**Viruses, The Immune System, and Immunology** Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Go to the HHMI Biointeractive *Virus Explorer* at [www.hhmi.org/biointeractive/virus-explorer](http://www.hhmi.org/biointeractive/virus-explorer) and click on Launch Click & Learn. Click on the “About” tab at the bottom. Read the information and list four (4) ways in which viruses can differ from each other.

Abbreviations: nm = bp =

ss = ds =

Close the “About” window, and locate the “i” next to each viral characteristic tab across the top. Click on these icons and answer the questions below associated with each viral characteristic.

Envelope: Not all viruses have an envelope. If a virus has this outer layer, explain how it forms.

Structure: What determines the shape of the capsid, or core?

Host(s): From the virus’ perspective, why is the host important?

Genome Type: Viral genomes may vary by four characteristics of their genetic information. What are they?

Transmission: Define the terms “vector” and “zoonotic.”

Vaccine: What is one advantage of being vaccinated against a particular virus?

Virus Scavenger Hunt: Use the home page of the Virus Explorer and the various viral characteristic tabs across the top to answer the questions below.

What is one difference between the rabies virus and the influenza virus?

Of the nine viruses shown, which is the only one that infects plants?

What are three characteristics that adenoviruses, T7 virus, and papillomaviruses have in common?

Recently, Zika virus has been in the news. Treatment of it is of particular concern. Why?

Which two viruses infect all the vertebrates included in the interactive?

Of the nine viruses shown, which is the only one that infects bacteria?

List four characteristics that human immunodeficiency virus (HIV) and Ebola virus have in common.

List four characteristics that HIV and Ebola virus do not share.

Locate the + next to each virus name. Click on these icons and answer the questions below associated with selected viruses.

Rabies virus: People often associate rabies virus with dogs. Why is this incomplete?

Influenza virus: Influenza virus has a segmented genome. Why is this an advantage for the virus?

HIV: HIV infects immune cells. Why is this a disadvantage to the infected person?

HIV: Where in the world is HIV most prevalent?

Adenovirus: Adenoviruses can cause many mild clinical conditions in humans. What are three?

Papillomavirus: What is the common name for papillomas?

Papillomavirus: What kind of symptoms do some human papillomaviruses cause?

Zika virus: Why is Zika virus of great concern to pregnant women?

Tobacco mosaic virus (TMV): Name one unique characteristic of the tobacco mosaic virus.

Ebola virus: What animal is associated with Ebola virus outbreaks?

Instructions: Click on the “Show Relative Sizes of the Viruses” tab at the bottom of the interactive home page and answer the questions below. (You will need a calculator for some items.)

Using the white scale bar, about how long (tall) is TMV? \_\_\_\_\_\_\_\_\_ What is the approximate diameter of HIV? \_\_\_\_\_\_\_\_\_

What is the approximate diameter of Zika virus? \_\_\_\_\_\_\_\_\_\_

So, how big is a nanometer? Study the sample problem below and then answer the questions, showing your work for each.

Sample Problem: An average small paperclip measures 3.0 cm in length. Calculate the length of the paperclip in millimeters, micrometers, and nanometers.

a. Millimeters (mm)? 30 mm

Since there are 10 mm in a centimeter, the calculation is completed in the following way:

3.0 cm x 10 mm/1 cm = 30/1 = 30 mm

b. Micrometers (µm)? 30,000 µm

Since there are 1000 µm in a millimeter, the calculation is completed in the following way:

30 mm x 1000 µm/1 mm = 30,000 µm

c. Nanometers (nm)? 30,000,000 nm

Since there are 1000 nm in a micrometer (µm), the calculation is completed in the following way:

30,000 µm x 1000 nm/1 µm = 30,000,000 nm

So, a small paperclip measures 3.0 cm in length, or you can say it measures 30,000,000 nm in length!

A single grain of salt measures 0.5 mm in width.

a. What is the width in micrometers (µm)?

b. In nanometers (nm)?

The average human skin cell measures 30 µm in diameter.

1. What is the diameter in millimeters (mm)?

b. In nanometers (nm)?

If you lined up human skin cells side-by-side, how many would fit along the length of the paperclip in the sample problem above?

Using your response to item 1 above, if you lined up TMV particles end to end, how many would fit along the length of the same paperclip?

Using your responses to item 6, if you lined up TMV particles end to end, how many would fit across the diameter of the average human skin cell?

*Claim*: An individual virus docks on the surface of a cell, infects it, hijacks the cellular machinery inside, and replicates itself, sometimes thousands of times.

*Justification*: Based on what you learned about size, scale, and the component parts of a virus, justify with scientific reasoning how a virus is able to accomplish this.

**The Immune System**

Go to the HHMI Biointeractive *Cells of the Immune System* at [www.hhmi.org/biointeractive/cells-immune-system](http://www.hhmi.org/biointeractive/cells-immune-system) and click on Start Click and Learn. Answer the following questions as you proceed through the activity slides.

1. Name one type of cell involved in each of the following processes:

a. Innate immunity: \_\_\_\_\_\_\_\_\_\_

b. Adaptive immunity: \_\_\_\_\_\_\_\_\_\_

c. Both adaptive and innate immunity: \_\_\_\_\_\_\_\_\_\_

2. Define innate immune system.

3. Where are the cells of the adaptive immune system found in humans? \_\_\_\_\_\_\_\_\_\_

4. Watch the video on slide 3 and answer the following.

a. How do B cells react to antigens?

b. Which cells conduct the immune system? \_\_\_\_\_\_\_\_\_\_

c. Which immune cells kill infected cells? \_\_\_\_\_\_\_\_\_\_

5. What is the purpose of humoral immunity?

6. How does antibody specificity arise?

7. Outline the specific steps involved in antibody production in response to infection with human immunodeficiency virus (HIV).

8. Define antigen.

9. A macrophage is also referred to as an antigen-presenting cell. Explain why that is an appropriate term.

10. Why is antigen-presentation important in fighting infection?

11. A T cell is a type of white blood cell that has surface receptors that recognize antigens. Does an individual T cell have the ability to recognize more than one type of antigen? Explain your answer.

12. Explain the relationship between the antigen-presenting cells and helper T cells.

13. Watch the video on slide 8 and answer the following questions.

a. What specifically results from the release of cytokines by helper T cells?

b. What is the problem with helper T cells carrying out this function in HIV infection?

14. What role do cytotoxic T cells play in fighting infection?

15. What two molecules on the surface of a cytotoxic T cell help the cell recognize infected cells?

16. What is the role of ubiquitin in host cells? Be specific.

17. What is the role of an MHC class 1 protein? Be specific.

18. What is the relationship between an MHC class 1 protein and a cytotoxic T cell?

19. What is a potential problem with respect to the timing for when a cytotoxic T cell recognizes a virally infected cell?

20. Summarize the main difference between the action of MHC class 1 and MHC class 2.

**Immunology Virtual Lab** – Go to [www.hhmi.org/biointeractive/immunology-virtual-lab](http://www.hhmi.org/biointeractive/immunology-virtual-lab) and click on Start Virtual Lab.

DIAGNOSIS

1. Where are antibodies found?

2. How can they be used in the laboratory?

3. What does ELISA stand for?

4. What are ELISA assays used for in labs?

5. What are the three important limitations of an ELISA? Explain each.

BACKGROUND

1. What test can be used to determine whether a patient has an infectious or autoimmune disease?

2. What does a positive result indicate?

3. The watery fluid of the blood is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. What is allowed to react with the target antigen?

5. Detection is possible when \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. Once isolated, the secondary antibody can be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. What is the signaling system?

8. What happens when the appropriate chemical (substrate) is added?

9. How is the test quantified?

10. What does the amount of color reflect?

LAB NOTEBOOK - Proceed through the entire lab simulation protocol. Be sure to read the captions below the pictures (left side) and the information in the lab notebook (right side). Be sure to "start over" to begin the lab. You CANNOT skip any steps. Answer the following questions as you proceed.

1. What is systemic lupus erythematosus (SLE)?

2. From Figure 1 (click on it), what are the four steps of an ELISA protocol?

a.

b.

c.

d.

3. In step 1, you centrifuge the samples. What does a centrifuge do?

4. What are you preparing in step 2? Why are there three different solutions?

5. In steps 3 and 4, you prepare an ELISA plate. What has the ELISA plate been pretreated with? Why?

a. What is the positive control? (Step 4)

b. What is a primary antibody? Please define.

c. What is the negative control? (Step 4)

d. Why is it necessary to have a positive and a negative control? (Step 4)

6. Why incubate the plate in step 5?

7. Next, in step 6, the plate is washed. Why wash the plate?

8. In step 7, a secondary antibody is added. What is a secondary antibody? Please define.

a. What is the attached enzyme in this assay? (Step 7)

b. What is the specific substrate for HRP? What color does it produce? (Step 7)

9. How can the yellow color be quantitatively measured? At what wavelength? (Step 10, in "why")

10. Record your results. Indicate on this page and on the computer which boxes turned color.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | A | B | C | + (positive) | + (negative) |
| 1:2 |  |  |  |  |  |
| 1:10 |  |  |  |  |  |
| 1:100 |  |  |  |  |  |

11. Did you complete the ELISA correctly? (Yes/No)

If yes, proceed to #12 and #14.

If no, proceed to #13 and #14.

12. What do the results indicate about:

Patient A:

Patient B:

Patient C:

13. Explain what you did wrong and what you will need to do next time. For more information, check your printable summary page. Did your incorrect procedure provide you any results? Explain what went wrong.

14. This virtual lab was testing for lupus. How is this same test used to test for the presence of HIV? If the results for an HIV test were the same as in this exercise, what would they indicate about the three patients?

**Chapter 17 Reading Guide - Viruses**

***Overview***

Experimental work with viruses has provided important evidence that genes are made of nucleic acids. Viruses were also important in working out the molecular mechanisms of DNA replication, transcription, and translation. Viruses have been important in the development of techniques of manipulating and transferring genes. As you learn about viruses in this chapter, you will build on the foundation necessary for an understanding of the molecular techniques of biotechnology.

***Section 1***

1. What was some early evidence of the existence of viruses? Why were they difficult to study?

2. What are the four forms of viral genomes?

3. What is a capsid? What are capsomeres? What different shapes may capsids have?

4. As you see, all viruses consist of a nucleic acid enclosed in a protein coat. Some viruses also have a membranous envelope. What are the components of a viral envelope? Which component is derived from the host cell, and which is of viral envelope? Which component is derived from the host cell, and which is of viral origin?

5. What is the role of an envelope in animal viruses?

|  |  |
| --- | --- |
| 6. For the virus shown in the following figure, label the protein capsid, tail fibers, head, tail sheath, and genome.  a. What type of virus is this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ b. What does its name mean? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  c. What is its host? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ d. Is the genome of this virus DNA or RNA? \_\_\_\_\_\_\_\_  ***Section 2***  7. What property of a virus determines its attachment to a host cell membrane?  8. Viruses are obligate intracellular parasites. What does this mean? |  |

9. What is meant by host range? Distinguish between a virus with a broad host range and one with an extremely limited host range, and give an example of each.

10. Compare the host range for West Nile virus to that of the human cold virus.

11. What components of the host cell does a virus use to reproduce itself?

12. How does a DNA virus reproduce its genome?

13. How do most RNA viruses replicate their genome?

14. Explain the 4-step process of viral reproduction.

15. What are bacteriophages? Distinguish between virulent and temperate phages.

16. What portion of a phage enters the host cell? How does it do this?

17. What are restriction enzymes? How do they help prevent viral infection of bacteria?

18. Why don’t restriction enzymes destroy the DNA of the bacterial cells that produce them?

19. What are three ways bacteria may win the battle against the phages?

20. What is a prophage?

21. Since cells that have incorporated phage DNA into their genome may continue to divide and propagate the viral genome, this might be considered somewhat like the Trojan horse. What might trigger the switchover from lysogenic to lytic mode?

22. Describe the lytic and lysogenic modes of bacteriophage reproduction.

23. There are some general differences between bacteriophages and animal viruses. What are two elements that nearly all animal viruses have?

24. What is a retrovirus? How do retroviruses, such as HIV, replicate their genome?

|  |  |
| --- | --- |
| 25. Here is an illustration of HIV. Label these parts: envelope, glycoprotein, reverse transcriptase, RNA, and capsid.  26. Compare and contrast a prophage and a provirus. Which one are you likely to carry?  27. Explain the infection of a cell by HIV. |  |

28. The final section in Concept 17.2 is titled “Evolution of Viruses.” From this part, describe the two possible sources of viral genomes.

***Section 3***

29. What are three ways that viruses make us ill? Why do we recover completely from a cold but not from polio?

30. What tools are in the medical arsenal against human viral diseases?

31. Emerging viruses such as HIV, Ebola, and SARS seem to burst upon the human scene. What are three processes that contribute to this sudden emergence?

32. The 2009 flu pandemic is H1N1. What is a pandemic? What does the name of the flu mean?

33. Distinguish between horizontal transmission and vertical transmission in plants.

34. How do viruses spread throughout plant bodies?

**Chapter 35 Active Reading Guide - The Immune System**

***Section 1***

1. Phagocytosis plays an important role in the immune systems of both invertebrates and vertebrates. Review the process by briefly explaining the six steps to ingestion and destruction of a microbe by a phagocytic cell.

2. Explain the role of the Toll receptor in producing antimicrobial peptides.

3. List the three innate defenses vertebrates share with invertebrates and the two defenses unique to vertebrates.

4. In the following chart, describe how five examples of barrier defenses work.

|  |  |
| --- | --- |
| **Barrier Defense** | **How the Barrier Repels Pathogens** |
| Mucous Membranes |  |
| Saliva |  |
| Stomach Acid |  |
| Secretions from Oil and Sweat Glands |  |
| Skin |  |

5. Explain how Toll-like receptors are used in cellular innate defenses, using TLR3 and TLR4 as examples.

6. In the chart below, explain the role of the four phagocytic cells.

|  |  |
| --- | --- |
| **Phagocytic Cell Type** | **Role in Innate Defense** |
| Neutrophils |  |
| Macrophages |  |
| Dendritic Cells |  |
| Eosinophils |  |

7. Natural killer cells are not phagocytic. How do they assist in innate defenses and what types of cells do they detect?

8. Explain the role of the following two antimicrobial compounds.

interferon:

complement:

9. Explain the three steps of an inflammatory response.

10. It might seem like pathogens have little hope of mounting an infection, but do not forget that pathogens are constantly evolving ways to circumvent our immune system. As examples, how do the pathogens that cause pneumonia and tuberculosis avoid our immune responses?

***Section 2***

11. From the first four paragraphs of this concept, summarize where T cells and B cells develop, and give an overview of their functions. (Note that they are a type of white blood cell known as a lymphocyte.)

12. What is immunological memory, and why is it important?

13. Explain how cytokines help coordinate the innate and adaptive immune responses.

14. The following brief questions will serve as a beginning primer for immune system recognition.

a. What is an antigen?

b. What is the relationship between an antigen receptor, an antibody, and an immunoglobin?

c. How is an epitope related to an antigen? (Look at Figure 43.10 in your text.)

15. What forms the specific antigen-binding site? (Be sure to recognize that each B cell produces only one antigen receptor. For any one cell, all antigen receptors or antibodies produced are identical.)

16. T cells also display only one receptor on the surface of the cell. Compare and contrast a T cell with a B cell.

17. B cell receptors recognize and bind to antigens whether they are free antigens (like a secreted toxin) or on the surface of a pathogen. Explain the role of the major histocompatibility complex (MHC) to T cell receptor binding.

18. Explain how a host cell uses the MHC to display an antigen.

19. List four major characteristics of the adaptive immune system.

20. Explain how the body develops self-tolerance in the immune system.

21. Define the following terms.

effector cells:

memory cells:

clonal selection:

22. Using the blue text in the margin of Figure 35.11, explain the three key events to clonal selection.

23. Graphs similar to the one in Figure 35.12 have been seen on several AP Biology exams. It depicts the primary and secondary immune response. The first arrow shows exposure to antigen A. The second arrow shows exposure to antigen A again, and also antigen B. Explain the difference between a primary and secondary immune response.

***Section 3***

24. Explain the function of the two divisions of acquired immunity.

humoral immune response:

cell-mediated immune response:

25. Helper T cells play a critical role in activation of both T cells and B cells. Explain the three steps involved using Figure 35.13.

26. Explain the role of dendritic cells and macrophages in starting a primary and secondary immune response.

27. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are the effector cells in cell-mediated immunity.

28. What must occur for a cytotoxic T cell to become activated?

29. Explain the three primary steps that occur as a cytotoxic T cell destroys a target cell.

30. How is B-cell antigen presentation unique?

31. Explain the three primary steps that occur in B cell activation.

32. What is the difference between plasma cells and memory cells produced from the activation of B cells?

33. Explain these three ways antibodies can dispose of antigens.

viral neutralization:

opsonization:

activation of complement:

34. How do antibodies and natural killer cells work together to fight viral infections while the virus is inside the body?

35. Using examples, explain the difference between active and passive immunity.

36. Describe how immunizations can serve as an example of active immunity.

37. Explain how monoclonal antibodies are used in home pregnancy kits.

38. Why is the antibody response to a microbial infection polyclonal?

39. Why is immune rejection an example of a healthy immune system?

40. Briefly describe the following features of immune rejection.

a. Explain how antibodies against blood types are present.

b. What is the role of MHC in tissue and organ transplants?

c. Why are bone marrow transplants medically unique?

41. What are allergies?

42. Use Figure 35.17 to explain a typical allergic response.

43. Explain what happens if a person experiences anaphylactic shock.

44. Autoimmune diseases occur when the immune system turns against particular molecules of the body. Describe the cause and symptoms of the following autoimmune diseases.

lupus:

rheumatoid arthritis:

type 1 diabetes mellitus:

multiple sclerosis:

45. Explain how immunodeficiency diseases are different from autoimmune diseases.

46. Just as our immune system has evolved to thwart pathogens, pathogens have evolved to thwart our immune system. Describe the following pathogen strategies.

antigenic variation:

latency:

attack on the immune system: HIV:

47. Explain how the high mutation rate in surface antigen genes in HIV has hampered development of a vaccine for AIDS. (You might take note that HIV—human immunodeficiency virus—is the virus that causes the disease AIDS—acquired immunodeficiency syndrome. These acronyms are often used incorrectly.)