How Do Viruses Recognize a Target Cell?

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.

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.

Estimated time

- Class time 5 minutes (demo), 10 minutes (activity)
- Prep time 30 minutes

Materials

- 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, adhesive-backed circles
- Hot glue gun
- Spray paint (optional)
- Student pages
- Scissors

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.

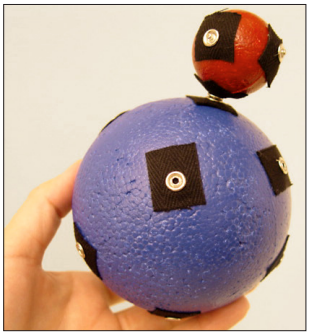
Once a ligand on the surface of a virus binds to a target cell receptor protein, the virus injects its DNA or RNA into the cell. Depending on the virus, the DNA or RNA either immediately takes over the cell's machinery to make copies of itself (lytic-type viruses), or the viral genetic information is 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.

Instructions

1. Demo - 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®).


2. Divide the class into two equal groups.
3. Distribute the Virus Cut-outs to one group, one cut-out per student.
4. Distribute the Cell Cut-outs to the other group, one cut-out per student.
5. Instruct students to cut out their Virus or Cell.
6. Instruct students to move around the room to find the viral ligand to match their cell receptor and vice versa.
7. 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.
8. You may also want to point out that viruses are much smaller than the cells they bind to and infect.

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.

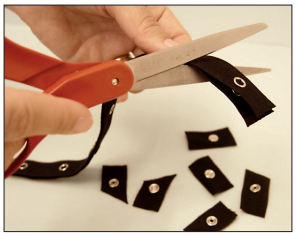
Adaptations

- 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 then 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.

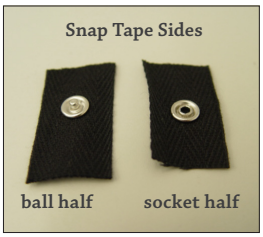
Materials Prep

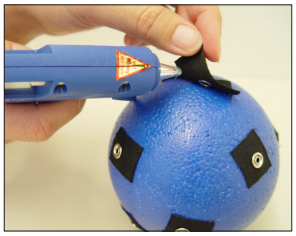
1. Spray-paint two 4-inch and two 1.5-inch STYROFOAM® balls (optional). Rough styrofoam balls disintegrate when spray-painted. You may want to paint each ball a different color.

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



3. 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.





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

5. 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.

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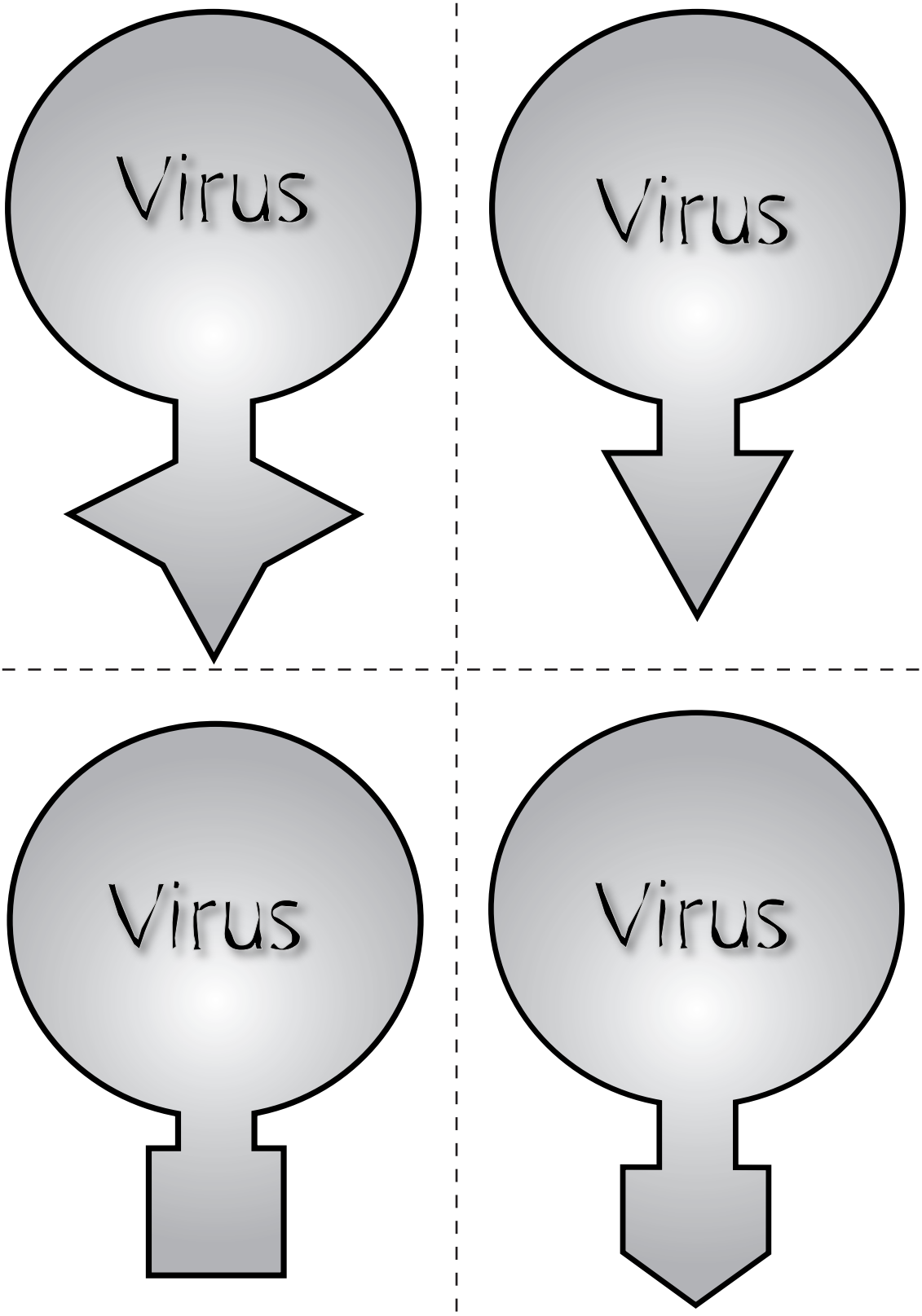
Virus Cut-Outs



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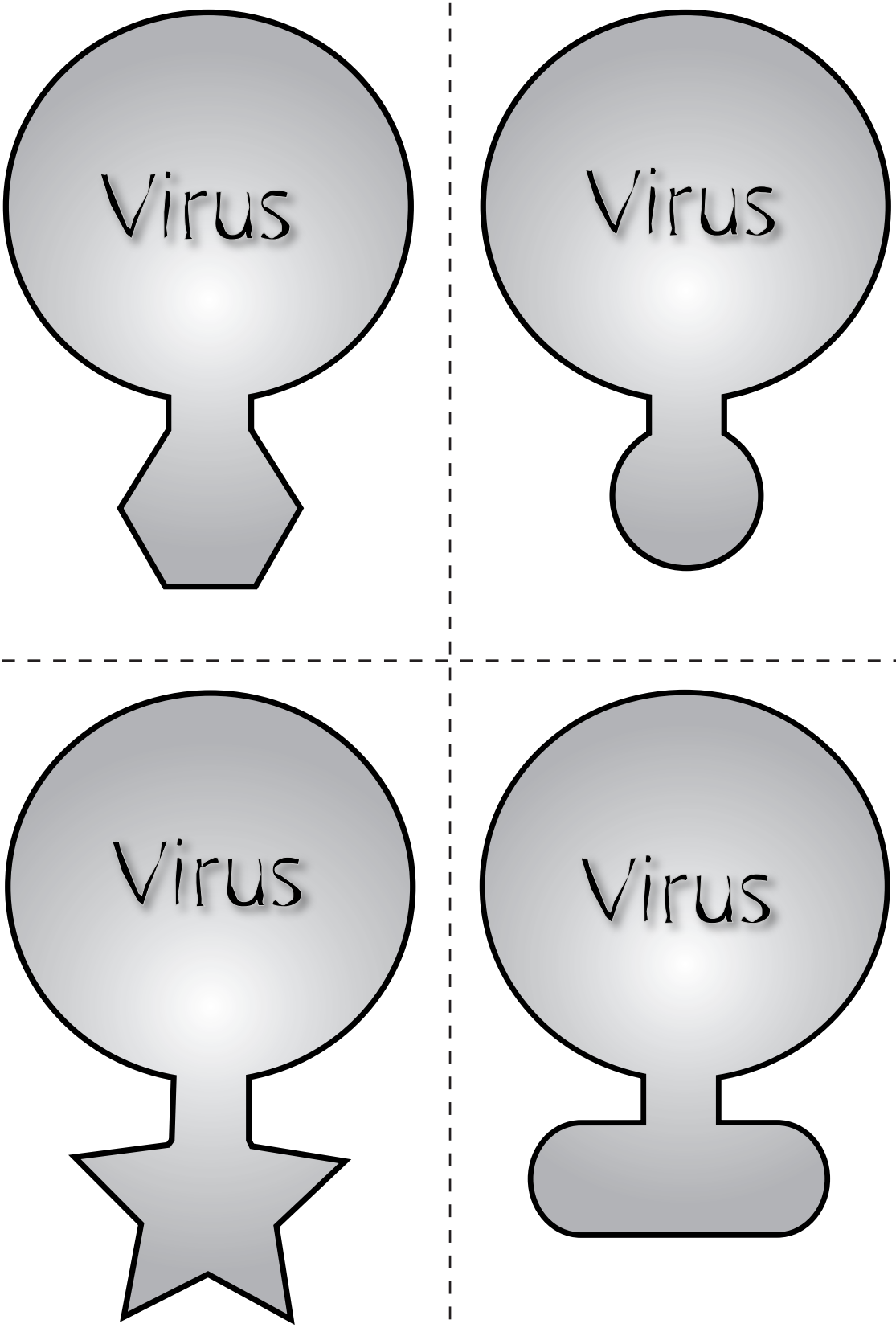
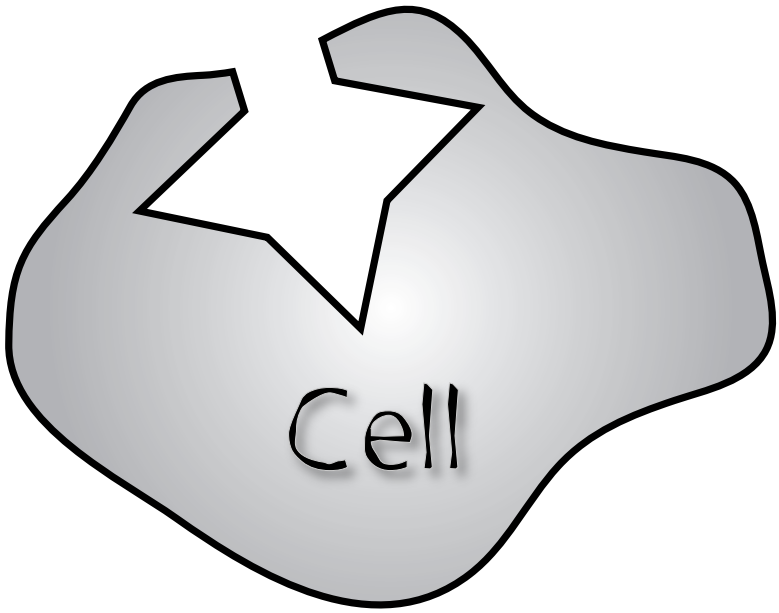
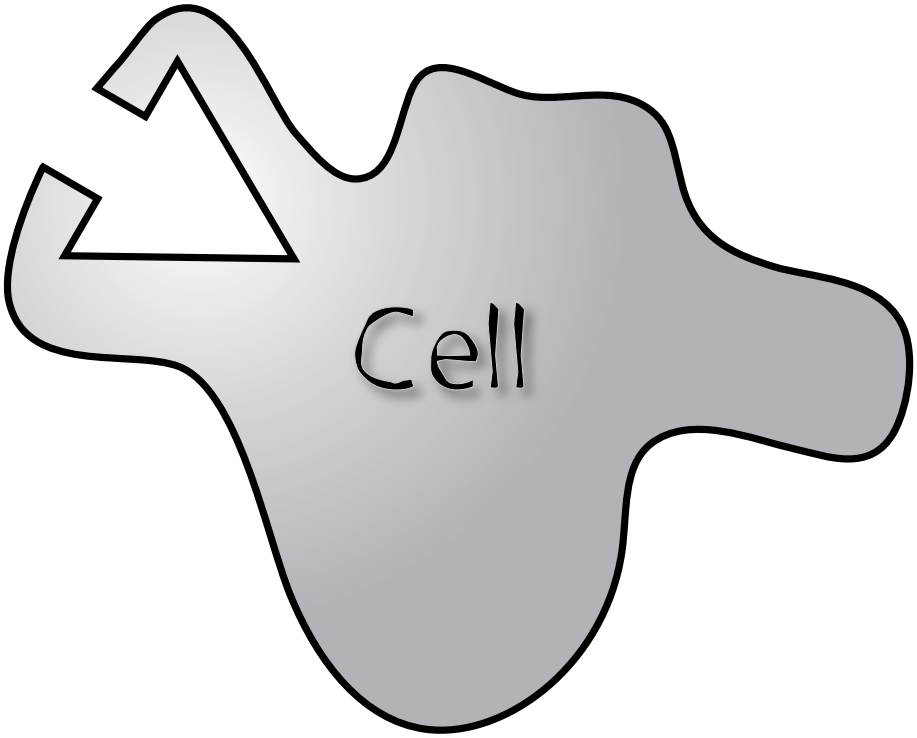


Cell Cut-Outs





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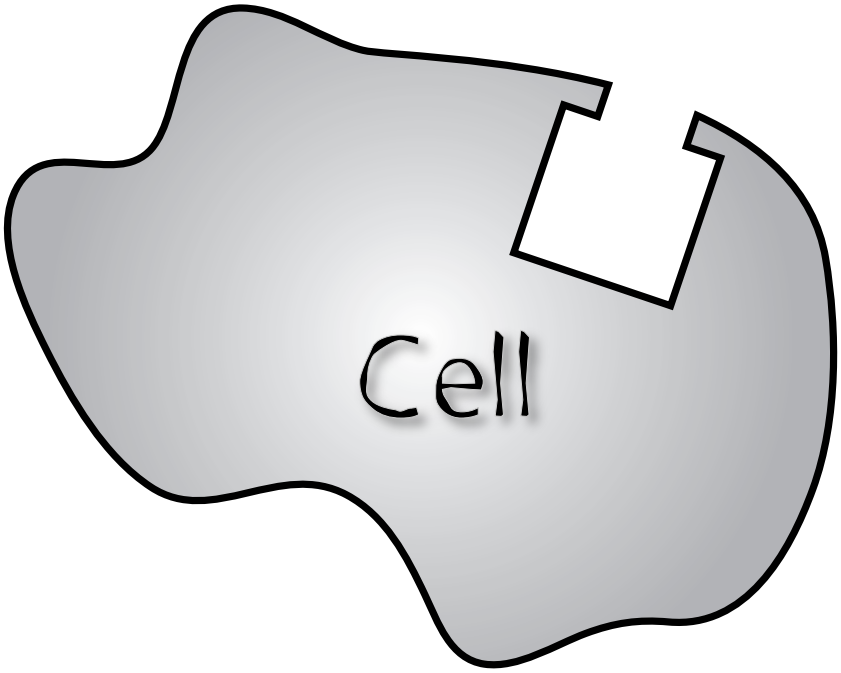

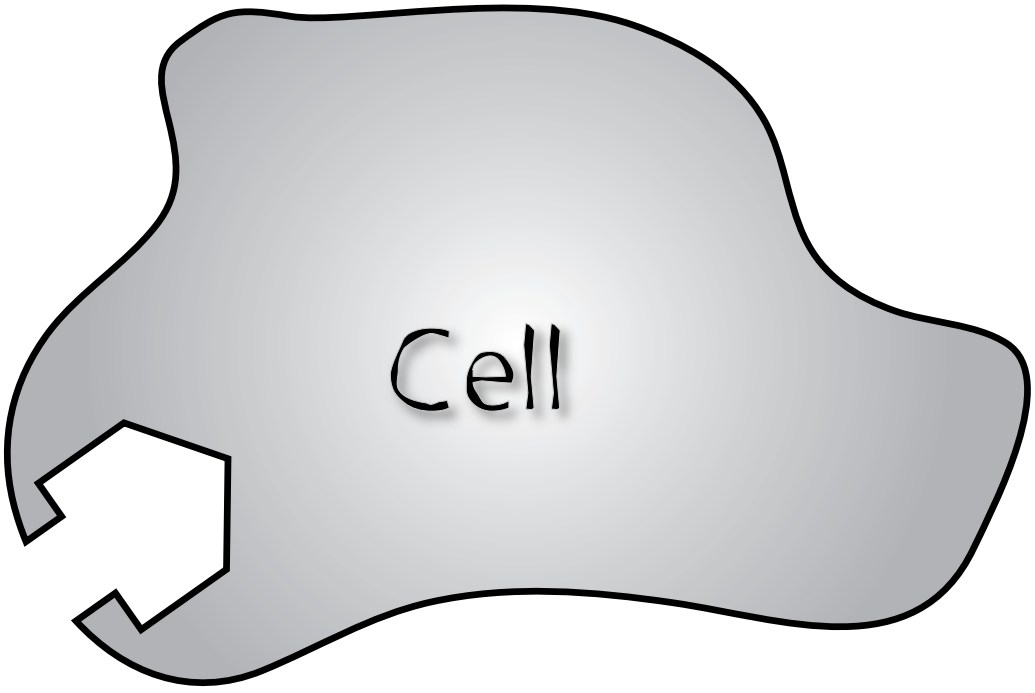

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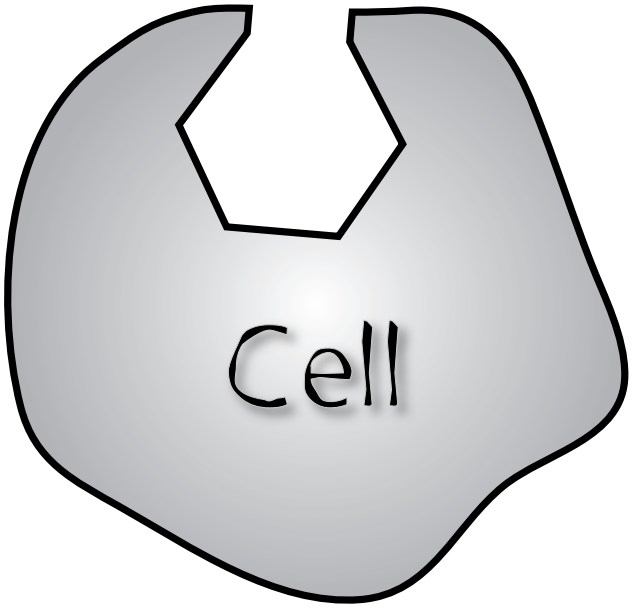

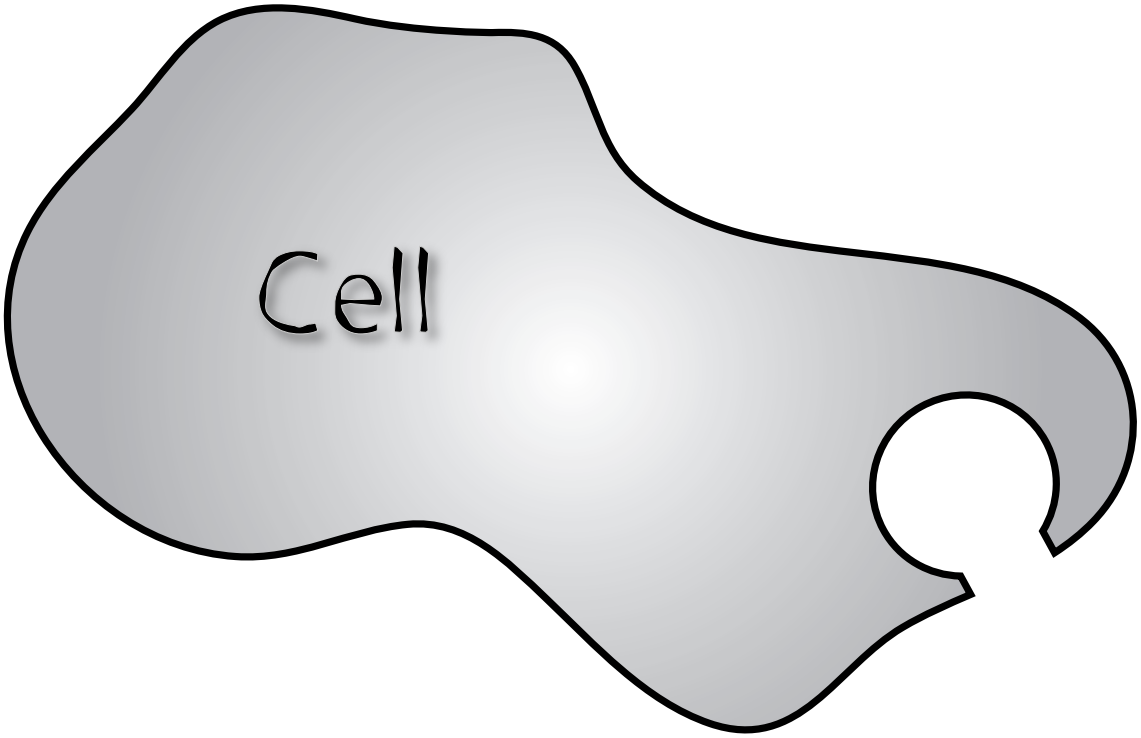

Cell Cut-Outs