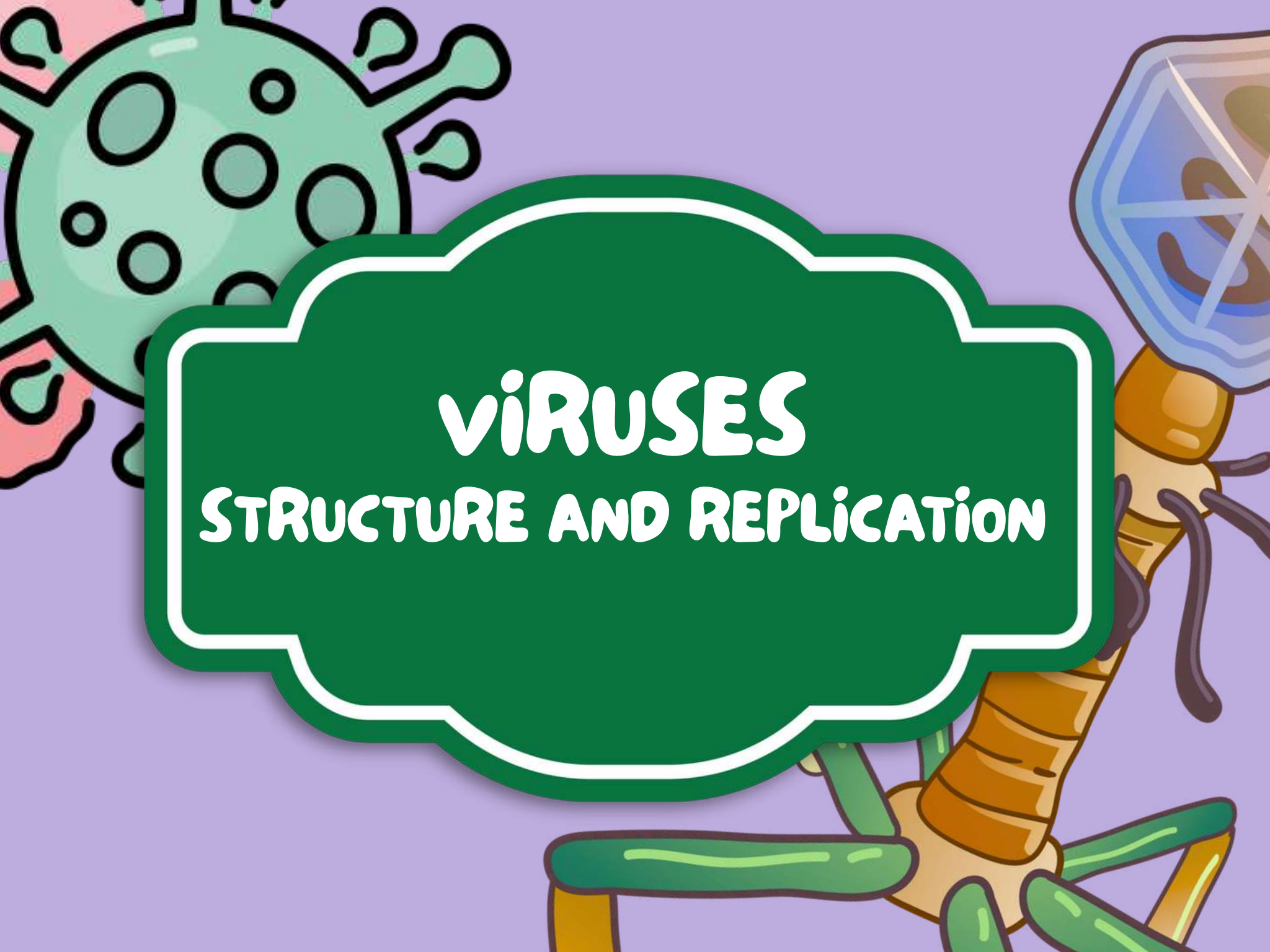

VIRUSES
STRUCTURE AND REPLICATION

# viRUSES

## Viruses & the Edge of Life

You're in a high-security containment lab on Earth, fresh off your return from a bio-research satellite orbiting deep space. Your mission was simple: retrieve environmental data. But what you brought back changed everything—a microscopic agent, invisible to the naked eye, yet powerful enough to shut down entire systems. It wasn't moving, it didn't eat, and it didn't grow... but once it found a host? It activated, replicated, and spread like wildfire.

Scientists across the globe are now asking the same question: Is it alive?

Welcome to the mysterious world of viruses—tiny particles that walk the line between life and non-life. In this unit, you'll explore the structure and behavior of viruses, investigate how they replicate using the lytic and lysogenic cycles, and compare their abilities to the characteristics of living things. You'll break down what makes something "alive," and why viruses challenge our definitions.

You'll analyze how viruses like influenza, herpes, HIV, and even COVID-19 infect their hosts, how they evolve, and how science uses vaccines and epidemiology to fight back. Through real-world examples and history-changing outbreaks, you'll uncover the truth: viruses may not be fully alive—but they're one of biology's most dangerous players.

By the end of this unit, you'll be able to:

- Identify the basic structure of viruses, including the capsid, genetic material, and envelope (if present).
- Describe and compare the lytic and lysogenic cycles of viral replication.
- Explain how viruses differ from living things in terms of cells, metabolism, growth, and reproduction.
- Apply the 8 characteristics of life to determine what separates living organisms from viruses.

- Understand how viruses spread through populations using concepts like outbreak, epidemic, pandemic, and endemic.
- Learn how vaccines work and how they help us control the spread of viral diseases.
- Explore the global impact of viral infections, including a case study on the COVID-19 pandemic and how epidemiologists respond to outbreaks.

This isn't just about science—it's about survival, systems, and the strange gray area between what's alive and what isn't. Get ready to investigate biology's most mysterious entity... the virus.

## VOCABULARY

| Vocabulary Word | Definition |
|---|---|
| bacteriophage | |
| capsid | |
| chicken pox | |
| DNA virus | |
| evolve | |

# VOCABULARY CONTINUED...

| Vocabulary Word | Definition |
| --- | --- |
| genetic material | |
| genome | |
| herpes | |
| host | |
| HIV – Human immunodeficiency virus | |
| infect | |
| influenza | |
| lysogenic cycle | |
| lytic cycle | |

| Vocabulary Word | Definition |
| --- | --- |
| pathogen | |
| retrovirus | |
| RNA virus | |
| vaccine | |
| viral dormancy | |
| virus | |

# PHENOMENON

"Code Red in the HAB"

Mission Log – Sol 63

Red emergency lights flash inside the Mars HAB. The bio-seal door to Med Bay hisses shut behind you as you stare at your crewmate, Dr. Elena Ruiz. She's pale, feverish, and coughing uncontrollably. Just days ago, she seemed fine—working on a deep core sample taken from beneath a Martian ice shelf. Now, her vitals are unstable, and she's showing signs of infection.

You access her medical scan data. No signs of bacterial growth. No environmental contamination. But then you see it—spherical structures swarming inside her cells under the nanoscope feed. Each one is surrounded by a protective capsid, and inside? A twisting strand of RNA. The structures are too small to be cells. They're not reproducing on their own. But her body is reacting. They're infecting, replicating, and destroying her healthy tissues.

It's a virus. But where did it come from?

Three sols ago, she handled a sealed core sample retrieved from beneath a Martian ice shelf. You remember—she joked about "Martian microbes" as she prepped the containment chamber. Now, you wonder: Was that joke foreshadowing something far more real?

You begin analyzing the data:

- The virus isn't visible until it enters the host cell.
- It appears to hijack cellular machinery to replicate itself—indicating a lytic cycle.
- But some copies lie dormant, hiding in the genetic material of Elena's cells—possibly the lysogenic cycle.
- There's no immune memory or antibody signature in her blood. This is novel. Earth has never seen this before.

You're now the mission's acting epidemiologist. The rest of the crew is at risk. You need to act fast.

Is this virus alive?

How does it replicate?

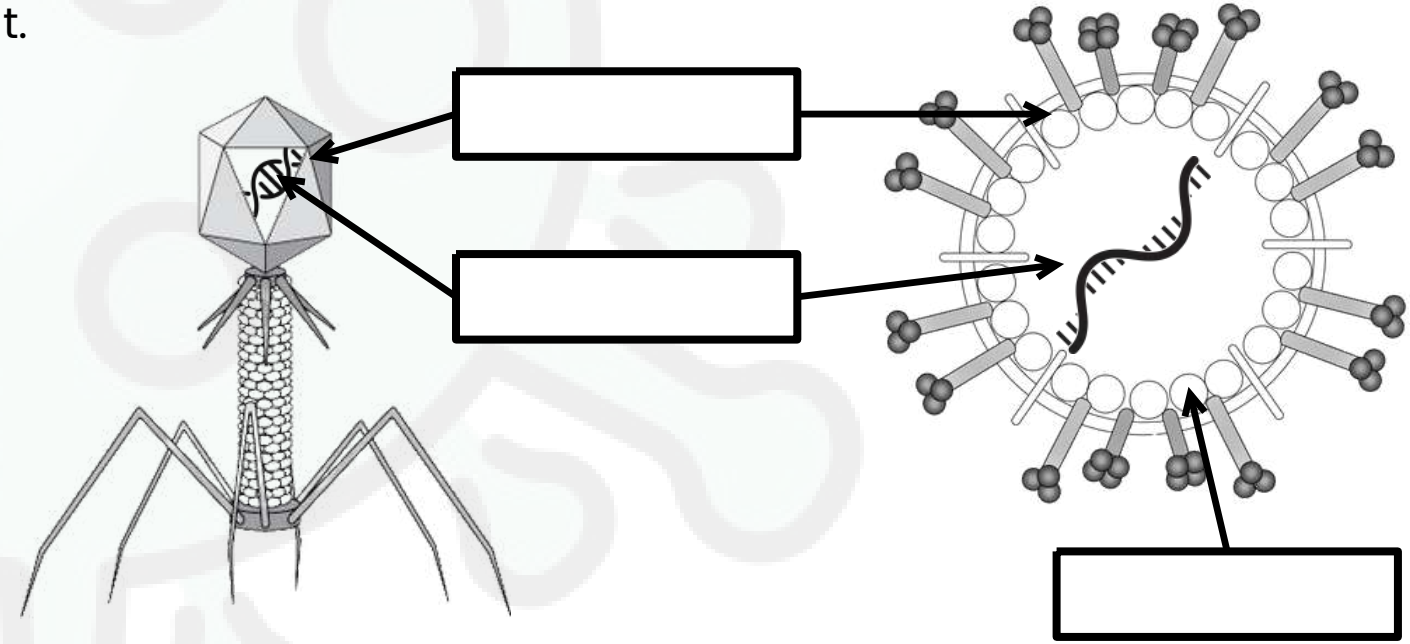
Can you stop the spread before the whole HAB is compromised?

1. Based on the story, what evidence shows that the Martian virus might not be considered alive?
    - "The virus might not be considered alive because it does not _____."
    - "According to the story, it cannot _____ without a host cell."
    - "Unlike living organisms, it lacks the ability to _____."
2. What part of the virus's structure helps identify it as a virus and not a living cell?
    - "The virus has a structure called a _____, which protects its _____."
    - "It contains genetic material, but it is not made of _____ like living things."
    - "This structure shows it is a virus because _____."
3. Which replication cycle is likely causing Elena's current symptoms, and why?
    - "The symptoms are most likely caused by the _____ cycle."
    - "This is because the virus is _____ and _____ cells."
    - "In the story, it says the cells are being _____, which matches the lytic cycle."
4. What evidence suggests the virus may also be using the lysogenic cycle?
    - "The virus may be using the lysogenic cycle because it _____."
    - "The story says the virus is inserting _____ into the host's DNA and staying _____."
    - "This matches the lysogenic cycle because _____."
5. Why is it important to understand how this virus spreads, and what can you do to prevent an outbreak in the HAB?
    - "Understanding how the virus spreads is important because _____."
    - "In the HAB, one way to prevent the spread is by _____."
    - "Since it spreads quickly in closed spaces, we should also _____."

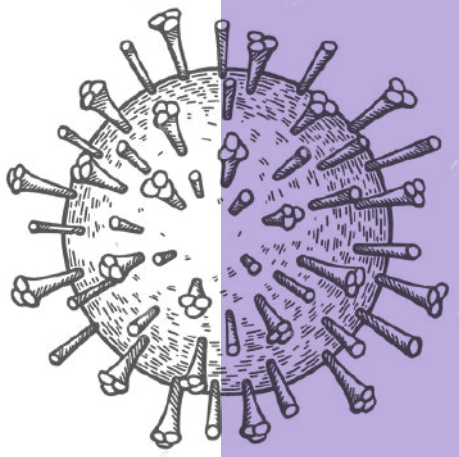
# INTRODUCTION

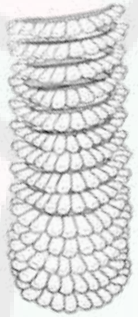
What is a **Virus**?

- A virus is a tiny germ that can make you sick. It's not alive like plants or animals.
- Parts of a virus:
  - **Capsid**: This is like a shell that protects the virus.
  - **Genetic material**: This is like a recipe that tells the virus how to make more of itself.
  - **Lipid envelope** (if applicable): Some viruses have a coat made of fat.

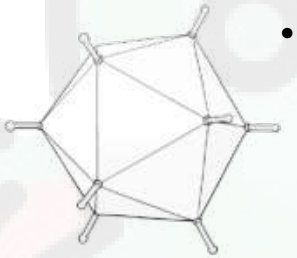


- Types of Viruses by Shape
  - **Spherical Viruses**
    - Description: These viruses are roughly spherical or round in shape.
    - Examples: Influenza virus, Adenovirus

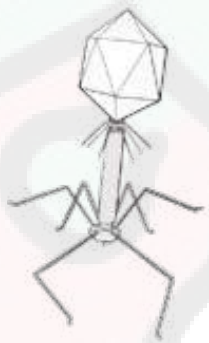




- **Helical Viruses**
  - **Description**: These viruses have a helical or spiral shape, resembling a spring.
  - **Examples**: Tobacco mosaic virus, Ebola virus



- **Icosahedral Viruses**
  - **Description**: These viruses have a roughly spherical shape with 20 triangular faces.
  - Examples: Poliovirus, Herpes simplex virus



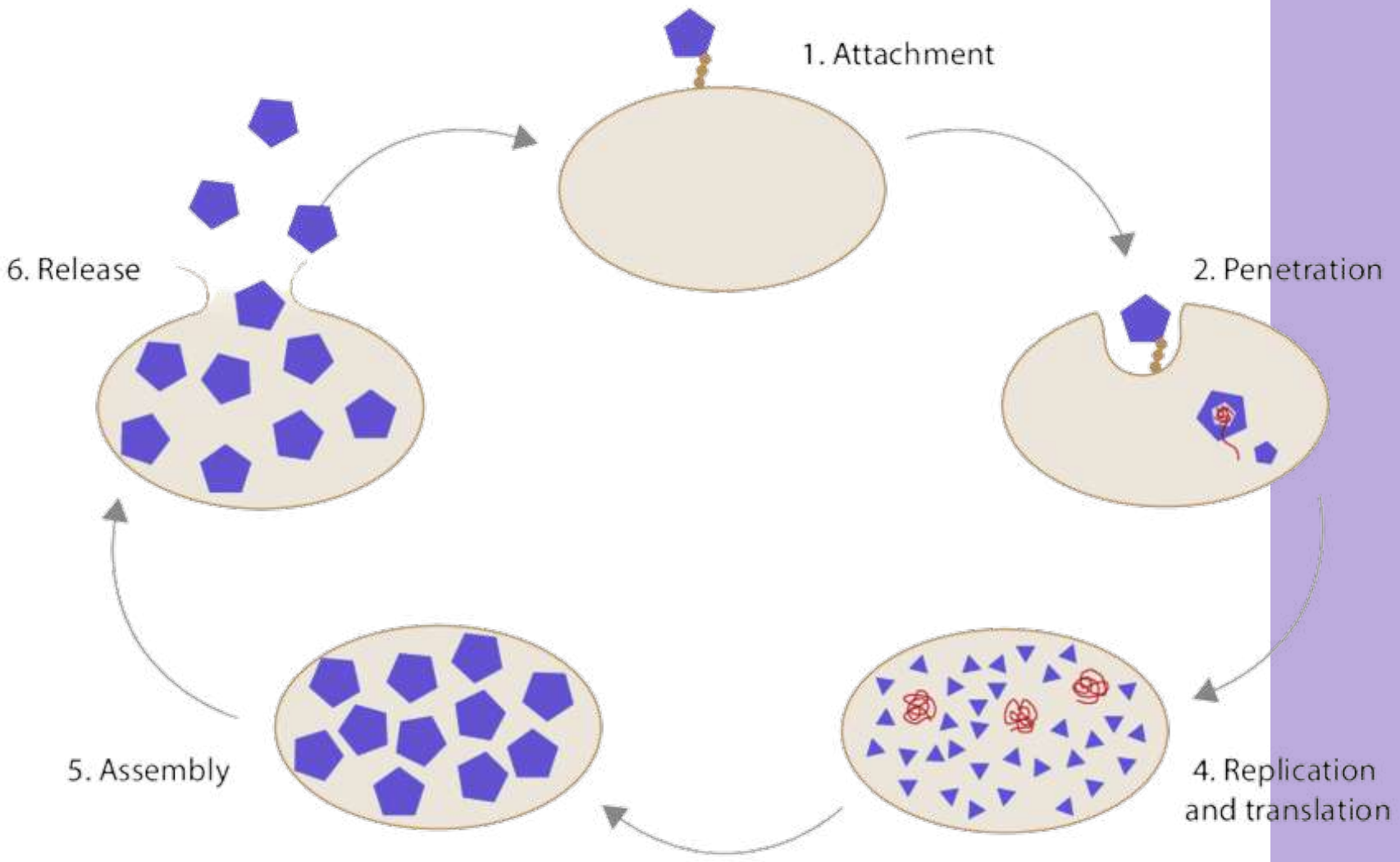
- **Complex Viruses**
  - **Description**: These viruses have a complex structure that does not fit into the other categories.
  - **Examples**: T4 bacteriophage, Vaccinia virus

# LYTIC CYCLE

**How Viruses Make More of Themselves: The Lytic Cycle**

- When a virus infects a cell, it uses the cell to make copies of itself.
- Steps of the **lytic cycle**:
  a. **Attachment**: The virus sticks to the cell.
  b. **Penetration**: The virus gets inside the cell. DNA or RNA, depending on the virus type enters the host cell.
  c. **Biosynthesis**: The virus makes copies of itself using the cell's machinery.
  d. **Maturation**: New viruses are put together.
  e. **Release**: The cell bursts and new viruses go out to infect other cells.
- **Examples**:
  - Influenza
  - Ebola
  - Covid - 19

# LYTIC CYCLE


1. Attachment
2. Penetration
4. Replication and translation
5. Assembly
6. Release

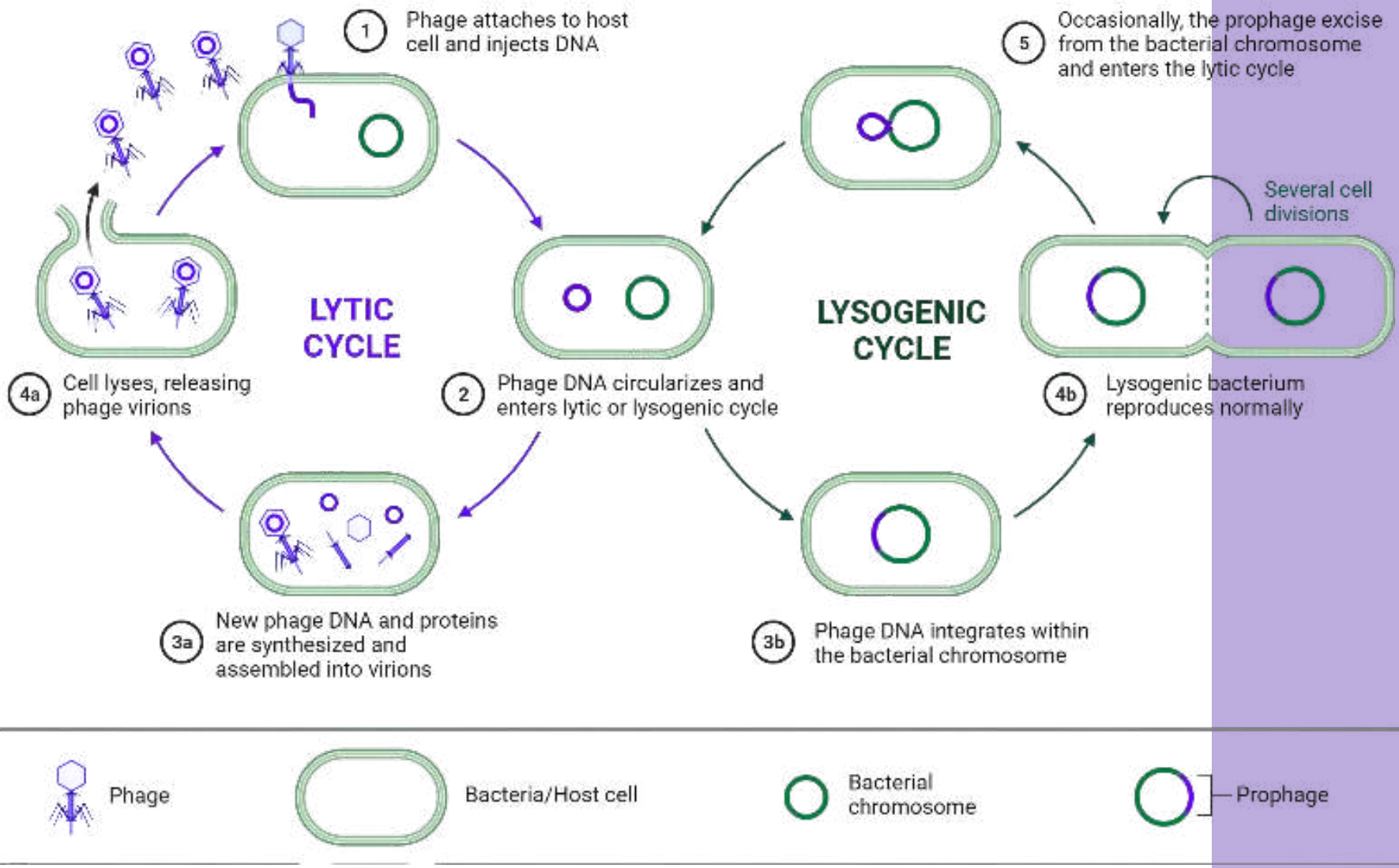
1. What are the main stages of the lytic cycle? Turn and talk with your partner about the different stages of the lytic cycle. Which part did you find most interesting and why?
2. How does a virus infect a host cell in the lytic cycle? Discuss with your partner how a virus attaches to and enters a host cell. Can you describe what happens after the virus enters the cell?
3. What happens to the host cell during the lytic cycle? Turn and talk about the changes that occur in the host cell during the lytic cycle. How does the virus use the host cell to make more viruses?
4. Why is the lytic cycle important for viruses? Discuss with your partner why the lytic cycle is crucial for viruses. How does this cycle help viruses spread to new cells?
5. What did you find surprising or confusing about the lytic cycle? Talk with your partner about any parts of the lytic cycle that you found surprising or difficult to understand. How can you help each other understand it better?

# LYSOGENIC CYCLE

How Viruses Can Stay Hidden: **The Lysogenic Cycle**

- Sometimes, a virus can hide in a cell and does not make copies right away.
- Steps of the lysogenic cycle:
  - **Attachment and Penetration**: The virus gets into the cell.
  - **Integration**: The virus puts its genetic material into the cell's DNA.
  - **Dormancy**: The virus stays quiet and doesn't make copies of itself, but the cell undergoes constant cell division making copies of the viral genetic material in each new cell.
  - **Activation**: Something triggers the virus - **Lytic cycle** begins: start making copies and cause illness.
- Examples:
  - **HIV**
  - **Herpes**

# LYSOGENIC CYCLE



1. What are the main stages of the lysogenic cycle? Turn and talk with your partner about the different stages of the lysogenic cycle. Which part did you find most interesting and why?
2. How does a virus integrate its genetic material into the host cell's DNA during the lysogenic cycle? Discuss with your partner how a virus's genetic material becomes part of the host cell's DNA. Why is this step important for the lysogenic cycle?
3. What happens to the host cell during the lysogenic cycle? Turn and talk about the changes that occur in the host cell during the lysogenic cycle. How does the host cell behave while it contains the viral DNA?
4. Why is the lysogenic cycle beneficial for viruses? Discuss with your partner why the lysogenic cycle is beneficial for viruses. How does this cycle help viruses remain undetected by the host's immune system?
5. What did you find surprising or confusing about the lysogenic cycle? Talk with your partner about any parts of the lysogenic cycle that you found surprising or difficult to understand. How can you help each other understand it better?

# ARE VIRUSES ALIVE?

**How Viruses Are Different from Living Things**

- **Living Things:**
  - **Cells**: all living things are made of cells/cells are the basic unit of life, viruses are not made of cells
  - **Metabolism**: Living things use food for energy, but viruses don't.
  - **Growth**: Living things grow bigger, but viruses only make more copies of themselves.
  - **Reproduction**: Living things can make babies, but viruses need HOST to make more of themselves.
  - **Response to stimuli:** living organisms respond to their environment, viruses do not.
  - **Homeostasis**: living things maintain a stable internal environment, but viruses can not.
- **Non-living Things:** Viruses
  - **Genetic Material**: Viruses have genetic material (DNA / RNA) like living things.
  - **Adaptation / Evolution**: Viruses can change to continue infection similar to living things' actions to survive.

HOST

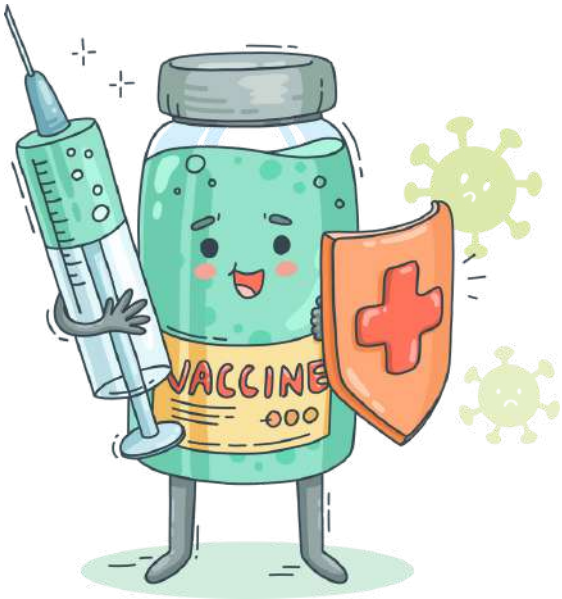
| Characteristic | Virus | Cell |
| --- | --- | --- |
| Structure | | |
| Reproduction | | |
| Genetic Material | | |
| Growth & Development | | |
| Obtain & Use Energy / Metabolism | | |
| Response to Stimuli | | |
| Evolution / Adaptation | | |
| Homeostasis | | |

1. What are the 8 characteristics of life? Turn and talk with your partner about the 8 characteristics that all living things share. Which characteristic did you find most interesting and why?
2. Why is reproduction important for living things? Discuss with your partner why the ability to reproduce is a key characteristic of life. Can you think of examples of different ways organisms reproduce?
3. How do living things respond to their environment? Turn and talk about how living things respond to changes in their environment. Share an example of how an animal or plant might react to its surroundings.
4. What does it mean for living things to maintain homeostasis? Discuss with your partner the concept of homeostasis and why it is important for living things. How do you think your body maintains homeostasis?
5. What did you find surprising or confusing about the 8 characteristics of life? Talk with your partner about any parts of the 8 characteristics of life that you found surprising or difficult to understand. How can you help each other understand it better?

# EPIDEMIOLOGY

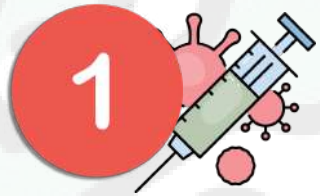
How We Study and Control Viruses: **Epidemiology**

- Epidemiology helps us understand how diseases spread and how to stop them.
- Parts of Epidemiology:
  - **Watching** for Sick People: We keep an eye on people getting sick.
  - **Finding** the Source: We try to figure out where the sickness started.
  - **Prevention**: We use things like vaccines to stop the sickness from spreading.
- What are **Vaccines**?
  - Definition: Vaccines are substances that stimulate the immune system to produce **antibodies**, providing immunity against **specific** diseases.
  - Purpose: Vaccines help **prevent** the spread of infectious **diseases** by creating **immunity** without causing the disease itself.



# VACCINES

- **How Vaccines Work:**
  - Vaccines contain **weakened** or **inactive** parts of a **virus** or **bacteria**.
  - When the vaccine is administered, the immune system recognizes these parts as foreign and produces **antibodies** to fight them.
  - **Memory cells** are also created, which **remember** the **pathogen** and can quickly produce **antibodies** if exposed to the actual virus or bacteria in the **future**.





- Components of Vaccines:
  - **Antigens**: These are the parts of the virus or bacteria that stimulate the immune response.
  - **Stabilizers**: These help maintain the effectiveness of the vaccine during storage and transportation.
  - **Preservatives**: These prevent contamination of the vaccine.
- Effectiveness of Vaccines:
  - Many Vaccines are highly effective at preventing diseases and their complications.
  - Some vaccines may require booster doses to maintain immunity over time.
  - Vaccine effectiveness can vary depending on factors such as the individual's age, health status, and the specific vaccine.
- **Immunity and Vaccinatio**n:
  - Vaccination helps create immunity by stimulating the immune system to produce antibodies.
  - **Immunity** can be achieved through vaccination or by recovering from the disease itself, but vaccines (depending on the virus) are safer and more effective.
- **Herd immunity** is achieved when a sufficient portion of the population is immune to a disease, reducing the spread of the disease and protecting those who are not

1. How do vaccines help protect us from diseases? Turn and talk with your partner about how vaccines work in our bodies. Why are they important for preventing illnesses?
2. What is the immune system and what are its main functions? Discuss with your partner what the immune system does. How does it help keep us healthy?
3. How does the body respond to a vaccine? Turn and talk about what happens in your body after you receive a vaccine. How does this help you build immunity to a disease?
4. Why is it important for many people to get vaccinated? Discuss with your partner why it's important for a large number of people to get vaccinated. How does this help protect everyone in the community?
5. What did you find surprising or confusing about vaccines and the immune system? Talk with your partner about any parts of the information on vaccines and the immune system that you found surprising or difficult to understand. How can you help each other understand it better?

# Summary

1. What are the basic parts of a virus, and how are they different from the parts of living cells?
   - "A virus is made of _____, which include _____ and _____."
   - "Unlike living cells, viruses do not have _____ or _____."
   - "This shows that viruses are structurally simpler because _____."
2. How do viruses reproduce, and what are the key differences between the lytic and lysogenic cycles?
   - "Viruses reproduce by _____."
   - "In the lytic cycle, the virus _____, which causes _____."
   - "In the lysogenic cycle, the virus _____ and stays _____ until _____."
   - "The main difference between the two is _____."
3. Why aren't viruses considered living things according to the characteristics of life?
   - "Viruses are not considered living because they do not _____."
   - "One characteristic of life that viruses lack is _____."
   - "Even though they have genetic material, they can't _____ without a host."
4. In what ways are viruses similar to living organisms?
   - "Viruses are similar to living things because they _____."
   - "For example, they have _____, which allows them to _____."
   - "They can also _____ over time, which is a trait of living things."
5. How does epidemiology help us understand and control virus outbreaks?
   - "Epidemiology is the study of _____."
   - "It helps scientists by _____ and _____."
   - "Using epidemiology, we can identify _____ and prevent _____."
6. What is a vaccine, and how does it help protect individuals and communities from viral infections?
   - "A vaccine is a substance that _____."
   - "It helps the immune system by _____."
   - "Vaccines protect communities by creating _____, which means _____."

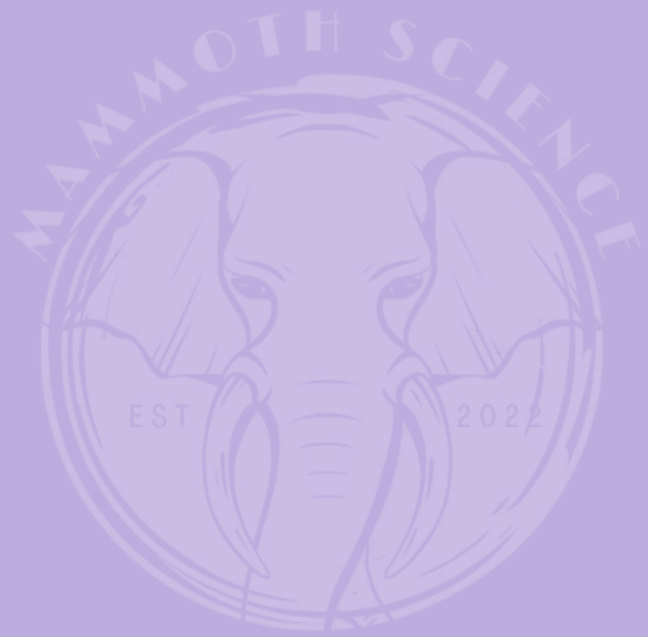
# RESOURCES

Amoeba Sisters. (2018, May 22). Viruses (Updated) [Video]. YouTube. https://www.youtube.com/watch?v=8FqlTslU22s

Osmosis from Elsevier. (2020, July 23). Viral structure and functions [Video]. YouTube. https://www.youtube.com/watch?v=01TetEto1ls

Bozeman Science. (2012, April 3). Viruses [Video]. YouTube. https://www.youtube.com/watch?v=L8oHs7G_syI

TED-Ed. (2015, January 12). How do vaccines work? - Kelwalin Dhanasarnsombut [Video]. YouTube. https://www.youtube.com/watch?v=rb7TVW77ZCs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