Genetic Engineering

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Overview

This curriculum unit is designed to have middle school students apply biology content knowledge to the controversial issue of genetic engineering. The students will learn the basic biological principles that allow for the various applications of genetic engineering, such as cloning, xenotransplantation, gene therapy, and genetically modified foods. They will examine the process for each application as well as examine all the ethical implications. Throughout the unit the students will examine and evaluate the research about genetic engineering and keep track of how their own opinion is changing as their knowledge base increases. They will use this information to decide whether to plant genetically modified foods in the school garden. One major purpose of this unit is to teach the students that, in order to make an informed decision about a highly technical issue that has an impact on many of their lives, they will need to have a high level of scientific literacy.

Rationale

This unit is designed for the biology portion of a 7th grade science class. In this unit students will be deciding whether genetic engineering is appropriate. They will explore the various applications of genetic engineering, through readings, labs, discussions, and debates. The students will explore cloning, gene therapy, transgenic transplantation, and genetically modified foods. For each of these topics students will be presented with readings about each topic. The students will be asked to identify bias in the readings and evaluate the validity of sources. After each new topic the students will use a discussion protocol to justify to their classmates if genetic engineering is appropriate. They will be tracking their position throughout the unit plan recording which information and which student's arguments impacted their position most. The students will also perform many hands-on and virtual labs to help them better understand the processes of genetic engineering and how it relates to their understanding of cellular anatomy and physiology,

genes and genetics, and natural selection and evolution. The students will end the unit with a class town hall debate to determine whether we should plant genetically modified vegetables in our schoolyard garden.

To make an informed decision about genetic engineering the students should have a good understanding of many aspects of basic biology, including cell structure and function. The students should know all organelles inside of a cell and what jobs each organelle performs. For genetic engineering students will need to know that the nucleus of a cell contains the genetic material, DNA, and controls cellular activities. Ribosomes located in the cytoplasm and on the endoplasmic reticulum use the genetic material to create proteins that help regulate cellular processes inside the cell or can be packaged and shipped to other cells in conjunction with the Golgi Complex. The mitochondria are able to produce energy for the cell, and cell membrane is able to regulate the passage of materials into and out of the cells. In addition to understanding what functions organelles inside of a cell perform, students should also understand the structure and function of the genetic material inside of cells.

DNA the main molecule that contains the code for all living organisms is composed of two basic parts, the sugar phosphate backbone, and the nitrogenous base. These two components combine to make the nucleotides that are bound together in the familiar double helix shape. There are four possible bases adenine (A), guanine (G), cytosine, and thymine (T) each base pairing with only one corresponding base, A pairing with T and C pairing with G. In the genetic code the order of these bases along the DNA molecule create a code for the sequence of amino acids in various proteins. Proteins are polymers consisting of long chains of amino acids. The instruction for a protein is called a gene. Genes are located on thread like structures called chromosomes found in the nucleus. A complete set of genetic material for an organism is called a genome. Simply stated each base could be thought of as letters in the language of DNA. These letters combine to make sentences, or complete thoughts, called genes. The genes combine to make up the chapters of a story called chromosomes. The complete story would be a genome. All of this genetic information can be found in almost every cell of an organism. So every cell has all the information to create not only another cell, but a whole organism. If unwound this DNA molecule would stretch almost 6 feet in length, but be so thin it is not visible to the eye.

Every time a cell divides, called mitosis, it must first copy all the genetic material to ensure that both cells will have all the genetic material to function. This copying takes place during interphase, the longest stage in cell life. During the first stage of mitosis, prophase, the nuclear membrane dissolves, the chromosomes condense, centrioles migrate to opposite poles of the cell, and spindle fibers form. The second stage is metaphase, in which the chromosomes now condensed are aligned along the cellular

equator. These copied, condensed, and aligned chromosomes are split apart and pulled to opposite poles of the cell during anaphase. The final stage of mitosis is telophase. During telophase the nuclear membrane reforms, chromosomes unwind, and spindle fibers dissolve. The cell is then able to split in two to create two exact copies of the original cell. Scientist use the cell's ability to make proteins specified by genes in the DNA and the ability of a cell to make exact copies of itself to first manipulate the DNA of a cell to produce certain proteins and then make multiple copies of the cell. Scientists are able to determine what proteins are produced, using genes from any organism and inserting that code into another organism.

Genetic engineering is manipulation of the DNA of an organism. There are many applications of genetic engineering including the creation of an identical organism from a single cell. This is called cloning. One of the most common forms of cloning called somatic nuclear transfer involves removing the genetic material from a somatic cell, a body cell that contains a full set of genetic information, of a host organism, and placing it into an enucleated egg cell. The egg cell containing DNA from the host is then incubated inside of a surrogate mother. The egg will then grow into a clone of the original organism. This is method has been used to clone many species of mammals including Dolly the sheep. Dolly was the first successful mammal cloned using somatic nuclear transfer. While the process seems very straightforward there are many risks involved with cloning. The first being a very high failure rate, success varies from .1 to 3 percent (What are the Risks of Cloning). The second being premature aging, Dolly was diagnosed with arthritis at a very early age (A Life of Dolly).

Genetic engineering does not always involve creating entire organisms, a vast majority or genetic engineering involves moving only genes from one organism to another. In most living things almost all cell function is controlled by proteins that are coded for by genes. For example the Green Fluorescent Protein is responsible for making a species of jellyfish glow green under UV light. Skin color is determined by the protein melanin, the more melanin present the darker your skin. When scientists move genes from one species to another it is called transgenics. This is now a common practice in agriculture, where plants are being implanted with genes to grow their own pesticide or to resist certain herbicides. The percent of corn and soybean food crops grown in the United States that is genetically modified has grown to over 80%. (Genetically Engineered Crops in Pet and Human Food) Genetically modified foods have become a major issue in our modern society that needs to feed and increasing larger population on a shrinking amount of land. There are many concerns about the safety of these genetically modified crops. The first area of concern is with the health impacts of consuming genetically modified foods. While no health risks have been associated with the consumption of genetically modified foods, many of the studies used to test the safety of these foods have

been conducted by or funded by the companies that produce these foods. In the United States genetically modified foods are considered to be generally recognized as safe, however in most of Europe these food crops have been banned as the companies have been unable to prove the safety of these foods.

In addition to the health concerns, there are many environmental concerns with the use of these genetically modified organisms. The introduction of these organisms into a natural ecosystem can cause many harmful outcomes. The first being the release of these genes into native plants, creating "super weeds" that are unable to be controlled with current herbicides Or transferring the gene for pesticide production to native plants that will then alter the natural ecosystem. Another problem is the destruction of beneficial insects from the use of large areas of crops with the Bt gene. In addition to the destruction of beneficial insects, the concern of resistance from the harmful insect species to the Bt toxin will be harmful to not only conventional farmers, but also to the organic farmers whose choice of natural insecticide is already very limited. (Environmental Dangers of Insect Resistant Bt Crops, 2004) However, there are many benefits including the reduction of the amount of toxic pesticides sprayed on the crops, polluting air, soil, and water.

Genetically modified crops can also increase the nutritional content of foods by the addition of vitamins to commonly consumed staples such as rice, thus reducing diseases caused by vitamin deficiencies. Farmers are able to produce more food on less land with less erosion using genetically modified foods.

So the issue of genetically modified foods presents a multifaceted problem to citizens of a modern society, in which the benefits of technology are weighed against the dangers of altering a natural environment that has co-evolved over millennia.

Strategies

My unit plan is based on a student centered learning environment. In a student centered classroom students are required to take an active role in the learning process. While there is direct instruction, the focus of information acquisition is moved from the teacher to the student. Student centered learning incorporates a variety of pedagogical approaches such as inquiry based learning, peer teaching, and problem based learning. This methodology has been proven to increases student science literacy skills (Brickman, Gormally, Armstrong, and Hallar).

One of the main pillars of student centered learning in a science classroom is inquiry based instruction. Inquiry based instruction is when students questions and ideas drive instruction. In an inquiry based classroom students will be constructing their own hypotheses and testing them, they will be creating their own ideas about concepts rather than just memorize facts. Inquiry learning challenges students. It requires them to collaborate with peers, construct usable knowledge by linking new and old ideas, and

relate new science content to their lives in and outside of school. This approach has proven to increase standardized testing performance and reduction in the achievement gap experienced by African American students (Geier, Robert, Phyllis C. Blumenfeld, Ronald W. Marx, Joseph S. Krajcik, Barry Fishman, Elliot Soloway, and Juanita Clay-Chambers.)

Connecting the concepts to real world issues and asking the students to make decisions about these issues allows them to analyze information and identify key concepts. By moving the responsibility of identifying key concepts to the students it compels them to engage with the material at a level beyond direct instruction. This type of instruction helps the students move up to higher levels of Bloom's Taxonomy. Giving students the opportunity to work with real life issues moves the students beyond just recall or remembering to understanding and analyzing. When you then ask them to make decisions about these issues you are then giving them an opportunity to apply and evaluate these concepts and issues in a meaningful way. In addition to increasing the cognitive difficulty you are also increasing engagement (Yoon, Susan).

When students are meaningfully engaged in subject they are going to play a more active role in their own learning. This increased engagement will also lead to greater understanding and higher test scores (Yoon, Susan). When students are passively listening to an instructor give notes and note taking they are relying on their teacher for all the information, and are more likely to tune out or not be cognitively engaged with the subject area. They are less likely to make connections and think critically about the information. However, when students are seeking information in order to solve a problem or complete a task they are going to listen to the teacher and think more critically about the information, analyzing if the information presented helps them with their task or problem. This analysis and application is required if the students are going to be engaging in a discussion or debate.

By asking the students to engage in a debate or discussion about a topic, students need a rich understanding of the issues involved because they will not only need to state an opinion, but will then need to support and defend their ideas to the other students who are also well versed in the same content. The addition of an interactive and peer component raises student engagement and comprehension. Student outcomes are improved when students are provided challenging and engaging activities (Willis, Judy).

Objectives

The objectives for this unit are organized into 3 categories, content objectives, science skills, and behavioral skills.

The objective of this unit is to teach basic cellular biology by exploring the controversial issues surrounding genetic engineering in our society. Then use that information to make an informed decision about whether to use genetically modified seeds in their schoolyard garden.

In order to truly understand and make an informed decision the students need to have a full understanding of cellular anatomy and physiology. The students must understand what is in a cell, and they must understand what organelles are in a cell and what they do. They will also need to understand the structure and function of the DNA molecule. Finally the students will need to know how genes are transcribed and expressed in organisms.

The students will also need to know how to observe, and ask questions, this will help them gain a better understanding of the science concepts and technology involved in studying cells and genetic engineering. Observation and questioning will also help them plan and carry out investigations, and help guide their research. The students will need to interpret data from their own investigations and analyze data from other research, to help explain scientific concepts. They will also use this data to help create their own ideas and opinions that need to be supported through argumentation and debate.

In this unit students will need to learn how to respectfully listen to another person's ideas and respond and critique without malice. They will need to learn how to craft an argument that is supported with evidence. The students will also need to learn how to view an issue from many viewpoints, while simultaneously analyzing the strengths and weaknesses of the arguments presented by each side. The students will have to practice being metacognitive. Because learning is an active process students need to evaluate what they know, how they know what they know, and how they came to think that way. The students will practice analyzing their own opinions, and reflecting on what information or person was most influential in the formation of their opinion.

State Standards

PA Biology Standards
3.3.7.A. Describe the similarities and differences that characterize diverse living things.
3.3.7.B. Describe the cell as the basic structural and functional unit of living things.
3.3.7.C. Know that every organism has a set of genetic instructions that determines its inherited traits.

PA Inquiry and Design
3.2.7.A. Explain and apply scientific and technological knowledge.
3.2.7.B. Apply process knowledge to make and interpret observations.

PA Unifying Themes
3.1.7.E. Identify change as a variable in describing natural and physical systems.

Classroom Activities

This curriculum unit will serve as the introduction to a much longer unit of study in which the students will do detailed research into the various applications and ethics involved in genetic engineering in today's society. The student will then use this information to participate in a town hall debate to decide whether to use genetically modified seeds in the school's garden. The unit of study takes place over 12 weeks, alternating between introducing new biology content, and examining the implications of genetic engineering. The activities and content of the unit of study are outlined as follows.

Week 1: Introduction

- Introduce the unit
- Learn to play the Discussion Game
- Clone the dog activity

Week 2: Cell Anatomy

- Review the organelles structure and function
- Project: Students build model cells

Week 3: Cell Physiology

- Review Cell Material Transport
- Lab: Gummy Bear Osmosis

Week 4: Cell Physiology

- Review Cell Respiration and Photosynthesis

Weeks 5-7: DNA

- Review Structure of DNA and Protein Synthesis
- Activity: Students read, How Does Gene Therapy Work?
- Activity: Discussion Game
- Activity: Students research a genetic disorder
- Activity: Students read case study of Jesse Gelsinger.
- Activity: Group Discussion on Pros and Cons of Gene Therapy
- Activity: Discussion Game
- Activity: Students read, And This Little Piggy Went to the O.R
- Review Xenotransplantation and Transgenic Organisms
- Activity Group Discussion about the ethics of moving genes or organs from one organism to another
- Activity : Discussion Game

Week 8: Heredity

- Review Meiosis, Dominant and Recessive Traits, Genotype and Phenotype, and Punnett Squares
- Lab: Zebra Fish Breeding. Students cross Zebra fish with a variety of traits and predict the offspring's phenotypes

Week 9-10: Natural Selection/Evolution

- Review the process of natural selection and its role in evolution
- Activity: Read Playing God in the Garden. As students read they identify all special interest groups who are stake holders in Genetically Modified Foods
- Review the process of Transgenics (inserting genes from one species into another)
- Activity: Students select a special interest group that they most identify with and write a letter to the special interest group that is most opposite that group, explaining their position on genetic engineering.
- Activity : Students then respond to their letter as the opposing group trying to address their original position
- Activity: Discussion Game

Week 11: Town Hall

- Activity: The students will participate in a Town Hall Debate to decide whether to plant genetically modified plants in our schools vegetable garden. Students select a special interest group to represent, and then use research to present their cases to a student based Town Council. The Council after listening to all positions decides on the use of GMO foods for our school.

Week 12: Reflection

- Activity: The students review how their ratings about genetic engineering have changed over the last 12 weeks. They also discuss what ideas were most powerful to forming their ratings. The students will then examine who in the class influenced their opinion the most, and why that person was able to influence their view of genetic engineering.

Classroom Activities for Week 1

Day 1: Introduction Discussion Game

The beginning of the unit will serve as a baseline to track changes in student's opinion of genetic engineering throughout the unit. Later in the unit the students will look back on how their ratings changed over time, and what information led to the change.
Throughout the unit students will be playing a discussion game. In the discussion game students find someone unoccupied, tell their partner their rating, then listen to their partners rating. The students will then give their reasons for their rating, and try and convince their partner to move their rating closer to theirs. When complete, students

should repeat with the other students in the class. After discussions the students should record their ending rating. This procedure allows the students to catalogue how their own opinion changed, the classroom content that inspired the change, as well as the arguments and opinions of their classmates they felt were most compelling. This information will help the students prepare for a class town hall meeting to conclude the unit.

Students give a personal rating to the question "Is Genetic Engineering Appropriate?" The students should give a rating from -5 to 5, and they should also give a rationale. -5 meaning they do not find genetic engineering appropriate, and have a negative opinion of it. +5 they do find genetic engineering appropriate, and have a positive opinion of it. 0 meaning they have neutral opinion or do not have enough information to make an opinion. At this point most students have no exposure to Genetic Engineering so this is just meant to give a baseline rating to compare to later, so many students will have a rating close to 0. This activity also allows the teacher to assess the amount of background knowledge students have of genetic engineering. The students will then learn how to play the discussion game.

Day 2

Review the results from the discussion game. Then have the students brainstorm all the applications of genetic engineering. Then give a brief summary of each application.

The students will have to develop a procedure to clone a dog. The students are given the following scenario: "You have the best dog in the world and would like to keep him around forever." You need to develop a process to clone him. Before the students begin, explain to the students that all scientist need to do a lot of research about a topic before they can experiment, so they must make a list of what information they will need to complete the task. When compiling this info they cannot use a word they cannot define. If the students are reluctant because of their lack of familiarity with the topic the teacher may choose to ask some general guiding questions such as:

> If you want to clone a dog what might you take from the dog to clone?
> *Students may respond cells, blood, hair, etc.*
> What is in that material that you will need to clone a dog?
> *Students may respond DNA, genes, etc.*
> Why would they take DNA?

A word of caution, this activity is designed to set the stage to make the students responsible for their own information and thinking. If you ask too many guiding questions then you will end up with all groups producing identical procedures that only answer guiding questions. It is more important to encourage student generated responses and thinking. This encouragement now will help foster the independence and reflection that will be needed throughout this unit.

In order to complete this activity students need to know that all organisms are composed of cells. DNA (genome) is a set of instructions for an organism and each somatic cell in an organism contains a full set of DNA. They will also need to know that DNA can be found in the Nucleus of a cell. This also provides some insight about the scientific process. In science, before a person tries a new procedure they must analyze all known information about that topic before they can perform an experiment.

The key to this lesson is that students need to be metacognitive. They need to analyze what they know and what information they will need to know to be successful. Students need to play an active role in their own learning for it to be meaningful. This student-centered approach allows the teacher to facilitate and guide rather than just provide information. In a traditional classroom the teacher presents information, and the students listen and take information. The teacher decides all important concepts and how to present them. With this format the students also provides some input on what information is important. It requires them to take inventory of what they know, and then analyze what information is important. The instructor then compiles and answers student's questions about cloning, cells, and DNA.

When the groups have completed compiling a list of what information they need to know, they will then rank the questions in order of importance. (During this time it would be helpful for a teacher to walk around viewing the students' lists. The order of questions should be noted so that the teacher might be able to answer questions in the most logical order.)

Day 3

The students, in groups of 3-4, then use the information they gathered to create their own procedure to clone a dog.

Day 4

The students will then visit the website, http://learn.genetics.utah.edu/content/tech/cloning/clickandclone/ and follow the steps to virtually clone a mouse. As they proceed they should write down all the steps they used to clone a mammal. They should also reflect back to their information gathered in Part 1 and write down why each step is necessary.

Day 5

As a wrap up, students should write a reflection on how their procedure compared to the actual procedure. They should include what information they did not think of during the initial activity. Then play the discussion game recording their personal rating, rationale, and if anyone made them move their rating during discussion.

Annotated Bibliography/Works Cited

This is an article that explains the rapid growth of genetically engineered crops and highlights some risks associated with genetically engineered foods. Can be for students or teacher background.

"Advocacy For Animals." *Advocacy For Animals Genetically Engineered Crops in Pet and Human Foods Comments*. N.p., 24 Aug. 2009. Web. 03 June 2013. <http://advocacy.britannica.com/blog/advocacy/2009/08/consumers-beware-genetically-engineered-crop-ingredients-in-pet-foods-and-human-foods/>.

This article links student centered learning modalities to an increase in students' science literacy and confidence in the subject area. This article is for teachers.

Brickman, Gormally, Armstrong, and Hallar. "Effects of Inquiry-based Learning on Students' Science Literacy Skills and Confidence." *International Journal for the Scholarship of Teaching and Learning* 3.2 (2009): n. pag. Print.

This is an online activity that reviews the process of how to clone a mammal. This is an activity for the students

"Clone a Mouse." *Click and Clone*. University of Utah, 2003. Web. May 2013. <http://learn.genetics.utah.edu/content/tech/cloning/clickandclone/>.

This article explains the impact of Bt crops on beneficial insects.

"Environmental Dangers of Insect Resistant Bt Crops." GreenPeace, 2004. Web. <www.greenpeace.dk>.

This is an article that demonstrated that student-centered teaching also increases standardized test scores. This is an article for teachers.

Geier, Robert, Phyllis C. Blumenfeld, Ronald W. Marx, Joseph S. Krajcik, Barry Fishman, Elliot Soloway, and Juanita Clay-Chambers. "Standardized Test Outcomes for Students Engaged in Inquiry-based Science Curricula in the Context of Urban Reform." *Journal of Research in Science Teaching* 45.8 (2008): 922-39. Print.

This article explains how scientists are able to get genes into cells, then how they use these cells. This article is for teacher background and students reading.

"How Does Gene Therapy Work?" - *Genetics Home Reference*. N.p., n.d. Web. 03 June 2013. <http://ghr.nlm.nih.gov/handbook/therapy/procedures>.

This is an article exploring the possibility of using genetically modified pigs to grow human organs. It also introduces the ethical considerations of inserting human genes into food animals. This is an article for students.

Kahn, Jeffery P., Ph.D. "And This Little Piggy Went to the OR." *CNN*. Cable News Network, 2000. Web. 03 June 2013. <http://www.cnn.com/HEALTH/bioethics/9811/xenotransplants/template.html>.

In this article the author is trying to decide whether to plant and eat genetically modified potatoes in his garden. To gain further information the author describes how genetically modified potatoes are created then interviews conventional farmers, organic farmers, environmental scientists, and government agencies to better inform his decision. This is an article for the students.

Pollan, Michael. "Playing God in the Garden." *The New York Times*. The New York Times, 25 Oct. 1998. Web. 03 June 2013. <http://www.nytimes.com/1998/10/25/magazine/playing-god-in-the-garden.html?pagewanted=all>.

This article explains the cloning of Dolly the Sheep, who was the first mammal to be cloned using embryonic nuclear transfer. It also discusses some of the problems that Dolly experienced as the result of her being a clone. This is an article for teacher background and student research.

"The Roslin Institute." *(University of Edinburgh)*. N.p., n.d. Web. 03 June 2013. <http://www.roslin.ed.ac.uk/public-interest/dolly-the-sheep/a-life-of-dolly/>.

This article explains the death of Jesse Gelsinger the first person known to have died as result of clinical trial using gene therapy. This article is used as a counterpoint to all the benefits of gene therapy. It serves as a cautionary tale for the students reading.

STOLBERG, SHERYL. "F.D.A. Officials Fault Penn Team in Gene Therapy Death." *F.D.A. Officials Fault Penn Team in Gene Therapy Death*. N.p., 09 Dec. 1999. Web. 03 June 2013. <http://partners.nytimes.com/library/national/science/health/120999hth-gene-therapy.html>.

This article reviews some of the risks of cloning. This is for teacher background and student research.

"WHAT ARE THE RISKS OF CLONING?" *What Are the Risks of Cloning?* N.p., n.d. Web. 03 June 2013. <http://learn.genetics.utah.edu/content/tech/cloning/cloningrisks/>.

This article explains some of the many benefits of cooperative, student centered learning on student critical thinking and investment.

Willis, Judy. "Cooperative Learning Is a Brain Turn –On." *Middle School Journal* (2007): n. pag. Print.

This is a case study that explains how using a town hall debate can help increase student investment of those students in classrooms that are typically the least invested.

Yoon, Susan. ") Account 7 Motivating the Unmotivated and Empowerment through a Town Hall Debate." *Analyzing Exemplary Science Teaching*. N.p.: McGraw-Hill International, 2204. N. pag. Print.

Appendix/Content Standards

State Standards

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3.1.7.E. Identify change as a variable in describing natural and physical systems.