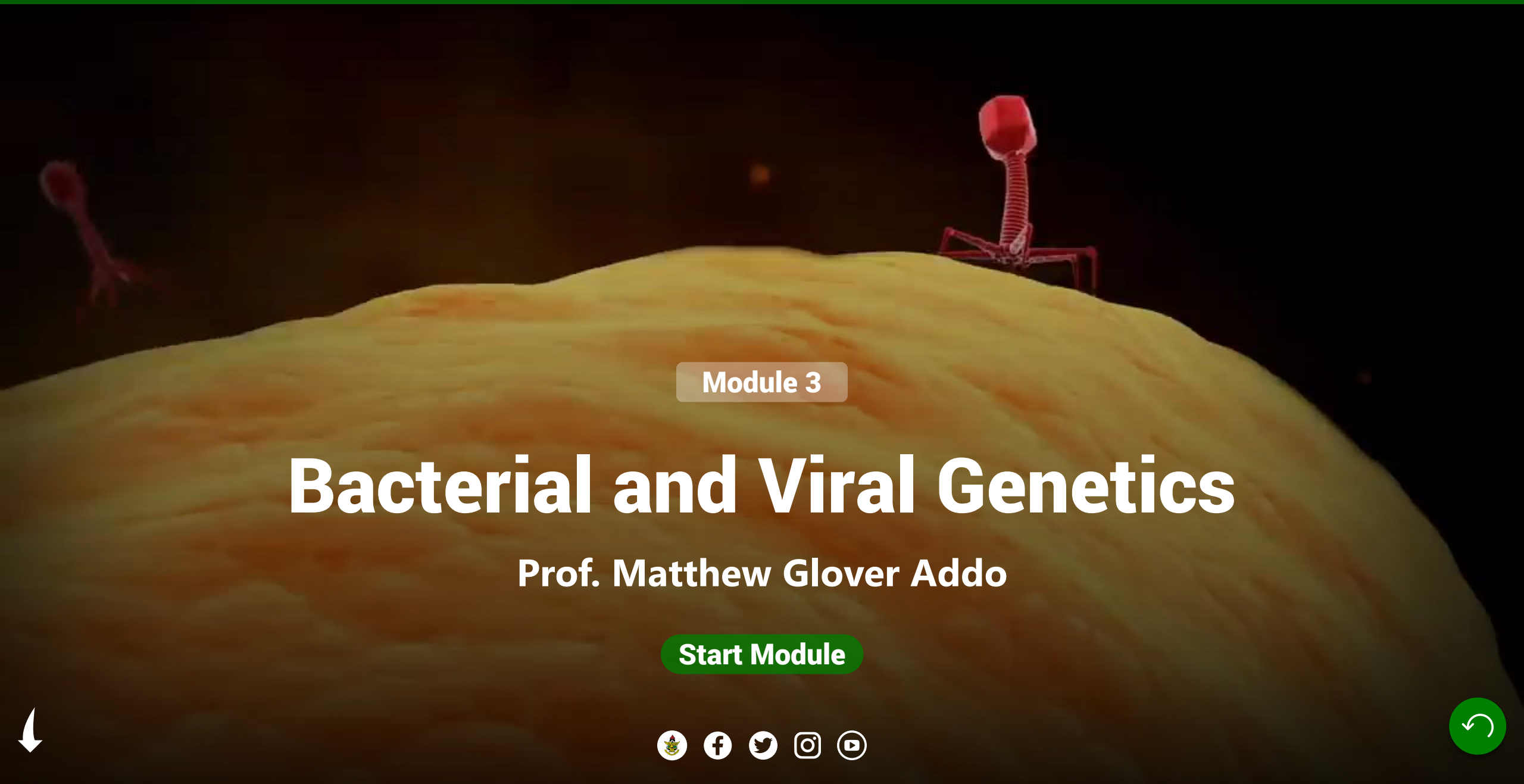


Module 3

Bacterial and Viral Genetics

Prof. Matthew Glover Addo

Start Module

Module 3

Bacterial and Viral Genetics

Module Dashboard

- Dashboard
- Objectives
- Lessons
- Assignments

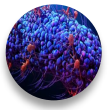
End of Module

Lessons
3

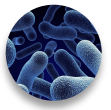
Assignments
0

Start Learning

Pick a Lesson



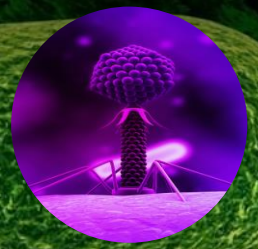
Lesson 1
Introduction



Lesson 2
The Bacterial Chromosome

Lesson 3
Genetics of Viruses

2



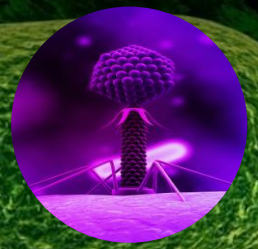
Module 3

Bacterial and Viral Genetics

Module Objectives

1. Bacterial transformation (how an exogenous DNA is taken up by a recipient cell using bacteria)

2. Will consider the two types of transformation (i.e. natural and artificial)



Module 3

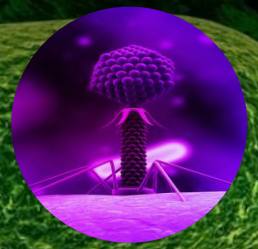
Bacterial and Viral Genetics

Module Objectives

End of Module

3 **Viruses:** Consider the definition, structure, classification, their life cycles and some properties of phage lambda (the lytic and lysogenic cycles)

4 **Transduction:** which is also one of the major mechanisms of transferring genetic material from one bacterium to another



Module 3

Bacterial and Viral Genetics

Module Objectives

5 Will be considering the two types of transduction (i.e. generalized and specialized)

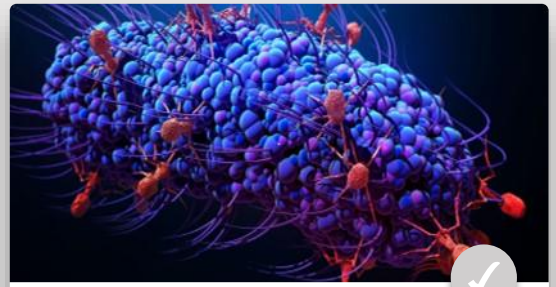
Module 3

Bacterial and Viral Genetics

Module Lessons

- Dashboard
- Objectives
- Lessons
- Assignments

End of Module



Lesson 1

Introduction

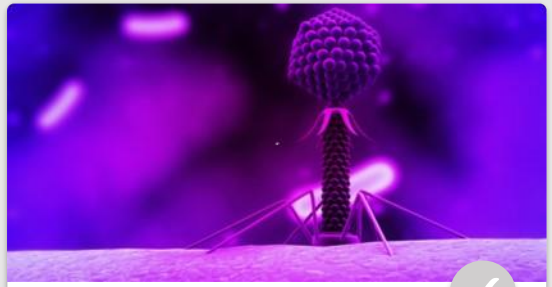
Learn about the reasons for studying bacterial and viral genetics

Start ▸

Lesson 2

The Bacterial Chromosome

Start ▸



Lesson 3

Genetics of Viruses

Start ▸

Lesson 1

Introduction

Learn about the reasons for studying bacterial and viral genetics

Learn Now ▶

Introduction

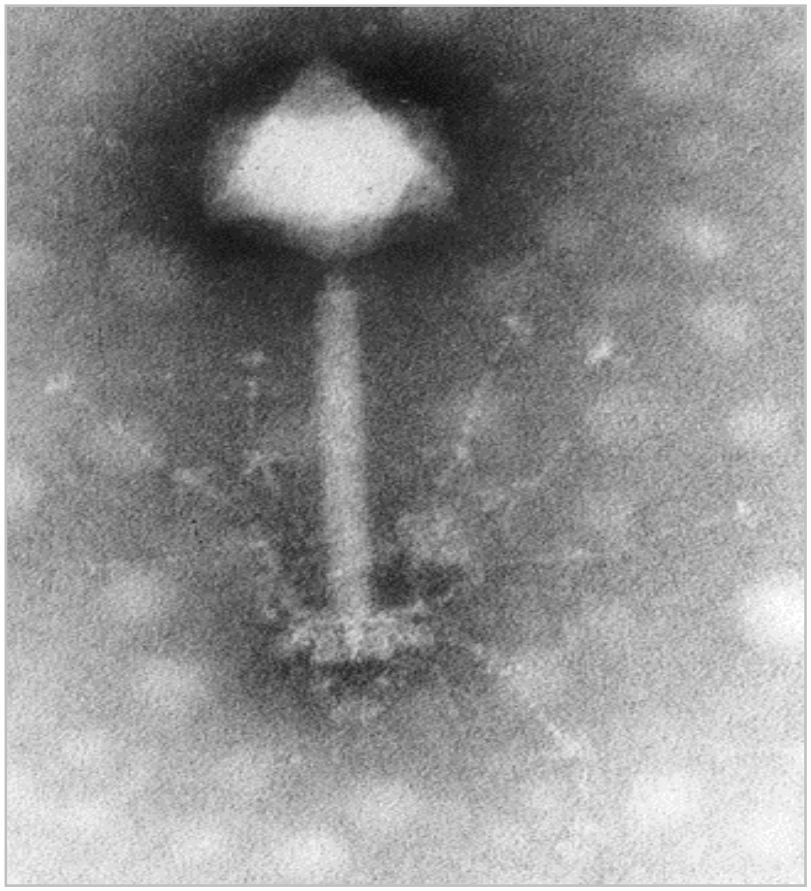
Why do we Study

Bacterial and Viral Genetics?

Learn More

Why Study Bacterial and Viral Genetics?

Since the 1940s, the genetic systems of bacteria and viruses have contributed to the discovery of many important concepts in genetics

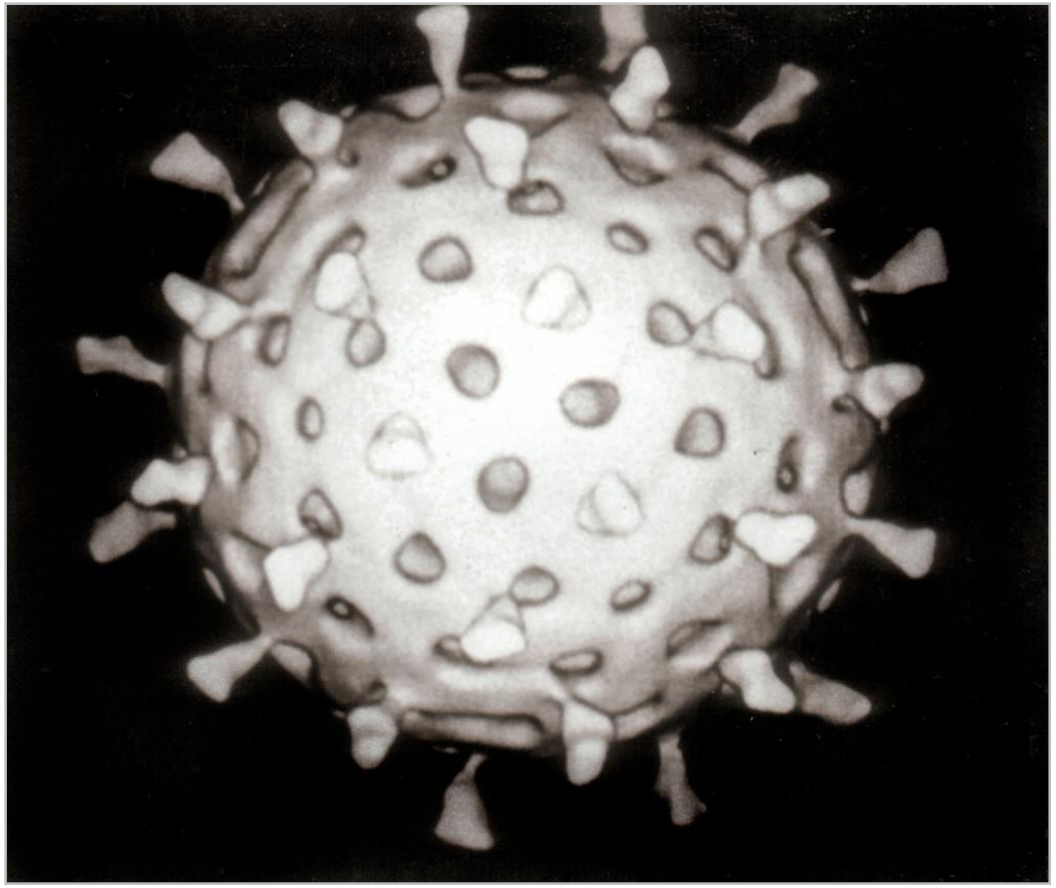


Bacteriophage

Learn More

Why Study Bacterial and Viral Genetics?

The study of molecular genetics initially focused almost entirely on their genes

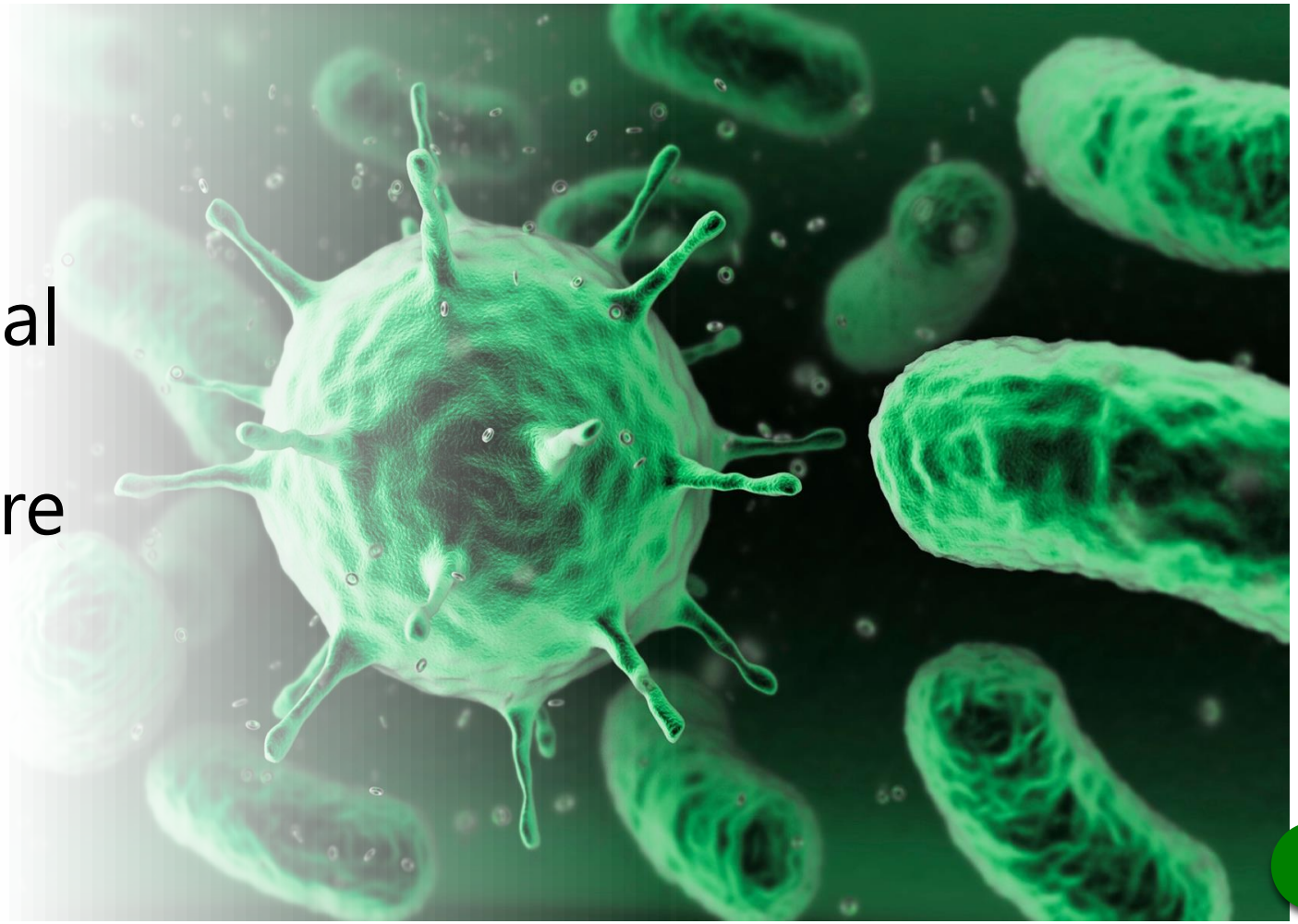


A rotavirus gene

Learn More

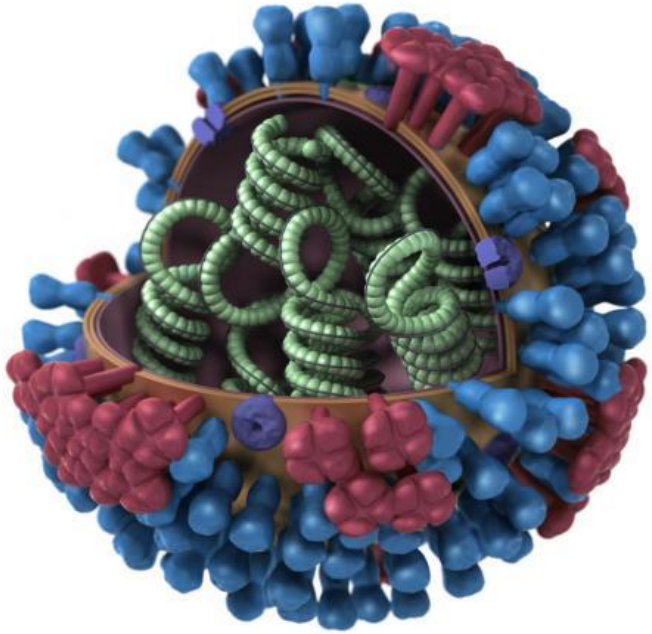
Why Study Bacterial and Viral Genetics?

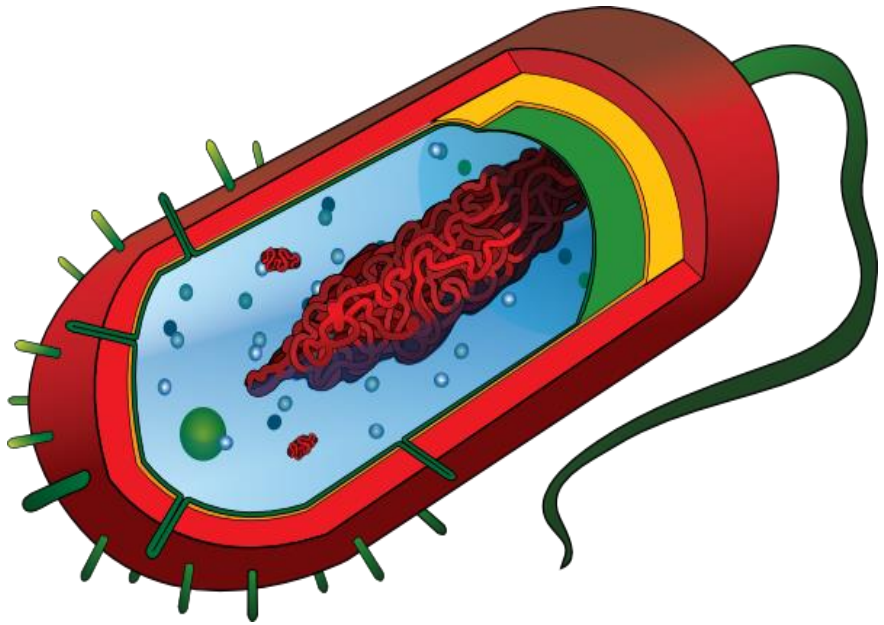
Today, bacteria and viruses are still essential tools for probing the nature of genes in more complex organisms



Why Study Bacterial and Viral Genetics?

Partly because they possess a number of characteristics that make them suitable for genetic studies





Inside a virus and a bacteria

Why Study Bacterial and Viral Genetics?

The genetic systems of bacteria and viruses are also studied because these organisms play important roles in human society

Why Study Bacterial and Viral Genetics?

They have been exploited to produce a number of economically important substances, and they are of immense medical significance, causing many human diseases

Introduction

Summary of some

Advantages of using Bacteria and Viruses in Genetic Studies

Learn More

Advantages of using Bacteria and Viruses...

1. Reproduction is rapid
2. Many progeny are produced
3. Growth in the laboratory is easy and requires little space
4. Genomes are small
   (About 100-fold less that of eukaryotic cells)

Advantages of using Bacteria and Viruses...

5 Techniques are available for isolating and manipulating their genes

6 They have medical importance

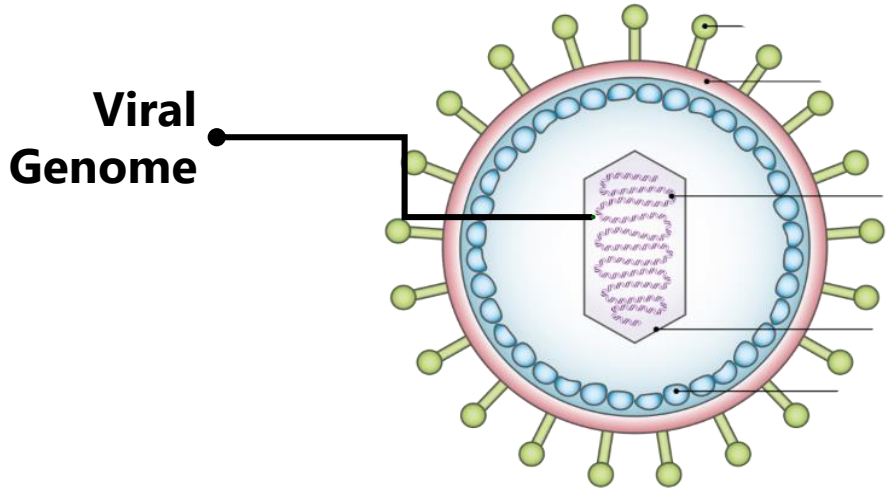
7 They can be genetically engineered to produce and transfer genes of interest in large amounts

Introduction

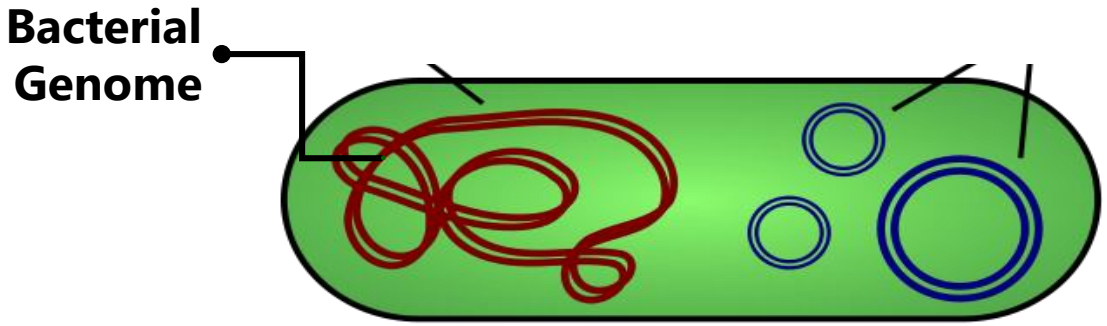
Genetic analysis in bacteria and viruses are different than that in eukaryotes

Introduction

This is because bacteria and viruses have special genome organization, therefore different techniques and methods are used to analyze their genes and mutations



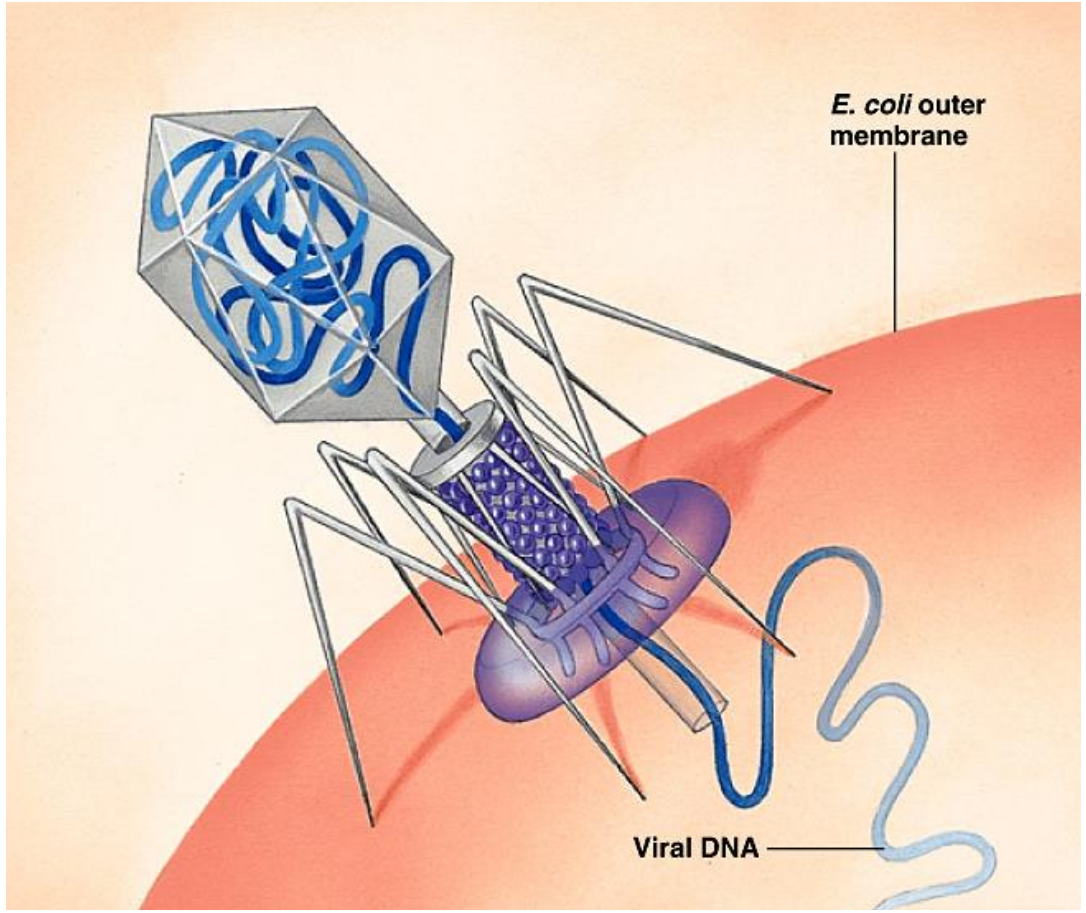
Virus



Bacterial

Introduction

Because they grow rapidly and also make their DNA rapidly, they are often used as host cells or vectors in recombinant DNA technology



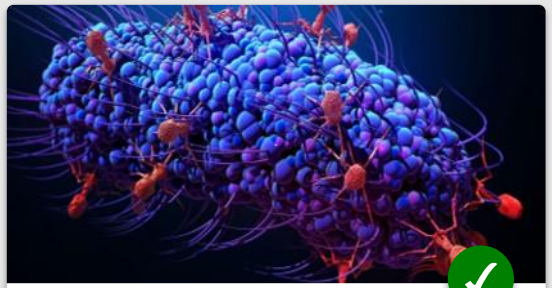
Module 3

Bacterial and Viral Genetics

Module Lessons

- Dashboard
- Objectives
- Lessons
- Assignments

End of Module



Lesson 1

Introduction

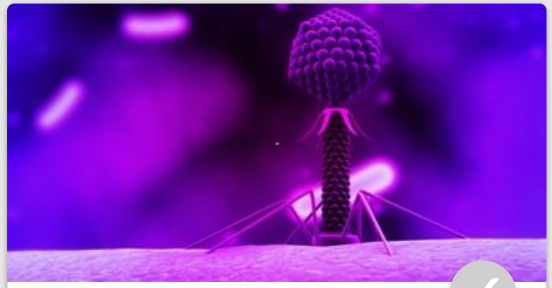
Learn about the reasons for studying bacterial and viral genetics

Start ▸

Lesson 2

The Bacterial Chromosome

Start ▸



Lesson 3

Genetics of Viruses

Start ▸

Lesson 2

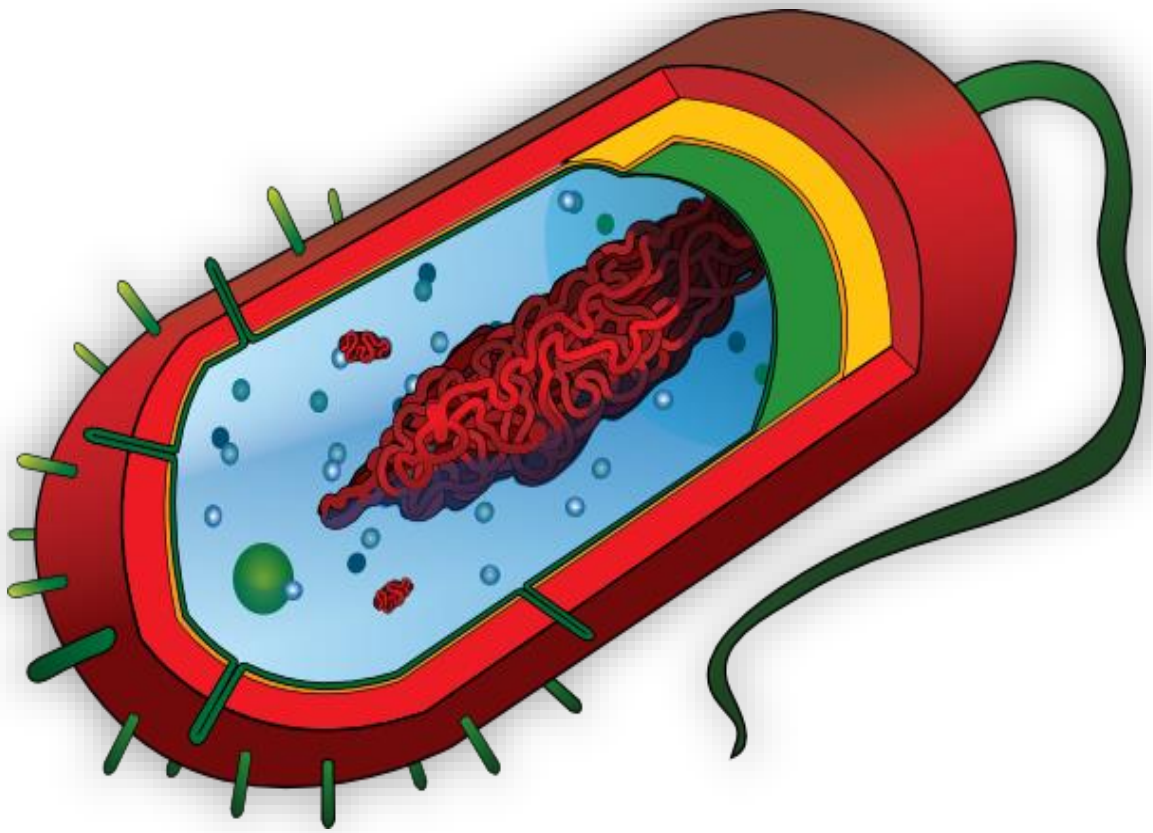
The Bacterial Chromosome

Learn more about bacteria and how their DNA are organized

Learn Now ▸

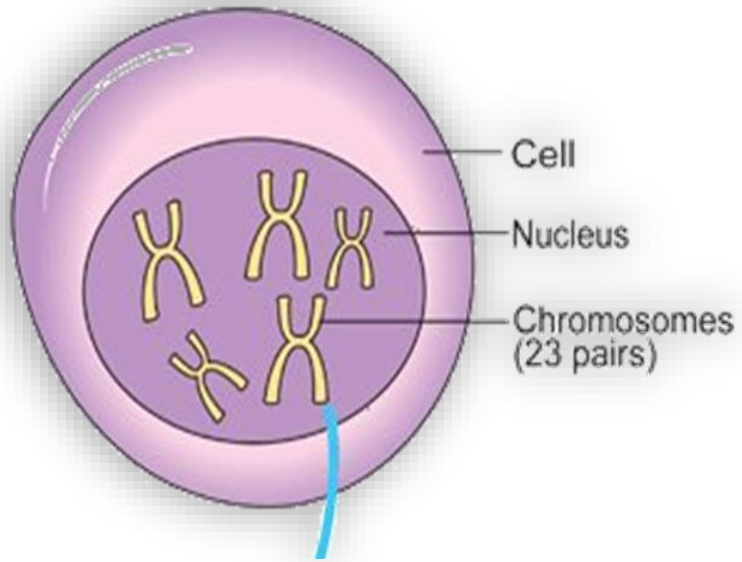
The Bacterial Chromosome

Bacterial chromosomes are highly compacted structures and share many properties with their eukaryote counterparts, despite not being contained within a cell nucleus

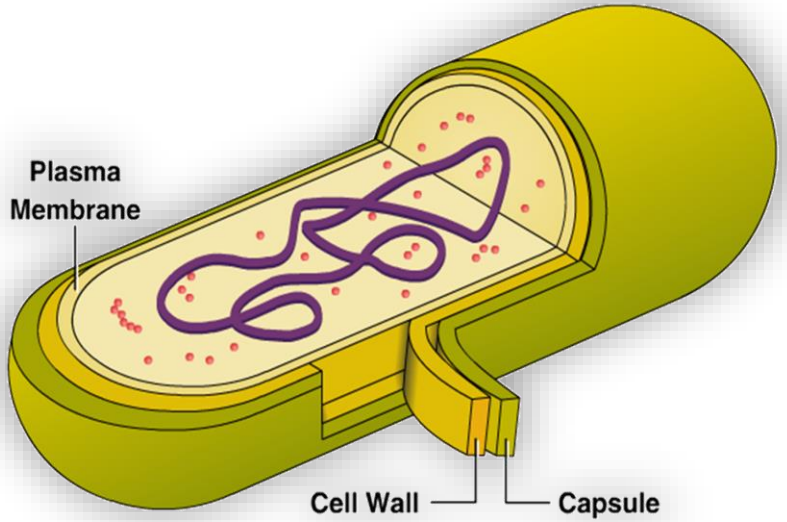


The Bacterial Chromosome

While eukaryotes have two or more chromosomes, prokaryotes such as bacteria possess a single chromosome composed of double-stranded DNA in a loop



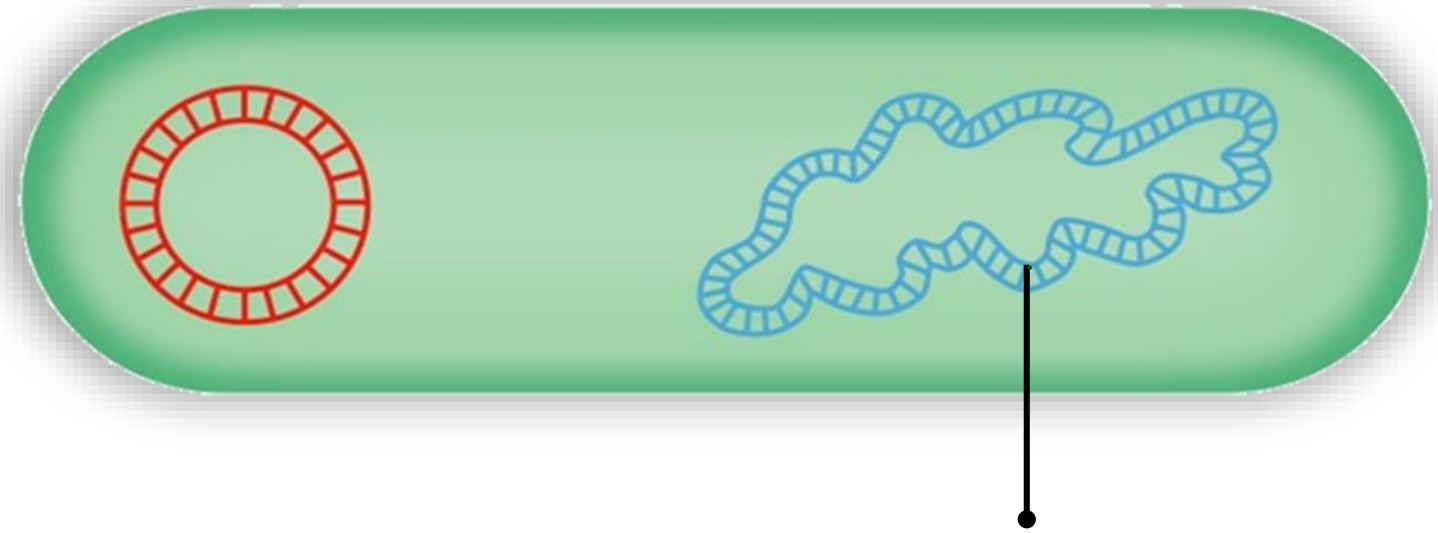
Eukaryotic Cell



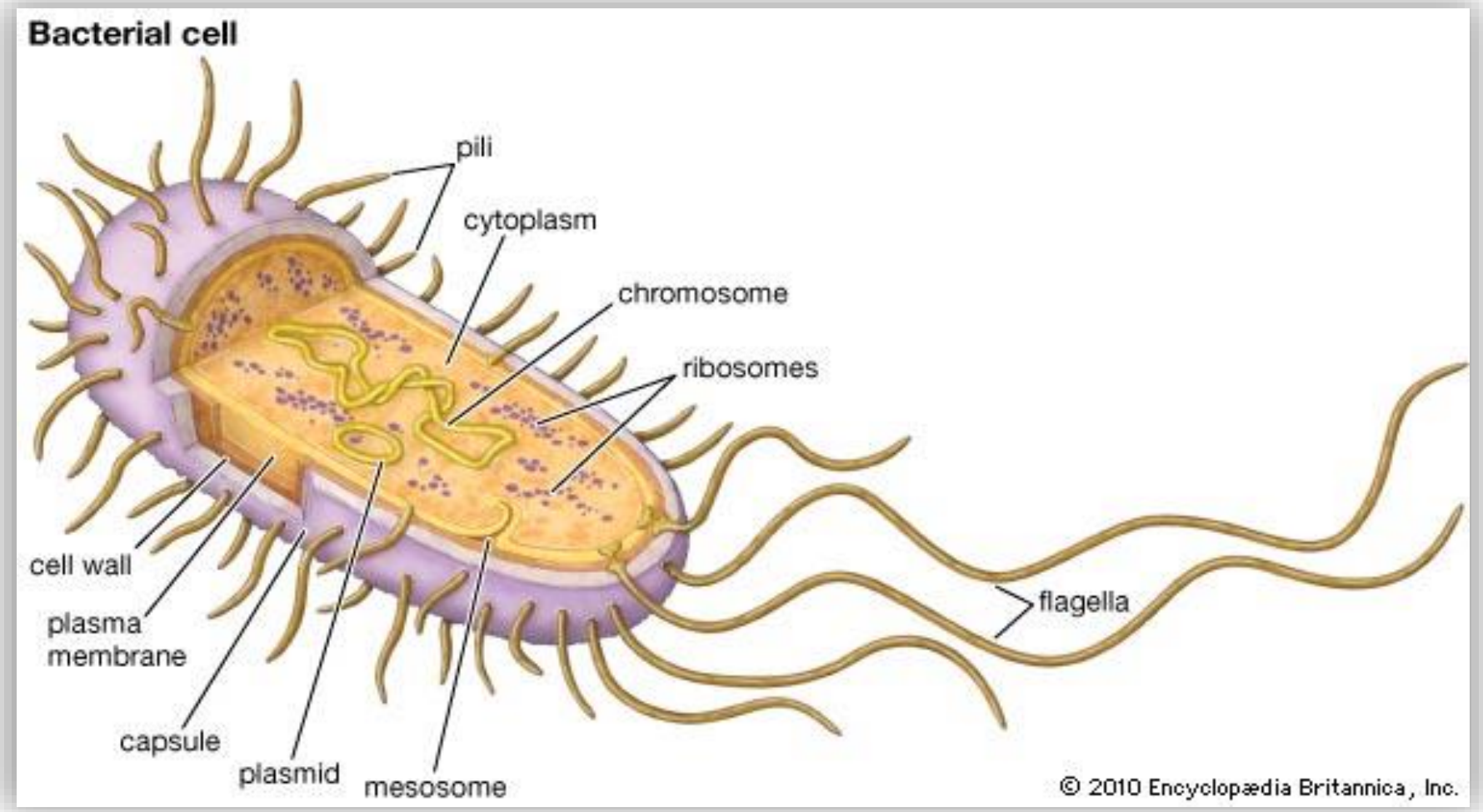
Prokaryotic Cell

The Bacterial Chromosome

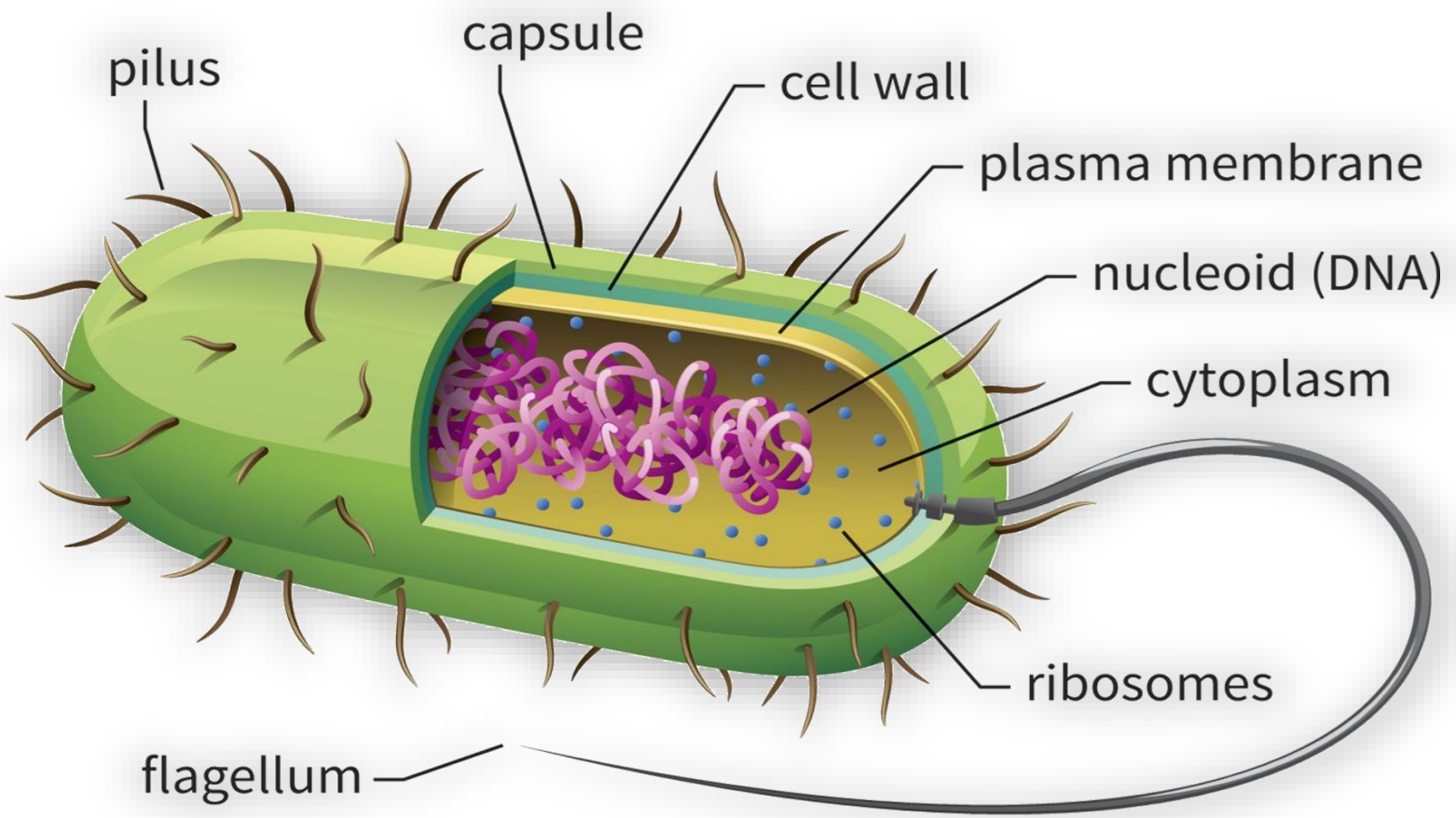
The DNA is in the form of a double helix which forms a closed ring or circle with no free ends



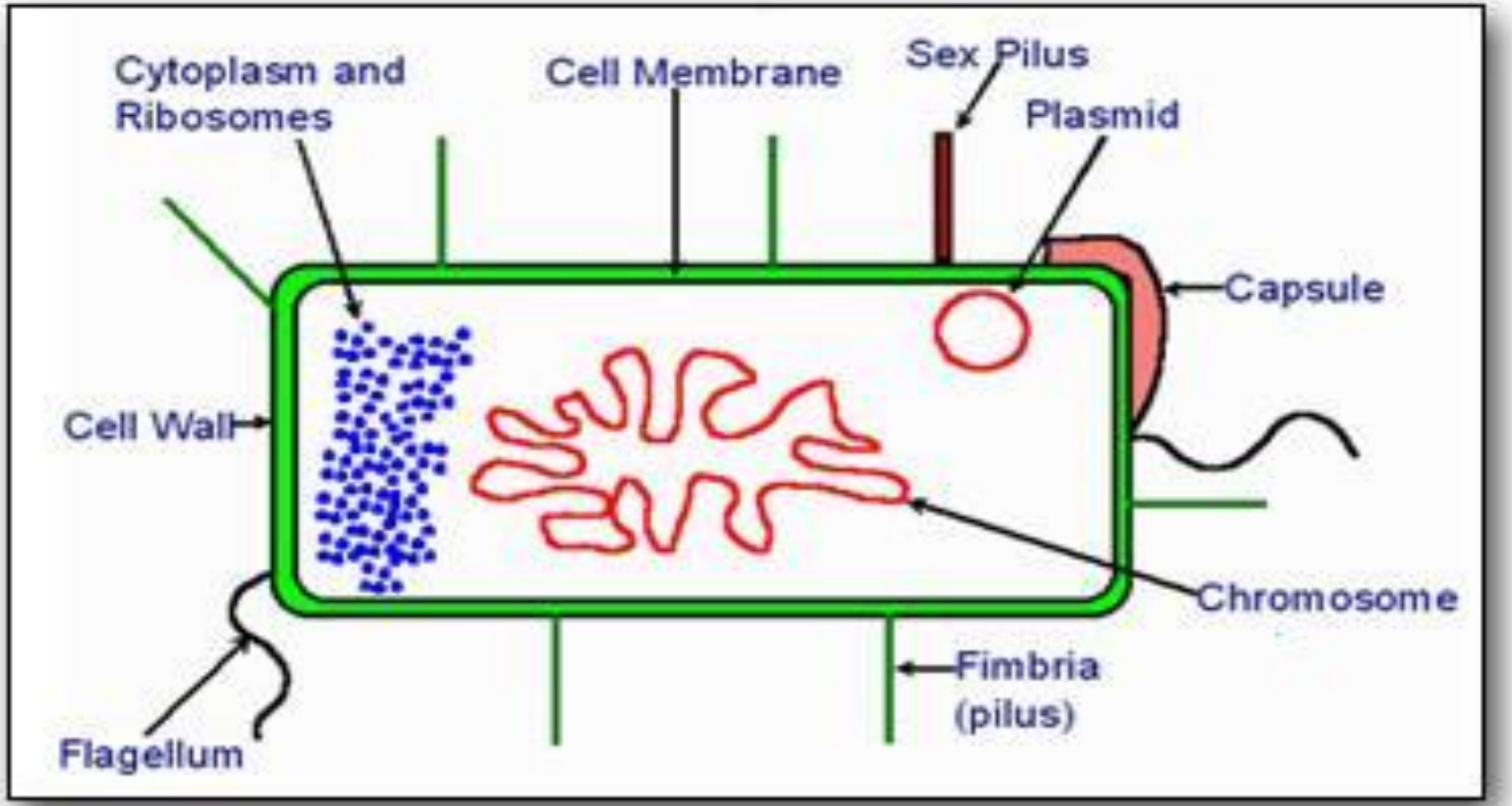
The Bacterial Chromosome



The Bacterial Chromosome

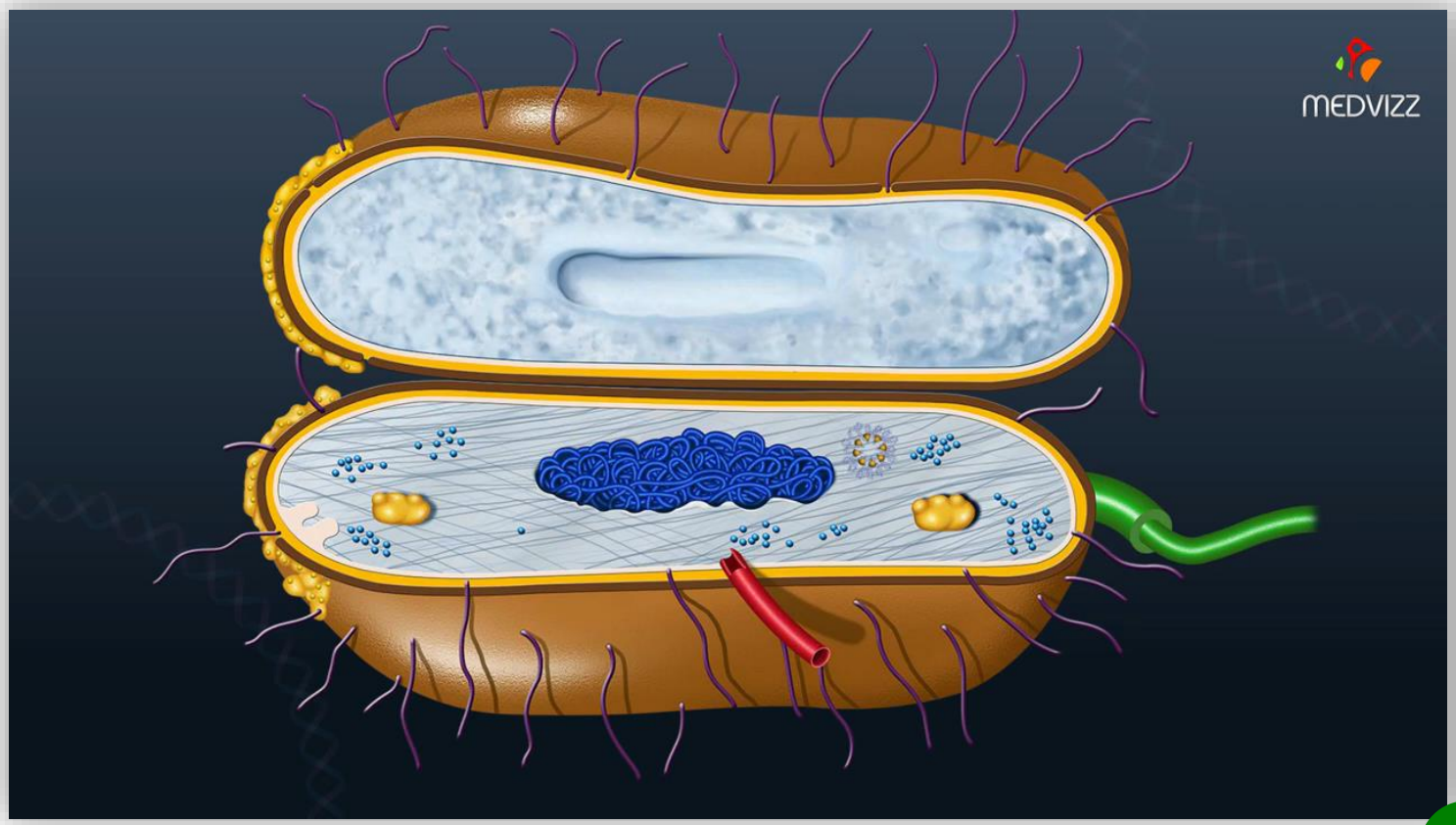


The Bacterial Chromosome



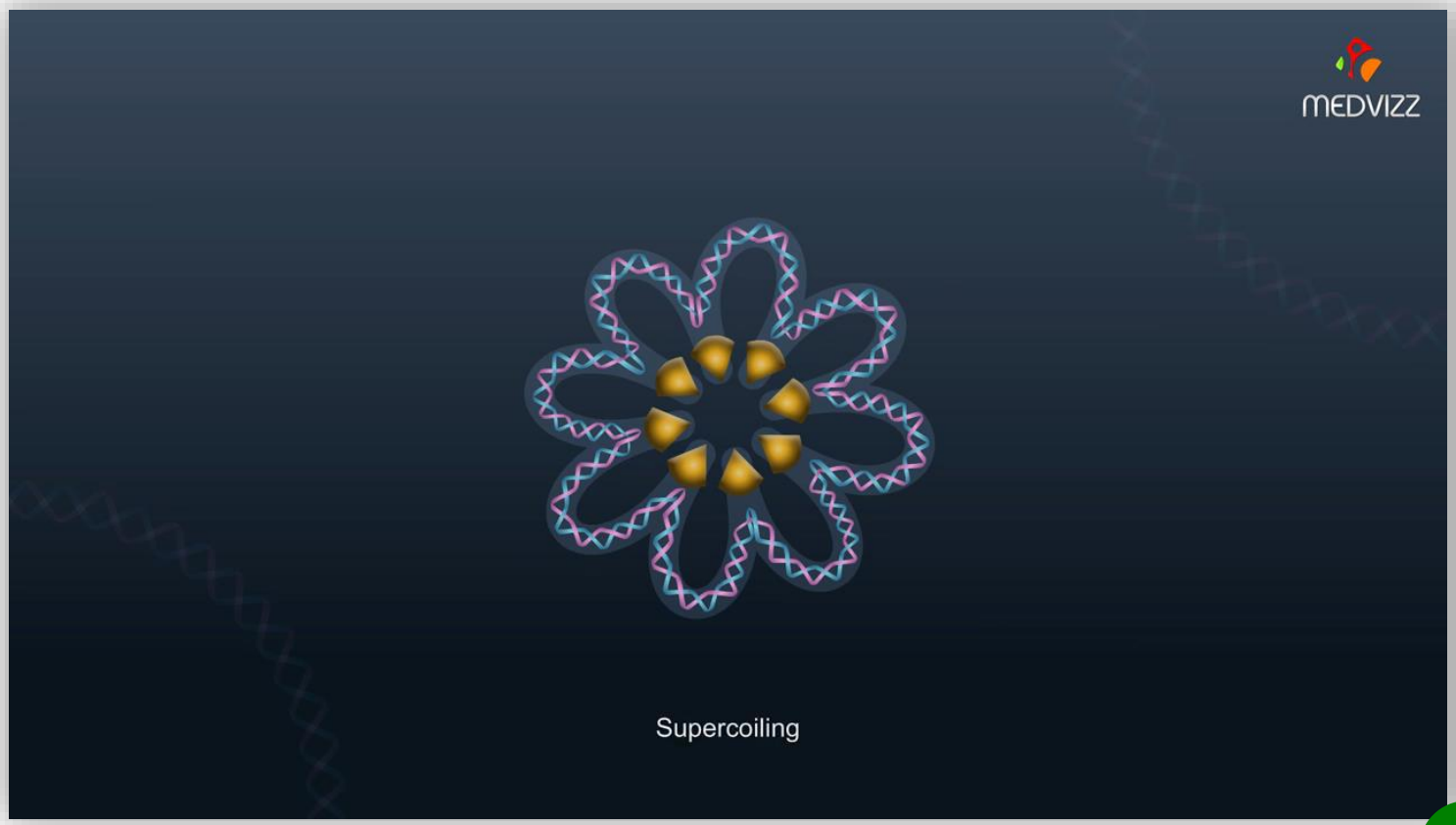
The Bacterial Chromosome

The bacterial chromosome must be tightly packed to fit into the small volume of the bacterial cell



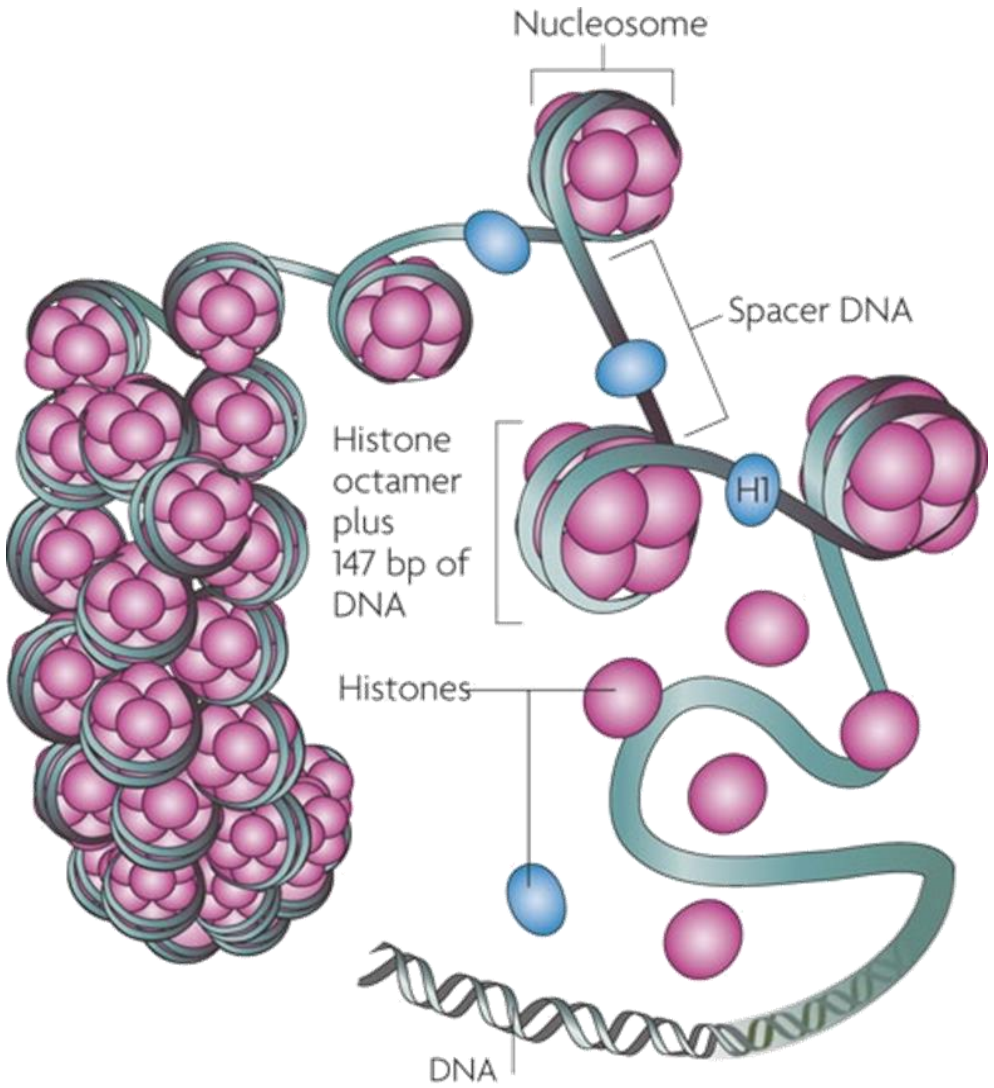
The Bacterial Chromosome

Compacting the DNA involves supercoiling, or further twisting of the twisted chromosome



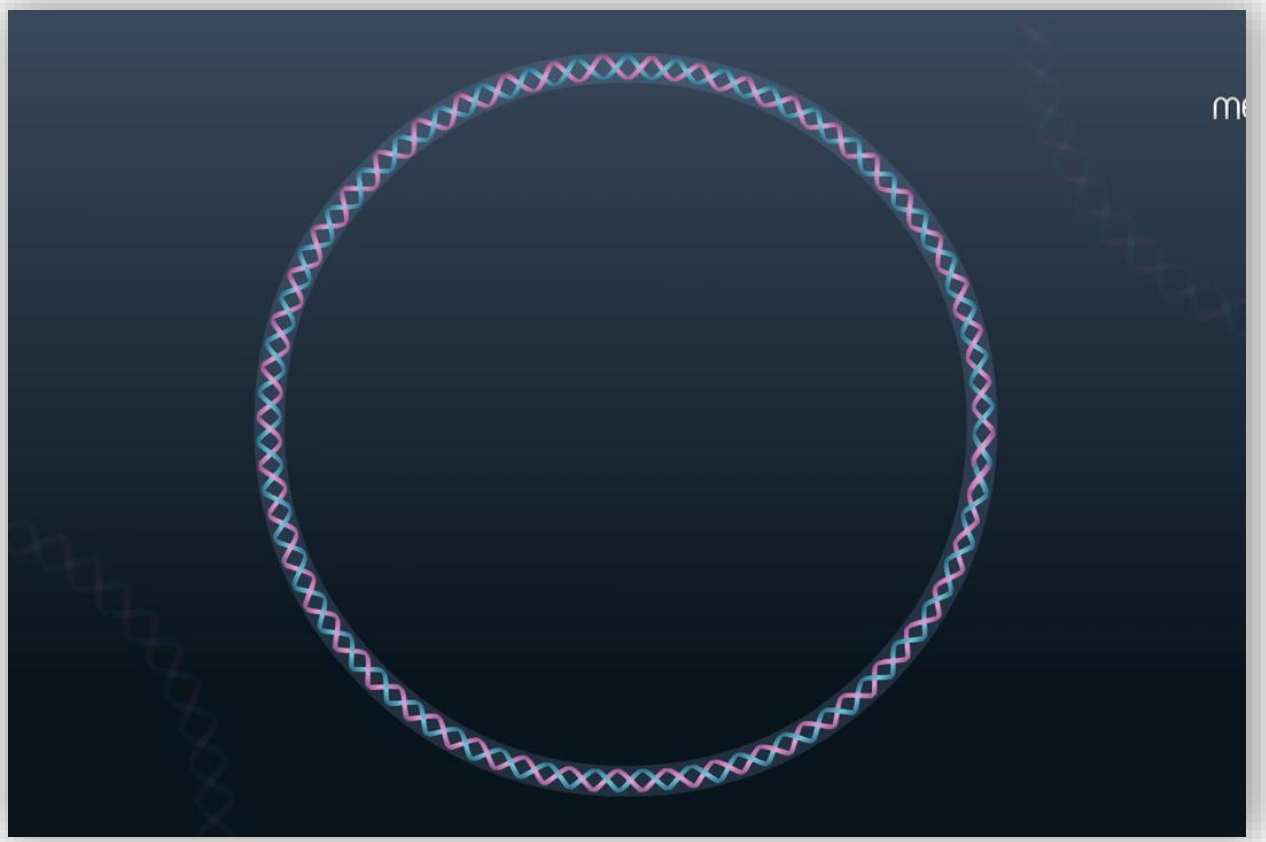
The Bacterial Chromosome

Bacteria lack the histone proteins that are found bound to the DNA and that form the nucleosomes of eukaryotic chromosomes



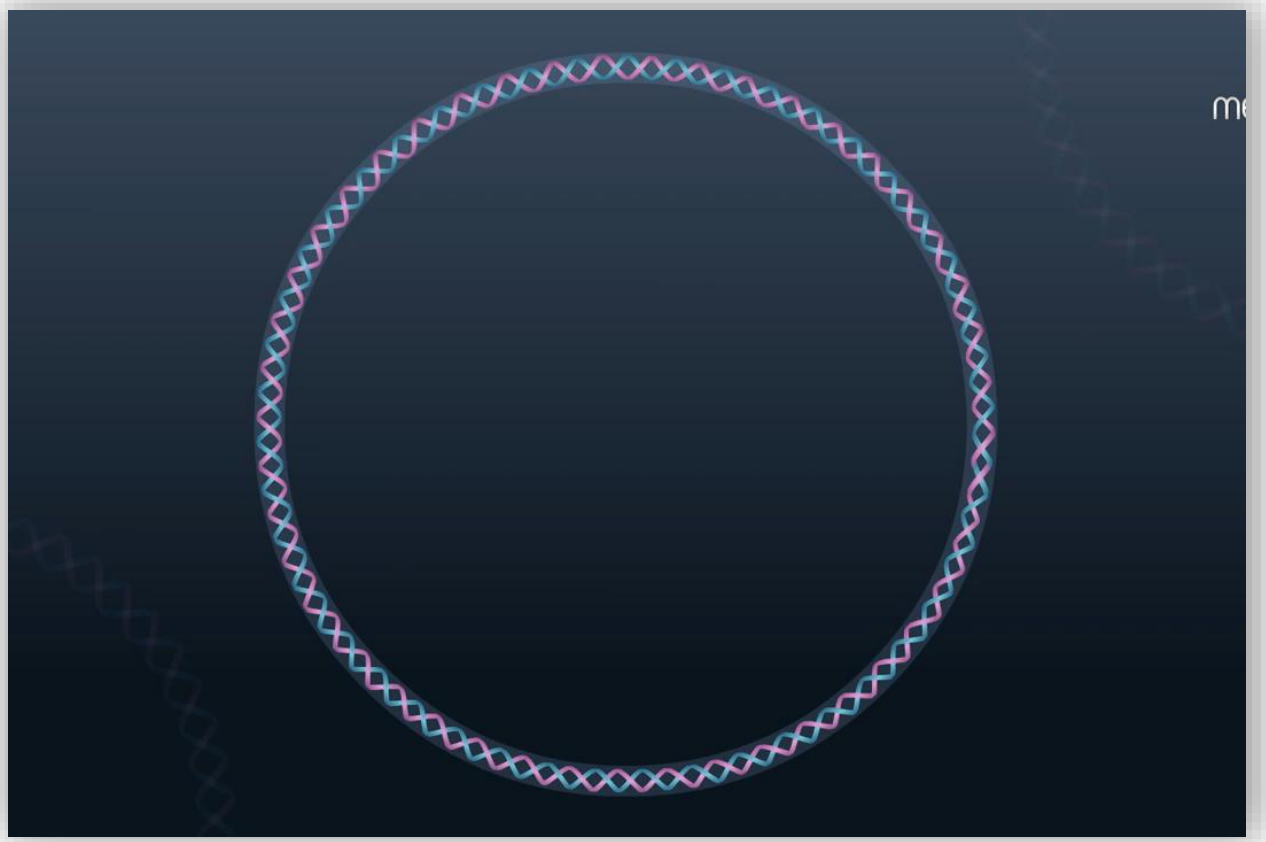
The Bacterial Chromosome

It is believed that polyamines (organic molecules with multiple NH_2 or amine groups) such as spermidine, as well as some basic proteins, aid in compacting the bacterial chromosome



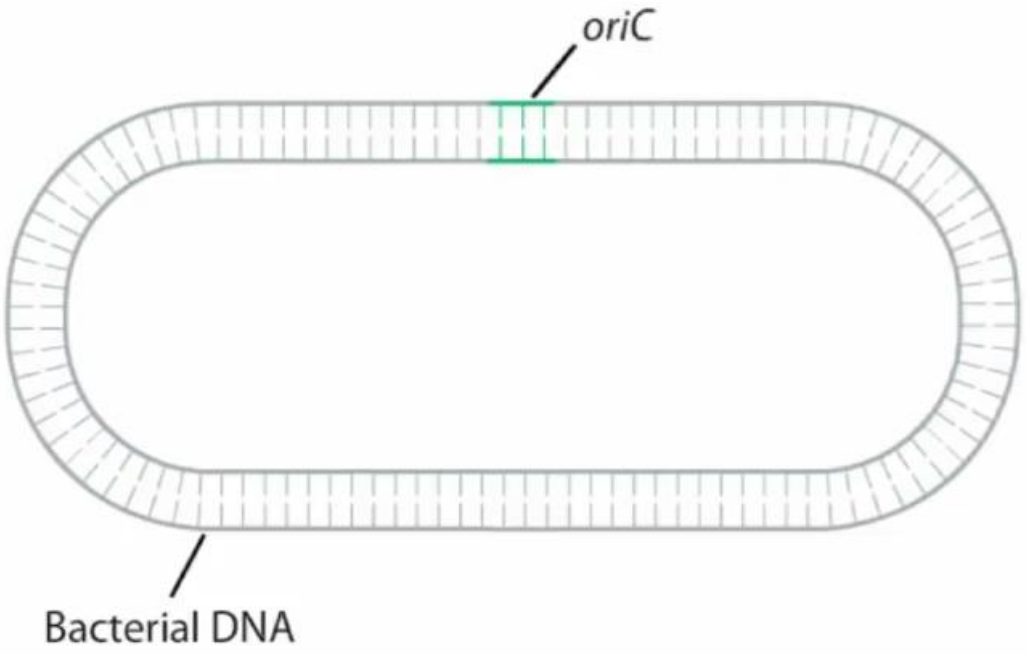
The Bacterial Chromosome

These basic proteins have a net positive charge that bind them to the negative charge of the phosphates in the DNA backbone



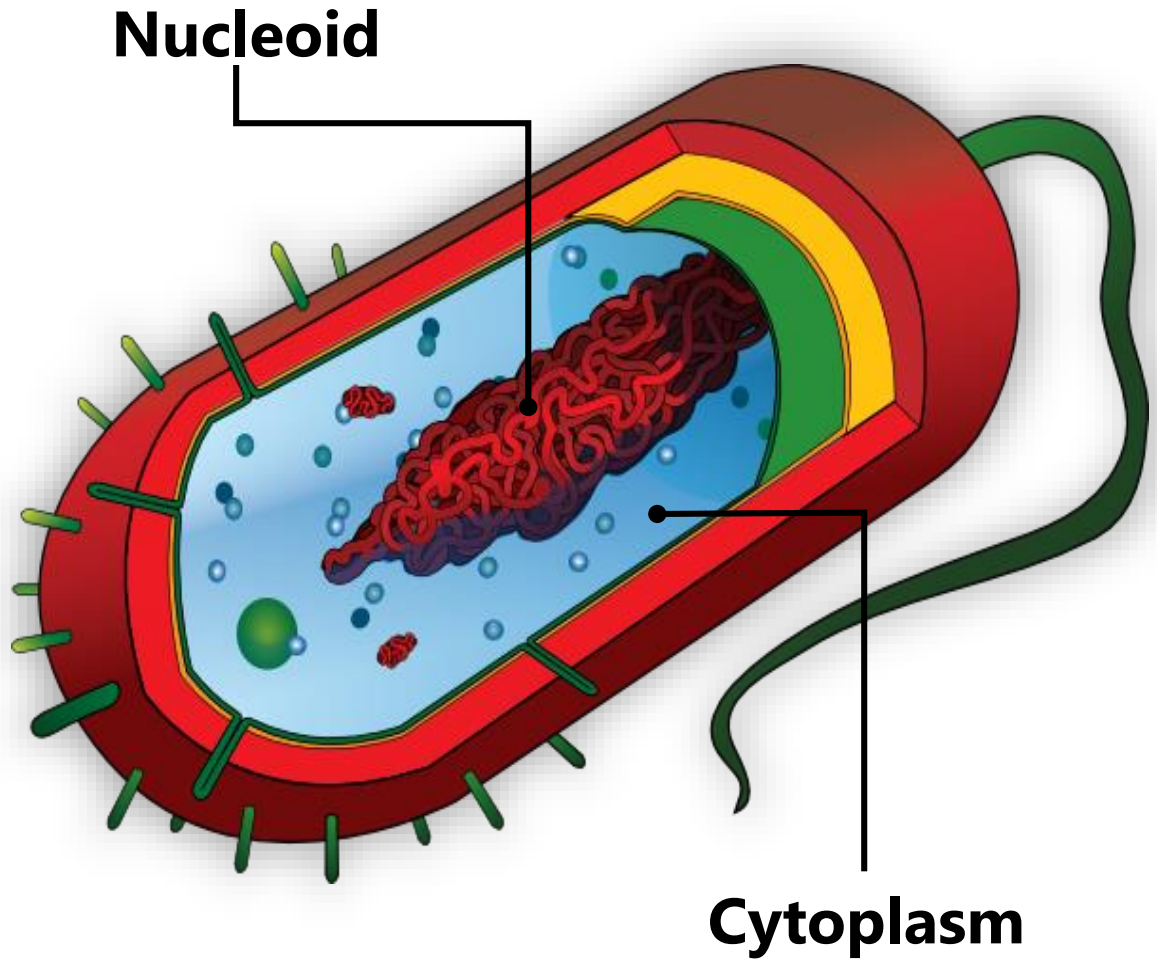
The Bacterial Chromosome

Replication of the circular chromosome begins at a single point, called **OriC**, and proceeds in both directions around the circle, until the two replication forks meet up



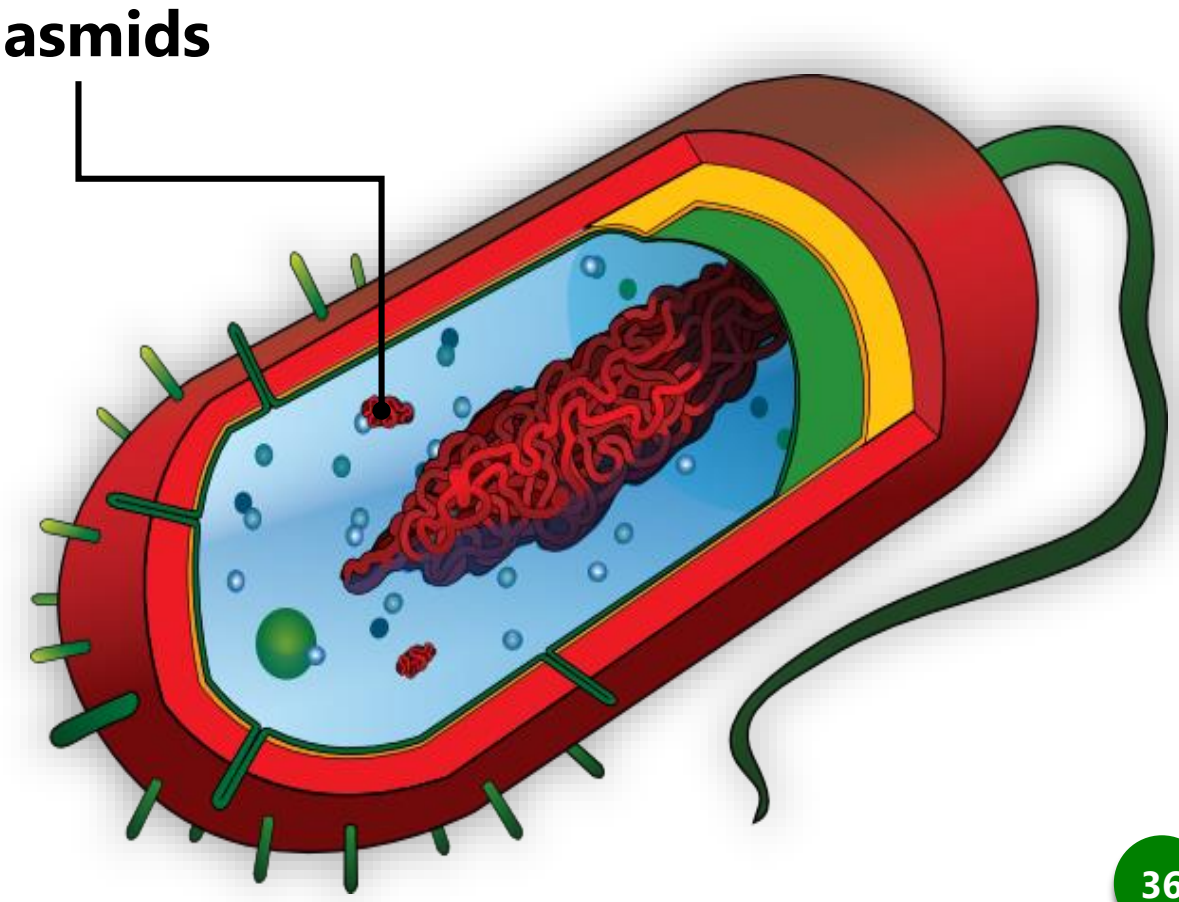
The Bacterial Chromosome

The bacterial chromosome lacks a protein coat and it is in direct contact with the cytoplasm, since a nuclear membrane is absent and it is called **nucleoid**



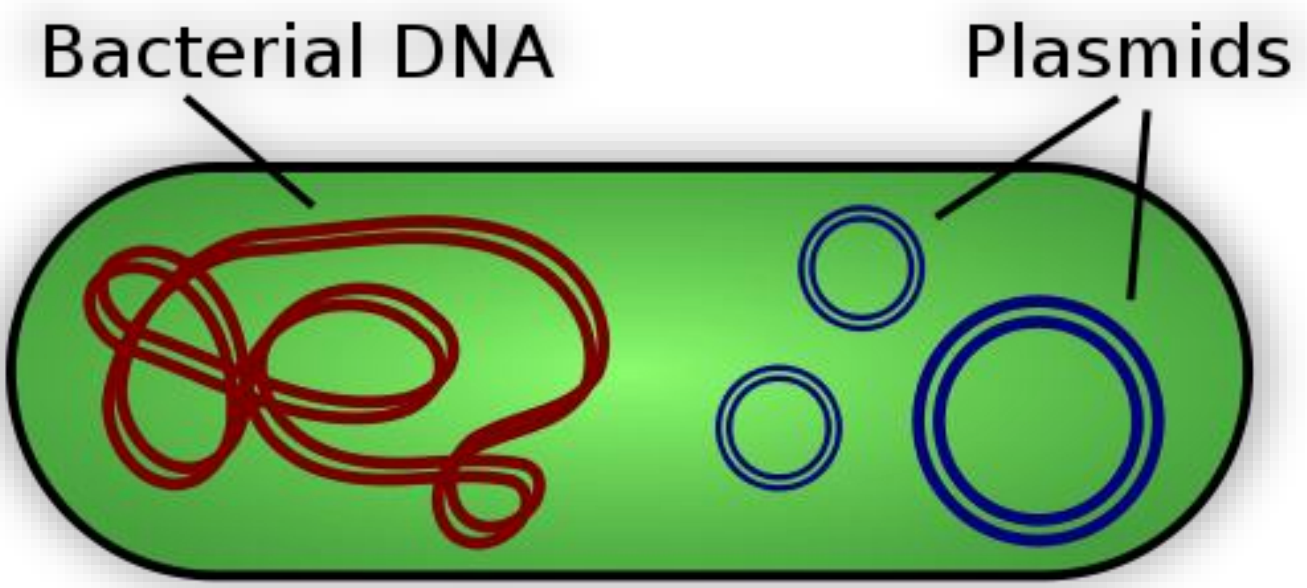
Plasmids

In addition to the nucleoid, a bacterial cell may show the presence of extra chromosomal DNA molecules called **plasmids**



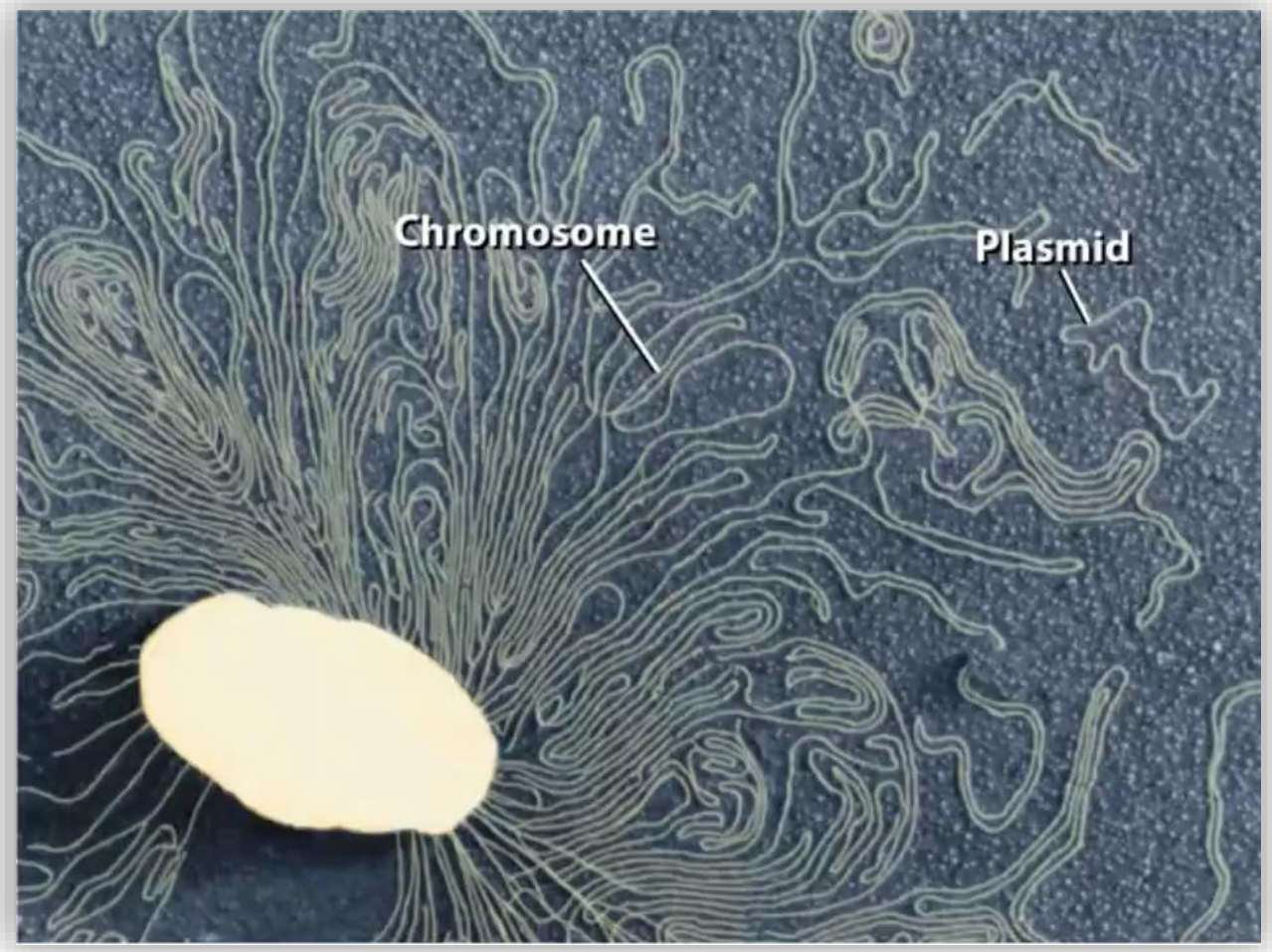
Plasmids

Like the bacterial chromosome, plasmids are double stranded circular DNA molecules which can replicate and function independently



Plasmids Replication

The plasmid has its own replication origin and the replication of plasmids is independent of the replication of chromosome

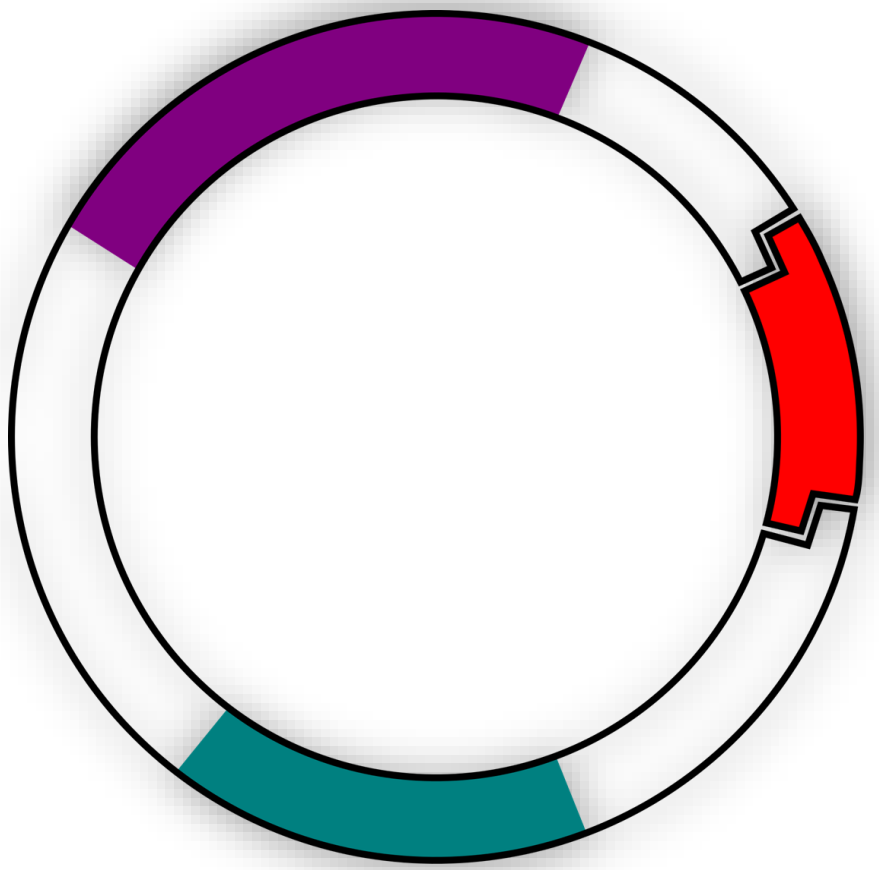


Plasmids Characteristics

The plasmids mainly carry genes responsible for characteristics like:

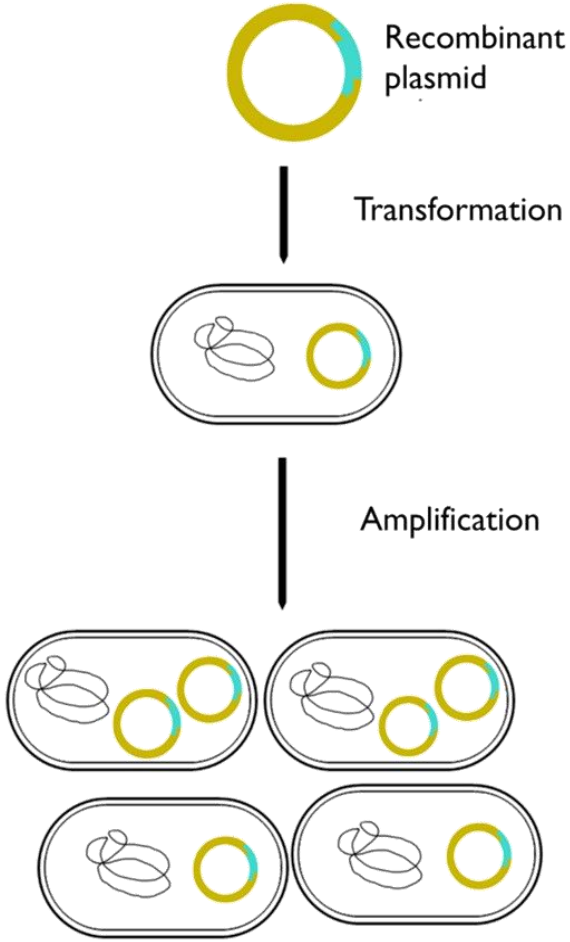
1. **Fertility**
2. **Antibiotic resistance**
3. Production of **bacteriocin**

   (a protein that kills closely related bacteria)



Plasmids Characteristics

The plasmids can be easily isolated from or introduced into the bacterial cells



Introducing plasmids into bacteria cells

Plasmids Characteristics

1. They are small, circular DNA molecules

2. Autonomous, extrachromosomal genetic elements

3. Usually not essential to bacterial function but can be

Plasmids Characteristics

4. Many of the plasmids first isolated and characterized carried genes for antibiotic resistance

5. Plasmids control their own replication

6. Episomes, such as the F (fertility) factor, can either exist as freely-replicating plasmids or by integrating into the chromosome

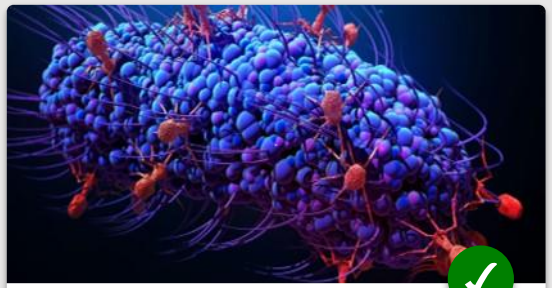
Module 3

Bacterial and Viral Genetics

Module Lessons

- Dashboard
- Objectives
- Lessons
- Assignments

End of Module



Lesson 1

Introduction

Learn about the reasons for studying bacterial and viral genetics

Start ▸

Lesson 2

The Bacterial Chromosome

Start ▸

Lesson 3

Genetics of Viruses

Start ▸

Lesson 3

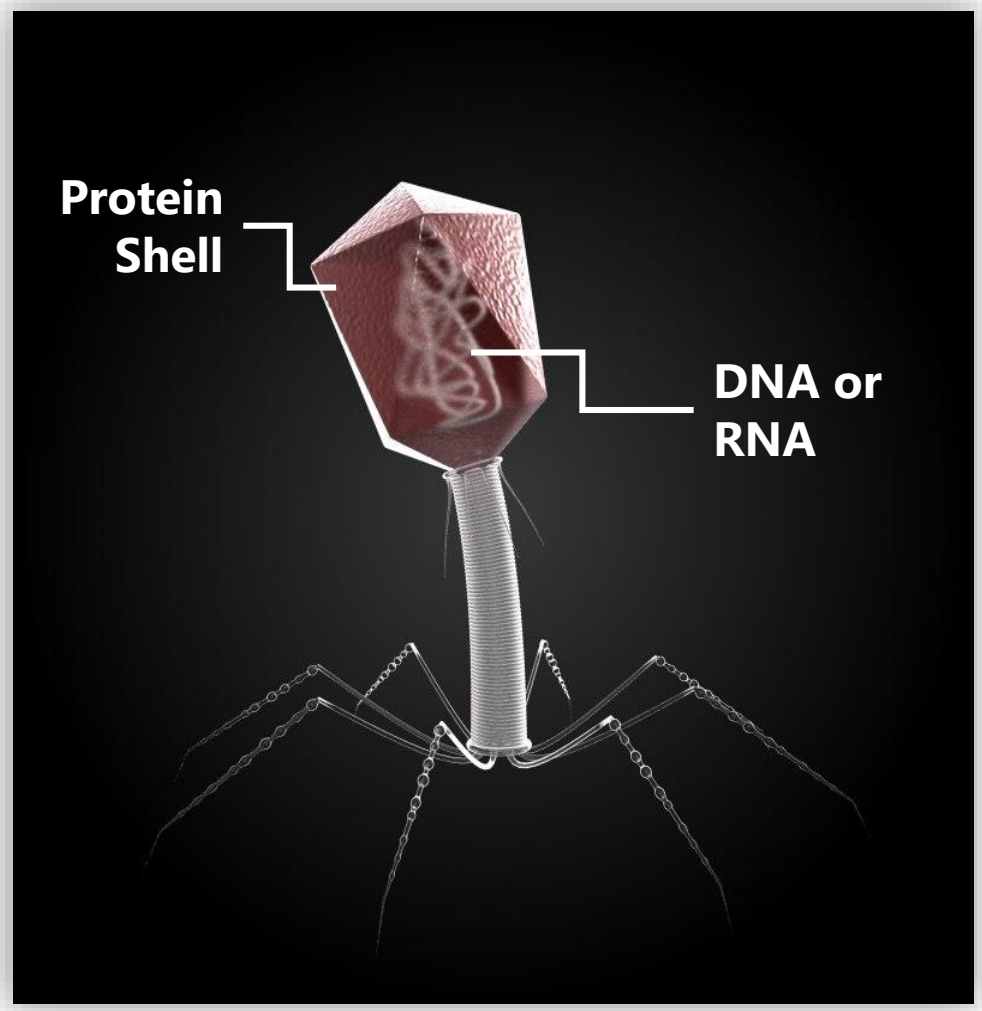
Genetics of Viruses

Learn more about viruses including their genome structure, replication, how they infect cells etc.

Learn Now ▶

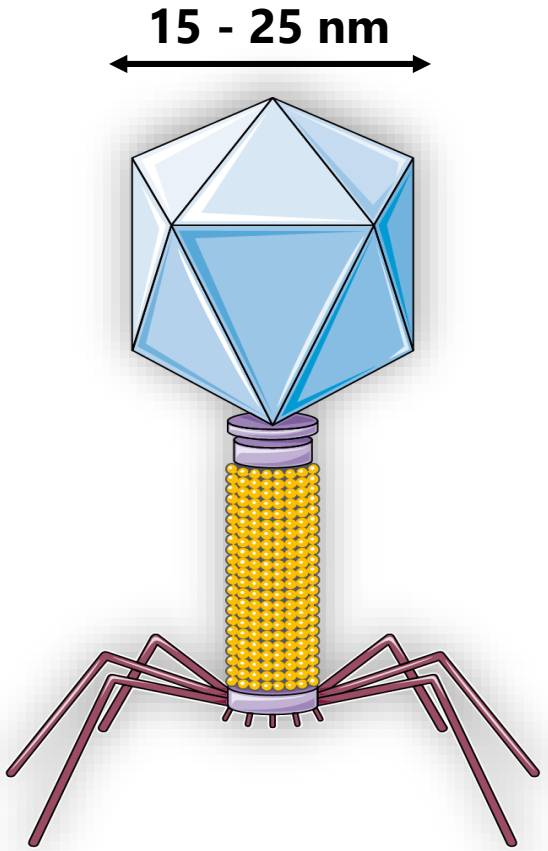
Genetics of Viruses

A virus particle, also known as a virion, is essentially a **nucleic acid** (**DNA** or RNA) enclosed in a protein shell or protective coat



Genetics of Viruses

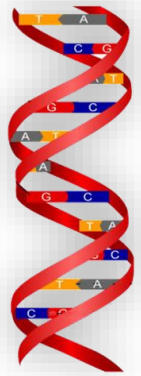
Viruses are extremely small, approximately **15 - 25 nanometers in diameter**



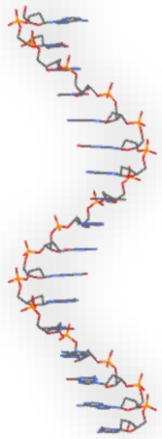
Genetics of Viruses

Viral genomes are much different than prokaryotes and eukaryotes:

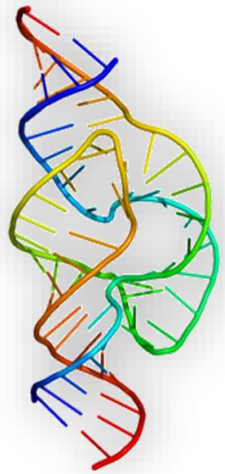
1. May be



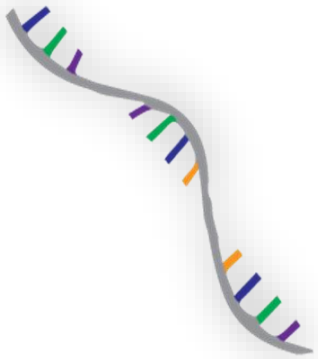
Double-stranded DNA



Single-stranded DNA



Double-stranded RNA

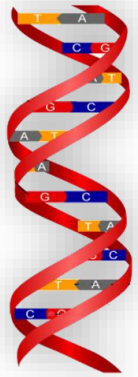


Single-stranded RNA

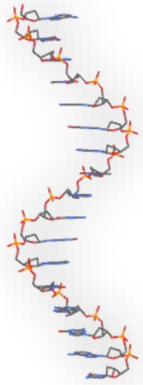
Genetics of Viruses

Viral genomes are much different than prokaryotes and eukaryotes:

2. Organized as single nucleic acid molecules in linear or circular arrangements



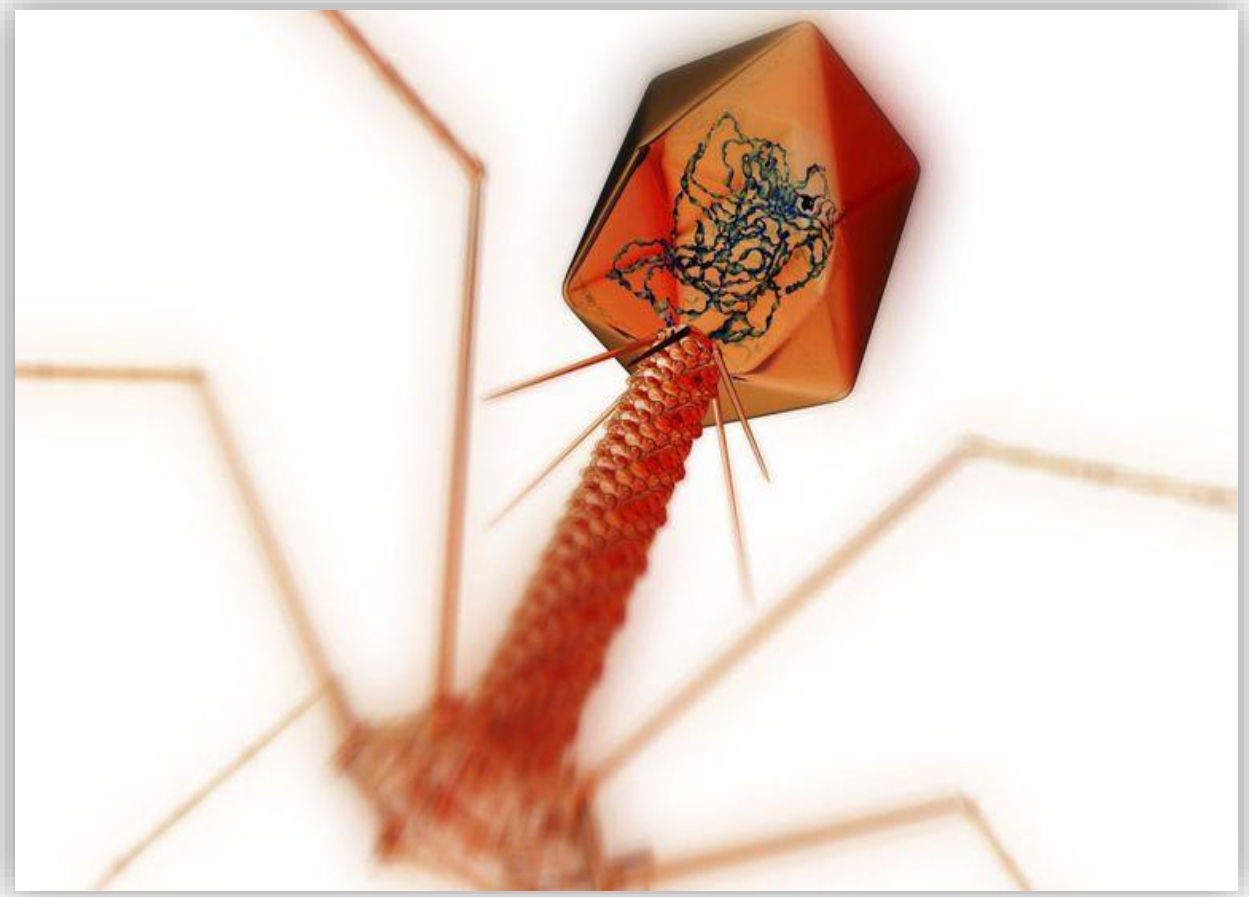
Linear



Circular

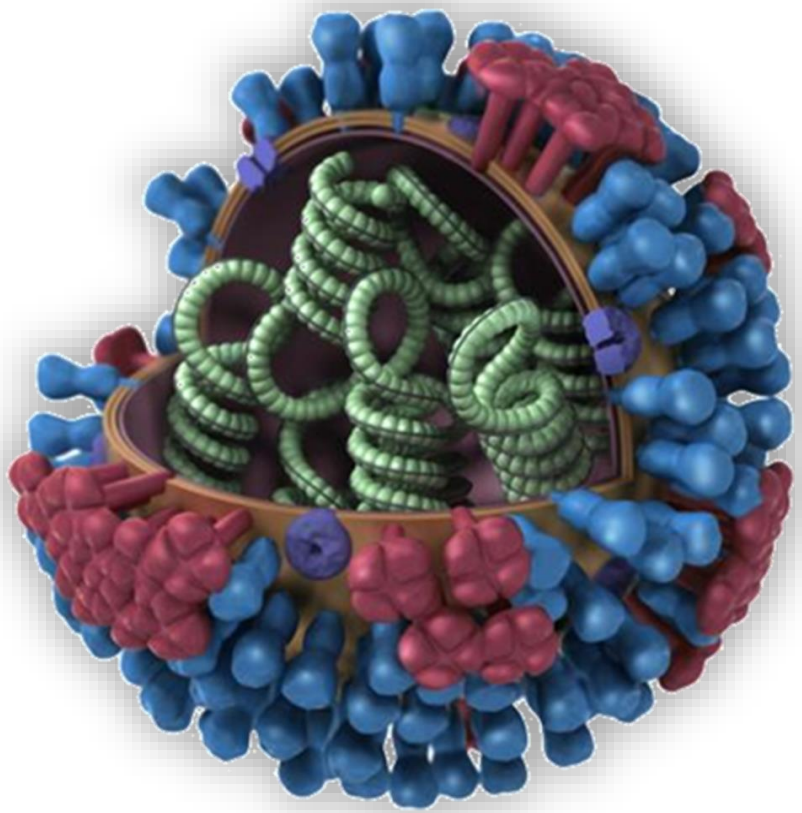
Genetics of Viruses

The type of genetic material found in a particular virus depends on the nature and function of the specific virus



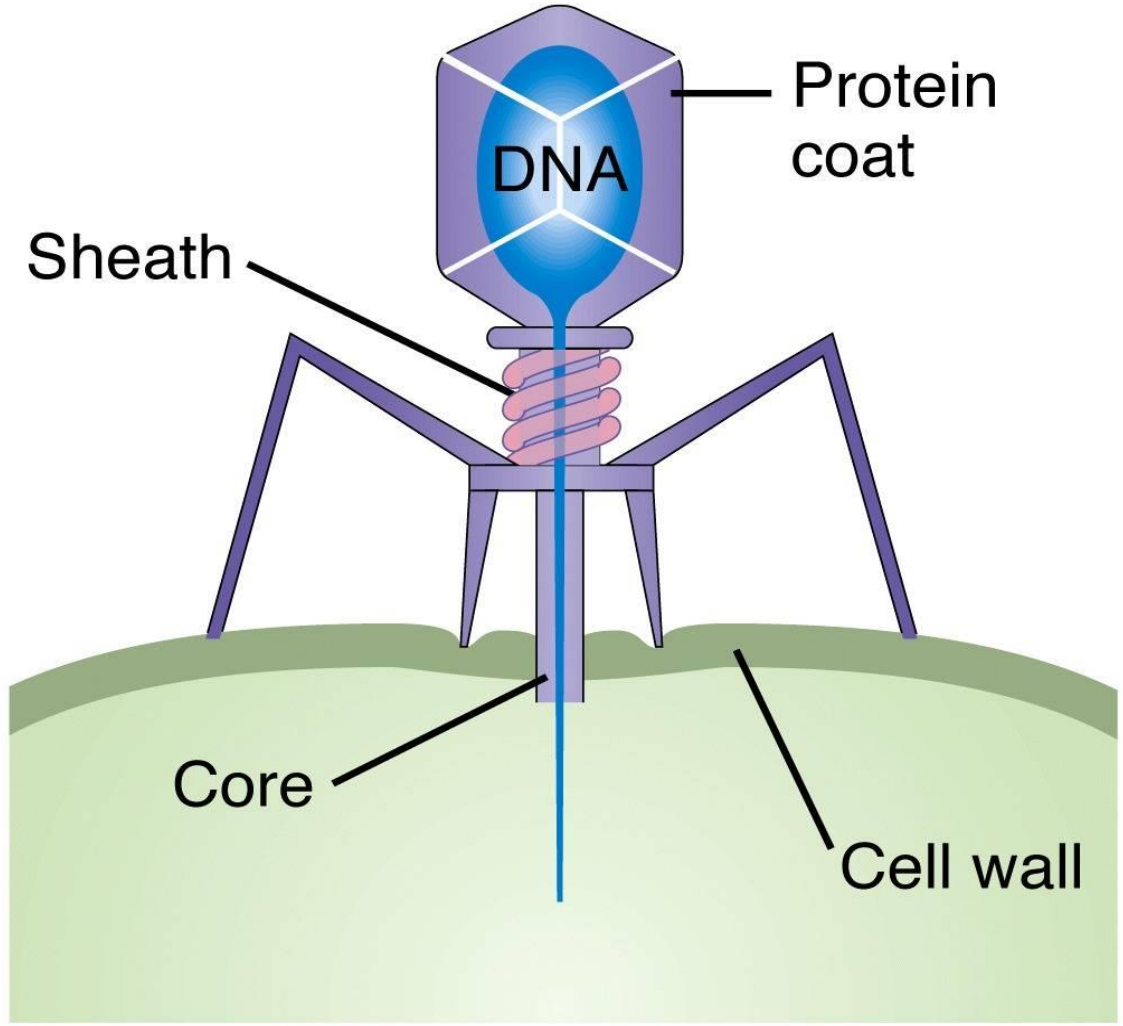
Genetics of Viruses

The viral genome can consist of a very small number of genes or up to hundreds of genes depending on the type of virus



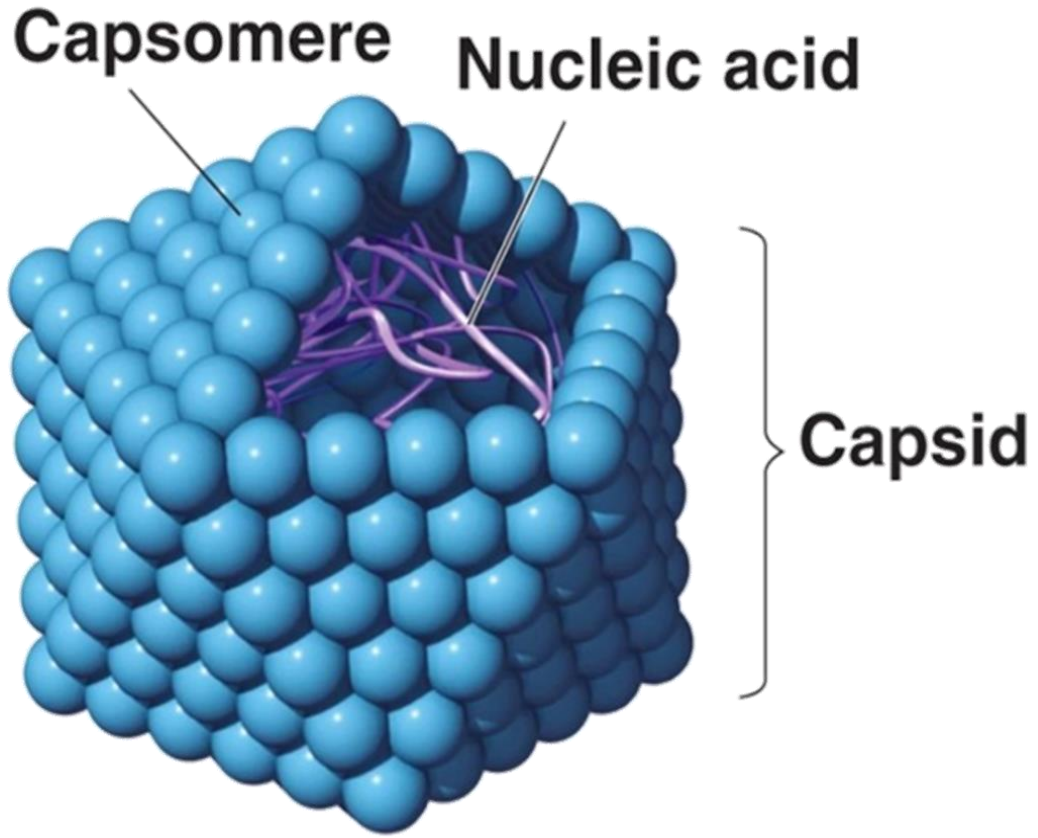
Viral Structure

The protein coat that envelopes viral genetic material is known as a **Capsid**



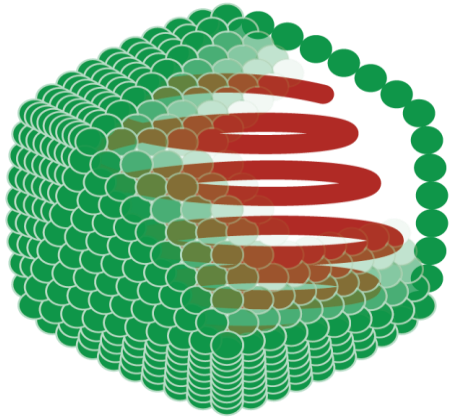
Viral Structure › Capsid

A capsid is composed of protein subunits called **capsomeres**

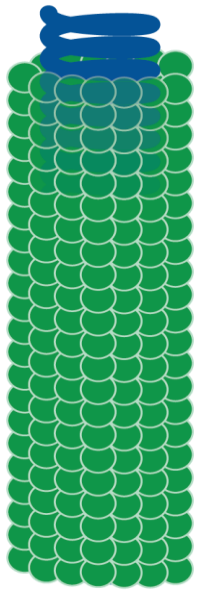


Viral Structure › Capsid

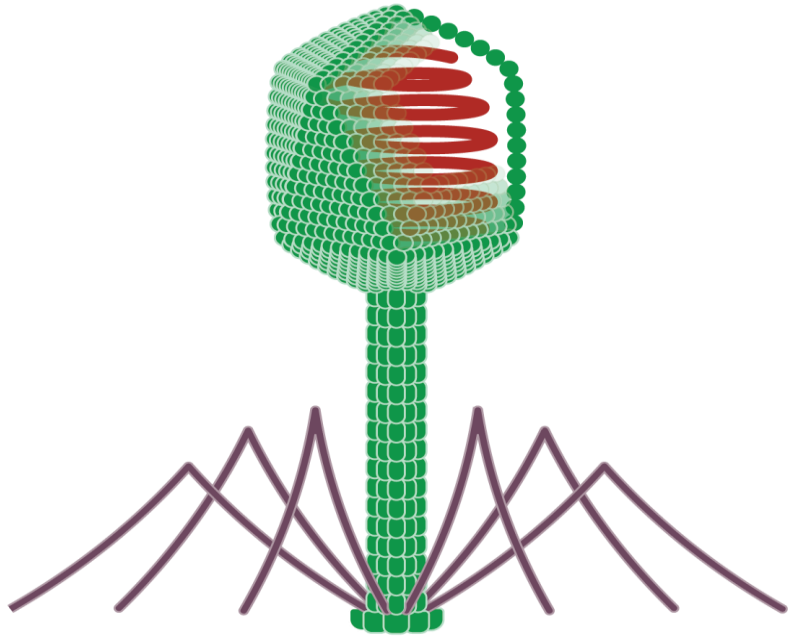
Capsids can have several shapes:



Icosahedral



Helical

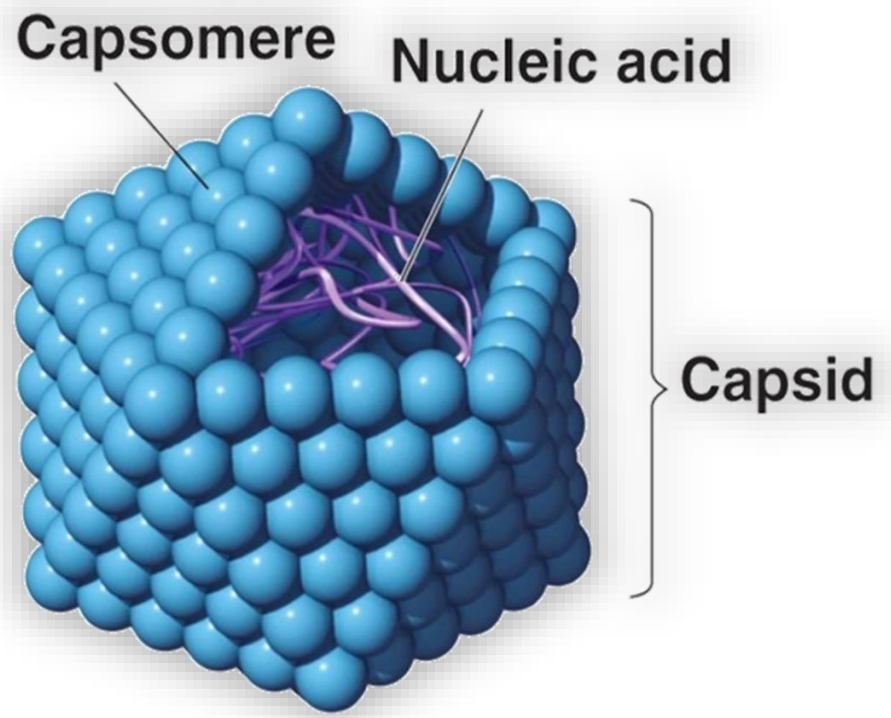


Complex

Viral Structure › Capsid Functions

The capsid has three functions:

1. It protects the nucleic acid from digestion by enzymes
2. Contains special sites on its surface that allow the virion to attach to a host cell
3. Provides proteins that enable the virion to penetrate the host cell membrane…



Viral Structure › Capsid Functions

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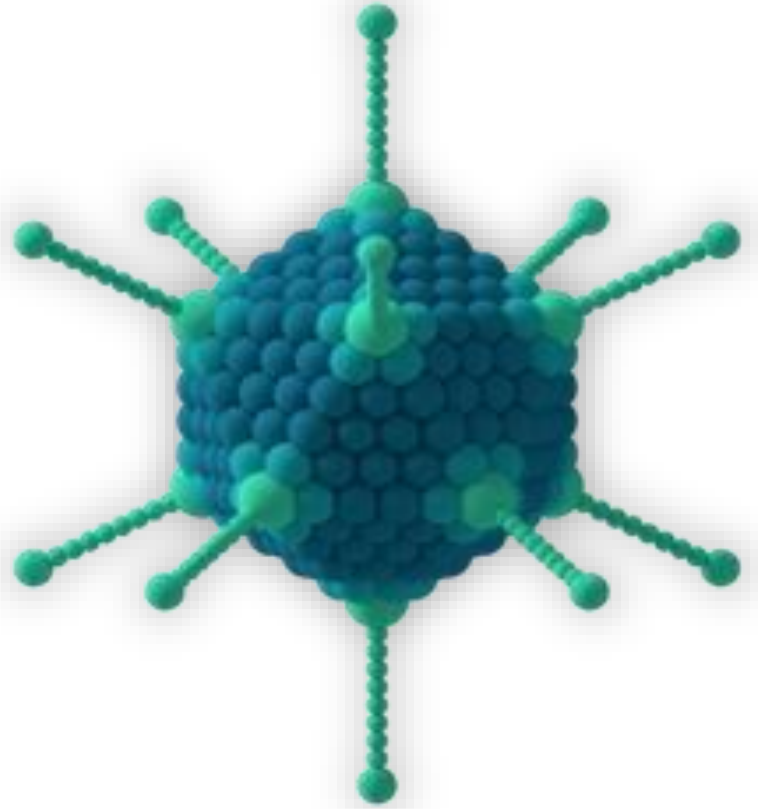
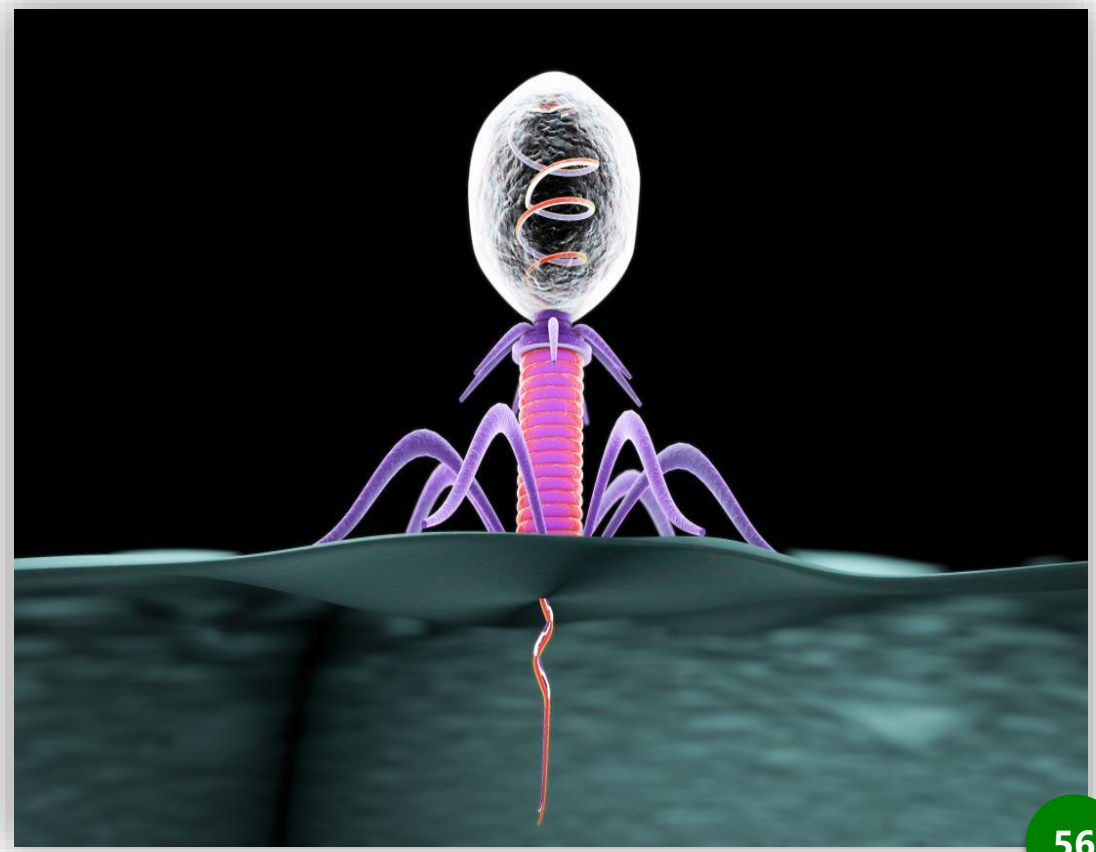


Viral Structure › Capsid Functions

The capsid has three functions:

to attach to a host cell

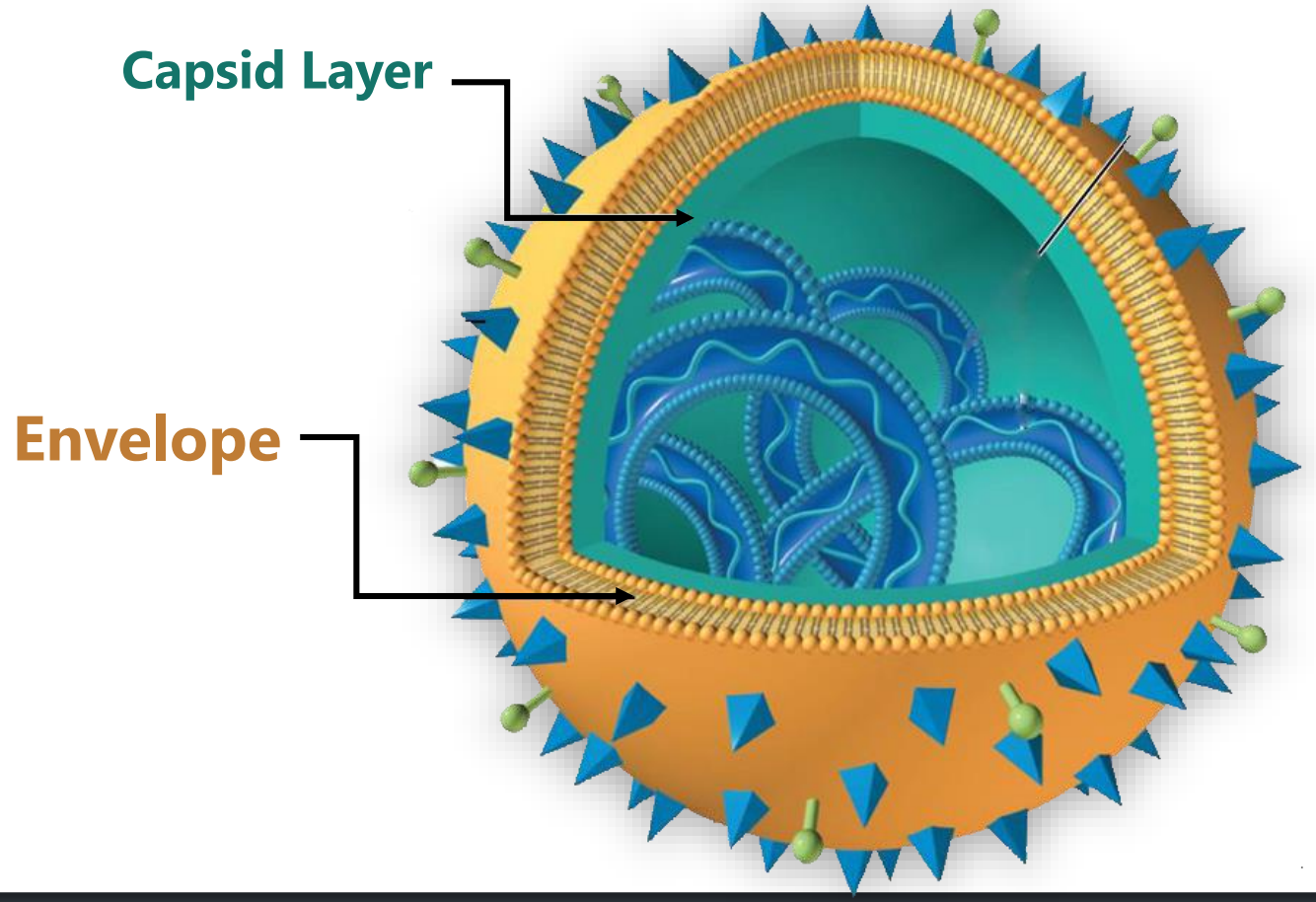
3. Provides proteins that enable the virion to penetrate the host cell membrane and, in some cases, to inject the infectious nucleic acid into the cell's cytoplasm



Viral Structure

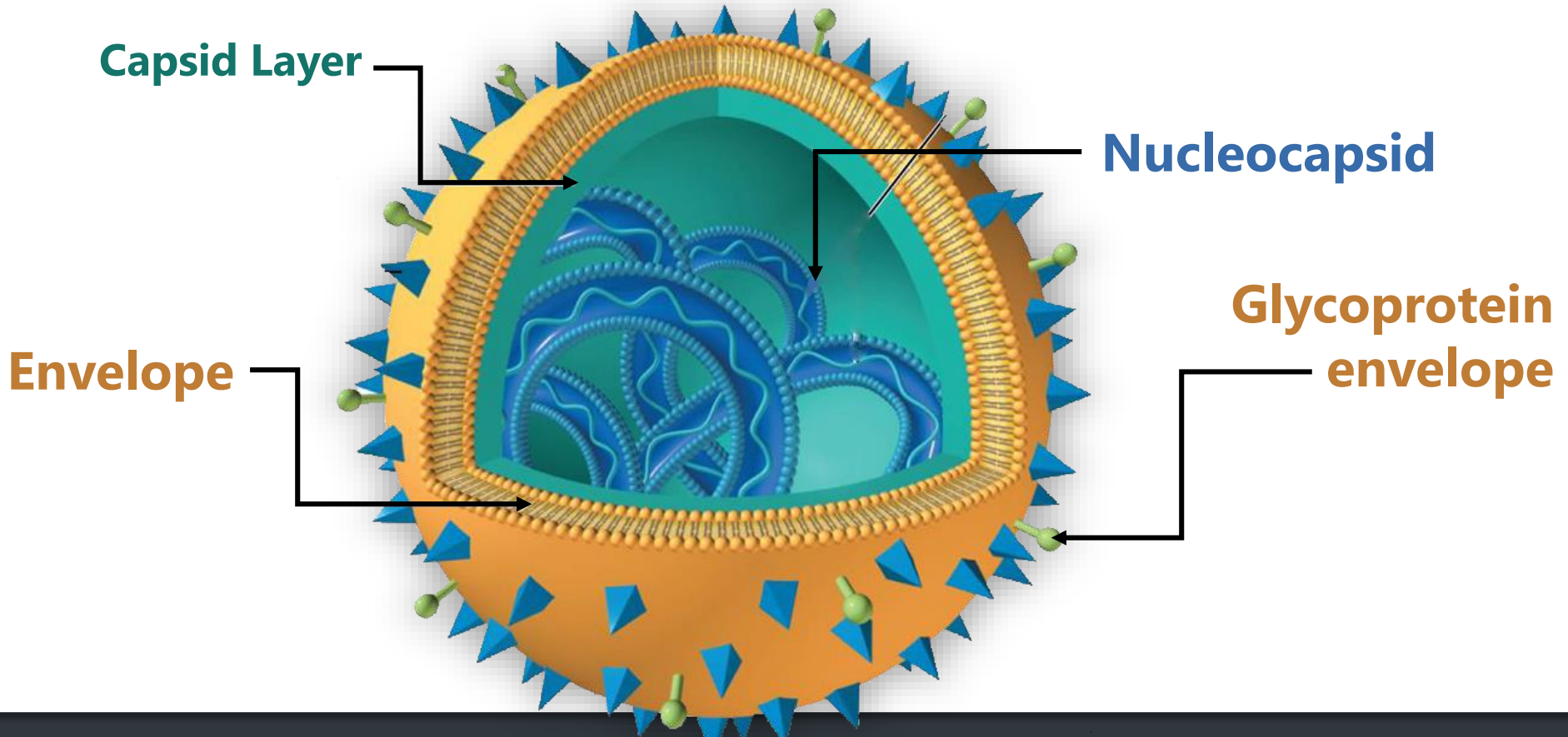
In addition to the protein coat, some viruses have specialized structures

For example, the flu virus has a membrane-like envelope around its capsid



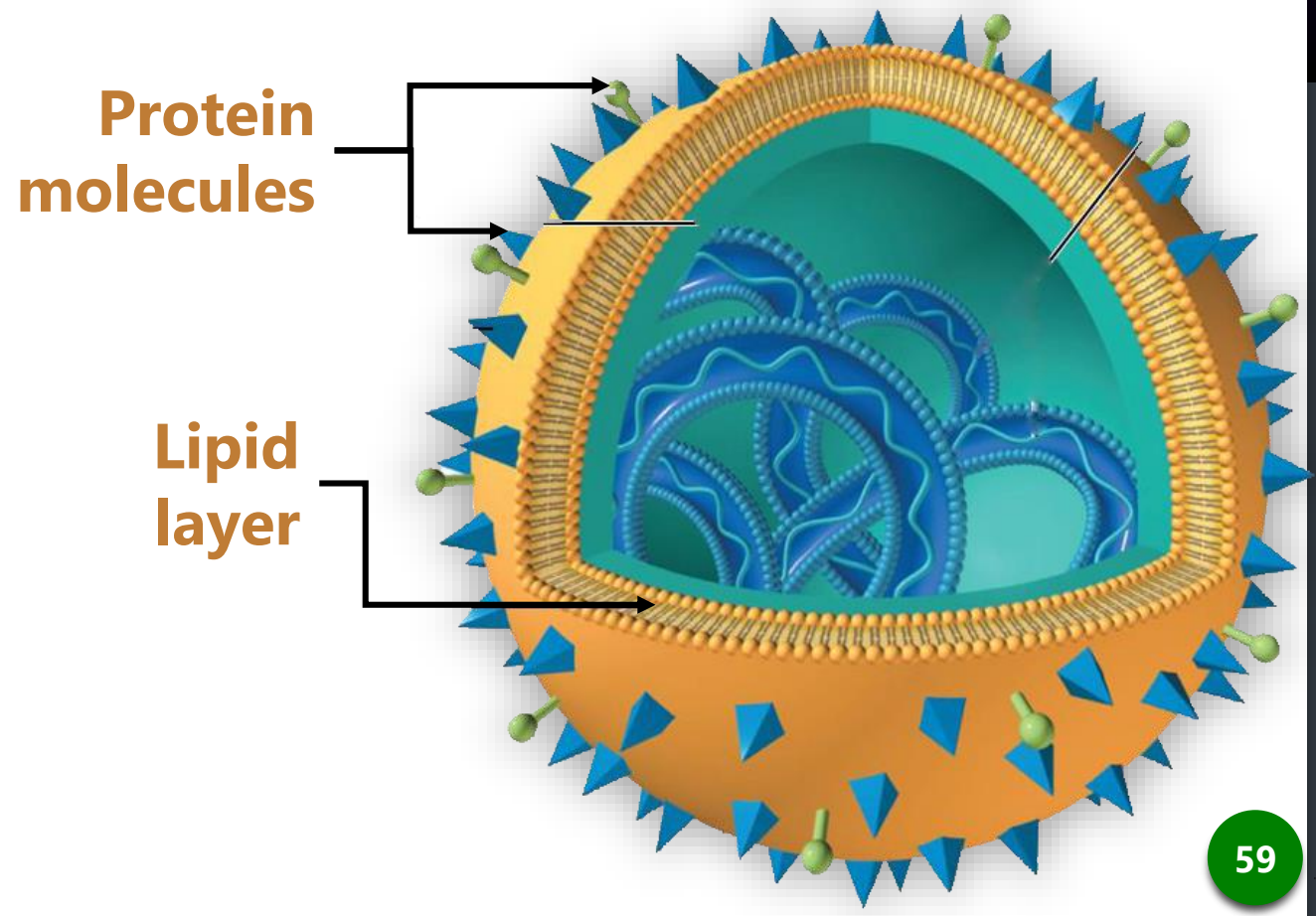
Viral Structure › Envelope

Many types of virus have a glycoprotein envelope surrounding the nucleocapsid



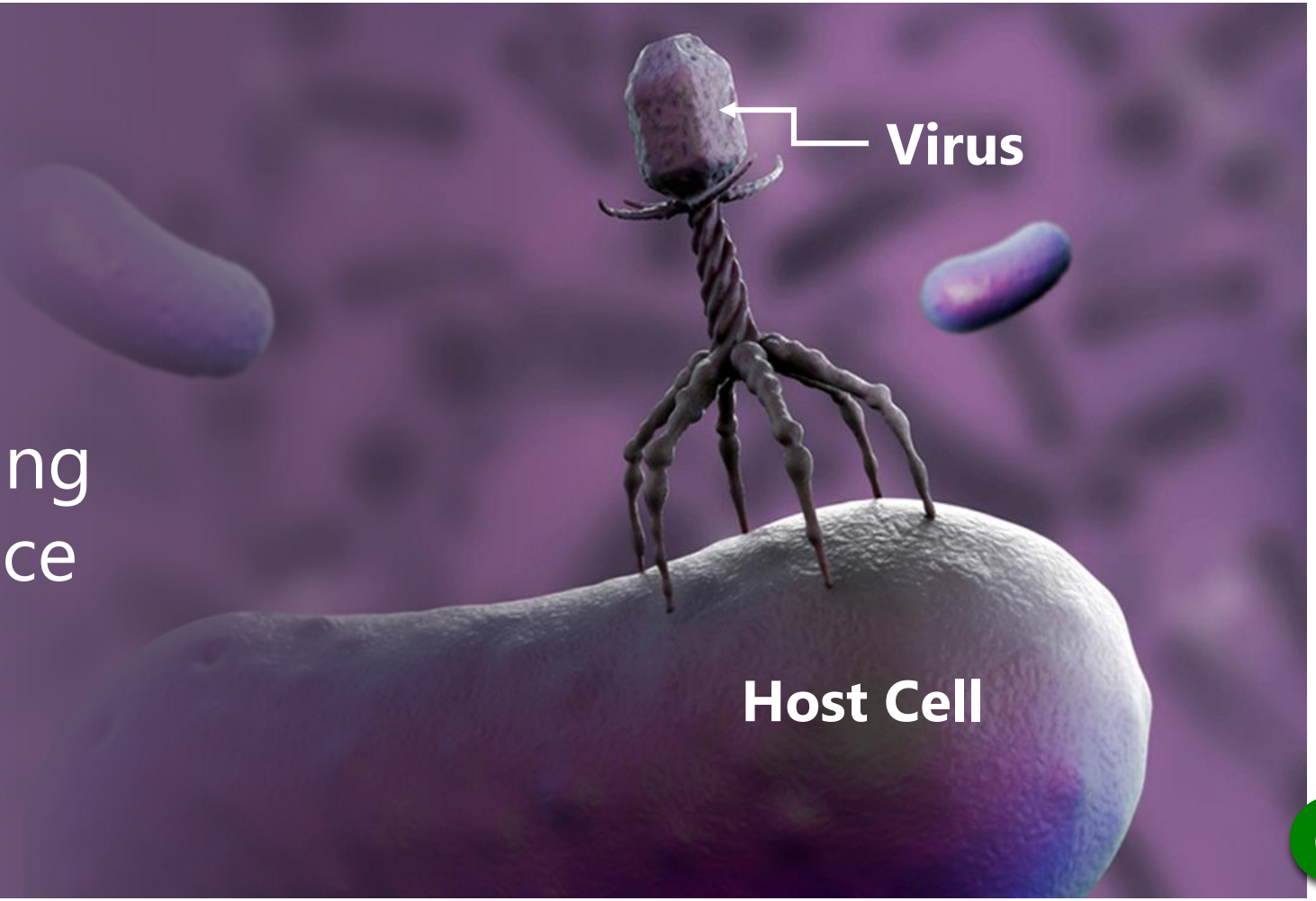
Viral Structure › Envelope

The envelope is composed of two lipid layers interspersed with protein molecules (lipoprotein bilayer) and may contain material from the membrane of a host cell as well as that of viral origin



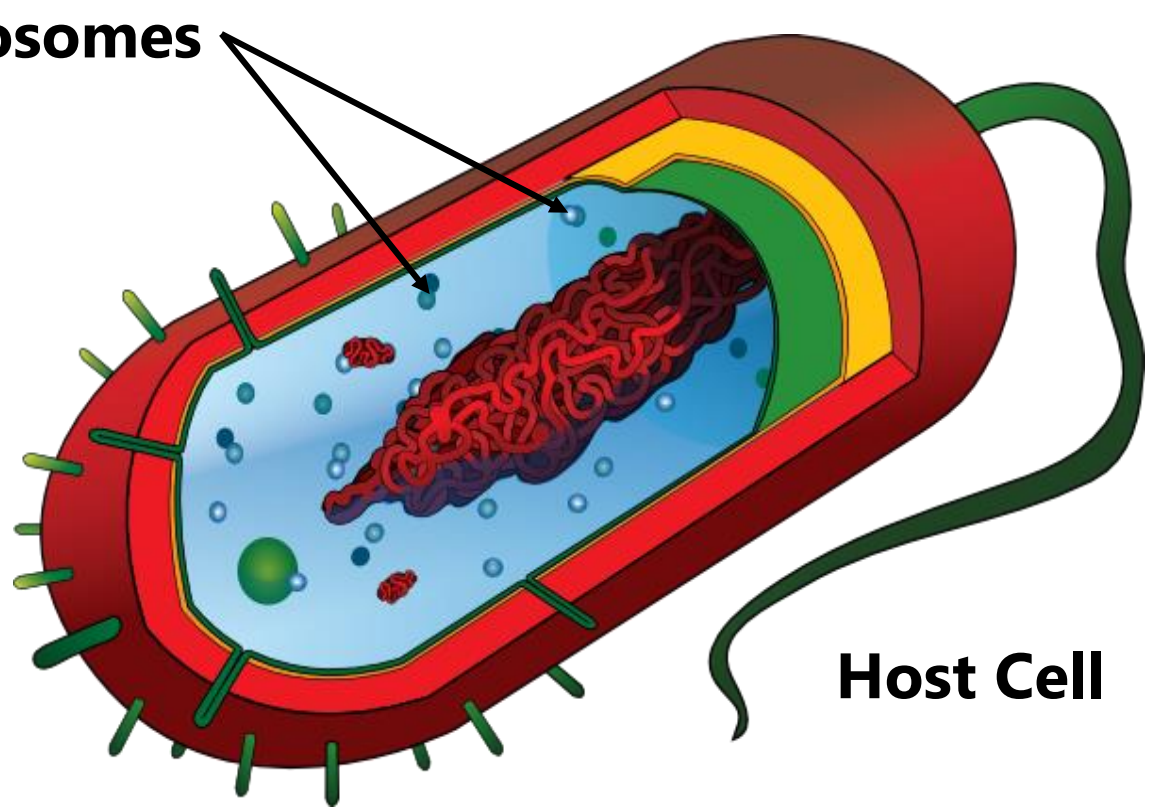
Viral Structure › Host Cell

Without a host cell, viruses cannot carry out their life-sustaining functions or reproduce



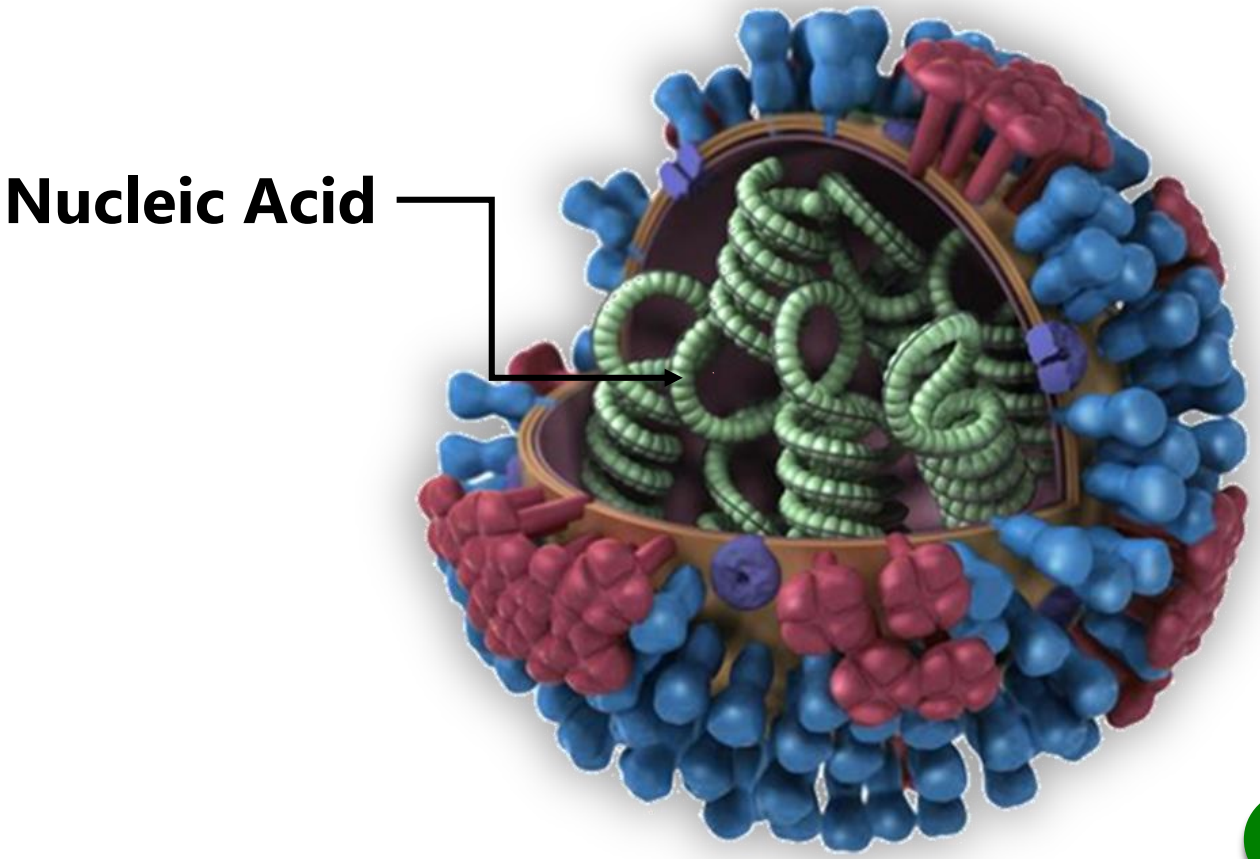
Viral Structure › Host Cell

They cannot synthesize proteins, because they lack ribosomes and must use the ribosomes of their host cells to translate viral messenger RNA into viral proteins



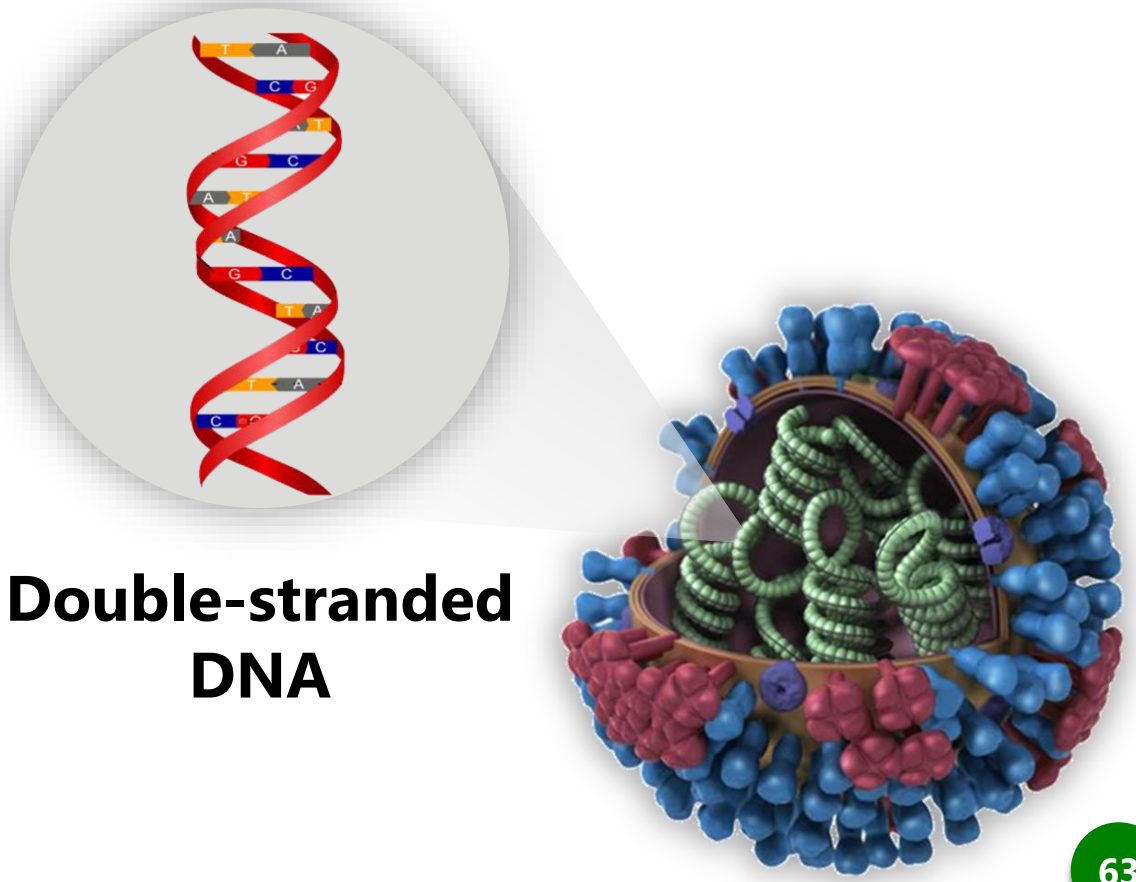
Viral Structure › Nucleic Acid

Just as in cells, the nucleic acid of each virus encodes the genetic information for the synthesis of all proteins



Viral Structure › Nucleic Acid

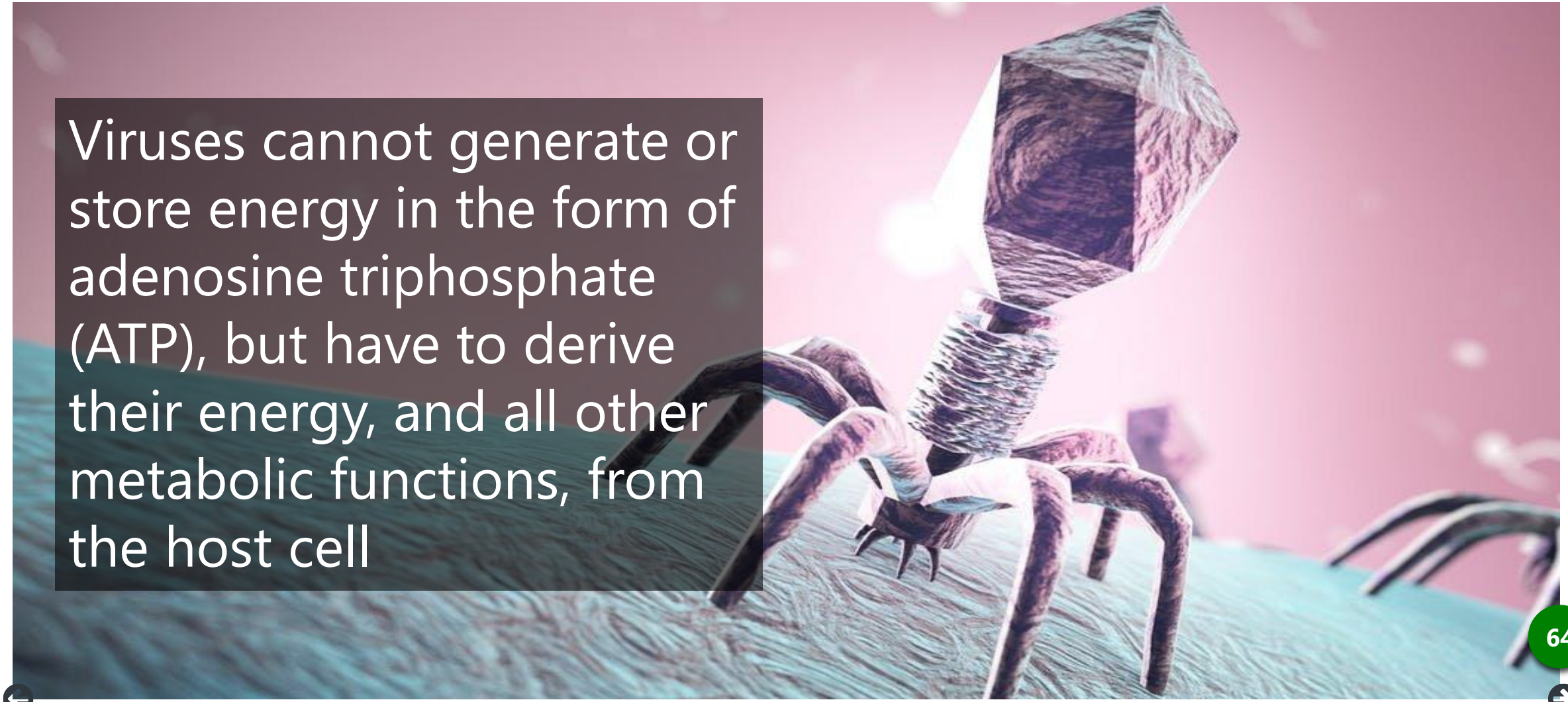
While the double-stranded DNA is responsible for this in prokaryotic and eukaryotic cells, only a few groups of viruses use DNA



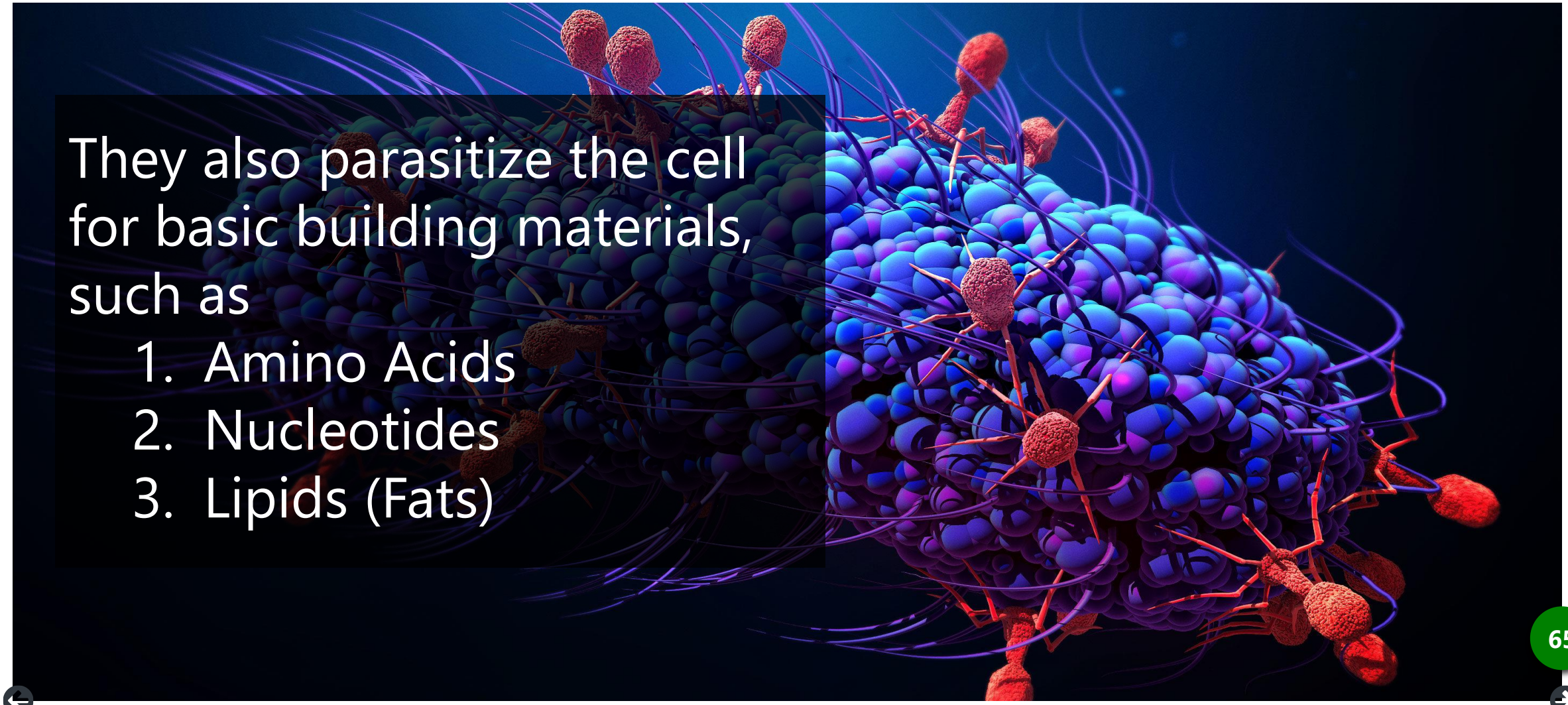
Double-stranded DNA

Characteristics of Viruses

Viruses cannot generate or store energy in the form of adenosine triphosphate (ATP), but have to derive their energy, and all other metabolic functions, from the host cell



Characteristics of Viruses



They also parasitize the cell for basic building materials, such as

1. Amino Acids
2. Nucleotides
3. Lipids (Fats)

Characteristics of Viruses

1. Viruses can reproduce only within a host cell

2. They are obligate intracellular parasites – i.e. can only express genes from living cells

3. Viruses have specific host range, or a limited number of host cells that they can infect

Characteristics of Viruses

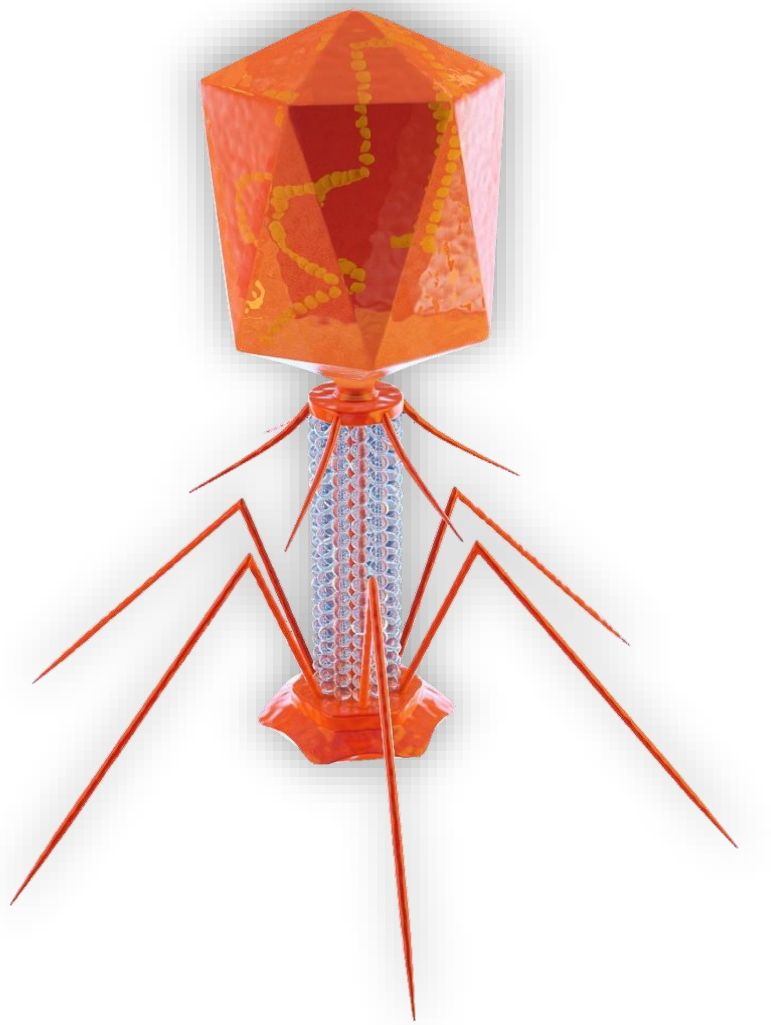
4 Some have very narrow host ranges and infect single species or single tissue types of one species

For example: The AIDS virus can only infect certain white blood cells, whilst the cold virus will only infect cells of the upper respiratory tract

Viral Replication

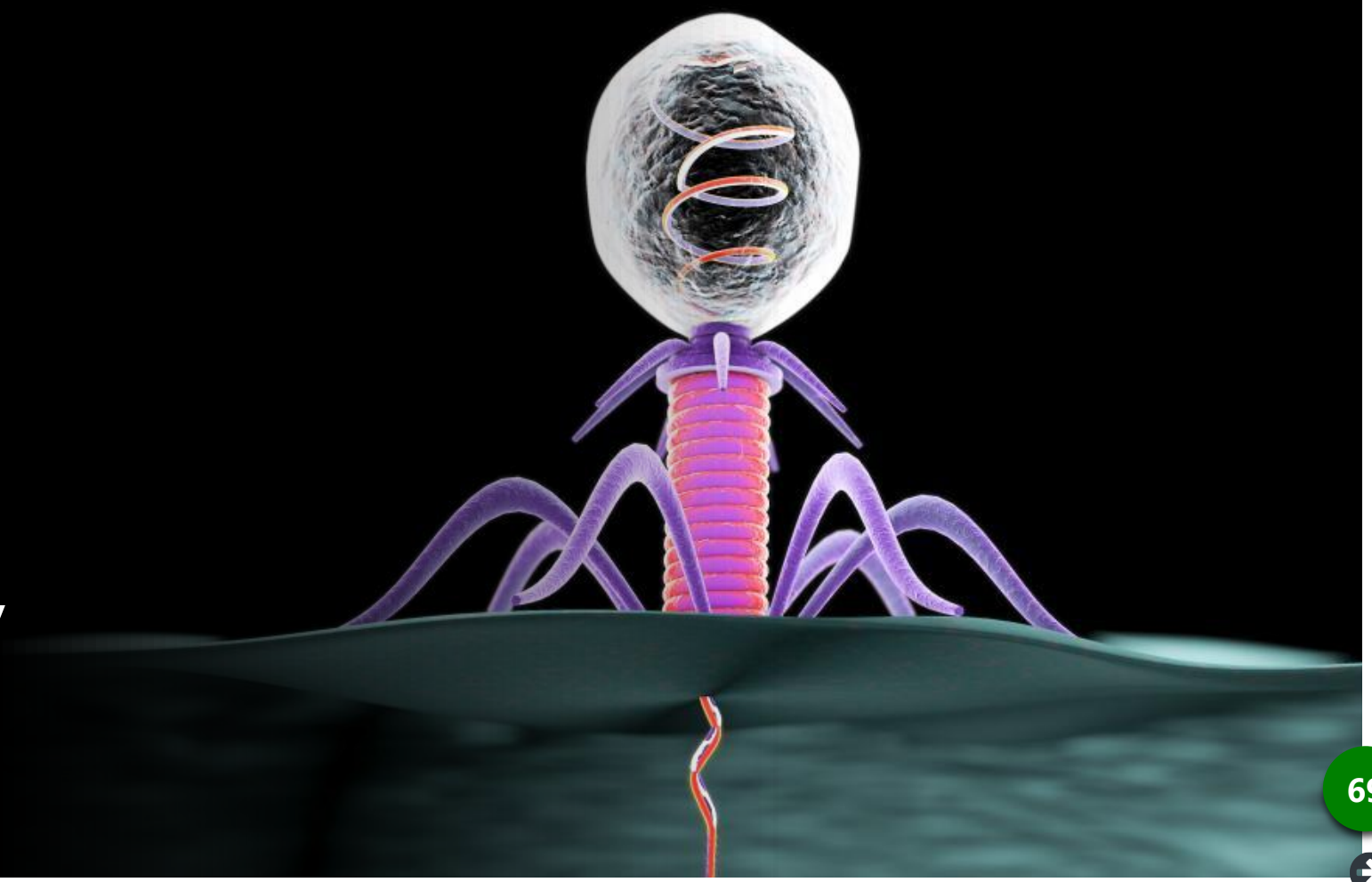
A single virus particle or virion in itself is essentially inert

It lacks needed components that cells have to reproduce



Viral Replication

When a virus infects a cell, it marshals the cell's ribosomes, enzymes and much of the cellular machinery to replicate

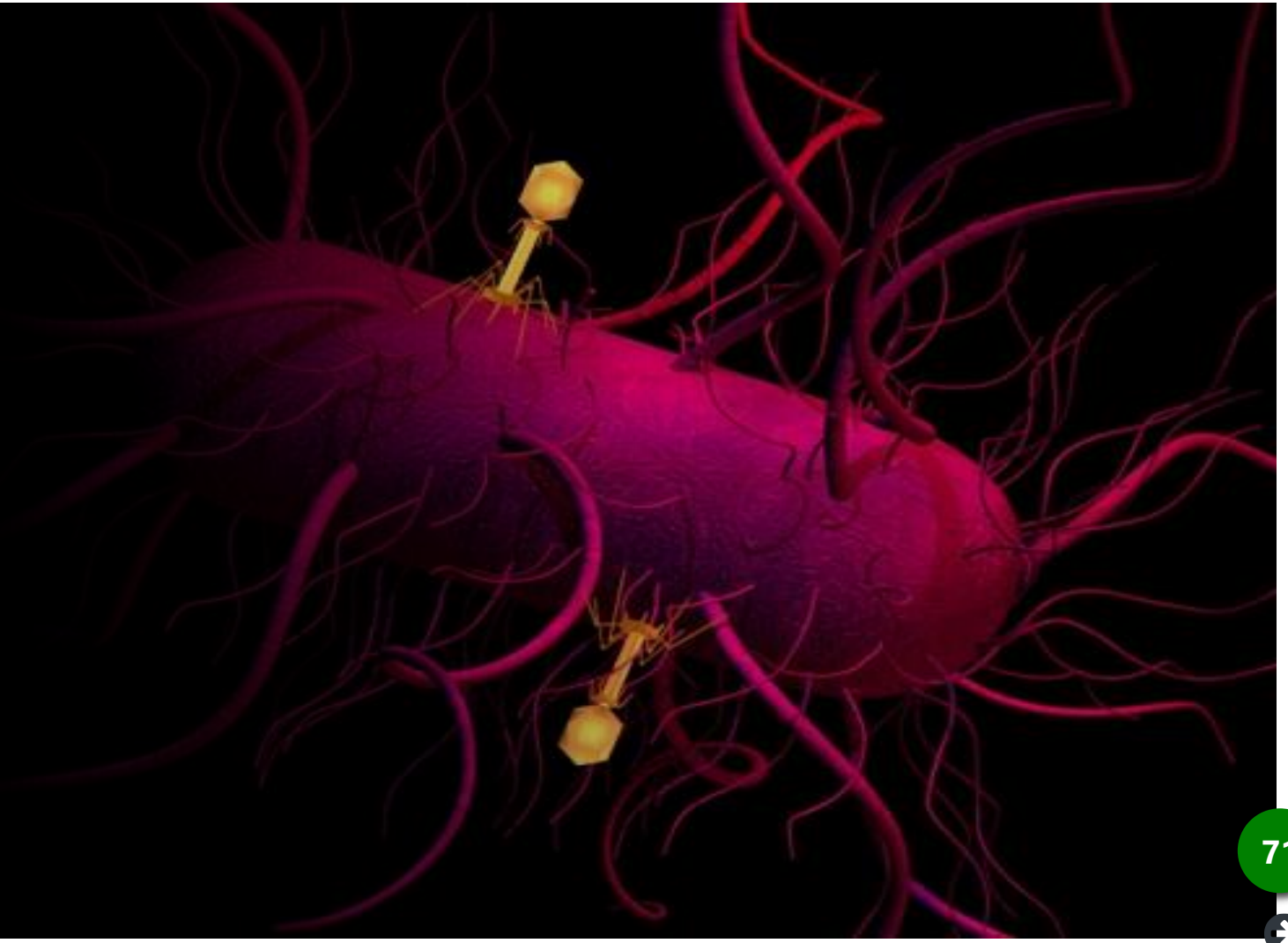


Viral Replication

Viral replication produces many progeny, that when complete, leave the host cell to infect other cells in the organism

Viral Replication

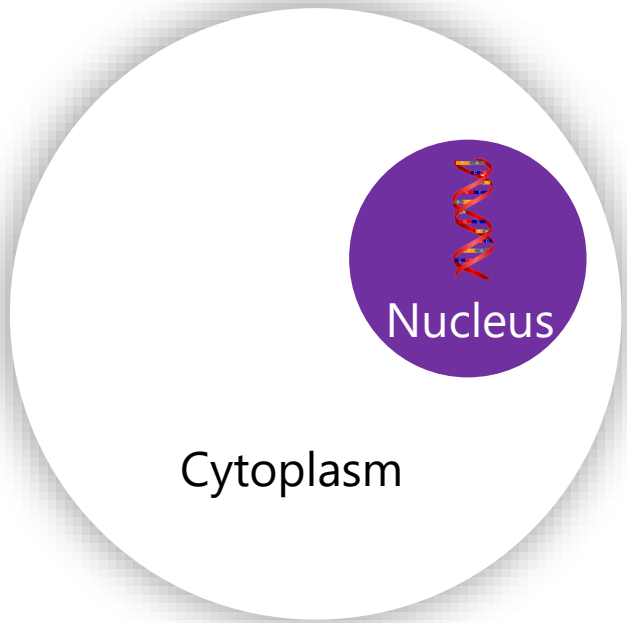
The exact nature of what happens after a host is infected varies depending on the nature of the virus



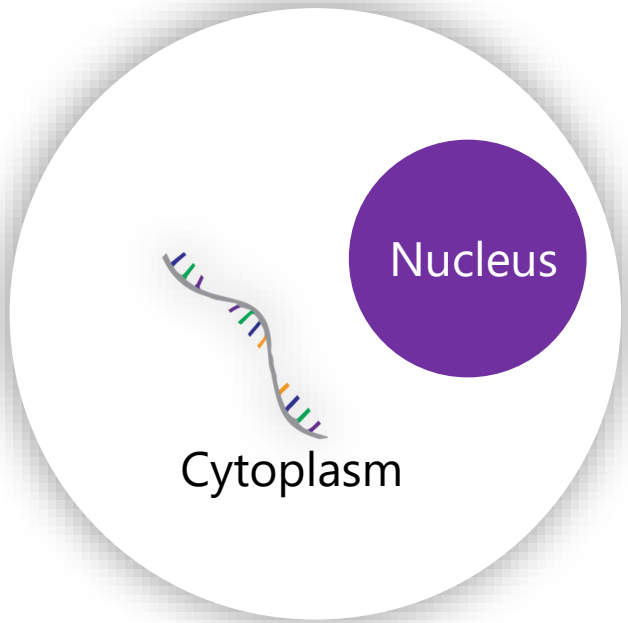
Viral Replication

The process for double-stranded DNA, single-stranded DNA, double-stranded RNA and single-stranded RNA viral replication will differ

Viral Replication



Double-stranded DNA viruses typically must enter the host cell's nucleus before they can replicate



Single-stranded RNA viruses replicate mainly in the host cell's cytoplasm

Viral Replication

Once a virus infects its host and the viral progeny components are produced by the host's cellular machinery, the assembly of the viral capsid is a non-enzymatic process

It is usually spontaneous

How Viruses Infect Cells

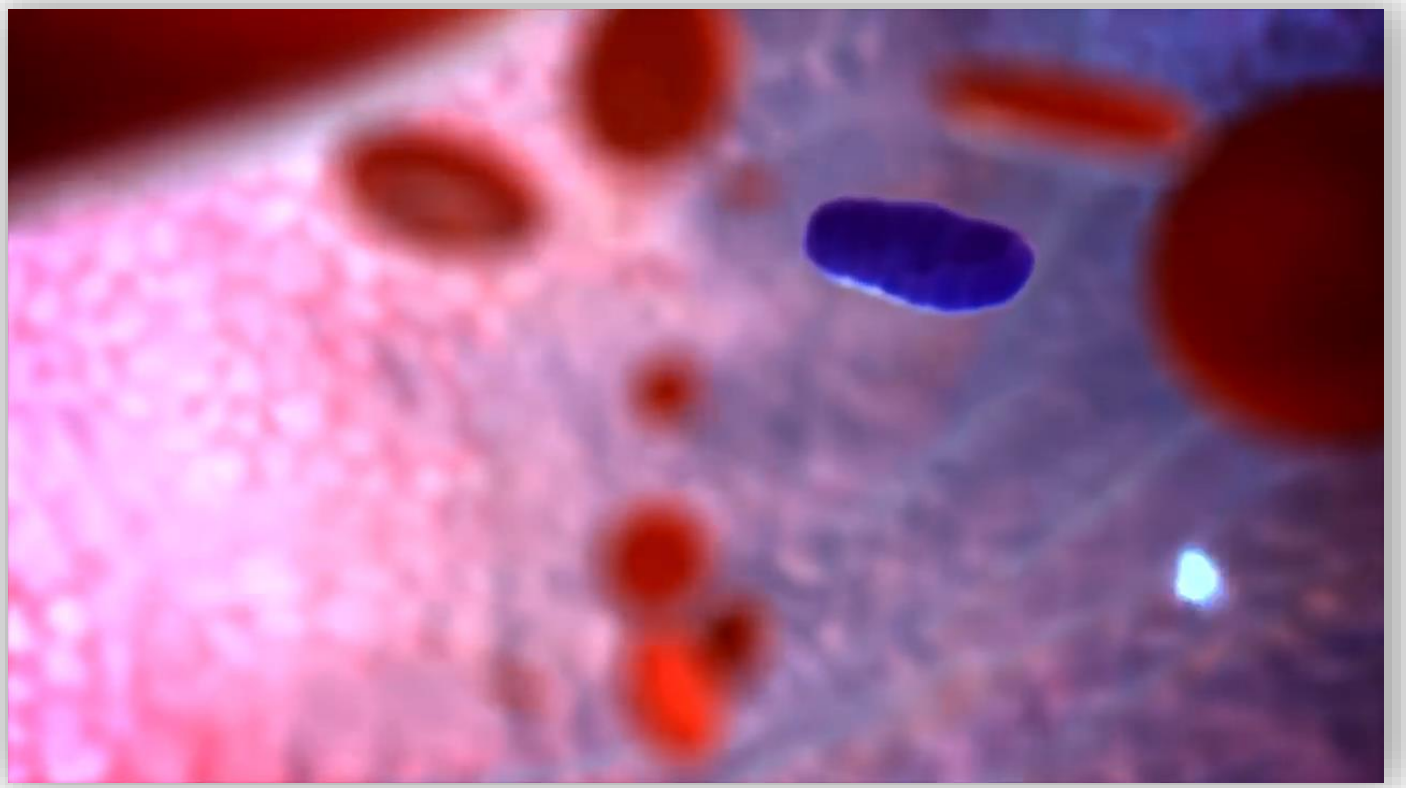
Watch an
Overview Video

How Viruses Infect Cells

The basic process of viral infection and virus replication occurs in 6 main steps

1. **Adsorption/ Attachment**

   virus binds to the host cell



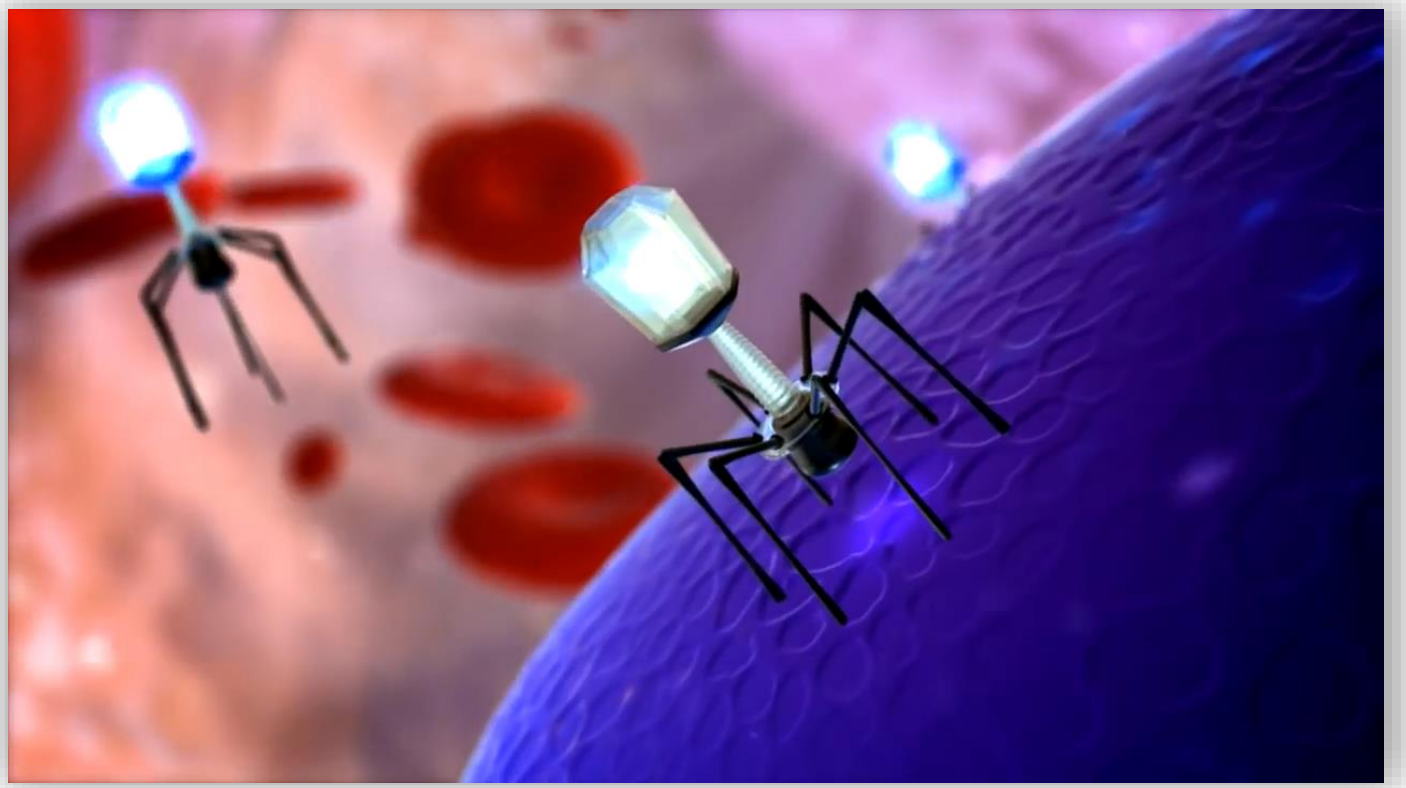
How Viruses Infect Cells

The basic process of viral infection and virus replication occurs in 6 main steps

2 **Penetration**

Virus injects its genome into host cell

At this point, the virus can no longer be recovered from the intact cell

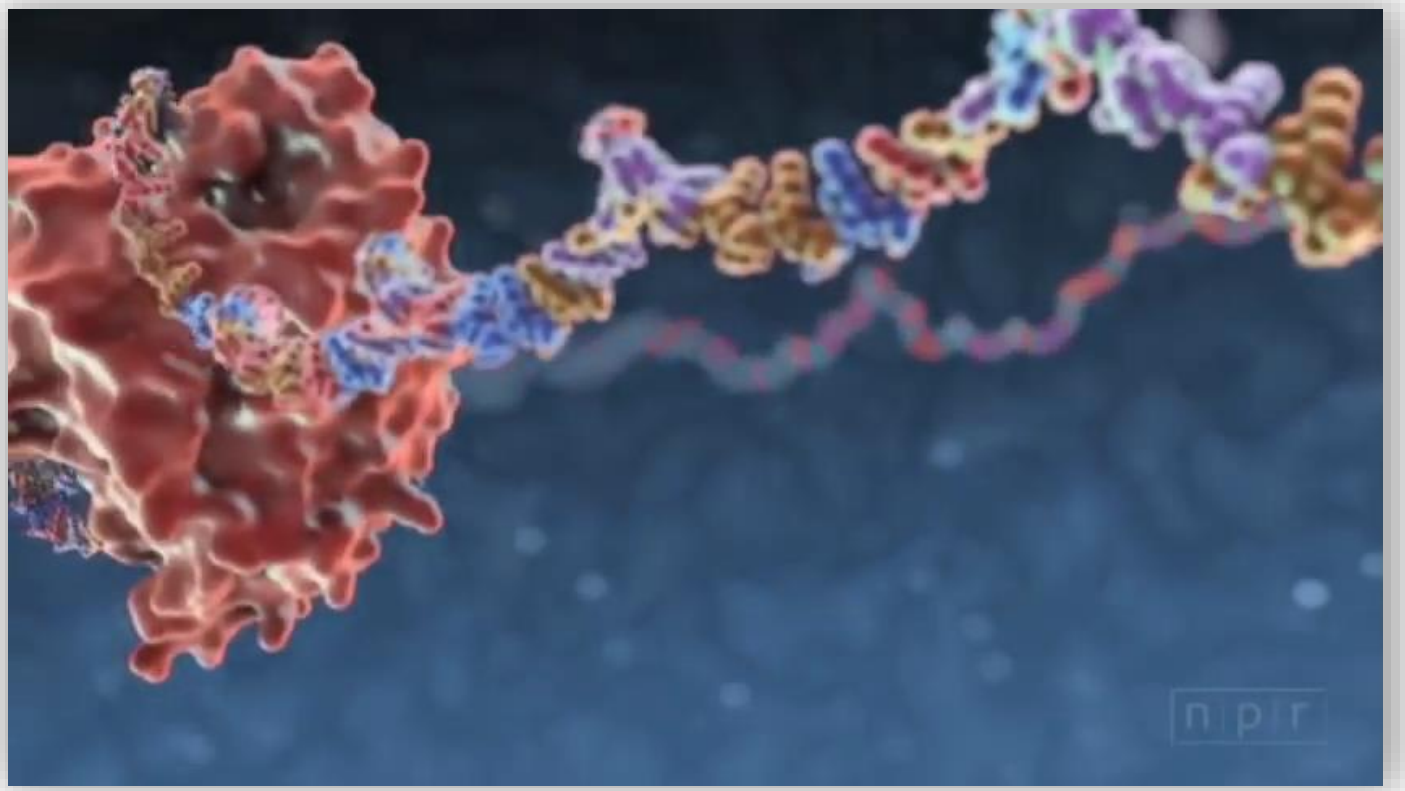


How Viruses Infect Cells

The basic process of viral infection and virus replication occurs in 6 main steps

3 **Replication or Synthesis**

The viral genome replicates using the host's cellular machinery

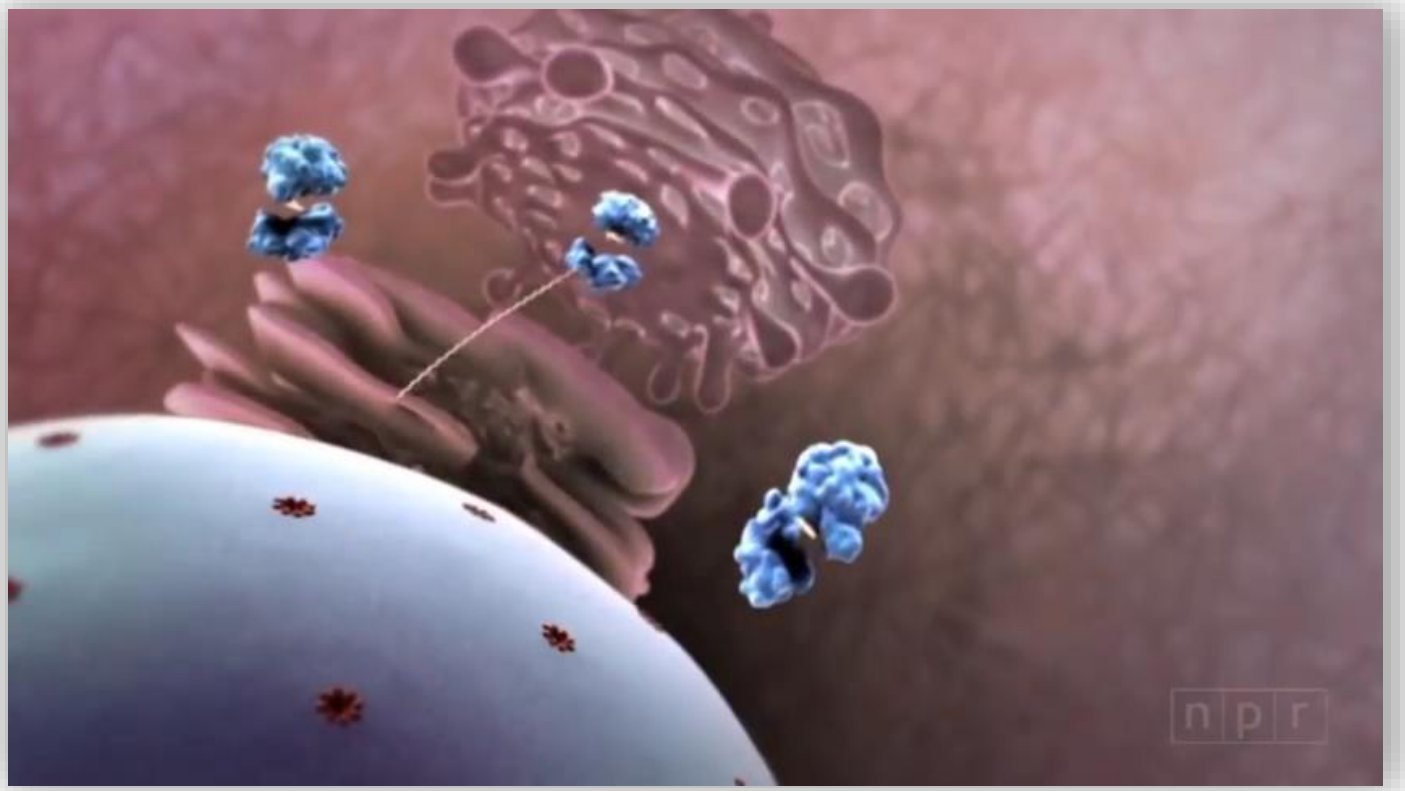


How Viruses Infect Cells

The basic process of viral infection and virus replication occurs in 6 main steps

4 **Assembly**

Viral components and enzymes are produced and begin to assemble

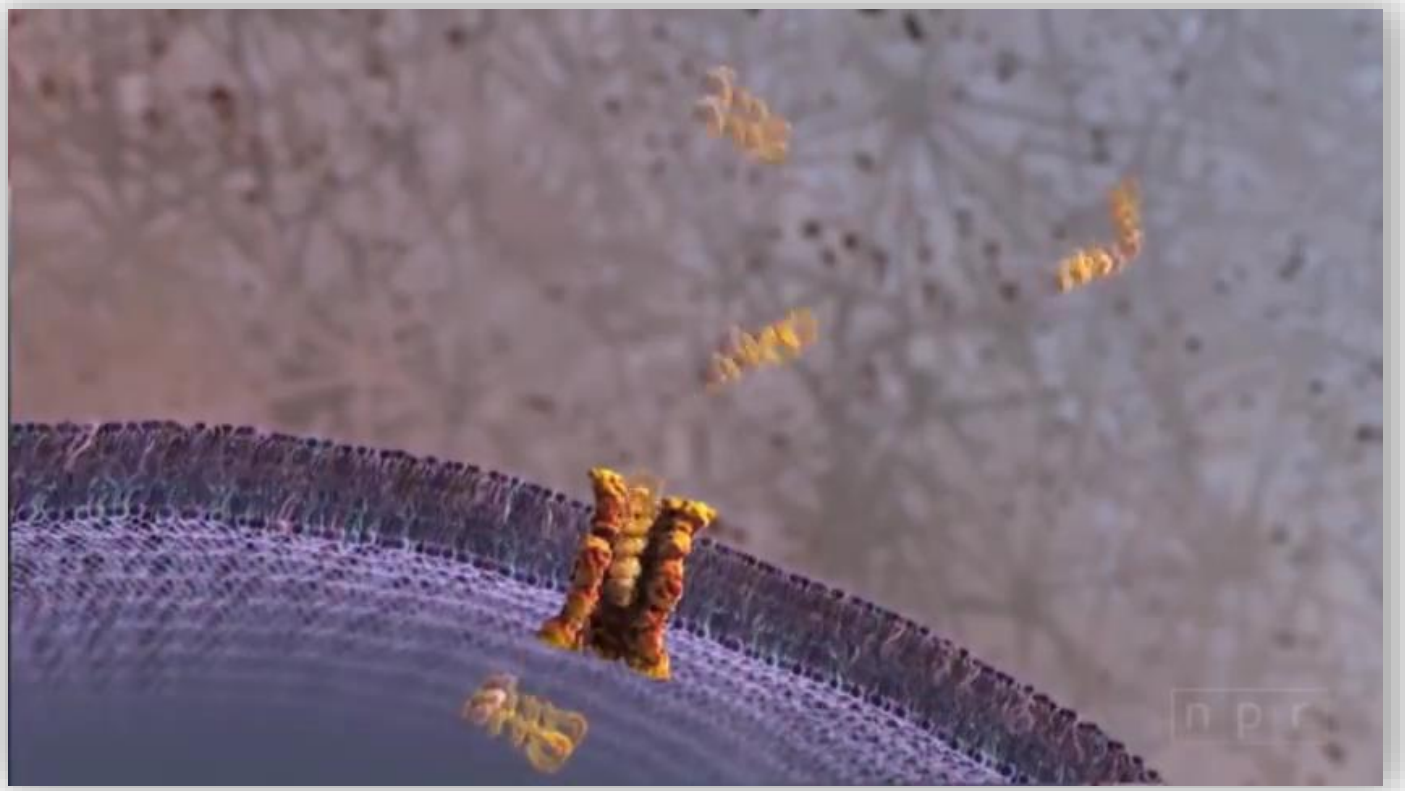


How Viruses Infect Cells

The basic process of viral infection and virus replication occurs in 6 main steps

5 Maturation

Viral components assemble and viruses fully develop



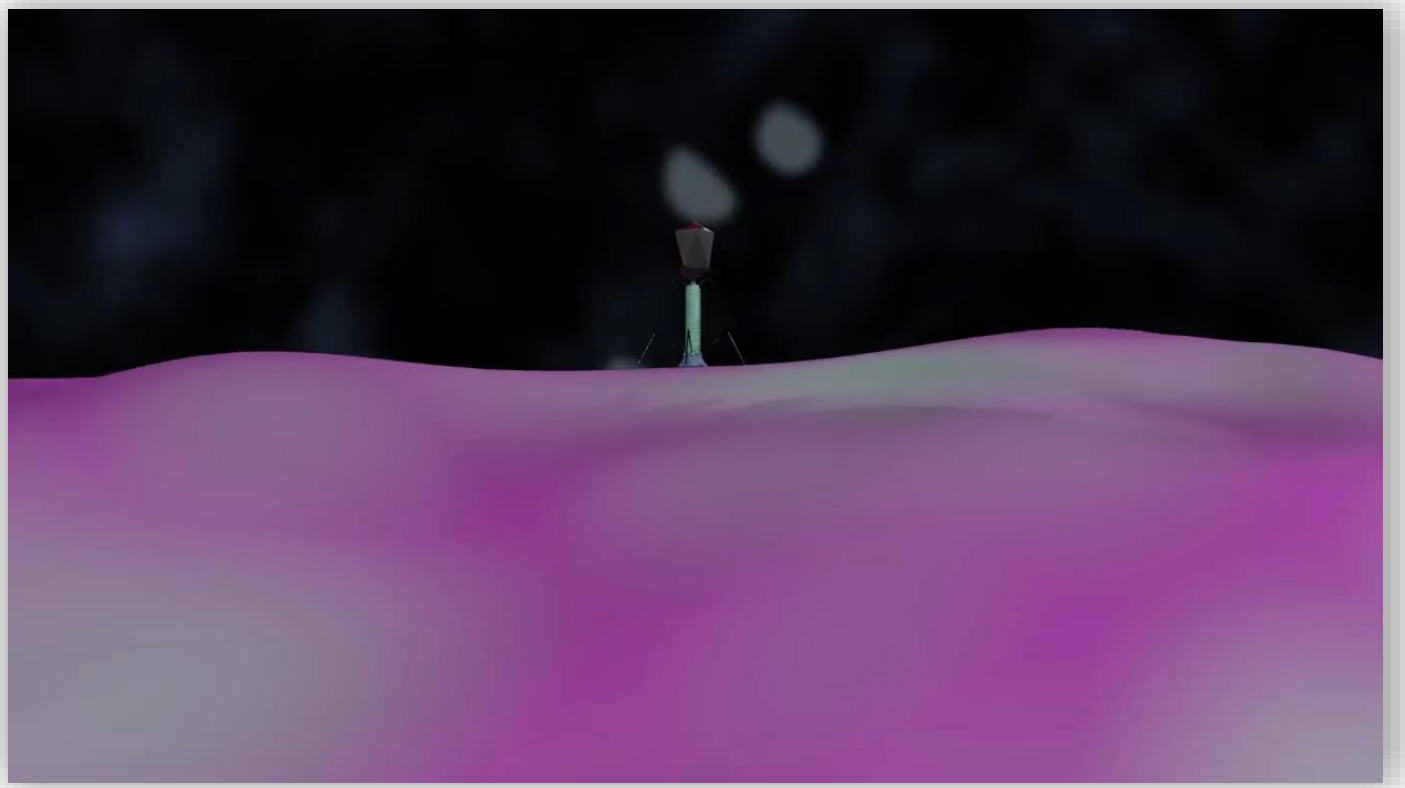
How Viruses Infect Cells

The basic process of viral infection and virus replication occurs in 6 main steps

6 Release

Newly produced viruses are release from the host cell

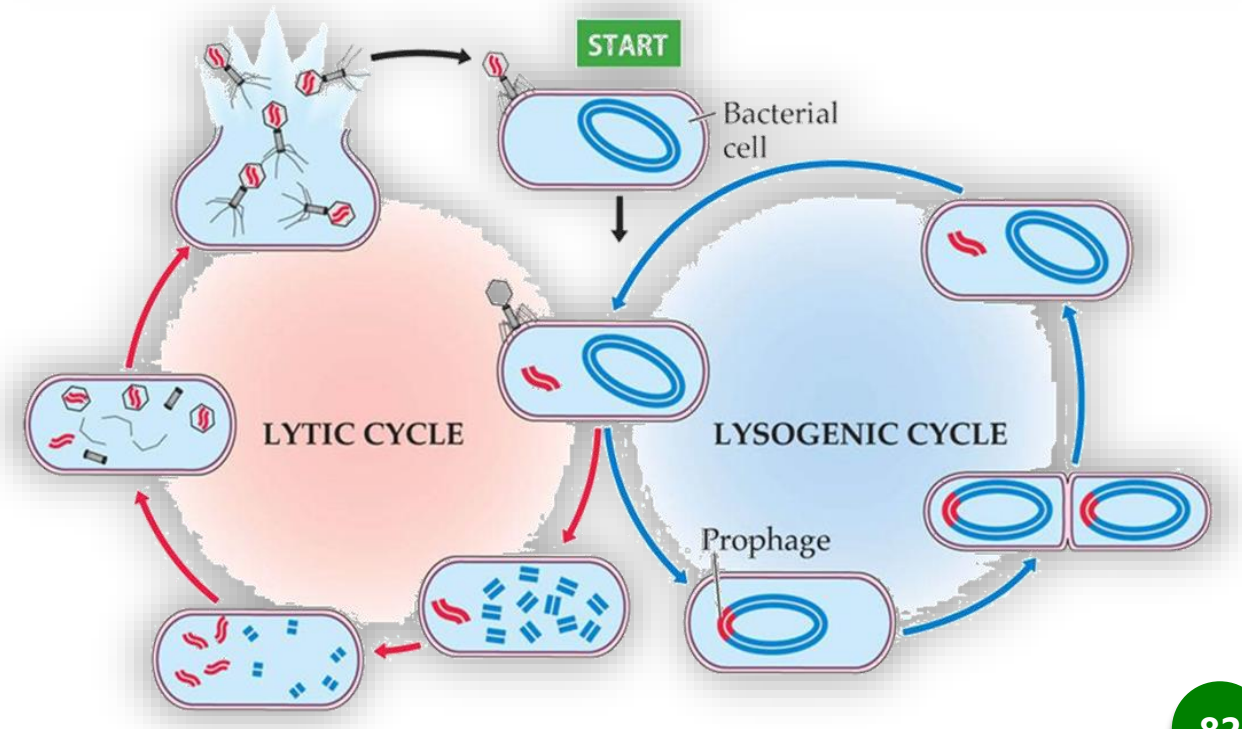
The virus releases enzymes to break the cell wall and the cell wall bursts



General Viral Life Cycle

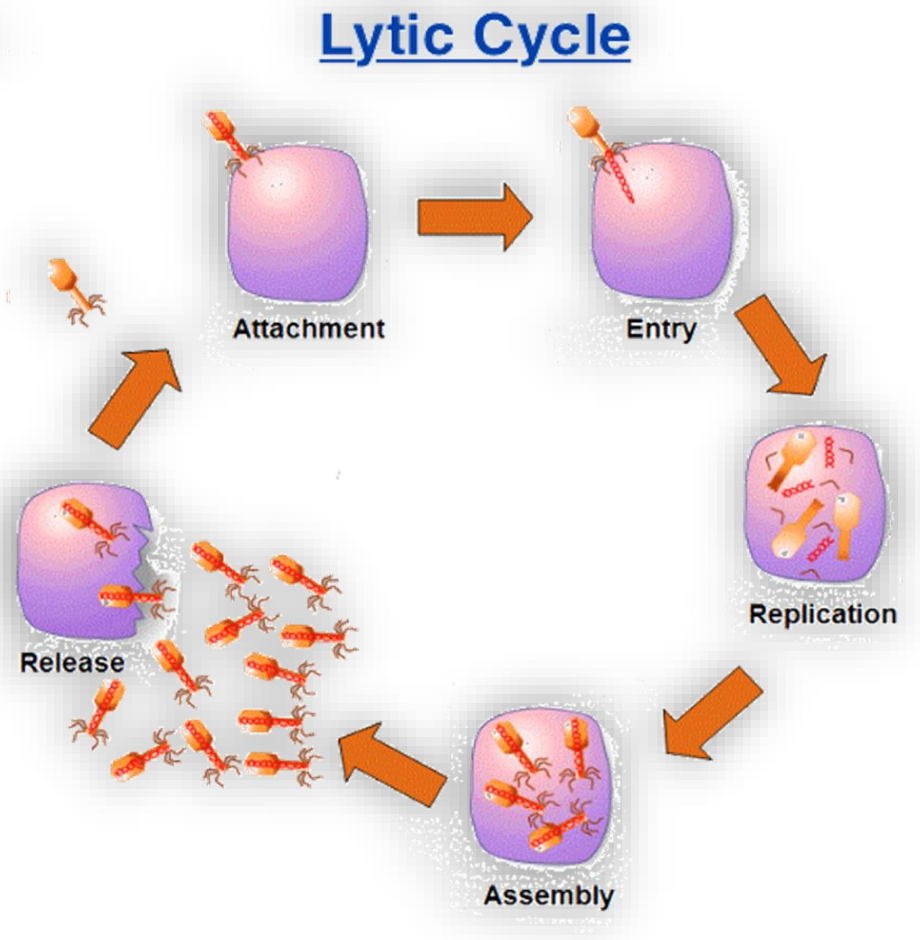
A virus undergoes either of the following cycles to reproduce

1. **The Lytic Cycle**
2. **The Lysogenic Cycle**



General Viral Life Cycle › Lytic Cycle

The lytic cycle is thought to be the major method of viral replication as it results in total cell lyses (that is, cell destruction of the infected bacterium)

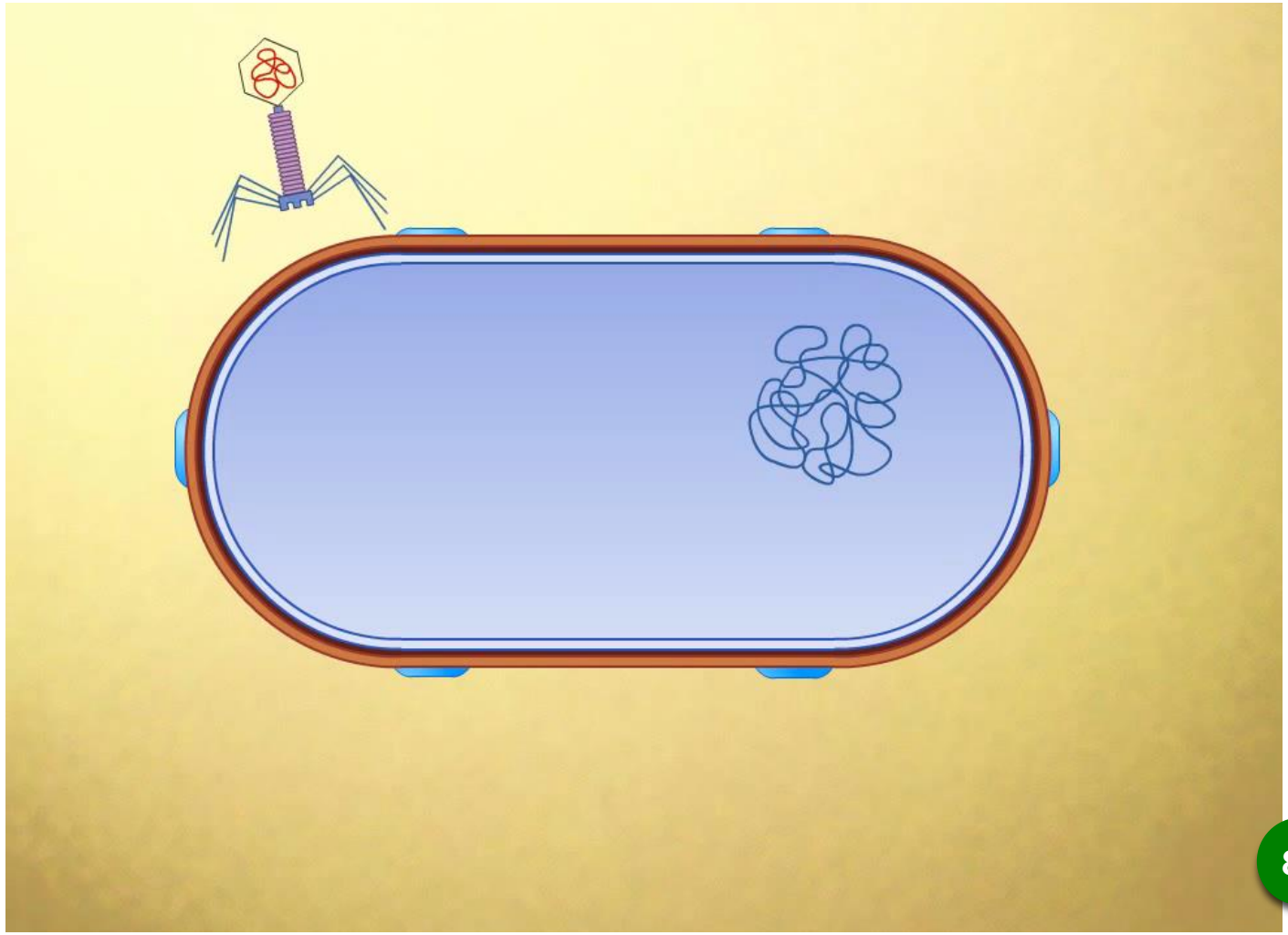


General Viral Life Cycle › Lytic Cycle

The viruses that undergo lytic cycle are called **virulent viruses**

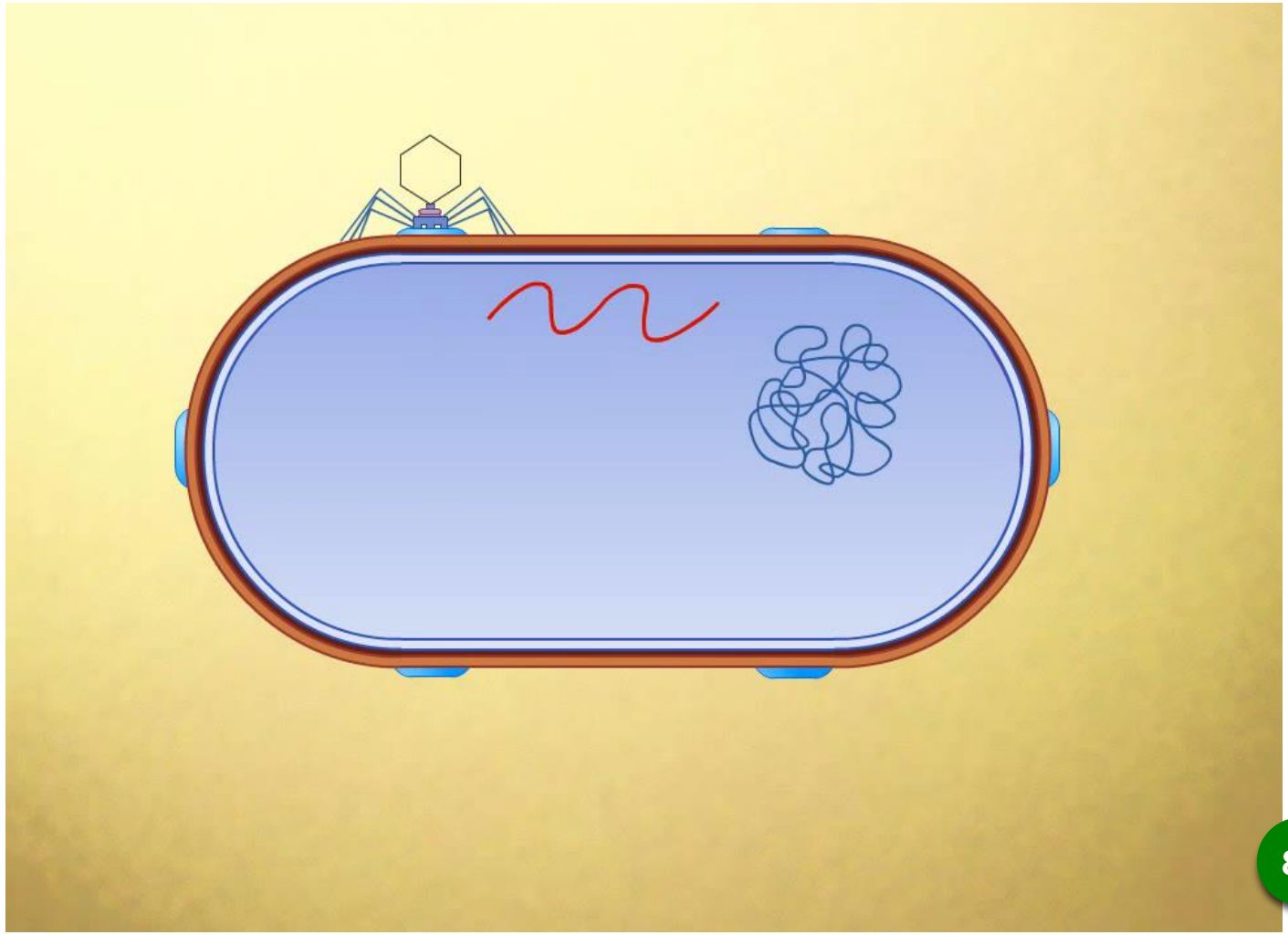
General Viral Life Cycle › Lytic Cycle

The virus injects its nucleic acids into the host cell that form a circle in the center of the cycle



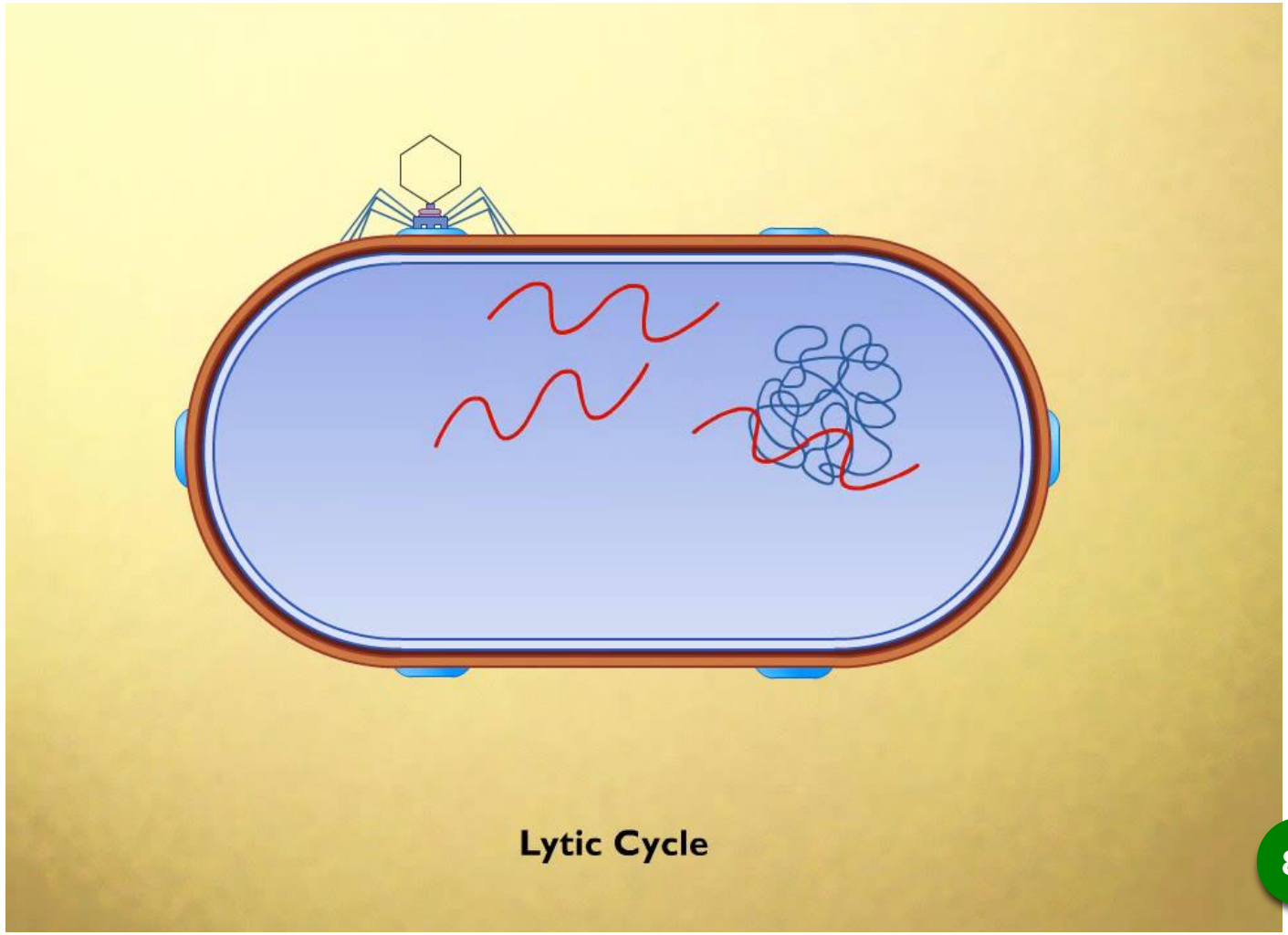
General Viral Life Cycle › Lytic Cycle

The host cell is then "tricked" or "directed" into replicating the viral nucleic acid instead of its own nucleic acids



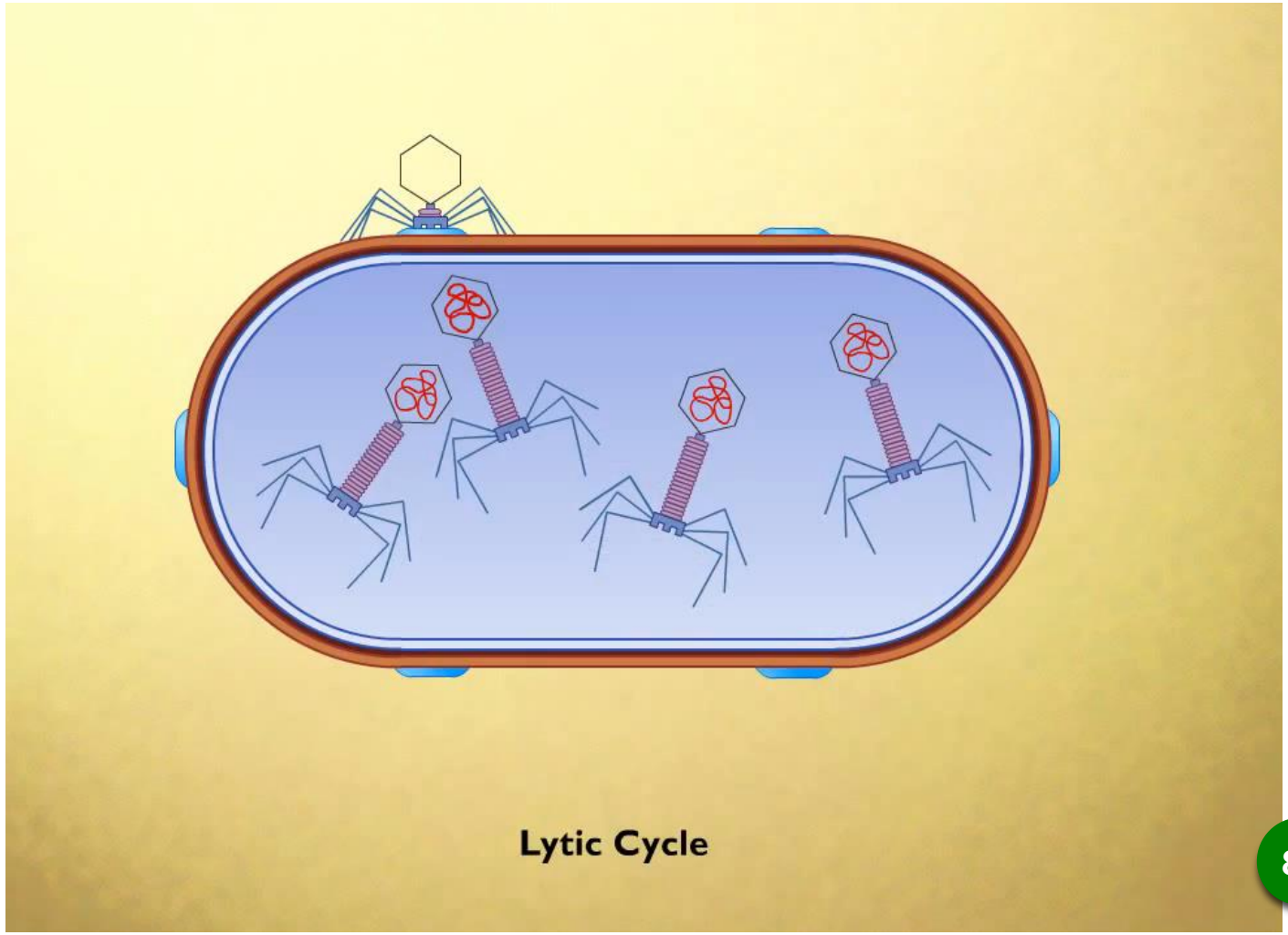
General Viral Life Cycle › Lytic Cycle

This viral DNA then begins organizing itself into a viral cell inside the host cell



General Viral Life Cycle › Lytic Cycle

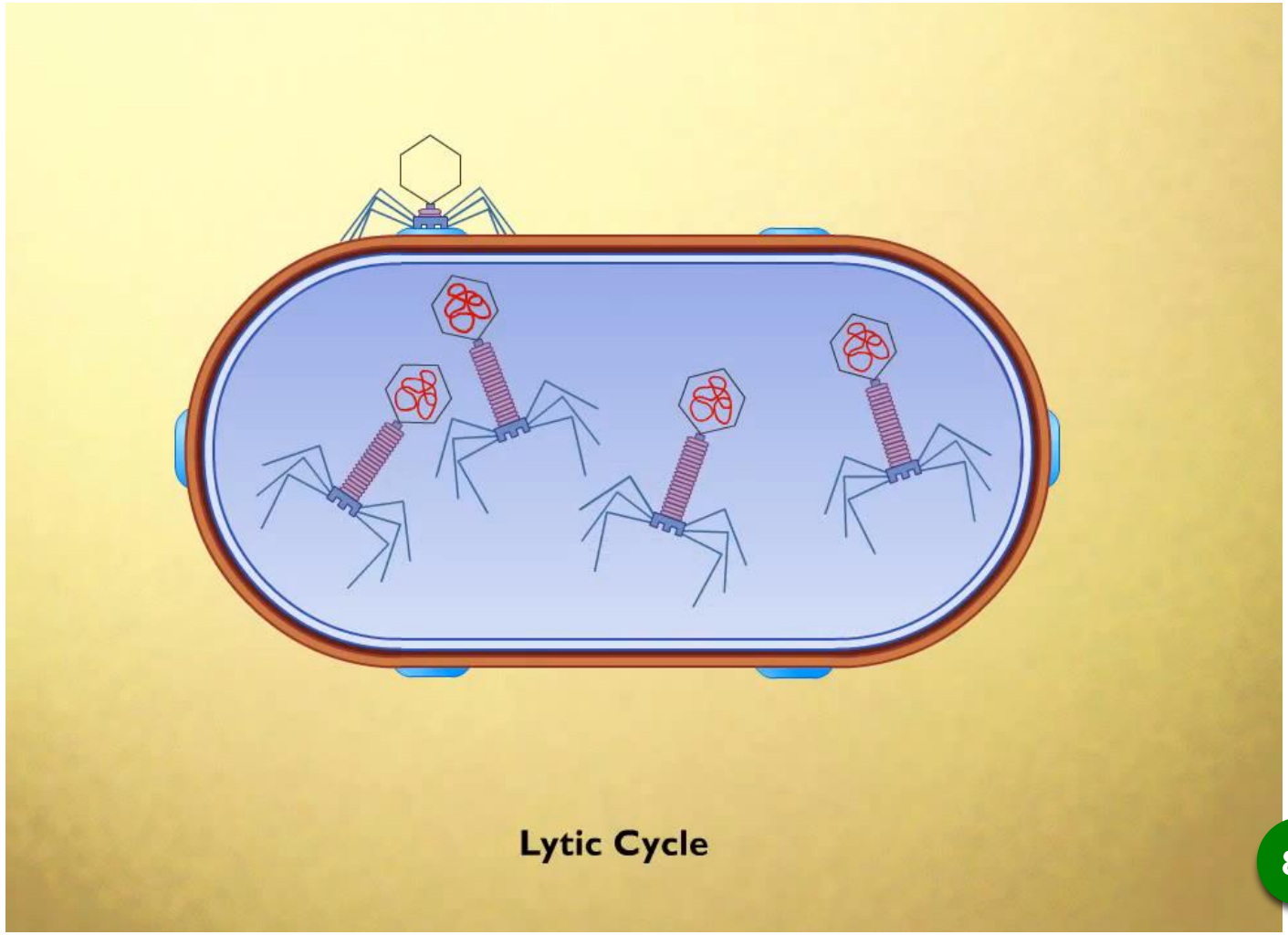
When the number of viruses in the host cell increases, it causes the cell membrane to split or lyse under the pressure from so many cells



General Viral Life Cycle › Lytic Cycle

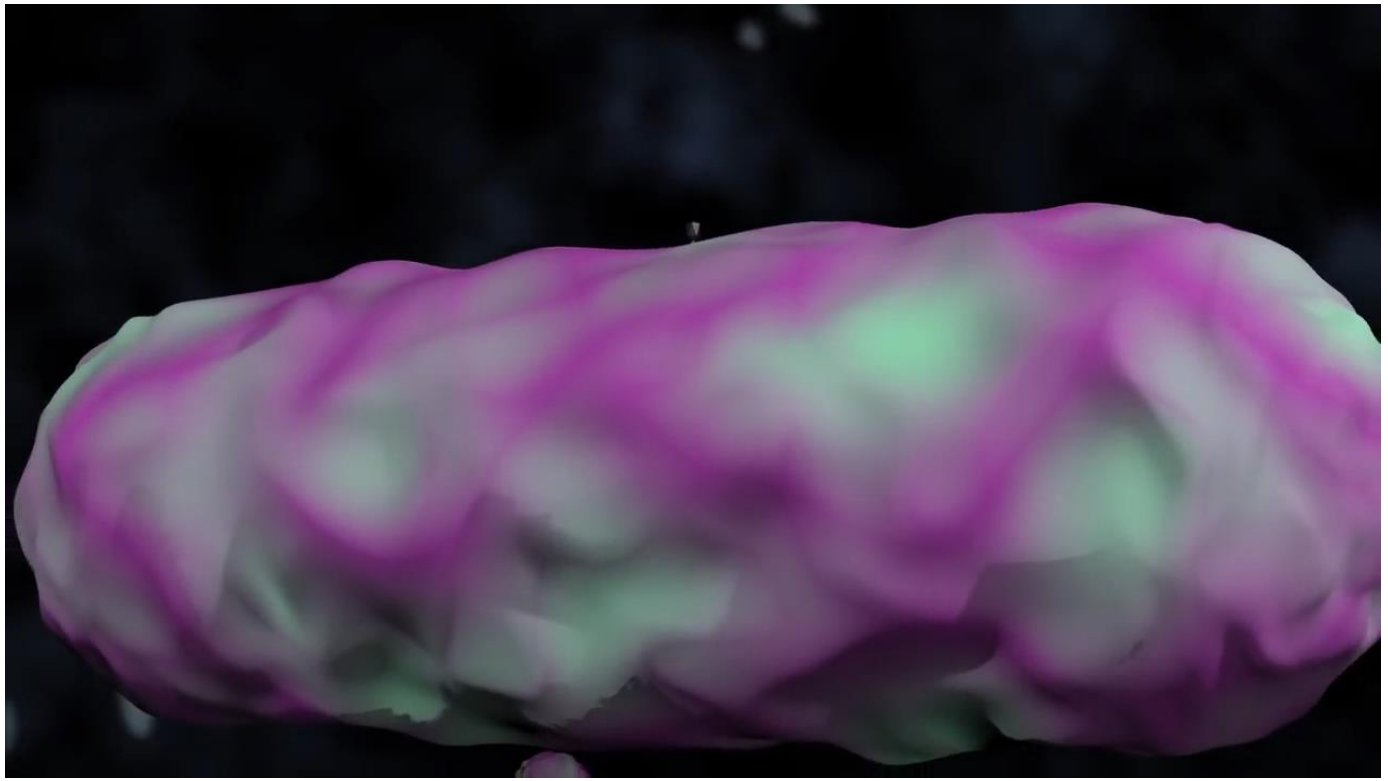
Thus, the viruses are released from the host body and ready to infect another cell

A host cell releases about 100 to 200 viruses approximately



General Viral Life Cycle › Lytic Cycle

These viruses cause cell lyses, thus giving rise to the name **lytic cycle**

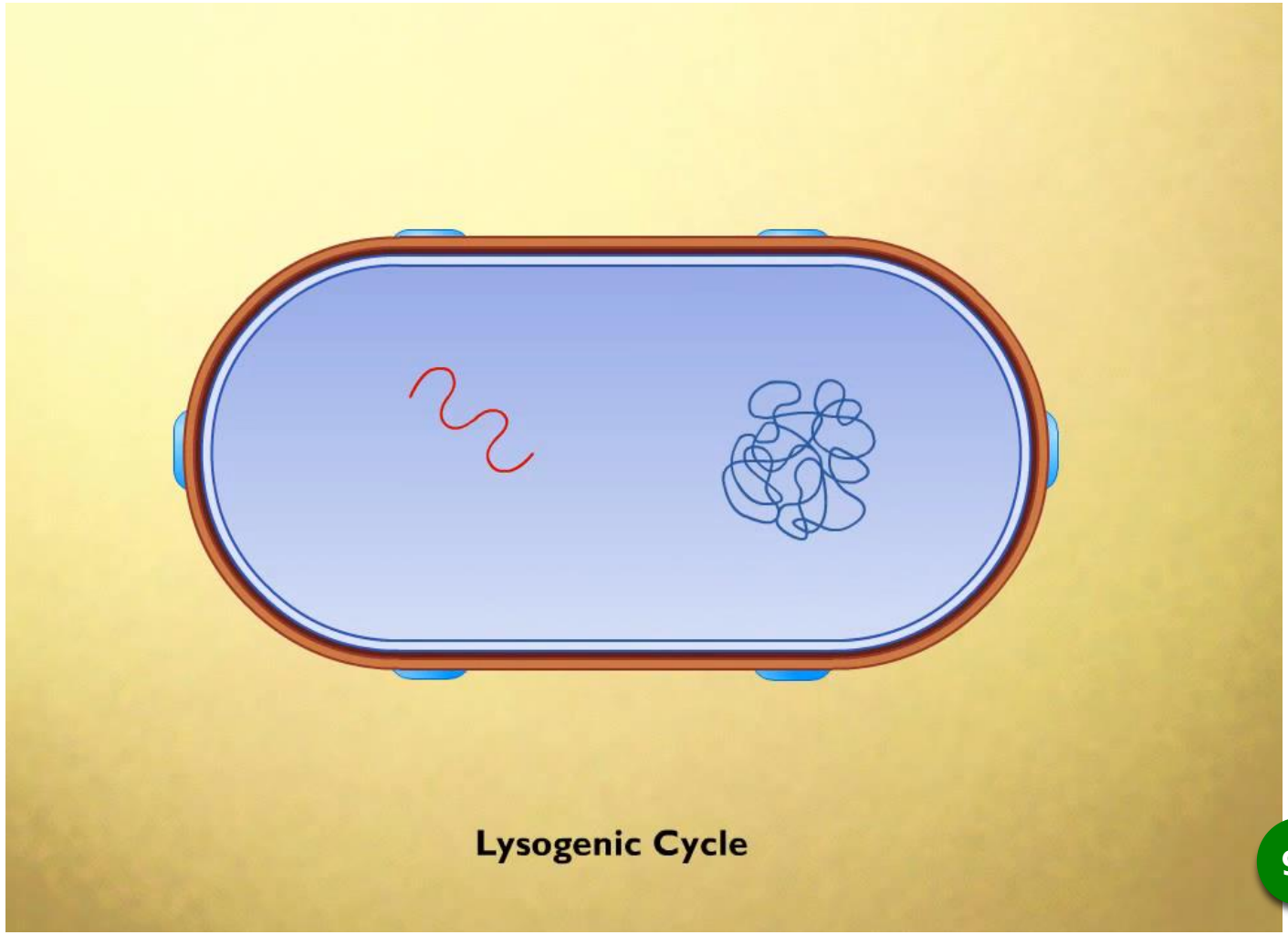


General Viral Life Cycle › Lytic Cycle

UV radiation, hydrogen peroxide and nitrogen mustard are chemical or physical agents that can lead to release of new phases into the environment through the lytic cycle

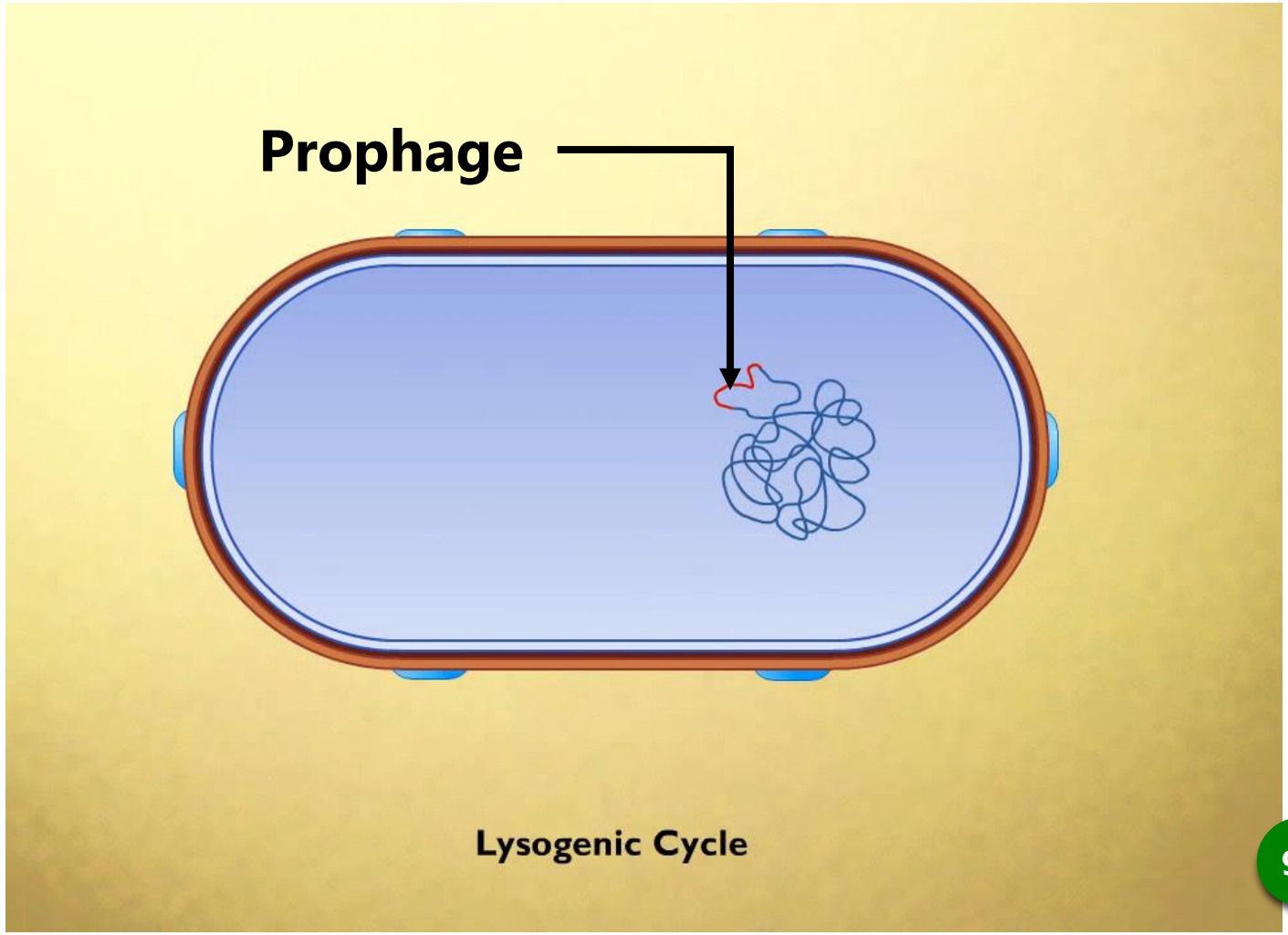
General Viral Life Cycle › Lysogenic Cycle

Lysogenic cycle is the integration of the bacteriophage nucleic acid into the host genome



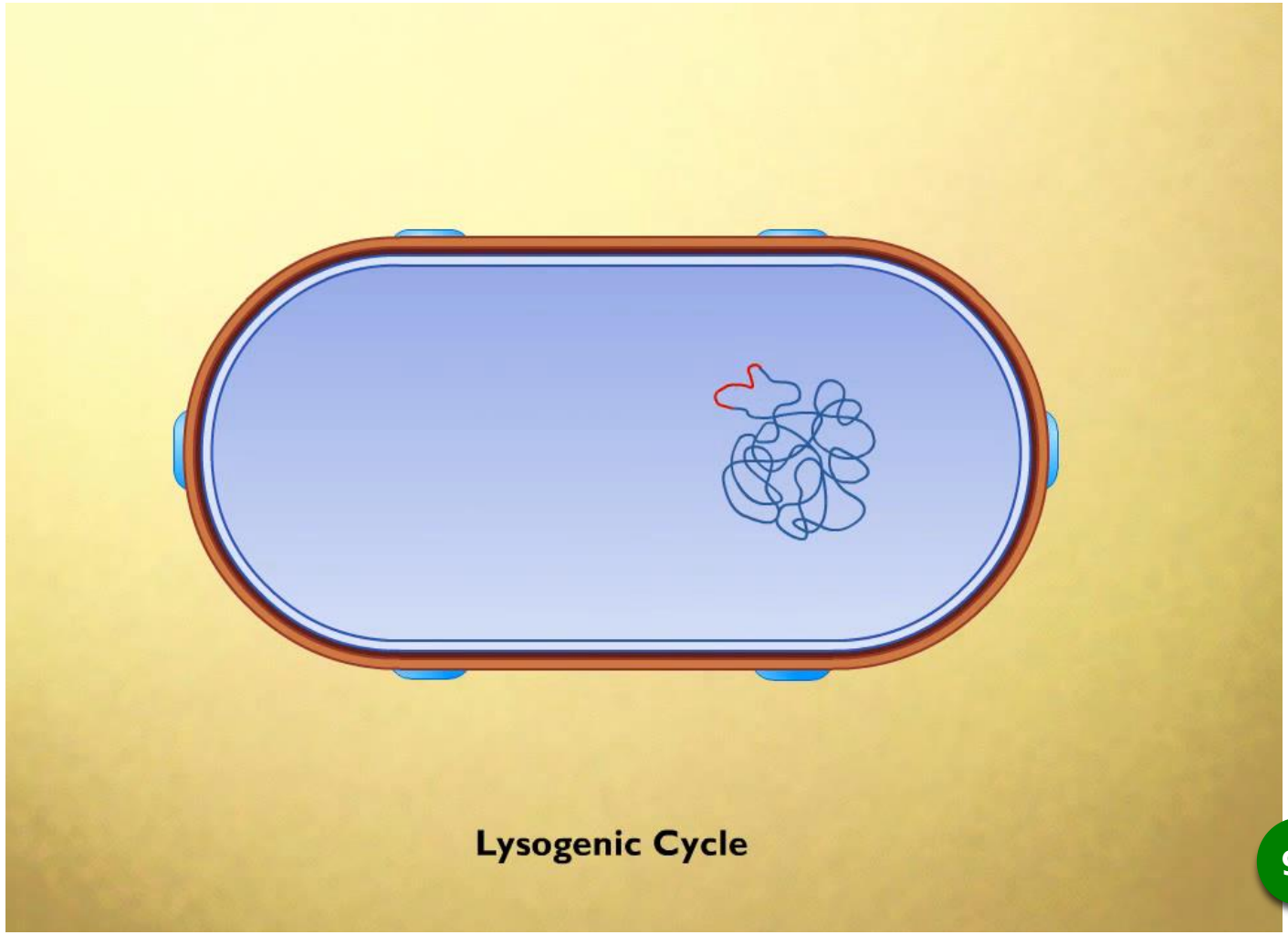
General Viral Life Cycle › Lysogenic Cycle

The new genetic material integrated into host cell is called a **prophage**



General Viral Life Cycle › Lysogenic Cycle

A prophage is transferred to the daughter cells of the host cell after each subsequent cell division



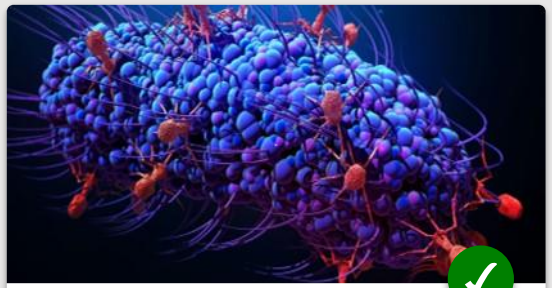
Module 3

Bacterial and Viral Genetics

Module Lessons

- Dashboard
- Objectives
- Lessons
- Assignments

End of Module



Lesson 1

Introduction

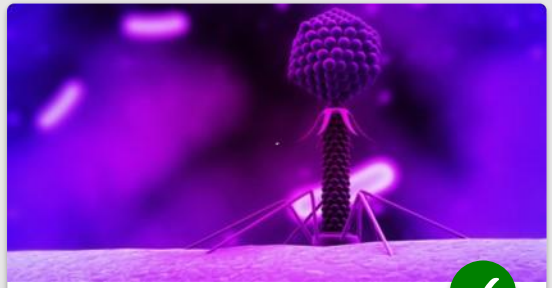
Learn about the reasons for studying bacterial and viral genetics

Start ▸

Lesson 2

The Bacterial Chromosome

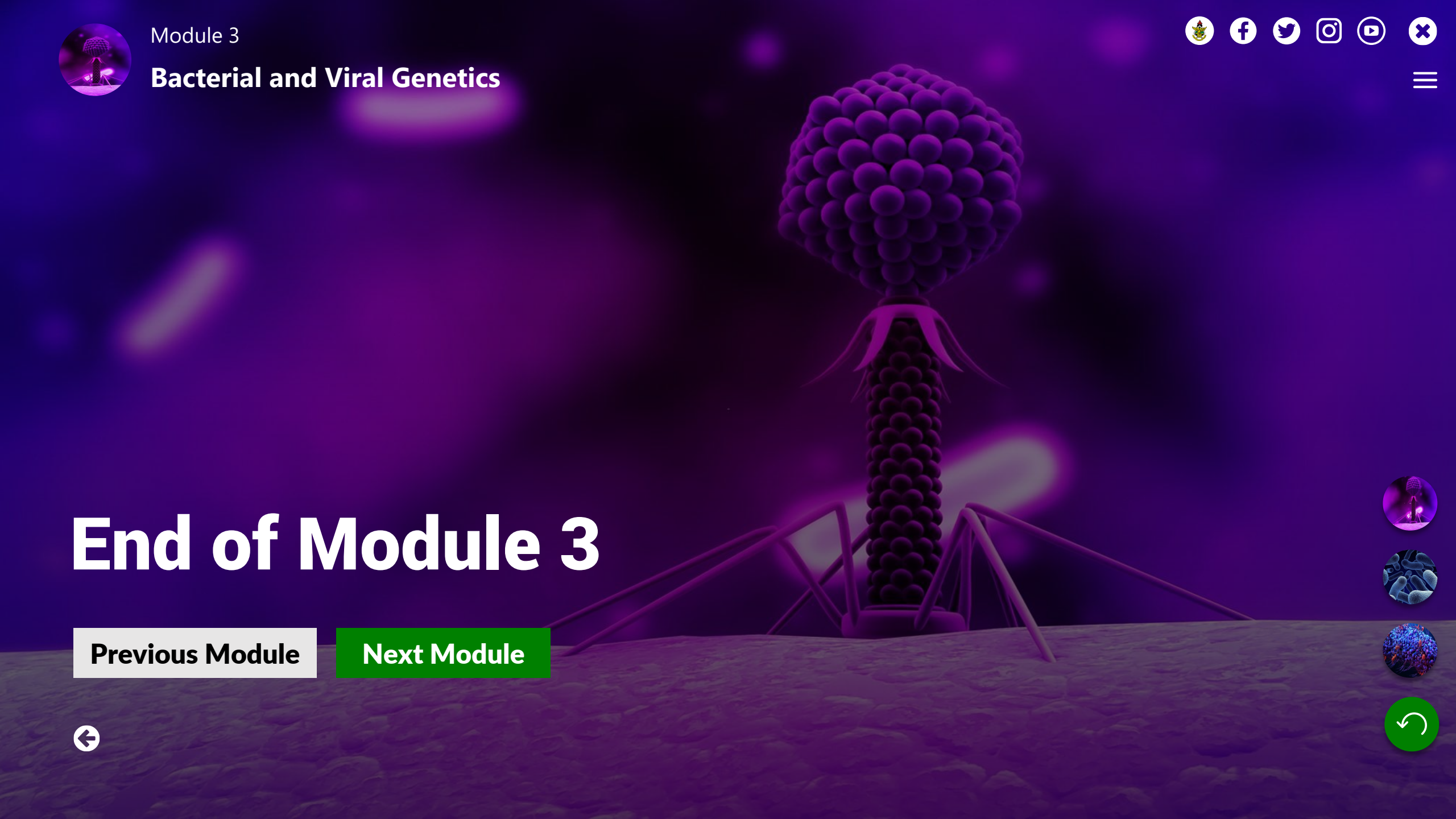
Start ▸



Lesson 3

Genetics of Viruses

Start ▸



End of Module 3

Previous Module

Next Module