

# Introduction to Virology

## Course

Medical  
Microbiology

## Unit V

Microorganisms

## Essential Question

How do you  
detect a viral  
infection and  
what can be  
done to prevent  
it?

## TEKS

103.207 (c) 4B,  
4C, 4D, 5A, 5C,  
5D, 5F

## Prior Student Learning

History of  
Microbiology,  
Microorganisms,  
Bacteria

**Estimated time**  
3-5 hours

**\* Remember to  
follow your  
school district  
policy for  
viewing online  
videos**

## Rationale

The presence of a virus has a tremendous effect on global economics. The study is important because of the impact on individual and community health.

## Objectives

Upon completion of this lesson, the student will be able to:

- Identify the structure of a virus
- Classify viruses based on structure or nucleic acid composition
- Compare and contrast viruses to cells
- Describe viral replication and explain the function of different viral structures
- Describe what medical technology is available to diagnose a viral infection
- Describe the role viruses play in cancer development
- Distinguish retroviruses from other viruses
- Explain the implication of vaccines on the immune system and the global society

## Engage

Watch video, "Flu Attack!" found on NPR blog, Khurлович Wonders or at: <http://www.npr.org/blogs/kurlovich/2011/06/01/114075029/flu-attack-how-a-virus-invades-your-body>.

*Alternate engage:* Compare and contrast the difference between viruses and bacteria.

## Key Points

- I. A virus is a submicroscopic acellular particle containing genetic material surrounded by protein. Virus particles can only be observed by an electron microscope.
- II. The classification of viruses is based on the type of nucleic acid contained within.
  - A. RNA viruses can be single-stranded like the mRNA in human cells (Hepatitis A or C or Picornavirus). They can also be double-stranded like human DNA (Rotavirus).
  - B. DNA viruses can be double-stranded like human DNA (Adenovirus, Herpes virus, poxvirus Hepatitis B), but a few are single-stranded (Parvovirus aka Kennel Cough).

1. *Note:* The common names used do always not indicate similar viral families like the Hepatitis'. Hep C is in the family *Flaviviridae* while Hep B is in the *Hepadnavirus* family due to their different genetic make-up although they are transmitted and cause similar disease effects.
  - C. Remember the difference between RNA and DNA is a Ribose or Deoxyribose sugar and the use of Uracil (RNA) for Thymine (DNA).
- III. Recognizing the shape, size and structure of different viruses is critical to the study of disease.
- A. Viruses have an inner core of nucleic acid surrounded by a protein coat or capsid. Many viruses will have another layer outside the protein layer that is a lipid bilayer called the envelope. The envelope is built by the virus 'budding' out of the host cell and taking some of its lipid bilayer with it.
  - B. There are glycoprotein spikes attached to the outermost layer of the virus. These spikes are how the virus attaches to host cells and how the virus is 'recognized' by antibody attachment.
  - C. Most viruses demonstrate an icosahedral (soccer ball) shape (influenza, Herpes viruses, and many others), while some are helical (tobacco mosaic virus or Ebola) or complex like pox viruses or the tailed phages. You may find envelopes around icosahedral or helical shapes or they may be without and known as 'naked' viruses.
  - D. Most viruses range in size from 20 to 300 nm, compared to prokaryotes at 0.5-5 micrometers and eukaryotes at 1-100 micrometers.
- IV. Viruses replicate within a host cell while utilizing the host cell's DNA. The viral life cycle may exist in one of two cycles. Videos of these cycles can be easily found on YouTube one example is:  
<http://youtu.be/wLosIN6d3Ec>, Called: Virus Lysogenic and Lytic cycle.
- The Lytic Cycle:**
- A. Attachment – Matching receptors and glycoproteins allow the virus to attach to the host cell. Remember: No Match = No Entry = No Infection.
  - B. Penetration--The virus may be engulfed in an endosome, or fuse with the host cell releasing genetic material.
  - C. Uncoating – Envelope is removed and the capsid broken apart to expose just the genetic material.
  - D. Multiplication-- The host cell uses its own machinery to transcribe and translate the genetic material to make many more copies.
  - E. Assembly – The host cell also creates many more capsids around the genetic copies.

- F. Release -- Capsids may bud out of the host cell acquiring an envelope along the way or the cell may rupture releasing all the viral copies to infect other cells.
- V. The Lysogenic Cycle has many steps in common with the Lytic cycle but it never actively creates new viruses. The virus will go into an actual lysogenic cycle when it wants new virus particles created.
  - A. Attachment and Penetration -- and again, remember: No Match = No Entry = No Infection
  - B. Incorporation – the viral genetic material is incorporated to the host genome as if it was its own DNA.
  - C. Replication – each time the host cell replicates its own DNA before cell division the viral genetic code is copied right along with it
  - D. Distribution – as each new daughter cell is created after cell division it already contains a copy of the viral genetic code and they could each go into Lytic cycle to create more viral particles or just continue the Lysogenic cycle.
- VI. Retroviruses – unlike the other methods mentioned above retro viruses replicate differently than most RNA viruses. They have RNA as their genetic material to begin with. Next they use the host cell to copy the RNA genome into DNA. From the DNA it can be replicated to make more viruses or simply inserted into the host cell genome. The virus must carry the enzyme reverse transcriptase within its capsid in order to replicate in a new host cell. The steps of the Retrovirus cycle are: attachment, penetration, reverse transcriptase, integration into the DNA, replication, synthesis of virus particles, assembly, budding and release to maturation.
  - A. Human Immunodeficiency Virus or HIV is the most famous of the retroviruses. The HIV cycle will follow the normal retrovirus pathway after a person is newly infected causing flu-like symptoms and replicating the virus. After a few months the virus goes into the lysogenic cycle and simply gets replicated into new daughter cells waiting to finish its cycle. With HIV the patient may wait years or even decades before the symptoms return and the virus is active again. A patient will test positive for viral antibodies about 6-12 weeks after exposure even if the virus is not actively replicating.
  - B. Great video to show how retroviruses work differently available at: <http://youtu.be/RO8MP3wMvqg> Called: HIV Replication 3D Medical Animation.
  - C. Other retro viruses include HTLV I and II which is linked to Adult T-cell and hairy cell leukemia.

VII. The cultivation of viruses is complex and includes three common methods.

- A. Chicken egg culture – was once the only method and now is very rare; mainly used for research. Requires the egg to be inoculated and the virus to grow in the membrane just under the shell. Very technique-dependent and very time consuming
- B. Cell culture – very common but still only done in specialty virology laboratories or in research laboratories. Cell culture requires a sustainable cell line grown in sterile containers free of bacterial and other viral infections. Cells are observed under a microscope for evidence of cytopathic effect, or CPE, where you can see the host cells swelling, fusing, and floating due to viral infection. Unlike bacterial colonies that can be seen with the naked eye, viruses are so small that even when heavily infected you can still only see the effect they have on the host cell, not the actual virus. (Analogy: you cannot see the wind; you can only see the effect that the wind has on other things.) These cell cultures can be dyed with immunofluorescent stains to get a positive identification by using monoclonal antibodies specific to the virus.
- C. Animal inoculation – only used in research or vaccine production
- D. Antigen and Antibody Detection (Serology) – very easy and low cost method used in most laboratories. Many common viruses can be detected using these tests that are often done with EIA or ELISA western blots, RIBA, Chemiluminescence or fluorescent methodologies. Most of these tests can be run on large automated machines that give good turnaround times and accuracy. These are used for common stable viruses like HIV, all the Hepatitis's, EBV, HTLV, Influenza, and RSV to name a few.
- E. Amplification methods – these are the future of Viral Medicine. Amplification does not require the virus to be viable to detect the infection; it simply needs the genetic material for the virus to be present. Then it makes copy after copy to amplify the material. The product is then detected using tagged fluorescent molecules, particles or antibodies specific to the sequence amplified for that virus. These methods are mainly automated and have good accuracy, however, the turnaround time is longer than the antibody/antigen methods. These tests are often very expensive and require a large hospital or reference laboratory to run the procedures.

VIII. Viral Diseases

- A. Elaborate on these after student presentations being sure to fill in gaps left by the students or emphasizing material you may want to test on.
- B. Cancer – still being heavily researched. There are documented links

between many viruses and different types of cancers. Some of the most common are Human Papilloma Virus (HPV) and cervical cancer, Herpes Virus, specifically Epstein-Barr Virus and Burkitt's Lymphoma and Nasopharyngeal cancer, Hepatitis B virus and hepatocellular carcinoma, HTLV and Adult T-cell lymphoma and hairy cell, HIV and Kaposi's Sarcoma. The method for how a viral infection leads to cancer is still getting worked out but we do know that all the same parts of the cell that are used for viral replication have safety measures that keep the cell from replicating exponentially that are changed to allow viral replication. These changes could lead to the cancer production.

- C. Each virus causes its own disease but some of the more common ones are:
  - 1. Influenza from influenza virus A and B or similar symptoms from parainfluenza 1, 2, 3 or 4.
  - 2. Rabies animal to human (very deadly in humans)
  - 3. HIV and AIDS
  - 4. Hepatitis caused by Hepatitis viruses A or B or C
  - 5. Common STDs may include Herpes virus, HPV, HIV, and Hepatitis B and C
  - 6. Varicella Zoster and the Chicken Pox
  - 7. Epstein-Barr Virus and Infectious Mononucleosis and cancers mentioned above
  - 8. Adeno and Enteroviruses can cause different symptoms depending on the body site of the infection
  - 9. Rota, RSV and CMV -- often seen in the very young or the very old and can be life threatening
- D. As students present and these disease processes are reviewed clarify how these viruses are transmitted. Some examples are:
  - 1. Fecal-Oral: Hepatitis A virus, Rotavirus, Adeno and Enteroviruses
  - 2. Blood Borne: HIV, Hepatitis B and C
  - 3. Droplet Spray: Influenza A and B, Parainfluenza 1, 2, 3 and 4, RSV
  - 4. Contact: Herpes Simplex viruses, Varicella Zoster (also airborne), Adeno and Enteroviruses
  - 5. Vector: West Nile and Yellow Fever virus (mosquito bites)

IX. Vaccines are found in two main forms

- A. Live attenuated vaccines are weakened but still whole viruses. They cause a small infection triggering your body to develop an antibody to the virus. (Examples include measles, mumps, rubella, varicella and influenza)
- B. Inactivated vaccines are often only particles from the virus or proteins that look like the virus. The immune system will recognize the

particles and proteins as foreign and create an antibody to match. There is no real risk of getting an infection from an inactivated vaccine. (examples include polio, hepatitis A and rabies)

- C. The flu shot is new every year because, unlike the other viruses that have stable proteins to build antibodies to, the influenza virus changes drastically enough that a new antibody is needed for each new strain. For more details check out the world health organization or WHO. There is no vaccine for HIV or Hepatitis C for a similar reason. They change so fast that producing one per year does not even keep up.

### **Activities:**

- I. Create viral models in Viral Structure Activity
- II. Complete the Viral Research Activity
- III. Complete the Replication Activity
- IV. Watch an excerpt from the video, “And the Band Plays On” and debate the impact of the discovery of the AIDS virus on world politics and ethics. *Alternately research and debate the HPV vaccine and what population should be given the vaccine.*

**\* Remember to follow your school district policy for viewing videos.**

### **Assessment**

Multimedia Rubric

HOSA Biomedical Debate Event Rubric

### **Materials**

See Structure activity

<http://www.virology.net/big-virology/bvhomepage.html>

“Brock Biology of Microorganisms; Madigan, et al.; Prentice Hall, 2000; chapter 8

<http://www.hosa.org>

HOSA Biomedical Debate Event Guidelines

### **Accommodations for Learning Differences**

For reinforcement, the student will diagram stages of viral replication.

For enrichment, the student will research professional journals to identify possible links of viruses to cancers.

### **National and State Education Standards**

National Health Science Cluster Standards

HLC01.01 Health care workers will know the academic subject matter required (in addition to state high school graduation requirements) for

proficiency within their area. They will use this knowledge as needed in their role.

HLC06.02 Health care workers will understand the fundamentals of wellness and the prevention of disease processes. They will practice preventive health behaviors among clients.

### **TEKS**

130.207 (c)(4)(B) identify chemical processes of microorganisms;

130.207 (c)(4)(C) recognize the factors required for microbial reproduction and growth;

130.207 (c)(4)(D) explain pathogenic and non-pathogenic microbes in the human body; .

130.207 (c)(5)(A) outline the infectious process;

130.207 (c)(5)(C) categorize diseases caused by bacteria, fungi, viruses, protozoa, rickettsias, arthropods, and helminthes;

130.207 (c)(5)(D) explain the body's immune response and defenses against infection;

130.207 (c)(5)(F) examine reemergence of diseases such as malaria, tuberculosis, and polio;

### **Texas College and Career Readiness Standards**

English/Language Arts Standards III. Speaking B. 3. Plan and deliver focused coherent presentations that convey clear and distinct perspectives and demonstrate solid reasoning. IV Listening B. 1. Listen critically and respond appropriately to presentations. V. Research B. Select information from a variety of sources 1-4.

Science Standards III. Foundation Skills: Scientific Applications of Communication C. Presentation of Scientific/Technical information and D. Research skills / information literacy.

VI. Biology B. 1. Understand the major categories of biological molecules: lipids, carbohydrates, protein and nucleic acids. D. 3. Understand the molecular structures and the function of nucleic acids.

## **Viral Structure Teacher Instruction Page**

**Objective:** Students will be able to create a model of the structures of an animal virus or bacteriophage.

**Time:** Estimated 15 minutes to create; 5 minutes to follow up

**Overview:** Viruses are nonliving particles that are composed of genetic material, capsid or protein layer, envelope bilipid layer and glycoproteins. (Bacteriophages would be genetic material, capsid, tail and tail fibers).

**Materials:** Can be what you have on hand; some ideas include:

- Play dough: multiple layers of play dough, pipe cleaners and toothpicks
- Bolt and Nut: small bolt, two nuts, one washer and pipe cleaner pieces
- Cut and Paste: paper diagram using drawn or computer created parts, glue, tape and scissors

### **Follow up discussion questions:**

1. Judging by their appearance, what do you think the function of each part in the model might be?
2. What did you use for the capsid of your virus? What would the capsid be made of in reality? (answer: protein)
3. What would be found in the capsid of a real virus? (answer: genetic material)
4. What structural parts do all viruses have in common? (answer: capsid and genetic material)



## Viral Research Activity

**Time:** Estimated 30 minutes to research; 5 minutes to present per pair

**Objective:** Research and design a multimedia presentation on one of the following viruses:

- |                                 |                                |
|---------------------------------|--------------------------------|
| a. Adenovirus                   | k. Mumps                       |
| b. Cytomegalovirus              | l. Parainfluenza Virus         |
| c. Ebola virus                  | m. Poliovirus                  |
| d. Epstein-Barr Virus           | n. Rabies Virus                |
| e. Enterovirus                  | o. Respiratory Syncytial Virus |
| f. Herpes virus I or II         | p. Rhinovirus                  |
| g. Human Immunodeficiency Virus | q. Rotavirus                   |
| h. Influenza Virus              | r. Smallpox virus              |
| i. Marburg Virus                | s. Varicella Zoster Virus      |
| j. Measles                      | t. Yellow Fever Virus          |

Be sure to include the following:

- Prevalence of the virus:
- Mode of transmission:
- Signs and symptoms:
- Disease and course of the disease:
- Treatments vaccinations available:
- Morbidity and mortality rates:

# Multimedia Rubric

Student: \_\_\_\_\_

Class: \_\_\_\_\_

Title: \_\_\_\_\_

Other Group Members: \_\_\_\_\_

Date: \_\_\_\_\_

Scoring criteria	5 Excellent	4 Good	3 Needs Some Improvement	2 Needs Much Improvement	1 N/A
Clearly and effectively communicates an introduction of the theme/objective of the project.					
Clearly and effectively communicates the content throughout the presentation.					
Integrated a variety of multimedia resources to create a professional presentation (transition, graphics).					
Presentation holds audience attention and relates a clear message.					
Timing between slides is beneficial for the viewer to read or observe content.					
Each image and font size is legible to entire audience.					

## Scale:

26-30 A Excellent

21-25 B Good

16-20 C Needs Some Improvement

11-15 D Needs Much Improvement

6-10 F Not Appropriate

**TOTAL=**

**Comments:**

## Replication Activity

**Overview:** Diagram the lysogenic and lytic cycles like a cartoon giving each step its own frame to be drawn in.

**Lysogenic Cycle** has 4 main steps.

1. Virus finds matching receptors on a host cell and inserts its genetic material.
2. The host cell incorporates the material as DNA to its own genome.
3. When the cell replicates before division the viral genetic sequence is replicated along with its own genome.
4. The new daughter cells each have a copy of the viral genetic sequence that will only get used in the Lytic Cycle.

Diagram each step, making sure to label the virus, cell wall/membrane, viral genetic code, host DNA, and daughter cells throughout the drawings.

**Lytic Cycle** is used to replicate viral genetic code and create new viral particles. Remember the lytic cycle does not always end with host cell death as some viruses 'bud' out of the cell wall or membrane leaving the host cell intact to produce more viruses. There are six steps to the lytic cycle.

1. Virus finds matching receptors on the host cell wall or membrane.
2. Virus enters the host cell by one of three ways: Bacteriophages dock with tail fibers and insert genetic material; others maybe engulfed into an endosome in the host cell or they may fuse with the host cell wall/membrane releasing the capsid and genetic material into the cell.
3. The viral genetic material is transcribed and translated using the host cell's machinery.
4. The host cell will create proteins and genetic material needed to make new virus particles.
5. New viruses are assembled with the virus particles made by the host cell.
6. Viruses lyse the cell to release lots of newly made viruses to infect other cells. (Viruses may also 'bud' out of the host cell creating an envelope as they go.)

Again, be sure to label each part and use different colors if you have them!

**Lysogenic Cycle**


**Lytic Cycle**
