Study guide
MICROBIAL DIVERSITY **NAME:**

This study guide covers the two chapters on viruses: BROCK CH. 9 and TL CH. 8.

BROCK CH. 9

1. A virus is a microorganism that… (give definition).

    a. What characteristic or life stage distinguishes viruses from other genetic elements?

        i. Name a genetic element that does not have this characteristic.

        ii. Describe the characteristics of viruses in this state.

        -Define **virion:**

        -Describe the virus particle/virion in this stage:

    b. What is meant by the 'intracellular state'?

        i. What happens during the intracellular state?

        ii. Define **infection**.

        iii. How do viruses replicate? Is this during the intracellular phase or another phase?

2. True or false: all viruses are harmful to host cells.

3. True or false: offspring of infected hosts, in some cases, can inherit the viral genome.

4. True or false: all cells have DNA as their genetic material.

5. True or false: all organisms have DNA as their genetic material.

6. True or false: all viruses have genetic material.

7. Draw Fig. 9.1. Use the chapter to provide an example of a virus that falls into each category, and list those below the figure. (On the figure, the abbreviations 'ds' and 'ss' are used. Make sure you know what those mean.)

8. Define **bacteriophage:**

    a. What is one way in which bacteriophages are useful in modern biology?

    b. What does the term 'phage' mean?

9. True or false: animal viruses (viruses infecting animals) have been more extensively studied than viruses infecting plants.

10. What characteristics are shared among viruses in the same viral family?

    a. What suffix is used in every viral family name?

11. How big are viruses (or, well, I guess you could ask – how small are viruses)?

a. Give an example and the size of a large virus, and an example and the size of a very small virus.

b. One virus of note is 200nm (nanometers) in size. What is its size in microns (μm)?

12. What is the size range of most bacterial genomes (in kilobase pairs, or kb)?

a. What is the size range of most viral genomes (in kilobase pairs, or kb)?
NOTE that Table 9.1 gives values in **base pairs**, not in **kilobase pairs**.
1000 base pairs = 1 kilobase pairs, just as 1000 meters = 1 kilometer.

b. What characteristic do the bacteria with the smallest genomes share with viruses?

13. The nucleic acid (genetic material) of a virus is always located in what part of the virion?

a. What are some other terms used to refer to this same part of the virion?

b. The capsid is composed of structural subunits, which are individual protein molecules that are arranged in precise and highly repetitive patterns around the nucleic acid. Some viruses have only one sort of protein in the capsid or coat, but others have chemically distinct portions called capsomers, which are large enough to be seen under what kind of a microscope?

c. The complete complex of protein and nucleic acids in a virion is called:

d. Draw and label an enveloped virus and a naked virus. Name an example of an enveloped virus and a naked virus.

i. What two components generally make up the membrane of an enveloped virus?

14. What are the two types of symmetry seen in viruses? Give the term for each, describe the shape that each term refers to, name a virus that displays each symmetry type, and give the dimensions of each virus.

Type of symmetry	Description of shape	Example	Size

15. Do the lipids and the proteins in the membrane of an enveloped virus come from the same source? Name the origin of each.

16. Some viruses contain enzymes, such as lysozyme. Describe the two roles of lysozyme in the interactions between bacteriophage and host cells.

17. Cell cultures are typically used in the study of animal viruses. Describe the steps used to establish cell cultures, using the following prompts:

    a. Cells are taken from…

    b. Cells are separated from one another (disassociated) by

        i. treatment with…
        ii. and then…

    c. Cells produce the following, which allow them to adhere to smooth surfaces….

        i. This thin layer of cells is called…

    d. The thin layer of cells is covered by …

18. What is meant by the term ‘permanent cell lines’?

19. What is meant by the term ‘virus infection unit’?

20. One of the most efficient ways to quantify virus infectivity is via the *plaque assay*. This is described at length in the text. I would like you to be familiar with how this works, in general. Make sure that you understand Fig. 9.6 and 9.7 -- but you won’t have to recreate them on the exams. In general terms, what do the plaques represent?

21. Draw and label the five stages of replication in a bacteriophage.

22. To understand the diversity of viruses requires an understanding of the remarkably diverse ways in which they replicate. This is difficult material and the presentation in the book is a little thick. I have tried to clarify it here. I suggest that you read the following, then go to Fig. 9.11 and read the following again, using the figure to reinforce the text I’ve written here.

    Necessary background: Replication of viral proteins must occur as part of viral multiplication. The production of these proteins requires viral-specific messenger RNA (mRNA). For some types of RNA viruses, the genome of the virus itself serves as the mRNA. Most viruses, however, have to synthesize mRNA. Viruses that have a double-stranded DNA genome synthesize mRNA like the rest of cellular life does. That is,

    DNA → RNA → protein

    First arrow = transcription (information contained in a section of DNA is transferred to mRNA, facilitated by RNA polymerase and transcription factors)

    Second arrow = translation (mRNA is translated in ribosome into a polypeptide chain, the basis of a protein)

Other viruses, however, may have only single-stranded DNA, single-stranded RNA, or double-stranded RNA. David Baltimore (who discovered retroviruses) classified viruses on the basis of the relationship between viral genomes and mRNA.

Class I viruses work as described above.

Class II viruses are single-stranded DNA viruses. These viruses (1) synthesize a complementary DNA strand, so that they become double-stranded, and then (2) proceed as described above.

Viruses in classes III-VII work differently. To understand these requires the following information:

- mRNA is complementary to the DNA strand that was its template.
- mRNA can be translated into protein
    - mRNA is, by convention, said to be in the *plus* configuration
    - the complement of mRNA is said to the in the *minus* configuration

      Therefore, a virus with a single-stranded RNA genome that is configured in the same way as its mRNA is a *positive-strand RNA virus*

      And a virus with a single-stranded RNA genome that is complementary to its mRNA configuration is a *negative strand RNA virus*

Class IV (we'll come back to Class III in a minute) viruses are single-stranded, positive-strand RNA viruses. In this case, the RNA of the virus itself serves as the mRNA.

Class V viruses are single-stranded, negative-strand RNA viruses. These viruses have to make mRNA first. They do this by injecting RNA polymerase into the host cell, which allows the – strand to be transcribed, yielding a + strand of mRNA.

Going back to Class III viruses – these are double-stranded RNA viruses. Like Class V viruses, they inject RNA polymerase into the host cell, which allows the – strand to be transcribed, yielding a + strand of mRNA.

Class VI viruses are retroviruses. These are amazing; they use **reverse transcriptase** to make DNA from RNA. The process of making DNA from RNA is called reverse transcription. The Class VI viruses carry reverse transcriptase in their virions. In this case:

ss RNA (+) undergoes reverse transcription to yield ds DNA
ds DNA is transcribed to yield mRNA

Finally, class VII viruses have ds DNA, but instead of acting like Class I viruses, they replicate through an RNA intermediate, which requires reverse transcriptase. Thus, class VII viruses also are retroviruses.

23. Bacteriophages generally have what kind of genome?

24. Are most bacteriophages naked or enveloped?

25. What is a “virulent” virus?

26. Viruses T1-T7 are… (circle one answer)

    A. Bacteriophages
    B. Virulent viruses
    C. Model systems
    D. Double-stranded DNA viruses
    E. All of the above.

27. Check out the cool morphology of bacteriophages in Fig. 9.12, especially with regard to the ds DNA viruses.

28. How does T4 ensure that its own genes, rather than the genes of its host, are transcribed?

29. What is a “temperate” virus?

    a. Give one example of a well-studied temperate bacteriophage.
        i. What species does this bacteriophage infect?

        ii. True or false: this virus is a double-stranded DNA virus.

    b. What is lysogeny (a lysogenic state)?

    c. Note that temperate phage genomes can be duplicated along with that of the host. During cell division (by the host), the viral genome can be passed from one generation to the next. The transmission of a symbiont (for example, a virus) from one generation to the next is called **vertical transmission** *(not defined in the chapter).*

    d. Note that the presence or replication of a virus is not problematic for most cells. Instead, it is the ***expression of the viral genome*** that leads to the production of new virions and cell death. Bacterial cells that contain latent viruses are called **lysogens**. In this case, the virus does not exist in a mature, infective state in the host cell; instead, the cell is said to be infected by a…

        _____ or a virus in the _____ state.

e. Look at Fig. 9.16, which shows the consequences of infection by a temperate bacteriophage.

    i. Which pathway results in incorporation of the viral DNA into the host DNA?

    ii. Which pathway results in cell death?

f. Lambda, a bacteriophage infecting *E. coli*, has both the lytic pathway and the lysogenic pathway. Define each pathway using the definitions at the start of the chapter.

    i. I would like you to be able to draw and label Fig. 9.16. You can do so in the space below. For the purposes of this class, you do not need to memorize the details of Lambda infection and and the lytic pathway (text starting at the end of p. 251, and all of 252, 253, and 254). It's pretty neat, though, so I suggest that you read this section – lambda phage is amazing.

30. What is a latent infection? Define, and give one example of a virus that forms latent infections in humans.

31. Check out the amazing diversity of animal viruses in Fig. 9.22 (wow). Note that unlike bacteriophages, the entire virion of a given animal virus enters the host cell.

32. What is cancer?
    a. What prevents normal cells of mature organisms from dividing extensively?
        i. Name the process whereby infection by a virus leads to uncontrolled cell division.

ii. Distinguish between malignant and benign tumors by defining each.

iii. What is metastasis?

iv. Name at least three factors, besides viruses, that can lead to cancer.

v. Growth and division of normal cells is governed by two factors. Name them, and state the role of each.

33. A virus infecting an animal cell can lead to four outcomes. What are the outcomes? The easiest way to put these all together might be to draw Fig. 9.23, labeling the steps as you go along.

34. Retroviruses …(circle one answer)
    a. Are enveloped
    b. Use reverse transcriptase to transfer information 'backward' (from RNA to DNA)
    c. Include Human Immunodeficiency Virus (HIV)
    d. Were the first viruses to be studied for their carcinogenic effects.
    e. All of the above.

35. Describe one way in which retroviruses may be used to treat human diseases.

36. List and describe the steps involved in replication of a retrovirus.

37. Why is medical treatment of viral diseases with drugs very difficult?

38. What is a viroid?

a. Give an example of a viroid, and state how many bases are present in the genome of that viroid.

b. Viroids…(circle all that are correct)
   A. Have capsids
   B. Are naked RNA
   C. Cause important plant diseases
   D. Are replicated in the host cell nucleus
   E. Have no protein-encoding genes in their RNA
   F. Are thought to be remnants of the 'RNA World'

39. What is a prion?

a. Prions… (circle all that are correct)
   A. Contain no nucleic acid
   B. Include the causal agent of bovine spongiform encephalopathy
   C. Are studied as model systems in their interaction with yeast
   D. Modify the protein(s) produced normally by host cells
   E. Cause host cells to produce more of the pathogenic protein

For exam 1, please be sure that you can distinguish among the following: prion, viroid, virus, cellular life.

TOL Chapter 8

1. True or false: viruses have arisen once in the history of life.
2. True or false: viruses average 1/100th of the size of most bacteria.
3. According to this chapter, how many virus 'species' are known? How many families, and how many genera?

4. The ebola virus is a member of which viral class (for example, is it a single-strand DNA virus, a retrovirus…)?
    a. The ebola virus is a member of what family?
    b. What other infamous hemorrhagic virus is a member of this family?
5. Poliovirus is a member of which viral class?
    a. The poliovirus is a member of what virus family?
    b. What other human virus is a part of this family?
6. Most viral families are a member of which two viral classes?
7. Name the three hypotheses that have been presented to describe the origins of viruses.
    a. One hypothesis states that some RNA viruses have been present on Earth since the beginning of life (3.8. by ago). Under this hypothesis, simple RNA molecules arose from pools of free nucleotides as a result of physical and chemical attraction between nucleotides. Some of these RNA molecules went on to become viruses; others became enclosed in membranes (as described by the RNA World Hypothesis). Which hypothesis is this?
    b. A second hypothesis suggests that viruses arose when mRNA escaped from host cells. This mRNA gained the ability to be replicated and packaged in a protein-based coat. Which hypothesis is this?
        i. What classes of viruses are thought to have arisen in this way?
        ii. Under this scenario, are viruses as old as the first origins of life?
    c. The third hypothesis suggests that viruses are descended from formerly free-living bacteria that have lost functions, DNA, and various structures. This hypothesis was previously accepted, but is not supported by molecular data. Which hypothesis is this?

i. If this hypothesis were true, what would the tree of life look like (draw below)?

8. Distinguish between a **grade** and a **clade**.

a. Are viruses though to represent a grade, or a clade?

9. Describe the potential role of RNA transcriptase in the transition from the RNA world to the DNA world.

10. What family includes West Nile virus?

    a. What class of viruses includes this family (see Table)?

    b. Name another member of this family (see Table).

11. The chapter concludes with a statement about Darwin's 'other' metaphor for the tree of life. Why might this other metaphor fit well for viruses – perhaps even better than the tree of life?