

Unit 3: DNA and Genetics

Module 7: Biotechnology and Genomics

NC Essential Standard:

- 3.3 Understand the applications of DNA technology



True or False ...What do you think?

1. DNA is located in blood cells, but not any other type of cell.
2. Different cells from an organism contain different DNA.
3. A child has all of the DNA of his/her father and all of the DNA of her/his mother.
4. DNA fingerprinting occurs when police use ink to “fingerprint” suspects.
5. Genetic engineering can be used to remove existing genes.
6. Genetic engineering directly affects protein synthesis.
7. Genetic engineering allows us to put a gene from any species into another species to have that trait expressed in exactly the same manner as in the original species.
8. As a result of the Human Genome Project, we know the location of each gene in the human genome.
9. The Human Genome Project is a project designed to make it possible for humans to choose desired traits for a baby.
10. Adult stem cells come from adults and embryonic stem cells from unborn children.

I. How can we use DNA to help humans?

A. DNA Fingerprinting

1. Each individual (except clones and identical twins) has a unique DNA sequence. This sequence can be used to produce a **DNA fingerprint**, a unique band pattern of DNA fragments.
2. A DNA fingerprint is produced using a gel electrophoresis. A **gel electrophoresis** is a machine that separates pieces of DNA based on size (the number of base pairs).
3. The process of producing a DNA fingerprint can be described in three basic steps:
 - a. A **restriction enzyme** is used to cut the DNA sample into pieces. A restriction enzyme binds to a specific sequence of DNA bases, called a restriction site, and

Compare a DNA fingerprint with a typical fingerprint:

cuts (cleaves) the DNA between two of the bases in that site. This produces many pieces of different sizes.

- b. Once the restriction enzymes have recognized all the restriction sites and have cleaved the DNA into pieces, the sample is loaded into a **gel** for electrophoresis. Electricity forces the DNA pieces to move through the gel. Smaller pieces are able to move farther than larger pieces. The electrophoresis creates a separation of pieces by size – making a column of bands.
 - c. The DNA sequence of different individuals will have different numbers of restriction sites, or restriction sites in slightly different places. The variation of restriction sites means that an individual’s band pattern will likely be different from other individuals. By comparing band patterns, we can determine many things.
4. DNA fingerprints can be used for several applications.

- a. A DNA Fingerprint can be used to identify an individual, or determine the source of DNA left at a crime scene.

Example:

A bloody knife was found a short distance from a murder victim. Two suspects have been identified:

Blood on Knife Victim Suspect A Suspect B

_____	_____	_____	
_____			_____
_____		_____	_____
_____	_____		
_____	_____		_____

Find ONE WORD that describes each of the three steps of making a DNA fingerprint. A hint is given! Write the word below:

1. C _____

2. E _____

3. C _____

Highlight the shortest piece of DNA in this fingerprint.

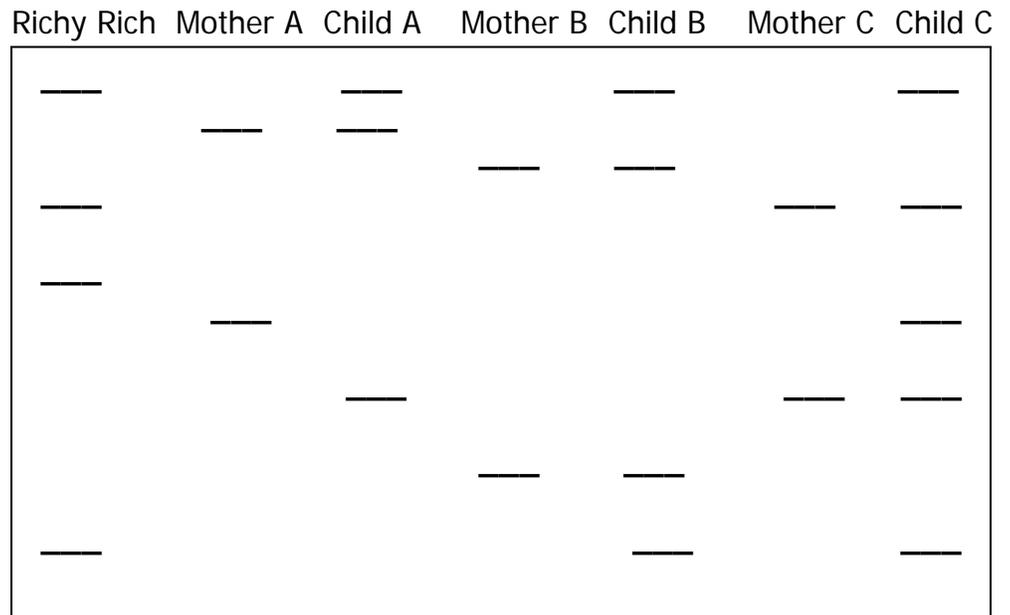
What tool/process was used to create this fingerprint?

Explanation: The blood on the knife came from two sources – the victim and another person (we can eliminate the bands of the victim, but other bands remain). By comparing the remaining bands, it is clear that Suspect A is cleared, and Suspect B is ... suspect.

b. A DNA Fingerprint can be used to determine paternity.

Example:

A millionaire has been charged with several paternity cases. His lawyers ordered DNA Fingerprints:



How is analyzing a DNA fingerprint for paternity DIFFERENT than analyzing a fingerprint to identify an individual's DNA from a crime scene?

Explanation: Because half of your DNA is inherited from your mother and half from your father, each band in a child's pattern will also appear in either the pattern of the mother or of the father. Child A could NOT be Richy Rich's child because of the third band in the child's pattern. Child C could NOT be Richy Rich's based on the third band in the child's pattern. Child B COULD be Richy Rich's child.

- c. DNA fingerprinting can be used to catalog endangered species. For example, researchers have developed DNA banks of endangered species protected by law. This allows them to prove if endangered species are used in products, such as medicines or foods.

Check Yourself!

1. What is a DNA Fingerprint?
2. What technology is used to make a DNA Fingerprint?
3. What type of enzymes are used to cut DNA?
4. What are three uses for DNA fingerprinting?



B. Genetic Engineering

1. **Genetic engineering** is the modification of DNA. Modification means changing, such as adding or removing parts of the DNA sequence.
2. Genetic engineering may be used to produce a **transgenic** organism (an organism containing foreign DNA) to use in gene therapy or gene cloning.
3. Genetic engineering can be used for several applications:
 - a. Creating a transgenic, or genetically modified organism
 - i. Restriction enzymes are used to cleave the foreign DNA source in order to isolate the desired gene. For example, removing the insulin gene from human DNA.
 - ii. The same restriction enzyme is used to cleave the vector (which may be a bacterial plasmid). A **vector** is the structure used to carry the foreign DNA.

A transgenic organism is also called a....

G_____

M_____

O_____

aka "GMO"

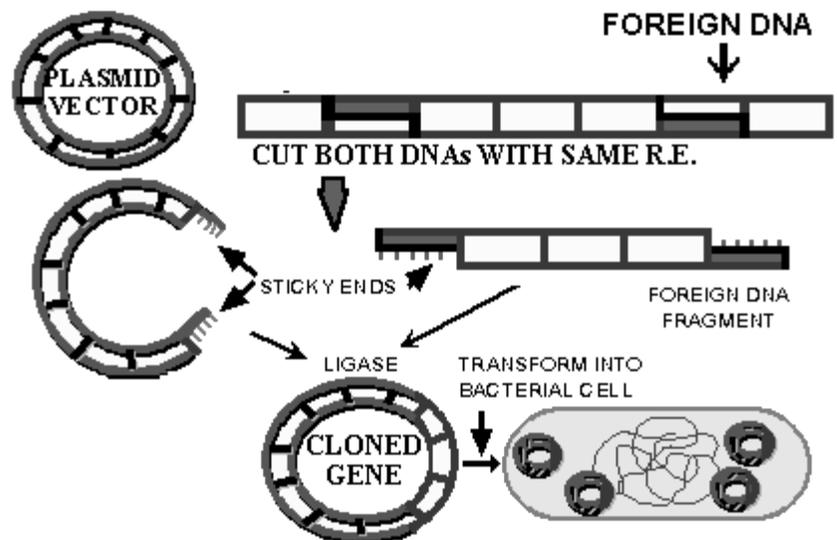
How are each of the words related to genetic engineering?

1. Vector –
2. Recombinant DNA –
3. Host cell –

- iii. The foreign DNA fragment (the desired gene) and the vector are combined/spliced together. The combination is possible for two reasons. First, DNA is similar in all organisms. Second, the same restriction enzyme is used on both samples of DNA.
- iv. The combined DNA (called **recombinant DNA**) is inserted into the **host** (which may be a bacteria cell). The host cell will copy/clone the recombinant DNA as it reproduces and will produce the protein (such as insulin) from the desired gene during protein synthesis.

Find ONE WORD that completes the short description of each of the four steps. A hint is given! Write the word below:

1. C_____ DNA
2. V_____ opened
3. C_____ together
4. I_____ into host



- b. Genetic engineering may be used for **gene therapy**. Gene therapy has been used to treat Severe Combined Immunodeficiency (SCID) and cystic fibrosis (CF). It has been shown to be safe for up to 10 years to treat SCID, but patients have the risk of developing leukemia. In treating cystic fibrosis, the results have

been limited because the patient's immune system is fighting off the virus used to carry the correct gene to the target cells.

Summarize the process of using GENE THERAPY:

- i. Defective genes are identified within the DNA sequence. Individuals may be tested for the presence of the defective gene (for example, the IL2RG gene in SCIDS).
- ii. A functioning gene, isolated from a donor's DNA is "packaged" into a vector/carrier (such as a cold virus used for CF gene therapy).
- iii. The vector is introduced to the organism with the defective gene. The functioning gene is delivered to target cells and randomly inserts itself into the DNA (this is what likely caused the leukemia in the SCID treatment). Now the cell can produce the correct protein.



4. Genetic engineering has many practical purposes.

- a. Medical applications include producing large quantities of human proteins (such as insulin and human growth hormone) cheaply and providing animal models of human genetic diseases (such as knock-out mice).
- b. Agricultural applications include producing plants that are herbicide or pest resistant and plants that have higher nutritional value. These plants are commonly called GMOs (genetically-modified organisms).
- c. Industrial uses include using microorganisms to clean up mining waste, sewage treatment, and environmental disasters.

Watch It!



5. Genetic engineering raises serious bioethical concerns.
 - a. The question may need to be “Should we?” instead of “Could we?” For example, should we alter the natural variation of human genes by genetic engineering?
 - b. Creating plants with new genes may trigger allergic reactions. For example, adding a gene from a peanut plant to a corn plant in order to increase nutrition may cause an allergic reaction in some people.
 - c. Creating organisms that are not naturally occurring may create problems in the environment or for humans. For example, an oil digesting bacteria may get into oil-based machinery and our oil supplies.

Check Yourself!

1. What is genetic engineering?
2. What is a transgenic organism?
3. How are restriction enzymes used in genetic engineering?
4. What is gene therapy?
5. List two practical applications of genetic engineering.



How is the Human Genome Project like creating a map of the world?

- II. How do we know where human genes are located on chromosomes?
 - A. The **Human Genome Project** (HGP) is a collaborative effort among scientists around the world to map the genes of a human.
 - B. The purpose of the HGP was to identify the location and sequence of genes on chromosomes to better understand human genetics.
 - C. A primary application of the Human Genome Project is to determine whether individuals may carry genes for genetic conditions such as sickle cell anemia. Once scientists determine the location and DNA

sequence of the defective gene, they may be able to develop gene therapy or genetically based medicines to correct the condition.

D. The Human Genome Project raises serious bioethical questions.

1. The HGP has allowed for the development of **genetic screening**. For example an individual can be tested for the presence of a gene that may contribute to breast cancer. Should the patient be notified of the presence of this gene, even though the presence of the gene does not guarantee breast cancer and may change the way they live their life? Should insurance companies be able to require genetic testing before they will insure people?
2. The HGP has identified the location of genes. Research is now focusing on the function of those genes – including those controlling physical traits. Should humans be able to use the results of the HGP to create “designer babies”?
3. The HGP has allowed scientists to determine DNA sequence of genes important to medicine. Should pharmaceutical companies be allowed to patent gene sequences for use only within their company?

Genetic screening:

Pros -

Cons -

III. Are stem cells the next “big thing” in genetic research?

A. **Stem cells** are unspecialized cells that continually reproduce themselves.

These cells have the ability to differentiate into one or more types of specialized cells. Scientists hope to learn to control that differentiation.

B. There are two basic types of stem cells:

Differentiate between embryonic and adult stem cells....

1. **Embryonic stem cells** are cells found in an embryo that have not yet differentiated into various cell types. These cells are taken from eggs that are fertilized *in vitro* and then donated for research.
2. **Adult stem cells** (sometimes called somatic stem cells) are found in the organs and tissues of an organism that

can renew itself. These cells can differentiate to yield some or all of the major cell types of that tissue or organ. These are more limited than embryonic cells.

C. Stem cell research, though very controversial, is a very active area of research. Scientists have recently demonstrated that stem cells, both embryonic and adult, differentiate into one or more types of cells in a lab. There are several potential applications of stem cells:

1. Learning how to control cell differentiation to treat cancer
2. Using stem cells to test new drugs on many cell types by creating those cell types in a lab with stem cells
3. Stem cells, directed to differentiate into specific cell types, may allow a source of replacement cells to treat diseases like Alzheimer's, spinal cord injuries, stroke, and diabetes.

D. Ethical concerns about stem cell research center around the source of stem cells. A significant number of people believe removing cells from an embryo, whether or not the embryo is formed in a lab, is destroying human life. This raises an ethical question about when life begins, and whether it is ethical to sacrifice that life (if it has begun) to potentially save another life via research or cell-based therapies.

Watch It!



Check Yourself!

1. What is the Human Genome Project?
2. Name two uses of the Human Genome Project?
3. What is a stem cell?
4. What are the two types of stem cells?



Genetic Engineering

Recombines

DNA

from

___different species

requires

3 steps

___/cut gene of interest

using

to

Cut open bacterial

Remove desired

___/"glueing"
DNA

To make

of

A _____ (plasmid or virus)

To place

Recombinant DNA into a host cell (now _____)

Which allows

_____ and _____ of gene

Used to make

Human growth hormone

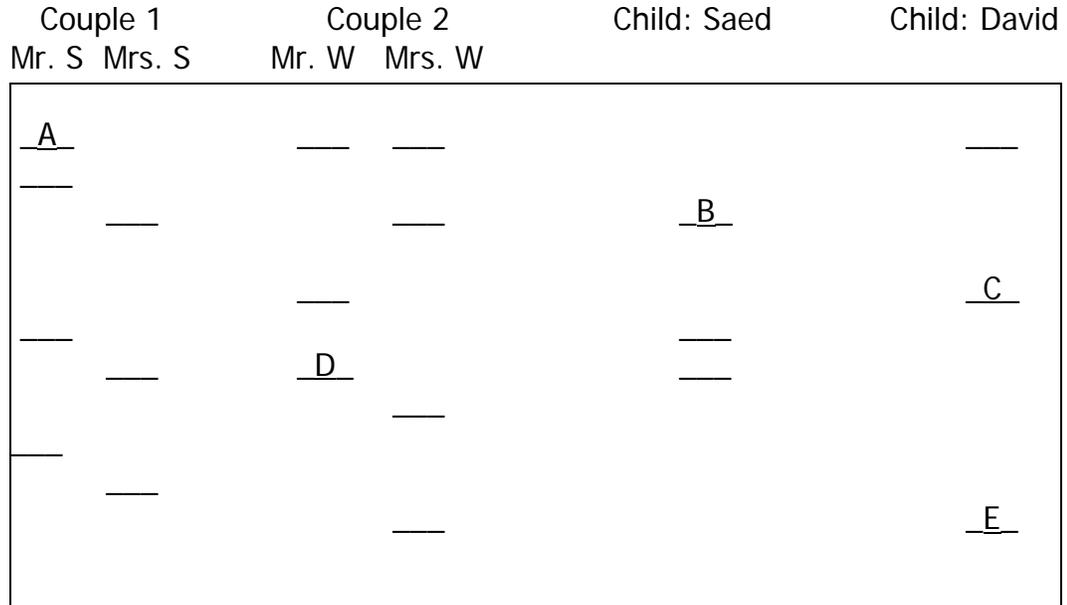
Insulin

Word Bank:

2	Recombinant DNA
Cleave	Replication
Expression	Restriction Enzyme
Gene	Splice
Insert	Transgenic
Plasmid	Vector

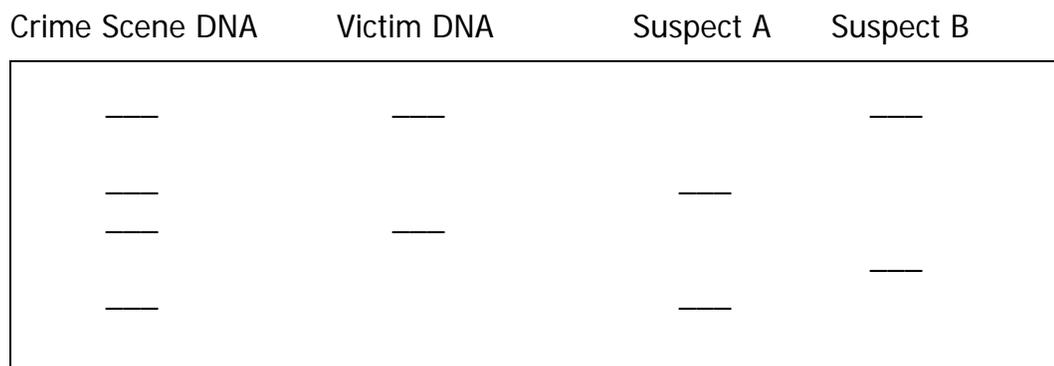
Unit 3 / Module 7
Problem-Solving Set

1. Use the DNA gel results below to answer the following questions:



- Of the labeled pieces (A, B, C, D, E) which piece is the longest fragment? _____
- How many fragments of DNA does Mr. W have? _____
- Which couple are the most likely parents of David? _____
- Which couple are the most likely parents of Saed? _____

2. Use the DNA gel results below to answer the following questions:



- Does it appear that the crime scene DNA sample may contain DNA from the victim? How do you know?
- Which suspect was more likely at the crime scene? How do you know?

3. Label the following diagram with the words below. Parentheses indicate places you need to label. Then, answer the questions.

Word Choices:

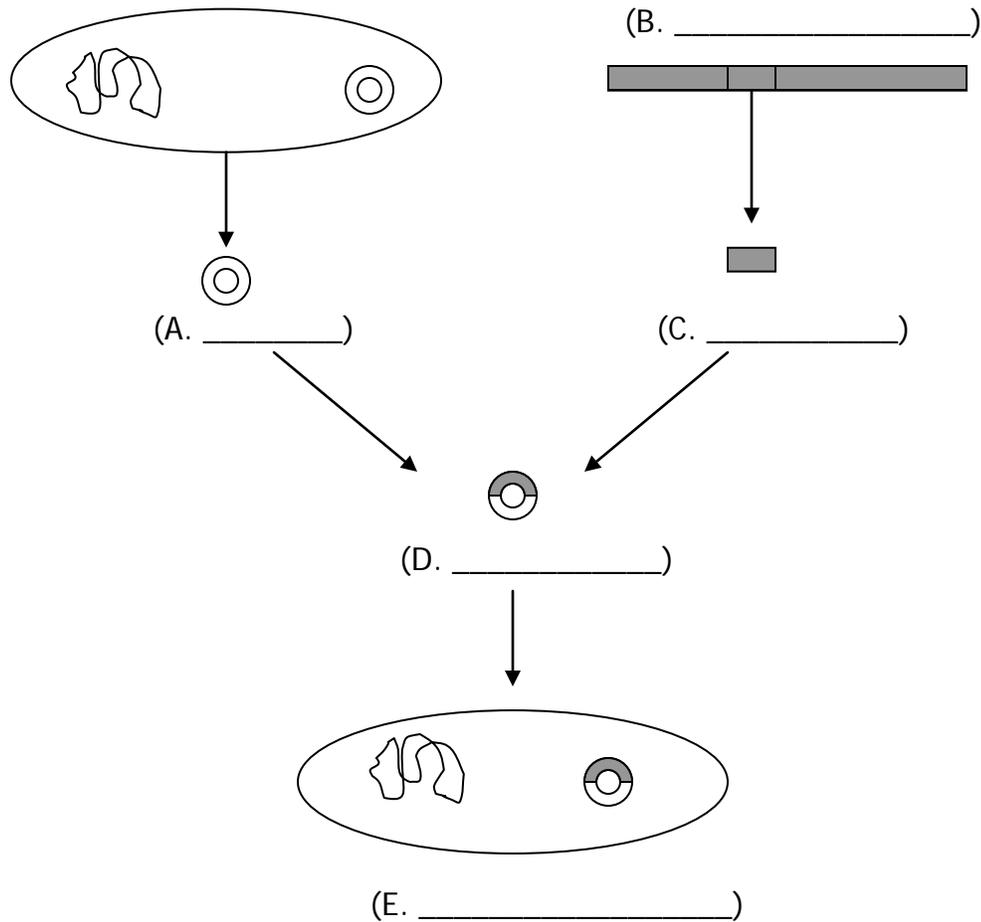
Desired gene

Transgenic Organism

Foreign DNA

Vector

Recombinant DNA



- A bacteria cell provided the vector. What is the name for this particular kind of vector? _____
- What will happen to the vector when the bacteria cell divides using binary fission? _____
- What chemical "tool" was used to cut out the desired gene and open the vector? _____
- If the desired gene in this diagram was human growth hormone, would the bacteria cell be able to produce the human growth hormone being engineered? Why/why not? _____

4. What do you think? For each of the following statements, circle the number that best describes your response. Then, use the underlined terms in each statement to describe YOUR stance on the issue. Make sure you use ideas and concepts we have discussed in this unit and write in complete sentences!

a. DNA fingerprints are very reliable and should be used as evidence in criminal cases and to determine paternity of children.

Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
1 2 3 4

Response: _____

b. Using genetic engineering to make transgenic organisms is necessary to produce human proteins, such as insulin, for people who cannot produce the proteins.

Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
1 2 3 4

Response: _____

c. Producing plants that are pest resistant and have higher nutritional value by using genetic engineering does not outweigh the risks of GMO's, such as possible allergic reactions.

Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
1 2 3 4

Response: _____

d. People should be able to use the information discovered by the Human Genome Project to select physical traits of offspring and create designer babies.

Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
1 2 3 4

Response: _____

