Science Stories:

Using Case Studies to Teach Critical Thinking

Clyde Freeman Herreid
Nancy A. Schiller
Ky F. Herreid

NSTA press
National Science Teachers Association

Science Stories:

Using Case Studies to Teach Critical Thinking

Science Stories:

Using Case Studies to Teach Critical Thinking

Clyde Freeman Herreid
Nancy A. Schiller
Ky F. Herreid

NSTA press
National Science Teachers Association

Arlington, Virginia

NSTA press®
National Science Teachers Association

Claire Reinburg, Director
Jennifer Horak, Managing Editor
Andrew Cooke, Senior Editor
Wendy Rubin, Associate Editor
Agnes Bannigan, Associate Editor
Amy America, Book Acquisitions Coordinator

Art and Design
Will Thomas Jr., Director

Printing and Production
Catherine Lorrain, Director
Jack Parker, Electronic Prepress Technician

National Science Teachers Association
Francis Q. Eberle, PhD, Executive Director
David Beacom, Publisher
1840 Wilson Blvd., Arlington, VA 22201
www.nsta.org/store
For customer service inquiries, please call 800-277-5300.

14 13 12 11 4 3 2 1

Library of Congress Cataloging-in-Publication Data
Herreid, Clyde Freeman.

Science stories : using case studies to teach critical thinking / by Clyde Freeman Herreid, Nancy A. Schiller, and Ky F. Herreid.
p. cm.
Includes bibliographical references and index.
ISBN 978-1-936137-25-1
1. Science--Study and teaching--Case studies. 2. Critical thinking--Study and teaching. I. Schiller, Nancy A., 1957- II. Herreid, Ky F., 1965- III. Title.
Q181.H394 2011
507.1--dc23
2011036547

eISBN 978-1-936959-91-4

Contents

Contents

Introduction

Clyde Freeman Herreid

Critical thinking is like Mark Twain's quip about the weather—everybody talks about it, but nobody does anything about it.

Teachers are fascinated by facts, esoteric minutiae that beguile, tantalize, and titillate their fancies. They spend their time in the classroom trying to convince students to appreciate the same ideas. Yet when you ask teachers what they prize most, they will say critical thinking. They claim they want this most of all in their students—the ability to reason (Yuretich 2004). But teachers love their Krebs cycle, Henderson-Hasselbalch equations, tooth formulae, digestive enzymes, hormones, bones, and scientific nomenclature too much to give them up. Nor would I want them to. But let's face the facts: They are not teaching critical thinking.

Most teachers cannot define critical thinking. To take only one example, in 1995, the California Commission on Teacher Credentialing and the Center for Critical Thinking at Sonoma State University initiated a study of college and university faculty throughout California to assess current teaching practices (Paul, Elder, and Bartell 1997). Of the faculty surveyed, 89% said critical thinking was a primary objective in their courses, but only 19% were able to explain what critical thinking is and only 9% were teaching critical thinking in any apparent way. Furthermore, 81% of the faculty believed that graduates from their departments acquired critical-thinking skills during their studies, but only 9% could articulate how they would determine if a colleague's course actually encouraged critical thinking.

Experts do not really agree on a precise definition of critical thinking. But I like Moore and Parker's (2004) approach that critical thinking is the careful, deliberate determination of whether one should accept, reject, or suspend judgment about a claim and one's degree of confidence about one's position. So, critical thinking involves evaluating evidence and examining relevant criteria for making a judgment. It involves logic and clarity, credibility, accuracy, precision, relevance, depth, breadth, significance, and fairness in dealing with an argument. These are the topics of textbooks on critical thinking. Major emphasis is placed on informal logic (often said to be equivalent to critical thinking). Informal logic deals with analyzing and evaluating arguments and addresses how to avoid many of the major mistakes that humans can make. These qualities are said to constitute critical thinking.

To varying degrees, all of these qualities are desirable for anyone, not just scientists. But can they be taught, and how best to do so? We make the argument in this book that such habits of mind can be taught, and case studies are one avenue to achieve this end. In the chapter "The 'Case' for Critical Thinking," David R. Terry brings the critical thinking literature to bear on this issue.

Another approach to critical thinking is seen in Bloom's 1956 taxonomy of "learning domains" in approaching problems. The cognitive domain is especially relevant. Bloom and his team ranked learning in a hierarchy, starting with simple knowledge at the bottom, then comprehension, application, analysis, synthesis, and evaluation at the top of a pyramid. Bloom's original domain arrangement is shown on the pyramid in Figure 1. Anderson et al. (2001) revisited the categorization and produced the arrangement on the right in Figure 1. The differences are small. The new version has translated the original terms into action verbs and switched the order of the top two domains.

Where does critical thinking fit into these schemes? For our purposes, critical thinking corresponds to the learning categories on the upper part of both diagrams. In contrast, in traditional science courses taught by the lecture method, the focus is on the lower part of the pyramids. Students are asked to remember facts, terms, and concepts—hardly critical-thinking exercises. In contrast, the upper part of the pyramid—which deals with application, analysis, synthesis, and evaluation—fits squarely in the critical-thinking camp. So the first goal of this book is to provide a way for teachers to enhance student skills in these areas. But as cognitive scientist Daniel Willingham (2009) points out, critical thinking cannot be taught with abstract exercises. It must be taught in the context of a discipline. Critical thinking in art, music, English literature, or history is not the same as it is in natural science.

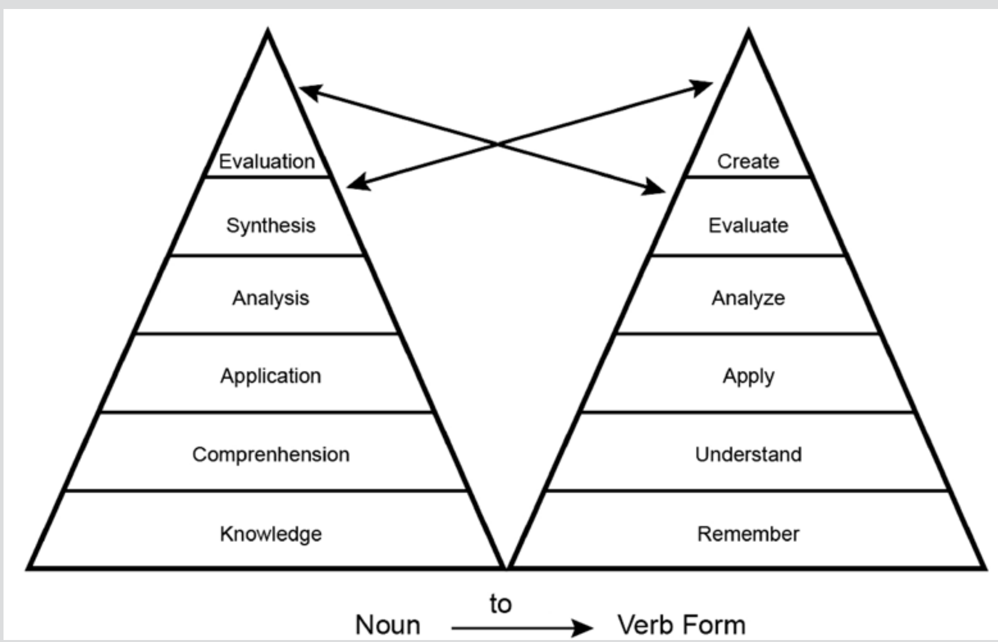
What, if any, are the unique features of critical thinking in science, and how do case studies help teach these skills? I argue that it boils down to that hoary chestnut, the scientific method. Recall the steps of the classic scientific method (sometimes called the hypothetico-deductive method): We ask a question, propose a hypothesis to answer the question, devise a test or experiment to test the hypothesis, collect the data from the test, and reach a conclusion. With repeated iterations of the process, the question is solved and science marches on. In Kathy Galluci's chapter "Learning About the Nature of Science With Case Studies," she examines the nuances of the method in detail. You will notice that much of this process is not special. People ask questions and make guesses all the time. But few of us ever do much testing and retesting to see if the data we collect are consistent with our hypotheses. This single feature is the essence of the scientific enterprise and the essence of critical thinking in science. Yes, science is a collection of facts and principles about the physical world, but what is essential to us is that it is a *way of knowing*.

Consequently, if we want to teach students about science, we need to do two things: Give them science content, and teach them the critical-thinking skills that scientists use. We need our students to have a good grounding in science content so they will be able to ask intelligent and relevant questions, suggest hypotheses, and know how to interpret data to reach reasonable conclusions that are consistent with what we already know. But if we are to teach our students about how scientists really go about their business, we need to help them learn about experimental design. We must look closely at the third step in the scientific method.

In short, we want them to know about controlled and uncontrolled experiments, the importance of replicability, the fact that correlation is not the same as cause and effect, falsification, prospective versus retrospective tests, the differences between historical and experimental science, blind and double-blind tests, the placebo effect, human error, fraud, and wishful thinking, as well as how the peer-review process helps identify and prevent flaws and mistakes. So throughout this book, there is an emphasis on experimental design—in fact, it is the dominant theme. If we can get students to be respectful skeptics—the major emphasis of my chapter "Can Case Studies Be Used to Teach Critical Thinking?"—we have gone a long way toward achieving our goal of developing scientifically literate citizens.

Figure 1. Cognitive Domains

Bloom's Original Model (1956) **Anderson et al. Model (2001)**



Source: L. O. Wilson, Ed.D., Professor Emerita, School of Education, University of Wisconsin-Stevens Point. *http://www4.uwsp.edu/education/lwilson/curric/newtaxonomy.htm*. Used with permission, 2011.

Introduction

The Case Study Approach

There is a price to pay for our typical approach in science, technology, engineering, and math (STEM) education, and for our devotion to facts, the lecture method, and multiple-choice tests. Let's mention the obvious: We lose large numbers of excellent students who choose to major in other fields. Sheila Tobias (1990, 1992) reported that our beloved lecture is the prime culprit. Science majors have a high tolerance for boring material that seems to have nothing to do with their lives—a kaleidoscope of facts without apparent rhyme or reason. These presumptive scientists have faith that these facts will eventually become relevant in time. Nonscientists have no such faith, and, without context, they decide to leave the game. They are not intrigued by the detailed structure of the atom or the cell. It is not that they do not think it is important; they simply do not see why it should be important to them. We have not shown them how the cavalcade of facts relates to global warming, the debate over creationism versus evolution, natural disasters, cancer, AIDS, sex, or anything else they might care about.

We certainly have not helped them understand the scientific process either. They leave our STEM classrooms filled with revealed truths, believing that is what science is all about—a grab bag of oh-my-gosh facts. They certainly do not have a clue about the long, hard struggle that is involved in digging out the answers to even minor questions. Jon Miller's (1988) pronouncement that only 5% of the American public is scientifically literate did not help the situation. To illustrate the point, he used as his example of American science illiteracy that few people know what DNA is or how the seasons of the year are produced. These might be important factoids, but it is hardly sufficient to gauge scientific literacy. Far more relevant is to have a public that can make intelligent decisions about issues such as oil spills, vaccinations, alternative medicines, health insurance, cloning, and energy. Facts are important, but critical thinking is essential too, and we are doing a poor job of teaching it.

Teaching with case studies can make a difference. Why? Because whatever else they may do, they put learning into context. Case studies tell stories, and people love stories. That's why we have novels, movies, reality shows, and bedtime stories. Stories entertain us, and the best of them leave us memories and scaffolding on which to hang our facts. Jesus told parables. Aesop told fables. Homer told heroic adventures, and the brothers Grimm told fairy tales. And these stories have been remembered for centuries.

This is a storybook of case studies that show critical thinking in action in science. We have chosen these particular cases because they emphasize how science is really done. Our aim is to put flesh and bones on the scientific method, but not the classic method that schoolchildren memorize and parrot back: observation, question, hypothesis, experiment, data collection, and conclusion. A moment's reflection will reveal that not all scientists proceed along these lines. Astronomers and paleontologists have difficulty doing experiments (they are historical scientists), but they do test their ideas against the data. Theoretical physicists do not run experiments themselves, as they work with pen and paper or computers. Yes, the hypothetico-deductive method (the "scientific method") is the *modus operandi* for the scientific enterprise for part of the process. But it is also much more than that.

Our overarching purpose is to show scientists in action—to show how they operate and the rules that they live by. The first chapter, "The Scientific Method Ain't What It Used to Be," as the title suggests, aims to correct the common misconception that many first-year science textbooks perpetuate—namely, that science proceeds by a linear series of steps. The chapter emphasizes how scientists interact with each other and society at large. We want students to recognize how the discoveries and failures of science can affect the general public. We want them to know how results can be manipulated, distorted, and reinterpreted by folks with different experiences and agendas. We deeply care about ethical concerns. We want scientists to keep their part of the bargain to follow the canons and traditions of the discipline. We want students to know how changing social mores can force a reinterpretation of what is ethical. We want them to learn how our technological *tours de force* have created new ethical dilemmas that future generations must solve. Case studies perhaps can do all of this better than most other ways of dealing with the material because they place the students in the position of making decisions about real-world problems; they put learning into context.

The cases in this book are drawn from our website for the National Center for Case Study Teaching in Science (*http://sciencecases.lib.buffalo.edu/cs*). In this book, we present each case and an abbreviated version of its teaching notes, including a section on misconceptions that the case addresses. These misconceptions, common among our students, reveal flaws in critical thinking. More complete teaching notes for the cases can be found on our website, along with answer keys where available. The book is designed for college and high school teachers (and may also be of interest to middle school science teachers), who can select case exercises for use in their classrooms. We expect that teachers who plan to use the cases will download the individual case PDFs from the website and distribute them to students in class rather than directing students to the website itself, where the teaching notes are displayed.

To help teachers choose cases for their classes, Appendix A provides summary information about each case; Appendix B shows how each case is aligned with the National Science Education Standards for grades 9–12; and Appendix C is a discussion of ways to evaluate student work.

To give students a real sense of how scientists go about their work, we first present four historical cases in section II. These cases involve real events and people, such as Ignaz Semmelweis, whose simple observation about hand-washing and mortality rates among women in a hospital maternity ward saved countless lives, and John Snow, another physician, who set out to discover the source of cholera in Victorian London. We also meet in this section Nobel Prize winners J. Robin Warren and Barry Marshall, who discovered that ulcers were caused by a bacterium that could be treated with antibiotics. There is also a case that explores the Salem witch trials that took place in Massachusetts in the late 1600s. What caused the hysteria? Could there be a scientific explanation for what happened? Students will attempt to find a plausible explanation for a mystery that remains unsolved.

Douglas Allchin (from the University of Minnesota) has written extensively on the subject of historical cases. His article "How *Not* to Teach Historical Cases in Science" is a valuable resource (Allchin 2000). He is also the co-author of *Doing Biology* (Hagen, Allchin, and Singer 1996), a set of 17 historical case studies, and he maintains a website devoted to historical problem-based cases (*http://ships.umn.edu*). It is important to note that his focus is on the historical features of the stories. In this book, we focus on the discovery process and how the elements of scientific methodology are highlighted by these cases.

Next, in section III, we present six cases of scientific inquiry. When most people think of a scientist, they think of someone in a lab cooking up experiments. A lot of scientists do just that. They pose questions, make hypotheses and predictions, think up ways to test them, collect the resulting data, and draw conclusions. The cases we have selected put students through many of these same steps, all in one or two class periods. In this section, you will find cases such as the one based on the true story of statistician Ronald Fisher, who designed an experiment to test a woman's claim that she could always tell if milk was added before or after her tea had been poured into the cup. Other case studies challenge students to re-create experiments probing such matters as a possible cause for Alzheimer's disease, preferential feeding behavior in coots, how PCBs wind up in remote Alaskan lakes, whether drivers really leave their parking spaces faster if others are waiting, and whether a traditional Native American remedy relieves the skin's allergic reaction to the toxin found in poison ivy.

In section IV, we examine six cases that verge on the edges of pseudoscience, claims that are not in the mainstream of science, claims of questionable validity. Of course, we know that many of the world's most important discoveries were initially met with skepticism. With repeated testing, some of these ideas were vindicated—but not all. As Carl Sagan reminds us, "The fact that some geniuses were laughed at does not imply that all who are laughed at are geniuses. They laughed at Columbus, they laughed at Fulton, and they laughed at the Wright Brothers. But they also laughed at Bozo the Clown" (Sagan 1980, p. 34). Certainly claims of extrasensory perception and the healing power of prayer, for example—just two of the topics explored in the cases collected here—require close and careful scrutiny.

In sections V and VI, we present cases that explore the effects of science on society and society on science and show some of the ways that the news media puts spin on the scientific process. We finish in section VII with some of the ethical dilemmas that confront scientific researchers. All along we try to present cases that examine real data even as we deal with the sociology of science.

Long after students have left the classroom and forgotten glycolysis, Avogadro's number, Fresnel's transmission coefficient, biostratigraphy, and the ideal gas law, they will need to read newspapers and blogs and listen to CNN, or the future equivalents. After college, for the next 60 years of their lives, they will be bombarded by problems infused with science. They need to be able to consider claims that will be made and ask the first and most important questions of a critical thinker: Is it true? Why should I believe this? What is the evidence? Is there counterevidence that should be considered? And then they will need to look carefully at the logic of the argument, identify *ad hominem* attacks when they occur, and consider the consequences of their (and others') actions. We hope this book helps them on the way.

References

Allchin, D. 2000. How not to teach historical cases in science. *Journal of College Science Teaching* 30 (1): 33–37.

Anderson, L. W. et al., eds. 2001. *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* Boston: Allyn & Bacon (Pearson Education Group).

Bloom B. S. 1956. *Taxonomy of educational objectives, handbook I: The cognitive domain.* New York: David McKay.

Bloom, B. S., and D. R. Krathwohl. 1956. *Taxonomy of educational objectives: The classification of educational goals, by a committee of college and university examiners. Handbook I: Cognitive domain.* New York: Longmans, Green.

Hagen, J. B., D. Allchin, and F. Singer. 1996. *Doing biology.* New York: HarperCollins College Publishers.

Miller, J. 1988. The five percent problem. *American Scientist* 72 (2): iv, 18.

Moore, B., and R. Parker. 2004. *Critical thinking.* New York: McGraw-Hill Co.

Paul, R. W., L. Elder, and T. Bartell. 1997. *California teacher preparation for instruction in critical thinking: Research findings and policy recommendations.* California Commission on Teacher Credentialing, Sacramento California, 1997. Dillon Beach, CA: Foundation for Critical Thinking.

Sagan, C. 1980. Broca's brain: Reflections on the romance of science. New York: Ballantine.

Tobias, S. 1990. *They're not dumb, they're different: Stalking the second tier.* Tucson, AZ: Research Corporation.

Tobias, S. 1992. *Revitalizing undergraduate science: Why some things work and most don't.* Tucson, AZ: Research Corporation.

Willingham, D. 2009. *Why don't students like school?* San Francisco, CA: Jossey-Bass & Sons.

Yuretich, R. F. 2004. Encouraging critical thinking: Measuring skills in large introductory science classes. *Journal of College Science Teaching* 33 (3): 40–46.

Chapter 36

Selecting the Perfect Baby: The Ethics of "Embryo Design"

Julia Omarzu

The Case

The research team assembled quietly in the lab. There were some difficult decisions to be made today. Kelly, a new research assistant, looked forward to the discussion. Privately, she hoped Dr. Wagner and the rest of the team would agree to help the couple that had appealed to them.

"Good morning, everyone," Dr. Wagner said to begin the meeting. "We have a lot to talk about. I'll summarize this case for those of you who may not have had time to read the file. Larry and June Shannon have been married six years. They have a four-year-old daughter named Sally who has been diagnosed with Fanconi's anemia. Sally was born without thumbs and with a hole in her heart. Shortly after her birth, she began suffering symptoms related to impaired kidney function and digestion that have only increased in severity. Fanconi's anemia is a progressive disease that often results in physical abnormalities and a compromised immune system. Sally needs a lot of special care and has already had several surgeries. She can't digest food normally or fight off infections as easily as a normal child would. If she doesn't receive a bone marrow transplant, she will develop leukemia and die, most likely within the next three to four years. Neither Larry nor June had any clue they were both carriers of this disease."

"A frightening diagnosis," said Kevin, a research technician.

"Difficult to live with, as well. Not only will they probably lose this child, they must be crushed about the possibility of having another child with this illness," commented Liz Schultz, the team's postdoctoral researcher in gynecology and fertility.

"Exactly their problem," continued Dr. Wagner. "The Shannons are interested in having another child and have approached us regarding pre-implantation genetic diagnosis (PGD). They are aware of the risks and the odds of success. They are anxious to begin the process as soon as possible."

"Kelly, you're new to the team, so let me summarize the PGD process for you. It's a three-step process, with chances of failure and complications at each step. First, in vitro fertilization (IVF) is performed. Some of June's ova would be removed and fertilized with Larry's sperm outside of June's womb. If this procedure works, we should have several viable, fertilized embryos. Our second step is to perform genetic analysis on the embryos, removing a cell from each and testing for the presence of the Fanconi's anemia genes. If we find embryos that are free of Fanconi's, we can then perform the third step, which would be implanting the healthy embryos back into June's uterus."

"Wait a minute," said Kelly. "How many embryos are we talking about? They just want one child, not a half dozen."

Dr. Wagner laughed. "Yes, I know. But during the in vitro fertilization and implantation processes, we almost always have embryos that do not survive. There is only about a 23% chance of any implanted embryo thriving. There is a better chance for a positive outcome when we remove and fertilize multiple ova. In this particular case, the odds of a multiple pregnancy are very small, given the limitations on the ova we will be able to implant."

"Okay, I know I don't understand all of this. But how can Mrs. Shannon produce that many eggs all at the same time?" asked Kelly. "She wouldn't normally do that, would she?"

"No," said Liz. "So before we even begin any of these procedures, June would have to take hormones to increase the number of ova she releases. As Dr. Wagner said, there are risks involved with every step of this procedure. Hormone therapy can have some side effects, including mood and cognitive effects. Some women suffer physical complications as well, although this is relatively rare. There are some studies that link hormone therapy to increased risks of ovarian cancer, although there is other research that contradicts that."

"Plus," Dr. Wagner added, "along with the risks to June, there is no guarantee that the procedure will be successful. Many couples must undergo the IVF procedure more than once before the implantation is successful in producing a healthy, full-term baby. In this case, it will be even more complicated because we cannot use all of the fertilized embryos but must limit ourselves only to those that are free of Fanconi's anemia."

"But we've done several of these types of procedures with a pretty high rate of success," said Kevin. "Why should this one be different? You've screened the couple, right, and you said they're aware of the risks?"

"Yes, but this case is very complicated." Dr. Wagner sighed. "The Shannons have requested not only a Fanconi's-free child, but one that will be a perfect bone marrow match for Sally. Sally's illness may be treated with a transplant of healthy cells into Sally's bone marrow. Because Fanconi's patients are so fragile, however, the donor's cells have to be a near perfect match, and that's hard to find. Siblings are the best bet. In the meantime, Sally's condition is deteriorating. The Shannons naturally want to give Sally as many years of normal life as possible so they want to take aggressive action. They want to cure Sally's disease by planning and creating another child with specific genetic markers."

"How would that work?" asked Kelly.

"You've heard of stem cell research?" began Liz. "Stem cells are special cells that can produce all the different organs and tissues of the human body. They are found in embryos or fetuses, and are usually obtained for research from embryos that die or are rejected in fertility procedures. That is the kind of research that has been so politically controversial. But a less potent type of stem cell is also found in adult humans and can also be obtained from umbilical cord blood. If we were to help the Shannons and the procedure was successful, the blood from their new baby's umbilical cord could be used for Sally's bone marrow transplant, resulting in no injury at all to the baby and a possible cure for the worst symptoms of Sally's illness."

"The Shannons are suggesting that we perform the PGD procedure as we normally do, but select only those embryos that are both free of Fanconi's anemia *and* are also a perfect match for Sally," said Dr. Wagner. "This presents some real ethical dilemmas for us. We have never tried this before. People have had PGD done to detect and prevent a variety of illnesses in their children, just as we have done here before. But what we are proposing now would be selecting for a specific combination of genetic traits, a combination that will not benefit the planned child but will save an existing child. We will be selecting an embryo and then using it essentially as a blood donor for its sibling. It will be umbilical cord blood, which would be discarded anyway, but it's still a controversial procedure. If we agree, it also means we will be destroying embryos that are perfectly healthy, but are just not a match for Sally. I'm interested in pursuing this, but these are serious issues to consider. Not the least of which is that we may have trouble getting it approved. Before I run it past the review board, I want to know how you all feel about trying it."

"Well, I say go ahead with it. It will be a genetic breakthrough. In time, we'll be able to prevent all kinds of problems with this procedure. Why not start now?" urged Kevin.

Another doctor on the team who had remained silent nodded in agreement.

"I'm not sure yet how I feel about this," said Liz. "I feel a little uncomfortable with the precedent this might set. We'll be opening the door to who knows what type of genetic selection. Do we want the responsibility for that?"

A couple of others on the team seemed to side with her.

"Yes," said Kelly. "But think about the poor Shannons. And especially Sally. Does she deserve to suffer just because we're arguing about ethical problems of the future?"

"Well, it sounds like we all need to talk about this some more before we can reach a real consensus," Dr. Wagner concluded. "I don't want to start on a case this important without everyone's agreement."

Questions

1. How could baby Sally inherit Fanconi's anemia even though neither parent suffers from it?
2. What other illnesses or developmental disabilities can be inherited in this way?
3. What are the odds that the Shannons' second child would also have this disease?
4. What are the basic processes of IVF and PGD?
5. What risks are involved in this whole procedure?
6. How could a sibling's blood help cure Sally?
7. How could PGD be used to create a sibling to help cure Sally?
8. What is so unusual about the PGD proposed by the Shannons?
9. What are some ethical issues related to the use of IVF? What are some ethical issues related to the use of PGD? What do you think about those issues?
10. What do you think the research team should do? What should the Shannons do?

Teaching Notes

Introduction and Background

This dilemma and discussion case was designed for an introductory course in developmental psychology but it can be used in many introductory science classes. Although the debate and doctors described are fictional, the case is based on actual events from the late 1990s that were extensively reported in the public press and in a documentary film.

In 1994, Jack and Lisa Nash had a daughter, Molly, who inherited a rare genetic disorder called Fanconi's anemia. By having another child with specific genetic markers, the Nashes could use stem cells from the new baby's umbilical cord blood to effectively cure Molly. Their search for doctors to provide this type of pre-implantation genetic diagnosis and treatment was controversial. Screening their embryos to eliminate the genetic disorder in a second child was not the problem. The controversial step was to eliminate some healthy embryos and implant only those that matched Molly's needs. Eventually they were successful in obtaining the treatment. Molly now has a little brother whose umbilical cord blood was used to treat her. Currently, she appears to be doing fine.

Prior to my use of cases in the classroom, I used the story of Jack and Lisa Nash to initiate student discussion. Students were eager to debate the ethical issues of genetic manipulation and fertility treatment. I observed that in previous semesters students easily identified with the parents in the story and with the suffering child. I wanted them to approach the issue from the scientist's point of view, so I wrote the fictional research team debate to frame the story.

Objectives

- To demonstrate a basic understanding of how developmental disorders can be transmitted genetically, including the differences between disorders triggered by recessive genes, X-linked genes, and genetic mutation
- To explain in vitro fertilization and pre-implantation genetic diagnosis, including basic risks involved with the procedures
- To consider and discuss ethical issues involved in these procedures

Common Student Misconceptions

- There is always a clear right or wrong answer in science.
- At least one parent must directly display a trait or characteristic for a child to inherit it.
- Fertility treatments are generally simple and successful procedures.

Classroom Management

In my course, students read the case and the questions that accompany it individually; we then discuss the material as a class during the next meeting. Students later complete individual follow-up papers. This case could also be assigned for small-group discussion. I have avoided this option because I find that students often have strong opinions on reproductive issues. Conflicts between students are not uncommon and I prefer to have them take place when I am mediating the whole-class discussion.

Students complete the case as homework and use their text and other sources to help them with any background information on genetics they might need. We spend the next hour (at least) of class time discussing the case. I usually begin the discussion by asking students what the Shannons want and what their possible options are. This can lead to a discussion of recessive-linked disorders and a calculation of the risk of having another child with Fanconi's anemia. Students can generate a list of options available to the couple, including the procedures outlined in the case. I focus on these procedures and discuss the ethical problems related to each. I round out the discussion by turning to the research team in the case. Students present their views on what the research team's dilemma is and the risks they run. We list their options and conclude by taking a vote on what the research team should do.

Various other assignments can be completed for this case. I have had students choose a genetic marker in their own family and draw a family tree tracing it through as many generations as they can. My students also complete an informed opinion paper after the discussion in which they address any or all of the following questions:

If a problem were suspected during a pregnancy, would you want to know? Would you consider using IVF or PGD yourself? Why or why not? What do you think is the most important ethical issue associated with PGD? Describe both sides of the issue.

Web Version

The case and its complete teaching notes, references, and answer key are found on the National Center for Case Study Teaching in Science website at *http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=347&id=347*.

Index

*Page numbers printed in **boldface** type refer to figures or tables.*

Stories put "flesh and blood" on scientific methods and provide an inside look at scientists in action. Case studies deepen scientific understanding, sharpen critical-thinking skills, and help students see how science relates to their lives. In *Science Stories*, Clyde Freeman Herreid, Nancy Schiller, and Ky Herreid have organized case studies into categories such as historical cases, science and the media, and ethics and the scientific process. Each case study comprises a story, classroom discussion questions, teaching notes and background information, objectives, and common misconceptions about the topic, as well as helpful references. College-level educators and high school teachers will find that this compilation of case studies will allow students to make connections between the classroom and everyday life. *Science Stories* is sure to make science engaging and enlightening for both students and teachers.

Science Stories: Using Case Studies to Teach Critical Thinking

PB301X
ISBN: 978-1-936137-25-1

College
NSTA press
National Science Teachers Association