AZERBAIJAN MEDICAL UNIVERSITY
DEPARTMENT OF MEDICAL MICROBIOLOGY and IMMUNOLOGY

Lesson 8.

Classification, morphology and ultrastructure of viruses

FACULTY: General Medicine
SUBJECT: Medical microbiology - 1

Discussed questions:

- Features of viruses, their differences from other microorganisms.
- Morphology of viruses
- The structure of the virion: nucleic acid, capsid, symmetry types of viral capsid, envelope.
- Modern principles of classification of viruses.
- DNA-viruses
- RNA-viruses.
- Prions.
- Viroids.

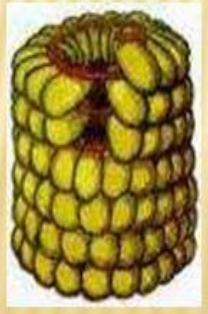
Purpose of the lesson:

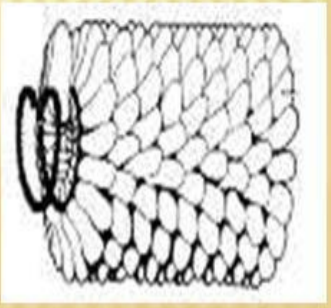
- To inform students about non-cellular microorganisms (viruses, prions and viroids), to acquaint them with the general characteristics of viruses, classification, morphology and structural features of viruses.

✓*“The word "virus" means "poison" in Latin. This term was first used by L. Pasteur for agents filtered through a bacterial filter.*

Discovery of viruses

On the existence of viruses, the Russian botanist D.I. Ivanovsky identified in 1892 the mosaic virus from tobacco as an infectious agent filtered through a bacterial filter

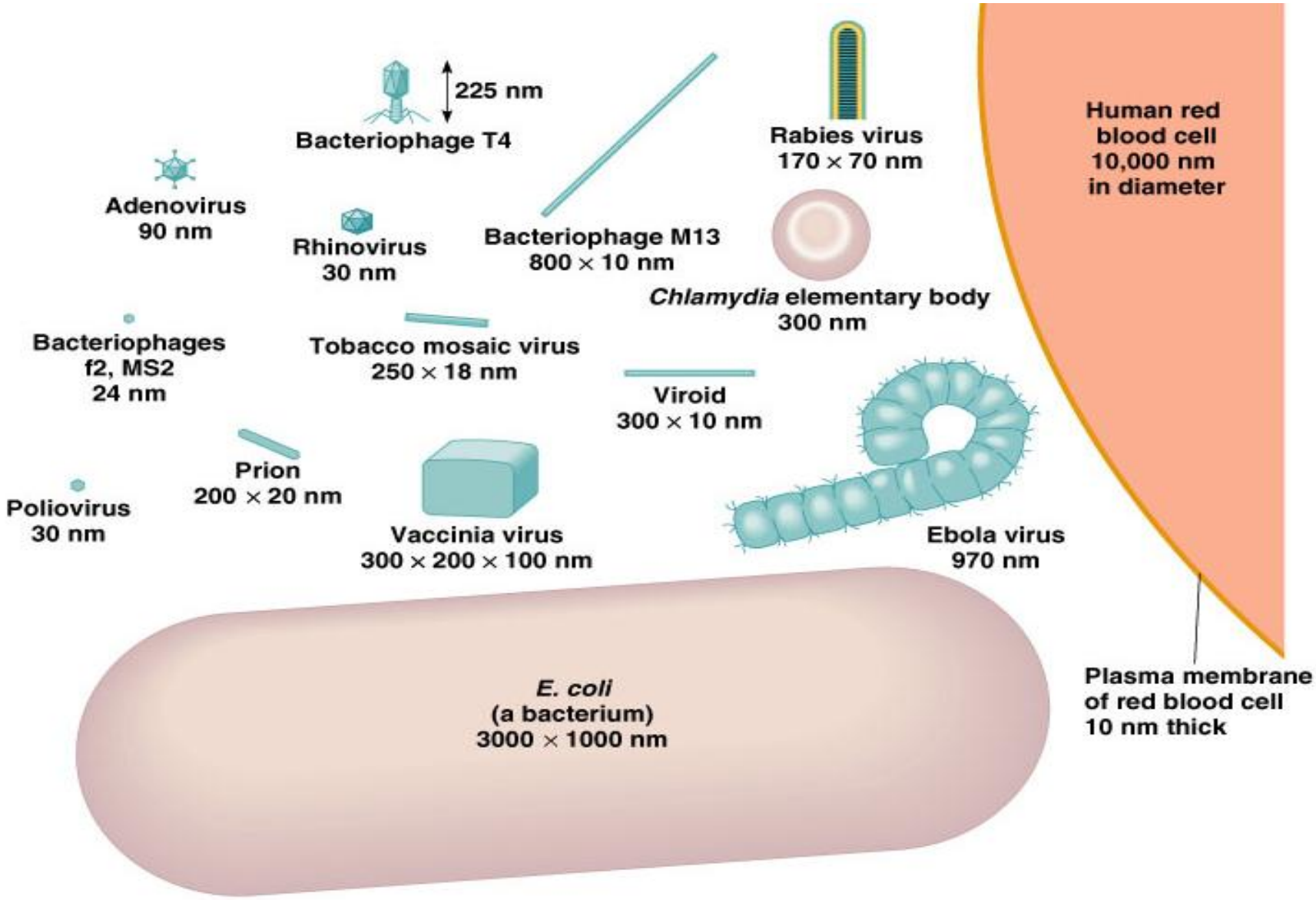




Viruses differ from other microorganisms in a number of features

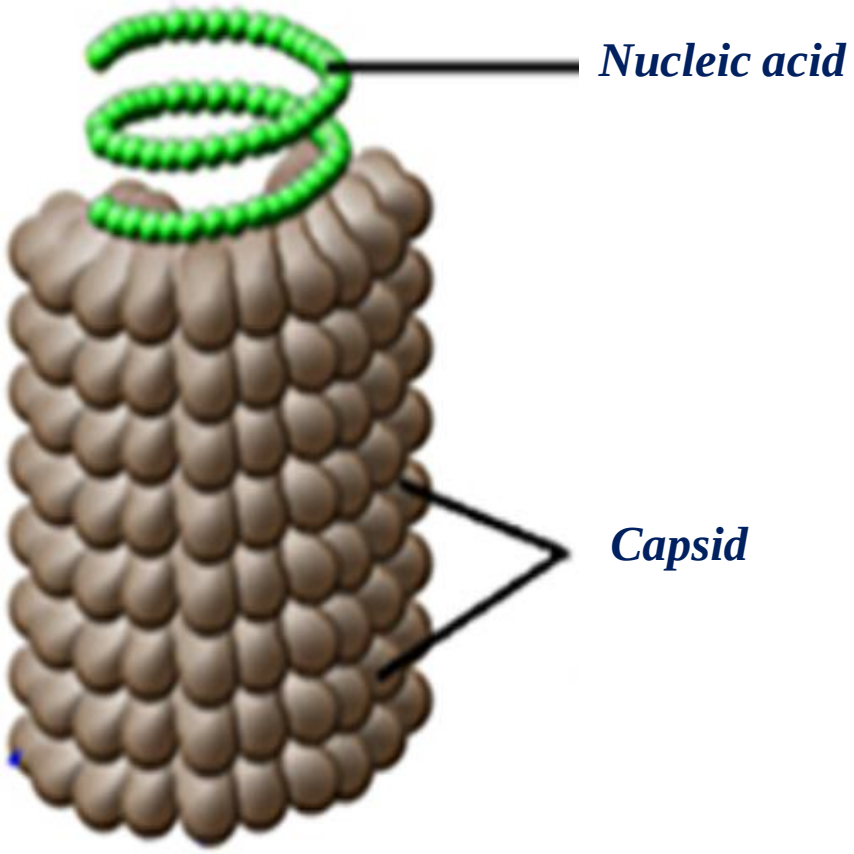
- Viruses have not a cellular structure. Cell structures found in other microorganisms - cell membranes, cytoplasm and intra-cytoplasmic structures, nucleoids (nuclei), etc. not present in viruses;
- Viruses have not ribosomes
- Viruses are very small in size and are measured in nanometers (1 nm = 10-3 μm), ranging from 15-20 nm to 350-400 nm;
- Unlike other microorganisms, viruses contain only one of the nucleic acids, either DNA or RNA;
- Viruses can only multiply inside the cell. They do not have free metabolic systems, being intracellular parasites;
- Viruses are propagated by a unique method of reproduction - replication

Viruses (comparative dimensions)



Structure of the virion

- At the center of the virion exist the nucleic acid - DNA or RNA
- Nucleic acid is surrounded by a capsid (Greek, capsa - box). The capsid is made up of protein particles - capsomeres. The number of capsomers is constant
- Virion is composed from a nucleocapsid



Morphology of viruses

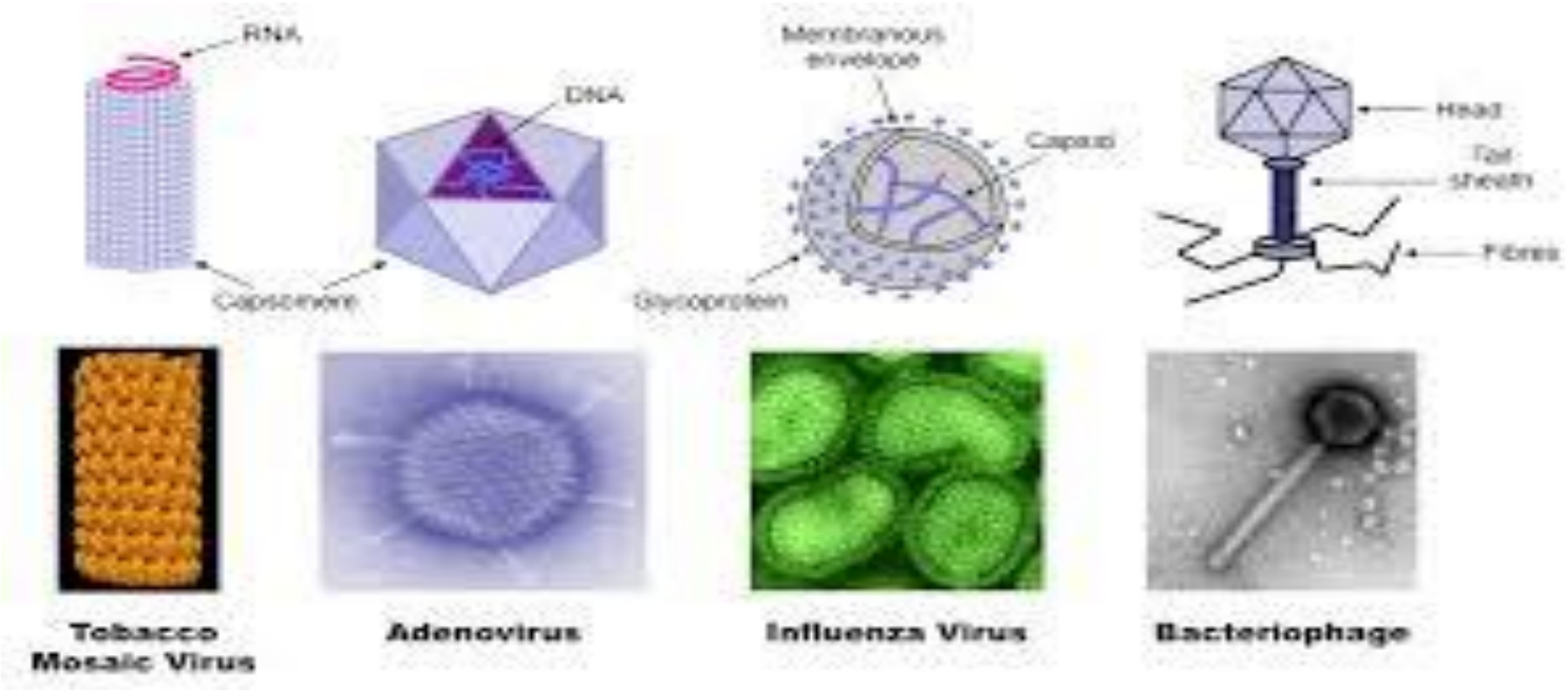
Viruses are divided into the following groups according to their morphology

1. *Spherical or spherical viruses: Influenza, mumps, measles*

2. *Bullet- or rod-shaped viruses: rabies*

3. *Cubic viruses: natural flowers, human and animal papillomaviruses, adenoviruses, enteroviruses*

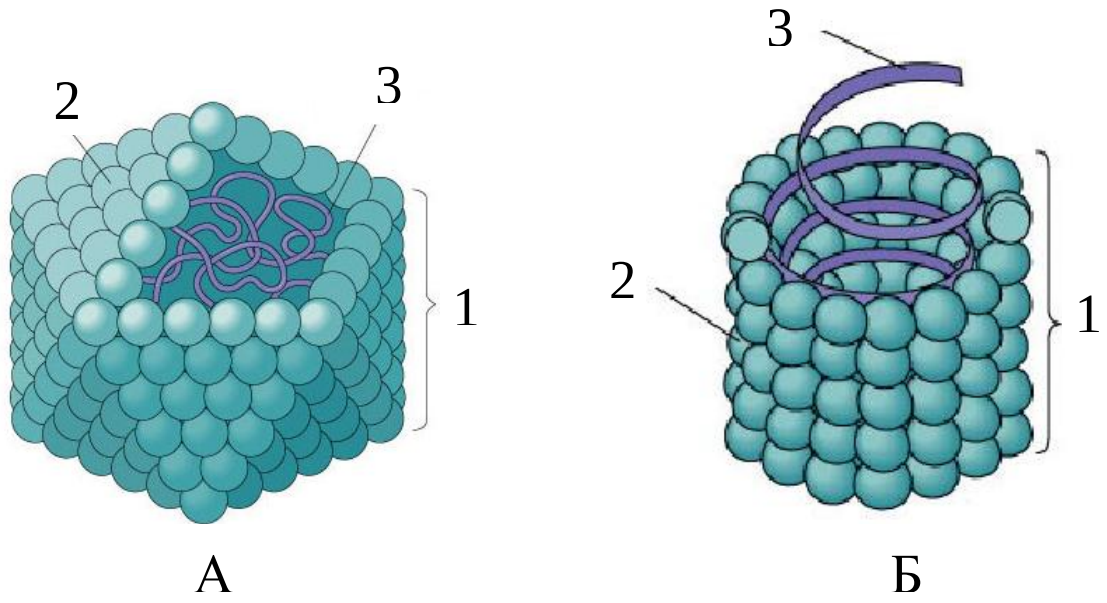
4. *Spermatozoa-like viruses: bacteriophages*



Arrangement of capsomeres in the capsid membrane - symmetry types of nucleocapsid may differ in different viruses

- There are three types of nucleocapsid symmetry
- In some viruses, capsomeres are arranged in such a way that they form polyhedral, polygonal spatial figures (icosahedrons). This is called cubic (icosahedral) symmetry (for example, in adenoviruses). This type of symmetry gives to many viruses a spherical shape
- In some viruses, the capsomeres are arranged in a spiral around the nucleic acid. This is called spiral symmetry and is mainly characteristic of rod-shaped viruses (eg. rabies virus)
- In some viruses, mix-type symmetry is observed. For example, the head of bacteriophages has a cube, and the protrusion has a spiral symmetry

Types of capsid symmetry in viruses

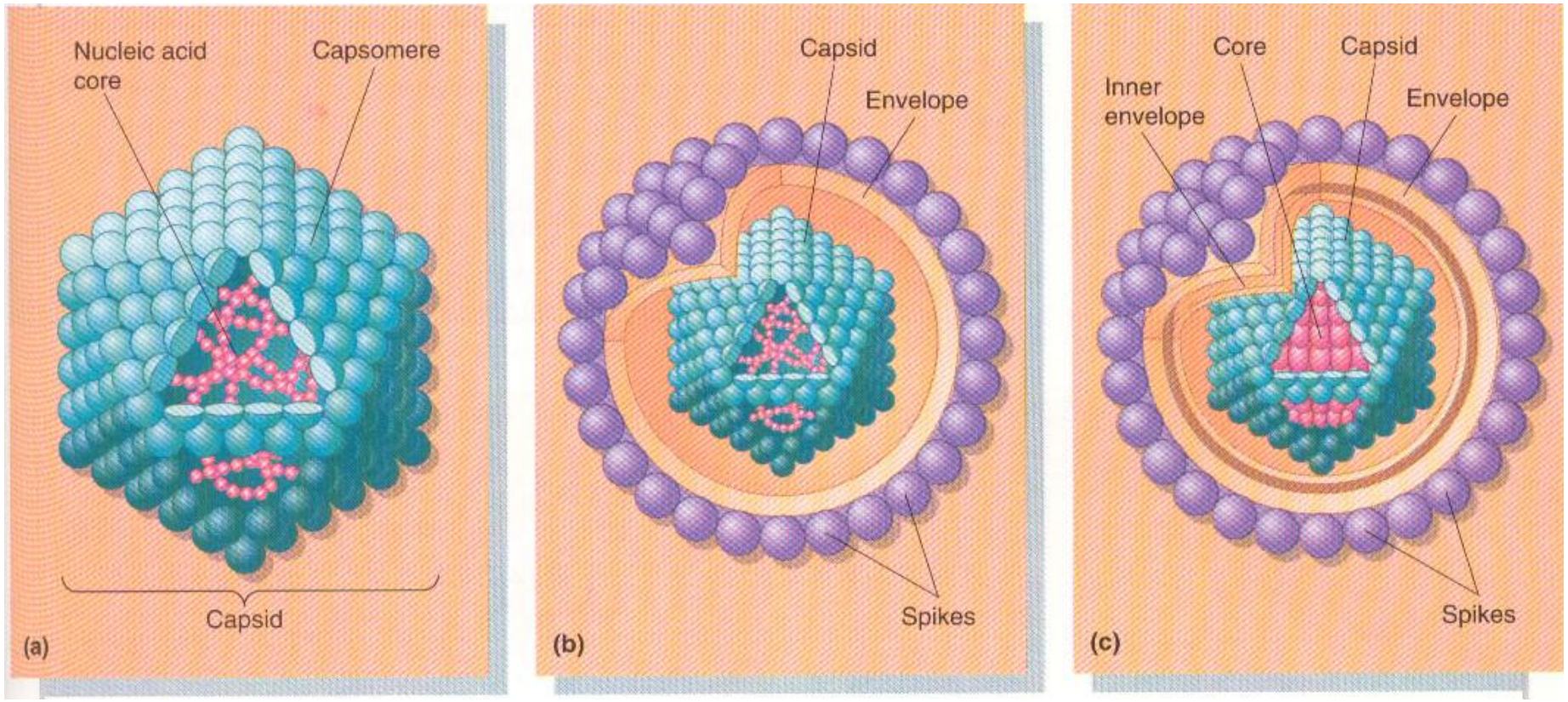


А - icosahedral, В - spiral summetry;
1-capsid, capsomers, 3-nucleic acid

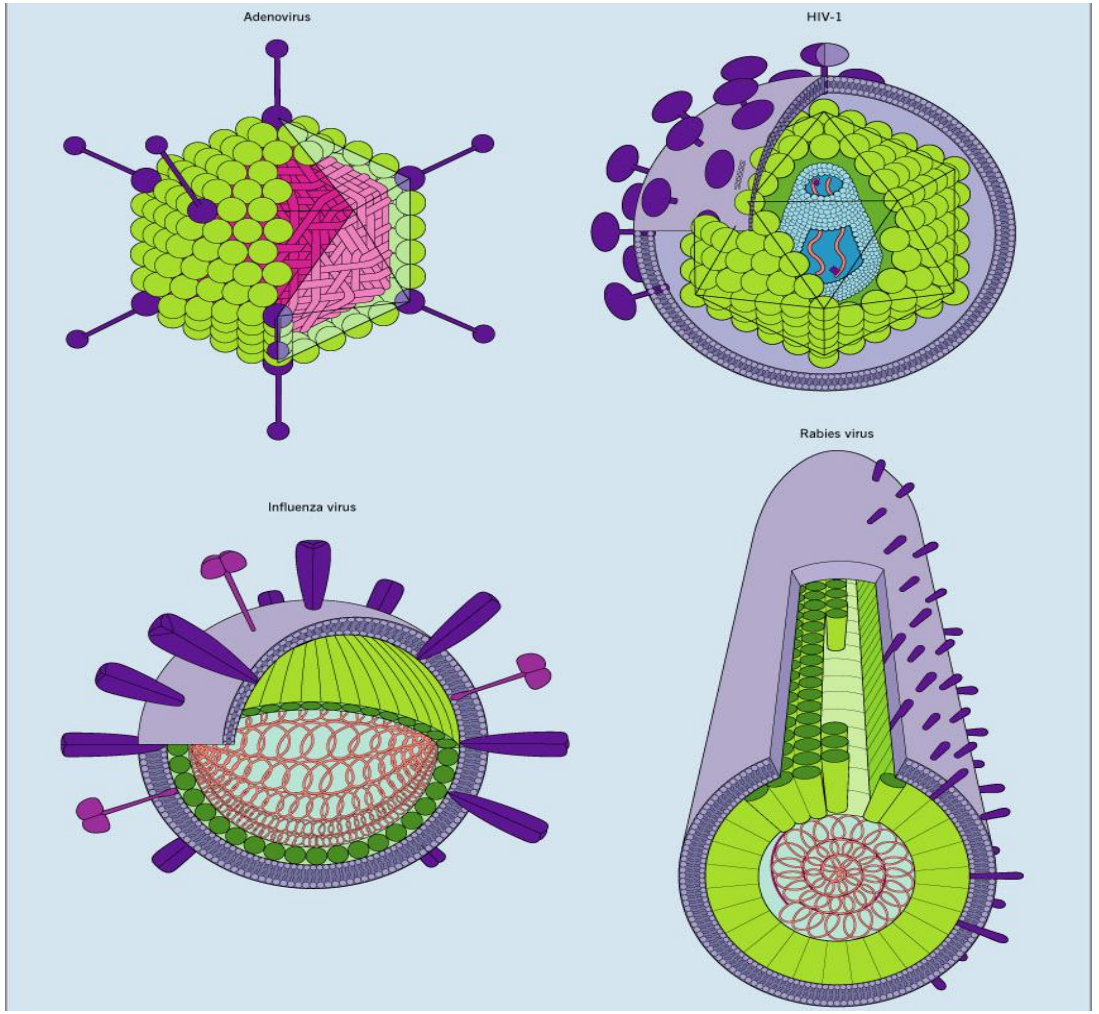
Simple and complex viruses

- ***Simple viruses*** *consist only of nucleocapsids.*
- ***Complex viruses*** *In complex viruses, in addition to the nucleocapsid, virus is surrounded by an outer membrane - peplos, or supercapsid.*
- *This membrane, made up of double lipids, is formed when the virus leaves the host cell.*

Simple and complex viruses



In the outer membrane of many complex viruses are founded glycoprotein-type spikes (peplomers)



Chemical structure of virion

- The virion is mainly composed of nucleic acids and proteins Therefore, viruses can be considered chemically as ***nucleoproteins***
- Complex viruses also have a ***lipid-containing foreign supercapsid membrane***
- Viruses also contain ***virus-specific enzymes*** that allow them to replicaton inside the host cell

Nucleic acid in viruses (DNA)

- In viruses, DNA can be double-stranded, circular (for example, in parvoviruses) and linear (for example, herpesviruses)

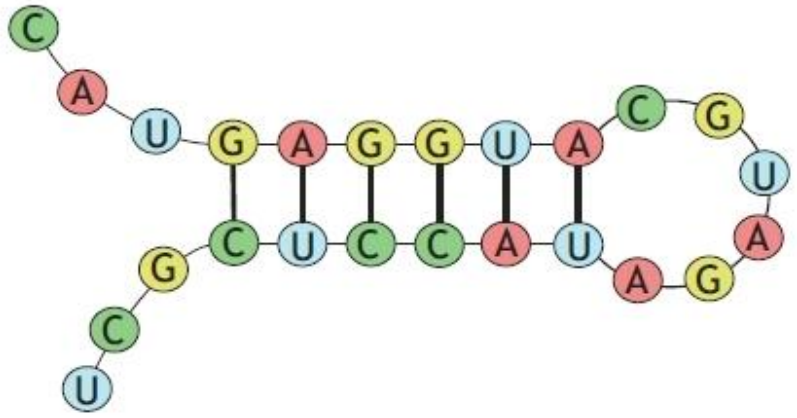
- Some viruses have single-stranded DNA (for example, parvoviruses)

- The molecular weight of viral DNA varies between 106 and 108 D, which is ten to a hundred times less than that found in bacteria.

Straight and inverse sequences

• Viral DNA has a unique nucleotide sequence, where identical nucleotide sequences are found only once, but straight and vice versa can be present at the ends of the molecule.

•This allows the DNA strand to be looped (straight and inverse sequences are combined on the basis of complementarity)



Nucleic acids in viruses (RNA)

- In viruses, RNA is mainly in a single-stranded, but can sometimes be in a double-stranded (for example, in reoviruses)
- In some viruses RNA are segmented (fragmented) (for example, in influenza viruses)
- Such structure significantly increases the coding capacity of RNA

Virus RNA is divided into two main groups depending on its function

- In some viruses, RNA has the ability to transmit hereditary information directly to the ribosomes of the host cell, it can play the role of direct information-RNA. These are called positive-sense-stranded RNA (+ RNA) or positive genomes

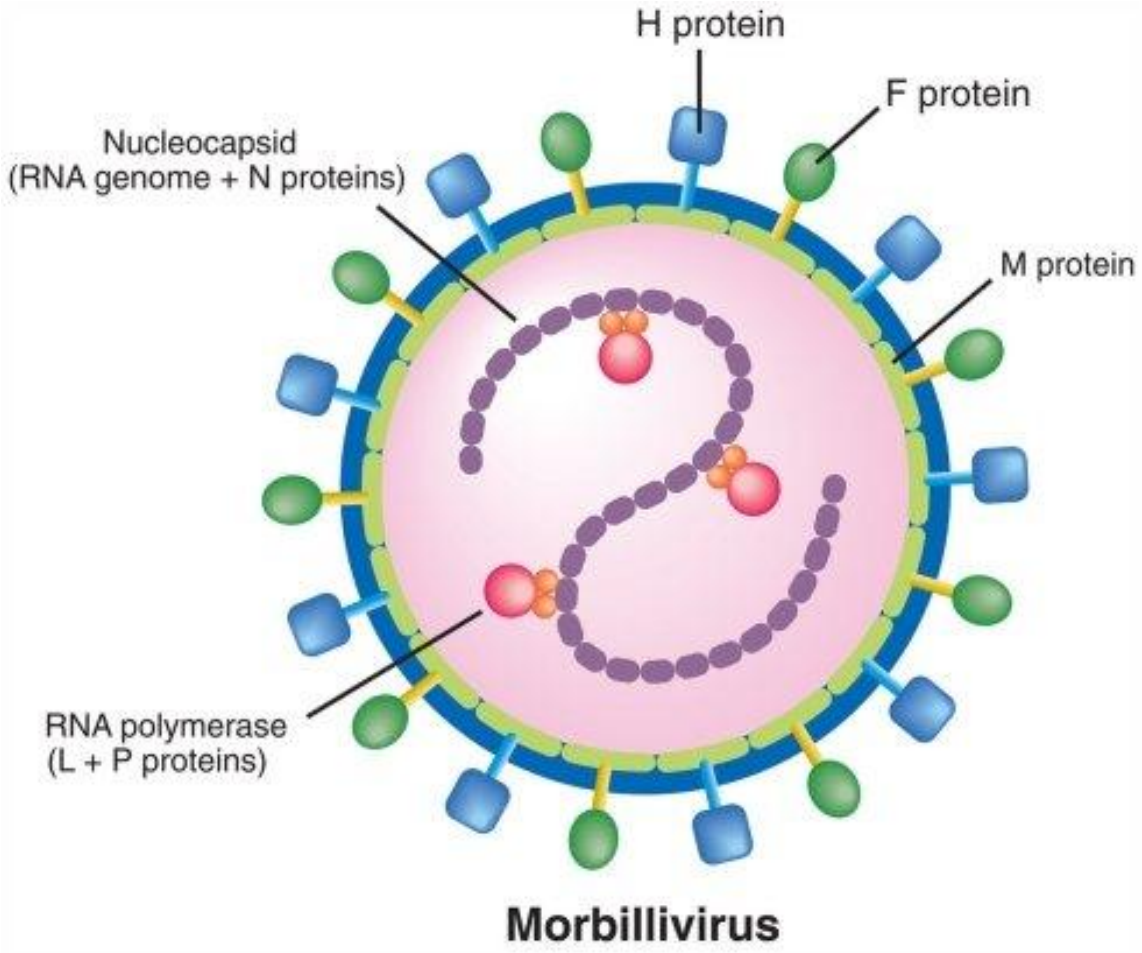
- In other viruses, RNA cannot transmit hereditary information directly to the ribosomes of the host cell, that is, it cannot play the role of direct information-RNA. These are called negative-sense-stranded RNAs (-RNAs), or negative genomes

- At this point, + RNA is first synthesized on viral RNA

Virus proteins

- Mainly has a structure and enzymatic function
- The capsid membrane of viruses consists of proteins
- In addition, the outer membrane of viruses with complex structures also contains proteins (outer membrane protrusions are glycoprotein in nature)
- The **matrix protein (M-protein),** one of the important structural elements of complex viruses, is located on the inner surface of the viral membrane and interacts with the nucleocapsid proteins of this membrane to interact with the virus

Structure of Rubeola (measles) virus



Modern principles of classification of viruses

The current classification of viruses is based on the following criteria:

1. Morphology, sizes and forms
2. Presence and absence of membrane
3. Types of symmetry of the nucleocapsid
4. Characteristics of nucleic acids - its molecular weight, type, number of chains in the molecule, the presence of segments, etc.

Classification of viruses

- According to the type of nucleic acid, all viruses are divided into two major groups:
- RNA viruses
- Contains viruses

Nomenclature of viruses

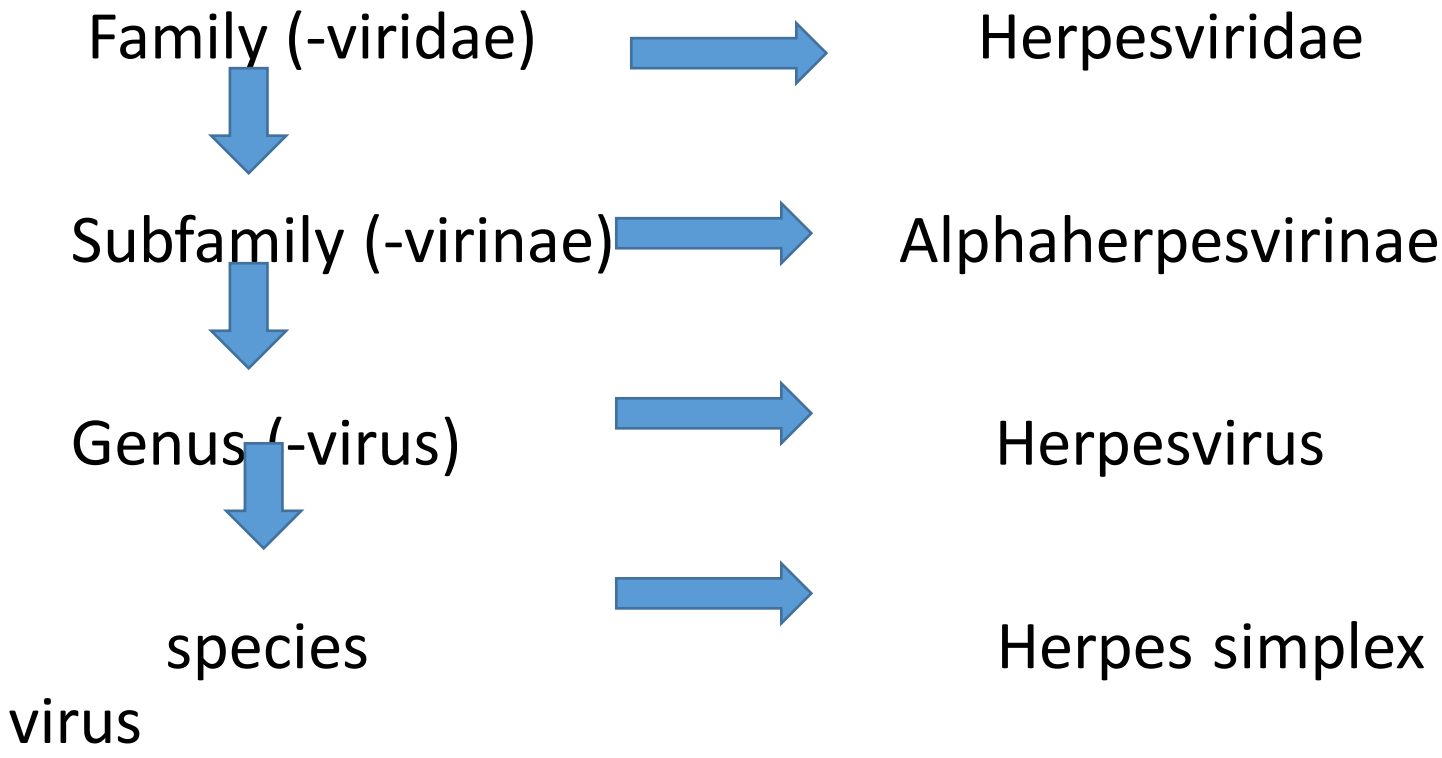
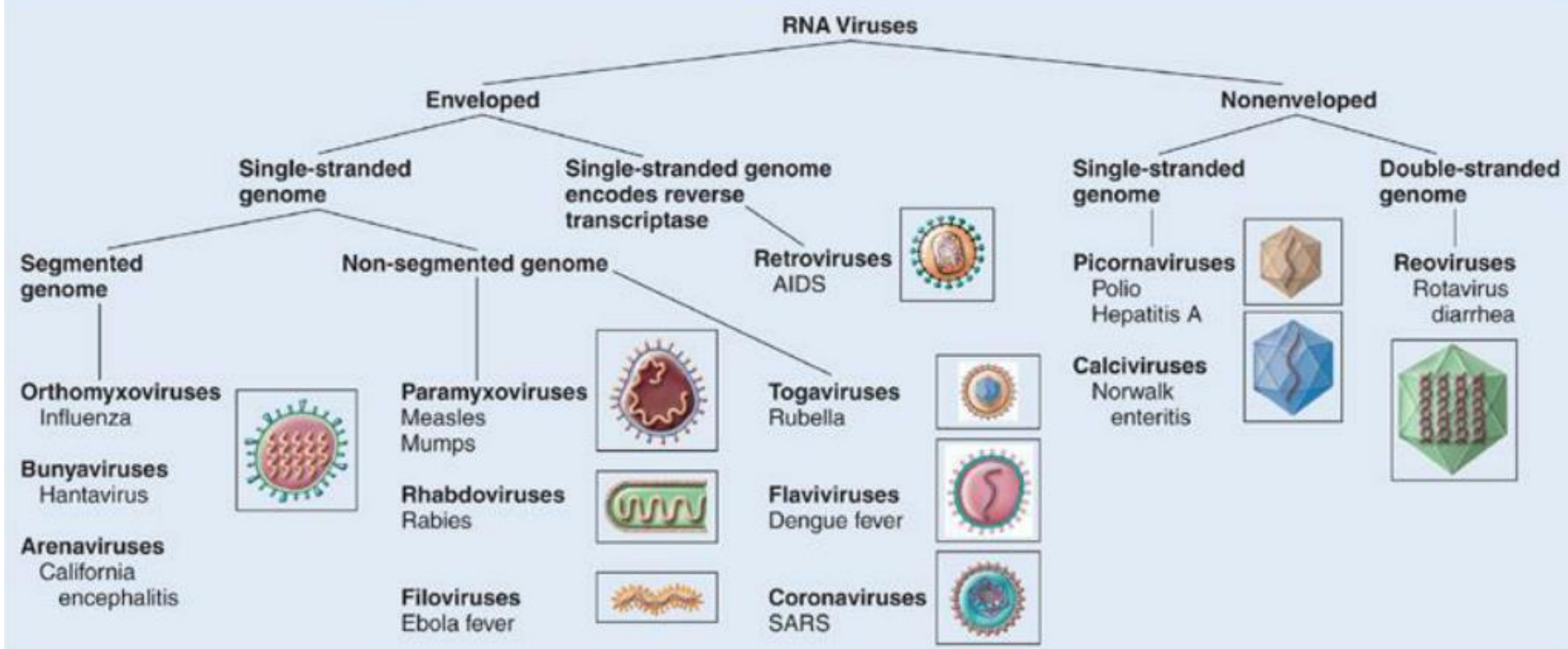


TABLE 25.1

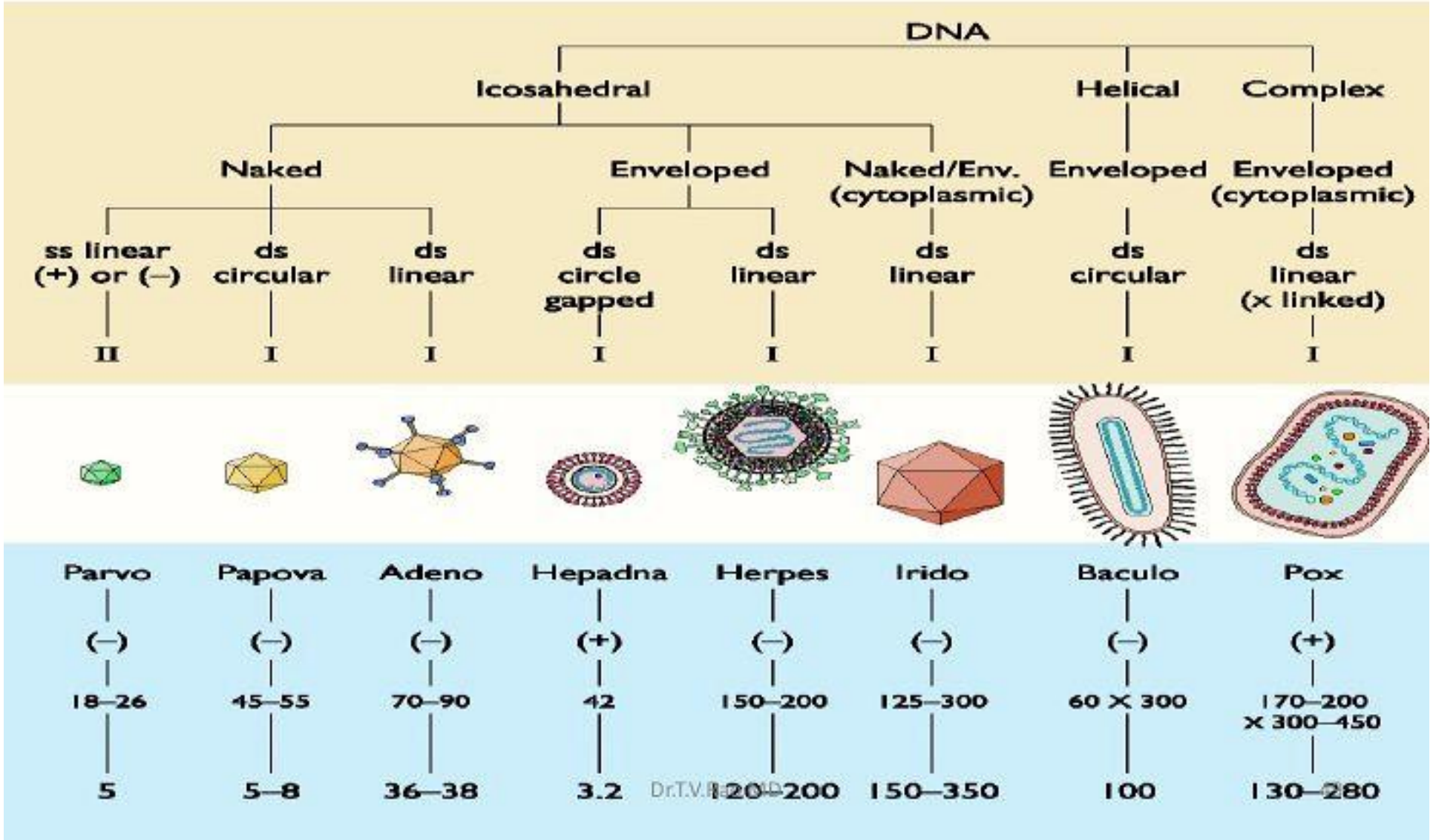
RNA Viruses with Examples of Diseases



RNA viruses

Families	Types
Picornaviridae	Poliomiyelitis, Hepatitis A
Togaviridae	Rubella virus
Flaviviridae	Hepatitis C, Yellow fever, Dengue fever, tick borne encephalitis viruses
Caliciviridae	Gastroenteritis viruses
Coronaviridae	Human Coronavirus,SARS virus, CoVİD-19
Retroviridae	Human Immnodefficiency Virus
Filoviridae	Marburg and Ebola viruses
Bunyaviridae	Hemorraghic fever viruses
Arenaviridae	Lymphocytic choriomeningitis virus
Orthomyxoviridae	Influenza viruses
Paramyxoviridae	Rubeola (Measles), Parainfluenza,epidemik patotit viruses (Mumps)
Rhabdoviridae	Rabies virus

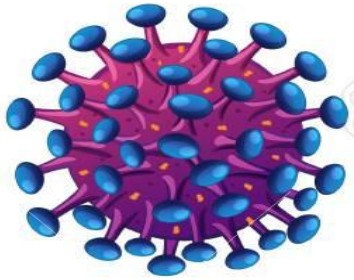
DNA viruses


DNA
Icosahedral
Helical
Complex
Naked
Enveloped
Naked/Env. (cytoplasmic)
Enveloped
Enveloped (cytoplasmic)
ss linear (+) or (–)
ds circular
ds linear
ds circle gapped
ds linear
ds linear
ds circular
ds linear (x linked)
II
I
I
I
I
I
I
I
Parvo
Papova
Adeno
Hepadna
Herpes
Irido
Baculo
Pox
(–)
(–)
(–)
(+)
(–)
(–)
(–)
(+)
18–26
45–55
70–90
42
150–200
125–300
60 X 300
170–200 X 300–450
5
5–8
36–38
3.2
120–200
150–350
100
130–280

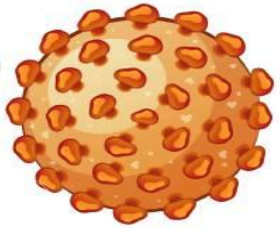
DNA viruses

Families	Types
Parvoviridae	Human Parvovirus
Polyomaviridae	Human Polyomavirus
Papillomaviridae	Human Papillomavirus
Adenoviridae	Adenovirus
Herpesviridae	Herpes simplex virus, Cytomeqalovirus
Poxviridae	Pox virus
Hepadnaviridae	Hepatitis B

Different structure of viruses

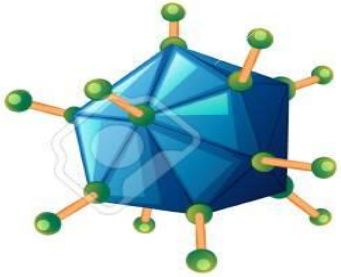


HIV

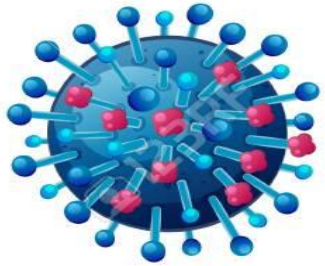


Hepatitis B

Ebola Virus



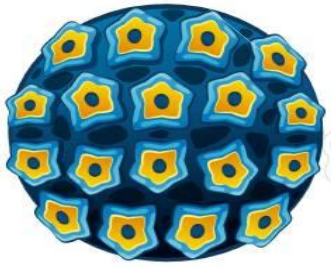
Adenovirus



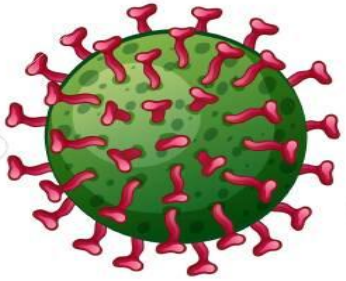
Influenza

Rabies Virus

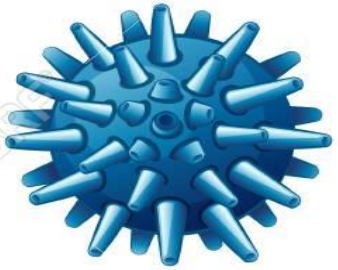
Bacteriophage



PaPillomavirus



Rotavirus



Herpes Virus

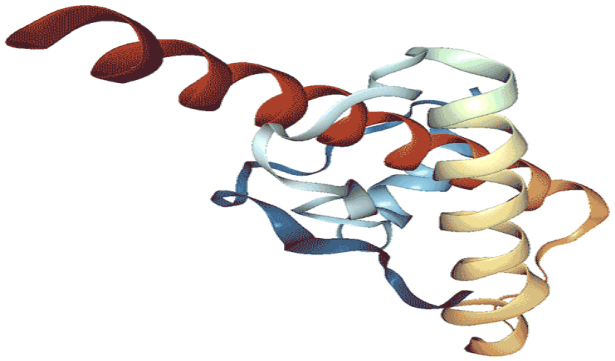
Prions

❖The term prion was used in 1982 by the American scientist S. Pruziner. Prions (from the English word "proteinaceous infectious particle")

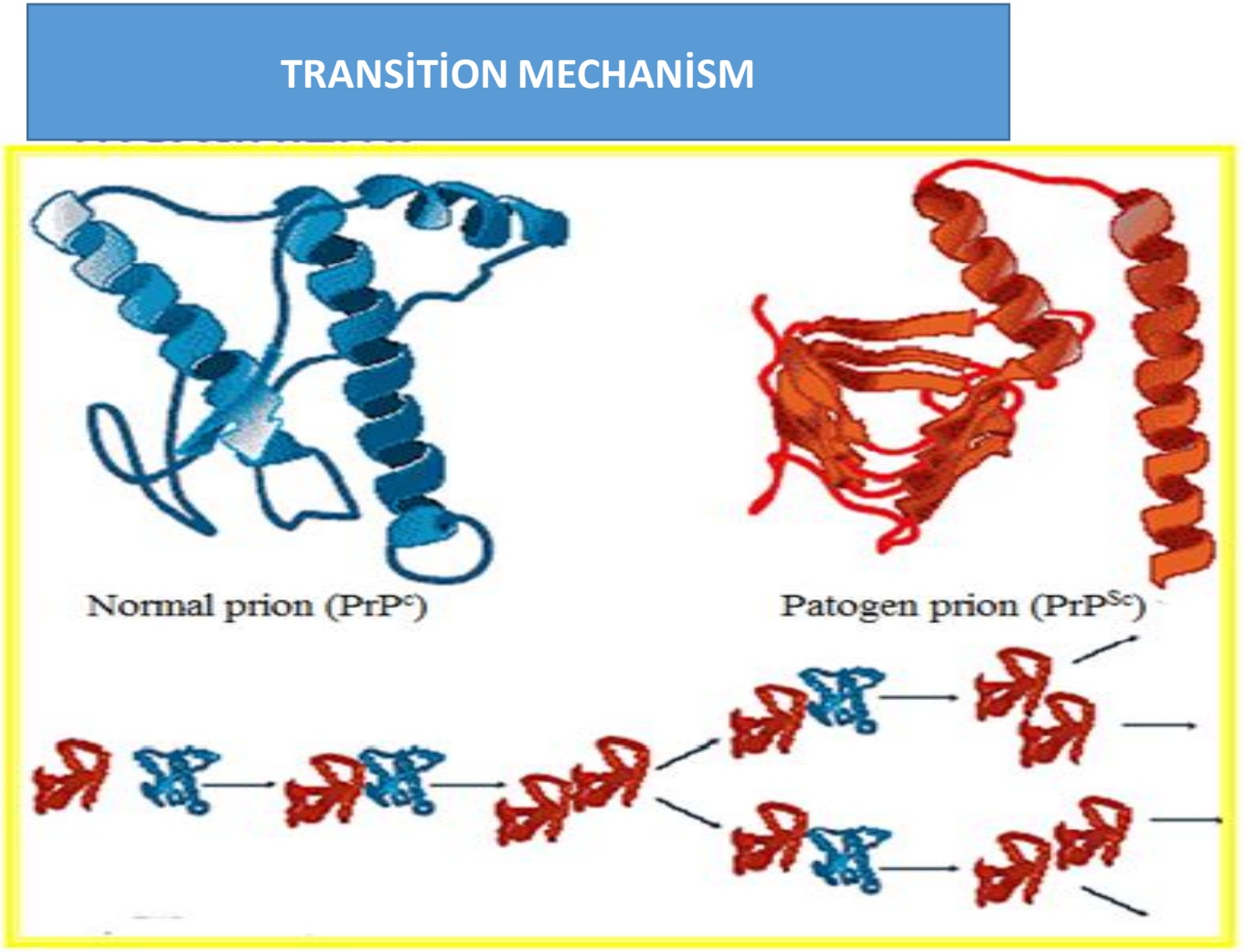
❖ No nucleic acids

❖ Normal prion protein (Prc) is present in animal as well as human bodies and performs a number of regulatory functions

❖Normal Prion protein synthesis is encoded by the Prc gene located on human chromosome 20

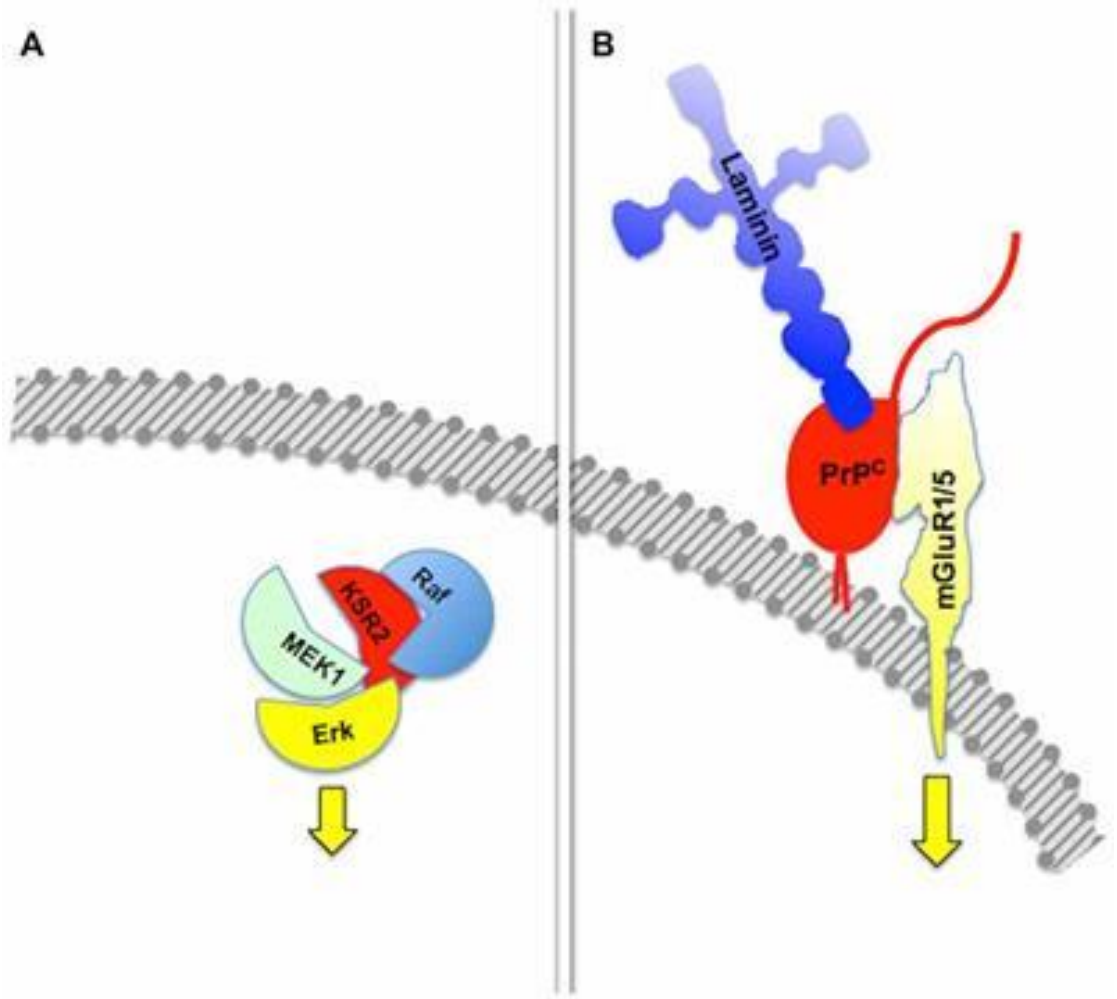


Infectious prion protein differs from normal prion protein in its tertiary and quaternary structure



Synthesis of prion protein in the cell

Localization of prion protein in the cell membrane



Prion disease

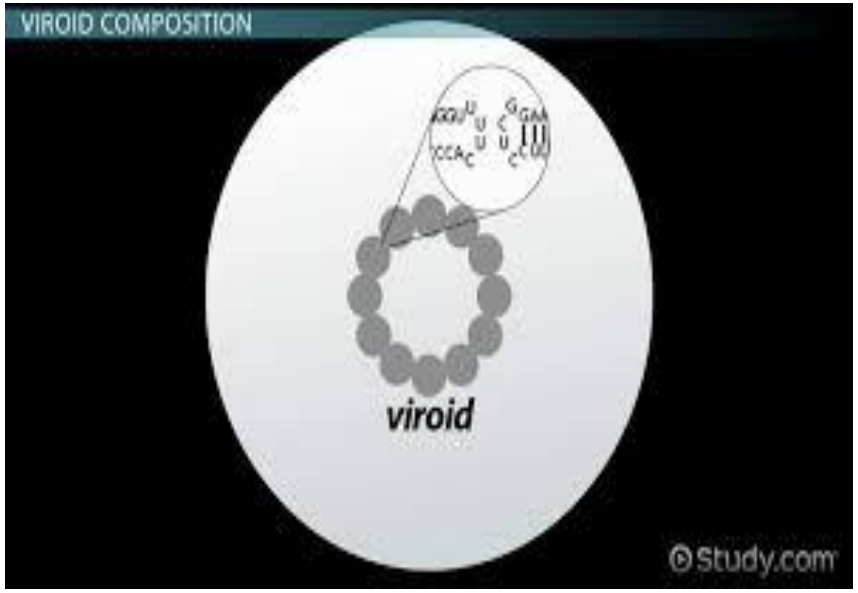
- Kuru - discovered in 1057 in New Guinea by K. Gaidushek. Central nervous system disorders occur during Kuru disease
- Creutzfeldt–Jakob disease is characterized by progressive dissimilation symptoms of the pramidal and expramidal nerve pathways.
- Epizootics of spongiform encephalopathy in cattle (cattle rabies) began in 1996 in England, Northern Europe
- Prion diseases do not cause immunity

Diagnosis

- Recognition of pathological processes caused by prions is based on histological examination of relevant tissues (nerve tissue).
- The nature of the pathological process is studied in histological sections prepared from the brain.

VİROİDS

• Viroids are structurally composed of a single stranded RNA
•They are protein-free viruses
•They have no antigenic properties
•Viroids are very small
•The lengths of RNA molecules are 1-10 (-6)
• They are composed of 300-400 nucleotides



Viroids mainly cause diseases in plants (viroid-damaged potatoes)

▲ **Figure 13.21 One effect of viroids on plants.** The potatoes at right are stunted as the result of infection with PSTV viroids.