackle the difficult decisions they will be most likely called upon to make. Dr. Mayer, President Emeritus, Biological Curriculum Study University of Colorado, says that it is unfortunate that biology is

often taught as a predetermined body of data that leads to a fixed curriculum. Moreover, this curriculum is taught without relevant applicability and does not take into account the fact that our present knowledge is quickly changing.² In addition, new discoveries in genetics are accumulating at a rate that make it impossible for educators to keep students up-to-date on the facts. This new data is often discussed in magazines, newspapers, and on television before being incorporated into the classroom.² When the information does finally reach the classroom, it is often taught as a series of abstract facts and theories with complete avoidance of the social and moral aspects of the technology.³ This cold, fact-based presentation seems to preclude the idea that all of these students are well on their way to becoming research biologists. This is not the case. Not only does this type of presentation not prepare genetics students for the participatory role they will likely be asked to take on in the future, but it has the potential to turn students against genetics altogether.

This frightening occurrence is already being seen with the popular support of such anti-science groups as "Science for the People" and followers of Jeremy Rifkin.

The problem is further complicated by the media. Since the press competes for audiences, often sensationalism is maximized at the expense of the objective viewpoint. Genetics often bears the brunt of the anti-science attacks because it is seen as invading man's very being, his soul. more and more frequently, geneticists are seen as trying to "play God." There is a very real danger that the average citizen may not be able to distinguish legitimate concerns from exaggerated ones.⁴

The standard genetics course will have to be radically changed if educators are to adequately prepare their students for the impact new genetic technologies will have on their lives. Mayer emphasized the need for a shift from a fact-based course, stating that in the 21st century biotechnology will have a remarkable impact on current students' lives, and that an understanding of both the potentials and hazards of biotechnology is essential.²

The central aims of genetic education must be reevaluated. Although certain facts must be taught to satisfy standardized test questions, the more important goal so far as society is concerned is to teach people how to evaluate the social impact of new technology. Students need to be taught how to look at data, who to

believe, and how to assess potential costs and benefits. Science education can no longer shy away from social and ethical implications of technology. In fact, it must help students develop the skills to help them solve real-life problems and make sound decisions based on new information that is sure to affect their lives as science increasingly interacts with society.² The application of science is becoming an everyday part of life. The focus of science education--and primarily genetics--must be shifted to an issues approach that focuses on such things as analysis, assimilation, evaluation, unbiased reasoning, and decision-making concerning applications of genetics to society.² Educators would do a greater justice to future students to teach them how to think scientifically rather than merely memorizing scientific facts.

It is imperative that society make social and ethical decisions, because science cannot do it. Science can only answer questions that have "correct" answers; it cannot solve problems that involve value judgments.⁴ However, if we don't teach our students how to solve these problems, we cannot expect them to make appropriate decisions. They are all too likely to be swayed by people such as Jeremy Rifkin, who presents

sensational scenarios that are often popularized by the media but have no real scientific basis. This can already be seen in the unfounded fears that abound in the controversy over recombinant DNA. Many opponents of this technique argue that one of these "man-made bugs" may escape the laboratory and cause massive disease and destruction. In actuality, this is impossible. These organisms have been engineered to be inferior and could not possibly compete against normal bacteria, except under precise laboratory conditions. For these reasons, educators must reevaluate how they teach genetics.

Cheong Siew Young, of the Department of Mathematics and Science Education, Faculty of Education, University of Malaya, says, "Establishing a close link between school learning and society's functions has always been a matter of importance, but in recent years it has become a matter of urgency." He argues for a change in the content and scope of today's biology classes and offers some guidelines that would be particularly helpful in the restructuring of genetics. High school genetics courses should enable students to:

- determine interactions between genetics, technology, and science
- participate responsibly in

community development

- develop an understanding of how genetics affects social problems
- develop reasoning abilities in decision making and problem solving
- distinguish between fact and opinion
- develop responsible methods to resolve community problems
- pursue further biological studies²

It is obvious that, although social applications of new technologies are important for students to learn, they must also learn a certain amount of the "facts" also. The "curriculum" cannot be completely thrown out the window to accommodate those that call for social enlightenment. This brings us to the question of how we utilize the curriculum to fulfill all of our objectives while still preparing students for other courses and examinations they will be expected to be prepared for. Nothing can change the fact that genetics is a very complex area of study that students find confusing to learn and teacher find difficult to teach.⁵ However, this may be partly the fault of the method that has been

used to teach genetics. Often, when asked about genetics, students will say that genetics was discovered by some monk named Mendel that found things called chromosomes and alleles, and that these things have something to do with the colors of pea flowers.⁶ To improve upon this, we must change the method.

From my recollection of high school, the most often-asked question of teachers by students was, "When will I ever use this stuff?" The great thing about genetics is that students will use it. They will be affected by it on a daily basis; they can see it on the news and in the magazines. If it is a highly complex subject, it is also an incredibly interesting one. The trick is to find areas that are of interest to high school students and use this interest to help the students learn.

One way to do this is to use case studies that are of personal interest to the students. In East Tennessee, the recent controversy over the custody of frozen embryos is a good case in point. This trial, covered in all the area papers, could be used in the classroom. Mitosis could be discussed as well as other genetic principles that lead to this technology. This teaches students not only facts about the technology but

also helps students to see that any scientific discovery is likely to have a social impact eventually.

Case studies are easy to find (or devise). They can be used, not only to help students increase their reasoning capacities, think scientifically, and solve problems, but they can also be used to make the data students must memorize more interesting and therefore less confusing.⁷

So what is the best way to use case studies in the classroom? Recent educational studies encourage small group activities. These types of activities, when properly designed, can offer many advantages. Teachers can give more specialized help. Students can learn concepts better by "teaching" each other. Independent thinking and problem-solving is emphasized rather than memorization. Moreover, case studies provide an easy way to utilize small groups. The teacher can divide the class into several groups of 4-6 people each and give each group a pertinent "case" that emphasizes a particular area of genetics technology. Each group should also be given information which will help them understand and make decisions about their case. A period of time (perhaps one week) should be given to the students to allow them to fully discuss the potentials

of their case. The teacher may encourage the students to "role play" or may raise questions that the group had not considered. At the end of this period, each group should be expected to make a presentation to the rest of the class about its case and the observations or decisions it has come to. Each group should be allowed to come up with its own format for the presentation :ie role playing, open forum, etc. Each group should be given approximately one class period to present its case and the group must be expected to defend its conclusions to the class. After the presentation, time should be left for the class to ask questions and raise objections to the conclusions.

For example a group may be given a case such as:

Mrs. Brown is 6 weeks pregnant. She is 40 years old and has two healthy children ages 8 and 10. However, she has lived for the past six years in an area that was recently found to contain dangerously high levels of radiation in the water supply. Her gynecologist has encouraged her to allow a specialist in genetic disorders to perform a test that will asses the likelihood that the fetus has a genetic disorder.

The group is also given information about the test, how it is administered, how it works, the risks involved, etc. For the presentation, the group decides to "role play" one person being Mrs. Brown, one Mr. Brown, others being her children and doctors. The doctors explain the problem and the procedure as well as basic genetic theories involved. The scene ends with a family discussion in which they discuss the options and ultimately decide not to undertake the procedure because Mr. and Mrs. Brown object to abortion on moral grounds, so she would choose to carry the fetus to term anyway.

Now questions are raised by the class and teacher.

- What will the emotional impact be on the family if a seriously retarded child or one with a genetic disorder is born?
- If the child is born with a fatal genetic disorder, such as Tay Sach, where the infant will be in extreme pain and will die by the age of 4 or 5, is that fair to the child or family?
- What about the economic impact on the family and community if the infant

requires special care?

- What other things could this technology be used for?

As you can see, using this kind of format not only acts as a review of genetic material, but also teaches students how to think critically and independently. This will prepare students to make rational decisions involving technologies. The scenarios are sure to change as our knowledge advances, but the way to make rational decisions and weigh costs against benefits will not. By using this technique to teach applied genetics, we can accomplish many of the goals previously stated. Moreover, the students see directly how new discoveries can affect their lives. Surely students will find this type of format more interesting because, if nothing else, it breaks up the monotony of the lecture.

Often people are afraid of new ideas simply because they do not know how to deal with them and feel threatened by them. This often leads to an attempt to repress certain areas of science. Look at the Spanish Inquisition. There scientists were prevented from doing research, the conclusions of which the church thought might undermine faith. People are frightened even to

think about new discoveries because they might be used for evil. As educators, we must teach people how to look at these problems as they arise. If we can give students a method to use to face these problems and make rational decisions, then they can face the future and the new knowledge it will bring unafraid, confident they can cope with the at present unknown problems that will arise. Maybe they will then be able to see that technology will not be used "for evil" unless we use it for evil. Thus we will have prepared them to face life, because we will have armed them with knowledge and, therefore, we have accomplished our mission.

However, there is one major pitfall associated with this type of format. Educators must be careful to present all sides of an issue and not let personal values bias instruction. Teachers must avoid at all costs the temptation to impose moral values. The goal of this technique is to teach students how to look at problems coherently and objectively.

Often when students say they don't like genetics or biology, it is because they really just find it confusing. The problem of confusion can often be helped by making the concept more personal. It is easier to understand anything if you have a reference point.

Genetic concepts can be made much simpler if they are communicated by human examples rather than fruit flies, or mutant tobacco plants grown on wet paper. Whoever heard of *Drosophila* before an introductory biology course, and who cares if their eyes are red or white? Wouldn't it be much more interesting to apply Mendel's laws to me "and just see if that old man knew what he was talking about"? These examples are easy to find:

Single gene traits: • presence or absence of widow's peak;

• mid-digital hair;

• ability to roll tongue;

Sex linked:

• male pattern baldness;

• red green color blindness;

Polygenic traits:

• classification of fingerprint ridges;

• height.

These examples can be incorporated as mini-labs or extra-credit assignments to reinforce lecture. The following procedure is an example of how to utilize class fingerprints to discuss polygenic traits:

1. use a pencil to shade a square on a piece of paper large enough to cover your fingerprint;

2. rub one finger across the graphite darkening your entire fingerprint;
3. roll fingerprint across a piece of scotch tape;
4. attach tape with clear fingerprint onto record sheet;
5. repeat for all remaining fingers;
6. use a hand lens and classify each print according to pattern (arch, loop, whorl) and ridge count;
7. record data for each finger;
8. the instructor can collect all data and compare class averages to given data for males and females. The class can now use this data as well as values of complete dominance and recessiveness of all four genes involved to determine their probable genotype.⁸

Another problem occurs because students are frequently expected to visualize complicated procedure, such as DNA recombination. Often they are unable to fully grasp what is happening in a two-dimensional representation. They can only hope to memorize the diagrams and steps sufficiently to pass the test. This

does not facilitate understanding or interest. This problem could be greatly reduced by making three-dimensional models out of things such as cardboard, paper clips, string, slinkies, etc. Students could even be encouraged to make their own replicas of mitosis or recombinant DNA. It is always much easier to visualize things in your mind's eye if you have something to which to equate them. For instance, an alpha-helical strand of DNA will always be a segment of a telephone cord to me.

Genetics is a discipline that affects us all everyday. It does not have to be as complicated or mysterious or dangerous as it often seems. It also does not have to be abstract or impersonal. Genetic technology is a vastly increasing area with almost unlimited possibilities. Furthermore, these very possibilities are likely to have a drastic impact on our lives and our society. As a society, we will be expected to determine how to let genetic engineering affect our lives. Our children will depend on us to make rational decisions, even though the average citizen will not be able to understand the actual technology. Therefore, it is imperative that educators teach students how to reach rational decisions rather than

out-dated facts. Dr. William Mayer summed it up best by saying, "Because of the contribution biology has to make to the citizens of this planet, it should be not only the most sought after knowledge but that which is communicated in the most effective and accurate way possible."² To this end we must continually strive to make our teaching methods more interesting.

Educators should try harder to communicate with students about teaching methods. Ask the students what things they find helpful. Get suggestions from students about how to make genetics more interesting. The curriculum will not improve by itself, so it is up to teachers to look for ways to improve it.

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