InstaDeep™

Introduction to Immunology: Unveiling the Body's Defense System (Part 2)

Presented By: **Lina Ben Salem**

Plan

I. Immunology

II. Immune System

III. Homeostasis

IV. Lymphatic System

V. Types of Pathogens

VI. Protein, DNA & Viruses

VII. Immunology Buzzwords

VIII. Types of Immune Systems

Viruses

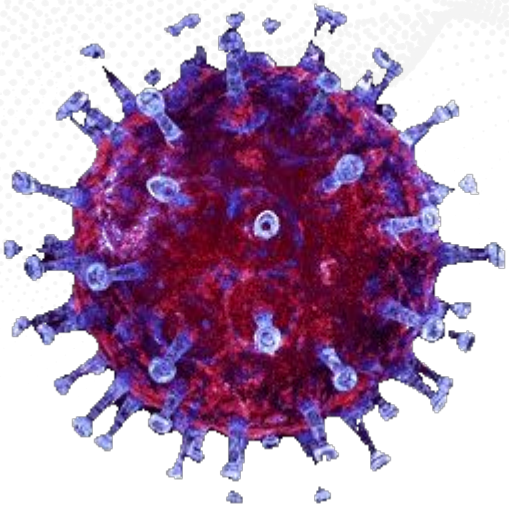
Viruses

1. Overview
2. Structure
3. Size
4. Taxonomy
5. Reproduction Mechanism

Viruses

1. Overview

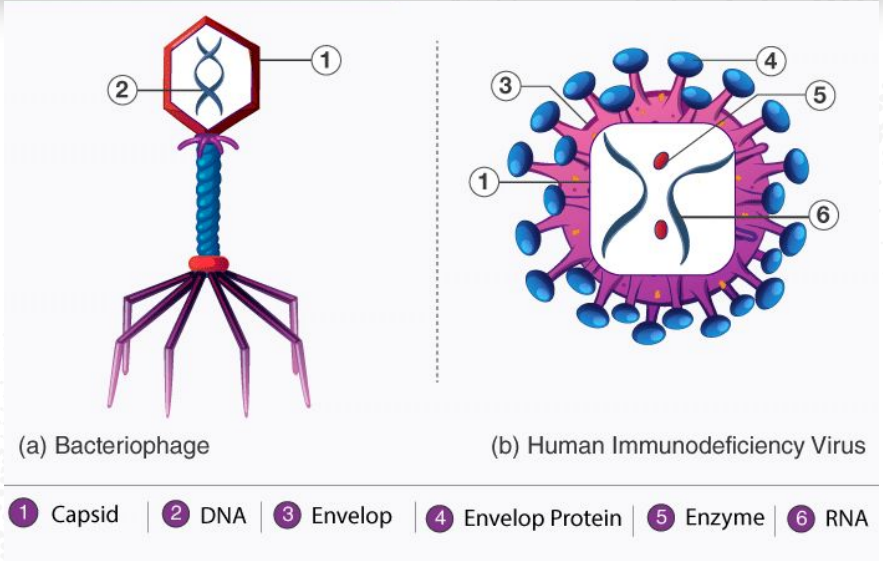
- Viruses are the most abundant form of life on Earth. But, they are not life!
- They can reproduce only through invading other cells
- There's an unknown number of different kinds of virus (millions). But only about **six thousand** have been studied in detail.
- They vary wildly and don't work in precisely the same way.
- It is possible to categorize them (exceptions)



Viruses

2. Structure

Capsid (1)
This is a protein shell that encloses the viral genetic material.
The capsid provides protection for the genetic material and helps to facilitate the virus's entry into host cells.



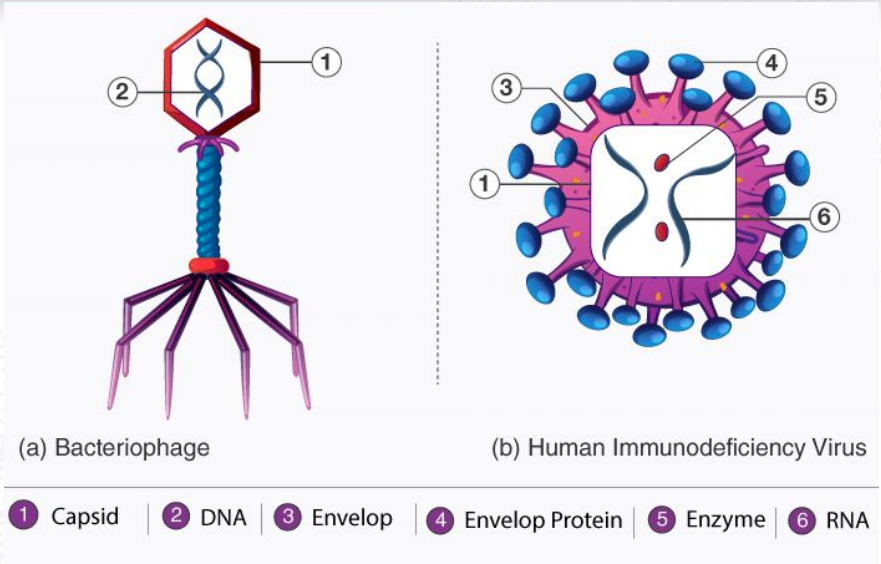
Genetic Material (Genome) (2+6)
This can be either DNA or RNA, which carries the genetic instructions necessary for the virus to replicate and produce more viral particles.

Viruses

2. Structure

Envelope (3)
Some viruses have an outer lipid membrane called **an envelope** surrounding the capsid derived from the host cell's membrane.

Surface Proteins or Glycoproteins (4)
These are embedded in the viral envelope or protrude from the capsid in non-enveloped viruses.



They play crucial roles in viral attachment to host cells, facilitating entry into the cell, and evading the host immune response.

glycoproteins = they have sugar molecules attached to them.

Viruses

2. Structure

Enzymes (5)
Certain viruses carry enzymes that are essential for viral replication and other aspects of the viral life cycle.

Matrix Proteins (7)
These are proteins located between the envelope and the capsid, providing structural support and assisting in the assembly and release of new viral particles.

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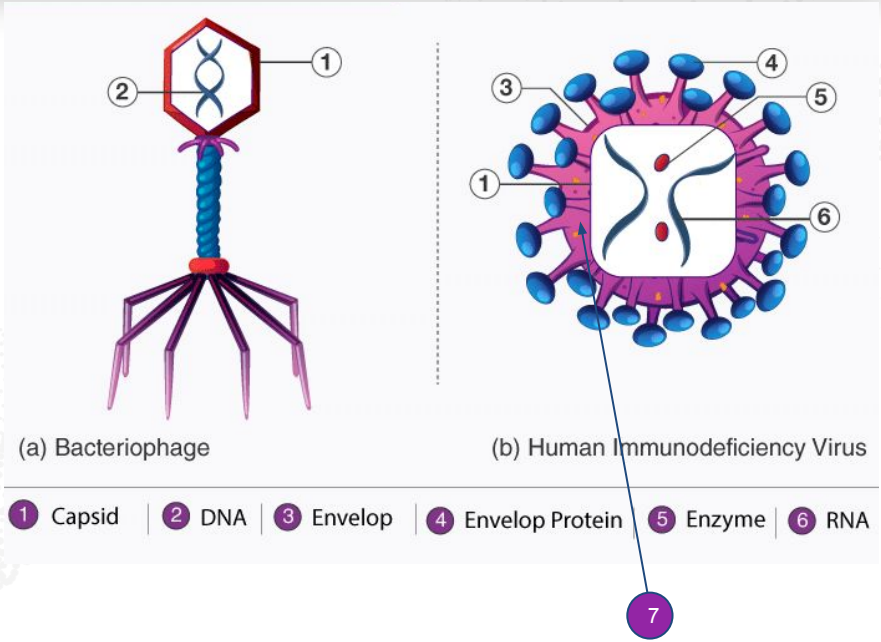
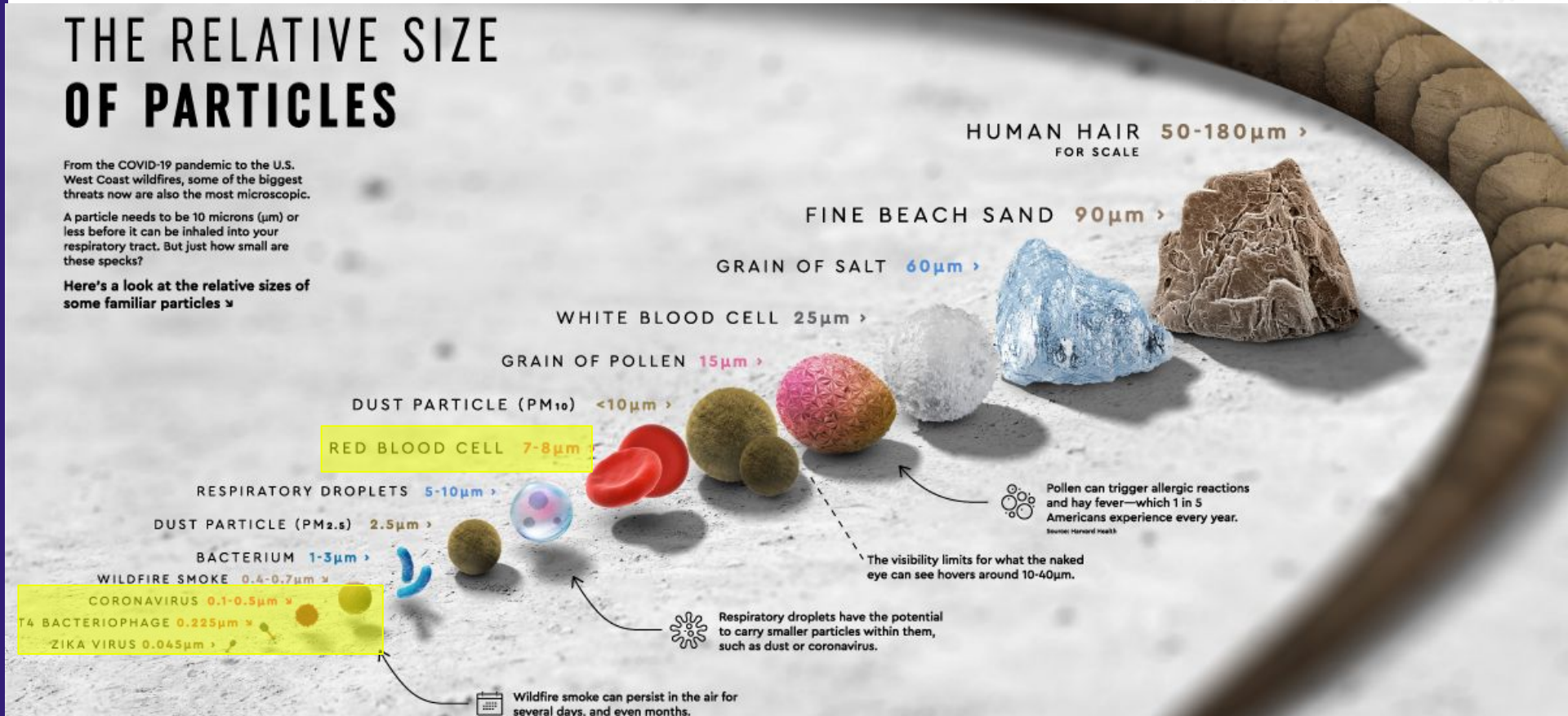


Viruses

3. Size



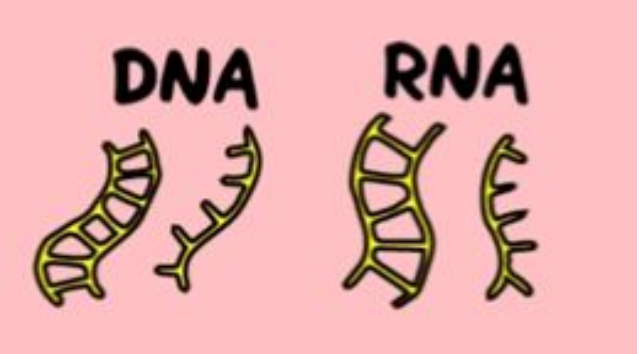
Viruses

4. Taxonomy

There are few ways to classify viruses.

4.1. By Genome:

The genome of a virus is either based on DNA or RNA and it is **either single stranded** or **double stranded.**



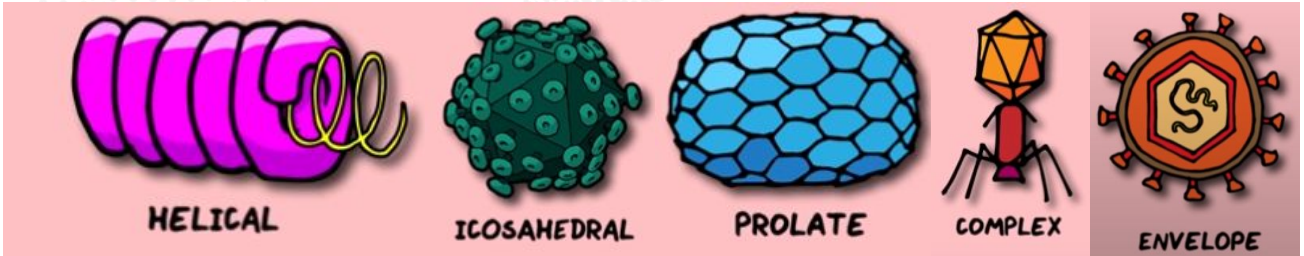
Viruses

4. Taxonomy

4.2. By Shapes:

The capsid of viruses are made of many of the same shaped proteins that self assemble into different shapes:

- **Helical** which is a spiral
- **Icosahedral**, made of shapes like triangles or hexagons or pentagon to make a shape like a twenty sided dice or soccer ball.
- **Prolate** which is the same kind of thing but stretched out.
- **Complex** which covers a wide range of viruses that don't fit into the other categories
- **Enveloped viruses** which we mentioned earlier.



4. Taxonomy

4.3. By Following The Official Taxonomy:

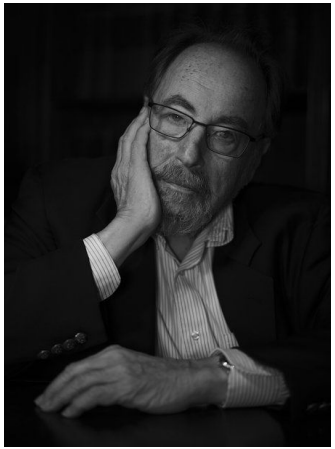
➢ The official taxonomic scheme for viruses is primarily governed by **the International Committee on Taxonomy of Viruses** (ICTV), which establishes guidelines for virus classification and nomenclature.

Viruses

4. Taxonomy

4.4. The Baltimore Classification:

- The Baltimore classification is a system used to categorize viruses based on their genetic material and the way they replicate.
- It is named after the Nobel Prize-winning biologist **David Baltimore**
- It looks at the genome of a virus, and it's pathway to encoding mRNA which the host cell uses to make the virus proteins.
- There are seven classes in the baltimore classification which represent different forms of single and double stranded DNA and RNA.

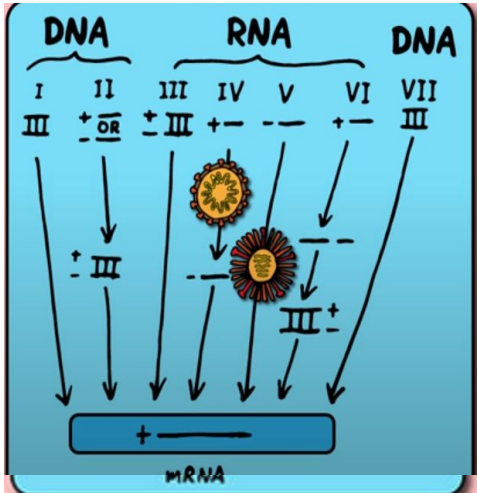


Viruses

4. Taxonomy

4.4. The Baltimore Classification:

- For an example let's look at the coronavirus that caused the 2020 pandemic.
- It is an enveloped virus, meaning that it is very vulnerable to soap which rips of the outer protective coat destroying it, which is why we've been told to wash our hands so often.
- And in the baltimore classification it is a class four virus which is a type of single stranded RNA virus.
- Interestingly this is different to seasonal flu which is a class five virus, so the two are not related.



5. Reproduction Mechanism

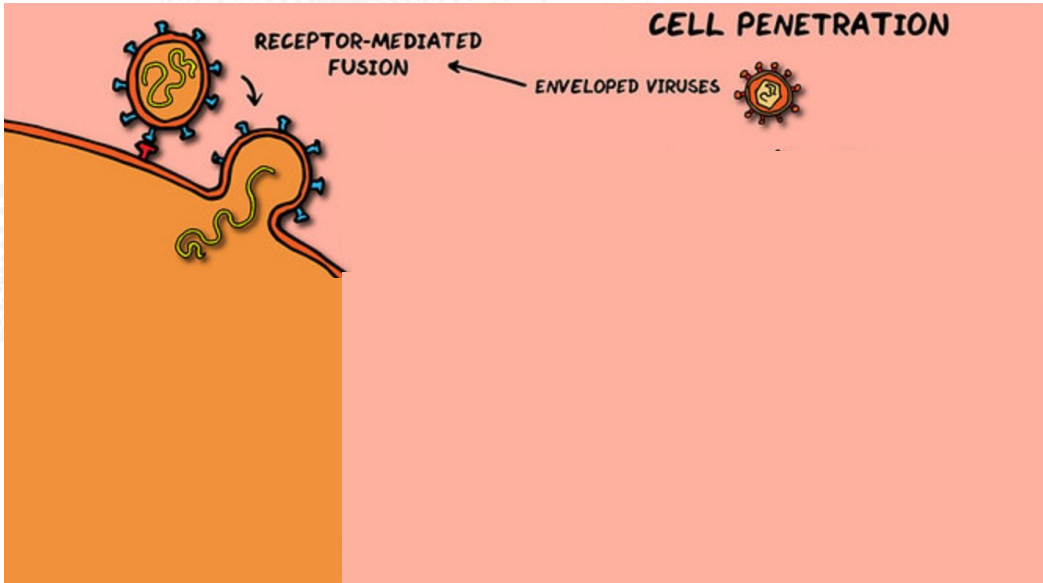
Now let's look in how viruses get into cells, how they reproduce and how they get back out again.

5.1. Cell Penetration

There are three main ways viruses get their genetic material into a cell.

5.1.1 Enveloped Viruses

They attach to receptors on the surface of the cell which then fuses with the membrane.
Since they are made of the same stuff because the virus took its envelope from the last cell it was in, so the new cell doesn't see that it is an invader.

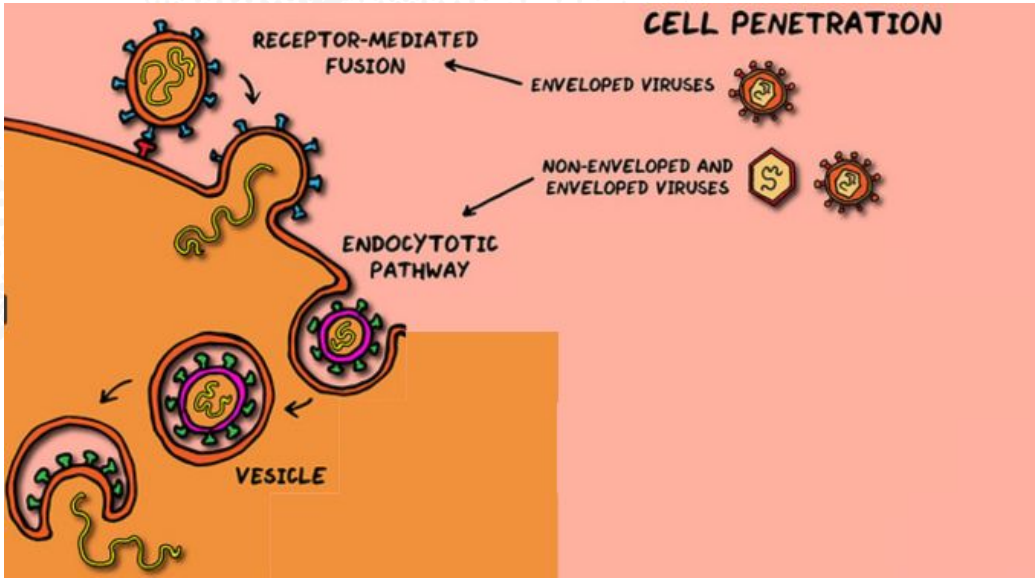


5. Reproduction Mechanism

5.1. Cell Penetration

5.1.2 Non-Enveloped Viruses

They essentially trick the cell into thinking that the virus is a harmless resource like nutrition, and engulfs it. This is called **endocytosis** and viruses with an envelope can enter a cell this way too.
This virus then has to break out of this **vesicle** to release its genetic material.



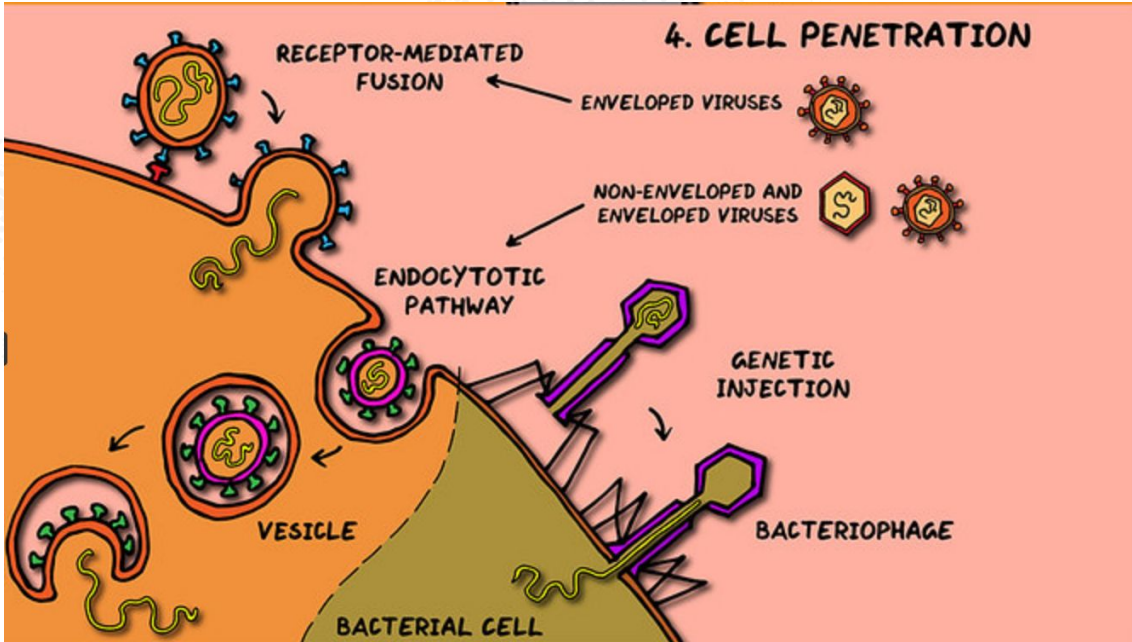
Viruses

5. Reproduction Mechanism

5.1. Cell Penetration

5.1.3 Genetic Injection

A less common method of entering a cell is genetic injection where the virus punches a hole in the cell membrane and directly injects its genetic material. Bacteriophages do this to bacteria, but not to human cells.

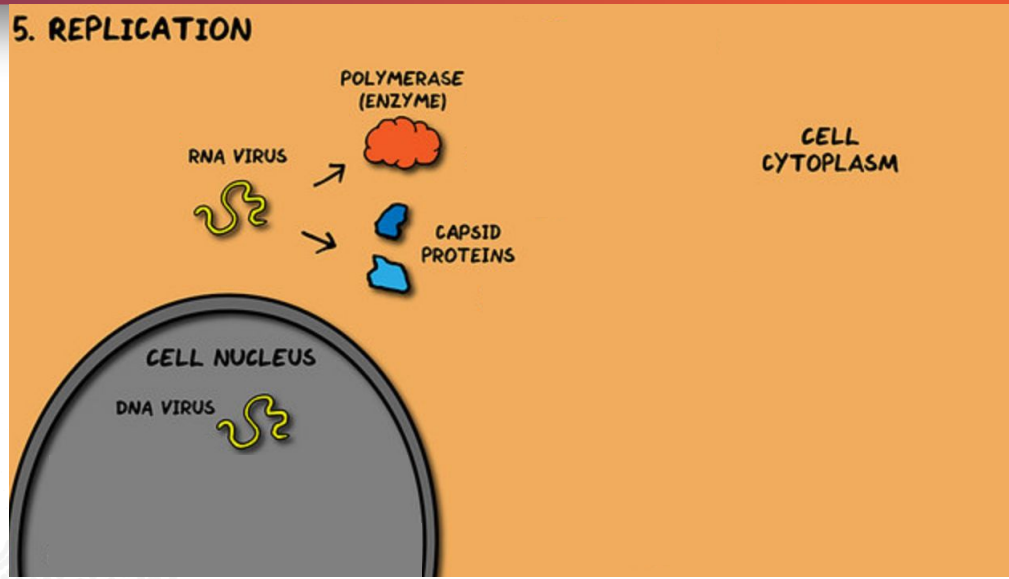


Viruses

5. Reproduction Mechanism

5.2. Replication

- In general RNA viruses replicate in the cell cytoplasm, and DNA viruses replicate in the cell's nucleus, but there are exceptions.
- The host cell then starts transcribing the viral genetic material without knowing that it is not native to the cell.
- The virus codes for essentially two things, an enzyme called **polymerase** and proteins which form the **capsid shell**.



video source: https://www.youtube.com/watch?v=754YnbOtmvA

Viruses

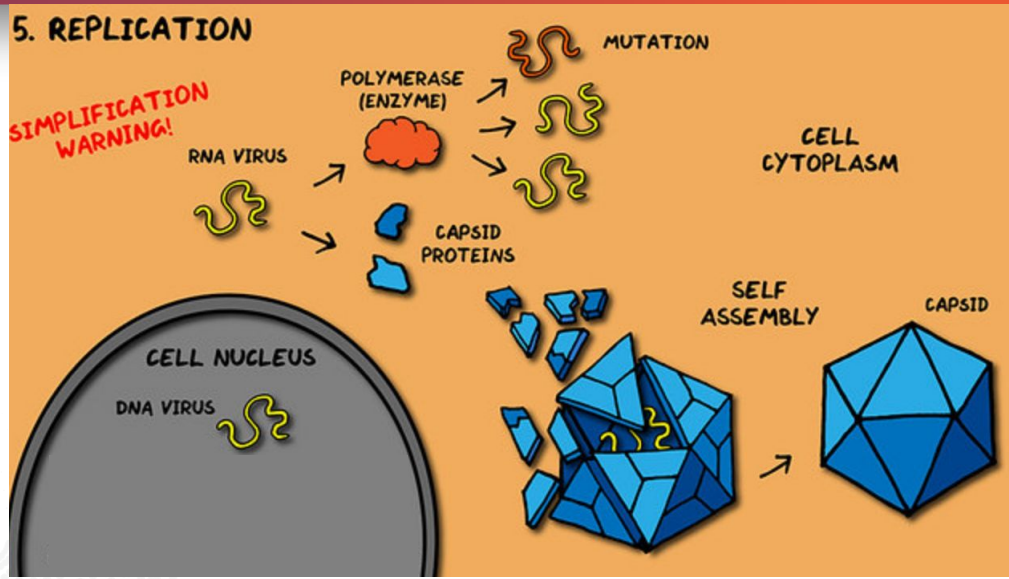
5. Reproduction Mechanism

5.2. Replication

For The Polymerase:

- They create copies of the viral genome.

- This is also when mutations can happen to the virus.



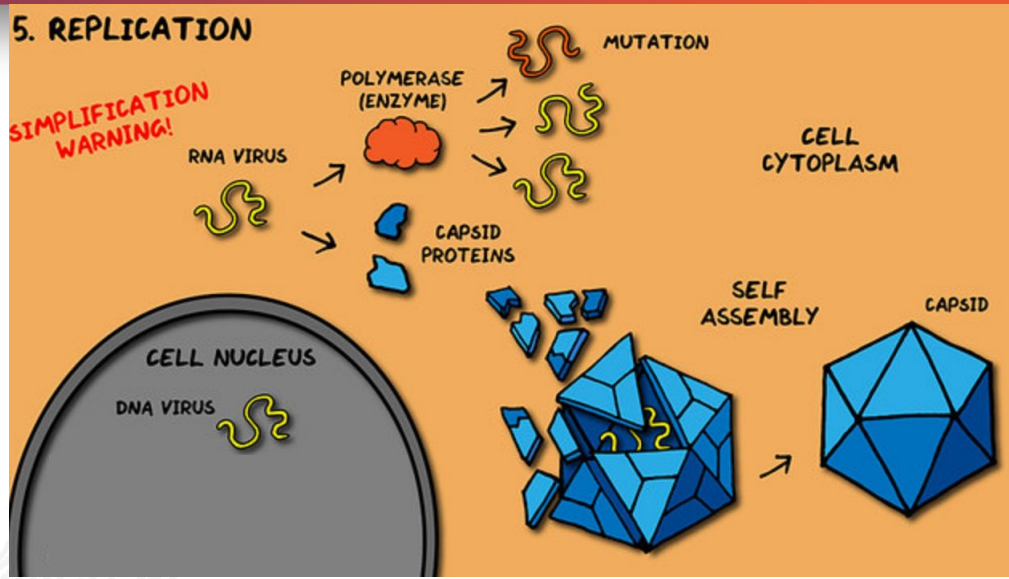
Viruses

5. Reproduction Mechanism

5.2. Replication

For The Capsid Proteins:

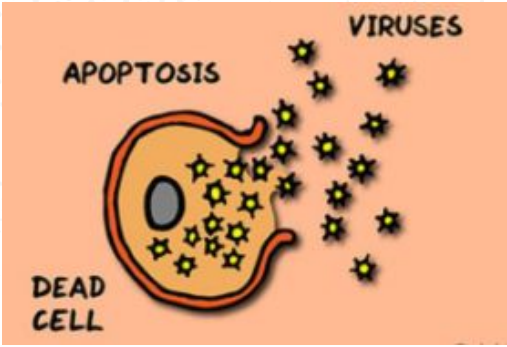
- The capsid proteins self assemble, from a couple of simple shapes they can form large complicated three dimensional structures which enclose copies of the genetic material inside, to form a new virus particle ready to leave the cell.



5. Reproduction Mechanism

5.3. Release

There are three ways viruses leave cells.



5.3.1. Apoptosis

It results in the death of the cell through a self-destruct mechanism.
The viruses either **burst** out as shown here, or more usually the cell death is a more controlled process where sections clump off to be absorbed by other cells like macrophages.

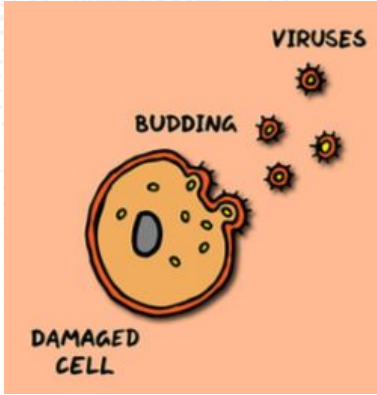
Viruses

5. Reproduction Mechanism

5.3. Release

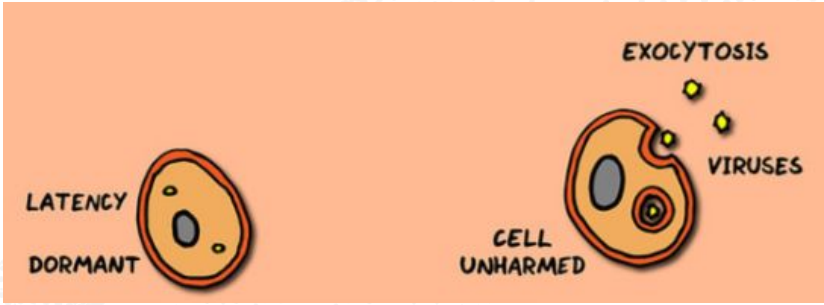
5.3.2. Budding

- **Budding** is where the virus exits the cell, taking with it an envelope of the cell's membrane.
- This doesn't kill the cell, but will degrades it over time and will eventually lead to the cell's death.



Viruses

5. Reproduction Mechanism



5.3. Release

5.3.2. Exocytosis

- It is where the virus has an envelope inside the cell, which it got from the nucleus membrane, or another membrane in the cell.
- Then the virus exits through the cell wall leaving the membrane behind. And this doesn't kill the cell.
- Some viruses can stay dormant inside cells for years at a time which is called latency.

Viruses

In a Nutshell:

Living	Non Living
Size	super tiny
Infection	Systemic - can affect entire body
Reproduction	Invades a host cell and takes over the cell causing it to make copies of the viral DNA/RNA. Destroys the host cell releasing new viruses.
Benefits	They are not beneficial. However, a particular virus may be able to destroy **brain tumors**. Viruses can be useful in **genetic engineering**.

Immunology Buzzwords

Immunology Buzzwords

Immunology buzzwords are terms commonly used in immunology:

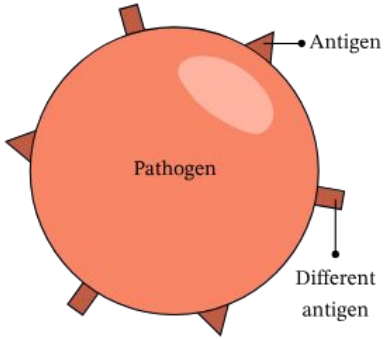
- **Immune response:** The coordinated series of actions and reactions by the immune system to defend the body
- **Tolerance:** The ability of the immune system to recognize and tolerate self-antigens
- **Autoimmunity:** A condition in which the immune system mistakenly attacks and damages the body's own tissues, leading to autoimmune diseases

Immunology Buzzwords

Immunology buzzwords are terms commonly used in immunology:

- **Leukocytes:** white blood cells

- **Pathogen:** a microorganism, such as a virus, bacterium, fungus, or parasite, that can cause disease by infecting the host organism

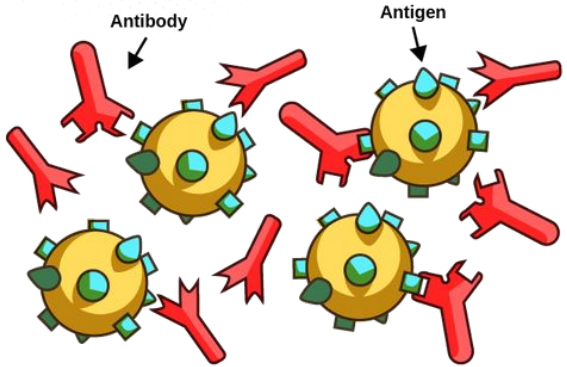


Immunology Buzzwords

Immunology buzzwords are terms commonly used in immunology:

- **Antigen:** typically molecule or parts of molecules that are recognized as foreign by the immune system. They can be derived from pathogens as well as non-pathogenic substances such as pollen, dust, or food proteins.

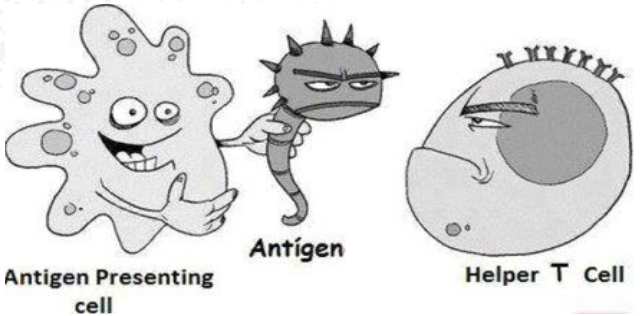
- **Antibody:** A protein produced by B cells in response to antigens. Antibodies bind to a specific antigens, marking them for destruction by other components of the immune system.



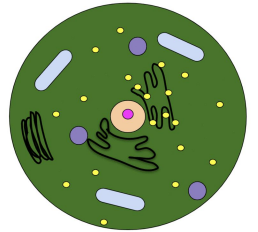
Immunology Buzzwords

Immunology buzzwords are terms commonly used in immunology:

- **Antigen-presenting cells (APCs):** Immune cells that capture, process, and present antigens to T cells to initiate adaptive immune responses



- **Apoptosis:** Programmed cell death, often used as a mechanism to eliminate infected or damaged cells



Types of Immune system

Innate Immunity

1. The innate
2. The adaptive
3. The innate vs adaptive

Innate Immunity

Innate Immunity

1. The Definition
2. The Key components
   - 2.1. Physical Barrier
   - 2.2. Chemical Barrier
   - 2.3. Cellular Components
   - 2.4. The Sensors of the Innate Immune system
   - 2.5. The Complement system

Innate Immunity

1. Definition

- It serves as the body's frontline defense against pathogens
- It is known also as native immunity or natural immunity or non-specific immunity
- It provides immediate protection
- The innate immune system is active from the moment the child is born “I was born ready”
- Influences the adaptive immune response by shaping the activation and function of adaptive immune cells.

Innate Immunity

2. Key Components:

2.1. Physical Barriers:

The body's external surfaces, such as the skin and mucous membranes, acts as physical barrier that prevent pathogens from entering the body. These barriers serve as the **first line of defense** against infection.

2.2. Chemical barriers: are about the body secretion such as:

- **Lysozyme**: is an enzyme found in various bodily fluids, including tears, saliva, mucus, and breast milk.
  It acts as a natural antimicrobial agent by breaking down the cell walls of bacteria, thereby causing their lysis (rupture) and death.

- **Sweat**: produced by sweat glands in the skin, contains various antimicrobial substances that help inhibit the growth of bacteria and fungi.

- **Stomach acid**: mainly hydrochloric acid (HCl), aids digestion and acts as a potent barrier against pathogens due to its **acidic pH**, effectively neutralizing them and preventing gastrointestinal infections.

Innate Immunity

2. Key Components:

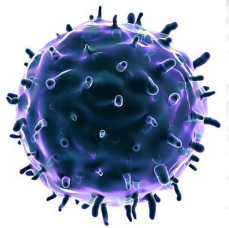
2.3. Cellular Components: include phagocytes, mast cells, basophils, eosinophils, natural killer (NK) cells, and innate lymphoid cells (ILCs).

2.3.1. Phagocytes

They are a type of immune cell that plays a crucial role in innate immunity by engulfing and destroying pathogens, cellular debris, and other foreign particles.
These cells have the ability to recognize and engulf pathogens through a process called **phagocytosis.**

Innate Immunity

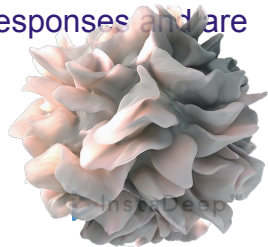
2.3.1. Phagocytes



There are several types of phagocytes:

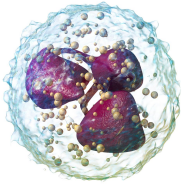
- **Macrophages**: Macrophages are found in tissues throughout the body. They also act as antigen-presenting cells, displaying antigens from engulfed pathogens to activate other immune cells and initiate immune responses **locally within tissues.**

- **Dendritic Cells:** are another type of antigen-presenting cell found in tissues, especially in areas exposed to the external environment.
  They capture antigens from pathogens and present them to other immune cells, initiating adaptive immune responses and are particularly adept at activating naïve T cells, thereby initiating adaptive immune responses.

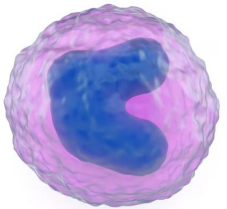


Innate Immunity

- **Neutrophils**: Neutrophils are the most abundant type of white blood cell and are among the first responders to sites of infection or inflammation.

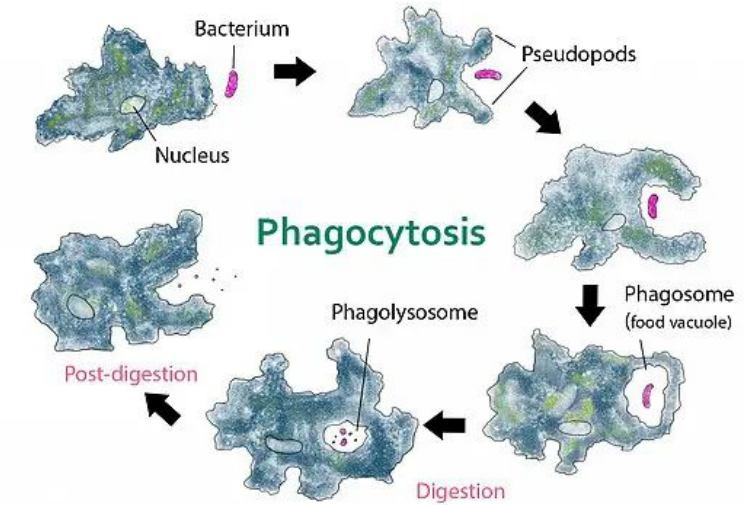


- **Monocytes:** Monocytes are circulating immune cells that can differentiate into macrophages or dendritic cells when they migrate into tissues.
  Like macrophages, they play a role in phagocytosis and antigen presentation.



Innate Immunity

- Phagocytes engulf and digest pathogens through a process called **phagocytosis**,
- **Phagocytosis** is a crucial process in which specialized cells engulf and digest foreign particles.
- This process is essential for clearing pathogens and other harmful substances from the body
- Phagocytes initiates immune responses, they release **cytokines and chemokines**, which recruit other immune cells to the site of infection and **activate adaptive immune responses**.



Innate Immunity

2.3.2. Mast cells and Basophils:

are granulocytes that release **histamine** and other inflammatory mediators in response to infection or allergens.

2.3.3. Eosinophils

Eosinophils are a type of white blood cell involved in immune responses against parasitic infections and allergic reactions. They release toxic proteins and enzymes to destroy parasites

2.3.4. Natural Killer (NK) Cells:

Natural killer cells are cytotoxic lymphocytes that play a key role in innate immune surveillance and defense against viral infections and cancer.

Thank you!