

Teacher Guide: How Do Viruses Recognize a Target Cell?

ACTIVITY OVERVIEW

Abstract:

This activity demonstrates the specificity of viral vectors for target cells in gene therapy delivery methods using two approaches: 1) STYROFOAM® models demonstrate viral ligand binding to receptor proteins on the surface of target cells; 2) Students use paper models of viruses and cells to find the appropriate match between viral ligands and cell receptors.

Module:

Gene Therapy: Molecular Bandage?

Prior Knowledge Needed:

Cell membranes contain protein receptors; virus structure; when a virus binds to a host cell, it injects its DNA or RNA into the host cell; gene therapy involves adding a normally functioning gene to cells to replace the function of a “faulty” gene.

Appropriate For:

Ages: 12 - 18

USA grades: 7 - 12

Key Concepts:

Ligand-receptor binding; viruses with specific ligands can be used as vectors to deliver genes to intended target cells

Materials:Demonstration:

2 - 4-inch smooth STYROFOAM® balls,
2 - 1.5-inch smooth STYROFOAM® balls, Snap
tape, VELCRO® hook and loop fasteners

Activity:

Student pages S-1 to S-6, Scissors

Prep Time:

30 minutes

Class Time:

5 minutes (demonstration); 10 minutes
(activity)

Activity Overview Web Address:

[http://gslc.genetics.utah.edu/teachers/tindex/
overview.cfm?id=ligand](http://gslc.genetics.utah.edu/teachers/tindex/overview.cfm?id=ligand)

Other activities in the *Gene Therapy: Molecular Bandage?* module can be found at:

<http://gslc.genetics.utah.edu/teachers/tindex/>

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I. PEDAGOGY

A. Learning Objectives

- Students will understand how a virus “recognizes” and binds to a target cell.
- Students will understand why specific viruses can be chosen to deliver genes to target cells.

B. Background Information

In general, a ligand refers to a specific molecule that can bind to a protein. With respect to viruses, a ligand is a protein on the outer coat of a virus that can bind to a receptor protein on the surface of a cell that the virus will infect. Ligands on the surface of a virus can only bind with specific receptor proteins. Different cell types contain different receptor proteins. Therefore, specific viruses can be used to deliver desired genes to targeted cell types.

Once a ligand on the surface of a virus binds to a target cell receptor protein, the virus injects its DNA or RNA into the cell. Depending on the virus, the DNA or RNA either immediately takes over the cell’s machinery to make copies of itself (lytic-type viruses), or the viral genetic information is incorporated into the host cell’s DNA where it lies dormant for a while (lysogenic-type viruses).

Lysogenic-type viruses with ligands that bind to the desired target cell type are selected for gene therapy. The viral genetic information is first removed and a copy of the desired gene is inserted. The newly modified virus is then placed in close proximity to the target cell type. The virus binds to the cell and inserts the DNA containing the desired gene, which becomes incorporated into the cell’s DNA.

C. Teaching Strategies

1. Timeline

- 3 days before activity:
 - Obtain the following for the demonstration:
 - 2 - 4-inch smooth STYROFOAM® balls
 - 2 - 1.5-inch smooth STYROFOAM® balls
 - Snap tape
 - VELCRO® hook and loop fasteners, self adhesive, round
 - Spray paint (optional)
 - Make virus and cell models as described in the *Materials Preparation Guide* (page 4).

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- Day before Activity:
 - Photocopy pages S-1 to S-6, making enough copies to give one Virus or Cell cut-out to each student.
- Day of activity:
 - Carry out introductory demonstration with the STYROFOAM® and snap or VELCRO® models
 - Divide class into two groups - Viruses and Cells
 - Distribute Virus and Cell cut-outs and scissors. Instruct students to cut out their Virus or Cell.
 - Provide time for students to find the matching viral ligand to their cell surface receptor and vice versa.

2. Invitation to Learn

- (Demonstration)

Hold up the large STYROFOAM® ball with snaps. Tell students that this represents a lung cell. Then show them the two smaller “virus” balls. Explain that both viruses and cells have proteins on their surface that will bind to their “mate” but not to other proteins. Ask a student to demonstrate which virus will bind to the “lung” cell (the virus with matching snaps). Now show students the large STYROFOAM® ball with VELCRO®. Tell students that this ball represents a heart cell. Ask another student to demonstrate which of the two types of “viruses” will bind to the heart cell (the virus with matching VELCRO®)



3. Classroom Implementation

- Divide the class into two equal groups.
- Distribute the Virus cut-outs (pages S-1 to S-2) to one group, one cut-out per student.
- Distribute the Cell cut-outs (pages S-3 to S-6) to the other group, one cut-out per student.

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- Instruct students to cut out their Virus or Cell.
- Instruct students to move around the room to find the viral ligand to match their cell receptor and vice versa.
- Once all virus and target cell matches have been found, explain that in the body, once a ligand on the outside of the virus has bound to a receptor protein on the surface of the target cell, the virus injects the DNA with the desired gene into the cell. This gene is then incorporated into the target cell's DNA. This specificity of viral ligands for target cell protein receptors is what makes viruses good vectors for gene therapy.
- You may also want to point out that viruses are much smaller than the cells they bind to and infect.

4. Extensions

- Advanced students can create their own vector/target cell models and use them to explain what is happening on a cellular level. Challenge them to include the transfer and incorporation of the desired gene to the target cell's DNA in their model.

5. Adaptations

- Begin class with the STYROFOAM® and snap/ VELCRO® demonstration but do not explain what it models. Instruct students to use the paper models (pages S-1 to S-6) to explain how this demonstration is analogous to viral ligand binding and specificity in gene therapy. Use their explanation as an assessment.
- Give each student a paper Virus or paper Cut-out at the beginning of class and instruct them to find their match. If students have previously explored the online materials for this module, ask them to explain how what they have just done models an important aspect of gene therapy. Or, you may explain how this exercise models viral ligand binding and specificity and how this can be used in gene therapy.

II. ADDITIONAL RESOURCES

A. Activity Resources linked from the online Activity Overview at:

<http://gslc.genetics.utah.edu/teachers/tindex/overview.cfm?id=ligand>

- Website: *Gene Therapy: Molecular Bandage?: Tools of the Trade* - extensive information about the use of viruses and other vectors in gene therapy. Includes an animation of the life cycle of a virus.
- Website: *Gene Therapy: Molecular Bandage?* - extensive information about gene therapy.

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III. MATERIALS

A. Detailed Materials List

- 2 - 4-inch smooth STYROFOAM® balls*
- 2 - 1.5-inch smooth STYROFOAM® balls*
- Snap tape, 1/4 to 1/2 yard (can be obtained at any fabric store)
- VELCRO® hook and loop fasteners, one package adhesive-backed circles (can be obtained at any fabric store)
- Hot glue gun
- Spray paint (optional)
- Pages S-1 to S-6 - enough copies to give one Virus or Cell cut-out to each member of the class.

* *Note: Rough STYROFOAM® balls disintegrate when spray painted.*

B. Materials Preparation Guide

Cell and Virus models for the Demonstration:

Spray-paint two 4-inch and two 1.5-inch STYROFOAM® balls (optional). You may want to paint each ball a different color.



Cut squares from the snap tape, one snap per square.



Using a hot glue gun, glue the squares containing the socket half of the snap in a random pattern on the outside of one 4-inch STYROFOAM® ball.



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Glue the squares containing the ball half of the snap on the outside of one 1.5-inch *STYROFOAM*[®] ball.



On the remaining two *STYROFOAM*[®] balls, repeat the steps above using the *VELCRO*[®] circles rather than snaps. Stick the pile side of the *VELCRO*[®] on the 4-inch ball and the hook side on the 1.5-inch ball.



Activity:

Photocopy pages S-1 through S-6. Make enough copies to hand one Virus or Cell cut-out to each student.

Separate the cut-outs by cutting the full pages along the dotted lines.

IV. STANDARDS

A. U.S. National Science Education Standards

Grades 5-8:

- Content Standard C: Life Science - Structure and Function of Living Systems; each type of cell, tissue and organ has a distinct structure and set of functions that serve the organism as a whole.

Grades 9-12:

- Content Standard C: Life Science - The Cell; cells store and use information to guide their functions; the genetic information stored in DNA is used to direct synthesis of thousands of proteins that each cell requires.
- Content Standard C: Life Science - The Molecular Basis of Heredity; in all organisms, the instructions for specifying the characteristics of organisms are carried in DNA.

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B. AAAS Benchmarks for Science Literacy

Grades 6-8:

- The Living Environment: Cells - different body tissues and organs are made up of different kinds of cells.

Grades 9-12:

- The Living Environment: Cells - every cell is covered by a membrane that controls what can enter and leave the cell.
- The Living Environment: Cells - cell behavior can also be affected by molecules from other parts of the organism or even other organisms.
- The Living Environment: Heredity - some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious.
- The Designed World: Health Technology - knowledge of genetics is opening whole new fields of health care; in diagnosis, mapping of genetic instructions in cells makes it possible to detect defective genes that may lead to poor health.

C. Utah Secondary Science Core Curriculum

Intended Learning Outcomes for Biology

Students will:

1. Use Science Process and Thinking Skills
 - b. Use comparisons to help understand observations and phenomena.
 - h. Construct models, simulations and metaphors to describe and explain natural phenomena.

Biology (9-12)

Standard IV: Students will understand that genetic information coded in DNA is passed from parents to offspring by sexual and asexual reproduction. The basic structure of DNA is the same in all living things. Changes in DNA may alter genetic expression.

Objective 3: Explain how the structure and replication of DNA are essential to heredity and protein synthesis.

- Research, report, and debate genetic technologies that may improve the quality of life (e.g., genetic engineering, cloning, gene splicing).

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V. CREDITS

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How do Vectors Recognize a Target Cell?

Virus Cut-Outs



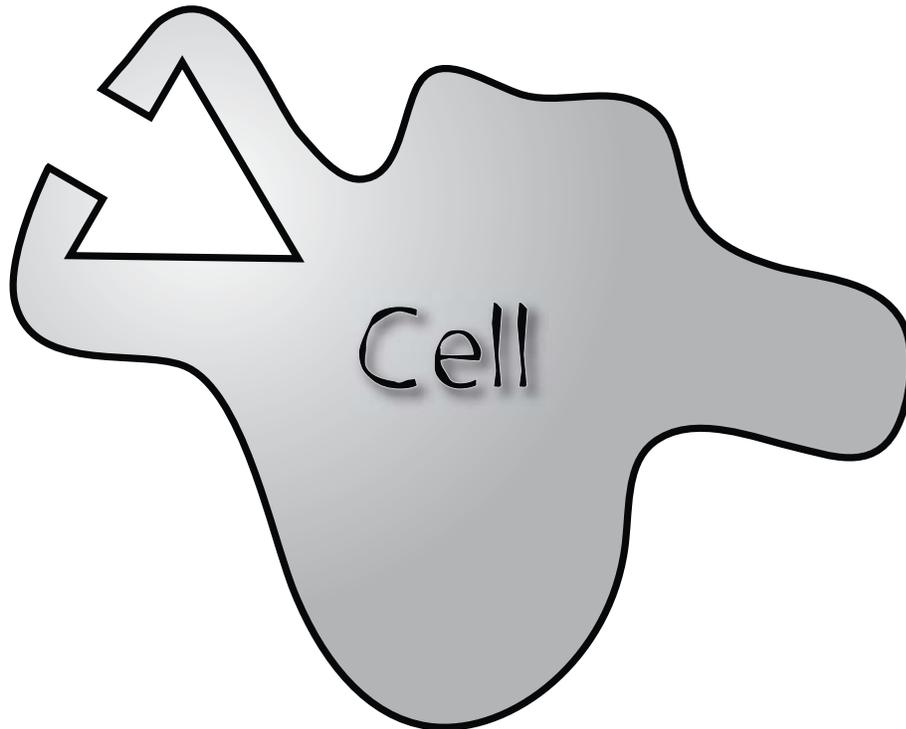
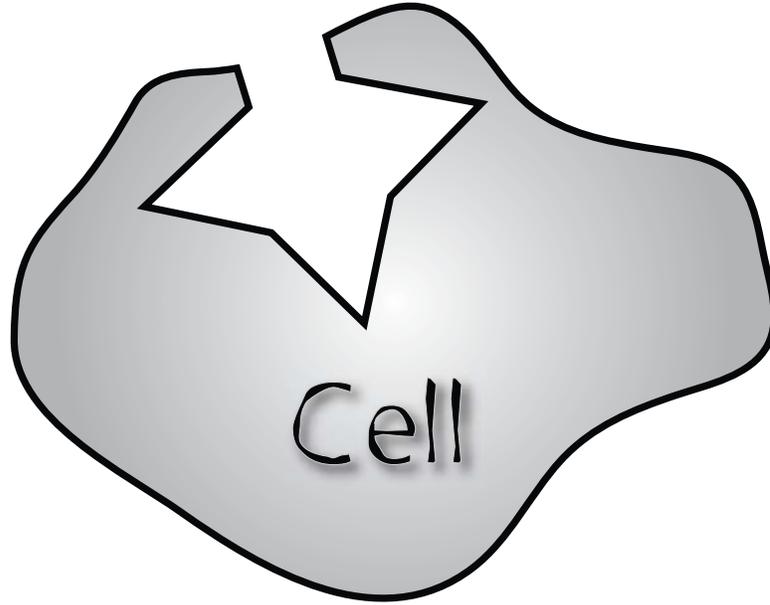
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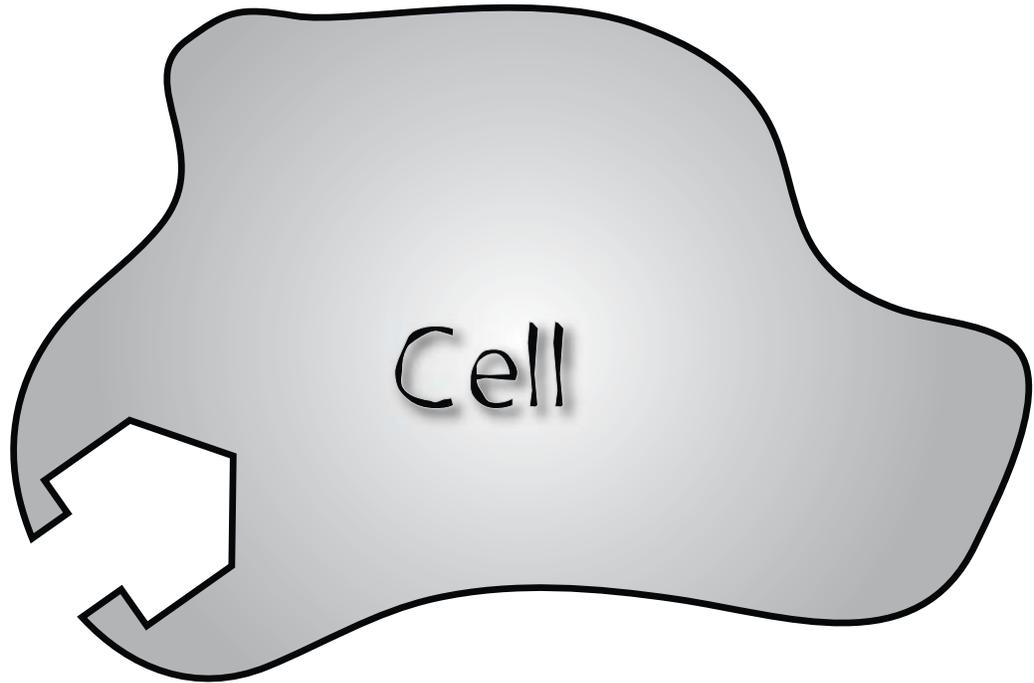
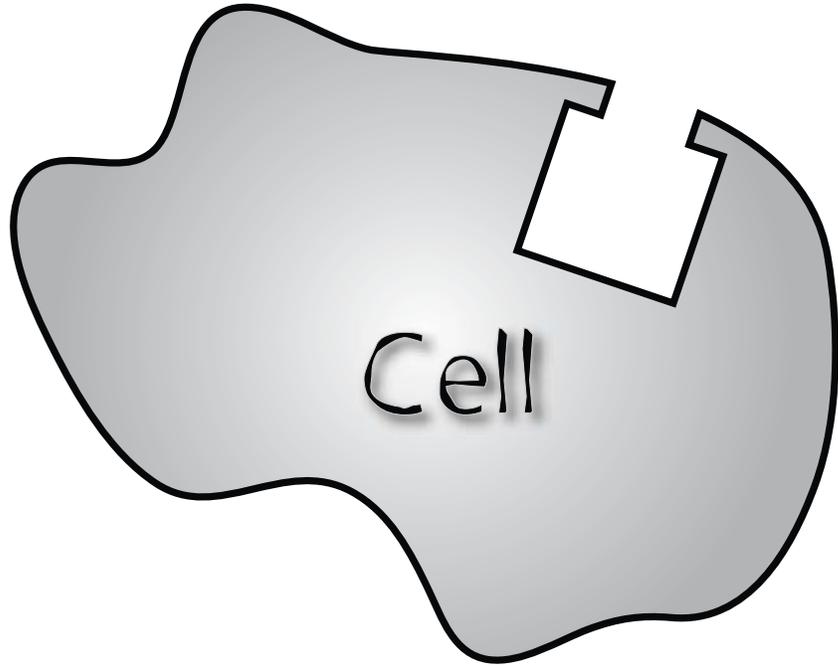


How do Vectors Recognize a Target Cell?

Target Cell Cut-Outs

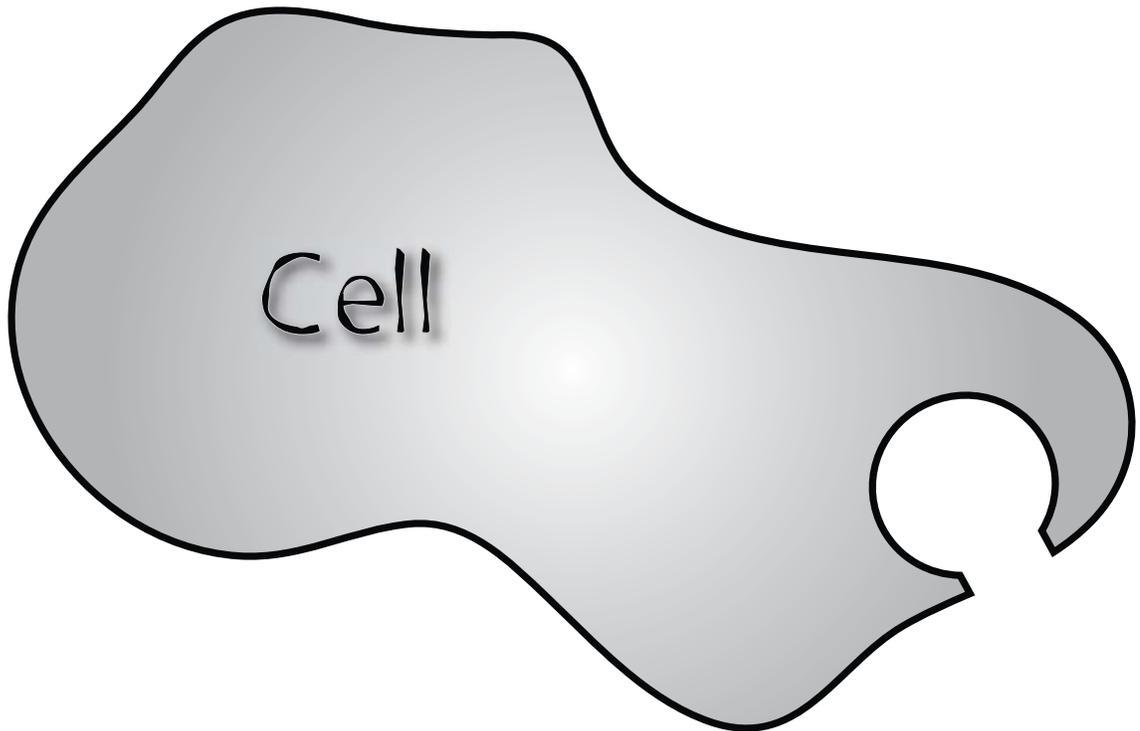
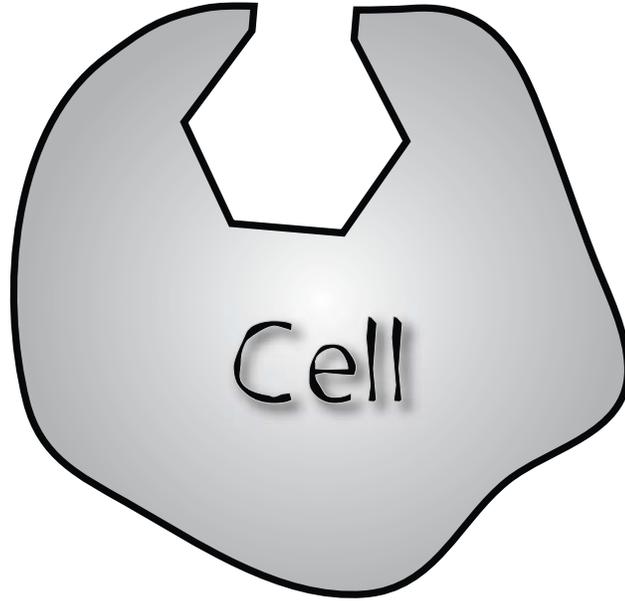


How do Vectors Recognize a Target Cell?



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Target Cell Cut-Outs



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