VIRUSES

What is a virus?

**A close up of text on a white background

Description automatically generatedViruses** are very diverse in classification, and there are arguments for and against whether viruses are living or not. In this chapter we will explore the ways viruses are classified and determine what factors make them living or non-living. **Virology** is the study of viruses which is in the field of microbiology.3 Viruses come in many shapes and forms such as a bacteriophage (Figure 1).

Figure 1 Bacteriophage structure

A virus is smaller than microorganisms known like cells, bacteria, and archaea. The success of a virus is dependent on a host. Host cells have active machinery and mechanisms that viruses need to replicate. Viruses are typically very specific in choosing a host. In nearly every ecosystem on Earth, a virus can be found. They are considered to be the most abundant type of biological unit.2 A virus’s core may contain RNA or DNA. This genetic material is surrounded by a protective protein coat called a **capsid**. Once the virus finds a host cell, it is able to attach itself and use the host cells machinery to make more viruses.3 Historically and today the collective perception of viruses focuses on its role as a pathogen. Have you ever had the seasonal flu? This is due to a common virus that is capable of mutating over time and has proven itself to be unpredictable and reoccurring each year. In the global population 5-15% will become infected by the influenza virus each year.5 Viruses may cause **epidemics** which is an outburst of contagious disease in a large group of people in a defined area over a defined time. The next level of this is a pandemic. A **pandemic** is similar to an epidemic but at a global rate. This is why the study of viruses is very important. Viruses have the potentially to effect people globally.

*Concept Check*

1. What is the most abundant type of biological unit?
2. What is the purpose of a capsid?
3. Describe an epidemic versus a pandemic.

History

The evolutionary history of how and where viruses came about are unknown. There is no established origin of viruses, but there are theories. Viruses are evolutionarily a key source of horizontal gene transfer. This is important for the increase of genetic diversity.4 Virologists have articulated three hypotheses including the progressive, regressive, and virus-first.6

* The Progressive- through a progressive process parts of genetic material that had the ability to move in a genome, eventually became capable of exiting one cell and entering another. The method of movement is very similar to an important component of eukaryotic genomes called retrotransposons.
* The Regressive- through a reductive process it is hypothesized that like in other cells, viruses could have evolved from something more complex and possibly free-living. Essentially over time a symbiotic relationship turned parasitic. The parasite becomes dependent on the host and loses its essential genes which leads to its inability to reproduce alone.
* The Virus-First- this hypothesis suggests that viruses came before cells. It suggests that viruses were self-replicating units that became more complex and enzymes for the synthesis of membranes evolved.

For the vast number of various viruses each hypothesis could be argued for a specific type. It is possible that the evolution of origin could be a combination of these or none at all. To think that viruses could be the origin of life is definitely interesting and will continue to be studied in the field of microbiology.6

Are they alive?

To begin the discussion of whether viruses are alive or not we must define the term alive. To be a “living” organism there are a few fundamental properties most biologists agree on including: the ability to reproduce, grow, evolve, maintain homeostasis, carry out metabolic processes, and respond to stimuli.6 Viruses do and do not meet these criteria. We know a virus is capable of reproducing, just not on its own. Each year there is a new flu vaccine because it is known to evolve. The biggest difference between viruses and living organisms is that a virus cannot generate ATP or carry out metabolic processes.6 Additionally, viruses need a host cell because they do not have the machinery needed for translation. Based on the definition above viruses are non-living. Although this is the most commonly accepted concept, several scientists argue that they are living matter because they can inherit genetic mutations similar to cellular organism’s natural selection. Because viruses are capable of replication, they are some part of lifeform.2 They just do not fit into the commonly understood definition of life.

*Concept Check*

1. Briefly describe the factors that make virus “living”
2. Describe why viruses are not considered “living”

Types of viruses

As we have discussed, viruses can carry DNA or RNA as genetic material, and we can break these down into six classes. Class I and II viruses carry DNA.

**Class I** consists of just one double-stranded DNA. In common animal viruses of this class the viral DNA inserts into the nucleus and enzymes begin to transcribe the DNA making mRNA.3 A common virus in class I that you might be familiar with causes chickenpox and is named *Herpesviruses.* There is a second type within the class I viruses that replicates in the cytoplasm of its host cell. This type within class I are collectively known as *poxviruses*. This type can cause smallpox and is used in vaccinations to produce immunity.3Class II are referred to as *parvoviruses.* **Class II** are simpler than the first class and contain only one molecule of single stranded DNA. The single stranded DNA is copied in the host cell into a double strand and then copied into mRNA.3

Classes III-VI are RNA viruses and a wide variety of animals are infected by these classes. These viruses have been very helpful in the study of translation, mRNA synthesis, membrane formation, and cell transformation. **Class III** viruses have double stranded genomic RNA and are used in research as pure mRNA. **Class IV** consists of just one plus strand of RNA and is identical to the viral mRNA. **Class V** consists of one negative strand of RNA. The sequence of the negative strand is complementary to the viral mRNA. Measles and mumps are caused by this class of virus. **Class VI** viruses are enveloped meaning it has an outer coat from the cell’s membrane. This class consists of two of the same plus strands of RNA. The RNA genome of this class guides the formation of DNA and is known as retroviruses. Retroviruses are known to cause cancer and these genes produced are called oncogenes. The virus transforms the cell after injection into a cancerous tumor cell.3

Viral Replication cycles?

The lytic and lysogenic cycles are key for virus replication. In the **lytic cycle** a virus attaches to a receptor on the outside of the host cell. Next the virus begins to inject its genetic material and the host cell replicates the material. There are four essential steps to visualize the lytic cycle: adsorption, penetration, replication, and release.3 The host cell replicates the virus until it bursts, or lyse, releasing several new copies of the virus.

In the **lysogenic pathway** the first steps are the same as the lytic cycle. The difference is that in lysogenic replication the virus’s genetic material isn’t copied by itself like in the lytic, but it is integrated into the host cell chromosome.

Real World Application

Viruses can be highly contagious. The year 2020 began with an outbreak of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), better known as COVID-19. This virus resulted in a rapid pandemic. In the search for a vaccine against SARS-CoV-2 researchers began to look at the genetic similarities with SARS-CoV. This virus variation caused an outbreak in 2003, but to a much lesser extent.1 While the virus is still being studied there has not been a vaccine developed. This time shows the importance of our understanding and knowledge of viral infections. Viruses such as Ebola, HIV, Influenza, and SARS-CoV-2 are commonly known and have impacted the world tremendously.

*Concept Check*

1. Write a short summary of what you have learned in this chapter.

Works Cited

1 Ahmed, S.F.; Quadeer, A.A.; McKay, M.R. Preliminary Identification of Potential Vaccine Targets for the COVID-19 Coronavirus (SARS-CoV-2) Based on SARS-CoV Immunological Studies. *Viruses* 2020, Petrova, V., Russell, C. The evolution of seasonal influenza viruses.*Nat Rev Microbiol* 16**,**47–60 (2018). https://doi.org/10.1038/nrmicro.2017.118

*2*, 254.

2 C Michael Hogan (Lead Author);Sidney Draggan Ph.D. (Topic Editor) "Virus". In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth May 12, 2010; Last revised Date December 30, 2010; Retrieved September 28, 2012. Encyclopedia of Earth

3 Lodish H, Berk A, Zipursky SL, et al. Molecular Cell Biology. 4th edition. New York: W. H. Freeman; 2000. Section 6.3, Viruses: Structure, Function, and Uses. Available from: https://www.ncbi.nlm.nih.gov/books/NBK21523/

4 Murphy, F. A., Fauquet, C. M., Bishop, D. H., Ghabrial, S. A., Jarvis, A. W., Martelli, G. P., ... & Summers, M. D. (Eds.). (2012). Virus taxonomy: classification and nomenclature of viruses (Vol. 10). Springer Science & Business Media.

5 Petrova, V., Russell, C. The evolution of seasonal influenza viruses.*Nat Rev Microbiol* 16**,**47–60 (2018). https://doi.org/10.1038/nrmicro.2017.118

6 Wessner, D. R. (2010) The Origins of Viruses. Nature Education 3(9):37