Elements of Biology
Genetics
Teacher's Guide

Grade Level: 9–12 | **Curriculum Focus**: Life Science | **Lesson Duration:** Two class periods

Program Description

DNA carries the instructions for a plant's or animal's characteristics. Unravel this large polymer and its four subunits A, G, C, and T. Then take a look at how scientists are working to unlock the mysteries of DNA.

Lesson Summary

Students consider the issues surrounding the use of genetic manipulation to correct or prevent problems in fetuses. Then students debate the ethical concerns surrounding this issue and assess the arguments to determine which side presented a more compelling case.

Onscreen Questions

Part 1, "Genes: The Blueprint of Life," "The Formation of Cells," and "Future Generations"

- How do genes control the processes of an organism?
- What was the purpose of the Human Genome Project?

Part 2, "Making Babies Genetically Correct"

- How will genetic manipulation be helpful for reproduction?
- What are some ethical issues concerning genetic manipulation in humans?

Lesson Plan

Student Objectives

- Describe the technologies make that make genetic manipulation possible.
- Identify situations in which genetic manipulation could solve a problem.

- Debate the positive or negative arguments of the ethical issues surrounding the use of genetic manipulation.

Materials

- *Elements of Biology: Genetics* program
- Paper and pens or pencils

Procedures

1. Begin the lesson by asking students to write what they might consider if they learned that a close friend or relative was pregnant with a child who has a genetic defect. Ask students what course of action they might suggest. Then ask them to put their suggestions away until the end of the lesson.
2. Show students the segment "Making Babies Genetically Correct." Then divide them into groups to discuss the program. Encourage them to address the following questions:
   - What do you think about the parents' decision to have a baby who would help correct the problems of their daughter?
   - What technological advances had to be in place before such an option was even possible?
   - What do you think about the second couple's decision to have a child, even though the father has Huntington's chorea?
   - What other situations can you think of in which genetic manipulation might be considered?
   - What are some ethical implications of genetic manipulation?
3. Give students a few minutes to discuss these questions in their groups. Then consolidate the groups into two teams. Have one team argue for the use of genetic manipulation and the second team against it.
4. Give students time in class to prepare for the debate. In addition to the information in the segment, students can learn more about this topic on the following Web sites.
   - http://kidshealth.org/parent/system/medical/prenatal_tests.html
   - http://www.genetics.com.au/factsheet/15.htm
   - http://www.genome.gov/10002401
   - http://www.geocities.com/geneinfo/facts/disabilities.html
   - http://www.hejweca.org/benoc/papers/ethicalhgp.doc

5. After students have completed their research, have the teams write their opening and closing statements and arguments. Make sure that each team is well prepared to challenge the other team's arguments.
6. Hold the debate during the next class period. Give each team a chance to present their position and at least one chance to rebut the other side's argument.
7. Discuss the outcome of the debate. Do students think that one team made a stronger case for their position? If so, why? Why were the arguments more compelling?
8. Conclude the lesson by asking students to revisit the suggestions they recorded at the beginning of he lesson. Based on what they have learned, would students still make the same suggestions? Or have they changed their ideas? If so, ask them to explain.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Students described in-depth new technologies that have made genetic manipulation possible; identified a variety of situations in which genetic manipulation could solve a problem; and developed clear and persuasive arguments of the ethical issues surrounding the use of genetic manipulation.
- 2 points: Students satisfactorily described new technologies that have made genetic manipulation possible; identified some situations in which genetic manipulation could solve a problem; and developed adequate arguments of the ethical issues surrounding the use of genetic manipulation.
- 1 point: Students had difficulty describing the new technologies that have made genetic manipulation possible; could not identify situations in which genetic manipulation could solve a problem; and did not develop complete arguments of the ethical issues surrounding the use of genetic manipulation.

Vocabulary

gene

Definition: A segment of DNA on a chromosome that contains the chemical instructions for a trait, such as height

Context: Gregor Mendel, a monk from central Europe, was one of the first scientists to discover that factors now known as genes determine which traits are passed from parents to offspring.

genetic disorder

Definition: A condition that is inherited through a faulty gene passed down from one generation to the next

Context: Sickle cell anemia, a disease in which the shape of red blood cells is malformed, is a genetic disorder.

genetic manipulation

Definition: The use of technology to replace genes or ensure that only certain genes are present in a fertilized egg so that genetic disorders are not passed on

Context: Some people oppose genetic manipulation because they think the medical and ethical considerations are too risky.

genetic testing

Definition: A means of finding a faulty gene, often through a blood test

Context: Genetic testing is available for many disorders, including Huntingdon's disease, cystic fibrosis, and some cancers.

in vitro fertilization

Definition: Creating a fertilized egg in a test tube

Context: After in vitro fertilization has been accomplished, scientists can test one cell to find out if faulty genes are present.

prenatal testing

Definition: A diagnostic test conducted in the early stages of pregnancy to determine the presence of a genetic disorder

Context: While prenatal testing can provide much information early in a pregnancy, it also raises serious questions, such as what should be done if a genetic disorder is detected.

Academic Standards

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K–12 Education addresses 14 content areas. To view the standards and benchmarks, visit http://www.mcrel.org/.

This lesson plan addresses the following national standards:

- Life Sciences—Understands the principles of heredity and related concepts
- Nature of Science—Understands the scientific enterprise
- Technology—Understands the nature and use of different forms of technology

- Language Arts—Viewing: Uses viewing skills and strategies to understand and interpret visual media

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K–12 to promote scientific literacy. To view the standards, visit this Web site: http://books.nap.edu/html/nses/html/overview.html#content.

This lesson plan addresses the following national standards:

- Life Science—Molecular basis of heredity
- History and Nature of Science—Science as a human endeavor

DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How to Use the DVD

The DVD starting screen has the following options:

Play Video—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

Video Index—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

Curriculum Units—These are specially edited video segments pulled from different sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

Standards Link—Selecting this option displays a single screen that lists the national academic standards the video addresses.

Teacher Resources—This screen gives the technical support number and Web site address.

Video Index

I. Genes: The Blueprint of Life (5 min.)
The passing of traits from parents to offspring is the process of heredity. Discover the structure of DNA and the basics of genetics and heredity.

II. The Formation of Cells (6 min.)
Examine the stages of mitosis and meiosis to see how specialized cells multiply to form tissues and organs in humans and other organisms.

III. Future Generations (6 min.)
Explore dominant and recessive traits and the effects of different genetic mutations while examining the goals of the Human Genome Project and the ethical controversy surrounding the science of genetics.

IV. Making Babies Genetically Perfect (30 min.)
Scientific research has lead to genetic procedures for reproduction that are giving hope to many people, but where should the ethical line be drawn?

Curriculum Units

1. DNA and Genetics
Pre-viewing question
Q: What do you know about genetics?
A: Answers will vary.

Post-viewing question
Q: Describe the structure of DNA.
A: Hereditary information is contained in the nucleus of each cell as molecules of DNA. A DNA molecule's two long strands of sugar and phosphates form a double helix, or spiral structure. The strands are bound together by pairs of bases that resemble the rungs of a ladder. A sugar, a phosphate, and a base together make up a molecule called a nucleotide.

2. Interphase and Mitosis
Pre-viewing question
Q: What kinds of cells do you know about?
A: Answers will vary.

Post-viewing question
Q: What happens during interphase?
A: Before mitosis can occur in plant and animal cells, a cell's DNA must be duplicated. This occurs during interphase, the stage in which the double helix comes apart like a zipper. Each DNA strand replicates itself so that the nucleotides and gene sequence are repeated exactly in

the new strand. This results in sister chromatids, or two copies of each chromosome. The cell now contains two complete copies of its genome.

3. The Process of Meiosis
Pre-viewing question
Q: What traits make you unique?
A: Answers will vary.

Post-viewing question
Q: How are gamete cells created?
A: Genetic material doubles; each chromosome lines up with its corresponding partner to exchange genetic material. The chromosomes collect in the middle of the cell and one chromosome from each pair is pulled to an opposite end. The cell divides in two; both new cells each contain half the original number of chromotids. Each cell divides again, splitting the chromotids in half. The process creates four gamete cells, reproductive cells containing half the necessary DNA. In a female, they will be an egg; in a male, they are sperm.

4. Genetic Mutations
Pre-viewing question
Q: What traits do you share with your parents or family members?
A: Answers will vary.

Post-viewing question
Q: What are some genetic mutations that create human diseases? How do they occur?
A: Mutations are errors that occasionally occur in the sequencing of nucleotides. Cystic fibrosis occurs when missing nucleotides prevent a gene from making a functional protein. Down syndrome is the result of an extra chromosome 21, resulting in total of 47 instead of the usual 46 chromosomes. A one-letter misspelling of a base pair brings about sickle cell anemia, meaning that one nucleotide is incorrect. Cancer is a mutation of the mechanism that regulates cell growth.

5. Embryonic Diagnostics
Pre-viewing question
Q: What might be some pros and cons of genetic testing in unborn babies?
A: Answers will vary.

Post-viewing question
Q: How do scientists make genetic diagnoses in embryos?
A: Such a genetic diagnosis takes place when an acid probe cuts through an embryo's wall to remove a single cell; an embryo usually has eight cells at this stage. Inside the cell's nucleus are 23 pairs of genetic chromosomes and inside them are as many as 25,000 genes that make up the human genome. Scientists can identify the genes in these cells that cause diseases by using

information from the Human Genome Project.

6. Ethical Considerations
Pre-viewing question
Q: What controversies surround advances in modern medicine?
A: Answers will vary.

Post-viewing question
Q: Do you think geneticists should help people have babies specifically to save children with life-threatening conditions?
A: Answers will vary.

7. Selecting Specific Traits
Pre-viewing question
Q: Which of your traits or characteristics would you like to pass on?
A: Answers will vary.

Post-viewing question
Q. What might be future applications of genetics beyond medical diagnosis?
A. The field of genetics may one day be able to assess from one cell a person's height, color of eyes, longevity, and sensitivity to certain diseases.

8. Your Genetic Future
Pre-viewing question
Q: Given the opportunity, would you undergo a test for genetic mutations?
A: Answers will vary.

Post-viewing question
Q: What might be the advantages and disadvantages of advances in the science of genetics?
A: Answers will vary.