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A Clone of Your Own: The Legal Issues and the Future of Genetic Engineering on Humans

Curriculum Unit 04.01.01
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This unit is intended for a senior honors or Advanced Placement Biology class and will require about two to four weeks to complete depending on the students' aptitude and prior knowledge. The New Haven Public Schools Science Curriculum demonstrates a commitment to the discussion of current science events among its teachers and students. The questioning of modern biological techniques and the discussion of its social and moral implications is a vital part of a science curriculum; this includes any legal issues that may arise. The bullets to be covered in the unit stem from the Connecticut Common Core of Teaching and Learning and were adapted by The New Haven Public School science curriculum committee; they include:

1. Prepare and defend a position on the ethics of genetic engineering

2. Prepare persuasive writing on gene splicing and cloning

3. Prepare and deliver oral presentations on possible benefits and problems of recombinant DNA technology

The objectives of this unit are as follows:

- Students will be able define cloning, including the various types
- Students will be able to construct a timeline of the history of cloning (1880 to present)
- Students will be able to simulate the processes of bacterial cloning (Recombinant DNA) and reproductive cloning.
- Students will be able to research and evaluate landmark court decisions and legal precedents to develop an argument as to whether people have the right to clone oneself.

While the first three objectives will provide the necessary scientific knowledge for the student to prepare a presentation it is not the main focus of the unit, the legal issues surrounding cloning and whether or not we

have the right to clone is the ultimate issue. The objectives lend themselves well to a variety of classroom activities that include Bloom's Taxonomy and Multiple Intelligence theory. Bloom's Taxonomy works under the principle that higher level thinking can only be achieved if the student first comprehends the information. After comprehension is achieved, then the student will be able to process and synthesize the material. The final stage of Bloom's Taxonomy is evaluation.

In this unit the student must first understand the basic biological process that produce clones, they will have the opportunity to simulate cloning in the lab and witness first hand the problems associated with the process. They will then read articles that deal with ethical and legal issues surrounding cloning and related subjects. With this information the student will have a balanced view of the subject, that is they will understand the negative and positive aspects of cloning. It is only at this point that the students can critically look at the issue and make their own evaluations and informed opinions. The point of any good science curriculum is to ensure that the student is armed with the tools to make them productive and informed citizens, ready to contribute to society.

This unit is scientific inquiry based, which also allows for the development and assessment of the student's critical thinking skills. Inquiry based assessment allows the students to learn while doing. The students themselves develop the questions that they want answered thereby making the subject more relevant to their needs and experience. The laboratory activity is a hands-on activity that is in keeping with sound multiple intelligence theory. The students will be called on to use their emotional, intrapersonal and interpersonal intelligences as well.

So what exactly is cloning?

In biology, the noun "clone" refers to a cell, an organism that is genetically identical to another cell or organism from which it is derived. The verb "(to) clone" refers to the process of creating cloned cells or organisms. There are three main types of cloning, Recombinant DNA technology or DNA Cloning, Reproductive Cloning and Therapeutic Cloning. When there are news reports on cloning they are usually speaking of Reproductive Cloning, which is "a technology used to generate an animal that has the same nuclear DNA as another currently or previously existing animal" (). It is this type of cloning that is the most difficult to execute successfully, and the one that sparks the most heated debate.

To put it very simply, a clone is a copy of another organism that has the exact same DNA as the original.

1. Recombinant DNA Technology (DNA cloning) is the "transfer of a DNA fragment of interest from one organism to a self-replicating genetic element such as a bacterial plasmid." (www.ornl.org)
2. Therapeutic cloning which is also called embryo cloning, this is the "production of human embryos for use in research" () this is commonly referred to as 'stem cell' production. The goal of this process is not to create cloned human beings, but rather to harvest stem cells that can be used to study human development and to treat disease.
3. Reproductive cloning which is a "technology used to generate an entire animal that has the same nuclear DNA as another currently or pre existing animal" () for example Dolly the sheep.

To nature, the process of cloning is nothing new it has been doing it for millions of years. Anyone that has done some gardening has probably witnessed cloning in action. When plants send out runners making new plants or we take a cutting of one plant to produce another, each new plant is a clone of the original. Certain animals have the ability to clone themselves; for instance the tiny water animal hydra can clone an entirely identical hydra form the original if a small part is cut off. In a process certain animals like salamanders and lizards, under the right conditions can undergo *parthogenesis* to make an exact clone of themselves. And of course the most obvious cloning in nature is the existence of identical twins. When the sperm fertilizes the egg an embryo is formed. Usually the embryo will divide and create one fetus. But sometimes the fertilized egg splits into two forming identical embryos that develop into two people with exactly the same DNA.

Nature has been cloning all along, and now it seems that humans are catching up. But while most people only became aware of our ability to clone animals with the birth of dolly the sheep in 1997 (the first cloned mammal) cloning in other animals had been relatively successful many almost a century prior. 1902 the German Embryologist Hans Spemann used a strand of human hair to tie around the embryo of a salamander and split the cell in two, mimicking the natural process of making identical twins. The result was two salamanders with identical DNA. Spemann had a vision of a "fantastical experiment", he suggested that an organism could be cloned if nuclear material could be transferred into an egg. The technology of his time limited him to a dream, but it is his idea that was the basis of cloning today.

In the in 1960's John Gurdon did exactly what Spemann had proposed. He took an egg from a frog (Frog A) and blasted it with radiation, which destroyed the nucleus. Then he took a fully differentiated cell from the skin of another frog (Frog B) and removed the nucleus. The nucleus from frog B was then implanted into the enucleated egg from frog A. The end result was a tadpole that was a clone of frog B.

It was this fundamental technology that led to Dolly. Dolly was cloned at the Edinburgh-based Roslin Institute by a team lead by Ian Wilmut. He and his colleagues built on the technology of Gurdon's experiments. Wilmut et al. had to reprogram the DNA of the donor sheep so that the cell would not develop into the part that it was taken from. An egg was taken from a Scottish Blackface sheep shortly after the sheep ovulated, the nucleus was removed with a pipette. Then the adult cell was taken from the mammary gland of a Finn Dorset sheep that was completely white. This cell was "starved" (denied nutrients) and not allowed to grow or divide. Then both cells were placed next to each other and electricity was used to jolt the cells into merging. The cell divided and developed into a normal embryo and was implanted into a surrogate mother that was also a Blackface sheep. When Dolly was born she was completely white, evidence that she was indeed a clone of the Finn Dorset sheep. This is shown in a fabulous diagram at www.howstuffworks.com

Cloning Timeline from A Brief History of Cloning (1880 to present)

1880 August Weissmann states that genetic information of a cell diminishes with each cell

1902 Hans Spemann divides a salamander embryo in two and shows early embryo cells

retain all the genetic information necessary to create an organism

1928 Hans Spemann performs the first nuclear transfer experiment

1938 Hans Spemann proposes a "fantastical experiment" to transfer one cell's nucleus into an egg without a nucleus, the basic method that would eventually be used in cloning

1952 Briggs and King clone tadpoles

1953 Watson and Crick discover the structure of DNA

1962 John Gurdon clones frogs from differentiated cells

1963 J.B.S. Haldene coins the terms ‘clone’

1978 The release of David Rorvik’s book, *In His Image: The Cloning of Man* , sparks a worldwide debate on cloning ethics.

1980U.S. Supreme Court rules live, human made organisms are patentable material

1990 Human Genome Projects begins

1996 Dolly, the first mammal cloned from adults cells, is born (not announced until 1997)

2000 Britain becomes the first country to grant a patent for cloned early-stage human embryos. Genron Corporation, which received the patent, says it has no intention of creating cloned humans

2000 Human Genome Project ends

The Possible Reasons for Human Cloning

To help infertile couples

One of the primary reasons that those who support cloning put froth in support of their cause is to help infertile couple achieve the dream of having a child that is genetically identical to them. In most cases when a couple cannot conceive naturally or are not suitable for in vitro fertilization it is because there is a problem with either the father’s sperm of the mother’s eggs. Cloning would allow either parent to produce offspring, but it would be genetically identical to only one of the parents.

Cloning is a reproductive right

There are supporters of cloning that do not necessarily believe that one should clone, but they fell that one does have the right to clone, in the same way that there is the right to other reproductive technologies, contraception and abortion.

Cloning to find cures for diseases

If a child has an incurable disease and the only way that he/she could be cured later on in life would be to have a transplant, either bone marrow or kidney that is genetically identical, then the parents could clone the child and perform the transplant. The older child would be cured and the younger child would also survive, as they can live with one kidney and the loss of some bone marrow. To support cloning for this reason would then be limited to kidney and bone marrow disorders, as any other transplant would result in the death of the clone.

To have children free of genetic disorders

If both parents were heterozygous for a deadly genetic disorder (each had a recessive allele) then there is a one in four chance that the offspring will be homozygous recessive for the trait (positive for the disorder). Neither parent has the disorder because they have one dominant allele and one recessive allele, so a clone of either one of them would produce offspring without the deadly affliction. Of course the offspring would have any other undetected genetic disorder the parent has.

To recreate a lost child or relative

If a child or family member dies then it would be possible to obtain some DNA from that individual and clone the, this could possible alleviate their grief. The Report of the President's Council on Bioethics discusses an example of this. In an imaginary case in which a father, mother, and child were involved in vehicular accident, the father is killed instantly, and the child is critically injured and dying. If the mother took cells from the dying child and cloned the that child, it could "allow her to preserve a connection with both her dead husband and her dying child, to create new life as a partial human answer to the grievous misfortune of her child's untimely death, and to continue the name and lineage of her deceased husband." (The President's Council came out very strongly against human cloning and so did not find this argument compelling)

To live through a later born twin

Some supporters of human cloning saw that because they had a particularly difficult childhood that they would like to have another chance to live the life that was meant to be theirs. Some people feel robbed of the opportunities they should have had in life and so would like the opportunity to live through a 'later born twin'.

Why Should We Care About Cloning?

Protecting the rights of children

One of the most powerful arguments against cloning is how it will harm the child who will be born as a result of the procedure, not only medically but emotionally as well. For instance if the child is the genetic copy of the parent, what sense of self will it have? Will the child have free will or is it destined to feel the burdens of 'sins of the father.' If the child was cloned from a dead sibling, what might the expectations be? Will they be realistic?

Cloned children will have confusing family relationships. If a couple clones the father as their son, then his father will also be their his brother, he would also be his mother's brother in law as well as her son. If there were any natural siblings then he would be their brother and their uncle as well. If he had children he would be their father in addition to being their great uncle since they will be the grandchildren of his father who is also his brother, making the children his grandnieces and nephews.

Cloned children would not be able to give their consent if they were to be used as kidney or bone marrow donors. They would also be part of an experiment to which they did not agree which goes against standard medical practice.

Medical Dangers of Human Cloning

There are a variety of medical dangers associated with human cloning. There is already evidence from the cloning of other mammals that shows this.

Cloned mammals die younger than non-cloned mammals and prematurely suffer from diseases associated with old age such as arthritis. Dolly the sheep died young and suffered from arthritis among other things. Studies have shown that cloned mice have died prematurely from tumors, damaged livers and pneumonia. Cloned animals are at a higher risk of having genetic defects and being born deformed and some cloned animals appear healthy at birth die for no known reason.

There are also significant health risks related to the mother. The Report of the President's Council on Bioethics warns that, "animal studies suggest that late-term fetal losses and spontaneous abortions occur substantially more often with cloned fetuses than in natural pregnancies. In humans, such late term fetal loss may lead to substantially increased maternal morbidity and mortality." (*Human Cloning and Human Dignity: The Report of the President's Council on Bioethics* . Public Affairs Reports, 2002)

The National Academy of Science also says "Results of animal studies suggest that reproductive cloning of humans would similarly pose a high risk to the health of both the fetus or infant and lead to associated psychological risks for the mother as a consequence of late spontaneous abortions or the birth of a stillborn child or a child with severe health problems." (Kass, Leon. *Life Liberty and the Defense of Dignity* , Encounter, 2004)

Societal Dangers of Cloning

If human cloning were to take place there could be more possible dangers that to just the clone and the clone's family, society as a whole would be most likely be affected. The president's Council on Bioethics warns that "the impact of human cloning on society at large may be the least appreciated, but among the most important factors to consider in contemplating the morality of this activity." They go on further to say "We are already liable to regard children largely as vehicles for our own fulfillment and ambitions/ The impulse to create 'designer children' is present today-as temptation and social practice. The notion of life as a gift, mysterious and limited is under siege. Cloning-to-produce children would carry these tendencies and temptations to an extreme expression. It advances the notion that the child is but an object of our sovereign mastery. A society that views children in this way is not a society most of us want to live in."

The Legal Issues Surrounding Cloning

There are a variety of federal laws and regulations covering biotechnology. Biotechnology is primarily regulated by three government agencies: The Food and Drug Administration (FDA), the Environment Protection Agency (EPA), and the U.S. Department of Agriculture (USDA). There are no rules that specifically regulate the cloning of human beings, or that ban the cloning of human beings. But is it possible for the government to ban human cloning? Or do we have the right to clone? " A right protected under the Fourteenth Amendment of the United States Constitution? Could a person, take his or her cries for justice and reproductive freedom all the way to the Supreme Court, unearth enough legal precedent to obtain a legal right to use cloning?" () There are arguments and evidence for and against a ban on cloning. There will be discussed in the following sections.

Arguments and evidence against a ban on cloning (the right to clone)

The strongest argument for cloning can be made by couples that want to clone to overcome reproductive failure. There are two types of couples that this would pertain to; couples who are both sterile and couples wherein both partners are carriers of autosomal recessive genetic disease. It seems that cloning may be the only way that these couples could produce genetically related offspring of any sort.

According to John Robertson in his paper Two Models of Human Cloning (27 Hofstra L Rev 609, 617 et seq. 1999) the right to clone "should only be denied them if substantial harm from cloning to have genetically-related children for rearing could be shown." Robertson goes on to say that one of the main objections to human cloning include possible harm to the child in the form of denying them "autonomy and a unique identity" and setting "unrealistic expectations that the child will have difficulty meeting."

Robertson feels that this is not relevant in the cases of parents that are gametically infertile because they "will have resorted to cloning as the only way of establishing a genetic or biologic relation with their children, they are less interested in having the child be a genetic copy of the husband than that the child be genetically related to him." These parents could indeed fall prey to the concerns of those that support a ban on cloning due to loss of unique identity but Robertson states that "there is good reason to think that these couples, who after counseling and preparation for these problems decide to proceed with cloning, will be competent, loving parents who are devoted to their child's unique identity and welfare, despite its cloned origin."

The argument for human cloning to be allowed for the reason of a couple's reproductive failure is important because it ensures that these couples are allowed to explore all possible avenues to have a child with a genetic link to themselves, the same way that other reproductive couples do. But is raises the question; do we have the right to procreate? According to Justice Douglas' comments striking down the law for the mandatory sterilization for habitual criminals in Skinner v. Oklahoma. (316 U.S. 535 1942) the court noted that the law interfered with marriage and procreation, which it considered to be among the "basic civil rights of man."

The petitioner (Skinner) was convicted in1926 of stealing chickens and again in 1929 and 1934 for armed robbery both times. Oklahoma law at that time required mandatory sterilization for habitual criminals as long as it was not detrimental to their health. The petitioner challenged the Act as unconstitutional under the Fourteenth Amendment and a jury agreed that a vasectomy should be performed. When the case was appealed and heard before the Supreme Court Justice Douglas aid in his reversal of the

decision that " We are dealing here with legislation which involves one of basic rights of man. Marriage and procreation are fundamental to the very existence and survival of the race…He is forever deprived of a basic liberty." (Skinner v. Oklahoma)

We must also take into account the fact that we have the right to avoid procreation by means of contraceptives and abortion. If we have this right, should we not also have the right to avoid procreation?

In determining an individual's right to be cloned one must consider the same "penumbras and emanations surrounding the Ninth and Fourteenth Amendments, first described by the Court in Griswold v. Connecticut that recognize a zone of individual privacy including marriage, the use of contraceptives and abortion." (www.princeton.edu/lawjourn) Can this zone of privacy be stretched to include noncoital reproduction (not involving sexual intercourse through cloning? If it is the case that a married couple is infertile or at risk for a child with a genetic disorder then could cloning be seen as the only option to produce genetically related offspring? According to Justice Douglas in his reversal of the Connecticut law to ban the use of contraceptives marriage is a special case where privacy should be protected.

"The Ninth Amendment provides; The enumeration in the Constitution, of certain rights, shall not be constructed to deny or disparage others retained by the people…The fourth and fifth amendments were described…as protection against all government invasions of the sanctity of a man's home and the privacies of life." (Griswold v. Connecticut 381 U.S. 479,1965)

The Supreme Court on several occasions has recognized a married couple's right to procreate in language broad enough to include coital and most noncoital forms of reproduction. In Meyer v Nebraska, for example the Court stated that constitutional liberty included the rights of an individual to "marry, establish a home and bring up children."(Meyer v. Nebraska262 U.S. 390,399,1923) In Stanley v Illinois the court observed that "the rights to conceive and raise one's children have been deemed 'essential,' 'basic civil rights of man,' rights far more precious… that property rights." (Stanley v. Illinois 405 U.S. 645,651,1972)

According to The Cleveland Board of Education v. LaFleur (414 U.S. 632, 1973). The court has noted that "freedom of personal choice in matters of marriage and family life is one of the liberties protected by the Due Process Clause of the Fourteenth Amendment. Further support for an individuals right to procreate can be found in Justice Brennan's opinion in Eisentadt v Baird (404 U.S. 438, 453, 1972):

"If the right to privacy means anything, it is the right of an individual, married or single, to be free of unwarranted governmental intrusion into matters so fundamentally affecting a person as the decision whether to bear or beget a child."

If it is possible for a couple to exercise their right to procreate by using contraceptives and it is possible for a woman to terminate her pregnancy through abortion, is it unreasonable to ask whether we can choose to have the type of child we want? Roe v. Wade held that the interest in protecting fetal life is not sufficient to override the right of privacy. If cloning were allowed, many of the early deaths would involve fetuses, not viable human beings. After the decision in Roe v. Wade it could be possible that the interest in protecting fetal life cannot be overridden by the right to choose.

In the case of Planned Parenthood of Southeastern Pennsylvania v. Casey, the justices gave the following opinion, "Constitutional protection of the woman's decision to terminate her pregnancy derives from the due process clause of the Fourteenth Amendment…Our law affords constitutional protection to certain personal decisions relating to marriage, procreation, conception, family relationships, childrearing and

education…These matters, involving the most intimate and personal choices a person may make in a lifetime, choices central to personal dignity and autonomy, are central to the liberty protected by the Fourteenth Amendment. At the heart of liberty is the right to define one's own concept of existence…and the mystery of human life.

"…If a person would choose not to reproduce if she knew that the child would have a disability or some other undesired characteristic, then she should be entitle to have that information and to act on it. Her right to avoid reproduction for any reason would entitle her to avoid reproduction for a particular reason. Similarly, her right to have offspring only if she thinks that offspring will have particular characteristics." (John A Robertson, Genetic Selection of Offspring Characteristics)

Then there is the case of the couples and single people that desire to clone when there is no reproductive failure. The case here is not as strong as for those who cannot conceive. The first type of couple would be one that wanted to clone a child that had died. The other type of couple would be a homosexual couple.

In the case of homosexual couples and more specifically lesbian couples, it can be argued that they have the right to clone because they desire to clone without any male involvement and therefore are equivalent of reproductive failure because sexual reproduction is not an option. As far as a homosexual male couple is concerned, their claim to clone may be viewed as less valid because while one male can donate the DNA to clone neither of them can carry the child and a woman's services would be necessary to carry the child to term. "Of course if heterosexuals are permitted to clone where there is no reproductive failure, then homosexuals should be free to do it as well…" (John Robertson. Two Models of Human Cloning)

The Argument Against Human Cloning

There is a strong argument that human cloning should not be allowed. There are many reasons why scientists and common citizens may feel that it is bad idea. There are many risks involved and many feel that these risks are not worth the human life that would be damaged or lost in the process. The three main objections are as follows and were discussed in the section, W *hy Should We Care About Human Cloning?*

1. To protect against suffering and early death

2. Psychological Harm to the clone

3. Use and exploitation of human beings

The President's Council on Bioethics, Human Cloning and Human Dignity: An Ethical Inquiry (2002) issued a minority and majority review on the issue:

Majority Recommendation: Ten members of the council recommended a ban on cloning-to-produce-children combined with a four- year moratorium on cloning-for-biomedical-research. We also call for a federal review of current and projected practices of human embryo research, pre-implantation genetic diagnosis, genetic modification of human embryos and gametes, and related matters, with a view to recommending and shaping ethically sound policies for the entire field…

Minority Recommendations: Seven Members of the Council recommend a ban on cloning-to-produce-children, with regulation of the use of cloned embryos for medical research.

Vocabulary List

Allele One of the forms of a gene for a given trait.

Base A portion of the DNA molecule. DNA has four bases: adenine(A), thymine (T), cytosine (C), and guanine (G).

Base Pair Two bases that combine and form a “rung” on the double helix DNA molecule. Adenine (A) can only bond with Thymine (T), and Cytosine (C) can only bond with Guanine (G).

Bioengineering Manipulating the genes of plants or animals for a specific purpose.

Bioethicist Someone who studies ethical issues in medicine and genetics.

Carrier A person who has a recessive gene for a genetic disease, but does not develop the disease because he or she also has a dominant partner gene that overrules the recessive gene

Cell fusion When two cells combine to become one. A sperm fertilizing an egg is an example.

Chromosomes Thread-like structures in a cell’s nucleus that contains its DNA

Clone Organisms that have the exact same DNA genomes

Cloning vector A virus or other kind of material that can be used to insert foreign DNA into a cell.

DNA (deoxyribonucleic acid) The basic molecule of heredity that contains all genetic material.

DNA sequencing The process of determining the exact order of the base pairs that make up the DNA in a given organism.

Dominant A form of a gene that can override its partner allele.

Double helix The shape of the DNA molecule, made up of two spirals, with hydrogen bases connecting them.

Gene The basic unit of heredity A gene is a portion of DNA.

Gene therapy A form of medicine in which genes are manipulated in order to correct diseases caused by genetic defects.

Genome The sum of all of the DNA on the chromosomes in a given organism. Every living organism has its own distinctive genome.

Heredity Passing of traits from one generation to the next.

Heterozygous When two alleles for a given gene are different.

Homozygous When two alleles for a given gene are the same.

Human Genome Project A joint scientific effort in which the entire human genome was mapped.

Mitosis nuclear division involving duplication and separation of the chromosomes.

Nuclear transfer A process of cloning in which the DNA from an adult cell is put into an egg cell that has had its nucleus removed. The resulting embryo is then implanted in an animal and brought to term.

Nucleotide A building block of DNA made up of a sugar, phosphate and a base.

Nucleus The central part of a cell that holds its chromosomes (not found in bacteria)

Phenotype The physical manifestation of an organism's traits.

Prokaryote A one-celled creature lacking a nucleus, such as bacteria.

Recessive An allele whose function is inactive if there is a dominant allele present. It functions only if two recessive alleles are present.

Somatic cells All the cells in a body except for the reproductive cells.

Stem cells Embryonic cells that are still undifferentiated and can develop into any kind of cell in the body.

Transgenic animal An animal that is made up of genes from more than one organism.

Vector In gene therapy, a way of delivering a gene into an existing organism's cells.

Lesson Overview

Lesson 1: What is cloning?

Major objectives

Students will be able to improve their decoding and reading skills

Students will be able to define cloning

Materials

News articles on cloning from various sources:

New Scientist Cloning Section

www.newscientist.com/hottopics/cloning/cloning.jsp

HumanCloning.org

www.humancloning.org

Dictionary

Vocabulary word search sheet (handout 1)

Sentence strips

Procedure

Students will be assigned one short cloning related article to read on their own. They will be asked note any words that are new and define them.

Next they will be required to write a one-paragraph summary of what they have read. They will then read this summary to an assigned partner who in turn will share their summary of a different article.

Each partnership will then be required to define the terms listed on the vocabulary sheet.

The teacher will ask each group to say out loud the definition of one of the vocabulary terms.

Finally, each group will use the sentence strip to write out one thing they already new about cloning, one thing they learned about cloning and one question they still had about cloning.

Closure

Each group will read these aloud and the teacher will post the questions on the blackboard. The class will revisit these questions at the end of the unit and hopefully all the new questions would be answered.

Handout #1

Introduction to Cloning

Objective: write in the meanings of the vocabulary words and then find them in the puzzle.

A H B L A D N Q B E X Y Z J R X K E Y L N L E G D

R E L L G B V F O U C I P T H W Z T R N T L K Y M

I M N P C W P D F T C K E T T B I W Z H B E E M L

H X G E M L A L S Q Z C G Q H D J A E T Y C X L U

D N L G O K G T I U L B P L E J Y R I H S M M G D

R L K I V E I P Y E O L I R P U A Q I B K E E X E

S U X F B A S I Y R X K E E C P S Q R K Q T U F Z

K D P V C O X F F T B H A J E F F O Y T R S O B H

U M P T H L R Y T F G B K U Q Z A D M Q M F U K O

A D N S A Q V X K A J N T F W G T U P A T J J I K

F N R B G M T P S F K I E N C O L J L M T E N E G

T E D E E C B E X U C N C F L V O P E S Y I M M B

J B I T E M T J U C N C D E O J V Q H S D Z C I K

Q T N L N X D D L P U O R U N X M O O Z O Q P A W

M A J O L A D O A R H J I E E X O X H I E S E A K

N Q J P M F N R E F S N A R T C I T E N E G L C B

P B Z E D I B I M O Q S G L O N G J G I L L O O R

I P O N N L S I B Y Y A F L L R B N O O Z F E W Y

C R F G P I O W R M D I I H J K A U M P H O N Q V

I S A X M Z B M A W O F Y G Q R M E T F P T J H W

N W N U C L E U S L F C Z A Q X A Q X V Q A L Y X

M I N P L R X X L G R J E T F U Y P K D K C K U M

X J W G J P L T A R H E B R R L R Y K J T L V I I

L U W T S S F H R F L O H P Z G K T H D T Z X L I

A A Y S M W W A T T G T U F S G G X Z E M A M N A

CELLS-

CLONE-

GENE-

GENETIC TRANSFER-

HEREDITY-

NUCLEUS-

RECOMBINANT DNA-

SOMATIC-

STEMCELL-

THERAPEUTIC CLONING-

TWIN-

Lesson 2 : What is Cloning?

Main Objectives

Students will be able to define cloning

Students will use directed reading to improve their reading comprehension skills

Students will improve their ability to use the Internet

Students will be able to describe the process of reproductive cloning

Materials

Access to a computer for all students. (Alternatively, the teacher may print the website pages needed and make a copy for each student. This does not work as well because there are short video clips that are useful.

http://gslc.genetics.utah.edu/units/clonin/whatiscloning

Directed reading sheet (modified if not using a computer)

Procedure

Directed reading is a method used to help students focus on what they are reading. Some students may have to have their vocabulary sheets to use as a reference.

Students will go to the following web site and fill in the directed reading sheet

Directed Reading Sheet #1 (adapted from middleschoolscience.com)

1. _____ is the creation of an organism that is an exact genetic copy of another.

2. There are human clones among us right now. They were not created in the lab, they are called _____, created naturally.

3. _____ is the relatively low-tech version of cloning. This technology mimics the natural process of creating identical twins.

4. Artificial embryo twining uses the same approach, but it occurs in a _____ instead of a mother's body.

5. Somatic cell nuclear transfer was a method used to create _____.

6. A _____ _____ is any cell in the body other than the reproductive cells.

7. It's the difference in our _____ that makes us unique.

8. To make Dolly, researchers isolated a _____ from an adult female sheep. Next, they _____ the

_____ from that cell to an egg cell from which the nucleus had been removed. After a couple of chemical tweaks, the egg cell. With its new nucleus, was behaving just like a freshly fertilized _____. It developed into an _____, which was implanted into a _____ and carried to term.

9. _____ (was the first ever mammal to be cloned from an adult somatic cell.

10. Play the natural reproduction movie for this question. Because the offspring contains a combination of the two sets of parent's chromosomes, it is not genetically identical to either parent but is, instead, _____.

11. Play the somatic cell nuclear transfer movie for this question. The somatic cell is _____ in a media that causes it to _____ _____ as an udder cell.

12. An egg cell is _____ from a different animal. The egg cell's _____ is removed.

13. The egg cell and the somatic cell are _____ using an _____ _____.

14. Go to this web site and follow the instructions

http://gslc.genetics.utah.edu/units/cloning/clickandclone/

List all the six steps in the "click and clone" procedures

1._____

2._____

3._____

4._____

5._____

6._____

15. What color is the cloned mouse? _____.

16. In the real mouse cloning experiment, what was the name of the first born survivor? _____.

Lesson Three:Performing Recombinant DNA Technology Lab

Main objectives

Students will be able describe the process of recombinant DNA technology

Students will simulate the process of transforming bacterial DNA using recombinant DNA technology.

Instructional Input

Bacterial cells are prokaryotic, that is they are single-celled organisms that do not have a nucleus. Since there is no nucleus to hold the chromosomes, bacterial DNA is found free in the cytoplasm. Bacterial DNA can be

found in a circular structure called a plasmid.

Recombinant DNA is a molecule formed when fragments of DNA from two or more different organisms are spliced together in the laboratory. Moving genes from the chromosomes of one organism to another is called genetic engineering. Today genes from human chromosomes can be routinely transferred into bacteria, thereby 'cloning' the gene.

In this activity students will simulate the process by which DNA from a human (the gene that codes for growth hormone) will be spliced into a bacterial plasmid that has been extracted from the bacterium *Escherichia coli* (E. coli). Please refer to Figure 1

A restriction enzyme, in this case EcoRI is used to cut out sections of DNA wherever the specific sequence CTTAAG occurs in the DNA molecule. It cuts it between the A and G, a site four bases apart on both strands, creating DNA fragments with single-stranded "sticky ends." Because the two single-stranded sticky ends have complimentary sequences, they can pair up with any other DNA fragment from any other organism cut by the same restriction enzyme.

Please find a diagram of this process at: www.accessexcellence.org

EcoRI is used to cut the growth hormone from the extracted human DNA and then used to cut out the same sequence on the bacterial plasmid. Next the human DNA fragment is inserted into the bacterial plasmid and the sticky ends match up and seal. The plasmid is then reintroduced into the bacterial cell and allowed to grow and divide. If the transformation is a success, then the new cells would produce human growth hormone.

Materials

Paper bacterial plasmid (circular colored paper with at least fifty base pairs, it must include the sequence CTTAAG and the complementary bases GAATTC)

Paper segment of human DNA (this must be another color, and about twenty base pairs long also with the same restriction enzyme sequence)

Scissors, tape, construction paper, poster board

Procedure

Make a handout of the instructional input and have students read it or assign appropriate reading in the text prior to start of this activity.

Make enough bacterial plasmids and human DNA fragments for each group before hand and assign groups.

Have students place the bacterial plasmid in the center of the poster board and have then draw a cell membrane around it. Use the scissors as the restriction enzymes and have students find the sequence of the DNA in the human fragment and have them cut it out and produce the human growth gene with stick ends. Next have students take the bacterial plasmid out of the cell and use the same EcoRI restriction enzyme scissors and cut the plasmid DNA at its one sequence. Then have students insert the human growth factor DNA into plasmid and seal it with tape. The bacteria haw not been transformed. Have students replace the plasmid and tell the students that the bacterial cell can now continue mitosis as normal and produce new cells with the human DNA. They have successfully cloned a gene!

Lesson Four: Position Paper

Main Objectives

Students will be able to develop and articulate an argument for or against human cloning

Students will be able to understand and evaluate scientific and legal literature

Instructional input

From the Report on the President's Council on Bioethics:

At the first Council meeting, the discussion of the ethics of human "reproductive cloning included the following distinctive strands. Some expressed and defined moral weightiness of an inarticulate or "instinctive" revulsion at the prospect of making cloned human children. Others, emphasizing the low success rate and the abnormalities observed in animal cloning, argued that any attempt at cloned baby-making would be (at least for now) a reckless experiment on the child-to-be, given the current state of scientific knowledge and technical facility. Both of these reactions gave the impression that saying no to human reproductive cloning is somehow obvious, or should be.

Perhaps this is true. But others disagreed. For one thing, people who are repelled by the prospect of cloning human beings are concerned not simply or primarily because the procedure is unsafe or might not work; their objection is to the results of a perfected cloning technology, and to a society that permits or embraces the creation of cloned human children. Moreover, the objection based on safety is not really an objection to cloning as such and may in time become a vanishing objection. Furthermore, several members believed that "moral repugnance" was an unreliable and untrustworthy guide to sound moral conclusions, and that, in any case, it was imperative that we try to articulate reasons or arguments that would justify such strong opposition to cloning.

The Cloned Child

The first cloned children--perhaps all cloned children--would be, so to speak, human experiments. They would be biological experiments--with grave risks of physical, developmental, and genetic deformity. They would be experiments in human identity – being the first human beings to inherit an identity already lived by another. They would be experiments in genetic programming and design, being the first children whose entire genetic make-up was known and selected in advance, They would be experiments in family and social life, confusing the relationships within the family and between the generations, for example, by turning "mothers" into "twin sisters" and "grandparents" into "parents."

Experience with animal cloning provides clear evidence to justify concerns about bodily harm to any child resulting from cloning seen as a biological experiment. But imaginig and reflecting on the prospect of being a cloned child leads to concerns about additional harms or injuries to the child related to the other ways in which cloning is an experiment on the child-to-be. Some of the leading concerns include:

1. A cloned child is at risk of psychic and social harm. For example:

a. He/she might experience a confused sense of self and a compromised belief in the openness of his future, knowing that he is in appearance and genotype identical to another person who has already lived.
b. He/she might suffer because his/her parents and others will not regard him/her as they would an ordinary child (a "mysterious stranger," a "surprise to the world"), but will instead constantly compare him to the "original" – not only to observe how similar he/she is, but also to wonder why he/she is not as similar as expected or planned.
c. He/she may suffer confusion of social identity, being both the twin and the offspring of only one biological "parent."

2. A cloned child may be injured (done an injustice), whether he/she knows it or not and quite apart from any experienced harm, by being treated as a product of parental design, whose "maker" stands above him/her not as a human equal but as a superior artificer.

We cannot be certain that any cloned child will in fact suffer the predicted psychic or social harms (item 1); knowledge about these matters would be largely empirical and would hence require producing cloned children before we could be certain. Yet given the likelihood of such risks and harms, and the question about the "justice" of cloning altogether, the accepted ethical principles governing human experimentation and the protection of human subjects, if fully regarded, might lead one to conclude that the cloning of a human child constitutes an unethical experiment on the child-to-be, even if and when the procedure could be rendered technically safe for use without the increased risks of serious bodily harm.

In arguing the ethics of reproductive cloning, we find ourselves in the strange position of "speaking on behalf" of human beings who do not yet exist and who may never exist. But such a paradox is an inevitable part of our embodied existence. One generation always springs from the previous one; and the previous generation whether it knows it or not, always "speaks on behalf" of the next when it chooses to bring it into existence. In the face if this radical new way of bringing children into the world, we are compelled to think even more deeply and protectively on behalf of our offspring, lest we do them irreparable harm and injury in the very act of giving them life.

Activity:

What would you do? Should cloning be allowed in any of these situations? Why or why not? Use evidence from the article and your prior knowledge to decide.

1. A couple has one child then they become infertile and cannot have any more children. Cloning would enable such a couple to have a second child, perhaps a younger twin of the child they already have.

2. A child is lost soon after birth to a tragic accident. Human cloning would allow such parents to have a twin of their lost baby, but it would be like other twins, a unique individual and not a carbon copy of the child that was lost under heartbreaking circumstances.

3. Two parents have a baby boy. Unfortunately the baby has muscular dystrophy. They have another child and it is a boy with muscular dystrophy. They decide not to have any more children. Each boy has over 20

operations as doctors attempt to keep them healthy and mobile. Both boys die as teenagers. The childless parents donate their estates to curing muscular dystrophy and to having their boys cloned when medical science advances enough so that their DNA can live again, but free of muscular dystrophy.

Teacher Resources

Human Genome Project Information. Cloning Fact Sheet

http://www.ornl.gov/techresources/Human_Genome

Human Cloning Activity

http://gslc.genetics.utah.edu/units/cloning/clickandclone/

Human Cloning Directed Reading

Human Cloning Articles

Human Cloning Articles

Animal Cloning Diagrams

Recombinant DNA Technology Diagrams

References

Garrison, Marsha. Scheneider, Carl. *The Law of Bioethics: Individual Autonomy and Social Regulation* . 2003. An casebook that includes a chapter on “Reproduction and Birth” as well as “Regulating Parental Choice”

Gralla, Preston D. *The Complete Idiot’s Guide to Understanding Cloning* . Alpha Books, 2004. A well written, easy to understand book on cloning and related topics.

Kass, Leon R. *Life Liberty and The Defense of Dignity The Challenge for Bioethics* . Encounter Books, 2004.

Wellington, Harry H. *The Supreme Court and The Process of Adjudication Interpreting the Constitution* . Yale University Press, 1990. A good reference book and also contains the entire constitution.