MICROBIOLOGY

MID – Lecture 1
Viral Morphology and Classification (Pt.1)

﴿ وَإِن تَتَوَلَّوْا يَسْتَبْدِلْ قَوْمًا غَيْرَكُمْ ثُمَّ لَا يَكُونُوا أَمْثَالَكُم ﴾

اللهم استعملنا ولا تستبدلنا

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1- Introduction to Virology: Viral Morphology and Classification

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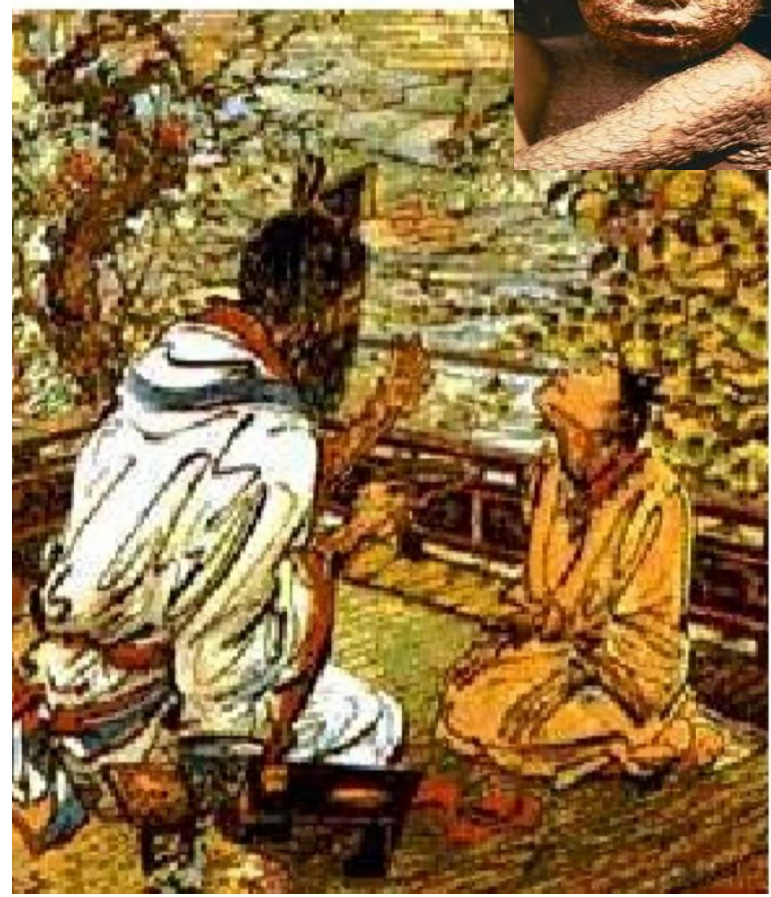
Objectives

1. Introduction to virology history and definitions
2. To understand the medical importance of virology
3. To understand the characteristics/properties of viruses
4. To examine the structure and composition of viruses
5. To understand the classification of viruses

History of Virology

Smallpox was endemic in China by 1000BC. In response, the practice of **variolation** was developed. Recognizing that survivors of smallpox outbreaks were protected from subsequent infection, variolation involved inhalation of the dried crusts from smallpox lesions like snuff, or in later modifications, inoculation of the pus from a lesion into a scratch on the forearm of a child.

Smallpox is a fatal disease (viral infection)



See the next slide for more details :)

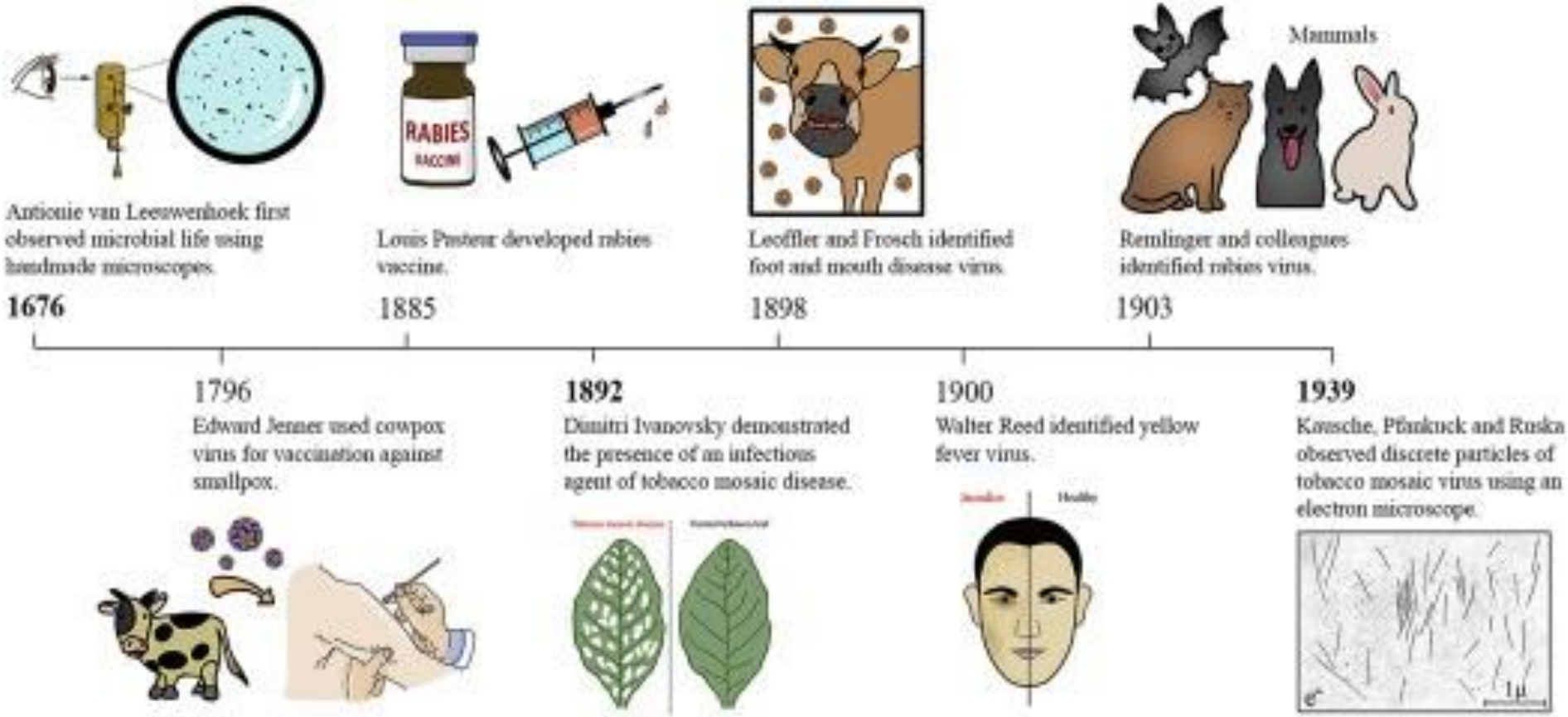
•Microorganism: tiny ,too small to be seen with the naked eye and include bacteria, fungi, (viruses are microorganisms but they're **acellular**)

• smallpox has been eradicated, and other diseases like chickenpox now serve as its counterparts (جدري الماء)

•The patients used to either die Or recover and if they were exposed to infected individuals afterwards, they would not get infected again (**The idea of Immunity**)

•**Variolation:** people would take the scabs from smallpox lesions which contained the virus. As the scabs dried, the virus became weaker. They would then take the dried scabs and either place them in the nose OR make a small scratch and insert the material. The child would develop a mild fever and slight itching, but then recover. This practice is somewhat similar to a **Vaccine**.

History



- Viruses were too small to be seen with the first microscopes.
- The cause of viral infections has been unknown for years.

Important Discoveries:

1. Louis Pasteur first proposed the term **virus** التبغ
2. Ivanovski and Beijerinck showed that a disease in tobacco was caused by a virus

A disease caused by a virus that infects plants and leads to the appearance of white patches resembling a mosaic that causes leaf damage (it's called Tobacco Mosaic Virus)

3. Loeffler and Frosch discovered an animal virus that causes foot-and-mouth disease in cattle

Viral infections can cause skin rashes, often resulting in general rashes that cover the entire body.

CLINICAL : in the Pediatrics department, if a child presents with a rash around the mouth, a smart doctor should examine the feet. If the same rash is observed there as well, it indicates **FOOT-AND-MOUTH DISEASE**.

4. Walter Reed discovered the yellow fever virus **(which can infect humans)**

•Many years of experimentation showed what we know today and by the 1950s virology had grown

Virus Properties

- A virus is defined as a nucleoprotein complex that infects cells and uses their metabolic processes to replicate. → **Nucleic acid + protein**
- Smallest known infective agents ranging from 20-450 nm

  Metabolically inert - no metabolic activity outside host cell; must enter host cell to replicate **obligate parasite/ intracelluler**
- Contain only one type of nucleic acid, either DNA or RNA but never both
- Lack enzymes for most metabolic processes and lack machinery for protein synthesis **(That's why it is metabolically inactive)**
- The nucleic acid is encased in a protein shell **(that preserves the genetic material in the core)** , which may be surrounded by a lipid-containing membrane .**The envelope is present in some viruses,** providing an additional layer of protection and aiding in the infection of host cells.
- The entire infectious unit is termed a "virion", **One virus is called *Virion***

Bacteria and humans both contain DNA, which can be transcribed into RNA and then into mRNA. However, the structure of human DNA differs from that of bacteria. Viruses, on the other hand, can have either DNA or RNA.

A virus can survive and replicate without cellular components like proteins, plasmids, or mitochondria because it relies entirely on the machinery of a host cell. It uses the host to produce its genetic material and assemble its protein capsid, ultimately destroying the host cell in the process. After the virus exits the host cell, its role is complete, and it moves on to infect another cell to repeat the cycle.

Importance

- ✓ If you understand the transmission process, you can prevent the disease, Viruses can be transmitted by air droplets or respiratory droplets(respiratory infections)Spread through tiny liquid particles that an infected person releases when they cough, sneeze, talk, or even breathe or by touch (skin rashes), blood, food, sexual transmitted diseases...

- Major **common** cause of human illnesses
- Quick transmission
- New strains: SARS, Corona, birds flue, etc
- Epidemics/pandemics: Ebola Virus, COVID-19, because of its "Quick transmission"
- Availability of treatment, Antiviral drugs, Viral infections are often harder to treat than bacterial infections because viruses live inside our cells, making them difficult to target without damaging the body. While bacterial infections can be cured with antibiotics, there isn't a complete cure for viral infections, in most cases.

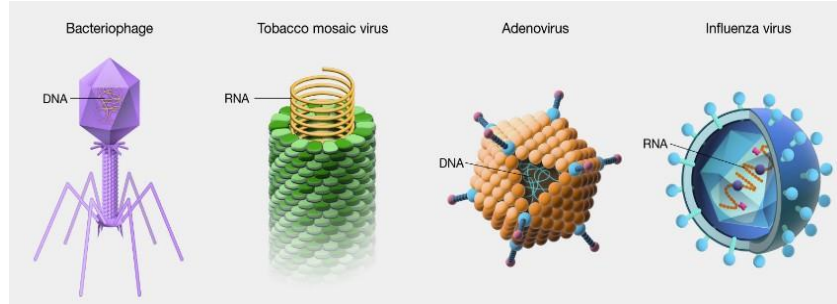
- ✓ Some viruses such as the coronavirus, kind of develop themselves, and then it's somehow transmitted to the human body and causes an infection

- SARS (Severe Acute Respiratory Syndrome) and
- MERS (Middle East Respiratory Syndrome) are both strains of coronavirus that can cause severe respiratory illness in humans

- ✓ epidemic is local, and a pandemic is global (for example covid-19)

Diversity

Viruses share common characteristics: they are all small, contain either DNA or RNA (but not both), have a protective capsule, and must enter a host cell to reproduce.



- Viruses vary greatly in structure, genome organization and expression, and strategies of replication and transmission.
- The virus infection may have little or no effect **(ex. common cold)** on the host cell or may result in cell damage **chronic disease** or death **fatal disease**
- The host range for a given virus may be broad or extremely limited.
- Viruses infect unicellular organisms, such as mycoplasmas, bacteria, algae, and all higher plants, animals, and vertebrates.

Broad Range: Some viruses can infect a wide variety of hosts. For example, the influenza virus can infect multiple species, including humans, animals, and plants, fungi, bacteria.. "broad spectrum virus"
Limited Range: Other viruses may only infect a specific species or even a particular type of cell within a host. For example bacteriophages (viruses that specifically infect bacteria)

Definitions

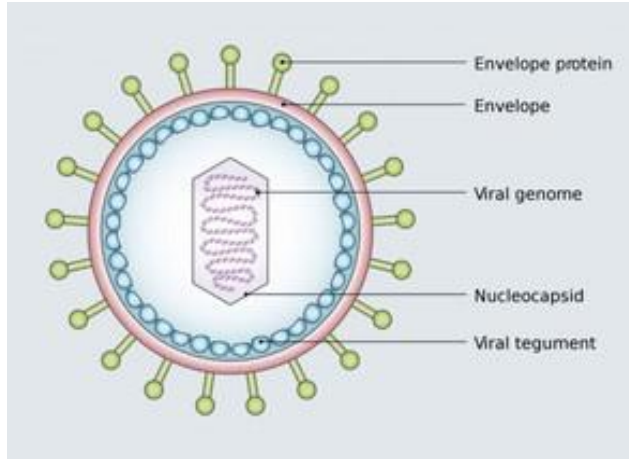
- Virion: The complete virus particle

Essential

Nucleic acid: Either DNA or RNA

Capsid: The protein coat that encloses the viral genome

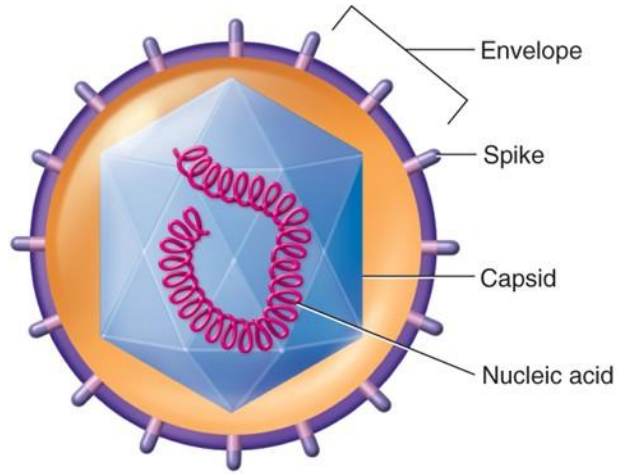
protection



optional

Envelope: A lipid-containing membrane that surrounds some viruses

Glycoprotein spikes: Projections from the envelope



Nucleocapsid= Nucleic acid + capsid (The protein-nucleic acid complex)

Definitions

Capsomeres: Morphologic units are seen under the electron microscope on the surface of icosahedral viruses.

✓ Capsomeres are protein subunits that assemble to form the capsid

Peplomers: Virus-encoded glycoproteins that are projected from the envelope

✓ Peplomers are the building blocks of the glycoprotein spikes found on the surface of some enveloped viruses

Defective virus: A virus particle that is functionally deficient in some aspect of replication

Structural units: The basic protein building blocks of the coat. They are usually a collection of more than one non-identical protein subunit “protomer”.

✓ Proteins are found both in the capsid and in the envelope of the virus.

1. Genome – Nucleic Acid

Genome- the total of the genetic information carried by an organism

They only have the genes necessary to invade host cells and redirect their activity The primary function of the viral DNA is replication. The virus seeks out a host cell to infect, and once inside, the host cell's machinery takes over the replication process.

What matters to the virus is how its DNA (or RNA) replicates. It doesn't have a plan for making enzymes or proteins on its own. The virus is only concerned with the formation of its genetic material along with the capsid that protects it.

DNA Deoxyribonucleic acid or RNA(Ribonucleic acid)

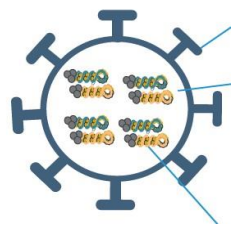
single - or double - stranded

Human : double stranded
Bacteria: double stranded
Virus: either single or double stranded
(note: double stranded circular RNA is not present in viruses)

linear or circular (in bacteria we have plasmid as a circular DNA)

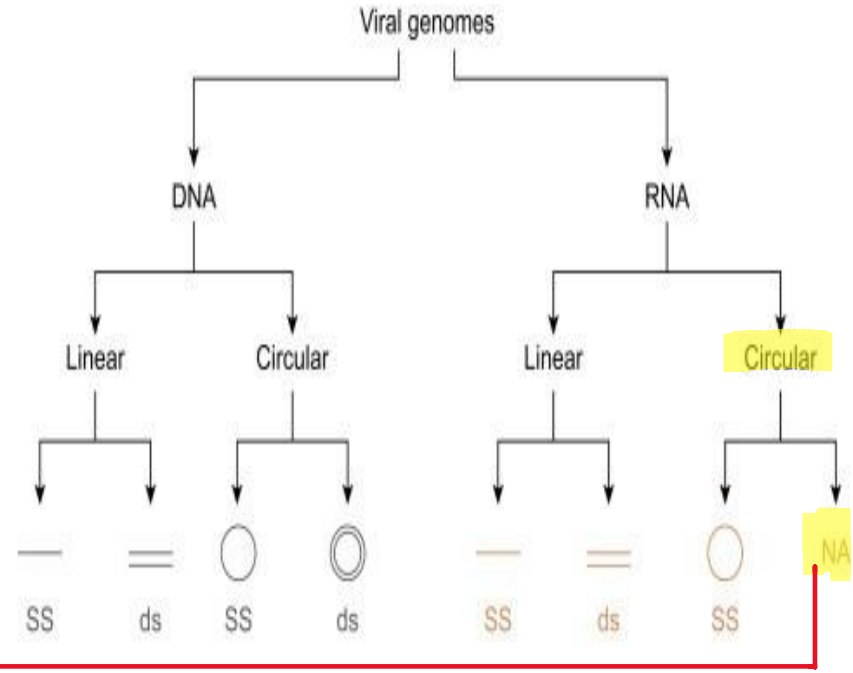
Segmented (different segments)or intact

RNA positive or negative sense



Bacterial ID :
Shape ,Gram staining ,arrangement

Viral ID

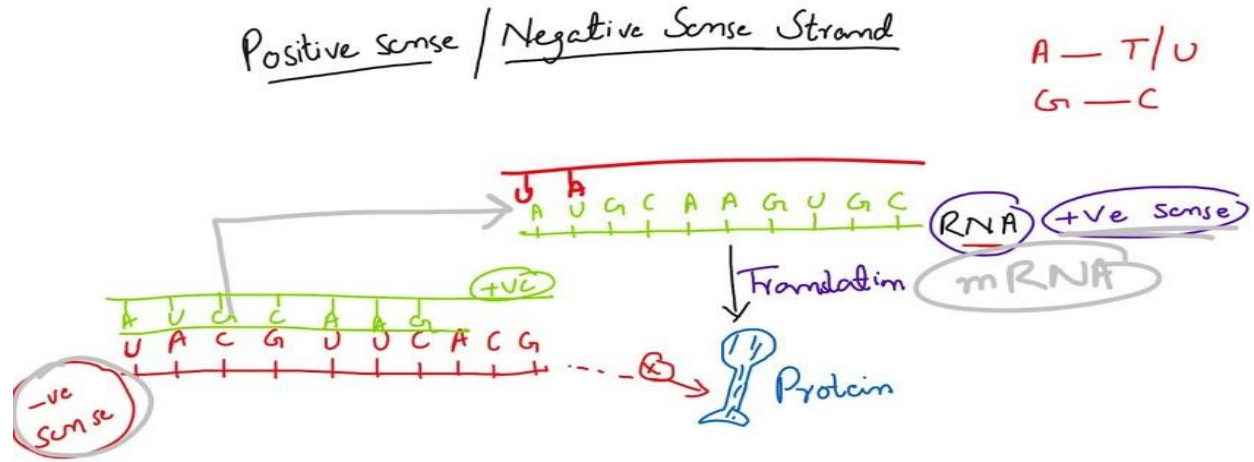


RNA positive or negative sense

An RNA virus can sometimes directly affect its host by prompting it to produce proteins. In such cases, the viral RNA reaches the ribosome and instructs it to produce a specific protein.

Positive-sense RNA viruses can immediately function as messenger RNA (mRNA) upon entering the host cell, allowing them to directly produce the required proteins or enzymes.

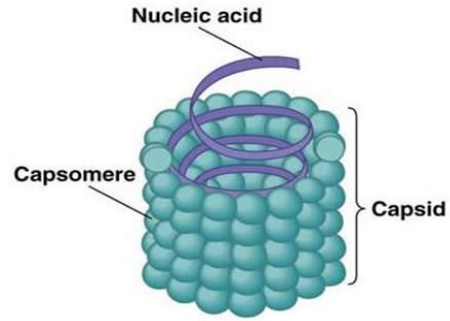
In contrast, negative-sense RNA (-RNA) viruses cannot produce proteins directly. Instead, they must first generate a complementary RNA sequence, which then acts as mRNA to synthesize the necessary proteins.

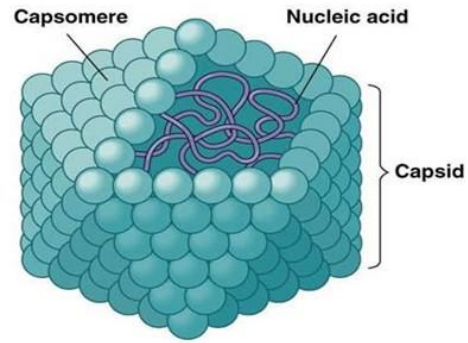


2. Capsid

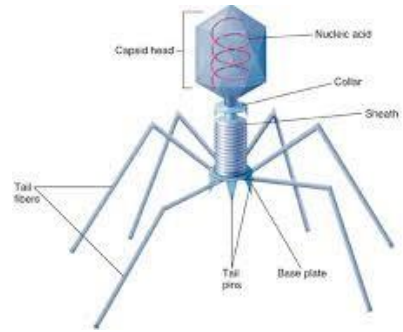
The capsid is a protein structure that encloses the virus's nucleic material (genetic material), and it is essential for protecting the genetic material and giving the virus its shape.
It is a must.

- Constructed from identical subunits called capsomers
- Made up of protein molecules
- Three different types
  - helical - tubular
  - icosahedral - isometric or cubic
  - complex - does not conform to either of above





The bacteriophage is considered complex because, when observed, its upper part has an icosahedral shape, while the middle part is tubular in structure.



3. Envelope

The envelope is the outermost layer of the virus, but it is not present in all viruses.

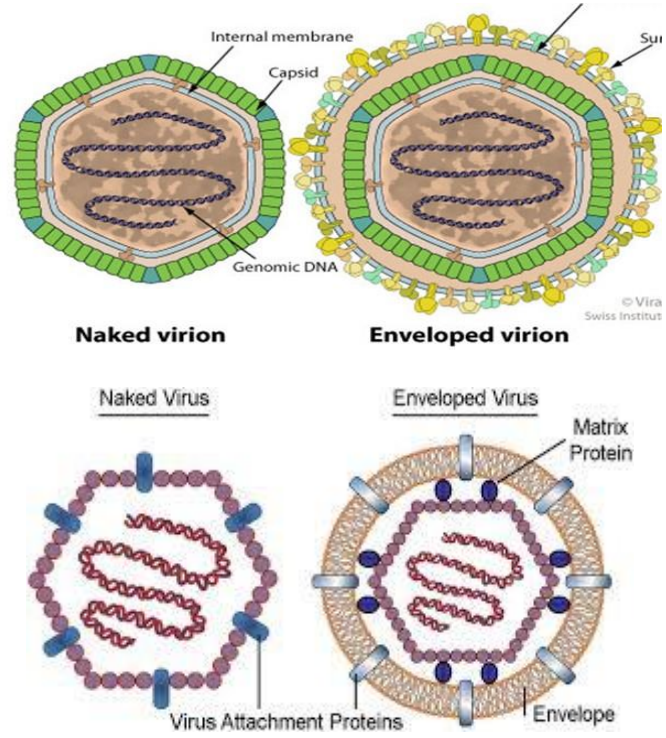
-Found in some viruses; lipoprotein envelope containing viral and host cell compounds

-Enveloped viruses take a bit of the host cell membrane in the form of an envelope

-Some proteins form a binding layer between the envelope and the capsid

(to keep the virus intact and stable).

-Glycoproteins remain exposed as spikes (peplomers)- essential for attachment



These spikes (glycoproteins) help the virus attach to the host cell from the outside, allowing it to inject its genetic material into the cell.)

- More clarification about point 2

Enveloped viruses take a bit of the host cell membrane in the form of an envelope.

The viral envelope is composed partly of materials produced by the virus and partly taken from the host cell. When a virus enters a host cell, it injects its genetic material, which integrates into the host's DNA. This integration forces the host cell to produce viral components, such as the capsid and additional genetic material.

As the virus exits the host cell, it often causes the cell to rupture, or lyse. To evade detection by the immune system, the virus appropriates a portion of the host's membrane to create its envelope. This envelope helps disguise the virus, making it appear as though it is part of the host's cells and reducing the likelihood of an immune attack. Inside the cell, the virus does not require the envelope, but it requires upon exit to avoid immune detection.

Functions of the Viral Capsid/Envelope

- Protects nucleic acids **help the virus escape from the immune system**
- Help introduce the viral DNA or RNA into a suitable host cell
- Stimulate the immune system to produce antibodies that can protect the host cells against future infections
- **Spikes help in the attachment**

Characteristics of Infectious Microorganisms

Characteristics of Infectious Microorganisms

Property	Bacteria	Viruses	Fungi	Protozoa
Size (nm)	100 -10,000	30 - 300	4,000 - 40,000	4,000 - 40,000
Nuclear structure	Prokaryotes	----	Eukaryotes	Eukaryotes
Obligate intracellular	No	Yes	No	No
Nucleic acids	DNA/RNA Haploid	DNA or RNA	DNA/RNA	DNA/RNA
Culture on Artificial media	Yes	No	Yes	Yes

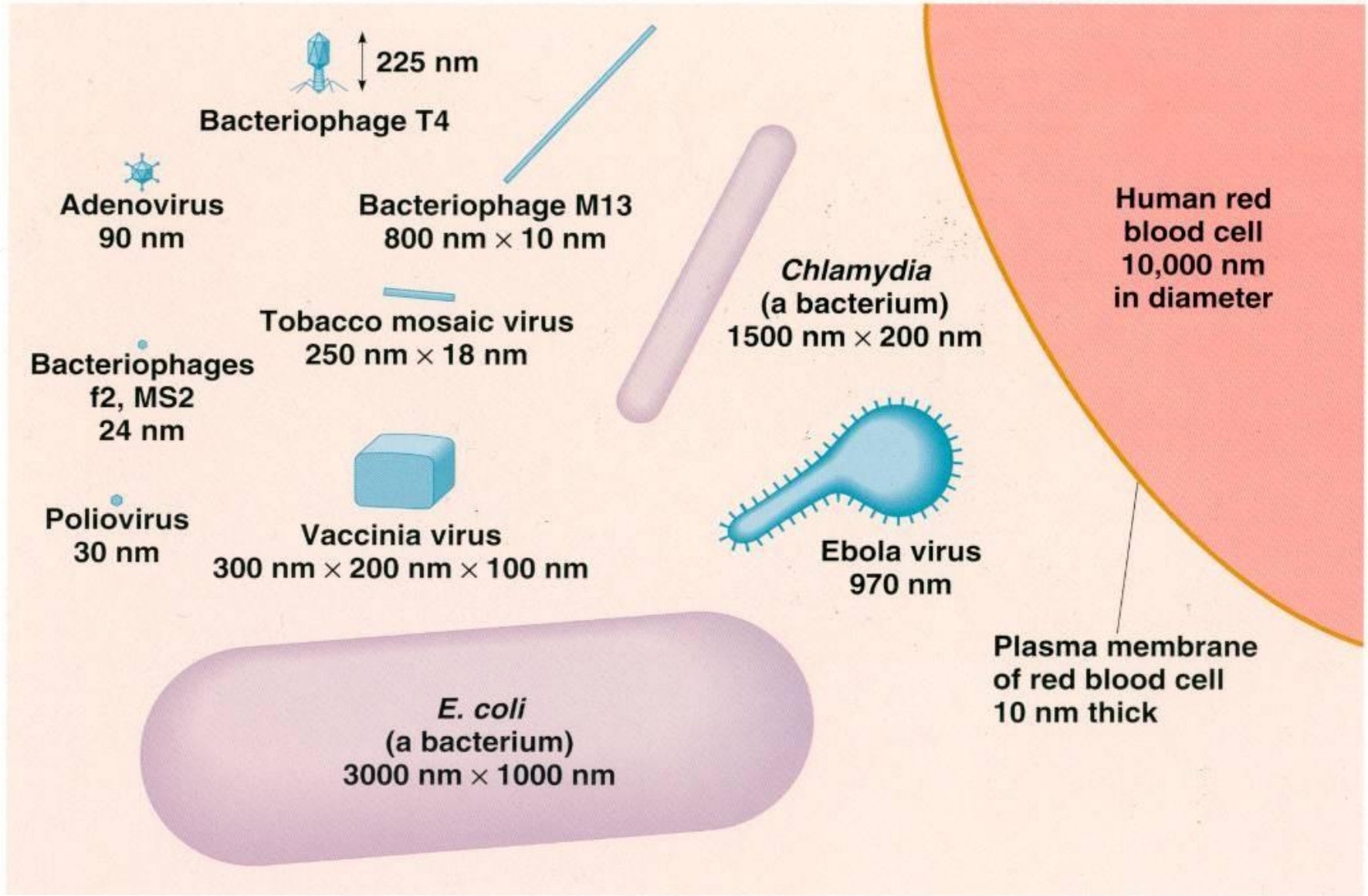
We can do cellular culture of the virus,not necessarily a host,but if we really need ,we can use animal host.

Characteristics of Infectious Microorganisms

Property	Bacteria	Viruses	Fungi	Protozoa
Organelles	Does contain some organelles(such as ribosomes)	No	Lots of organelles	Lots of organelles
The need of a host cell to survive/replicate	It can survive without host cell	Yes		
Cellular/Acellular	Cellular	Acellular	Cellular	Cellular
Causing diseases	Yes	Yes	Yes	Yes
Growth pattern	Binary fission	replicate inside a host cell (obligate intracellular parasites)		
Mutations /transmission	Slower	Faster		

Relative Sizes of Microorganisms

– Do not memorize the numbers.



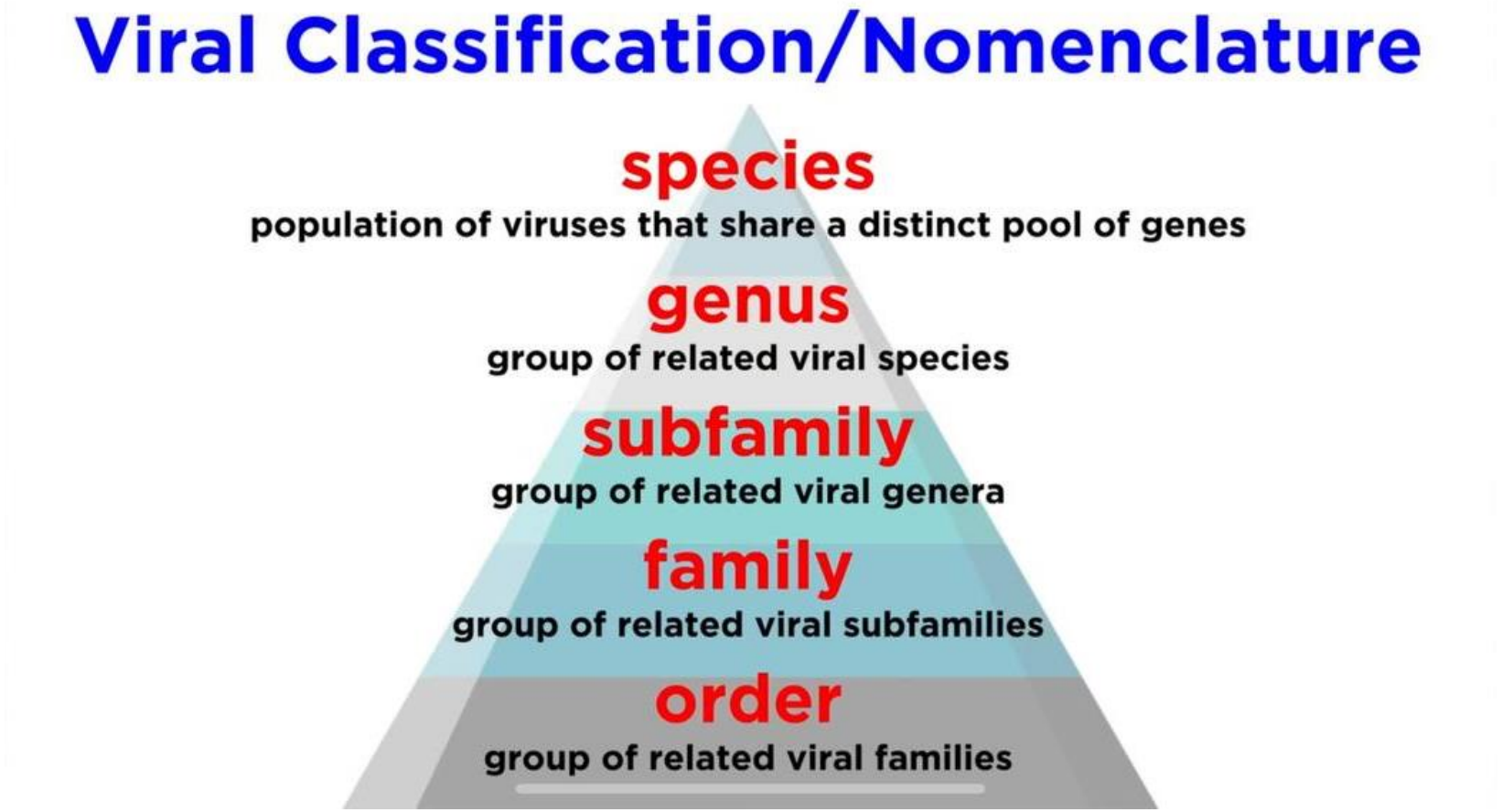
Virus Naming

- Viruses with similar structural, genomic & replication properties are grouped into families (suffix: viridae) e.g. Herpesviridae
- Families subdivided into genera (suffix: virus) e.g. Herpes simplex virus, Cytomegalovirus, Varicella zoster virus

What is the name of the family of cytomegalovirus ?
Cytomegaloviridae

- Subtypes based on nucleotide sequence and antigenic reactivities e.g. Herpes simplex virus type 1, Herpes simplex virus type 2

Additional


Viral Classification/Nomenclature
species
population of viruses that share a distinct pool of genes
genus
group of related viral species
subfamily
group of related viral genera
family
group of related viral subfamilies
order
group of related viral families

For any feedback, scan the code or click

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	12 5	The picture in the bottom left corner is in the wrong position. 1."Smallpox has been eradicated as many other diseases like chickenpox" 2. --	The position of the picture has been corrected, indicating the information that double-stranded circular RNA is not present in viruses. 1. "Smallpox has been eradicated, and other diseases like chickenpox now serve as its counterparts" 2. The definition of Microorganisms has been revised for clarity
V1 → V2			

Additional Resources: رسالة من الفريق العلمي:

قال تعالى)قُلْ يَا عِبَادِيَ الَّذِينَ أَسْرَفُوا عَلَىٰ أَنفُسِهِمْ لَا تَقْنَطُوا مِن رَّحْمَةِ اللَّهِ إِنَّ اللَّهَ يَغْفِرُ الذُّنُوبَ جَمِيعًا إِنَّهُ هُوَ الْغَفُورُ الرَّحِيمُ) [الزمر]53: