INTRODUCTION TO VIROLOGY

Done by: Abdelhadi Okasha

Topics discussed in this lecture

1) Introduction

- Obligate intracellular/ Smallest infectious agent/ contain sole genome/ Very diverse

3) Structures similar to viruses

- Defective viruses
- Viroids
- Prions

4) Origin of the viruses

- Viruses early hypothesis
- Regression hypothesis
- Escaped gene hypothesis

2)Structure of the viruses

→ Formed of: capsid + DNA/RNA + Envelope (NOT ALWAYS)

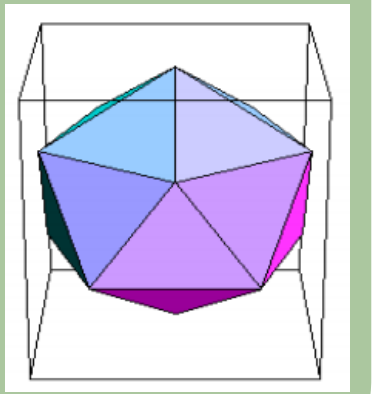
1) Capsid: regularly shaped protein shell structure that surround viral nucleic acid

- Functions: support and protect viral nucleic acid + helps in infecting cells

3 types:

a) Helical capsid: Helix of proteins
Flexible if long
Only –ssRNA

b) Icosahedral:
- 12 vertices
- 20 faces (equilateral triangles)
- 5-3-2 symmetry axes
- 60 identical subunits



c) complex: layers of lipids and proteins

2) Genetic material:
- May be DNA or RNA
- Single or double stranded
- Single RNA may be (+) or (-)

Note:(+) can be translated while (-) can't

3) Envelope: lipid bilayer + proteins
- Proteins may be glycoproteins or matrix proteins
- Virus without envelope is called "Naked" and usually stronger.

4) Enzymes: Helps in replication processes

5) Viruses classificaions

-Virion morphology (size, shape ..etc)
-Virus genome properties (DNA, RNA)
-Genome organization and replication (Segmented or no ….)
(Class related to genes rise genotypes)
-Virus protein properties
- Virus antigenic properties (rise serotypes)
(Note: Genomic classification is more accurate than protein or antigen classification, because the same antigen or protein can be occupied from two different genes)
- Physiological properties of the virion (effects of pH, ether ..etc) reflect the structure as naked viruses are stronger than enveloped.
- Biological properties (way of infection/ type of infected cells)

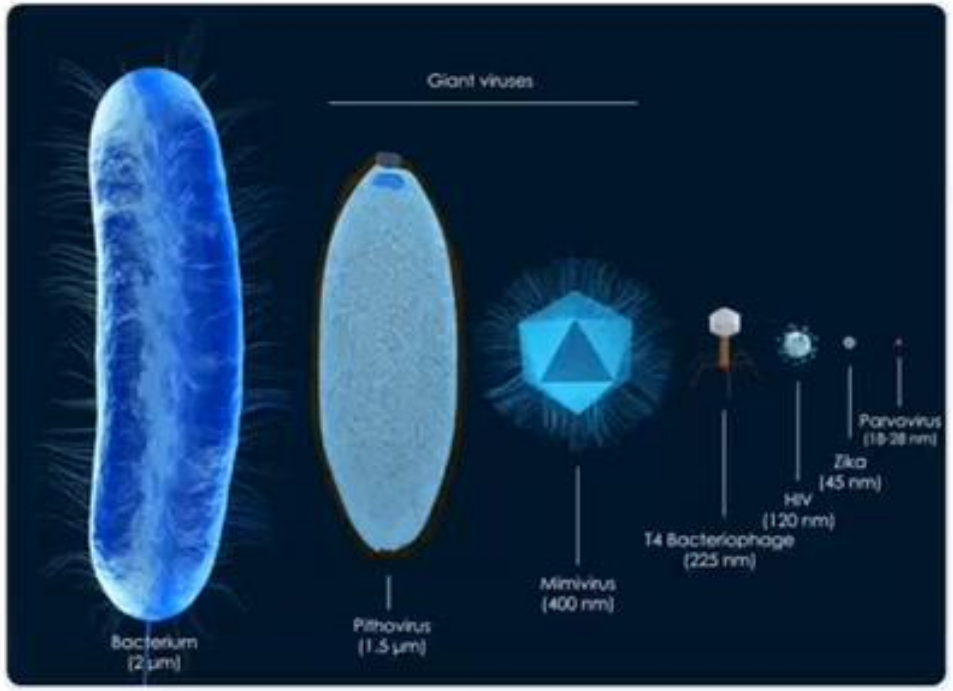
→ Two important classifications are: ICTV & baltimore

1) Introduction

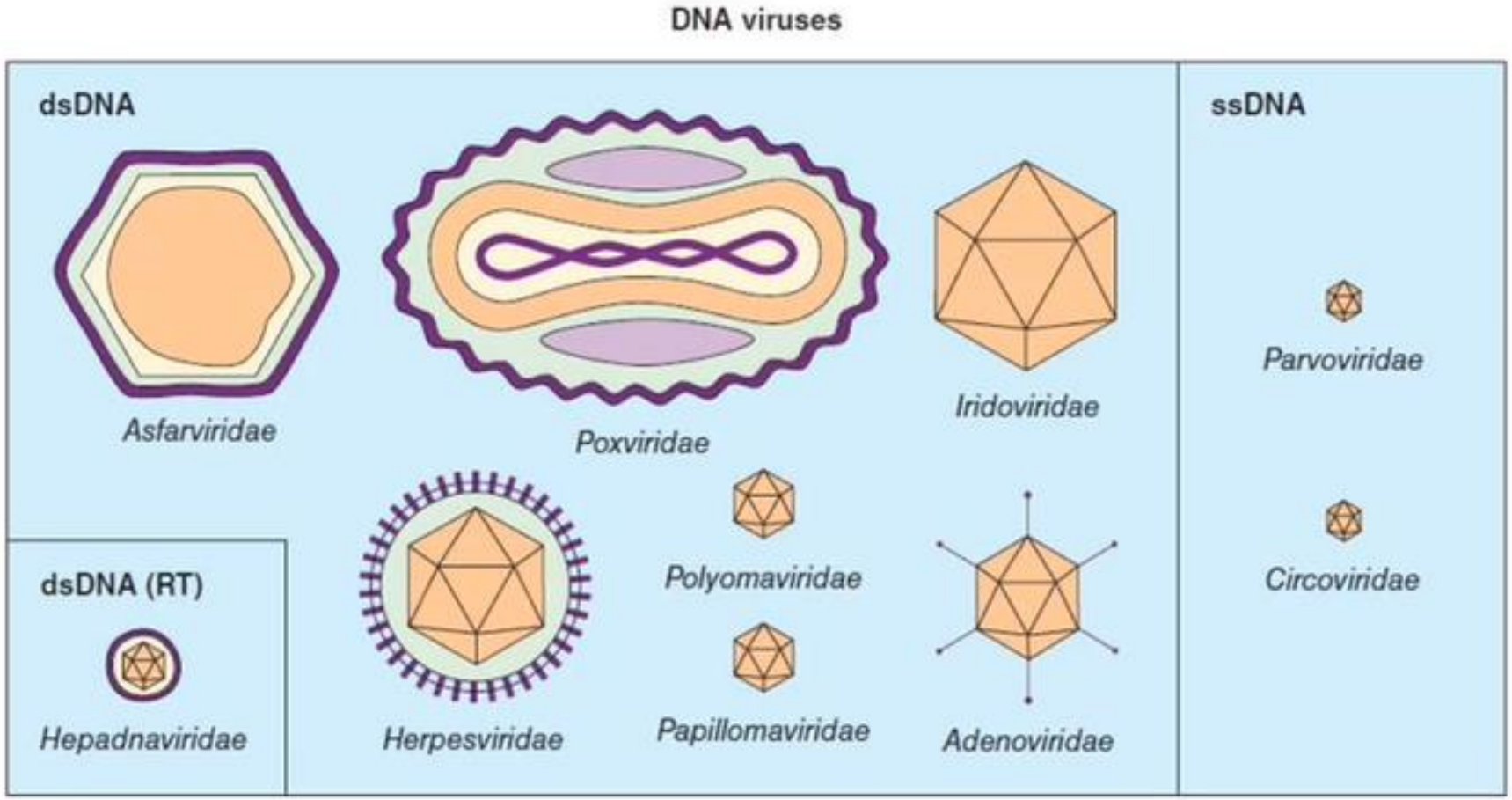
- Obligate intracellular: Can’t replicate outside cells.
- Smallest infectious agent.
- contain either DNA or RNA but not both (Exceptions are Hepatitis B and HIV in part of their replication cycle) .
- Very diverse: They can infect almost all other living organisms even bacteria (viruses that infect bacteria are called bacteriophages).
- Important clinically viruses have diameters between 20-300 nm.

Measuring the Sizes of Viruses

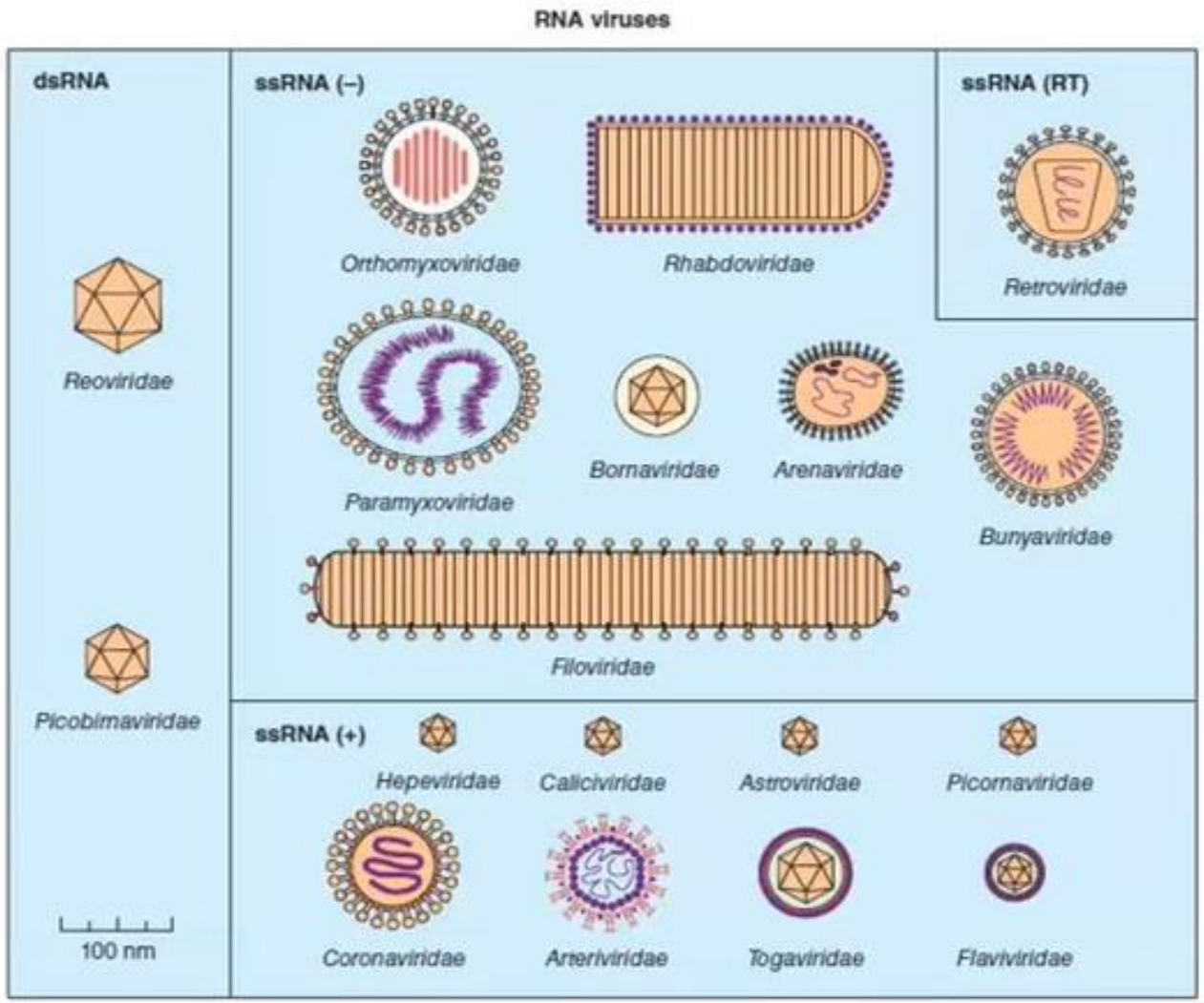
- Direct observation in the electron microscope is the most widely used method for estimating particle size.
- For comparisons, *Staphylococcus* species have a diameter of about 1000 nm (1 µm). (2) Bacterial viruses (bacteriophages) vary in size (10–100 nm). Some are spherical or hexagonal and have short or long tails. (3) Representative protein molecules range in diameter from serum albumin (5 nm) and globulin (7 nm) to certain hemocyanins (23 nm). (4) Eukaryotic ribosomes are about 25–30 nm in size, with mitochondria being much larger (1–10 µm). (5) Red blood cells are about 6–8 µm in diameter. (6) The width of a human hair is about 100 µm.



Shapes and relative sizes of animal DNA viruses of families that infect vertebrates



Shapes and relative sizes of animal RNA viruses of families that infect vertebrates

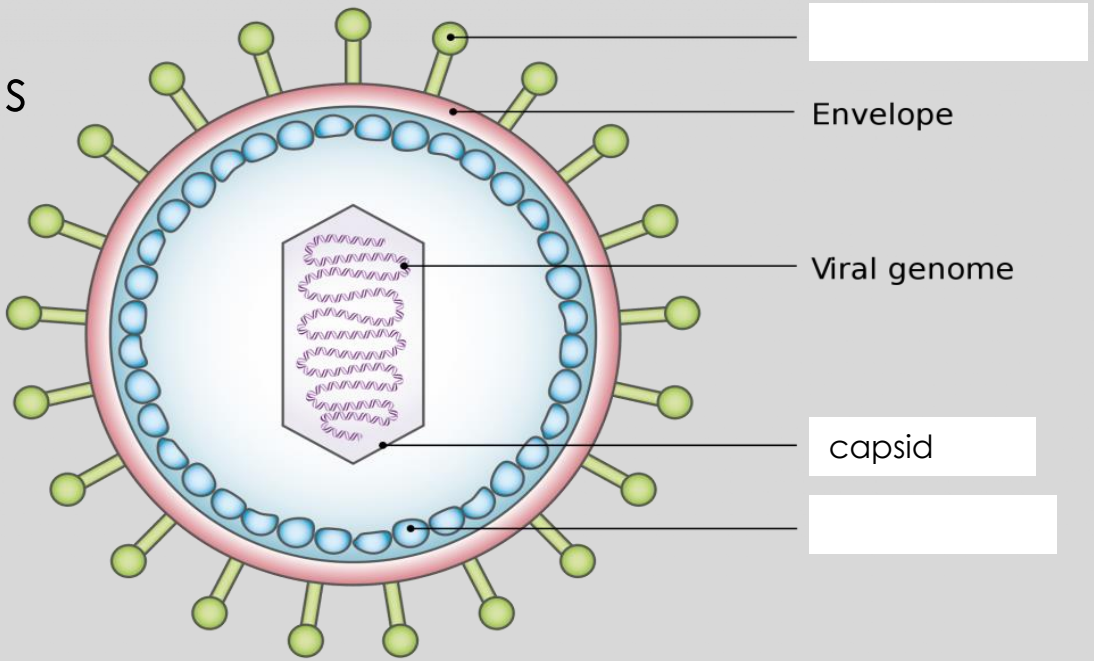


2) Structure of the viruses

- What are methods used for studying the structure of the virus?
  Electron microscope
  Cyro – Electron microscope
  X- ray

2) Structure of the viruses

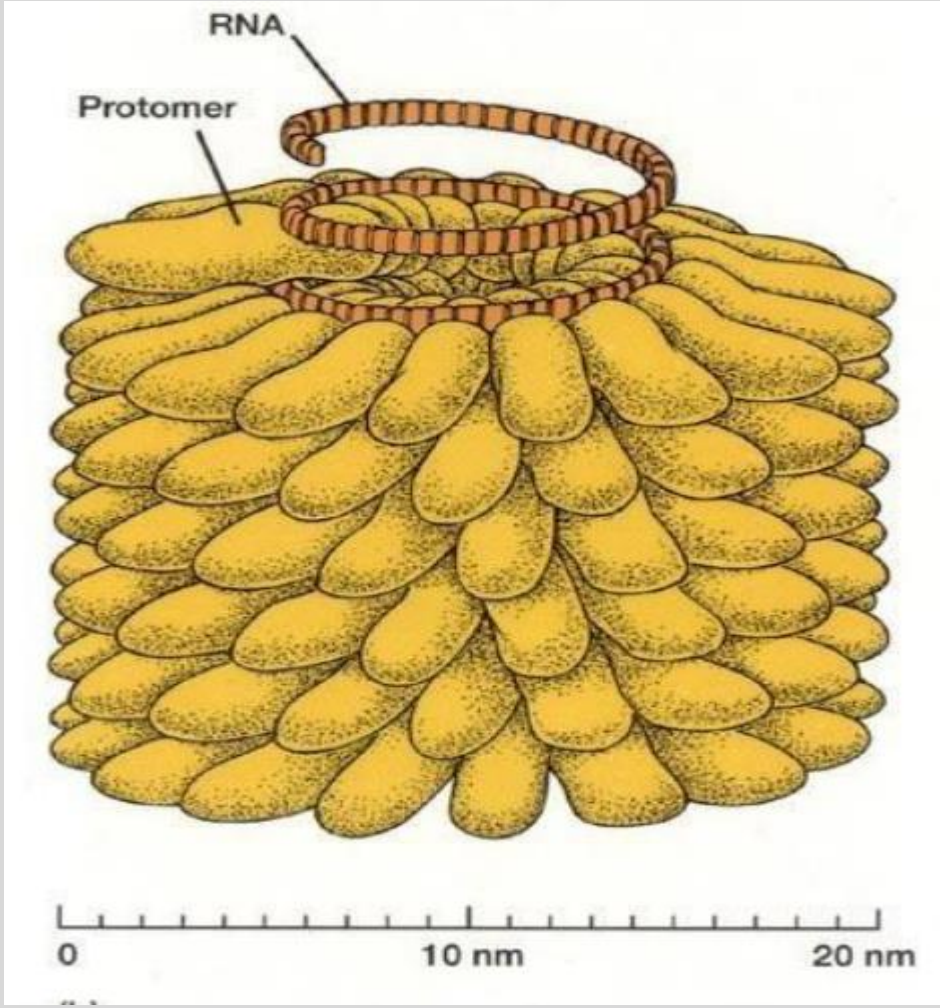
- They are made mainly of :
  a) capsid: Protein coat that encloses the Genome
  2)Genome
  3)envelope: a lipid membrane containing some proteins that surrounds some viruses
- Virion: The complete virus particle
- Nucleocapsid: Capsid + Genome
- Structural proteins: Capsid + Proteins of the envelope

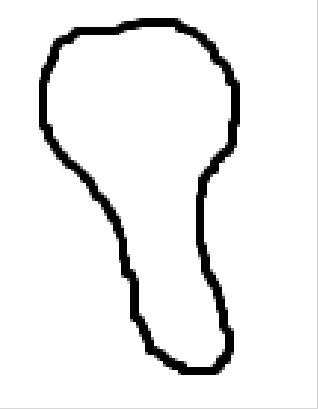


2) Structure of the viruses

- a) capsid: Protein coat that encloses the genome
  - Capsids are made of protomers (The basic protein building blocks of the coat. They're usually a collection of more than one non-identical protein subunit, also known as structural units)
  (Subunit: A single folded viral polypeptide chain)
- Functions:
  1- Protect viral nucleic acid
  2- Transport viral nucleic acid between cells for replication
  3- Helps in interaction with receptors on the host cells for penetration
- There are 3 main types of capsids:
  a1- Helical capsid
  a2- Icosahedral capsid
  a3- complex

A1- Helical capsid (most simple)



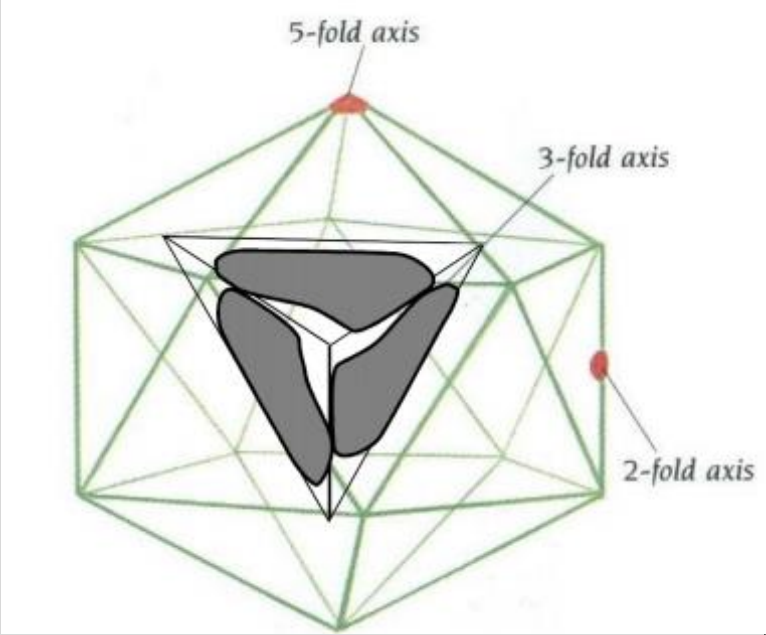


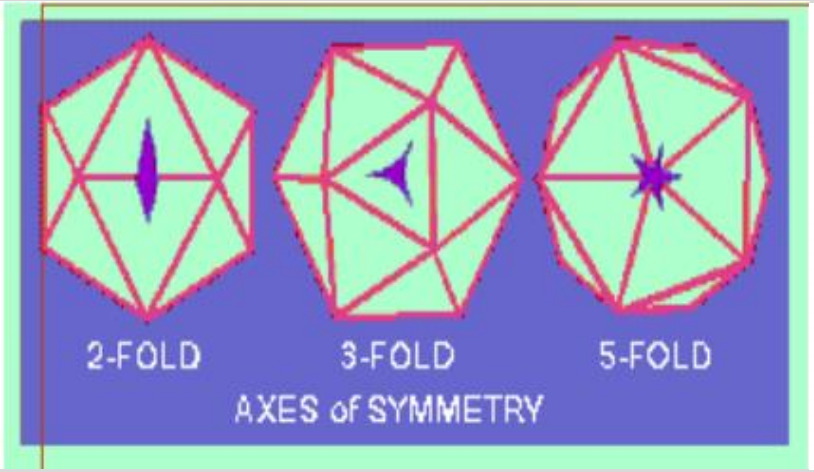
A1- Helical capsid (most simple)

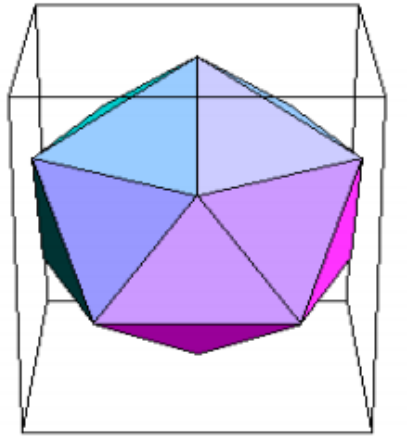
- Animal infecting viruses that have helical capsids share common characteristics such as:
  having an envelope/ Genome is RNA
- How does helical capsids form?
  - Protein subunits are bound in a periodic way to the viral nucleic acid, winding it into a helix
  - The nucleocapsid is then coiled inside the envelope (usually flexible and wound into a ball inside the envelope except for rhabdoviruses)
- So we can conclude:
  - There is a regular, periodic interaction between capsid protein and nucleic acid in viruses with helical symmetry.
  - It's not possible for "empty" helical particles to form

A2- Icosahedral capsids (Most common)

- A geometric shape composed of 60 Identical protein subunits, each 3 proteins form a equilateral triangle.
- Features of icosahedral:
  12 vertices
  30 Edge
  20 faces (equilateral triangles)
  5-3-2 symmetry axes

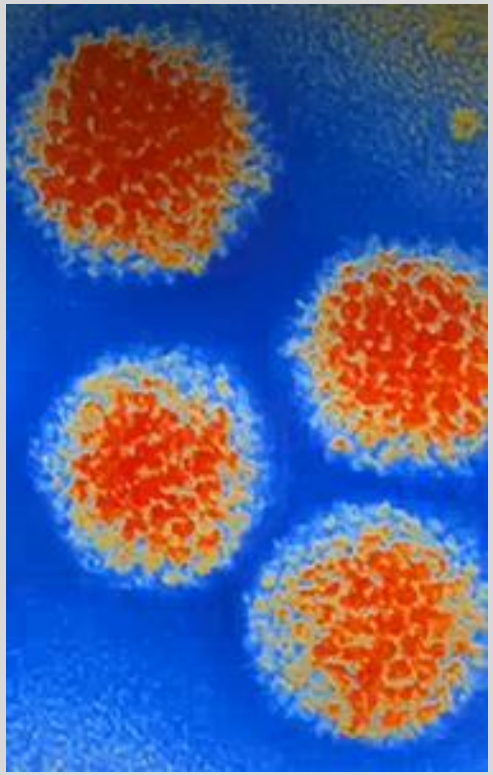






A2- Icosahedral capsids (Most common)

- Note: Most of them show spherical under the microscope
- Capsomeres: Morphologic units seen in the electron microscope on the surface of icosahedral viruses

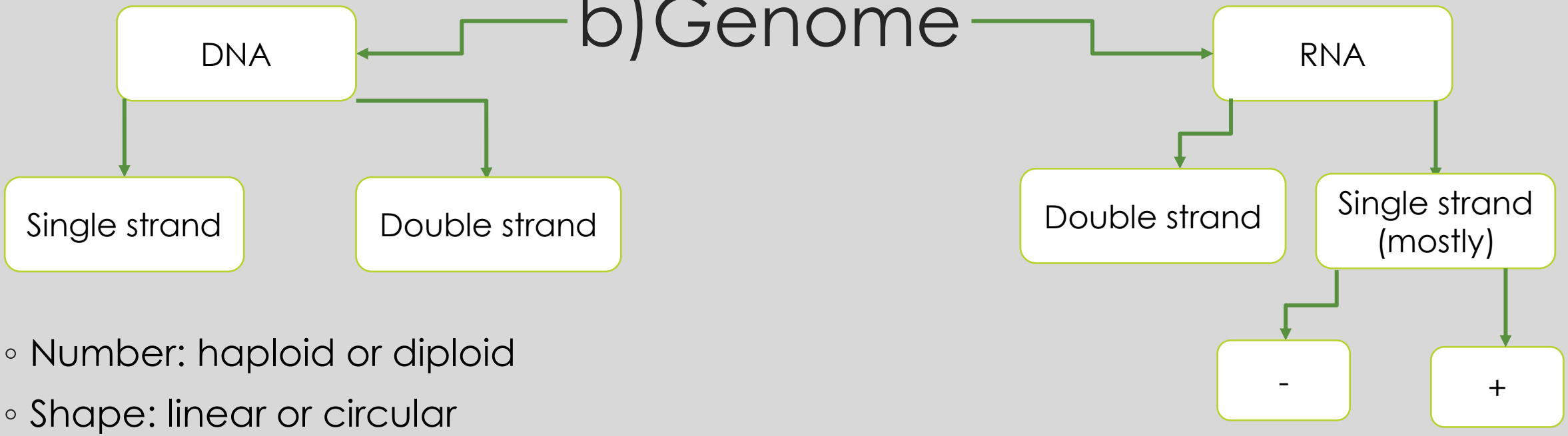


Capsomeres

A3- Complex Capsids

- complex viruses can not be simply defined by a mathematical equation . Like helix or icosahedral viruses
- For example, poxviruses are brick shaped, with ridges on the external surface and a core and lateral bodies inside

b)Genome



- Number: haploid or diploid
- Shape: linear or circular
  segmented (e.g. influenza) or non-segmented configuration
- → Single – stranded virus genomes may be either (+)sense (have the same polarity of nucleotides sequence as mRNA, so can be translated immediately) or (-) sense or ambience (mixture of both, usually act as a template to produce a +ve cells RNA which act as a mRNA to produce viral proteins)

b)Genome

- Size of genomes:
  - DNA: Ranges from 3.2 kb (e.g. hepadnaviruses) to 375 kb (poxviruses)
  - RNA: 4kb (picobinaviruses) to 32kb (coronaviruses)

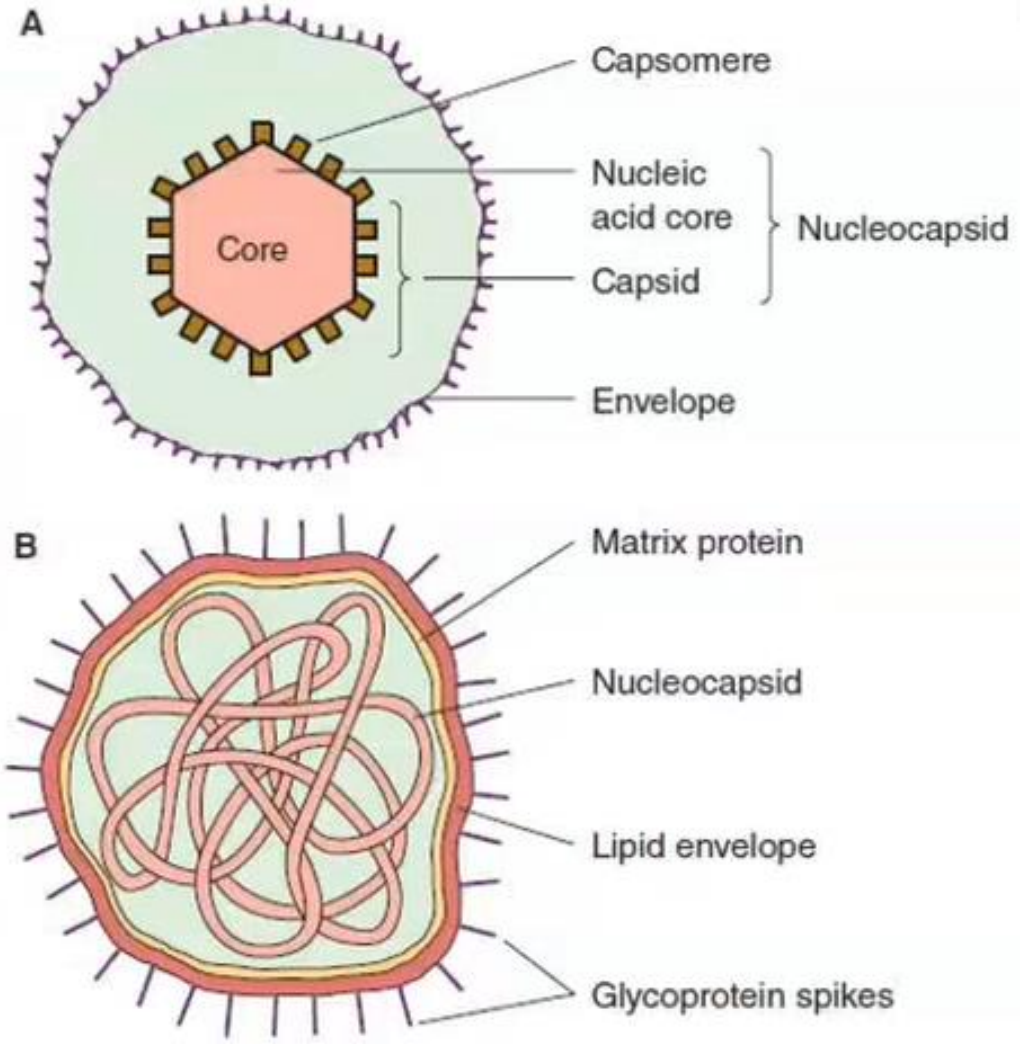
C) Envelope

- Consists of lipids and glycosylated proteins protruding from the envelope and exposed on the external surface of the virus particle (peplomers) (function is penetrating the host cell).
- Viruses that have envelope are called “enveloped” viruses, while those without envelope are called “naked” viruses
- Naked viruses are usually stronger against environmental factors (e.g. organic solvents) than enveloped viruses, an important example is ether:
  ether disrupts the envelope of the enveloped viruses stopping their infectivity, while naked viruses are resistant to ether.

D) Proteins

- Proteins are two types:
  1) Structural proteins: such as the capsid and the glycosylated proteins on the envelope
  function: Facilitate transfer of genome, participate of attachment of the virus to the host cell and determine the antigenic characteristics of the virus.
  2) Enzymes: present in small amounts
  function: replication (e.g. RNA polymerase)

Terms and definitions in Virology



3) Structures similar to viruses

- Defective virus: A virus particle that is functionally deficient in some aspect of replication, they need helper viruses (e.g. Hepatits D)

Other infectious agents

- **Viroids:** Small infectious agents that cause diseases of plants. They are composed of ss, ccc-RNA consisting of about 360 nucleotides and with a highly base-paired rod-like structure. Viroids replicate by an entirely novel mechanism.
- Viroid RNA does not encode any protein products and the devastating plant diseases induced by viroids occur by an unknown mechanism.
- To date, viroids have been detected only in plants; none have been demonstrated to exist in animals or humans.

Other infectious agents

- **Prions:** infectious particles composed of protein with no detectable nucleic acid.
- They are highly resistant to inactivation by heat, formaldehyde, and ultraviolet light that inactivate viruses.
- The prion protein is encoded by a single cellular gene.
- Prion diseases, called "transmissible spongiform encephalopathies," include scrapie in sheep, mad cow disease in cattle, and kuru and Creutzfeldt-Jakob disease in humans.

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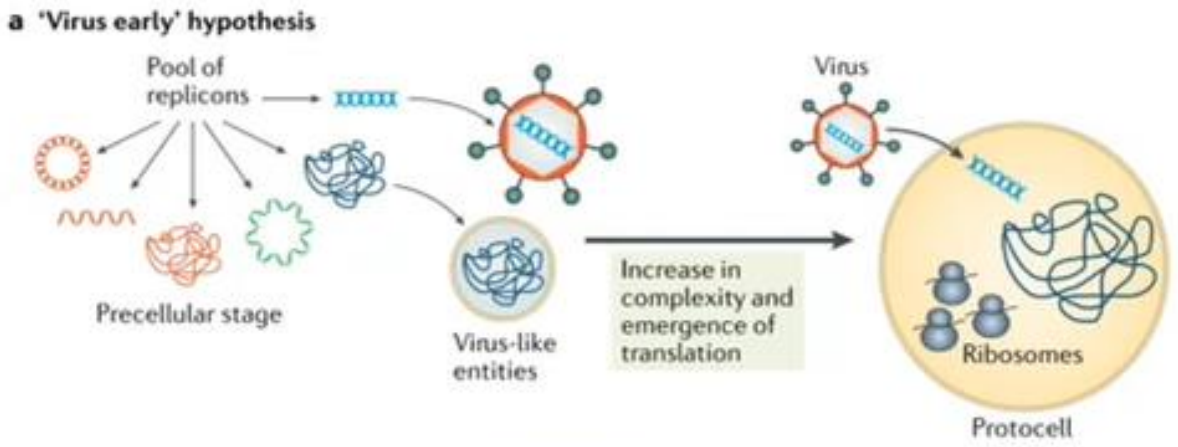
Monday, January 25, 1999 Published at 17:47 GMT

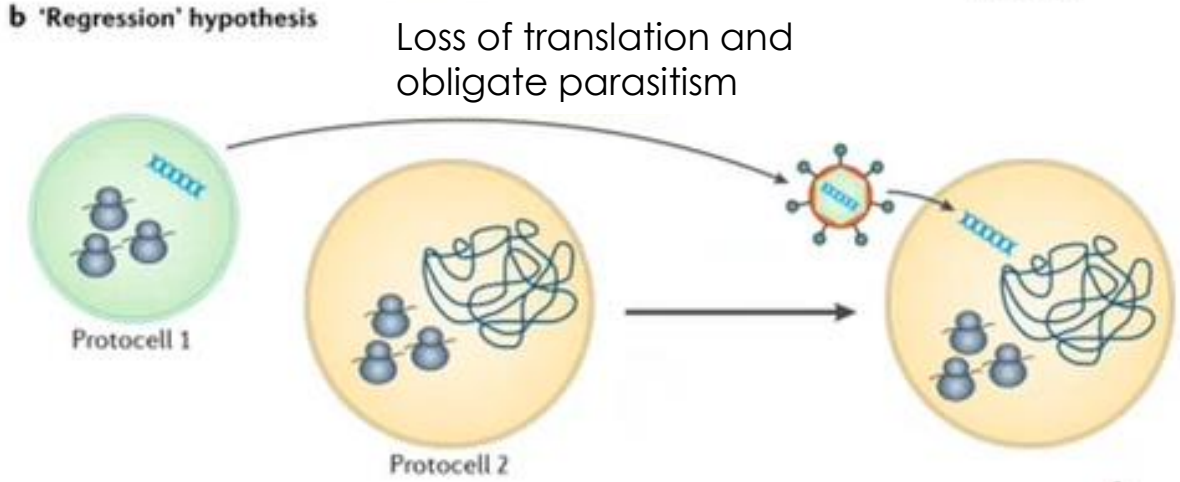
UK

One random meal could have caused CJD

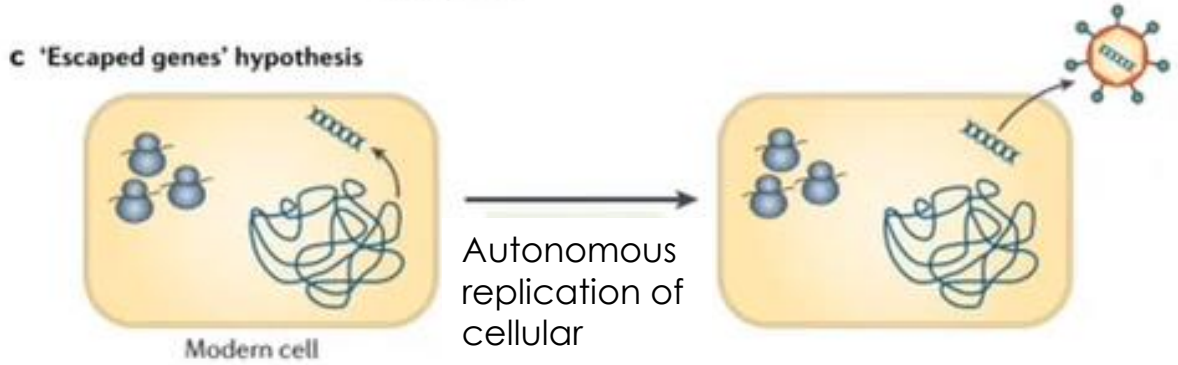
Stephen Churchill occasionally ate beefburgers and sausages

Britain's first teenage victim of new-variant Creutzfeldt-Jakob Disease may have caught the illness from just one random meal of contaminated meat, an inquest heard on Monday.





Loss of translation and obligate parasitism



Autonomous replication of cellular genes

6- Classification of viruses

- → Bases of classifications:
- Virion morphology (size, shape ..etc)
- Virus genome properties (DNA, RNA)
- Genome organization and replication (Segmented or no ….)
  (Class related to genes rise genotypes)
- Virus protein properties
- Virus antigenic properties (rise serotypes)
  (Note: Genomic classification is more accurate than protein or antigen classification, because the same antigen or protein can be occupied from two different genes)
- Physiological properties of the virion (effects of pH, ether ..etc) reflect the structure as naked viruses are stronger than enveloped.
- Biological properties (way of infection/ type of infected cells

6- Classification of viruses

- Types of classifications:
  1) ICTV (international community and taxonomy of viruses): updated periodically, scientists come to an agreement about the name and classification of any new virus
  2) Baltimore