How Much Science is in Science Fiction?

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INTRODUCTORY NARRATIVE

Science fiction is an oxymoron. Science is the study and theoretical explanation of natural phenomena in an orderly way, but fiction is something that is created or imaginary. If science describes fact while fiction is something created or imaginary, how does science fit into science fiction? It turns out that science can play a very important role in science fiction. Science makes the fiction much more plausible. But science does not make fact out of fiction.

We are all interested in the future. It is a given that science will change the way we live. All of us have experienced the nostalgia of elderly relatives and friends; we have difficulty imagining how people functioned without the advances of science... life before Game Boys, microwaves or antibiotics. This really brings home that cliché "you've come a long way, baby." One glory of science is that we can never predict exactly what the future holds, but imagining our future is thought provoking and, in the context of science fiction, entertaining.

It is easy to dismiss the science fiction world as mere fantasies of a writer or a screenwriter – until scientific breakthroughs show these outlandish ideas can and will be a reality. Science fiction is, by definition, a science-based form of literature that is not true to the reality of today, but may become so in the future. The good science fiction writer must do more than simply speculate about the future, they must be highly knowledgeable about the principles and practices of science and technology to describe a new world whose advanced are based on scientific fact. Often, we see science fiction providing the creativity to hard science; science imitates science fiction. One hundred years ago, H.G. Wells wrote about the possibility of cloning. Today cloning has become a reality with the cloning of the first adult mammal, Dolly, the sheep. This area of cloning is an excellent example of the blurred lines between science and fiction. Ultimately, science fiction films not only help to shape our scientific and technological past, it underscores its value in preparing society for whatever the future may bring, by giving us glimpses of possible futures.

As science teachers we can bury our heads in the sand when faced with the incredible universe seen through the movie camera lens. But to do so shortchanges our mission to educate. While "truth can be stranger than fiction," fiction often opens a door of inquiry to students through which they would otherwise not venture.

Educational pedagogy suggests that learning works best when rooted in prior knowledge and experience. Since so little is known about our world, finding that prior knowledge is not always easy…until you invite film into the classroom. Obviously, film,

as an educational tool can be a double-edged sword. Film takes the impossible and makes it conceivable, if only in the eyes of the writer and director. Yet as science fiction films become more technologically intricate and realistic, they make it harder to separate fact from fiction.

One of our goals as science educators is to give students the tools to recognize the kernels of scientific truth among the engrossing sensory experience of movies today. We can use film to entice students into the world of science under the guise of fiction and then direct them in their quest for fact. Showing students a seemingly far-fetched science fiction thriller can trigger their intellectual curiosity. Given the tools to discern reality from fantasy they can disconnect the science from the fiction, and have a good time doing so.

The field of genetics and the manipulation of genetic information are blurring the line between science and fiction. Our lives will change because of the daily advances in this field of science. Science fiction approaches the reality of the future like never before. Genetics has also been a long-standing gold mine for filmmakers as well. Movies like *GATTACA* (1997), *Jurassic Park* (1993) and *The Fly* (1958) use genetic manipulation to elicit emotion and intrigue for entertainment purposes and today they seem closer to reality than ever before.

When the film *GATTACA* was being publicized back in September 1997, Sony Pictures placed full page ads in *USA Today*, *The Wall Street Journal* and *The New York Times* offering "made to order" babies with a life-like check list of characteristics to make the "perfect" baby. Over 50,000 people called the *GATTACA* toll-free line in just the first week. When people called, they got a recording advertising the film. But, this brings home just how many people feel like this fictional science is available in the real world. Sony has developed a website, associated with the film, that allows students to participate in the process of "designing a baby" with all of the pitfalls of genetic engineering tied in along the way. This web page allows you to genetically design your own virtual children, determining everything from IQ to predisposition toward congenital diseases. The site takes off on the movie's theme, questioning the ethical issues of the genetic possibility of creating a race of superior people, with bioethics professors Arthur Caplan and Dr. Carl Elliott answering web queries. There are also links to related ethical discussions at the sites of the Universities of Pennsylvania and Minnesota.

This publicity stunt brings up another major issue surrounding genetic engineering and its portrayal in the movies: the bio-ethical ramifications. Here, again, movies are a powerful tool for educators. Movies simulate possibilities without leading to actual consequences. By evaluating a movie like *GATTACA*, in class, students can formulate personal philosophies that relate to concrete, if imaginary, situations, while staying in the safe environment of "fiction."

In my curriculum unit I propose to take several benchmark movies in genetic engineering and other aspects of science and develop a variety of activities that require students 1) to distinguish the "science" from the "fiction" and 2) to formulate personal opinions of the bioethical ramifications of science, biology and genetic engineering. Students would see a variety of films, learn how to identify fact from fiction through research and understanding, engage in activities that challenge their convictions on scientific principles and formulate educated opinions about possibilities in the future and associated ethical issues.

BACKGROUND

This curriculum unit serves an important purpose in my school community. As an Advanced Placement (AP) Biology teacher at DeBakey High School for Health Professions in the Houston Independent School District, I have a student population that has an inherent interest in both science and science fiction. DeBakey High School is a magnet high school created to provide a comprehensive and challenging pre-college academic and health-oriented educational program to enable students to pursue post-secondary health careers. Our students are selected from around the district and make a commitment to tackle our rigorous, science- and math-intensive curriculum. DeBakey students take five years of math and science as well as an intensive program of health science courses. All students participate in clinical learning experiences and preceptorships at Baylor College of Medicine, affiliated teaching hospitals and other health institutions in the Texas Medical Center.

DeBakey students take the standard sequence of science courses (Introduction to Physics and Chemistry, Biology, Chemistry, Physics) and in their senior year they are required to take an Advanced Placement science course. The majority of students choose the Biology Advanced Placement course, which means that I usually have between 100 and 130 students in my AP Biology classes. The school's rigorous curriculum insures that students come to my class with a solid foundation of scientific knowledge in a variety of subjects. Because of the caliber of students in our school, they also come to my class with an intellectual curiosity that makes combining the fields of science and science fiction a natural topic for enrichment and enjoyment. My goal in developing this curriculum unit is to hone my students' ability to distinguish science from fiction and utilize their interest in science fiction to expand their perception of the relationship between the two. From there, I hope that they will be able to formulate an approach to identifying and tackling the bio-ethical ramifications of both science and the science fiction that interprets it with a solid and balanced approach. Once the critical analysis skills have been developed, these students should be able to apply this process to many areas of pseudoscience, including what they see on television and read in the paper.

DEVELOPING CRITICAL THINKING SKILLS

One of the major aspects of this curriculum unit is to advance student's critical thinking skills. The glory in the format of the activities in this unit is that developing critical thinking skills is the last thing that students think that they are doing. The students assume that they are participating in an informal day of learning. They are excited to "take it easy" and watch a video. But as they hone their skills of identifying fact from fiction, the students are actually utilizing a set of skills that increases their depth and complexity of a particular subject.

Texas Essential Knowledge Skills

There are a series of skills that science educators are asked to instill in our students. Many of these skills focus on the development of higher level thinking skills and are mandated by the Texas Essential Knowledge Skills (TEKS) developed by the Texas Education Association for the state of Texas. They are some of the most difficult for science educators to incorporate into their curriculum. But a student's ability to utilize these skills shows that they have moved from rote memorization to true understanding of a particular topic and utilization of the process. By using film, a science teacher can elicit a variety of higher level thinking skills all within the guise of the enjoyable experience of watching a movie.

Here is a breakdown of the applicable TEKS for biology that are associated with critical thinking skills that are addressed in this curriculum unit.

Knowledge and Skill (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

A) Analyze, review and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information.

B) Evaluate promotional claims that relate to biological issues such as product labeling and advertisements.

C) Evaluate the impact of research on scientific thought, society and the environment.

These are the TEKS that science teachers have the most difficulty in incorporating into their curriculum. This curriculum unit offers teachers an informal, engaging and stimulating way to combine these requirements and still delve into the various content areas of their discipline. While this curriculum unit focuses on the role of science fiction in biology, it is important to remember that the process outlined in this curriculum unit is applicable to all of the fields of science, especially chemistry and physics.

Higher Level Thinking Skills

The development of critical thinking skills requires students to do a variety of tasks. Each of these tasks can be accomplished within the activities of this curriculum unit in a creative and enjoyable way for the students. One essential critical thinking skill that science educators want our students to master is determining relevance. This skill is an inherent part of this unit. Students are asked from the very beginning of their exposure to science fiction film to develop the ability of distinguishing fact from fiction. Built into that activity is the requirement to determine what a relevant aspect of the film is. What aspects of the film are worth asking the question "could that really happen?"

Another important critical thinking skill is the ability to prioritize. Again, students are asked to pick a few relevant concepts or clips from any given science fiction film to apply the fact vs. fiction litmus test upon them and intrinsic in that process is utilizing the ability of prioritizing. There are ultimately many nuances in science fiction films that the students will be watching. Students could not begin to tackle every one of them and they know that, so they almost subconsciously prioritize what is important to tackle and what is not.

Another significant critical thinking skill is the ability to judge information-using criteria. Again, the students do this naturally in the context of these activities. Even without clear cut guidelines, the process of identifying fact from fiction requires the students to develop the criteria by which they judge each aspect of the film. The bonus is that once they have been hooked by the plot line and interest in the story of the film, the student's intellectual curiosity takes over and they are eager to have their questions answered and welcome the challenge of identifying fact from fiction to satisfy their own interest. Within the context of a normal science assignment, it is very difficult to ask a student to develop their own criteria for judgment but within this unit, it happens naturally.

One of the most important critical thinking skills is the ability to differentiate fact from opinion. Again, this is built into the variety of activities associated with this unit. The immediate goal of this unit is for students to develop an ability to distinguish the science from the fiction in a few films shown in class. But, in the process, students develop the skill set to do this with any science fiction film. In fact, one of the activities within the lesson plan is for students to pick their own science fiction film and apply this process of differentiating fact from fiction. Ultimately, the student can not help but carry this skill into other aspects where scientific integrity is questioned, not only in film but also in other aspects of their life. This is especially important in the aspect of bioethics. This generation of students will face difficult decisions not as scientists but as voting members of society. As the amount of information that can be garnered from genetics increases, the uses and accessibility of that information must be decided. The role and uses of cloning is another important issue that must be faced in a public forum. Other bioethical issues that we see in the paper today will continue to be significant issues that

must be faced. Ultimately these issues will be decided in a democratic fashion where having the ability to distinguish fact from fiction makes these students an informed member of society that can impact change in the future.

An additional critical thinking skill developed in this curriculum unit is the ability to prove with evidence. By definition, the activities of this unit ask students to take ambiguous aspects of these science fiction films and identify their validity. The only way that students can do this is by finding evidence to prove these points one way or the other. Ideally, if the students have bought into the story line of the film, they are eager to do this and do not necessarily focus on the process but on the end result. Another aspect of this is that while the students may not necessarily concentrate on the process of doing research and gathering evidence, they are developing that skill and will be able to utilize it in a variety of other aspects of science and life.

Advanced Placement Program

The skills developed in this curriculum unit are also applicable to the Advanced Placement Biology program. The AP Biology curriculum has eight major themes that reoccur throughout the course. These themes allow students to organize concepts and topics in a coherent conceptual framework. Two of these themes are much enhanced by the use of film in the classroom. They include the major theme of (I) Science as a Process and (VIII) Science, Technology and Society. With the rigors placed on an Advanced Placement student, it is important to show them these aspects of biology and rewarding to do so in an informal, enjoyable way, and using a film is an excellent way to do that.

ETHICAL CONSIDERATIONS

One of the real strengths of this curriculum unit is its ability to elicit curiosity on the part of the students about the ethical implications of the scientific principles they see in these science fiction films. Part of the reason why science fiction is so compelling as a genre is because it manipulates the moral values of our society, often in a very disturbing way. When you walk away from a good science fiction film you are inevitably faced with many ethical questions that you perhaps did not have when you walked in. This gives science educators an excellent opportunity to delve into the ethical implications of some of the scientific principles that they discuss in class. As noted earlier, even the state standards (TEKS) require that students think about science in the context of society. While there are many ethical issues to be raised in the context of diverse scientific principles portrayed in film, I will focus primarily on bioethics, because they are most applicable to my particular setting. More specifically, the unit that lends itself best to ethical discussions is the genetics unit, because this is an area rife with ethical dilemmas. This does not mean that you should limit your ethical debates and discussions to the area of genetics, but it should offer you a guideline of how to tackle any of the ethical issues that arise in the context of this curriculum unit.

As we delve into bioethics, the ultimate concept that we must tackle is one of choice. Specifically, in the field of genetics, as we garner a better understanding of the technology of the discipline and we begin to unravel the mystery of development, we begin to face more and more choices about what to do with the new found information. As the technology begins to out pace the once far-fetched ideas of science fiction, we are each faced with how far these opportunities for manipulation should be taken.

In the context of genetics, there are several obvious areas where ethical quandaries abound. One such place is the concept of genetic testing and counseling. While this is an area that is currently characterized by a respect for patient autonomy, it is an area that will offer many choices and face many challenges in the future. This field lives in the shadow of the eugenics movement, which culminated in racial stereotyping, destruction of "inferior races" and forced breeding. A more current concern is the fear that new genetic technology will encourage parents to view their children as commodities, to pick and choose. Certainly, parents want to be informed about potential life-threatening diseases that their child might face, but the same technology can potentially indicate aesthetic disadvantages as well (i.e. obesity). Where do we draw the line?

The ambition of the Human Genome Project, which has mapped the human genetic blueprint, is that eventually we will be able to reverse genetic defects and use gene therapy to treat disorders at their root. Unfortunately, our ability to detect and predict genetic disease will precede by some decades any substantial ability to affect cures. At this point we face the problem that genetics is very good at uncovering many diseases but not so good at a cure or even treatment for most. In their future, students will face this conflict and it is one that is frequently portrayed in science fiction films. What do you do with the information currently available?

Another big issue associated with genetic information, is who should have access to it? As our ability to read the genetic information in an individual develops, these details can be gathered and accessed more easily. How much do you want to know about your future? How much do you want others to know about your past and your future? Ultimately, these are questions that must be faced in the context of any bioethical conversation.

Cloning is another hot button bioethical topic that is constant fodder for science fiction films. While most science fiction films portray the possibilities of what might occur once human cloning has been achieved, the reality is that the cloning of humans has not yet been done, although the technical expertise is almost upon us. Because of this point, it is possible to do some serious ethical thinking in advance of a scientific breakthrough. The reality of cloning is that the genetic blueprint is only part of a person's makeup that mixes with the totality of experience (which can not be easily duplicated) to create a unique individual. Many questions can be raised as to if and how cloning technology should be utilized.

You may notice that in this discussion of bioethics, I have simply raised some difficult questions without providing answers. This is what your students will do as well. In the field of ethics, there are no "right" answers and my goal in this curriculum unit is not to give students the answers but to show them how to develop educated, informed opinions of their own. Ideally, if a student is engaged in the plot of a film manipulating these ethical issues, they will naturally begin to ask some of these tough questions. It is the responsibility of the teacher to guide the student to gather sound scientific evidence and then allow the student to interpret it within their own personal context. Ideally, once students have been given an opportunity to do this, they will then be able to participate in a discussion or debate with an open-mind and a curiosity for evidence supporting one opinion or another.

There are several excellent resources listed in the teacher bibliography that will help educate teachers to facilitate a debate or discussion in bioethics. However, it is essential that in researching these ethical issues, teachers must find the most current and up-to-date sources. The field of genetics, biology and science in general is changing so rapidly that even references just a few years old can not adequately prepare a teacher for an effective discussion in ethics.

TEACHING STRATEGIES

The goal of this curriculum unit is to use science fiction films to enhance student's understanding of scientific principles by having them identify illustrations and violations of scientific principles portrayed in the film. In doing so, science fiction films can help reverse the negative attitudes that many students have towards real science by moving them from familiar experiences they enjoy to unfamiliar experiences the expect to be dull or difficult. This requires that the students undertake critical analyses of the films by applying abstract scientific principles they have learned in the classroom. Once they master how to do this with science fiction films, they can transfer the technique to other areas of pseudoscience including tabloids, TV, commercials, and "news" stories.

These science fiction films directly visualize the abstract scientific principles in a manner that is easier for most students to understand, making the abstract concrete. This process also allows students to understand the relationship among science, technology and society through the process of distinguishing scientific from pseudoscientific approaches to issues. Often times, students will learn scientific principles related to the film but not actually illustrated in the film because of their enhanced interest in science generated by science fiction films. Ultimately, this may lead to a positive shift in student attitudes towards science, in general.

There are a variety of ways that science fiction films can be incorporated into the science course curriculum depending upon resources, budgets, equipment availability,

and length of class periods and scheduling flexibility. Here are the major approaches of incorporating film in the classroom:

1) The film can be screened in its entirety in consecutive class periods. While this approach is time consuming there are some major advantages to it, including that it allows all the students to see the film and it only requires one copy of the film. I recommend that science teachers do this at least once, preferably early on in the year so that students begin the process of developing critiquing skills. In my Advanced Placement biology course, I show the film *Lorenzo's Oil* in the first six weeks in the biochemistry/enzyme unit. There is a relatively structured activity (see lesson plans) that accompanies the film and it allows me to stop and point out specific aspects of the film that the students should learn to identify as major scientific principles being illustrated or violated (teach by example).

2) The film can be screened in its entirety at one showing not during school hours. This requires that the students use their own time to see the film which may be difficult to do with large numbers of students and their busy schedules but it does allow student exposure to the film without utilizing class time. It is important to schedule viewings at several different times during the day to insure that the maximum number of students get an opportunity to see the film. It is also valuable to have copies of the film available for those students unable to attend a viewing.

3) Another alternative is to allow students to individually screen the film in its entirety either at school or at home, on their own time. This allows students to view the film at their leisure and also allows them to replay portions to better understand the scientific principles being illustrated or violated. Students must have access to a TV and VCR and to the film itself. This approach is especially useful when the students are given some leeway about which films they are asked to critique.

4) Short sequences of a film can be shown in class. This allows students to see how films manipulate scientific concepts without taking up large portions of class time. This strategy is most useful when the films being screened are popular, current films where it is likely that a majority of the students have already been exposed to the film, like *Jurassic Park* or *Star Wars*. Again, it is important to make copies of the entire film available to those students who have not seen them in their entirety.

Ideally, to effectively develop the skills outlined in this curriculum unit, science teachers should use a combination of these approaches. It is best to begin with example, showing students how to identify scientific principles in film and providing them with the questions about the integrity of what they see in the film. As the students become more adept at critiquing a film, then short sequences of films can be shown and ultimately students should be able to independently critique an entire film without teacher input or class time.

Student Activity Suggestions

Here are some generalized suggestions about student activities that can be associated with this process of identifying the science in science fiction. Some specific examples can be found in the lesson plan section.

1) The teacher can develop a series of questions to be answered before, during or after a student has watched a particular film. These questions should include some concrete recollection type questions to insure that the students remain on task but should also include some thought provoking questions and questions that extend the scientific principles portrayed in the film.

2) Students can be given an opportunity to tackle interdisciplinary concepts also covered in the film. Students can be challenged to identify ties to other disciplines including ethics, psychology, literature and political science. This can be done informally or more formally using a set of guidelines or criteria for the students to follow. For example, many science fiction films that focus on space include specific details about distances, speed, size and shape. Students can be asked to convert these numbers into meaningful numbers using relevant values to that the student can relate to.

3) Students can be given a particular scientific principle pervasive in a particular science fiction film and asked to gather as much evidence of specific ways in which that principle is addressed within the film, both accurately and erroneously. Adding an element of competition can enhance this activity. For example, if you allow students to work in groups and pit them against one another in finding accurate (or inaccurate) representations of a specific science principles in a film, you will often find that the students will identify obscure references that even the teacher may not have identified.

4) You can ask students to design an experiment to test whether a particular portrayal of a scientific principle in a science fiction film is accurate or not. The experiment does not need to be "do-able" rather this activity focuses on a student's ability to apply the scientific method and process to tackling a problem. For example, a student may design an experiment to identify if time travel is a possibility.

5) Students should be given an opportunity to participate in discussion or debate about scientific or ethical issues raised in a particular science fiction film. Students should be required to gather factual data to support one point of view or the other and ultimately contribute to debate about the identified issue. The questions that are used to elicit student discussion can be teacher-derived or student developed.

6) Students can be challenged to develop their own science fiction plot based on a scientific principle studied in class. This is an excellent opportunity for students to utilize their "creative juices." In order to manipulate a particular scientific principle in fiction, they must be very well versed in the facts behind the principle. (This can also be used as an enrichment or extra credit activity.)

7) Ultimately, students should be able to independently apply this skill set in critiquing science fiction (and pseudoscience in general) for accuracy. Students should be able to take any science fiction film and develop a series of criteria for identifying truth from fiction.

There are a variety of films that will help achieve the goals of this curriculum unit. *GATTACA* is an excellent film to begin with. Another film that lends itself to this sort of dissection is *Jurassic Park*. Last year, scientists retrieved a perfectly preserved woolly mammoth from the frozen tundra of Siberia and have stated their intention to extract its DNA and to clone this ancient beast. Much of the science behind this process sounds like a rough draft of *Jurassic Park*, including putting DNA from the mammoth into an Asian elephant's egg. Technologically, this process still faces major obstacles, but it exhibits how much science and science fiction play off one another. If the technology does become viable, it opens up an ability to reintroduce species long since extinct, and the ethical problems that go along with that.

Scientists in *Jurassic Park* grew live dinosaurs from DNA – the genetic code of all living matter – preserved inside amber-entombed mosquitoes. In real life, we do have the technology for extracting DNA from fossils and for cloning animals. But the researchers who study ancient DNA in amber (fossilized tree sap) find only incomplete DNA pieces, which do not contain enough information to put together a dinosaur. Scientists use the analogy of reconstructing a complete strand of fragment DNA to writing a book from a bowl of alphabet soup. In *Jurassic Park*, the scientists filled in the missing dinosaur DNA gaps with frog DNA, but that would be like writing a book with a combination of English and Chinese words. While research on fossilized DNA is valuable for studying the history and evolution of insects and other animals, it may never lead to a theme park with real dinosaurs.

A leading current topic that blurs the line between science and science fiction and is well documented in film is cloning. Ever since the sheep in Scotland was cloned in 1997, the world has been debating it as a breakthrough that converts science fiction to science fact. But the reality of cloning is not quite what had been imagined in film. Films such as *The Boys from Brazil* and *Multiplicity* seem to imply that cloning creates an exact carbon copy of an individual's body and mind. Science contradicts that image. Cloning merely produces a newly born genetic duplicate, like a twin, with as much potential for genetic change from the environment as any other sibling does.

Cloning is an ideal area for student investigation. Students know the nuts and bolts of the process of cloning, having studied cell division (mitosis) and genetic engineering in biology. Once the "science" is under their belt, they can then begin to develop views on the ambiguous social and ethical implications of this concept. Students would be shown clips of a variety of cloning-related science fiction films to see how clones are portrayed in film and then asked to distinguish fact from fantasy. They would then be challenged to identify the implications to the process of cloning and how the future could be molded by it.

One of the big challenges in tackling cloning in a classroom, especially though the lens of popular science fiction films, is distinguishing the role of cloning in *reproduction* vs. *therapy*. Scientists generally agree that there is tremendous, untapped potential in the therapeutic consequences of cloning. It is not out of the realm of possibility for today's students to one day donate blood cells that would be utilized to "clone" a new liver to replace a diseased one. The therapeutic implications of cloning and genetic engineering are encouraging and require the vision of current scientists as well as interest of students that could end up in the field.

But this aspect of cloning is not as frequently represented in film as the reproductive role. Most films that address the process of cloning do so at the organism level, producing complete individuals. The reproductive role of cloning comes in two forms: 1) the idea of "designer babies," choosing desirable traits in offspring, and 2) identical functional individuals. But as we look to the actual science of the reproductive role of cloning, we do not see the interest and potential that we see in the therapeutic realm. It is absolutely essential for students to understand why there is not an emphasis on this aspect of the field, namely the ethical implications of manipulating our understanding of genetics on the organism level. As these issues are regulated more and more, our students may ultimately be asked to cast their vote on these possibilities, not as a scientific expert but as a functioning member of a political society. Having an opinion well grounded in the balance between the reality and the possibility of this line of research will allow them to play an important role as an informed member of society.

So, what will the student do? After watching these films, they will be given a variety of activities that allow them to research and develop opinions about these topics. Some activities will be open-ended. Students will be asked to find their own example of a film that blends science and fiction and research the "hard" science facts that the story is rooted in, identify the likelihood of fiction becoming fact, and investigate the actual sources of the science in their chosen film (i.e. asking where did the author/screenwriter get their scientific information?). Students may also be responsible for generating a list of specific science topics within their chosen films that are accurately portrayed and those topics that are erroneous. Students may be asked to generate a list of all the helpful inventions that were initially described in science fiction film and literature. Another important activity will come in the form of debate. Student will be shown a film like *GATTACA* and asked to choose sides on an issue, in this case, genetic manipulation or

"designer babies." Students will then be required to gather facts and develop opinions to support their position. Ultimately, the students will participate in a formal debate on the topic with a follow up activity that asks them to script their own perspective on the issue. Students could also be asked to identify a particular problem that is important in our society today and develop a "science fiction" plot that focuses on that problem. Students would be asked to write a short science fiction story that is relevant to a science topic that they had discussed in class. Some specific student activities are outlined below.

LESSON PLANS

Lorenzo's Oil

Loosely based on a true story, *Lorenzo's Oil* is a film about a set of parents whose bright little boy inexplicably develops alarming behavioral problems. A series of investigation results in a diagnosis of adrenoleukodystrophy (ALD), but the boy rapidly deteriorates into a bed-ridden, inarticulate state. Frustrated by the medical profession's inability to help, the parents embark on a search for salvation, studying lipid metabolism, promoting international conferences and trying to disseminate their findings to other parents. Their insights lead them to experiment with several effective therapies including erucic acid (Lorenzo's oil). The film also tackles a mother's guilt as well as grief, when she understands that the X-linked disease is passed from mother to son.

The disease portrayed in the film, ALD, includes symptoms including dementia, loss of sight, hearing, speech and ambulation and is believed to be due to solubilization and removal of the myelin sheath around neurons by a buildup of very long chain, saturated fatty acids in the body. Without a myelin sheath, nerve cells do not conduct action potentials. Onset of symptoms usually begins between age 5 to 12; death occurs within a couple of years.

I like to show *Lorenzo's Oil* in the first six weeks of school. The film is an excellent way to enrich the relatively dry scientific principles of biochemistry, molecular structure and the functions of cellular organelles and enzymes. It also has some excellent tie-ins to genetic concepts (sex-linked inheritance) that will be tackled later in the semester. It also begins the process of developing the ability to articulate fact from fiction that will be developed throughout the year.

I give students a variety of questions to answer before and after they have watched the film. I begin with very concrete type questions and transition into some of the ethical issues over time. Several examples follow:

Film Guide for Lorenzo's Oil
Read the following questions before watching the movie. Answer them on another sheet of paper.

1) Diagram a fatty acid.
2) What is the function of enzymes?
3) Diagram a normal neuron.
4) What is a sex-linked disorder? How is it passed on?

After watching the movie:

1) How do Lorenzo's enzymes fail him?
2) From the description of the disease, ALD, sketch what Lorenzo's neurons most likely looked like after a year.
3) What was Augusto Odone's plumbing example used to explain? How do analogies often help us to understand a scientific problem?
4) How did Augusto use modeling (paper clips) to solve a scientific problem? Can you think of other "great discoveries" that employed models?
5) As you reflect on this movie, how did the Odone family use the scientific method? Start with the problem statement and use examples from the movie to illustrate the steps.
6) Why did the encounter resistance from the medical community and from the support organization? What did you learn from observing this behavior?
7) ALD is a recessive, sex-linked or X-linked disease. If this is a partial family tree for the Odone's, what are the probable genotypes of the family members listed? (Remember: XX = female; XY = male; XA = normal neurons; Xa = ALD)
   A) Aunt #1 B) Aunt #2 C) Aunt Dee D) Michaela E) Augusto F) Lorenzo
8) Diagram a Punnett square to show how Lorenzo inherited ALD from his mother.

There are some excellent ethical questions raised by this movie as well. Below are a couple of ethical questions that could stimulate student discussion and debate:

1) In the movie, physicians are not portrayed in a good light. Is this called "artistic license" to make you cheer for the Odones? What were the objections of the physicians and the reasons for their objections? Were they reasonable? Was it appropriate for the Odones to use themselves as "guinea pigs"? Could this have done more harm than good?
2) Is it appropriate for medical researchers to take the kind of chances with their patients that the Odones took with Lorenzo? Lorenzo's Oil is not without side effects, what medical problems could it produce?
3) Is it acceptable that we may never know the efficacy of Lorenzo's oil since Moser's study does not have a control group?
4) What methods did the Odones use to stimulate research?
5) What do you think about drug companies that refuse to study diseases like ALD? Should government develop new regulations that state that a percentage of profits be used to develop drugs for these types of diseases that only affect a few patients?

GATTACA

During the genetics unit in my Advanced Placement biology course, I will introduce my students to the film *GATTACA*. While watching the film, students will be required to pay close attention to the specific details of the film. They will be given a worksheet to complete once the film has been viewed. The worksheet will include questions like the following:

Read the following questions *before* you watch the movie *GATTACA*, then answer them on this sheet of paper once you have seen the movie. You may take notes on a separate sheet of paper during the movie. If you need help answering the questions, you might try the following website.

http://www.spe.sony.com/Pictures/SonyMovies/movies/Gattaca/home.html (Sony Pictures *GATTACA* movie home page)

1) Compare the genetic traits of Vincent and Anton.
2) What does the character "German" do for a living?
3) What is an "in-valid"?
4) List 3 ways that the society portrayed in the movie routinely "reads" a person's genetic profile.
5) What two major surgeries did Vincent have to enhance his genetic "imperfections?"
6) List three things Vincent did on a daily basis to maintain his "Jerome" identity.
7) Who is murdered in this film? Why?
8) What evidence pointed towards an "in-valid" as the murderer?
9) Describe the different attitudes Vincent and Irene have toward their imperfections.
10) What ultimately happened to Anton? Why?
11) If Anton was genetically superior to Vincent, why was their ultimate fate so different?
12) What is the relationship between Vincent and his brother? How is it ultimately resolved?
13) What is the significance of the word "Gattaca"?

Students could also be asked to read the article "Gene Readers" from the Nov. 1998 *Popular Science Magazine* and discuss the following: Describe the gene reading chips and how they work. There are a multitude of current periodical resources that could be used for enrichment by the students. Rather than list too many examples here, I encourage teachers to utilize the most relevant and up-to-date information.

Students will then be taken to the computer lab to interact with the *GATTACA* website to do the "Design a Baby" simulation described below.

In order to complete this activity, you will have to work with a partner to simulate a couple interested in having a child. Your partner does not necessarily have to be of the opposite sex, but you must keep in mind that all decisions made in this activity must be agreed upon by both individuals in the "couple." As you work, keep a log of the places

where you had differences of opinion and how you were able to resolve them. Some of the issues faced in this activity ask for some very personal information and opinions about potentially sensitive information. If students feel uncomfortable with any of the questions, they may choose to omit them.

Begin by logging on to the *GATTACA* website:

http://www.spe.sony.com/Pictures/SonyMovies/movies/Gattaca/home.html

Click on "Design a Child," where you are faced with the "Big Question"… "Do you wish to tamper with nature in anyway, or would you rather leave your offspring to chance?" Choose from either "YES, I want to design my own child" or "NO, I want to role the genetic dice." Follow the instructions given. Remember all decisions must be made mutually by both members of the "couple." Keep a log of all your choices along the way and note any interesting discussions.

Students will be asked for a genetic history of each parent, including questions about their physical makeup, IQ, athletic ability and sexual orientation. They will then be given a long checklist of inheritable diseases and asked if they are present in their family history. Students should be encouraged to answer honestly and to the best of their ability. Students are then asked about the presence of other inherited traits that occur in their family history including things like obesity, baldness, learning disorders, addictive susceptibilities, personality traits, intelligence and longevity.

Along the way students are asked if they would like to clone a child from one of the parents. This should also be a point of discussion for the members of the "couple." Students should delve into the ethical issues and dilemmas associated with cloning. Also, along the way, students are asked if they want to reconsider their choices, which should also spearhead discussion between the members of the "couple."

If the students elect to genetically engineer their child, they will eventually be given three genetic engineering options: 1) clone, 2) disease free child (which allows them to eradicate all inheritable diseases but not other undesirable traits, or 3) health and enhancement (which allows them to eliminate inheritable diseases and select desired traits including gender, physical characteristics, intelligence, physical prowess, musical/math/artistic ability and sexual orientation).

As the "couples" become more daring with their options, they are told along the way that undesirable traits can be eliminated for a "modest investment." This also brings up another important ethical issue: how much are you willing to pay for these services. Should they be available to everyone? How much would students be willing to pay? Encourage them to address these issues in their log. Again, students should be reminded that all decisions must be a consensus between both "parents."

For students that choose not to roll the genetic dice, they will also fill out genetic profiles and are given a list of traits (good and bad) that the child could potentially inherit.

Another activity associated with the *GATTACA* website is the Gen-ethics Discussion page. Students are asked to vote their opinions on three separate genetics issues and then able to see how they fare compared to others on each of these issues. They are then linked to a discussion site for each question. The questions include:

Topic 1: Your two-month-old baby is about to be taken off of life support. You and your partner can no longer bear children. Would you clone the child if it were an option?

Topic 2: Do you consider rejecting an 8-cell embryo to be an abortion?

Topic 3: You are an employer and know from genetic testing that the most qualified applicant for the job has a 70% chance of developing multiple sclerosis in one years time. Would you hire this person?

Students can log their votes and compare their perspectives with others. Students should be given time to research their particular stance for each of these questions and come prepared to participate in classroom debate. Tackling these ethical questions is an excellent opportunity to give students the details of a decision making model to approach these difficult issues. Students are encouraged to use a four step approach to making decisions: 1) Gather information – collect resources on both sides of the issue; 2) Consider Values – students should try to factor in as many values that could be potentially impacted in each issue, including economic and moral values; 3) Explore Consequences – students should develop a chart that defines the short term positive and negative consequences as well as the long term positive and negative consequences; 4) Make a Decision – this decision making model is one that they can use to tackle a variety of ethical dilemmas.

Independent Study Project

Once the students have developed the ability to watch science fiction films critically and discern accurate from fictitious information, they should be able to utilize those skills in an independent project. Below is a brief outline of the components of this student activity.

Students should begin by choosing a film of particular interest to them. In the filmography, there is a list of possible films that students might choose. They are certainly not limited to this list, but at least it offers some potential selections. Almost certainly, a student will pick a film with which they are familiar with, but it is essential that they take the time to watch the film in its entirety, with the specific purpose of focusing on how scientific principles are portrayed in the film.

Once they have chosen a film, they should begin by gathering the concrete details about it. When was it produced? Who was the director, cast, etc.? The student should also create a brief synopsis of the plot line of the film. The student should also try to identify the scientific background or motivation of the author. I require my students to develop a worksheet of questions about the film utilizing a variety of levels of questions that could potentially be given to other students. Their worksheet should include some simple concrete recall questions as well as probing ethical questions. Students should include a mix of factual, analytical, valuative and metaphysical questions in their worksheet. Make sure that students turn in the answers along with the questions.

Once the student has viewed the film, they should begin the process of identifying scientific principles portrayed in the film. Students should ultimately generate a list of clips in the movie that illustrate a particular scientific principle being manipulated. Using multiple and varied references should then identify whether those illustration are accurate or fictitious. It may be valuable to have the students cite their references. It is also useful to have the student tackle what is possibility that those current representations of fiction may one day become fact.

The student should be able to identify at least four or five clips within a movie and pinpoint fact from fiction. The student should ultimately turn in a well-organized assignment with the following information:

- Clip – Description of a clip from the film, including a brief description of the scene. It helps if the student includes some time frame indications for ease of identifying it to the reader.
- Fact – Description of the accurate factual scientific information portrayed in the clip.
- Fiction – Description of the violations of scientific accuracy in the clip.
- Possibilities – Addressing the likelihood that the fictitious events in the film could happen and when.

Upon completion of the activity, the student should turn in their synopsis of the film, their worksheet of questions that others would use to guide their screening of a film (and the answers to the questions!!) and their list of clips and their critical breakdown of fact vs. fiction.

One bonus of this activity is that after you have done this a couple of times, the teacher will develop an excellent database of science fiction movies and the scientific principles that they tackle. Many times students will identify films that depict a particular scientific principle that the teacher may not have been aware of and you have a built-in worksheet that allows the teacher to provoke thought as a new group of students watch the film.

ONE FINAL NOTE

One final note, while this curriculum unit focuses on the use of science fiction films in developing skills and enhancing concepts for science students, the role of non-fiction films can not be underplayed. The field of biology, and science in general, is a very abstract one. So much of the content that we convey to students is difficult to visualize and manipulate. Much of what drives the process of biology takes place at the microscopic level and few, if any, schools have the resources to allow students first-hand experiences at this level. Fortunately, through the media of film, many of these abstract, microscopic concepts can be easily portrayed and visualized by the students.
Gone are the old filmstrips with monotone narrators and childish cartoons. With the advent of powerful computers, cameras, microscopes and technology, today's science videos give access to many aspects of life never seen before. Anything done by the National Geographic is an excellent resource in the classroom. The PBS series NOVA has brought a variety of exceptional videos to science classrooms. Specifically, in the context of genetics, the *NOVA: Cracking the Code of Life* (2001) is an excellent juxtaposition to a science fiction film like GATTACA. In fact, in my classroom, I show these videos hand in hand to help students make the connection between fact and fiction. These non-fiction videos allow students to grasp the scientific concepts and principles initially which they then in turn can critically identify as accurate or erroneous in the science fiction films that they see in class or in their everyday life.

FILMOGRAPHY

The Boys from Brazil (1978) Twentieth Century Fox Film Corporation; Written by Ira Levin, Directed by Franklin J. Schafftner

> A young inexperienced Nazi Hunter stumbles onto a secret SS meeting in 1970's South America, led by the infamous Doctor Josef Mengele. Veteran Nazi hunter Lieberman first dismisses the plot of the Nazis as unimportant. When the young Nazi hunter turns up murdered, however, Lieberman investigates the mysterious meeting and discovers an insane plot to resurrect the Führer Adolf Hitler and establish the Fourth Reich.

Future Fantastic, Vol. I (1998) Twentieth Century Fox Home

> This video is a series co-produced by the BBC and The Learning Channel which tackles a variety of topics at the "intersection of science and science fiction" utilizing movie clips, science fiction authors and "traditional" scientist's perspectives.

GATTACA (1997) Sony Pictures; Written and Directed by Andrew Niccols

> *GATTACA* describes a near future in which genetic engineering determines one's state in life. In the film, Vincent Freeman (Ethan Hawke), who is genetically imperfect ("In-Valid") because he was conceived in the "natural" way, is willing to go to great lengths to satisfy his childhood dream of becoming an astronaut. Such a high-status assignment is reserved for perfect genetic specimens, and Vincent works out an arrangement to assume the identity of Jerome (Jude Law), a former star swimmer confined to a wheelchair after an accident. The film follows the complex ways in which Vincent assumes Jerome's identity, passing security checks at *GATTACA*, the corporation planning a flight to Titan, by carefully switching the latter's nail cuttings, fingerprints, hairs and blood and urine samples. Tension mounts after a murder of a *GATTACA* official just a few days before the planned space launch, and Vincent becomes a prime suspect of Detective Hugo (Alan Arkin).

Jurassic Park (1993) Universal Pictures; Written by Michael Crighton, Directed by Steven Spielburg

> Scientists develop a means of bringing dinosaurs to life using DNA taken from dinosaur blood, which has been preserved inside insects encased in amber. Whilst Hammond is showing off his dinosaur 'theme park' to a selected audience [a lawyer (Gerrano), mathematician (Malcolm), dino' expert (Grant), palaeobotanist (Sattler) and his grandchildren (Tim & Lex)], Nedry (computer expert) disables the security system so that he can make his escape with some stolen embryos,

which enables all the dinosaurs to escape their enclosures. It is left to the people on the island to contain the dinosaurs.

Multiplicity (1996) Columbia Pictures, Writer: Chris Miller III, Director: Harold Ramis

This comedy is about a construction worker Doug Kinney (Keaton) who finds that the pressures of his working life, combined with his duties to his wife Laura (MacDowell) and daughter Jennifer (Schlossberg) leave him with little time for himself. However, he is approached by geneticist Dr. Owen Leeds (Yulin) who offers him a rather unusual solution to his problems - cloning.

Nova: Cracking the Code of Life (2001) WGBH Boston Video

This non-fiction video offers an account of the development of the Human Genome Project. It investigates the complex implication of this project and the incredible impact that its discoveries will have in the future. It is an excellent juxtaposition of fact vs. several of the science fiction films included in this unit.

The following is a list of films that might be useful to students in analyzing a science fiction film independently:

20,000 Leagues Under the Sea (1954)
2001: A Space Odyssey (1968)
Alien (1979)
Aliens (1986)
Babylon 5: In the Beginning (1998)
Back to the Future (1985)
Batman Beyond: Return of the Joker (2000)
Blade Runner (1982)
Brazil (1985)
Clockwork Orange, A (1971)
Close Encounters of the Third Kind (1977)
Contact (1997)
Dark City (1998)
Dawn of the Dead (1978)
Day the Earth Stood Still, The (1951)
Delicatessen (1991)
Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb (1964)
E.T. the Extra-Terrestrial (1982)
Fantastic Voyage (1966)
Farscape (1999)
Forbidden Planet (1956)
Iron Giant, The (1999)
Matrix, The (1999)
Metropolis (1927)
Pi (1998)
Planet of the Apes (1968)
Quantum Leap: Genesis (1989)
Silent Running (1972)
Solyaris (1972)
Star Wars (1977)
Star Wars: The Empire Strikes Back (1980)
Star Wars: Return of the Jedi (1983)
T2 3-D: Battle Across Time (1996)
Terminator 2: Judgment Day (1991)
Terminator, The (1984)
The Andromeda Strain (1970)
The Day of the Dolphin (1973)
The Fly (1958)
Them! (1954)
Thing, The (1982)
Troops (1998)
Truman Show, The (1998)
Twelve Monkeys (1995)

Frequency (2000)
Hangar 18 (1980)
Invasion of the Body Snatchers (1956)
When Worlds Collide (1951)
X-Files, The
X-Men (2000)

ANNOTATED BIBLIOGRAPHY

Teacher Sources

Advanced Placement Biology Course Description, College Entrance Examination Board, 2001.

This pamphlet offers a brief summary of the Advanced Placement program and identifies topics, concepts and themes used in AP Biology. Of specific interest are the major themes or unifying constructs in biology, which can be enhanced by some aspects of this curriculum unit.

Brosnan, John. *The Primal Screen: A History of Science Fiction Film*. Little Brown & Co, 1995.

Brosnan discusses the history of science fiction film from silent forerunners to the more recent films. This work is divided by periods and themes. Brosnan readily admits that, although he is a great science fiction fan, he is annoyed by scientific inaccuracies. Brosnan covers many themes such as effects of technology, war, alien, invasion, dystopia, and space exploration.

Davis, Dena S. *Genetic Dilemmas: Reproductive Technology, Parental Choices and Children's Futures*. Routledge Publishers, New York, 2001.

This very current book of genetic dilemmas is an excellent resource in preparation for any ethical discussions that may take place. The author tackles many interesting genetic ethical issues including genetic counseling and testing, sex selection and cloning.

DeSalle, Rob and Lindley, David. *The Science of Jurassic Park and the Lost World; or How to Build a Dinosaur*, Harper Collins. 1997.

This book is good light reading about whether or not modern scientists could use cutting-edge laboratory techniques really clone dinosaurs and populate a true-to-life *Jurassic Park*. It explores the place where science fiction of today approaches the hard science of tomorrow. This book also includes fascinating facts, factoids and movie bloopers.

Dubeck, Leroy and Moshier, Suzanne and Boss, Judith. *Science in Cinema: Teaching Science Fact Through Science Fiction Film*. Teachers College Press 1988.

This teacher friendly book has several good examples of teaching the nuts and bolts of science using science fiction movies. It takes 10 science fiction films and offers a variety of useful information including credits of the film, plot summaries, scientific principles related to the film, classroom activities and scientific and literary commentary. It also has a plot summary and scientific summary of 24 other films. Perhaps most valuable is the Index which lists a variety of specific topics in science referenced with films that portray that topic. This is an excellent tool for students, especially when working independently to critique a science fiction film. The book is a bit dated, published in 1988, so it does not reflect many of the recent advances in science but it does have good activities.

Goldsmith, Maurice, *The Science Critic: A Critical Analysis of the Popular Presentation of Science*, Routledge and Kegan Paul Ltd, London, 1986.

This book focuses on the various media of conveying scientific information and the accuracy of each. It includes valuable historical information of the development of science in film. Of special interest is the chapter entitled "Science Fiction: Truth and Reality" which tackles questions like "does science fiction influence science?" and "what impact has science fiction had on popular understanding of science?"

Hardy, Phil, ed. *The Overlook Film Encyclopedia: Science Fiction*. Woodstock NY: The Overlook Press, 1994.

This reference covers a multitude of films dealing with science fiction, complete with plot synopses, credits, statistical information, trivia, and many photographs which capture the essence of this genre. Entries are arranged chronologically throughout the volume and alphabetically within each year. Unless otherwise indicated, all films are in color and made in the USA. It is a good introductory source to a variety of movies that the students could potentially use in independent analysis of science fiction films.

Hoffmaster, Barry, ed. *Bioethics in Social Context*. Temple University Press, 2001.

This collection of essays on bioethics is especially useful because of its ties to society. Of special interest is the chapter titled "Media Images, Genetics and Culture: Potential Impacts of Reporting Scientific Findings on Bioethics." While it does not specifically mention science fiction, it does tackle how the media is influencing society's opinion on genetics.

Is Research on Human Cloning OK? Los Angeles Times, March 11, 1997, p.2.

Written around the time when Dolly, the first cloned mammal, was born, this article asks the tough questions about not just how cloning works but if it should be done at all.

Mangireri, J. N and Collins Block, C. *Creating Powerful Thinking in Teachers and Students: Diverse Perspectives*, Harcourt Brace College Publishers: Orlando, Florida, 1994.

This book offers teachers strategies to improve thinking and professional competency. It also contains detailed methods of developing student's cognitive abilities and higher level thinking skills. These are the skills that are the goal of this curriculum unit. It also includes a chapter on targeting high-risk students with some excellent suggestions and activities.

National Research Council Inquiry and the National Science Education Standards: A Guide for Teaching and Learning, National Academy Press: Washington DC 2000.

One of the prominent features of the National Science Education Standards published in December 1995 is a focus on inquiry. This book helps define inquiry and defines teaching and learning strategies that enable scientific concepts to be mastered. It defines the various skill sets that students need to develop the skill of inquiry and offers many suggestions about specific approaches for development of this essential scientific ability.

Newton, Douglas P. *Making Science Education Relevant*, Kogan Page Books, London, 1988.

This book tackles the difficult task of making science relevant to our students, which ultimately contributes to their preparation as scientists and members of society. Of special interest is the chapter entitled " Doing More with Secondary School Science" which details supplementing and integrating the secondary school science curriculum to achieve wider aims, which includes using humanizing materials, of which film is certainly an effective example.

Nichols, Peter. Entry on "Cinema" in *The Encyclopedia of Science Fiction*. New York: St. Martin's Griffin, 1993.

This prolific reference book contains detailed information about science fiction authors. It breaks the literature down into different categories making it user friendly. There is an excellent glossary of science fiction terms.

Pohl, Frederik and Frederik Pohl IV. *Science Fiction Studies in Film*. NY: Ace Books, 1981.

This work discusses the history and evolution of science fiction films. Science fiction authors write entries for individual films and critics are scattered throughout the text and filmographies listing date, producer, and cast accompany discussions of each film.

Rielly, Philip. *Abraham Lincoln's DNA and Other Adventures in Genetics*. Cold Spring Harbor Laboratory Press, 2000.

This easy to read book uses 24 stories to educate the reader about genetics. Each chapter focuses on different roles of genetics in today's world, including the ethical issues that surround the recent advancements in genetics.

Sandison, Alan (Editor) and Dingley, Robert (Editor). *Histories of the Future: Studies in Fact, Fantasy and Science Fiction*. Palgrave, 2000.

This book is another excellent reference on the history and development of science fiction. Of particular interest is a chapter titled "A New World Made to Order: Making Sense of the Future in a Global Era" which tackles the implications of recent advances in science and how it is mirrored in science fiction.

Skal, David. *Screams of Reason: Mad Science in Modern Culture*. W.W. Norton and Company, 1998.

This is a remarkably detailed survey of the mad scientist, which has been a central figure in science fiction from its beginnings. This book looks at the evolution of how scientists are portrayed in film and comics. The author examines the parallels between science fiction and daily life with many useful examples.

Stocker, Jack. *Chemistry and Science Fiction*. American Chemical Society, 1998.

This book looks at the science of chemistry as filtered through literature, film, and television. It discusses classic works in science fiction and provides an in-depth look at the chemistry depicted in popular culture, particularly in *Star Trek*, *Star Wars*, and *Doctor Who*. The book also includes suggestions for using science fiction as an educational resource. This book would be especially useful for teachers adapting these activities for a chemistry classroom.

Student Resources

DeSalle, Rob and Lindley, David. *The Science of Jurassic Park and the Lost World; or How to Build a Dinosaur*, Harper Collins. 1997.

Dubeck, Leroy and Moshier, Suzanne and Boss, Judith. *Science in Cinema: Teaching Science Fact Through Science Fiction Film*. Teachers College Press 1988.

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Pohl, Frederik and Frederik Pohl IV. *Science Fiction Studies in Film*. NY: Ace Books, 1981.

Rielly, Philip. *Abraham Lincoln's DNA and Other Adventures in Genetics*. Cold Spring Harbor Laboratory Press, 2000.

Web Resources

http://us.imdb.com
Internet Movie Data Base
This website is an excellent database of information on movies. It serves as an excellent place to start when researching movies.

http://www.spe.sony.com/Pictures/SonyMovies/movies/GATTACA/
GATTACA Movie Home Page
This website, run by Sony Pictures in conjunction with the release of the movie, *GATTACA*, has several interactive sites which include a "Design a Baby" activity and a Genetics/Ethics discussion activity.

http://www.bigwaste.com/library/jurassicflubs/part1.shtml
Jurassic Park Flubs
This website contains a list of "flubs" or errors in the movie *Jurassic Park*.

http://scifimovies.about.com/movies/scifimovies/library.htm
Science Fiction Movie Library
This website offers a variety of articles and commentary about science fiction movies.

http://www.ucmp.berkley.edu/diapsids/bus/popular.html
Dinobuzz
This website, called Dinobuzz, Current Topics Concerning Dinosaurs, addresses the reality of science in a variety of scenes in *Jurassic Park*.

http://www.tea.state.tx.us/teks/
Texas Education Agency: Texas Essential Knowledge and Skills (TEKS)

This website lists the Texas Essential Knowledge and Skills (TEKS) which are the learning standards for public education in Texas. Of special interest is the science TEKS, more specifically those associated with critical thinking skills and scientific problem solving which is developed in this curriculum unit.

http://ethics.acusd.edu/
Ethics Updates

This website/search engine provides updates on current literature that relates to ethics. It is an excellent source for the latest, up-to-date research and discussion on a variety of ethical topics, but specifically useful for the multitude of bioethical issues including genetics and cloning.

http://carbon.cudenver.edu/~bstith/loreb.htm
The Use of the Movie "Lorenzo's Oil" as a Teaching Tool

This excellent website includes detailed information about the movie *Lorenzo's Oil*, the disease ALD, and a variety of excellent activities to use in the classroom.