Module 1
Biotechnology Basics

Investigation 1.1 Biotechnology Basics
- Biotechnology History PowerPoint Presentation (en Español)
- Timeline Activity (en Español)
- Biotechnology Terminology Activity (en Español)

Investigation 1.2 Cells to Cloning
- Where is the genome? Cell Structure and Function (Recursos en Español)
- Mitosis and Meiosis (Recursos en Español)
- Stem Cells (Recursos en Español)
- Cloning

Investigation 1.3 Enzymes and Biotechnology
- Lock and Key Model Activity
- Induced Fit Model Activity
- Enzyme Terminology Activity
- Food, Enzymes and Biotechnology- Chymosin Activity – Genetically Engineered Enzyme
- How Enzymes Work (factors affecting enzymes)
- Restriction Enzyme Activity
Module 1
Investigation 1.1 Biotechnology Basics

Objectives
1. Students will understand important discoveries in biotechnology.
2. Students will review terminology used in biotechnology.

Materials
- PowerPoint presentation – Biotechnology Basics
- Biotechnology cartoons
- Time-line Activity Sheet
- Biotech vocabulary puzzles

Procedure
1. Handout - Biotechnology Timeline
2. Review PowerPoint presentation. Students may want to take additional notes on the timeline.
3. Cut out Biotechnology Timeline Cards. Have students place cards in the correct sequence of events.
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000 C.E. - 2000 C.E.</td>
<td>Early domestication of animals and crops. Cheese, wine, bread use yeast and bacteria to ferment.</td>
</tr>
<tr>
<td>1600 C.E. - 1700 C.E.</td>
<td>1590 - Zacharias Janssen invents the microscope. 1663 - Cells are discovered by Robert Hooke. 1675 - Antoni van Leeuwenhoek first observations of protozoa and bacteria.</td>
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<tr>
<td>1700 C.E. - 1800 C.E.</td>
<td>Edward Jenner invents the smallpox vaccine in 1796. In 1980, the WHO declared smallpox to be eradicated.</td>
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<td>1800 C.E. - 1850 C.E.</td>
<td>1838-1839 Matthias Schleiden and Theodor Schawn propose all living things are made up of cells.</td>
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<tr>
<td>1850 C.E. - 1900 C.E.</td>
<td>1861 Louis Pasteur proposes the “Germ Theory.” 1865 - Gregor Mendel studies principles of genetics. 1859 Charles Darwin writes “Origin of Species.”</td>
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<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>1900 C.E. - 1950 C.E.</td>
<td>1911 - Thomas Hunt Morgan studying fruit flies discovers chromosomes carry genes. 1928- Fleming discovers penicillin, the first virus is discovered. 1944- DNA is the hereditary material.</td>
</tr>
<tr>
<td>1990 C.E. - 2000 C.E.</td>
<td>1990 Human Genome Project funded by Congress. The project sets out to map the genes in human chromosomes and other species.</td>
</tr>
<tr>
<td>2000 C.E. to present</td>
<td>2001 CC &quot;Carbon Copy&quot; the cat is cloned. 2001 - Stem cell research 2003 Human Genome completed. All the human genes are mapped. 2006 vaccine to prevent cervical cancer caused by virus. HPV (human papilloma virus vaccine)</td>
</tr>
<tr>
<td>Event</td>
<td>Year</td>
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<td>----------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Humans domesticate animals and crops</td>
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<tr>
<td>Flavr Savr tomato approved by the FDA</td>
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<tr>
<td>Smallpox vaccine invented by Edward Jenner</td>
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<tr>
<td>Dolly is cloned from an adult cell</td>
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<tr>
<td>Human Genome Project completed</td>
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<td>Cohen and Boyer discover restriction enzymes cut DNA</td>
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<tr>
<td>Watson and Crick describe the DNA molecule</td>
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<tr>
<td>Gregor Mendel discovers principles of heredity</td>
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<tr>
<td>Human insulin produced by genetic engineering</td>
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<tr>
<td>Los humanos</td>
<td>FDA aprueba el primer alimento Flavr Savr tomate</td>
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<td>------------</td>
<td>--------------------------------------------------</td>
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<tr>
<td>Domestican animales y cultivan alimentos</td>
<td></td>
</tr>
<tr>
<td>Dolly el primer animal producido por clonación</td>
<td>El Proyecto Genoma Humano se completa</td>
</tr>
<tr>
<td>Watson and Crick describen la estructura de ADN</td>
<td>Gregor Mendel descubre las leyes de la herencia.</td>
</tr>
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</table>
Biotechnology Today

Y B G E N E T I C S A R E O N
B G I Y F Y M B L N Y B S T O
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G E N E T H E R A P Y I I E T
U X C H R O M O S O M E B C Q
E L E C T R O P H O R E S I S
L L E C M E T S R O T C E V L

BIOETHICS
BIOINFORMATICS
BIOTECHNOLOGY
CHROMOSOME
CLONE
DNA
ELECTROPHORESIS
ENZYME
GENETHERAPY
GENETICS
GENOME
MICROARRAY
NANOTECHNOLOGY
PCR
PLASMID
PROTEOME
RESTRICTION
STEMCELL
TRANSGENIC
VECTOR

Created by Puzzlemaker at DiscoverySchool.com
Biotechnology Today Solution

L + + + + + B G E N E T I C S
L N O I T C I R T S E R + I Y
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(Over, Down, Direction)
BIOETHICS(9,11,W)
BIOINFORMATICS(1,9,E)
BIOTECHNOLOGY(7,1,S)
CHROMOSOME(14,3,S)
CLONE(7,6,NE)
DNA(10,13,E)
ELECTROPHORESIS(1,15,NE)
ENZYME(5,10,N)
GENETHERAPY(15,12,N)
GENETICS(8,1,E)

GENOME(6,3,W)
MICROARRAY(5,4,SE)
PCR(12,3,SE)
PLASMID(10,7,S)
PROTEOME(3,14,E)
RESTRICTION(12,2,W)
STEMCELL(1,8,N)
TRANSGENIC(4,15,E)
VECTOR(13,8,NW)
Biotecnología Moderna Solution

B + G + + + E + A + + + A P A
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A + O + N + E + I + + + I R I
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I NÓ I C I R T S E R C R T
C É L U L A S M A D R E S A +
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(Over, Down, Direction)
ADN (2, 8, SE)
BIOINFORMÁTICA (1, 1, SE)
BIOTECNOLOGÍA (14, 7, W)
BIOÉTICA (13, 8, N)
CLONES (3, 15, E)
CROMOSOMA (9, 11, NW)
CÉLULASMADRES (1, 14, E)
ELECTROFORESIS (7, 1, S)
ENZIMA (9, 6, N)
GEN (5, 8, SW)
GENOMA (13, 9, W)
GENÉTICA (3, 1, SE)
PCR (14, 1, S)
PLASMIDO (4, 12, E)
RESTRICCIÓN (12, 13, W)
TERAPIAGÉNICA (15, 13, N)
TRANSGÉNICO (1, 5, S)
VECTOR (14, 8, S)
Investigation 1.2 Cells to Cloning

Activity 1: Where is the Genome?

Cell Structure and Function

Objectives
1. Students will review how to use a microscope.
2. Students will learn to prepare slides for viewing under the microscope.
3. Students will be able to identify plant and animal cell structures.
4. Students will understand cell structure and function.
5. Students will be able to identify bacteria cell structure and function.

Materials
- microscope
- slides and coverslips
- onion, Elodea (Anacharis), cheek cells
- toothpicks
- water and eye dropper (or small drop bottles)
- samples of prepared slides: human blood cells, neuron, adipose, striated muscle (you can use others as well)
- sample of prepared bacteria slides
- Iodine and/or methylene blue stain
- Animal, plant and bacteria cell handouts

Terms to Know
- cell membrane
- cell wall
- cytoplasm
- chloroplast
- endoplasmic reticulum
- Golgi body
- lysosome
- mitochondria
- nucleus
- nucleolus
- ribosomes
- DNA
- prokaryote
- eukaryote
- plasmid
Procedure

1. Preparing wet mount of cells (onion, Elodea, cheek). Your instructor will demonstrate.
   - Use a clean slide
   - Place a drop of water on your slide
   - Place your sample in the water
   - Place coverslip

2. Use the high power objective to draw the cells. Draw cells in the circles of your student worksheet.

3. Cell structure is related to function: neuron, adipose, striated muscle, human blood cells. Cells have a particular shape or structure because they have a specific function.
   - Red blood cells carry oxygen
   - Muscle cells contract and help us move
   - Adipose cells store fat
   - Neurons in our brains and spinal cord help us think and react to our environment.
   - Bacteria are very small cells and lack a nucleus. Many are beneficial and help decompose and recycle materials in the environment, others can cause disease (pathogenic).
Activity 1: Cell Structure Review Student Worksheet

Name ____________________________________________
Activity 1: Cell Structure Review Student Worksheet

Name ________________________________________________________________
Animal Cell

Label the following parts
1. plasma membrane (cell membrane)
2. cytoplasm
3. nucleus
4. chromosome
5. mitochondrion
6. Golgi body
7. smooth endoplasmic reticulum
8. rough endoplasmic reticulum
9. lysosome
10. nucleolus
11. lysosome
12. ribosomes

Plant Cell

Label the following parts
1. cell wall
2. vacuole
3. chloroplast
4. nucleus
5. cytoplasm

Bacteria Cell

Label the following parts
1. cell wall
2. ribosomes
3. DNA
4. plasmid
Bacteria Cell

Bacteria Cell copyright Lance Phillips permission to use 2007.
Activity 2: Cell Division Review- Mitosis and Meiosis

Materials

Clay, Fun Dough or pipe cleaners
paper
prepared slide of onion root tip mitosis
rulers

Terms to Know

1. cell division
2. chromosomes
3. mitosis
4. meiosis
5. cell cycle
6. cancer
7. interphase
8. prophase
9. metaphase
10. anaphase
11. telophase
12. cytokinesis
13. centromere
14. chromatid
Procedure

1. Roll two different colors of clay or Fun Dough to approximately the size and width of a pencil.

2. Cut a one inch piece (look at your first finger joint for approximation) from each clay “strip.”

3. Cut a two inch piece from each color (approximately two finger joints).

4. During interphase, DNA replicates. Each sister chromatid is joined together at the centromere. Cut out additional pieces and join them to show DNA has replicated.

5. Use a blank piece of paper to represent a cell. The edges of the paper is the cell membrane (or if a plant, the cell wall).

6. Prophase
   - Place chromosomes in the center of the paper.
   - The nuclear envelope disappears during this stage and the centrioles migrate to opposite poles. The centrioles make the spindle fibers where the chromosomes will attach.

7. Metaphase
   - Chromosomes line up along the center of the cell. You can line up the chromosomes in any order.

8. Anaphase
   - Spindle fibers shorten and sister chromatids separate to opposite poles.

9. Telophase
   - Nuclear envelopes reappears around each set of chromosomes

10. Cytokinesis
    - Cell membrane furrows or begins to pinch in. In plants, the cell plate separates the newly formed cells.

Review Meiosis
Activity 2: Cell Division Review - Mitosis Student Worksheet

Name ________________________________

Interphase  

Prophase

Metaphase  

Anaphase

Telophase  

Cytokinesis
Activity 3: Biotechnology - Stem Cells and Cloning

Objectives
1. Students will understand basic concepts of stem cell research.
2. Students will understand where stem cells come from and the differences between embryonic stem cells and adult stem cells.
3. Students will understand the process of how cloning is performed.

Materials
Genetic Science Learning Center – Stem Cells in the Spotlight and Cloning
Focus (clone a mouse activity)  http://gslc.genetics.utah.edu
creating stem cells for research handout
color pencils
scissors
*NOTE: Starfish development slides to show various stages of development
- blastocyst stage of development may be interesting!

Terms to Know
1. embryonic stem cells
2. adult stem cells
3. cell line
4. fertilization
5. zygote
6. embryo
7. differentiation
8. cloning
9. blastocyst

Procedure
1. Show animation information on stem cells from the Genetic Science Learning Center – Stem Cells in the Spotlight.
2. Color and label stem cell handouts
3. Show animations found in Cloning Focus – What is cloning?
4. Color and label stem cell handouts
5. Let's Clone a Mouse activity - Use Handouts
Activity 3: Stem Cells and Cloning- Student Activity Worksheet
Name __________________________________________________

Answer the following questions after review animations and materials.
http://learn.genetics.utah.edu/units/stemcells/index.cfm

1. What are stem cells?

2. What are some different types of stem cells?

3. List some ways stem cell therapies can be used.

4. Ethical issues raised by stem cell therapy and cloning?
Investigation 1.3 Enzymes and Biotechnology

Objectives
1. Students will understand the specificity of enzymes and substrates using both the “Lock and Key” model and “Induced Fit” model.
2. Students will learn terms associated with enzymes.
3. Students will understand factors that affect enzyme activity.
4. Students will understand how restriction enzymes function.

Terms to Know
1. enzymes
2. catalyst
3. substrate
4. enzyme-substrate complex
5. product
6. active site
7. allosteric site
8. competitive inhibitor
9. fermentation
10. restriction enzymes
11. non-competitive inhibitor
Activity 1: Lock and Key Model

Materials

Various sizes of locks and keys.

Procedure

1. Divide students into groups (4-5 students in each group)
2. Each student group has 6-7 locks (more locks makes this activity more challenging!)
3. Each group will have 2 minutes to unlock the locks. Each student in the group will have 20 seconds to try to unlock the locks.
4. Review the teacher background information: Enzymes and Biotechnology

Activity 2: Induced Fit Model

Materials

Fun Dough or clay,

Procedure

1. Provide students with various colors of Fun Dough or clay.
2. Have students make their own enzyme and substrate complex.
Activity 3: Understanding Enzyme Terminology

Materials
foam squares or FUN DOUGH

Procedure

1. Using the foam squares or FUN DOUGH demonstrate your understanding of enzyme terminology.
2. Label the following terms on the diagram.
   - enzyme
   - active site
   - allosteric site
   - substrate
   - competitive inhibitor (dotted)
   - non-competitive inhibitor

Diagram permission to use Lance Phillips
Activity 4: Food, Enzymes and Biotechnology

Chymosin - First genetically engineered enzyme approved by the FDA in 1990.

Background Information (See printed material)
David B. Fankhauser, Ph.D.,
Professor of Biology and Chemistry
University of Cincinnati Clermont College
Batavia, OH 45103
http://biology.clc.uc.edu/fankhauser/Cheese/Rennet/Rennet.html

Materials
Chymosin (rennet) can be purchased from most biological supply catalogues.
milk (whole milk works best but you can use fat free and/or milk products to compare)
Dixie cup or small beaker
eye dropper
cheese and crackers (optional)

Procedure
1. Pour 50 ml room temperature milk into a small beaker or Dixie cup.
2. Mix one drop of chymosin with 50 ml of milk and place the beaker in a warm water bath (or you can leave at room temperature- it takes a little longer) for 30 minutes.
Food, Enzymes and Biotechnology Student Worksheet

Name__________________________________________________

1. Why is rennet necessary in cheese making?

2. What is curd? What is whey?

3. Cheese making. Choose one of your favorite cheeses to find out how it is made.
   (Cheddar, Roquefort, Swiss, Ricotta, Mozzarella, Colby, Blue cheese, Brie, Camembert, Gouda, Goat cheese, or cheese from other countries)

4. Why do you think the development of chymosin was important?

Activity 5: How Enzymes Work
Factors Affecting Enzyme Function

Objective
1. Students will understand two main factors affecting enzyme function: pH and temperature,

Procedure
1. Students choose one of the experiment options: **Option 1** - Beans the Magic Food or **option 2** Lactose Intolerant to demonstrate the scientific process.
2. Students will formulate a hypothesis, set up an experimental design, collect data, graph, state results and discuss.
3. Test glucose strips to be sure they work. Mix approximately 2g of glucose (dextrose) with 98 ml of water.

**Experiment Option 1: Beans the Magic Food**

**What is Beano?**
Beano is an enzyme that helps you break down complex carbohydrates in the digestive tract and reduce gas produced by eating foods like beans, peanuts, cauliflower, broccoli, and brussels sprouts. It is naturally made by a fungus called *Aspergillus niger*. The enzyme that breaks down complex carbohydrates is called alpha galactosidase.

**Materials**
- liquid Beano
- fat-free vegetarian refried beans
- beakers
- graduated cylinders
- test tubes
- test tube racks
- glucose sticks
- markers
- wooden sticks (stirrers)
- 1M HCl (hydrochloric acid)
- 1M NaOH (sodium hydroxide)
- warm water bath
- cold water bath (ice)
Procedure

1. **HYPOTHESIS:** Look at How Enzymes Work Student Worksheet and state your hypothesis.
2. Place approximately 1 tablespoon of fat-free vegetarian beans in a beaker and add 10 ml of water. **MIX** with your stirrer. Dip a glucose stick and record any color changes.
3. **Record** the color change on your student worksheet.
4. Add 5 drops of liquid Beano. **MIX** with your stirrer. Record color changes on your data table.
5. Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record any color changes.
6. What factors affect enzyme function?
   - **ACID.** Place approximately 5 drops of Beano in a test tube and add 25 drops of acid. **CAREFUL** not to spill or touch! Mix 1 tablespoon of beans. Dip a glucose stick and record any color changes. **Record at time 0.** Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.
   - **BASE.** Place approximately 5 drops of Beano in a test tube and add 25 drops of a base. Mix 1 tablespoon of beans. Dip a glucose stick and record any color changes. **Record at time 0.** Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.
   - **TEMPERATURE: COLD** Place 5 drops of Beano in a test tube and place it in a cold water bath for 10 minutes. Place approximately 1 tablespoon of fat- free vegetarian beans in a beaker and add 10 ml of water. Place in a cold water bath for 10 minutes. **MIX cold Beano** with cold bean/water mixture. Leave in the cold water bath and dip a glucose stick and record any color changes. **Record at time 0.** Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.
   - **TEMPERATURE: HOT** Place 5 drops of Beano in a test tube and place it in a hot water bath for 10 minutes. Place approximately 1 tablespoon of fat- free vegetarian beans in a beaker and add 10 ml of water. Place in a hot water bath for 10 minutes. **MIX hot Beano** with hot bean/water mixture. Leave in the hot water bath and dip a glucose stick and record any color changes.
Record at time 0. Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.

Experiment Option 2: Lactose Intolerant

What does "lactose intolerance" mean? Some people cannot digest lactose, the main sugar found in milk and dairy products. The enzyme lactase in our digestive tract breaks down lactose sugar (disaccharide) to **glucose** and **galactose**. When people lack the necessary amounts of lactase and eat or drink milk products, they may develop some of the symptoms associated with lactose intolerance such as gas, cramps, bloating, or diarrhea.

What is LACTAID (Dairy-Ease)? LACTAID is a dietary supplement containing lactase that is used to help break down lactose. The enzyme has been isolated from fungal or bacteria cultures and purified.
Materials
milk (regular, buttermilk, fat free, goat, sheep, lactaid)
LACTAID (liquid or gel)
beakers
graduated cylinders
test tubes
test tube racks
glucose sticks
wooden sticks (stirrers)
markers to label beakers
1M HCl
1 M NaOH
warm water bath
cold water bath (ice)

Procedure
1. HYPOTHESIS: Look at How Enzymes Work Student Worksheet and state your hypothesis.
2. Place small amount of milk (10 ml) into a beaker.
3. Dip glucose stick.
4. Add 5 drops of Lactaid (if liquid form is not available, use gel and crush) to the milk. **MIX** with your stirrer.
5. Dip glucose stick and record any color change.
6. Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record any color changes.
7. What factors affect enzyme function?
   a. **ACID.** Place approximately 5 drops of LACTAID in a test tube and add 25 drops of acid. **CAREFUL** not to spill or touch! Add 10ml of milk. Dip a glucose stick and record any color changes. Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.
   b. **BASE.** Place approximately 5 drops of LACTAID in a test tube and add 25 drops of a base. Add 10 ml of milk. Dip a glucose stick and record any color changes. Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.
   c. **TEMPERATURE: COLD** Place 5 drops of LACTAID in a test tube and place it in a cold water bath for 10 minutes. Place
approximately 10 ml of milk in a beaker and place it in a cold water bath for 10 minutes. **MIX cold LACTAID** with cold milk. **Leave it in the cold water** bath and dip a glucose stick and record any color changes. Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.

d. **TEMPERATURE: HOT** Place 5 drops of LACTAID in a test tube and place it in a hot water bath for 10 minutes. Place approximately 10 ml of milk in a beaker and place it in a hot water bath for 10 minutes. **MIX LACTAID** with hot milk. **Leave it in the hot water** bath and dip a glucose stick and record any color changes. Dip a different glucose stick after 1 minute, 2 minutes, 3 minutes, 4 minutes and record color change.
Hypothesis: Predict what you think will happen. (HINT: Read background information)

No enzyme added to your milk or beans

With the enzyme added to your milk or beans

Acid added to the enzyme

Base added to the enzyme

Enzyme placed in cold water

Enzyme placed in hot water

Materials and Procedures: Summarize in one paragraph. Do NOT list materials or copy procedures.
Results: Summarize results in one paragraph

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Color of Glucose stick before enzyme was added:

_________________________________________________________

TABLE 1
What Factors Affect Enzyme Function?

<table>
<thead>
<tr>
<th>Time (minute)</th>
<th>Enzyme Added</th>
<th>Acid</th>
<th>Base</th>
<th>Hot</th>
<th>Cold</th>
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<tr>
<td>0</td>
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Discussion: How did your results compare with your hypothesis. Do you accept the hypothesis or reject the hypothesis. Any problems or questions you have. Discuss why enzymes are important.

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Activity 6: Restriction Enzymes
Adapted from Montgomery College- Germantown Introduction to Biotechnology for Middle School Teachers

Materials
- Restriction enzyme teacher background information
- Bacteria plasmid, jellyfish DNA templates
- scissors
- tape

Procedures
1. Examine the sheet labeled Bacteria Plasmid DNA. Notice the ampicillin resistance gene (marker gene) which is used for selection. Color it BLUE.
2. Construct the plasmid. Cut the plasmid DNA strips along the solid black lines and tape them together in RANDOM order to form a circle. A plasmid is a small double-stranded circular piece of DNA that is found in bacteria. It carries fewer genes than the bacteria chromosome. Plasmids are sometimes called vectors because they can transfer DNA from one cell to another.
3. Construct the jellyfish DNA. Notice the gene that produces green fluorescent protein (GFP). Color it GREEN.
4. Cut the jellyfish DNA strips along the solid black lines and use tape them together IN ORDER from strip 1 to strip 6. This section of DNA represents only a miniscule part of the entire jellyfish genome.
5. Locate the restriction enzyme site. Look for the following sequences on both the plasmid DNA and jellyfish DNA. Use a color pencil and mark the location as indicated below.

AAGCTT Restriction site for HindIII
TTCGAA

pKAN
6. Cloning the gene. This engineered recombinant DNA plasmid is now ready to be inserted into *E. coli* for cloning. This process is called transformation. Many copies of the GFP gene will be made as the bacteria reproduce. The bacteria will begin to glow green when they produce enough GFP.
Teacher Background

Information: Biotechnology and Enzymes

Enzyme facts

- Enzymes are needed for all living organisms to function.
- Enzymes are proteins that cause chemical changes.
- Enzymes are catalysts that speed up chemical reactions without being changed themselves.
- Enzymes can be reused many times. They generally end in ase (lipases, sucrase, lactase)

Digestion, the break down of food, requires many enzymes. Building muscle from amino acids, growth and repair of cells, making bread, cheese and yogurt are all examples of processes that need enzymes.

The lock and key hypothesis model is one of the simplest ways to introduce students to how enzymes work. Each enzyme has a specific substrate. The substrate is the molecule the enzyme will act upon. Enzymes can bring two substrates together to make a more complex product or it can break down a substrate into two simpler products. Enzymes fit like a lock and key. The location where the substrate fits into the enzyme is called the active site. The lock represents the substrate and the key represents the enzyme. The grooves around the key represent the active site.

Extension:
The induced fit hypothesis model is the more accurate model today to represent enzyme function. A specific enzyme and substrate fit together however, the enzyme can change its shape slightly to fit the substrate.

Several factors can affect how enzymes work:

- pH (a scale to measure the acidity or alkalinity -base of substances). The scale ranges from 1-14. The neutral pH is 7. A pH below 7, is an acid. A pH above 7, is a base. Most enzymes in our cells work within a very narrow pH range (6.8 - 7.4).
- Temperature - Enzymes work best at normal body temperature.
Biotechnology and Enzymes

**What are plasmids?**

- Plasmids are additional small pieces of circular DNA found in most bacteria cells. They are beneficial to the bacteria because they provide antibiotic resistance, or can produce toxins.
- Plasmids are named to specify antibiotic resistance
  - pKAN – resistant to kanamycin
  - pAMP – resistant to ampicillin

**What are restriction enzymes (also known as endonucleases)?**

- Restriction enzymes are molecular scissors that cut DNA at specific sequences.
- They can produce blunt ends or sticky ends

**Blunt ends**

```
GTAACTCGGGGTACACAT   GTAACTCGGGT ACACAT
CATTGAGCCCCATGTGTA   CATTGAGCCCA TGTGTA
```

**Sticky ends**

```
G A A T C C
CTTAAAG
```

```
G A A T C C
CTTAA G
```

**How are restriction enzymes named?**

- Restriction enzymes are named after the bacteria they were isolated. The term restriction is derived from bacteria resisting virus attacks by removing viral sequences.
- 3 name system plus additional letters to specify strains and Roman numerals indicate order in which they were discovered in a particular strain.

  - *EcoR I* – *Echerichia coli*, strain RY 13, first identified order
  - *Hind III* – *Haemophilus influenzae*
  - *BamHI* – *Bacillus amyloliquefaciens*
In 1978, the first human gene was inserted into plasmid to produce human insulin introducing recombinant DNA technology.

In 1990, the FDA approves the first genetically modified food substance- an enzyme called chymosin. Chymosin is used for making cheese. Rennet (natural) comes from suckling calves stomachs.

Enzyme and Genetic Disorders

- PKU is a genetic disorder caused by the lack of an enzyme called phenylalanine. The build up of phenylalanine causes mental retardation. Babies in Oklahoma and many states are tested at birth for PKU.
- Tay-Sachs is a genetic disorder caused by the lack of an important enzyme known as Hex-A. The enzyme breaks down a fat called GM2 ganglioside. When it is missing, children build up fatty deposits in the brain and nervous system that destroy nerve cells.
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