Genetics Education

Innovations in Teaching and Learning Genetics
Edited by Patricia J. Pukkila

Tales From the Front Lines:
The Creative Essay as a Tool for Teaching Genetics

Kara E. Koehler and R. Scott Hawley
Department of Genetics, Section of Molecular and Cellular Biology, University of California, Davis, California 95616

ABSTRACT

In contrast to the more typical mock grant proposals or literature reviews, we describe the use of the creative essay as a novel tool for teaching human genetics at the college level. This method has worked well for both nonmajor and advanced courses for biology majors. The 10- to 15-page essay is written in storylike form and represents a student's response to the choice of 6-8 scenarios describing human beings coping with various genetic dilemmas. We have found this tool to be invaluable both in developing students' ability to express genetic concepts in lay terms and in promoting student awareness of genetic issues outside of the classroom. Examples from student essays are presented to illustrate these points, and guidelines are suggested regarding instructor expectations of student creativity and scientific accuracy. Methods of grading this assignment are also discussed.

THE OBJECTIVE

Creative writing is not normally a component of most science courses, except for occasional and desperate student attempts to obtain partial credit during the last few minutes of an exam. However, the increasingly potent advances in the biological sciences, the common public and media misperception of these new discoveries, and the incredibly delicate ethical and legal challenges they generate have caused us to rethink the standard educational notion that science classes should focus exclusively on the informational aspects of the subject. Here we describe the use of the creative essay as a tool in teaching human genetics at the college level, for both nonmajor and advanced courses. We have found it to be invaluable in expanding students' educational experiences and awareness of themselves and others and in helping them to integrate their newly found genetic knowledge with the increasingly complex genetic technologies and information that permeate our world.

One of our primary reasons for developing this tool was to encourage students to think outside of class about the topics encountered in class. We wanted students to think about the ethical and social aspects of what they were learning in the classroom, to view genetics as more than a subject they were studying in school, and to communicate with others about these ideas. It worked extremely well; we were almost immediately inundated with student tales of thinking about genetics while jogging, debating ethics with their classmates over coffee, and initiating family discussions about it when they went home to visit.

We also wanted an understanding of modern genetic issues to stay with our students after the course was over. Many of the students in our nonmajor classes are majors in human development or psychology and will go on to become teachers, counselors, social workers, and psychologists, professions in which a deep understanding of how heredity works and how it affects human lives can be crucial. Regardless of occupation, it is difficult to overestimate the positive impact that citizens who are informed about genetic issues can have on society. The potential for such situations is endless, ranging from hearing a news report about the discovery of a new "marker" that predisposes individuals who carry it to cancer or to mental illness, to reading a newspaper article about a new supermarket product made possible...
through recombinant DNA technology, to finding that they or a loved one is in need of genetic testing and/or counseling. In all of these cases, individuals who have worked with and truly grasped the scientific concepts and the moral dilemmas involved will be far better equipped to deal with such situations.

Another objective of using the creative essay in teaching genetics is that it gives students considerable experience in explaining scientific principles in lay terms. Such skills are invaluable, especially for students who are in training to become scientists themselves. We also suspect that requiring premed students to "get inside" the thoughts and emotions of individuals experiencing a dilemma related to genetic issues may represent a significant first step toward helping physicians of the future to develop compassion and empathy for their patients who are suffering from genetic disorders or illnesses.

THE ASSIGNMENT

Although we use the term "creative essay" to describe this component of our teaching arsenal, it in no way resembles the traditional expository essay or term paper in either style or content. First, we expect little to no independent reading or research outside of the required text and supplemental handouts for the course. All factual information required for the essay is covered completely in lecture, the book, and study guide of our design. However, we do encourage interested students to utilize the many family-based support groups for various genetic disorders accessible via the internet.

At the beginning of the course, we provide the students with approximately 6-8 essay prompts that ask science-based questions within a human context of interpersonal and family relationships and, frequently, larger social and ethical issues as well. Students must write about one of the choices provided. Creative approaches to these questions are stressed, and the resulting papers, generally 10-15 pages in length, are works of fiction that resemble short stories more strongly than essays in form.

Each student is asked to transform one of these brief scenarios into a detailed account of the lives of fictional human beings coping with a painful situation related to a genetic condition, who nonetheless have numerous and agonizingly real counterparts in the human population today. Student submissions for this assignment over the years have utilized an extensive range of creative options. We have read a large number of high-quality stories, but also have received excellent play scripts, screenplays, diaries, doctors' files, and even fictional correspondences consisting of a series of letters and postcards. The essays are due several weeks prior to the end of the course, so most, if not all, of the topic choices available have been covered in lecture as well as in the book and other class notes.

We try to avoid choosing prompts based on material that will be covered in the last 25% of class time, or less than a week before the essays are due, to ensure that students have enough time to familiarize themselves with their chosen topic before the assignment is due.

PROMPT DEVELOPMENT

In general, we attempt to draw the 6-8 essay topics evenly from most of the major subject areas to be covered in class. Subjects range widely, including a variety of genetic disorders and illnesses: Duchenne muscular dystrophy, Huntington's chorea, breast and colon cancer, ataxia telangiectasia, cystic fibrosis, fragile X, schizophrenia, manic depression, alcoholism, problems in sexual determination, ambiguous genitalia, and the consequences of aneuploid karyotypes, particularly Down, Klinefelter, and Turner syndromes. We have also asked students to reflect upon the consequences of possible genetic determinants of sexual orientation.

What all of our essay prompts have in common is their expectation that students will consider issues that venture into a substantially gray area of ethics. We also try to help students realize that many real-life genetic dilemmas may be complicated by such issues as a highly but not completely accurate diagnostic test, environmental effects upon the expression of the disorder, and/or conflicting desires and opinions among family members. Aspects of the relationship between science and society are also examined by asking students to write about subjects including counseling issues, the meaning of informed consent, regulating access to individuals' personal genetic information, the ethical and social obligations of scientists, the ownership and fate of information generated with taxpayer funds, and the patenting of genetic information.

Some of the prompts we have found to be most effective are presented in Box A. Originally, our first essay prompts, and even the idea to assign the essay, grew out of instructor comments in class lectures or student comments on ethics during discussion sections. For example, one of the very first prompts we ever assigned concerned the teenage girl with androgen insensitivity syndrome (Box A, Topic 3). The genesis of this topic began with a lecture on the molecular and clinical features of this syndrome (caused by a mutation in the Tfm gene), followed by a spontaneous editorial comment by the instructor asking students to imagine what it might be like to have a daughter with, or even be a teenage girl with, this condition. The subject came up again in discussion section, and we realized that our students seemed to be very interested in delving into the human consequences of such a situation: If you were a physician, how would you deliver this news to a 15-year-old girl? With her parents present? Would you tell the parents alone and let them decide how much to tell their daughter? How much does she need to know? Would
it be different (and if so, how) if the girl were 18 instead of 15? How is the news that she will never bear children different from the news that she will need surgery later in life to remove her undescended testicles? Out of this type of process have evolved many of our creative essay scenarios.

However, it is also important to stress that essay topics can come from virtually anywhere. We encourage instructors interested in developing such an exercise for their classes to explore resources such as internet support groups to develop a sense of the many different ways genetic disorders can impact real human lives. Essay prompts have also occasionally developed out of our own experiences (e.g., Box A, Topic 2). We have also based them on reports of true events, inspired, for example, by reading a newspaper or magazine article about a family who has been denied insurance for genetic reasons (e.g., Box A, Topic 5). In this period of rapid development in genetic knowledge and technologies, the media is literally saturated with stories about families who are suffering both expected and unforeseen consequences from innumerable genetic conditions. We are also willing to consider student suggestions regarding future prompt ideas, although in the interest of fairness to students who begin writing their essays early in the course, our policy does not include changing or adding to the topics available for a class already in progress.

We also attempt to embed as much potential for human conflict as possible within the structure of each prompt. Since this assignment requires students to write a fictional story, a necessary function of the prompt is to provide them with opposition or conflict to resolve within that story. Prompts should also guide students toward exploring all (or as many as possible) viewpoints and choices available. For example, a scenario might describe a grandparent who died from Huntington’s disease (HD) and then set up opposition between a newly married grandchild in her twenties, anxious to start a family but concerned about passing HD on to her offspring, and the parent in his forties who doesn’t want to know his HD status and is therefore perhaps angry with or trying to convince his child not to be tested for HD. This, however, is only one example of a possible essay scenario concerning HD (see Box A, Topic 4). Alternatively, in a situation involving a fetus afflicted with Duchenne muscular dystrophy, the essay prompt might include mention of both a key figure who is opposed to terminating the pregnancy under any circumstances and another family member who has been profoundly affected by either witnessing or experiencing firsthand the tremendous suffering and premature death caused by this genetic condition. Our essay prompts do not include elaborate details or suggest more than a basic outline of a conflict; they are intended as a starting point, a springboard for students’ imaginations. The creative details of and manner in which the story unfolds, the characters’ emotions and behavior, and the resolution are entirely within the domain of student choice, and form a large part of what we believe makes this exercise so valuable.

In addition to delving into the human aspects, there are necessarily scientific aspects of the assignment. We make an effort to equalize the prompts with respect to the level of scientific difficulty they present, although this is not always easy or even possible. We also make a special effort to cover particularly challenging points with respect to each genetic disorder. For example, with respect to inherited cancers due to mutations in tumor suppressor genes, students are required to explain completely and in their own words how this condition can be recessive at the molecular level and yet be inherited as an autosomal dominant. Depending on whether we are teaching majors or nonmajors, the complexity of the questions within a prompt range from asking students to demonstrate their understanding of simple, but often widely misunderstood, statistical issues (e.g., Box A, Topic 4) to explaining the complex inheritance patterns of fragile X.

A sampling of those topics we consider to be among the least effective—possibly because they are more structured and thus less amenable to creative student interpretation—are shown in Box B. In our experience, an important hallmark of a less effective topic is that virtually all student essays on the subject take very similar positions. This usually indicates that of questions posed to them in the prompt, one of the viewpoints students are asked to consider is too extreme or radical for them to feel comfortable writing an essay that sides with it. For example, one of our prompts (Box B, Topic 1) was inspired by previously made real-life claims of genetic predisposition to violent behavior in XYY males. After reading a number of essays written in response to this prompt, we have concluded that the topic is too one-sided to be truly effective in exercising students’ imaginations; as the currently available evidence suggests that any behavioral differences between XY and XYY males have nothing to do with violence, students are limited in the conclusions they can draw in their essays. Although we believe that asking students to think about possible connections between genetic predisposition and violent behavior and how society might cope with such situations is an important issue, at present we know of no specific genetic condition where the inheritance of such behavior patterns is either well understood or independent of genetic background. Thus, potential essay topics on the subject of violent behavior may perhaps be better focused upon fictitious or hypothetical disorders that are unequivocally linked to aggressive or violent tendencies. On a more subjective note, we also have found that prompts involving court cases sometimes elicit lengthy courtroom-scene descriptions from students, which in our judgment have ranked overall
among the less creative works of fiction we have received.

Another example of less effective essay topics (Box B, Topic 2) revolves around ambiguous genitalia, again with the common result that all essays responding to this prompt reach similar conclusions. All students writing on this topic have taken the position that parents whose child is born with ambiguous genitalia have little choice but to assign or have a gender assigned to their baby and that it is truly not possible at present to raise a genderless child in our society. They are usually sympathetic with the view that a choice of sex must be made based on the child’s karyotype and what the surgeons feel is possible to implement. (We might note, however, that in the last year of teaching, student viewpoints on this issue seem to be changing dramatically!)

**STUDENT RESPONSES**

The student response to the creative essay as an integral component of both nonmajor and advanced courses in human genetics has been overwhelmingly positive. Of over 1000 students in our classes over a period of the last five years, more than 95% of those who filled out course evaluations indicated that the story format of this writing assignment made their class experience and understanding of genetic disorders more illuminating and complete than a book report or term paper.

The quality and variety of work we have received for this assignment over the years spans a wide range of student interests and capabilities, but in general has been quite impressive. We have also had the opportunity to read many essays that might have been published professionally as short stories. More importantly, within the text of these essays we have found evidence that our purpose is being achieved: giving students experience in explaining genetic ideas in their own words, and helping them to integrate the information they learn in class into their conceptualization of human society. The essays represent the best proof of their own success; illustrative examples from some student compositions are excerpted in Box C. Passages have been selected that focus upon nonmajor students’ descriptions of scientific principles and information in lay terminology, as it has been our experience that this is generally a more challenging task for students who lack a science background than it is for biology majors. Examples specifically illustrating students’ depictions of the human struggles that result from coping with genetic maladies are not included here, primarily because it is our sense that the length of the essay excerpts required to adequately convey the depth of a student’s achievement in this area would be far too long for the scope of this article. Determining whether a student has written fiction that is good, engaging, or contains highly empathetic characters is also a much more subjective assessment than whether exposition of scientific concepts is clear. Nevertheless, several of the excerpts provided do suggest a sampling of the types of creative approaches taken by these students in their essays.

**GRADING**

Grading of papers can be a highly subjective and difficult process, especially if the class size is large or several individuals are doing the grading. However, we have designed a grading procedure that allows the essays to be graded efficiently and has also met with general student approval. Writing of the essay is mandatory for completion of the course; late essays are not accepted for any reason. Each individual essay is read by the instructor or an experienced teaching assistant and assigned a grade of honors, pass, or fail. Essays designated as honors or fail by someone other than the instructor are then read by the instructor to verify the decision.

To receive a grade of pass, essays must answer all science-related questions in the prompt completely, accurately, and in terms comprehensible to the average person; this information must be incorporated into a creative story-type format. Based on the idea that the best way to learn something is to explain or teach it to someone else, students are judged on how well they have explained scientific concepts in lay terminology. They are required to do this in their own words, rather than regurgitate from either the lecture or course textbook (see Possible Problems below for a discussion of plagiarism).

The designation of honors is reserved for truly creative or otherwise outstanding essays that also meet the above requirements; these usually comprise between 5 and 20% of the class submissions. Box C, which features excerpts from student honors essays, also contains italicized comments on the unique contribution made by each student that justified the honors designation.

The most common reason for failing an essay is a serious error in scientific accuracy—for example, suggesting that sons can inherit an X-linked trait from their fathers, or that a simple autosomal dominant trait has other than a 50% chance of transmission. Essays in the format of book reports instead of stories, on topics other than those provided, or that have otherwise not been written according to our directions are also not accepted. While we do not inflexibly expect all students to have perfected college-level writing skills, we have occasionally failed an essay due to numerous and egregious errors in grammar and spelling.

Since a passing grade on the essay is a requirement to pass the course, students who receive an essay grade of fail have one opportunity to rewrite their essay and resubmit it for regrading. However, students who fail to turn in an essay on the original due date receive an automatic F in the course and are not eligible to submit an essay on the resubmission deadline. Essays that failed
## TABLE 1
Number of students who wrote honors essays in each letter grade category

<table>
<thead>
<tr>
<th>Final grade</th>
<th>Upper-division class 1</th>
<th>Nonmajors class</th>
<th>Upper-division class 2</th>
<th>Total</th>
<th>Overall percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Honors essays</td>
<td>Total students</td>
<td>Honors essays</td>
<td>Total students</td>
<td>Honors essays</td>
</tr>
<tr>
<td>A+</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>11</td>
<td>18</td>
<td>19</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>A−</td>
<td>6</td>
<td>10</td>
<td>8</td>
<td>26</td>
<td>8</td>
</tr>
<tr>
<td>B+</td>
<td>8</td>
<td>19</td>
<td>14</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>15</td>
<td>6</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>B−</td>
<td>4</td>
<td>20</td>
<td>3</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>C+</td>
<td>2</td>
<td>11</td>
<td>2</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>12</td>
<td>1</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>C−</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>All</td>
<td>34</td>
<td>115</td>
<td>55</td>
<td>236</td>
<td>41</td>
</tr>
</tbody>
</table>

Data from three nonmajor and advanced human genetics courses taught within the past 3 years. Since no students earning grades lower than C− earned a grade of honors on the essay, data from such students have been omitted.

*This figure is artificially inflated due to the omission of scores lower than C−.

### POSSIBLE PROBLEMS

As effective a tool as the creative essay has been in our classroom, other unforeseen problems have sometimes arisen. Some students are not interested in investing the creative effort necessary to empathize with the struggles of people coping with genetic dilemmas, and submit essays that represent little more than a regurgitation of the scenario provided in the prompt. This is rare, however, as the vast majority of students appreciate the opportunity to be creative and view the essay as a more enjoyable writing assignment than a term paper. We also have had to deal with, on average, one case of plagiarism per class, either from the course or other textbooks, supplemental handouts written by us, or honors essays from previous years supplied to our current class as examples of outstanding work. To combat the latter problem, we recommend that instructors strongly consider rotating the selection of essay prompts from which students can choose each year.

The creative essay is indeed a creative vehicle; asking students to write fictional compositions can open up channels of imagination and artistry that would likely remain untapped in more traditional biology courses. These essays can also give instructors a substantial amount of insight into students’ personalities. A rare disadvantage to this has surfaced in the form of a few cases where students have expressed inappropriate sentiments or feelings in the essay, ranging from sexual to hostile, regarding the instructor or teaching assistants. We have in each of those cases met with the student privately and explained the basis for our concern. In each instance, the student claimed to have been “trying to be funny.” We have urged each of them to rewrite and they have done so. We have also encountered rather
unexpected political or religious views or approaches to problems. In one essay, a trisomy 21 fetus's karyotype became euploid through faith healing, an art in which the student assured us that she had full confidence. Another student described how a mutation in the Huntington gene was reverted by visiting aliens, claiming to have firsthand knowledge of such alien intervention.

SUMMARY

In an age when genetics is becoming increasingly personal, the process of science education must expand its focus to recognize that genetic technologies have significant consequences and that genetic knowledge is not merely a subject to be studied, but also powerful information that impacts many realms of human experience. The creative essay, as described above, represents a beginning step to transforming the way both biology majors and nonmajors think about genetic information and disorders. This assignment resembles a short story in form and requires students to clearly explain scientific information, but also emphasizes the too-often ignored human aspects of genetic problems. We have also suggested grading procedures that permit rapid evaluation of the essays without the difficulty of assigning letter grades to each paper, while still allowing exceptional performance on the essay to contribute significantly to a student’s course grade.

The experience students gain through this exercise in expressing scientific concepts in lay terms will benefit majors and nonmajors alike in developing both a deeper understanding of genetics and the ability to communicate with others about such ideas. Students may also be better equipped to make informed decisions regarding the regulation of access to genetic information in our present and future world: the wisdom and proper use of genetic databases, mandatory genetic testing by insurance companies and employers, genetically engineered food items, and new cloning and reproductive technologies are just a few of the ethically ambiguous issues and trends that are currently being debated in today’s society. It is also our hope that these students’ attempts to appreciate and understand the thoughts and feelings of other human beings enduring the consequences of their genetic fates will in some small way enhance their empathy toward all humanity and, ultimately, help to forge a better world.

We owe many thanks to Christina Boulton for her valuable assistance in coping with the mountainous terrain of course evaluations and previous class files. We also thank our former students Stacey Shultz, Laurie Sablotny, Sherry Muterspaugh, and Catherine Mori for their kind permission to reprint portions of their essays as examples. But most of all, we are grateful to all of our students over the years for making the experience of teaching a meaningful and rewarding one.
BOX A
CONSISTENTLY EFFECTIVE CREATIVE ESSAY TOPICS

1. Rick and Cindy have savored the past 10 years, watching their twin daughters grow. Jenny and Judy are not only best friends, but are also inseparable. The twins have always looked very different, and Rick and Cindy know that once they hit puberty their differences will become even more apparent. The parents have realized that they have to face reality and tell Jenny that she has Turner's syndrome. What does this mean, and how is it possible that only one of the "identical" twins has this condition? What are the external and internal phenotypes? Why is Jenny still alive? How and when should Rick and Cindy tell their child? Should Judy also be told? If so, when? What impact will knowledge of her condition have in Jenny's life? Should the family attend counseling? Write from the perspective of Jenny, Judy, Rick, Cindy, or any other person present in their lives.

2. Several years ago, after learning that I was a geneticist, a desk clerk at a hotel in Seattle asked me if she could talk to me about a private matter. Her name was Amber. Now, there's a wealth of danger in such conversations with strangers, but it was late and she seemed worried, so we had a cup of coffee and talked. Amber revealed that her husband had Klinefelter syndrome, a fact she was aware of and had accepted before her marriage. However, she had recently learned that her husband had a strong desire to dress as a woman while at home. Her physician had assured her that her husband's transvestitism had nothing to do with his genotype. Her doctor's bland explanation did little to comfort her. She told me that if the desire to dress as a woman reflected her husband's chromosomes, and thus was beyond his control, she could accept it. Otherwise, she felt that she couldn't live with it. What does this mean? Isn't someone's behavior either acceptable or not acceptable? Why might Amber be willing to accept this behavior, but only if its basis is biological? Amber was also concerned about what either the Klinefelter's or the clothes said about her husband's preference in sexual partners.

So...it's 1 AM in a brightly lit hotel coffee shop in Seattle. What do you tell Amber? Assume that, like me, you were dumb enough to get involved in this conversation in the first place. What is genetically wrong in Klinefelter syndrome? Why isn't this problem corrected by X inactivation? How are biological sex, sex role identification, and sexual preference connected? Do you believe her doctor? If so, on what basis?

3. Erin is a 15-year-old girl who has not yet started menstruating. Her parents take her to a gynecologist, Dr. Brown, who examines her and asks to meet with her parents. Dr. Brown tells them that their daughter has androgen insensitivity syndrome (Tfm) and will never menstruate or have children. He also tells them that Erin has undescended testicles that must be removed by her twenties to prevent testicular cancer.

Erin has been feeling very unsure of herself lately and her parents have noticed her mild depression. They are afraid that this news will destroy her already low self-confidence. Describe what Tfm is and how it is inherited. Should Erin's parents tell her about her disorder? If not, how long should they withhold it from her? When they do tell her, should they tell her the entire truth or just a part of it? How will Erin react when she learns the whole truth? Write from the doctor's, a parent's, or Erin's perspective.

(Continued)
4. Dr. Monica McKeen is interested in studying Huntington’s Disease (HD). She has found a large, multigenerational family on the island of St. Thomas, and moved a research team there. The HD gene has been cloned, which allows them to screen presymptomatically for affected individuals. What does it mean to have a gene cloned? How can they screen for the altered gene?

While the team was there, family members often asked the scientists questions about the disease and their screening results. The scientists would describe the inheritance of the disease, but said that individual results were confidential. What is the inheritance of HD? One of the subjects, Mary, found out that there was a 50/50 chance of inheriting the disease if one of her parents was affected. Why is this true? Her mother experienced prolonged suffering and a difficult death due to HD. At age 45, Mary did not show any symptoms; her only sibling, age 56, was also not affected. Mary thought that because her brother did not have the disease, she was doomed. She did not want to suffer her mother’s fate and committed suicide. What was wrong with Mary’s logic? Should the research team have given out more information? Should they have given the patients their test results? If so, what programs should have been established? What sort of counseling, if any, should have been provided? Who should pay for such counseling? Write from the perspective of Dr. McKeen, another scientist, Mary, or another family member.

5. Kathleen and Richard were extremely excited when they found out that they were going to have a baby. A week after they learned the good news, their insurance company, Insuremost, required that the fetus be tested for cystic fibrosis (CF). In fact, Insuremost has recently rewritten its policies to state that all Caucasian couples must be tested for CF carrier status. Why is screening the prospective parents relevant? What is the inheritance pattern of CF? How is the screen possible?

The results showed that Kathleen and Richard’s fetus is in fact affected with CF. They feel that the screen was an invasion of their privacy, not to mention that if they keep the baby, the cost of their insurance will rise drastically. Why would the insurance increase? Do insurance companies have the right to this type of information? Why does the company want only Caucasian couples screened for CF, and is this practice fair or discriminatory? Would your answer be the same if mandatory screening was enforced for sickle cell anemia in African-American couples? Could this type of selective screening be abused and utilized for nonscientific purposes? What should Kathleen and Richard do? Write from the perspective of Kathleen, Richard, or an employee at the insurance company.
1. The court room is brought to order. A man is on trial for the rape and murder of a teenage girl. The man's defense team presents the argument that, as he is an XYY male, he is genetically predisposed to violence and therefore should not be held responsible for his actions. What does it mean to be an XYY male and how does one arise genetically? Is there any evidence to support the man's defense? Should genetic predisposition ever be accepted as a defense for criminal actions? If so, how should the judicial sentences be altered? You may write from the perspective of the accused man, the judge, a member of the victim's family, or any other person associated with this case.

2. Terry is genetically XX but was born with ambiguous genitalia. Shortly after birth, Terry was put through surgery to appear female. "He" feels, however, that "he" was meant to be a male, and prefers to act and be treated as such. Terry, who is now 28, has not spoken to his parents in the past 3 years. He is furious that they permitted the surgery simply to conform to the social norms of sexuality. He thinks he should not have been operated on until he was old enough to decide what he wanted for himself. Terry's parents desperately want to make amends with their child, but they feel they chose the only acceptable option. Briefly describe the genetics of ambiguous genitalia. Should Terry's parents have allowed the surgery to occur? Should parents be given the burden of choosing a sex for their child? Should the child? If so, at what age is a child mature enough to decide? Could a child be raised in our society without the assignment of a sex? Please write from the perspective of either Terry or one of his parents.
**BOX C**

**COMMENTS ON AND EXCERPTS FROM HONORS ESSAYS WRITTEN BY STUDENTS IN OUR NONMAJOR HUMAN GENETICS COURSE**

**On Topic 1, Box A**

Too often, students write essays that suddenly cease to read like stories and abruptly launch into several pages of exclusively scientific explanation (frequently issuing from the lips of a doctor or genetic counselor), without an effective transition for this substantial change in tone. This student has succeeded in maintaining the narrative flow by channeling the scientific information through the mind of the main character. This preserves for the reader a constant awareness of the narrator as a layperson who is struggling to understand, rather than the sense that an excerpt from a textbook or pamphlet has been inserted into the story.

We spent hours in the library photocopying and highlighting. We discovered that Turner’s Syndrome occurs in 1 out of every 5000 births, so it isn’t as uncommon as we thought. The only victims are girls, since only they need two X chromosomes. The most likely cause of her missing an X chromosome is because it was lost during mitosis (when the body’s cells make copies of themselves...). Because of this, some of the cells being copied are normal (XX), while some only carry one X. So, Jenny’s cells are a combination of XO and XX; this combination is called “mosaicism,” because the [body] forms a sort of mosaic since it is comprised of both XX and XO cells. If a person has more XO cells, then she will be more severely affected than someone who has mostly XX cells. This means that there is a great deal of variability in Turner’s females.

Rick found an article that explained why she won’t be able to have children. It said that one of the Xs in each cell of a normal woman inactivates itself (or turns off), but it must reactivate itself in the oocytes (the sex cells) just before meiosis. The function of meiosis in females is to make an egg, so since Jenny only has one X in some of her cells, all of the XO oocyte[s]... die off during fetal development. This is what causes sterility and the rudimentary streaked ovaries.

—From “Love Always, Cindy” by Stacey Shultz

(Continued)
**Box C (Continued)**

**On Topic 2, Box A**

This essay demonstrates an unusually deep grasp of the big picture; for example, commenting on the purpose of meiosis is something that occurs to very few of our students, especially those who have only just been introduced to human genetics. This student also has a much better understanding of X inactivation and its role in fertility and sexual development than most, and this knowledge has been packaged within the context of dialogue that sounds much more like a conversation than a lecture.

“OK. As I said, Troy has two X chromosomes and one Y chromosome. You know that we are supposed to possess only two sex chromosomes. You possess two Xs and normal males possess an X and a Y. Troy, unfortunately, was the victim of a nondisjunction [event] in meiosis. The whole process of meiosis [is intended for] when a couple wants to reproduce and gametes need to be produced. Troy’s mother donated either a single X or two Xs, which occurred due to failure of [those] chromosomes to segregate. . .This means that Troy’s mother may have donated two, not one, X chromosomes to Troy. Or, the nondisjunction [could have] occurred in his father at meiosis I. Thus, Troy’s father [may have produced a] sperm with two sex chromosomes, one X and one Y. . .”

“I read a blurb on Klinefelter’s Syndrome a long time ago and it said that one of the two X chromosomes is inactivated, so shouldn’t that leave him a normal male? Or is it that extra X that makes him the way he is?”

“It is true that one of the two X chromosomes is inactivated; however, in the production of germ cells, the inactivated X is ‘reactivated’ and this has some deleterious effect or type of poisoning on the germ cell, thus rendering your husband sterile. But again, it is the amount of both female and male hormones in your husband that is essential to his development as a male. . .”

“Do you mind if I smoke?” I asked as I lit up.

“No, not at all.” She smiled.

—from “A Deeper Pain” by Catherine Mori

(Continued)
On Topic 3, Box A

We found this essay to be both extremely creative and clever. Although we never would have suggested that an essay could be written from the perspective of the undescended testicles, this student used the idea very successfully.

Everything plodded along happily for the first few weeks. At about eight weeks Erin’s TDF gene flipped on, which told her indifferent gonads to develop into testicles; thus, Tommy and I were born. We were working fine. We dutifully began cranking out testosterone and another neat hormone called Mullerian inhibitory factor or MIF. The MIF wreaked havoc on Erin’s Mullerian ducts (the fallopian tubes). . . Things were dandy. Tommy and I took great pride in our newfound work and happily cranked out high levels of testosterone, which should have led to the development of the penis, scrotum, and the rest of the male plumbing. Erin was a bastion of testosterone, with low levels of estrogen bobbing about in her young system. But remember, the [Tfm] gene wasn’t working. Erin’s body didn’t notice a single drop of the testosterone that was flooding her cells. Human bodies function not by recognizing actual levels of [sex] hormones, but rather by examining the ratios of hormones. Although there was very little estrogen in Erin’s body, when it was compared to the levels of testosterone (which according to Erin’s cells were completely absent despite all of our hard work), it seemed to Erin’s body that there were infinite levels of estrogen, making her develop the secondary sex characteristics of a female. She has a normal vagina, breasts, and a shapely figure, and so appeared completely female externally. Nobody knew that Tommy and I dwelled within her in the place of her uterus, cervix, and ovaries. We were destined to lie inside of her undiscovered for the next 16 years until this moment. . . It’s not easy to be a testicle in a female’s body, you know.

—From “A Suitcase Rutabaga” by Laurie Sablotny

On Topic 4, Box A

One concept that is sometimes difficult for our nonmajor students to grasp is the statistical issue of independent events. In our opinion, this student effectively finds the voice of a layperson here, illustrating the thought patterns of how someone might follow this common statistical misconception to a tragic conclusion.

Dr. McKeen was one of the doctors and she had a meeting at Grandpa’s house. She said she wanted to calm everyone down. She told everyone that only people who had sick parents could get the disease. And then, they only had a 50% chance. She said that each person has two genes for every trait in their body. Genes determine what we look like. Some genes are stronger than others and the strong genes are called dominant. The Huntington gene is the strongest of them all. Everyone who has it gets the disease and dies. No one knows who has the gene until they get the disease. . . People give the Huntington gene to their babies without knowing that they have it in the first place. . . Momma got a little confused about how the whole gene thing works. She figured that since her mother was sick, either she or Uncle Frank would get sick. She didn’t understand that every baby has an equal chance of getting each gene. . . I guess Momma thought that it was process of elimination. She would get whatever was left over from Uncle Frank. . . If he got to be too much older than 35 and he wasn’t sick yet, then she would know that it was her that got the bad gene.

—From “Suicide, Murder and One Last Twist” by Sherry Muterspaugh