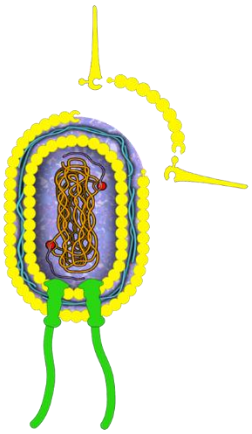
Cell Modeling Kit

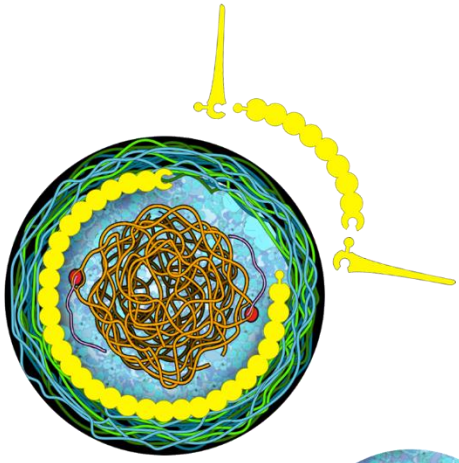
This kit has had significant modifications to provide maximum flexibility in modeling based on feedback from Cohort I participants. Both eukaryotic and prokaryotic cells can be modeled as well as several cell processes. Below are some basic assembly instructions and labeled parts.

Bacterial Cell Components

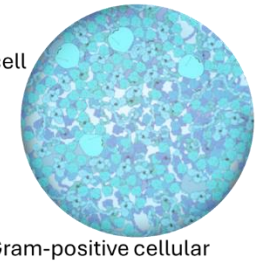


Gram-Negative Bacterial Cell

Gram-negative cellular landscape



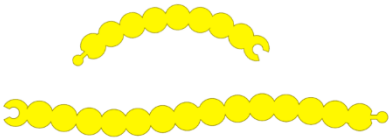
Gram-Positive Bacterial cell



Gram-positive cellular landscape

Both a Gram-negative rod and a Gram-positive coccus can be constructed. A cellular landscape without DNA can be inserted for each cell.

Membrane components

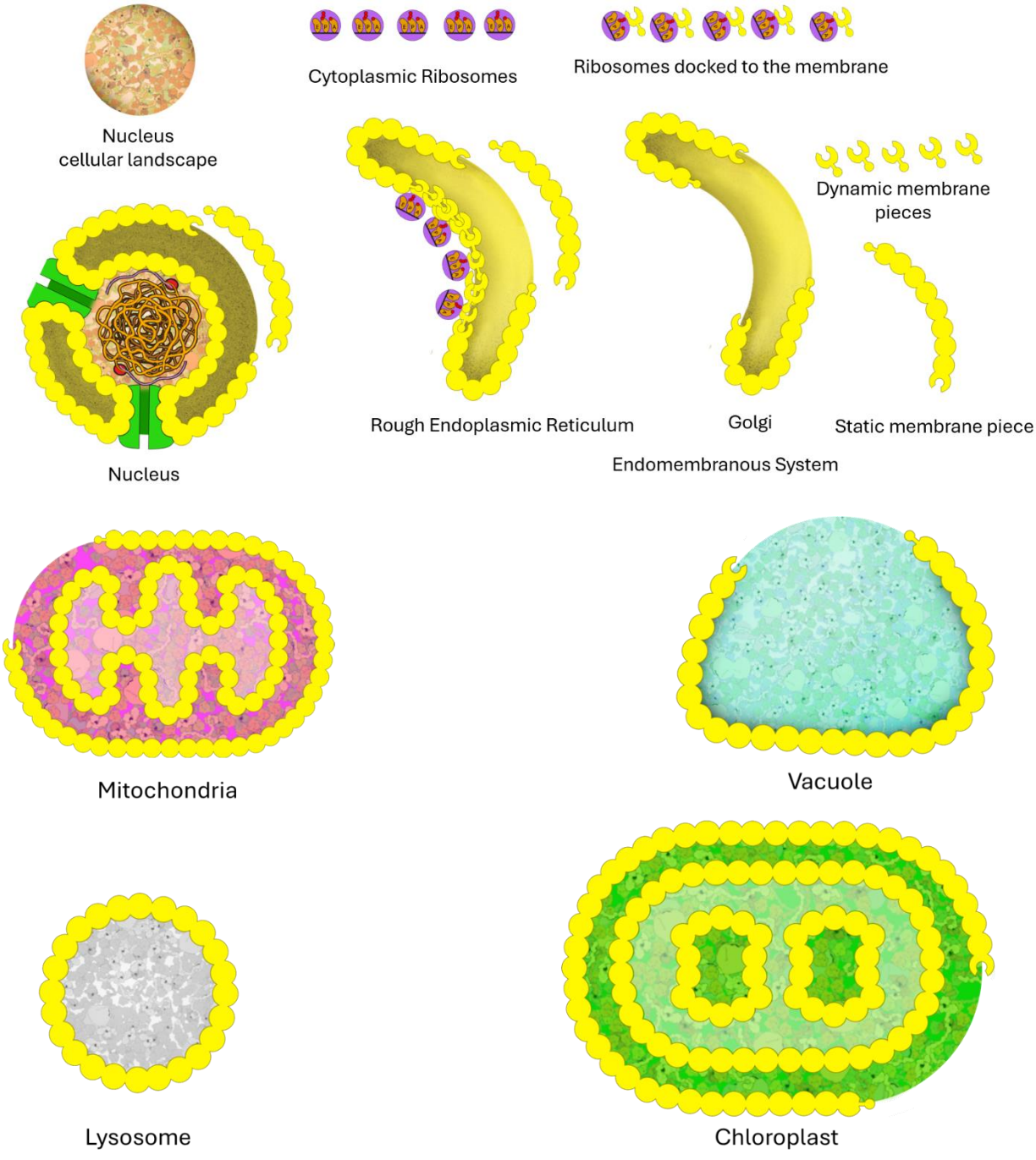


Static membrane pieces

Build your own dynamic membrane
(endocytosis, exocytosis, pinocytosis)

One of the biggest changes to the Cell Modeling Kit since the summer course is how to model membranes dynamically. Instead of using fixed membranes on a background, a dynamic cell membrane can be built using larger static membrane pieces and single membrane pieces that can rotate more easily. Modeling bulk movement of substances into and out of the cell can occur more naturally.

Eukaryotic organelles



Using the eukaryotic organelles and static or dynamic membrane pieces, a myriad of cell processes can be modeled.

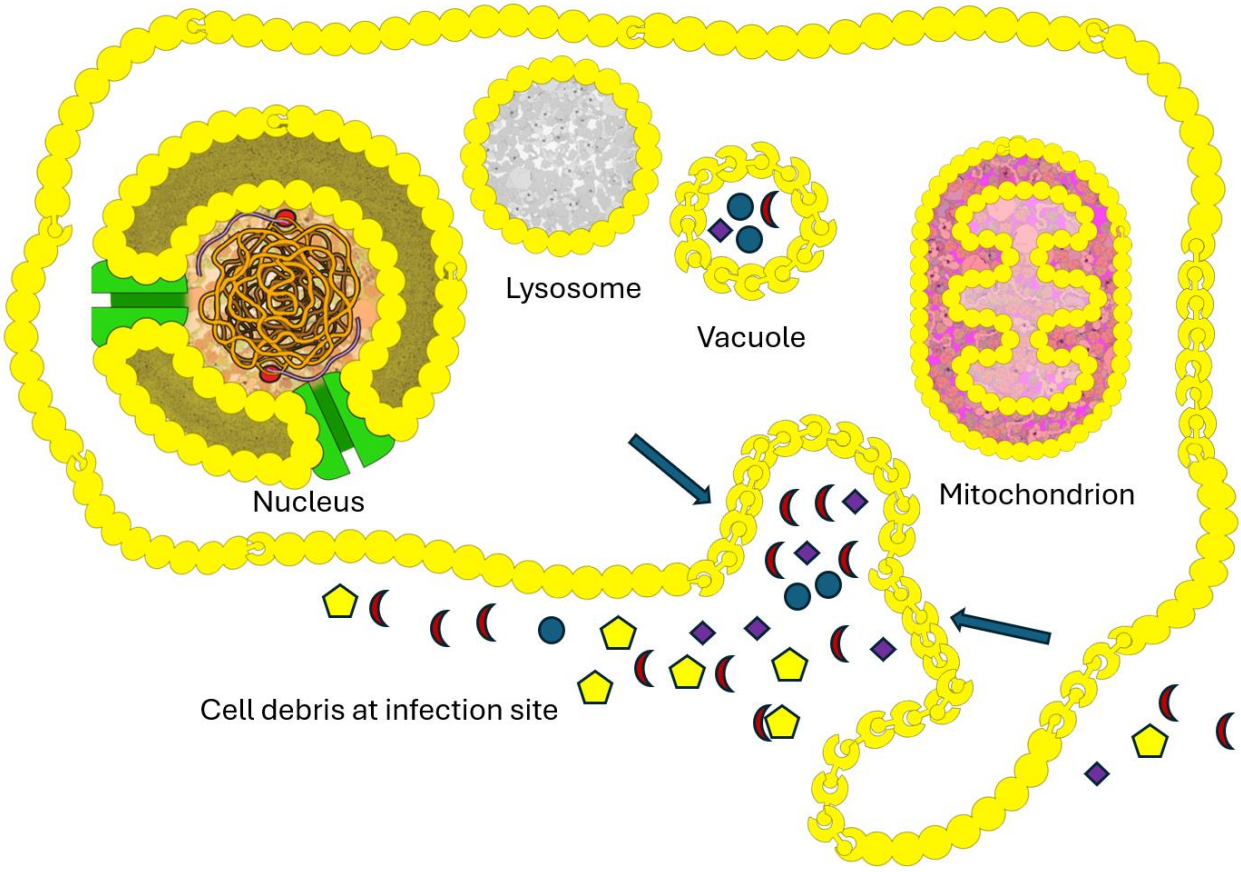
Modeling Bulk Transport

Non-selective endocytosis

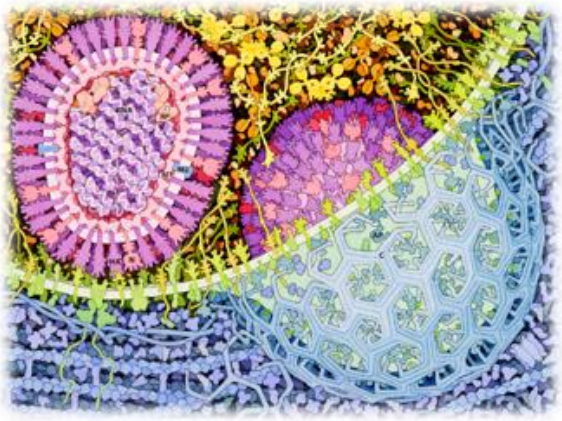
Pinocytosis is a type of non-selective form of bulk transport that does not require receptors. Immune cells, specifically dendritic cells, use this form of bulk transport to sample the site of infection to determine if other immune cells need to be recruited to the area. Mitochondria are necessary as active transport requires ATP. The cell membrane extends because of remodeling of the actin cytoskeleton (not shown in the kit).

Using both the static and dynamic pieces of membrane enables the modeler to move the pieces of the cell membrane together until they touch. Arrows indicate the direction of membrane movement. The membranes will fuse to form a vacuole. The vacuole contains whatever is in the extracellular fluid. The shapes shown below represent cell debris and are not provided with the kit. Once a vacuole is formed, it merges with a lysosome and digestion of the vacuole contents occurs.

How would exocytosis be modeled using these kit components?

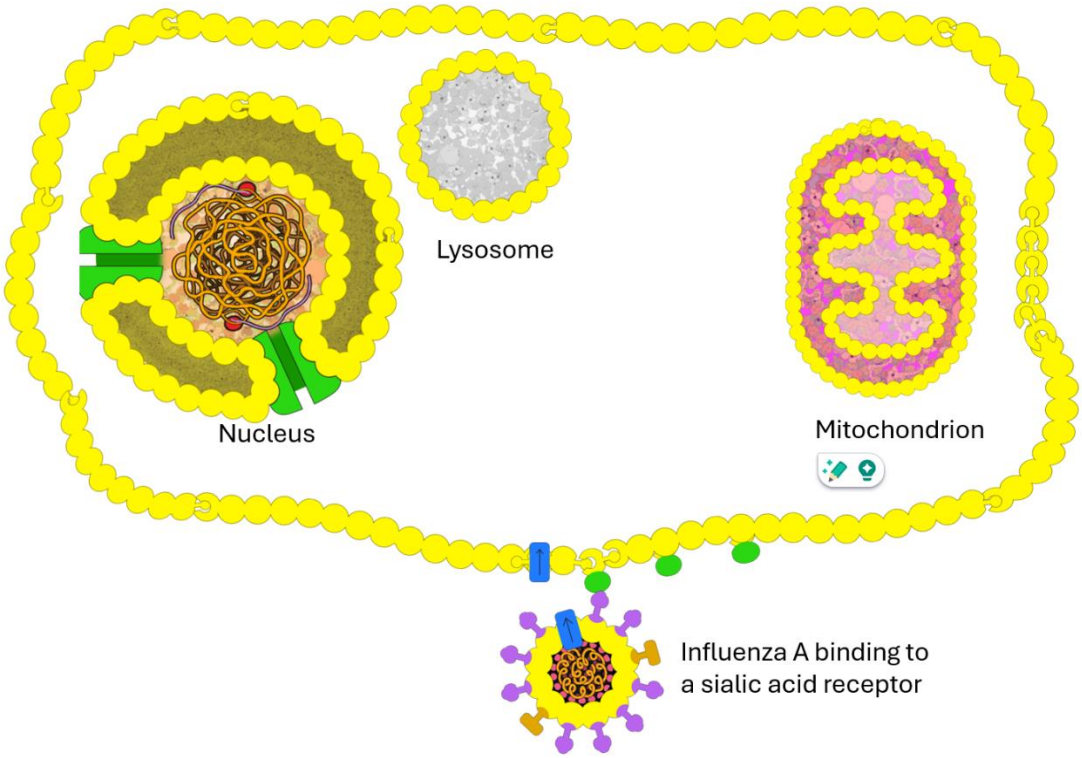


Receptor-mediated endocytosis

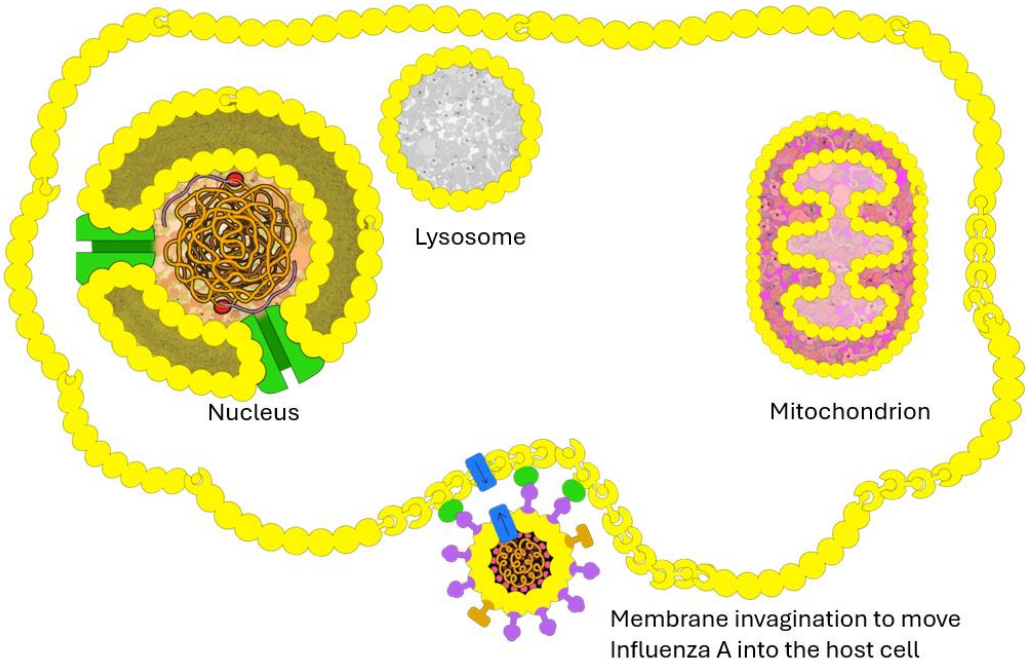


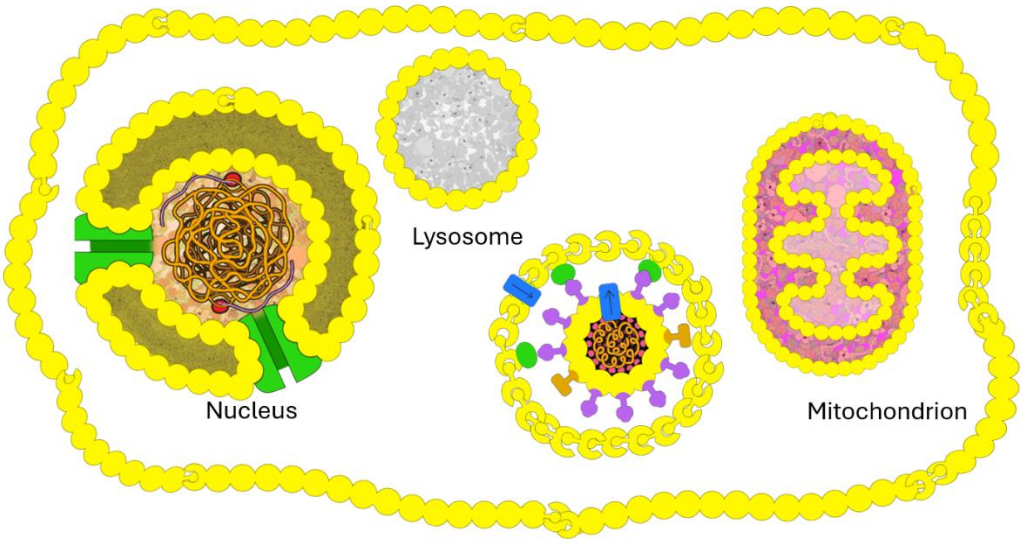
Many cells use receptor-mediated endocytosis to absorb specific molecules by the inward budding of the cell membrane. These molecules, also called ligands, bind to receptors found on the membrane in coated pits associated with the protein clathrin. Once binding occurs, many clathrin proteins assemble together on cytoplasmic side of the cell membrane. The coated pits fold inward to form a pocket around the ligand-receptor complex. A vesicle is formed when the pocket is narrowed and cut due to the mechanical force provided by the protein dynamin. Once inside the cell, the clathrin coat is removed and the vesicle fuses with an endosome where the receptors and ligands are sorted. Receptors move back to the cell membrane for reuse. Ligands are most often directed to a lysosome for further processing. In the image above, David Goodsell, PhD shows how the influenza virus takes advantage of this type of bulk transport to enter a host cell. The Cell Modeling Kit can be used to model these cell processes at the microscopic level. The roles of clathrin and dynamin are not shown.

Viral Attachment



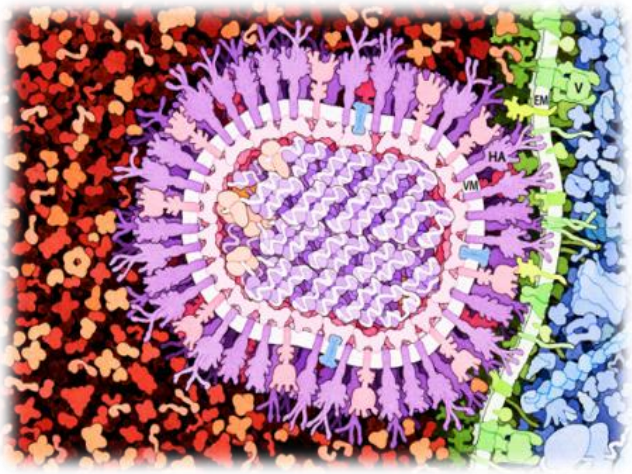
Viral Uptake





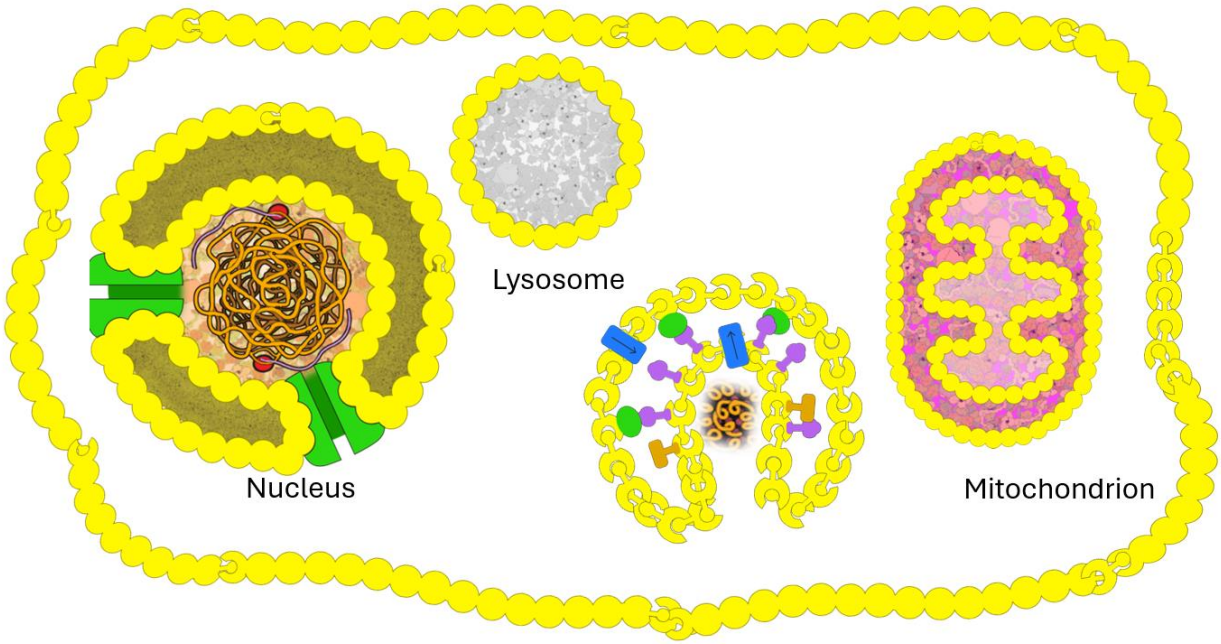
Uptake of Influenza A into the host cell vesicle

Once inside the host cell, the vesicle has a change in pH due to the movement of hydrogen ions into the vesicle as shown below by David Goodsell, PhD.



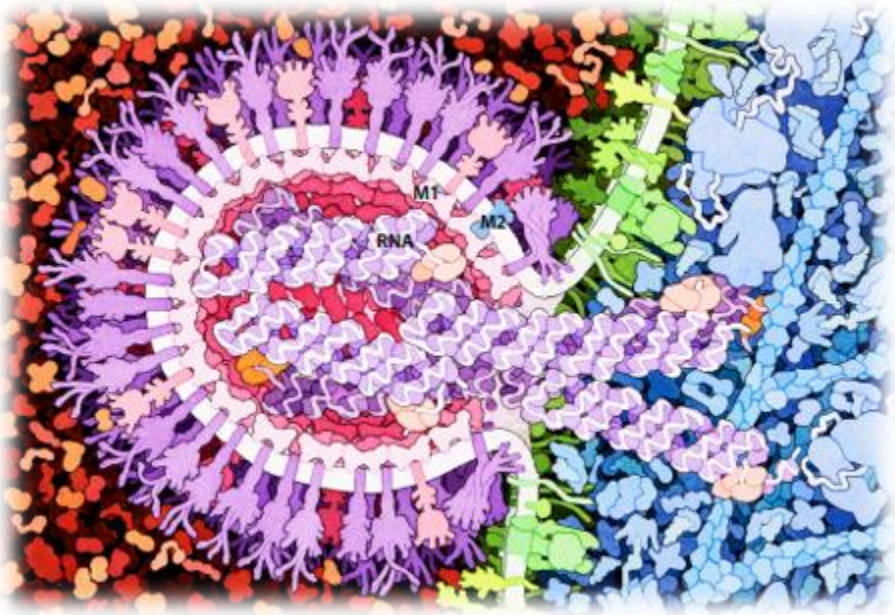
Membrane Fusion and Release of Viral Contents

This pH change leads to the fusion of the viral membrane with the vesicle releasing the viral contents into the host cell's cytoplasm as modeled below.



Fusion of host cell and viral membranes with release of viral contents

Segmented RNA pieces (shown in lavender) from the infuenza A virus enter the host cell's cytoplasm and move to the nucleus.



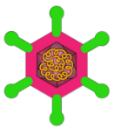
How might you model the production of viral components within the host cell?

How could you model the newly formed virus budding from the host cell?

Viral Infection Components

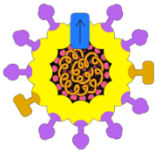
Bacteriophage

HIV



Adeno-Associated Virus

Coronavirus



Influenza

Sialic acid Receptor

Influenza Neuraminidase

Influenza Hemagglutinin

Proton Pump

Other viral infection cycles can be modeled. Students need to construct the host cell receptors for these infection cycles.

A slide deck of digital components for the Cell Modeling Kit is available on the Digital Modeling Hub for you and your students' use throughout this field test. Visit the playground (link).