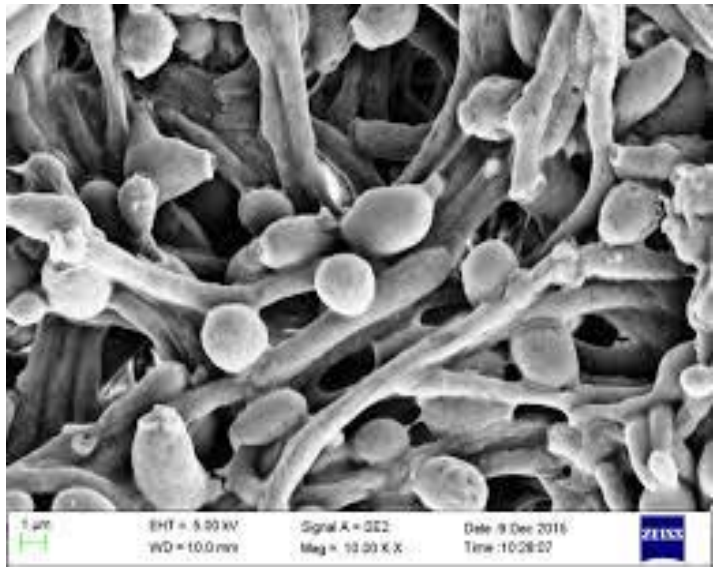
LESSON 2

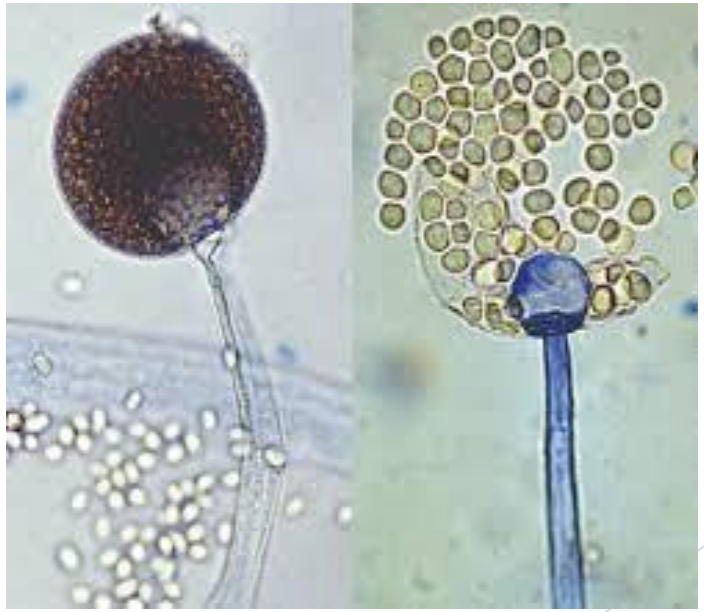
Classification, morphology, ultrastructure and investigation methods of fungi,protozoa and viruses.

Fungal morphology

- Mycelial or hyphal fungi (2-100µm)
- Yeast and yeast-like fungi (2-5 microns)



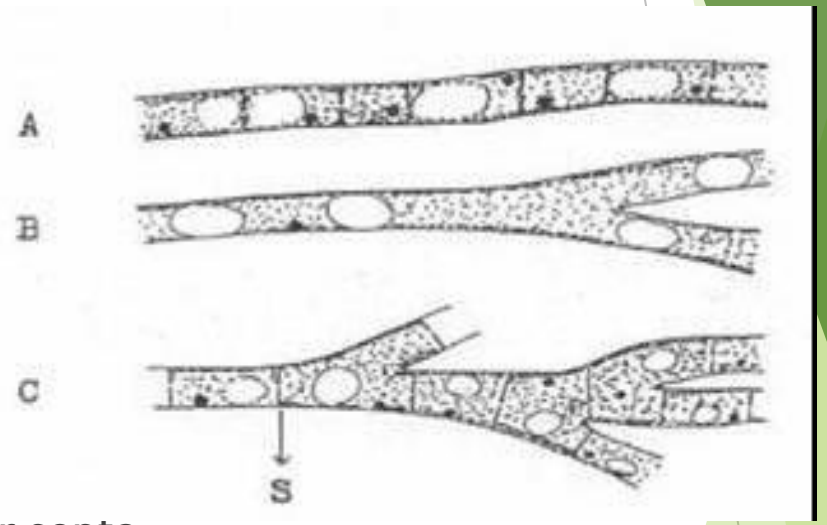
Fungi of the genus Candida (yeast-like)



Mucor (mycelial)

Mycelial or hyphal fungi

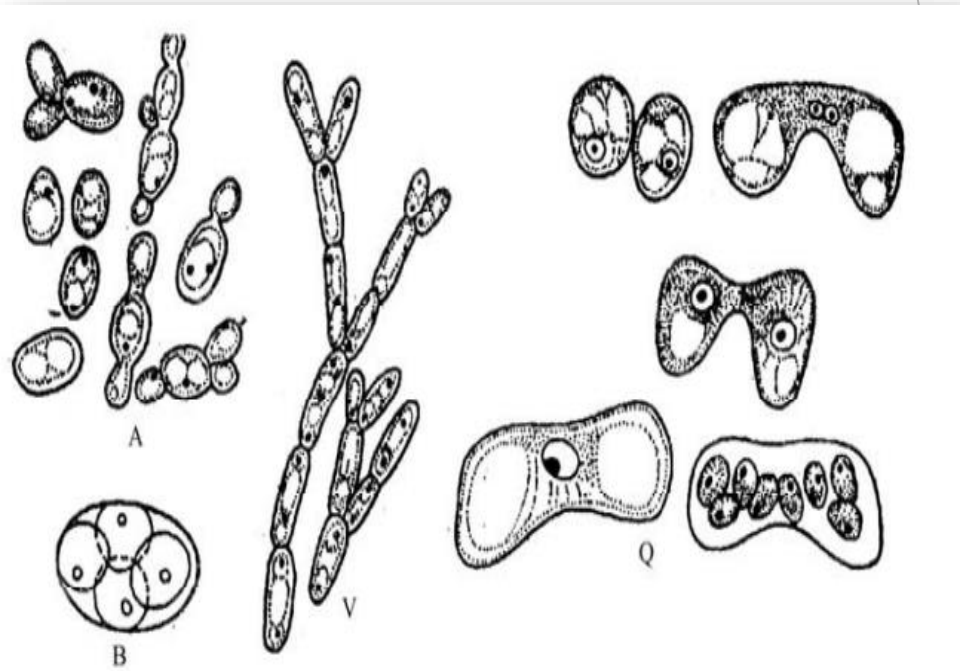
- They are presented in the form of long thin threads (hyphae) 2-50 microns thick.
- Branching hyphae form the mycelium.
- Mycelia come with a partition and without a partition.
- Hyphae of lower fungi do not have partitions.
-
- The hyphae of higher fungi are separated by partitions, or septa.
- Hyphae that grow into the nutrient substrate are called vegetative hyphae.
- Hyphae growing above the surface of the substrate are called aerial or reproductive hyphae.



Yeast fungi (Saccharomycetes)

- Yeast fungi (yeast) are large single-celled spherical, oval and rod-shaped cells with a diameter of 3-15 microns. They have sexual and asexual types of reproduction.
- Asexual reproduction of yeast fungi occurs by budding.
- Yeast fungi also reproduce using ascospores. In yeast, ascospores are formed inside the cells in bags (asci) in the amount of 2,4,8, etc.
- Yeast fungi are widely used in bread baking,

production of lactic acid products, etc.



***Şəkil 31. Maya göbələkləri**: A – tumurcuqlanan hüceyrələr; B– Saccharomyces cerevisiae kisəsi; V – psevdomitseli; Q – S. octosporada cinsi proses.*

Yeast-like fungi

- Yeasts and yeast-like fungi are morphologically similar to each other.
- These are single-celled fungi of spherical or oval shape that reproduce by budding.
- Sometimes the kidneys, without separating from the mother cell, can form pseudomycelium or false mycelium, consisting of chains of elongated cells. For example, fungi of the genus Candida.

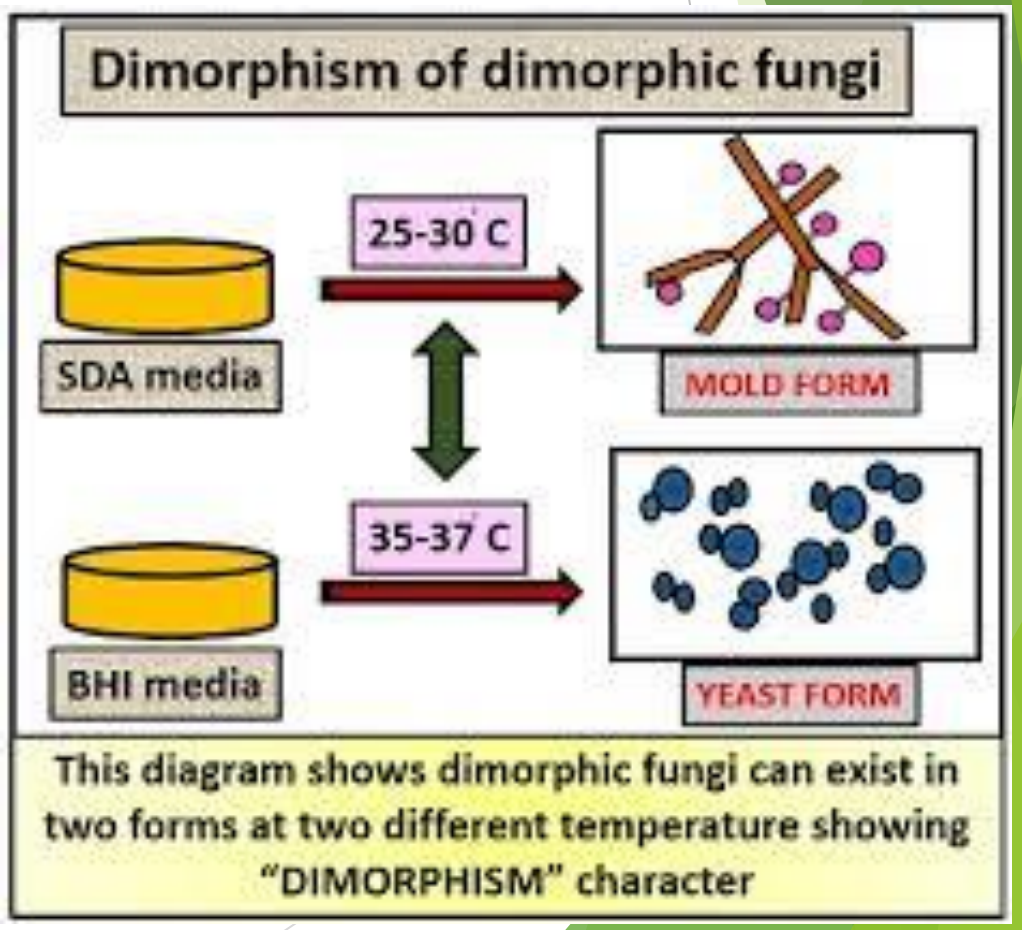
Грибы рода Candida

Dimorphism-morphological polymorphism

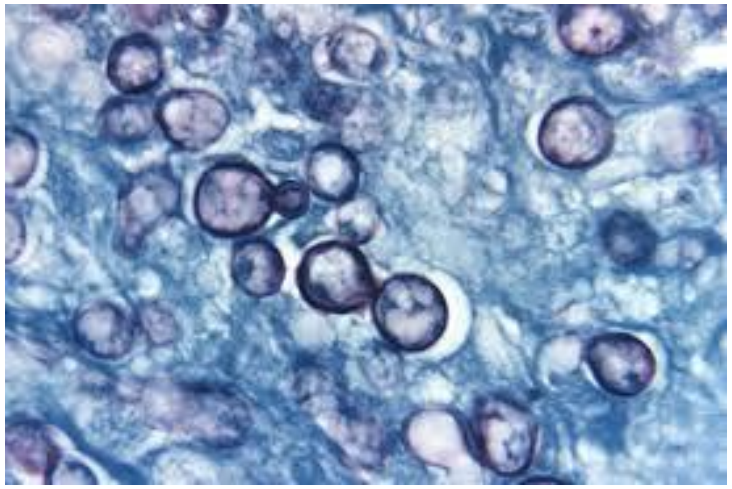
Dimorphism fungi

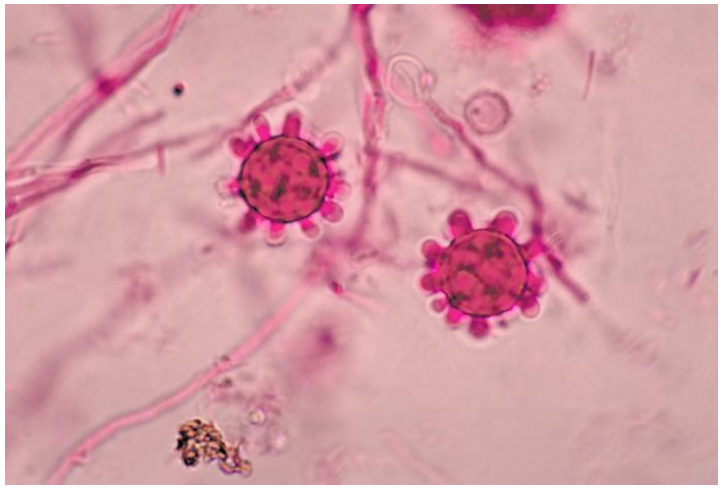
Depending on the living conditions in the infected organism, they grow in the form of yeast-like cells, and on nutrient media they form hyphae and mycelium.

Dimorphism is characteristic of many pathogens of subcutaneous and systemic mycoses.

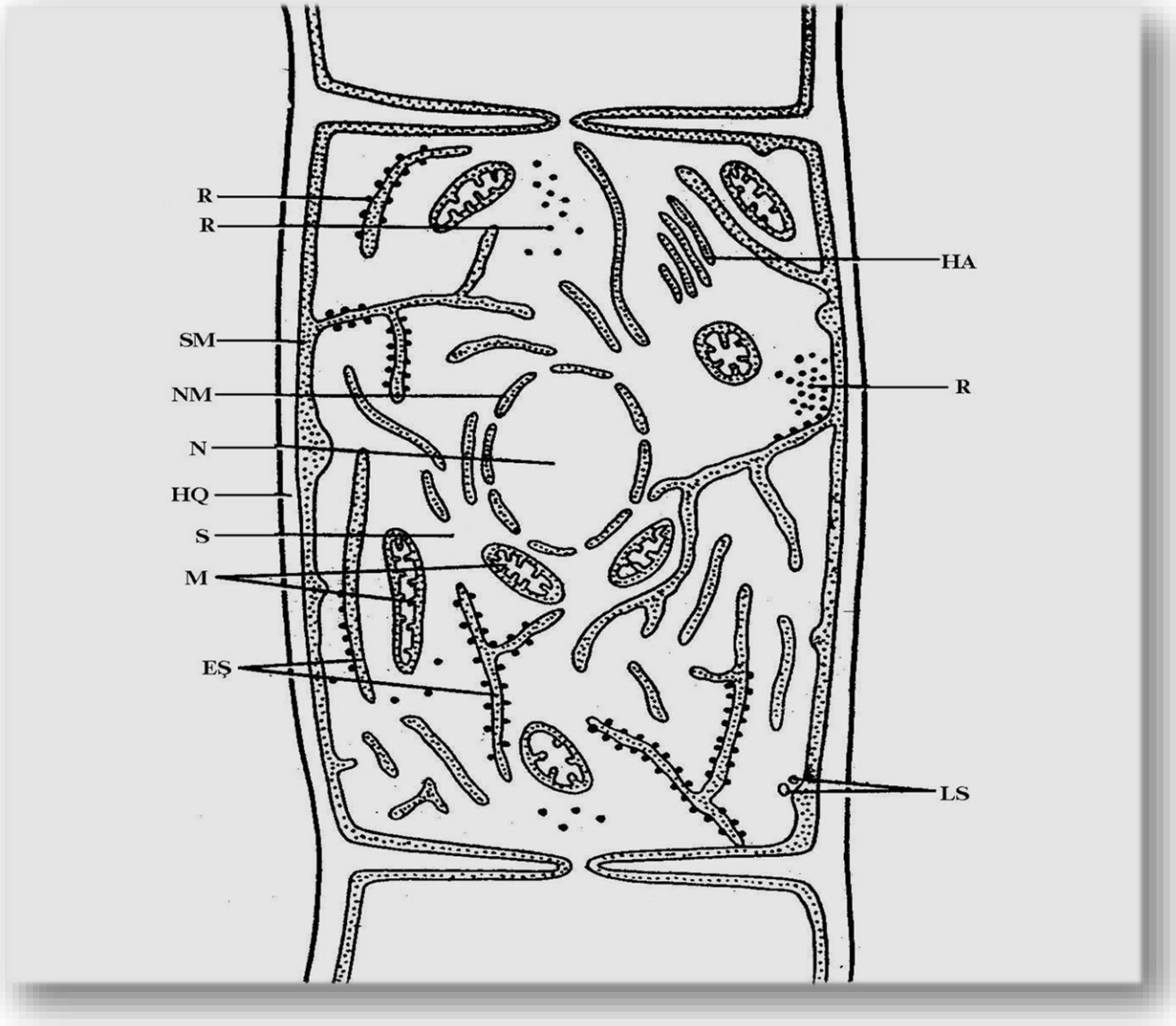


Dimorphism fungi





Hystoplasma capsulatum



Scheme of the cellular structure of the fungus:

R, ribosomes;

HA, Golgi apparatus;

CM, cytoplasmic membrane;

NM - nuclear membrane;

N-Nucleus;

HQ, cell wall;

S-cytoplasm;

M, mitochondria;

EC - endoplasmic reticulum.

Features of reproduction of fungi

- Sexual reproduction of fungi occurs with the formation of sexual gametes, sexual spores (zygospores, ascospores, basidiospores).

- Asexual reproduction occurs by budding, hyphal fragmentation, and asexual spores (arthroconidia, blastoconidia, chlamydoconidia).
- According to the nature of reproduction, fungi are divided into 2 groups:

❖Perfect (reproduce asexually and sexually)

❖imperfect (asexual reproduction)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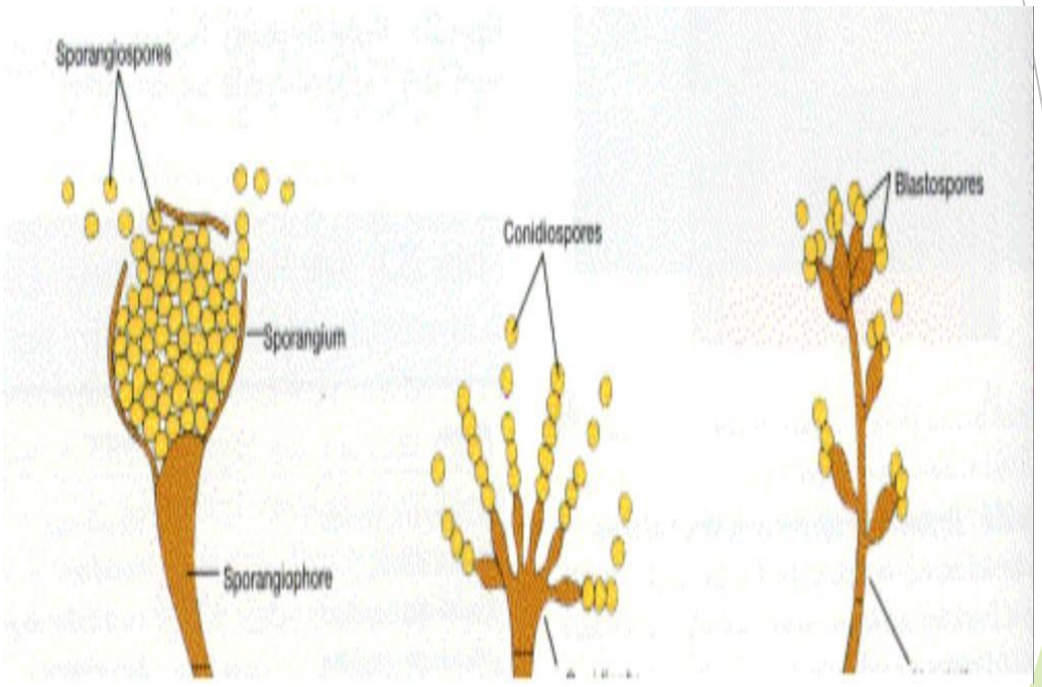
Sexual spores	Representatives
Basidospors *(Basidomycetes)*	**Cryptococcus**
Ascospores *(Askomycetes) septate hyphae*	**Histoplasma, Blastomyces, Piedraia hortae, Coccidiodes, Candida, Saccharomyces cerevisiae**
Zygospores *(Zygomycetes) (unsepted hyphae)*	**Mucor Rhizopus, Apsidia Pilobolus**
Oospores	**Does not cause disease in humans**

Asexual spores	Representatives
Blastospores	**Candida albicans**
Arthrospores	**Dermatofitlər, Trichosporon beigelii, Coccidioides immitis, Geotrichum candidum**
Chlamydospores	**Candida albicans**
Sporangiospores	**Mucor, Rhizopus, Prototheca**
Conidiospores	

Spores as the main reproductive organ of fungi

Spores as the main reproductive organ of fungi

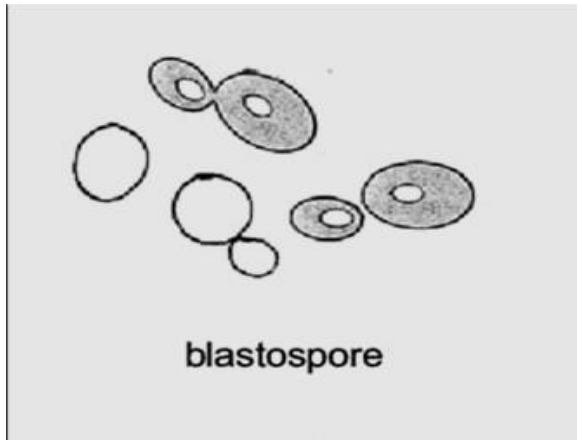
- Endospores mature inside a rounded structure, the sporangium.
- This type of sporulation is characteristic of fungi of the genus Mucor.
- Exospores (conidia) are formed at the tips of fruiting hyphae, the so-called conidiophores.

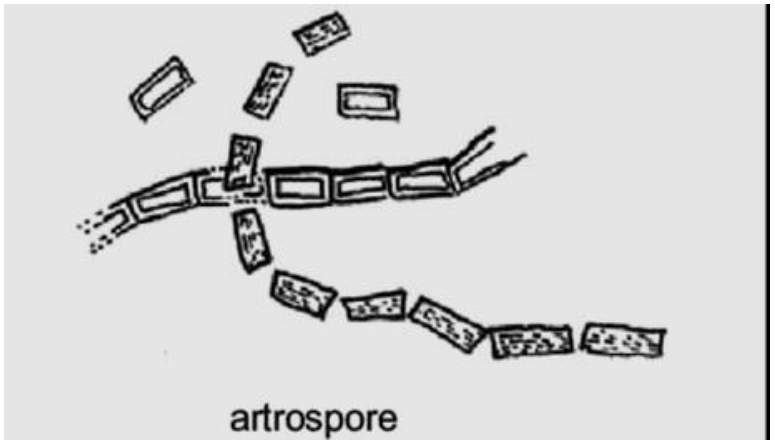


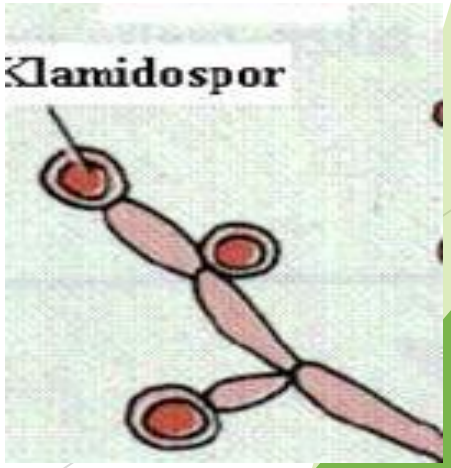
Endospores Exospores

Thallospores

Blastospores	Artrospores (arthros -joint)	Chlamydospores
Characteristic of yeast-like fungi. Blastospores are formed as a result of budding from the mother cell.	They are formed as a result of fragmentation of septate hyphae that break up into individual cells. These cells, surrounded by a membrane, turn into a spore (Geotrichium, Coccidiodies c.).	Formed inside the threads of mycelium or pseudomycelium in the form of thick-walled cells that turn into spores (Candida cinsi).



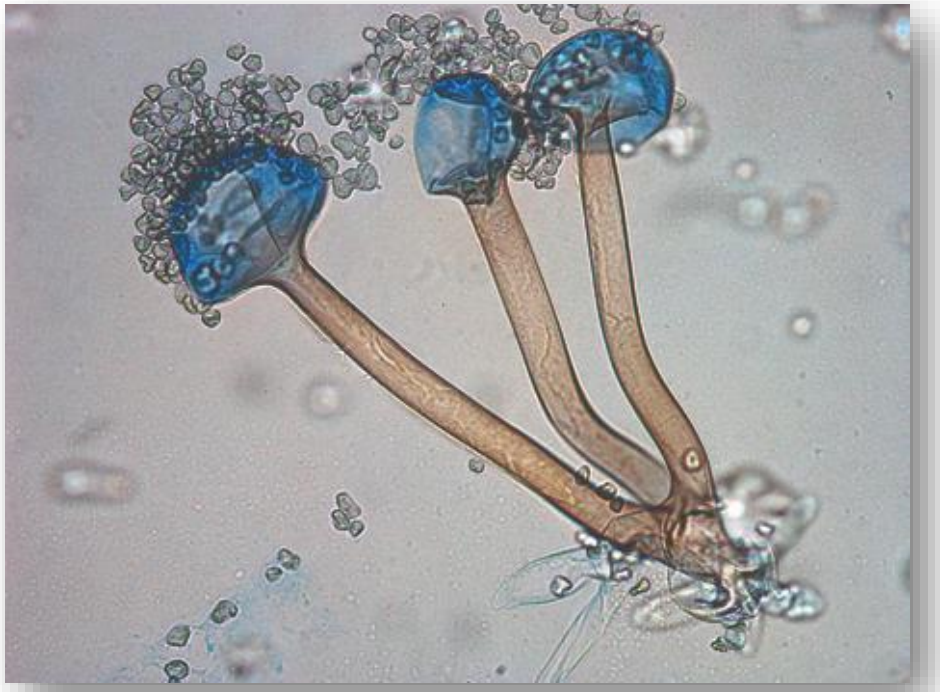




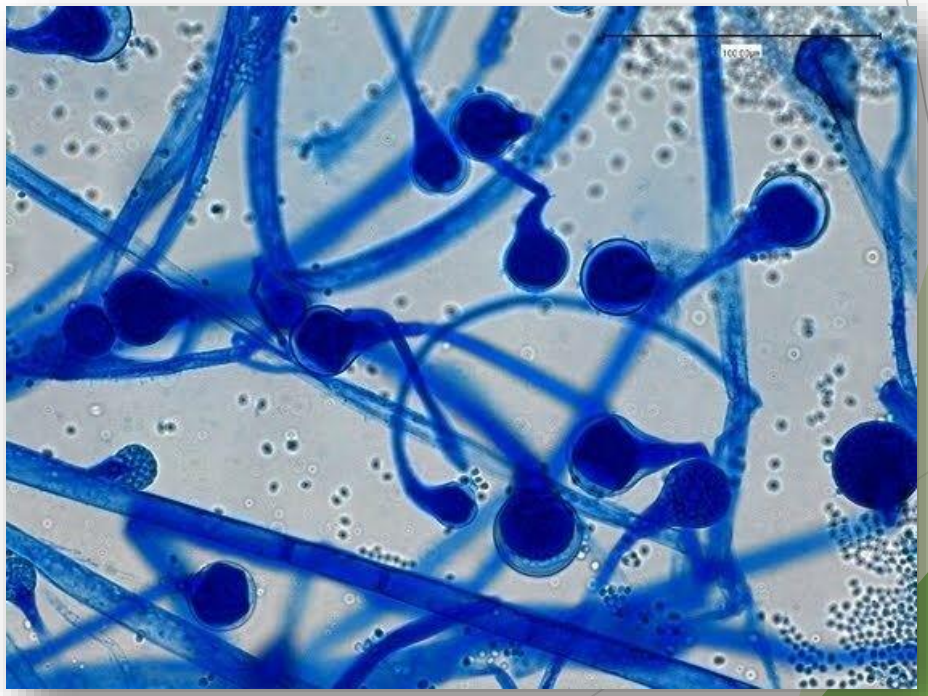
Classification of fungi

Kind Zyqomycota	**Rhizopus** **Absidia**	**Mucor**
Kind Ascomycota	**Blastomyces** **Histoplasma** **Candida cinsləri**	**Microsporium** **Trichophyton** **Coccidoides**
Kind Basidiomycota	**Filobasidiella neoformans** **Cryptococcus neoformans**	**Шляпочные грибы**
Deiteromycota(formal group)	**Epidermophyton** **Paracoccidioides**	**Sporothrix** **Aspergillus**

- ***Zygomycetes (type Zyqomycota) -*** *reproduce sexually and asexually. Sexual reproduction is carried out by the formation of zygospores, asexual reproduction occurs with the help of sporangiospores. Vegetative hyphae are devoid of partitions. Representatives of the genera are pathogenic for humans*
- ***Rhizopus, Absidia, Mucor and others.***

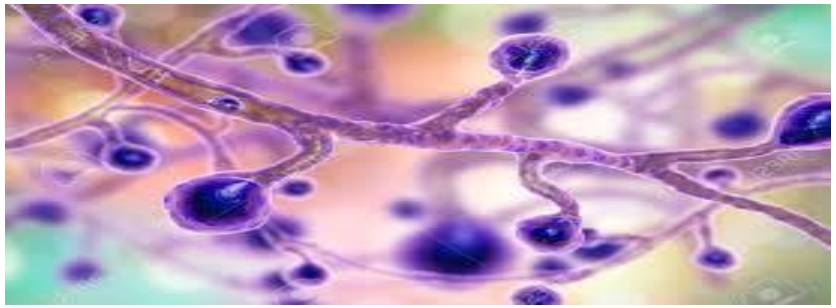


Rhizopus

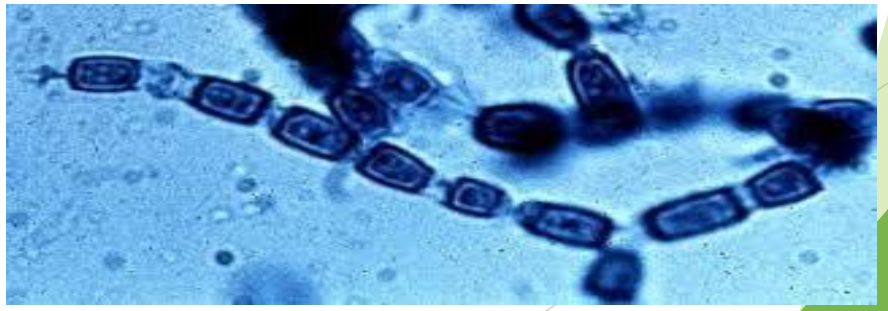


Absidia

Ascomycetes (type Ascomycota) includes a large number of pathogenic fungi of medical importance. Sexual reproduction is carried out with the help of ascospores (spores develop in special bags-asks (ask-bag)), asexual reproduction is carried out by conidia. Vegetative hyphae are septated. Ascomycetes include individual members of the genera Aspergillus and Penicillium, which reproduce only asexually. 85% of fungi are pathogenic for humans muna Ascomycota : *Blastomyces, Histoplasma, Candida* spp, *Trichophyton, Arthroderma, Saccharomyces and oth.*



Blastomyces

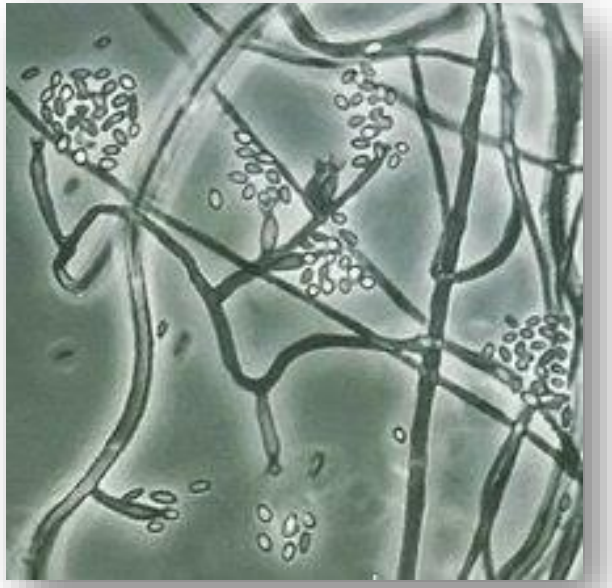


Coccidoides

- *Basidiomycetes (type Basidiomycota) - sexual reproduction is carried out by the formation of basidiospores. The mycelium is represented by numerous partitions.*
- *Pathogenic for humans are Filobasidiella neoformans, Cryptococcus neoformans, etc.*

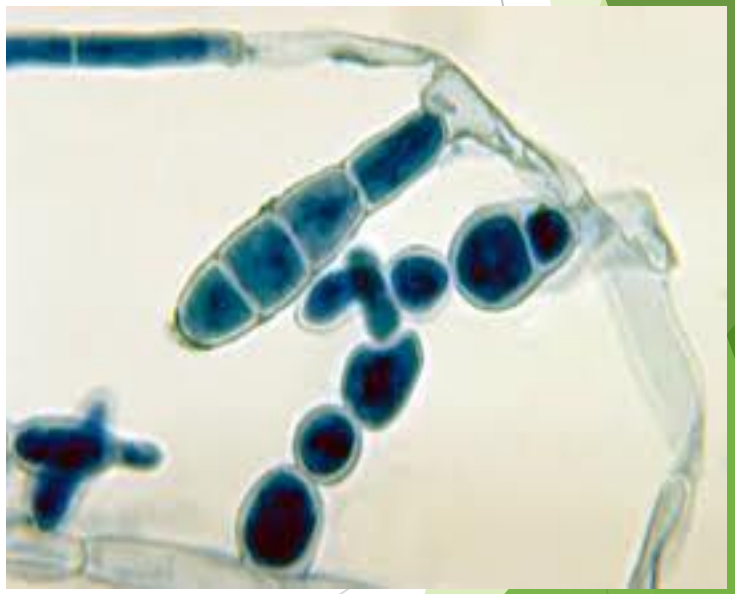
Cryptococcus neoformans

- Deuteromycetes (imperfect fungi-Deuteromycota, Fungi imperfecti) is a conditional, formal taxon of fungi.
- Representatives of the genera are pathogenic for humans *Coccidioides , Sporothrix, Aspergillus, Epidermophyton, Paracoccidioides, Phialophora.*



Phialophora

Sporothrix



Epidermophyton

Methods for studying fungal morphology

- Simple staining method, Gram stain, lactophenol stain, etc.
- Crushed drop microscopy
- Processing of fragments of the skin and its appendages (nails, hair), as well as other clinical samples with an alkali solution to detect elements of the fungus.

Protozoa

Morphology of protozoa

The simplest (Protozoa) (from the Greek protos-first, zoon-animal) are eukaryotic unicellular microorganisms. The sizes of the simplest range from 2 to 100 microns. Outside, the protozoan cell is surrounded by a pellicle membrane, which is an analogue of the cytoplasmic membrane of animal cells. They have a well-shaped nucleus with a nuclear membrane and a nucleolus and a cytoplasm containing organelles.

Morphology of protozoa

Protozoa move using flagella, cilia, or pseudopodia. In some protozoa, supporting microtubules perform the function of locomotion organs. The cytoplasm contains digestive and contractile (excretory) vacuoles. Protozoa reproduce asexually and sexually. The life cycle of some parasitic protozoa is characterized by a change

main and intermediate hosts. In adverse environmental conditions, protozoa form cysts.

The simplest subkingdoms of PROTOZOA are divided into 7 types according to morphological and biological properties. 4 types are pathogenic for humans

Sarcomastigophora

Sarcodina

❖Entamoeba histolytica

Mastigophora

❖Qiardia lamblia
❖Trichomonos hominis
❖Trichomonos tenax
❖L.tropica
❖L.donovani
❖Trypanosoma gambiensae
❖Trypanosoma cruzi

Apicomplexa

Sporozoa

❖**Plasmodium vivax**
❖**Plasmodium malariae**
❖**Plasmodium falciparum**
❖**Plasmodium ovalae**

❖**Toxoplasma gondi**

Ciliophora

❖**Balantidium coli**

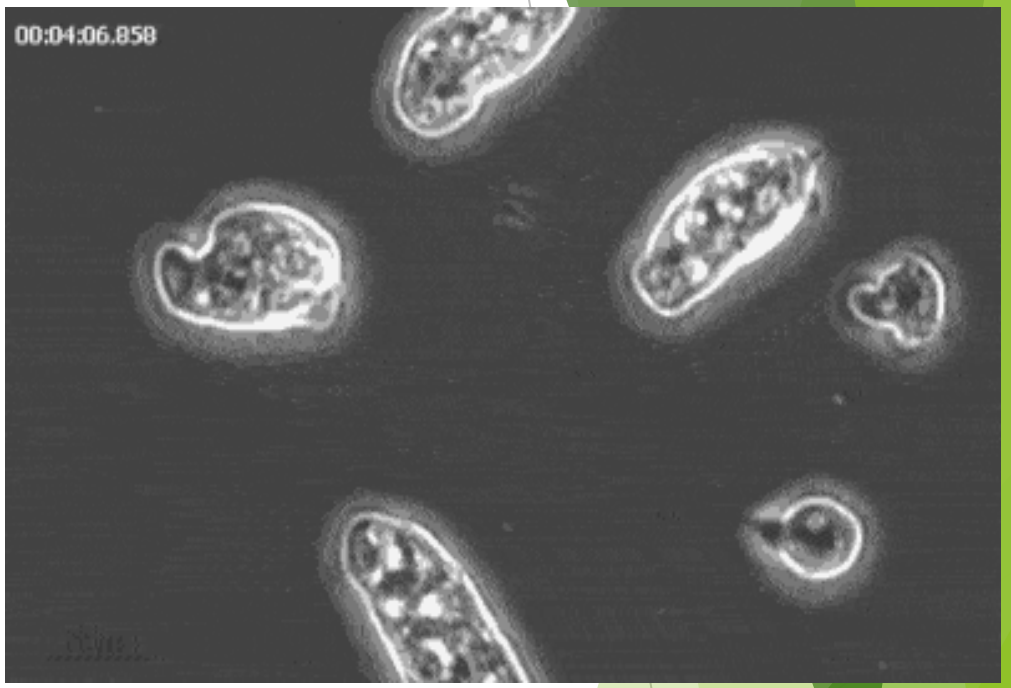
Microspora

Enterocytozoon, Encephalitozoon, Nosema и др.

Sarcomastigophora

Consists of subtypes Sarcodina and Mastigophora

The protozoa of the Sarcodina subphylum have a variable body shape, they move easily by the formation of pseudopodia or cytoplasmic outgrowths. The pathogenic representative is Entamoeba histolytica, the causative agent of amoebic dysentery.



Entamoeba histolytica

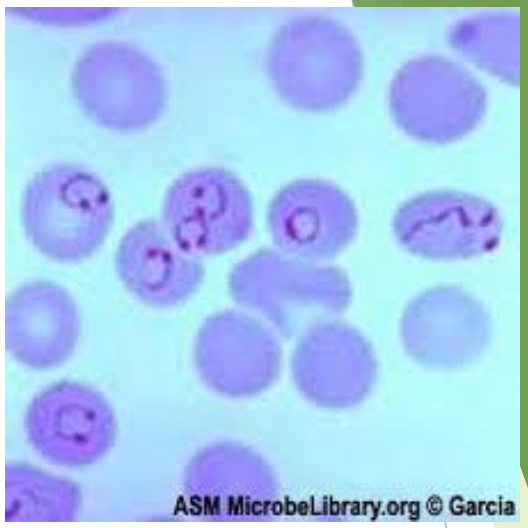
Type Sarcomastigophora

The simplest subphyla Mastigsphora are characterized by the presence of flagella. These include: Leishmania, the causative agent of leishmaniasis, Giardia, the causative agent of giardiasis, Trichomonas, the causative agent of trichomoniasis, etc.

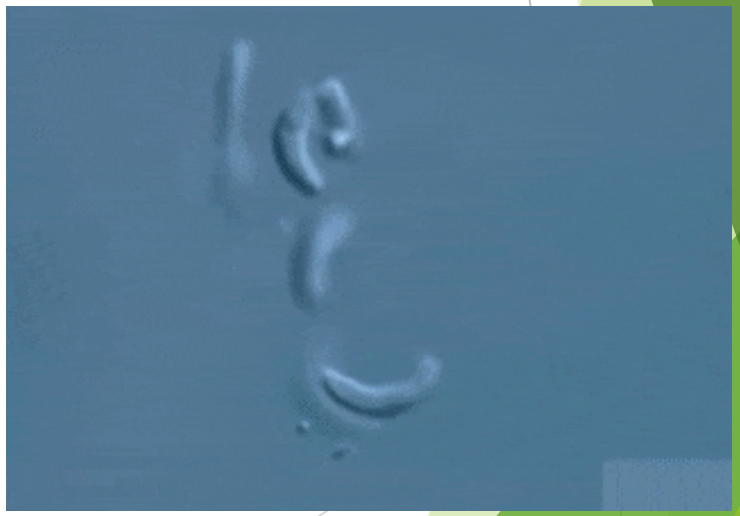
Giardia lamblia

Type Apicomplexa

- *They have an apical complex that allows them to enter the host cell for subsequent intracellular parasitism.*
- *intracellular parasites.*
- *They have a complex life cycle with alternating primary and intermediate hosts.*
- *Pathogenic representatives are Plasmodium malaria, Toxoplasma, etc.*



Malarial Plasmodium inside a red blood cell

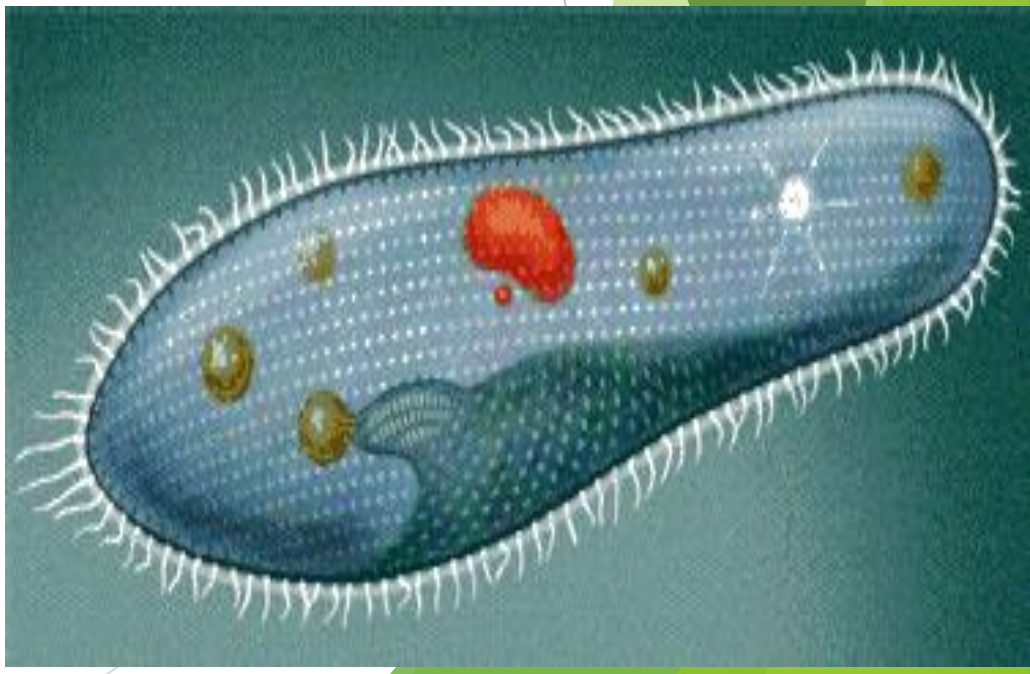


Toksoplazma gondii

Ciliophora

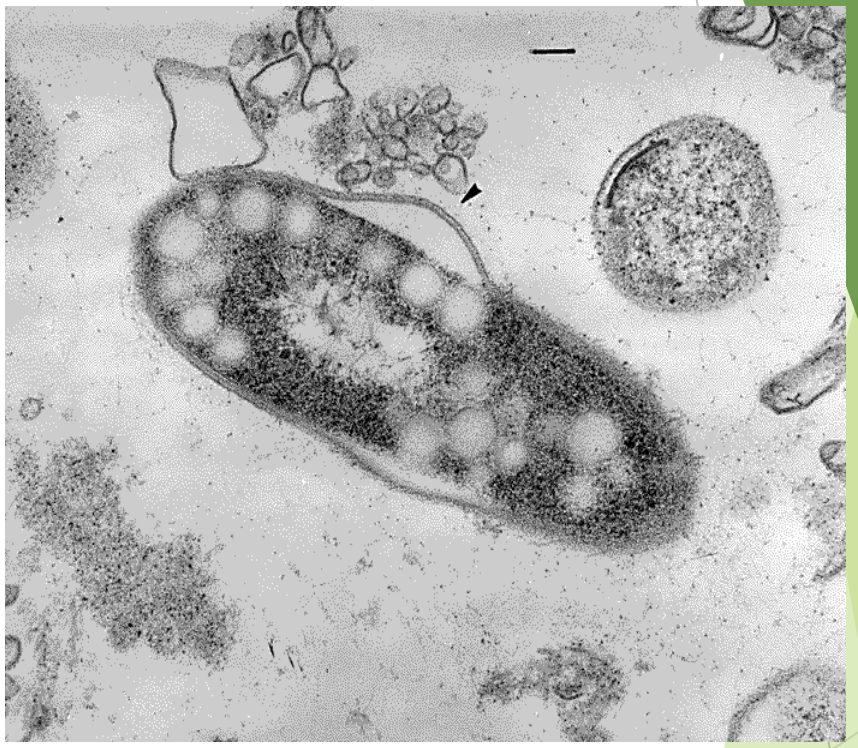
- Representatives of this type are mobile, have numerous cilia covering the entire surface of the body of the parasite.
- The pathogenic representative is Balantidium coli, the causative agent of balantidiasis, which affects the human colon.

Balantidium coli



Microspora

- Microsporidia are obligate intracellular parasites.
- In people with a weakened immune system, they cause diarrhea and purulent-inflammatory diseases.
- They have special spores with infectious material - sporoplasm.



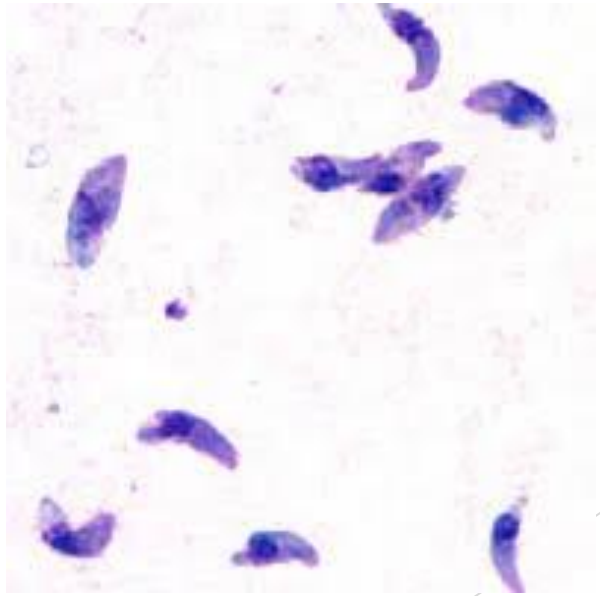
Microspora nosema

The main representatives of protozoa, pathogenic for humans

- Giardia lamblia
- Entamoeba histolytica
- Balantidium coli
- Trichomonos homonis,T.vaginalis,T.tenax
- Plasmodium
- Toxoplasma qondi
- L.tropica,L.donovani
- Trypanosoma gambiensae,T.cruzi

Methods for studying the morphology of protozoa

- Morphological features of protozoa are determined by microscopy of native and stained preparations. The Romanovsky-Giemsa method is usually used (the cytoplasm is stained blue, and the nucleus red).



Methods for studying the morphology of protozoa

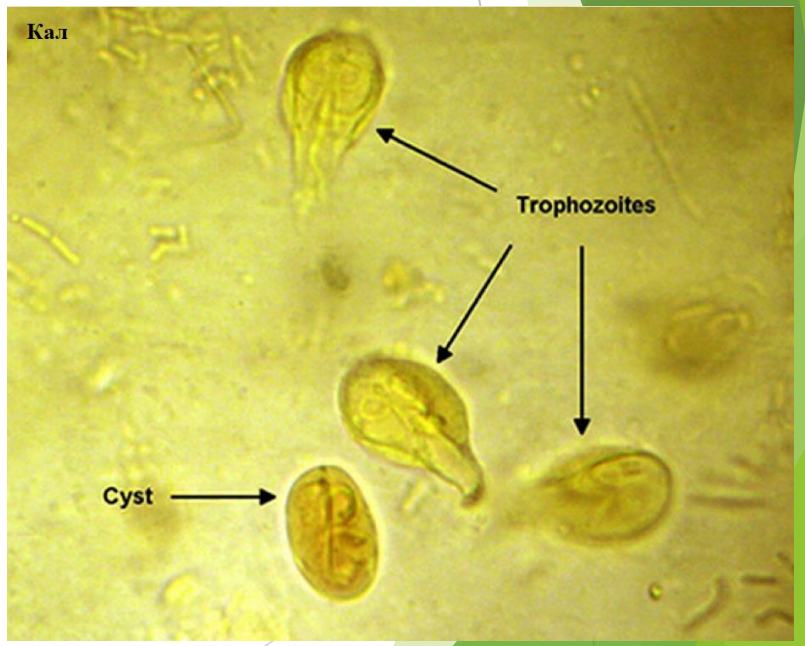
- The morphology of protozoa can be studied in the native state (in "crushed drop" preparations).
- Prepared native preparations are initially microscoped at low magnification (x10), and then at higher magnification (x40) in a dry objective. This allows you to observe the mobility of the vegetative form of parasites.
- Microscopy makes it possible to establish the affiliation of motile parasites observed under a microscope to a certain type (sarcode, flagellates, ciliates). In addition, intraspecific identification of some parasites by characteristic mobility is possible. For example, intense jerky movements are characteristic only for a large vegetative (tissue) form of dysenteric amoeba.

Methods for studying the morphology of protozoa

- In native preparations, parasite cysts, in contrast to vegetative forms, are characterized by a constant form. However, in native preparations, the structure of cysts is difficult to determine, for example, the nuclei of cysts are difficult to distinguish.
- However, in cysts of the dysenteric amoeba, chromatoid bodies can be observed in the form of light spots or clusters.
- For the purpose of differentiation, Lugol's solution is used to stain smears.

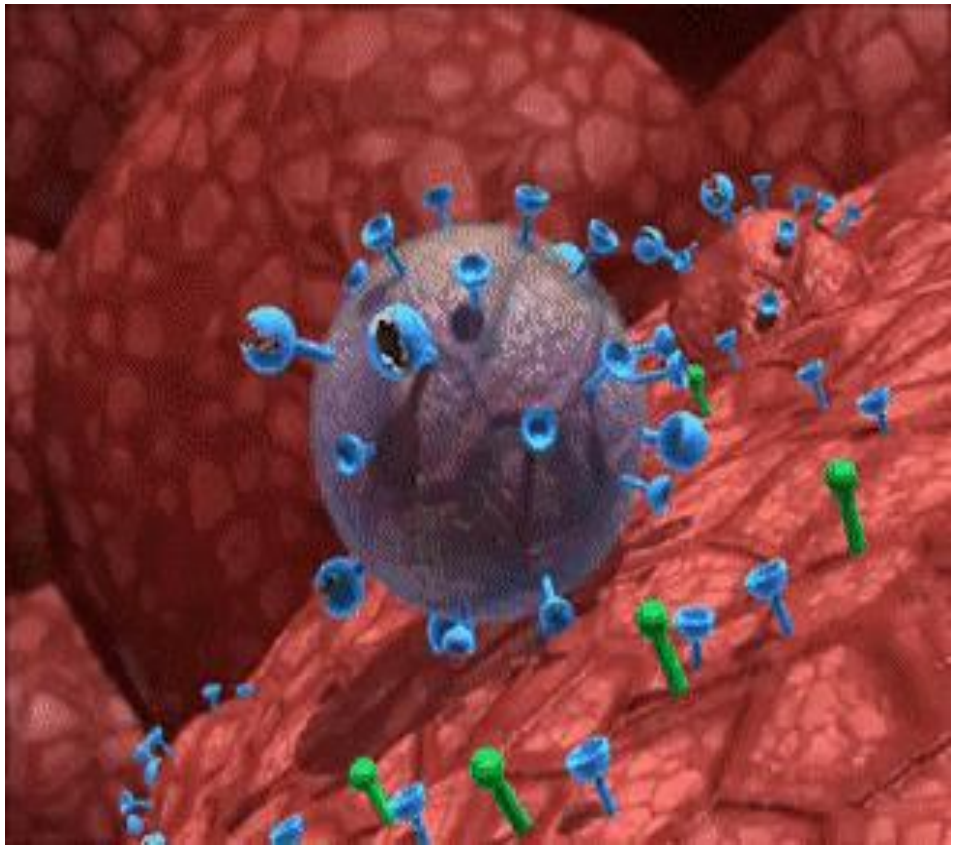
Methods for studying the morphology of protozoa (staining with Lugol's solution)

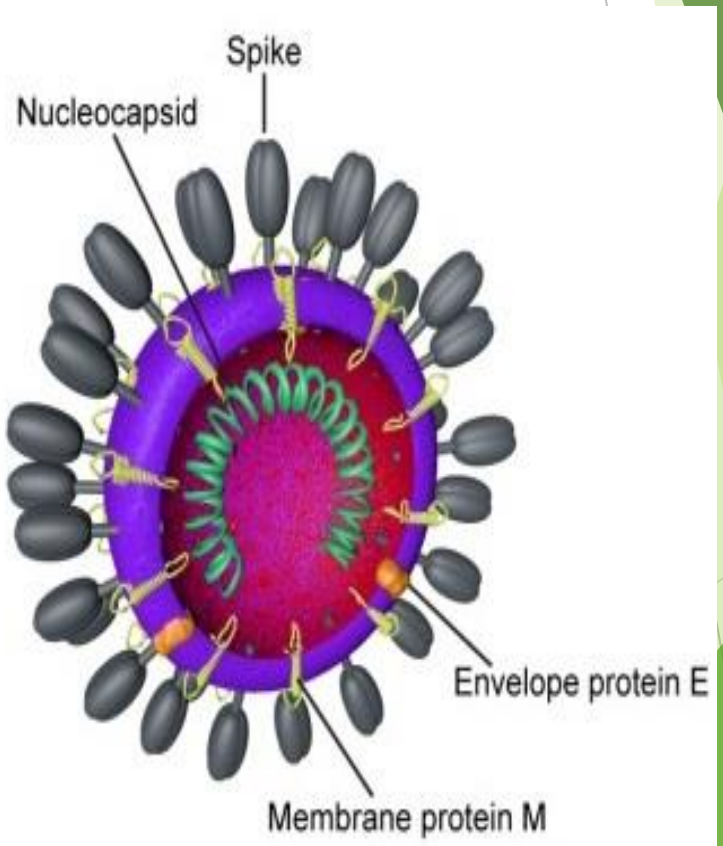
- The composition of Lugol's solution: potassium iodide-3g, crystalline iodine-1.5g, distilled water-100ml. Potassium iodide is initially dissolved in distilled water, and then crystalline iodine.
- In preparations stained with Lugol's solution, parasite cysts are stained golden brown.
- It should be noted that vegetative forms of parasites are difficult to detect in preparations stained with Lugol's solution, since they die upon staining.



Viruses

Morphology of viruses

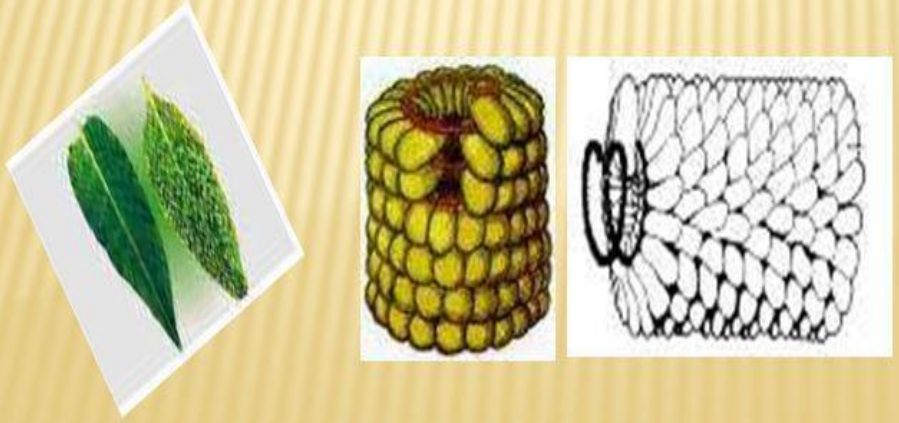




"Virus" in Latin means "poison". For the first time this term was used by L. Pasteur for infectious agents passing through bacterial filters.

Discovery history

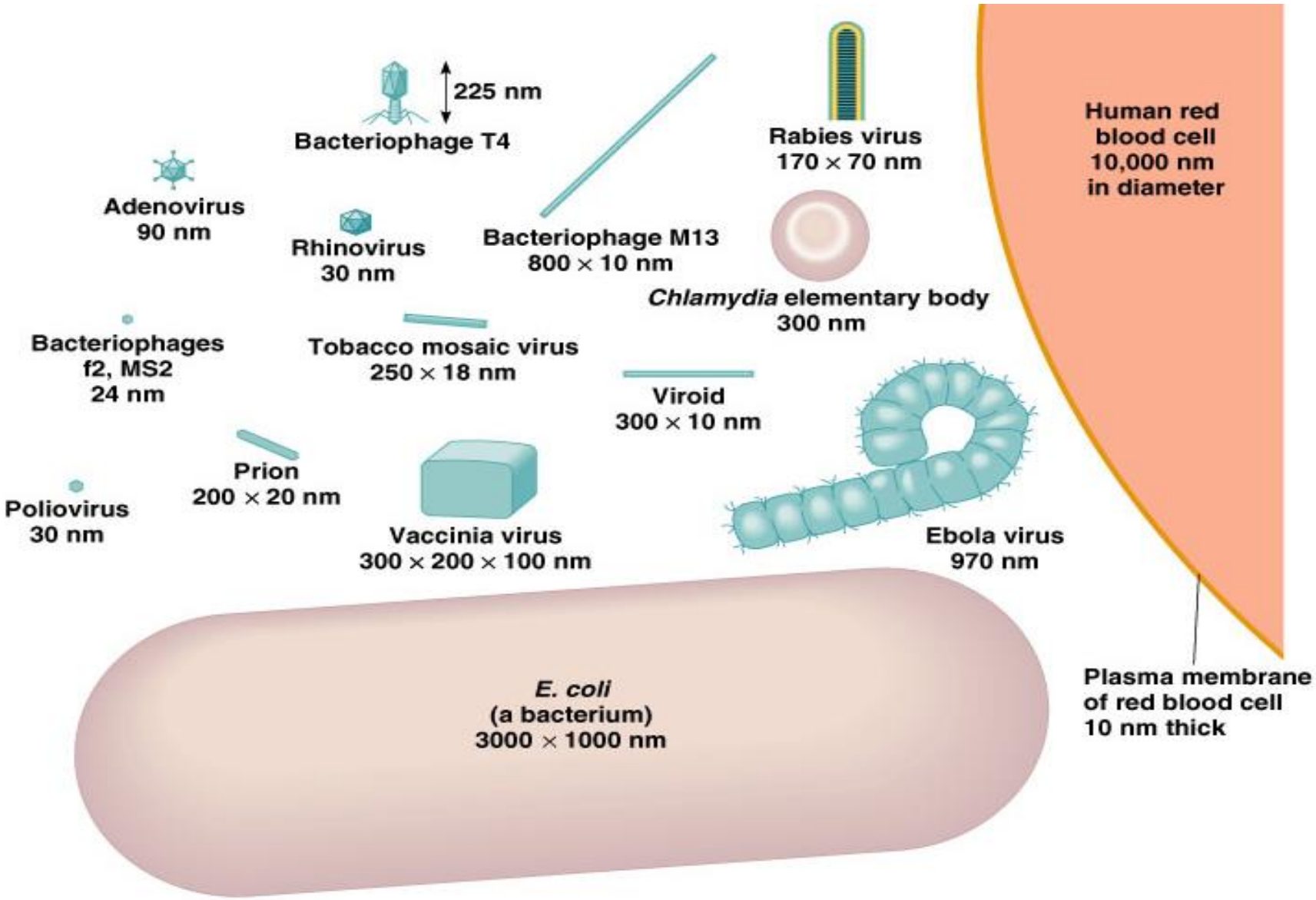
The true discoverer of the world of viruses was D.I. Ivanovsky, who in 1892 discovered filterable ultrafine infectious particles - tobacco mosaic virus.



Distinctive features of viruses from other microorganisms

- Viruses do not have a cellular structure. Unlike other microorganisms, viruses lack a cell membrane, cytoplasm with inclusions, nucleoid, etc.;
- Viruses do not have ribosomes
- They have very small dimensions, calculated in nm (1 nm = 10-3 microns), their sizes range from 15-20 nm to 350-400 nm;
- Viruses contain only one type of nucleic acid, either DNA or RNA;
- Viruses do not reproduce on their own, they are obligate intracellular parasites at the molecular level that do not have their own protein synthesis systems;
- Viruses are characterized by a special disjunctive (disjunctive) method of reproduction (reproduction).

Sizes of viruses (comparison)



Morphology of viruses

Viruses are divided into groups according to the shape of the virion:

Spherical: influenza, mumps, measles viruses

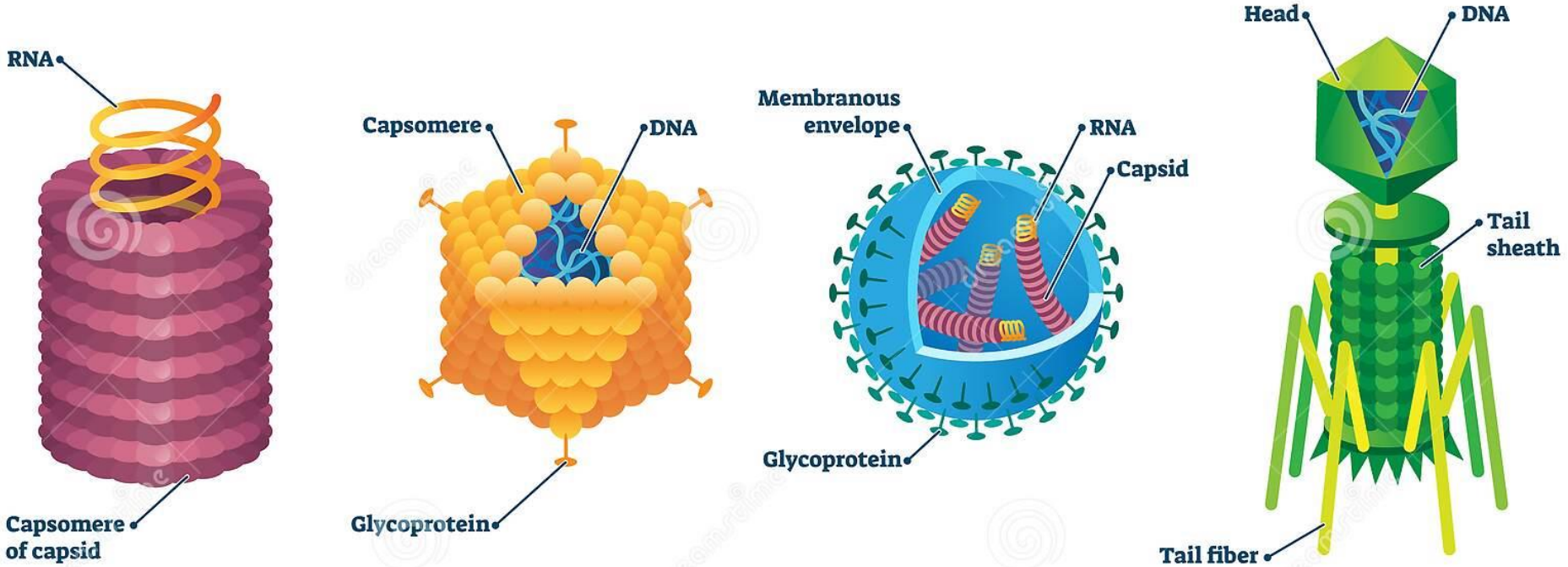
Rod-shaped: tobacco mosaic

Bullet-shaped: rabies virus

Cubic: variola viruses, papillomaviruses, adenoviruses, enteroviruses, reoviruses

Spermatozoa: bacteriophages

TYPES OF VIRUSES



HELICAL

Tobacco Mosaic Virus

POLYHEDRAL

Adenovirus

SPHERICAL

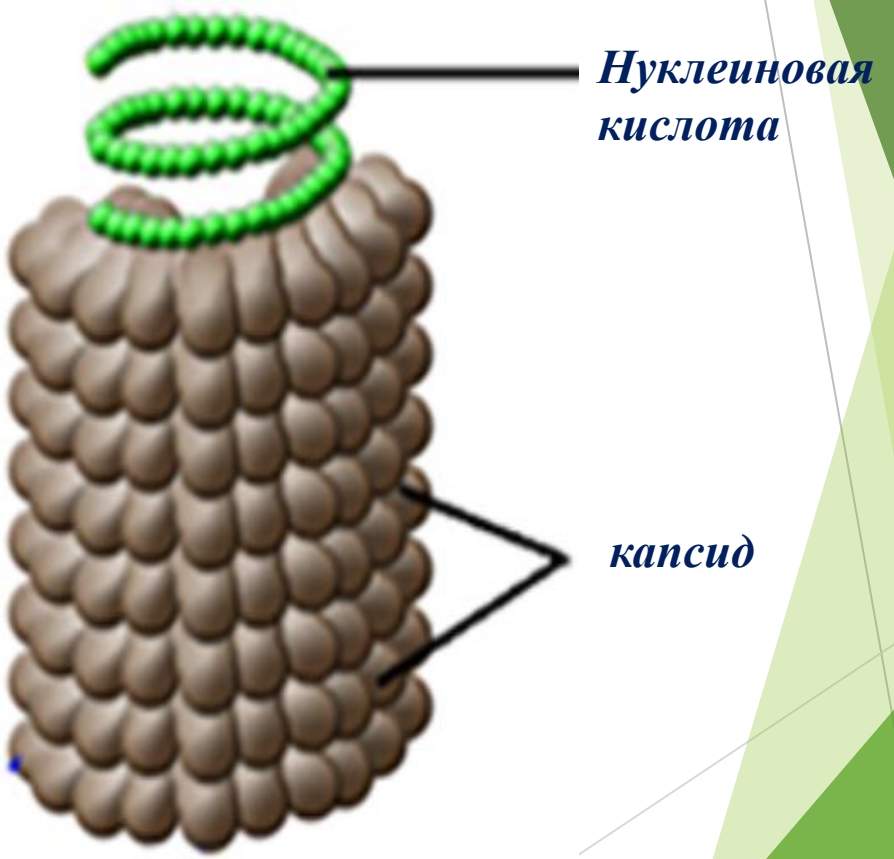
Influenza Virus

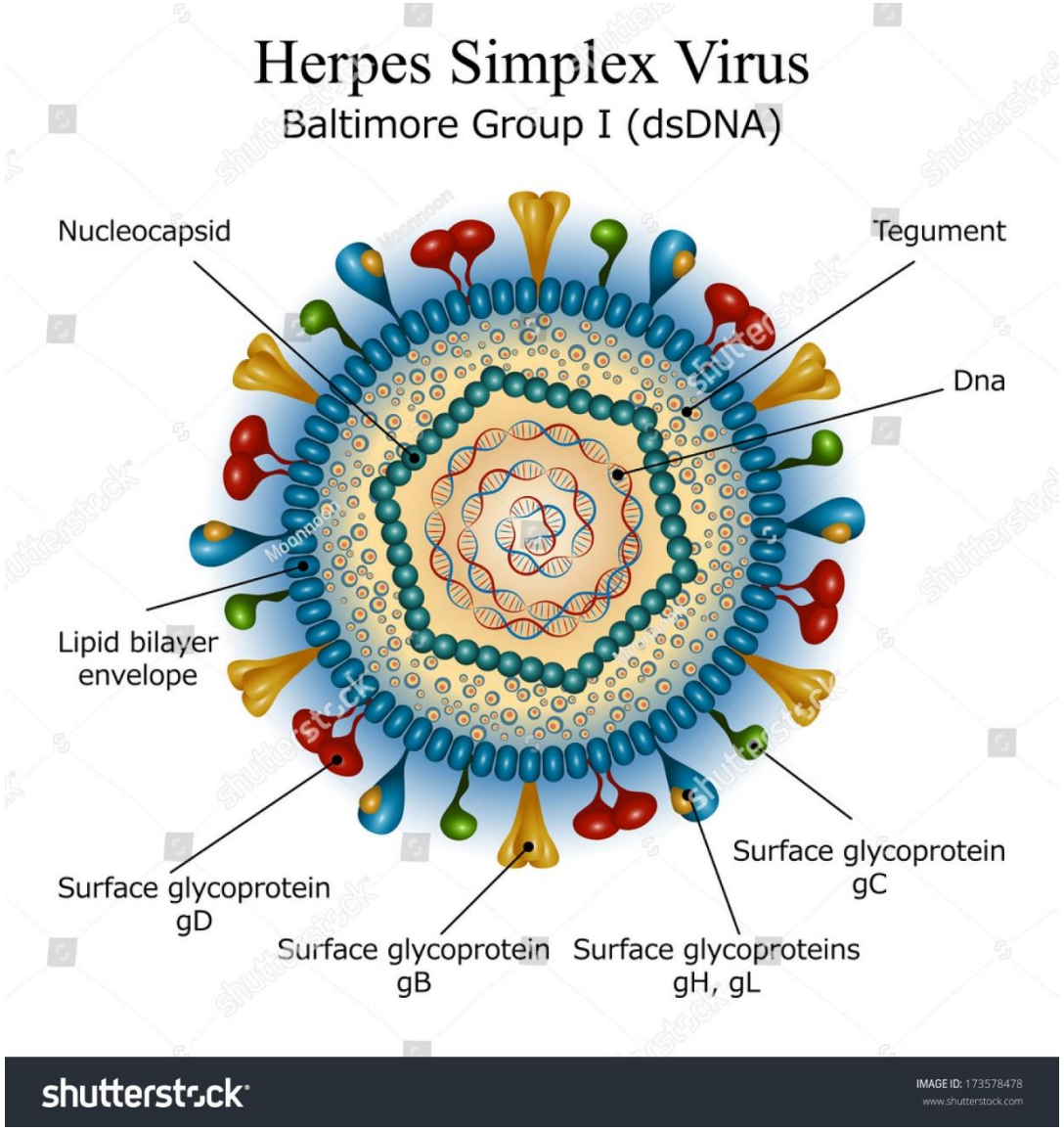
COMPLEX

Bacteriophage

Строение вириона

- В центре вириона расположена нуклеиновая кислота (ДНК или РНК).
- Нуклеиновая кислота покрыта капсидом (от лат. *capsa* - футляр), состоящим из белковых субъединиц-капсомеров
- Т.о., зрелый вирион состоит из нуклеокапсида.




Herpes Simplex Virus
Baltimore Group I (dsDNA)
Nucleocapsid
Tegument
Dna
Lipid bilayer envelope
Surface glycoprotein gD
Surface glycoprotein gB
Surface glycoproteins gH, gL
Surface glycoprotein gC
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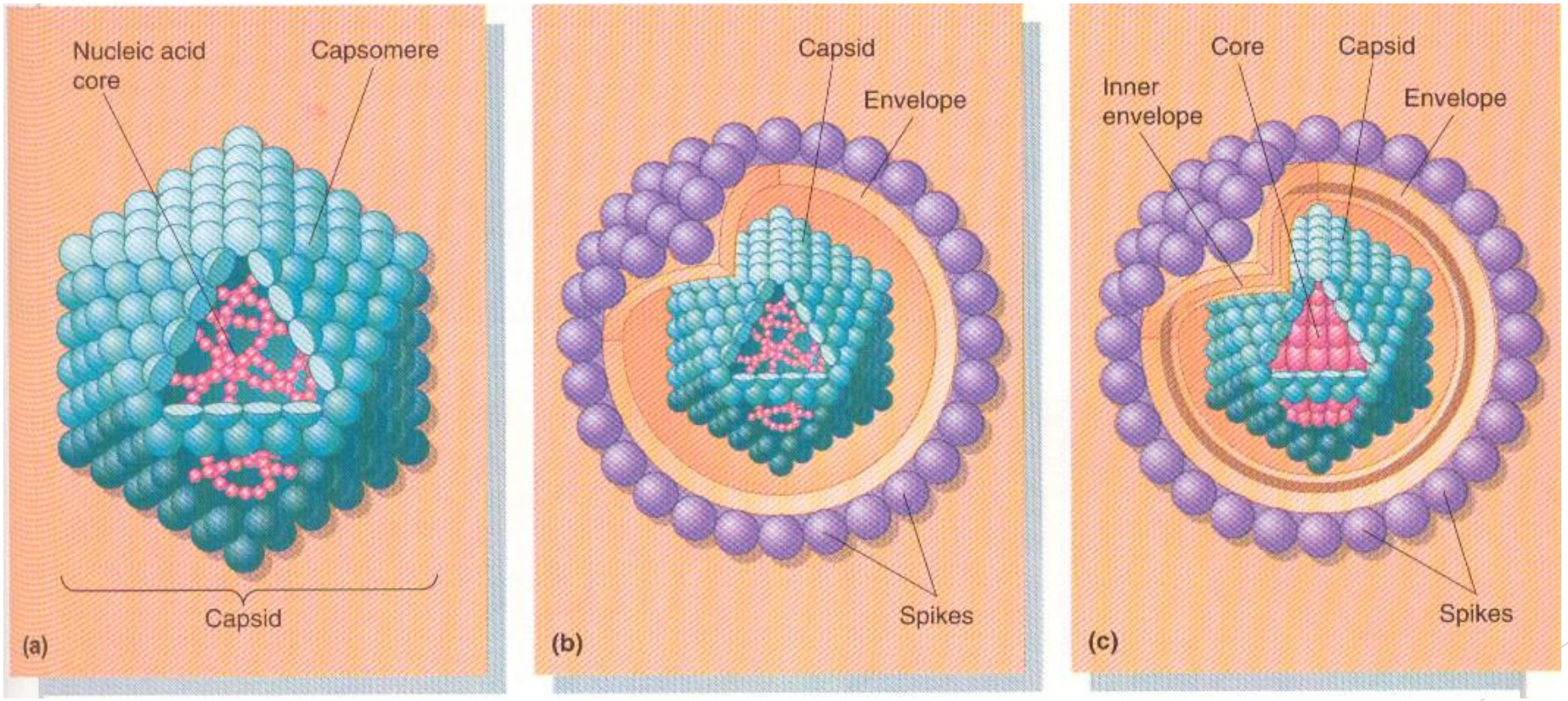
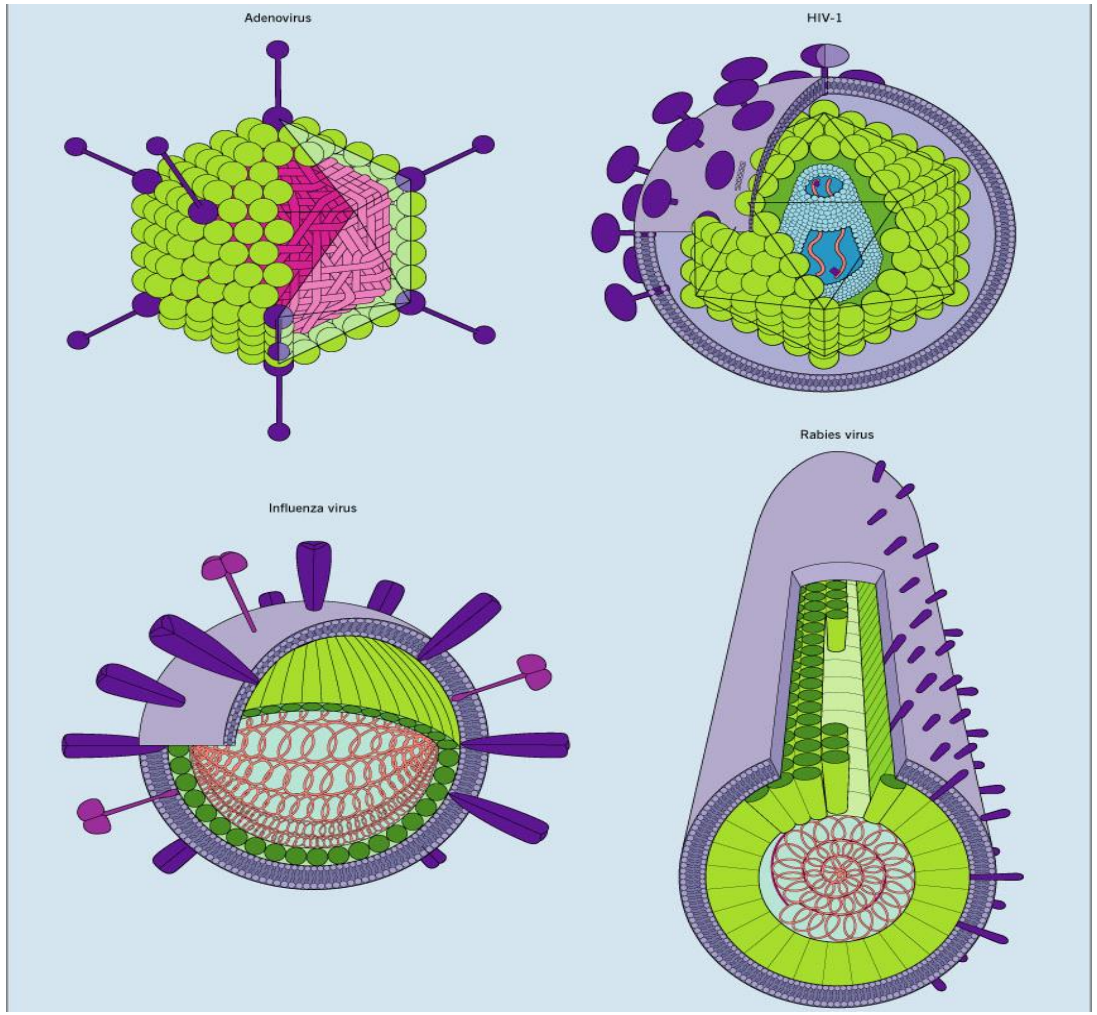
Simple and complex viruses

- Simply arranged viruses have only a nucleocapsid.
- Complicated viruses, in addition to the capsid, have a membrane double lipoprotein shell (supercapsid or peplos).

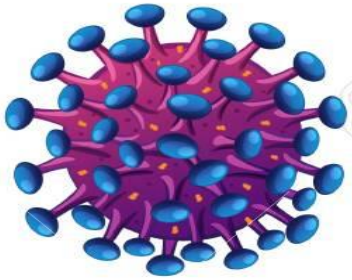
Simple and complex (enveloped) viruses



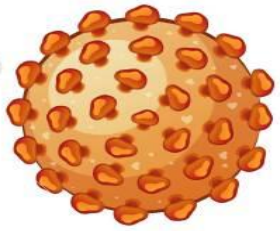
Some complex viruses have glycoprotein spikes (peplometers) on the surface of the envelope.



Virions of various shapes

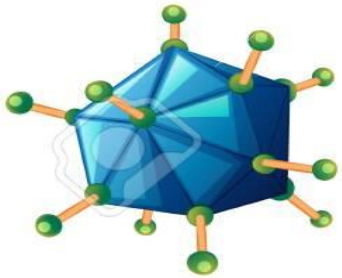


HIV

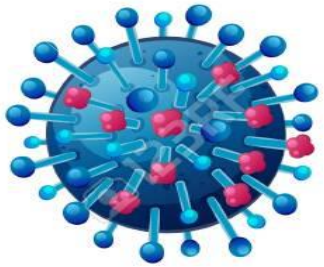


Hepatitis B

Ebola Virus



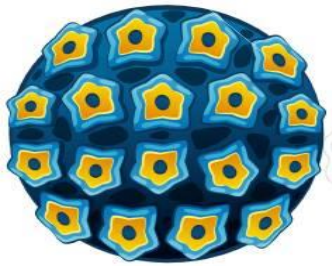
Adenovirus



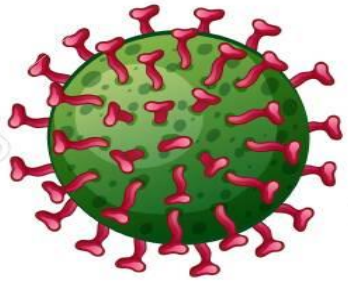
Influenza

Rabies Virus

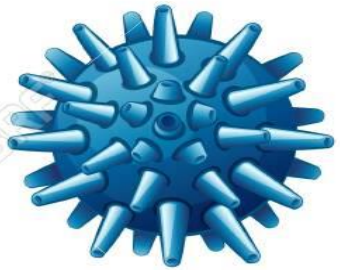
Bacteriophage



Papillomavirus

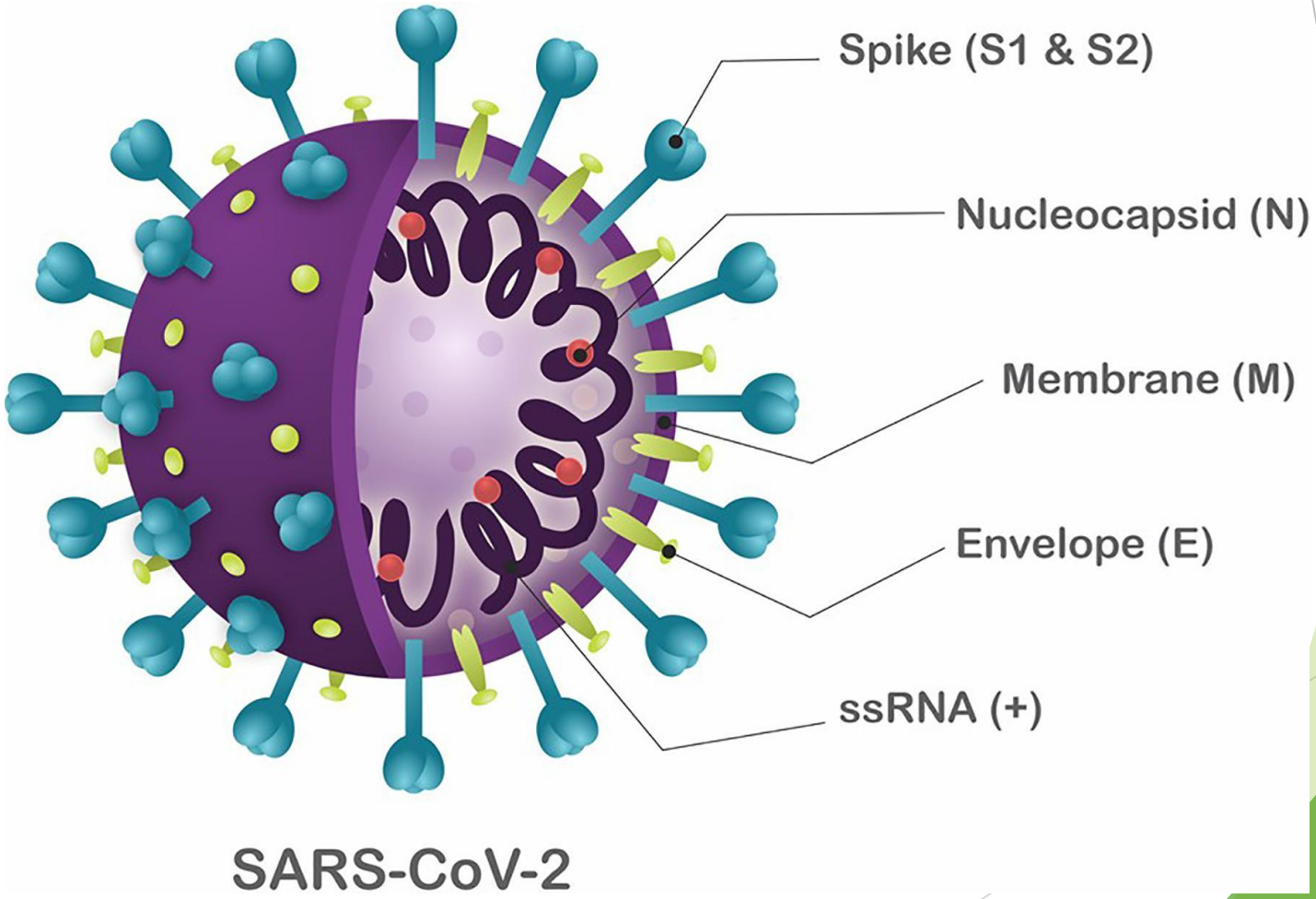


Rotavirus



Herpes Virus

Diagram of the ultrastructure of the Covid-19 virus

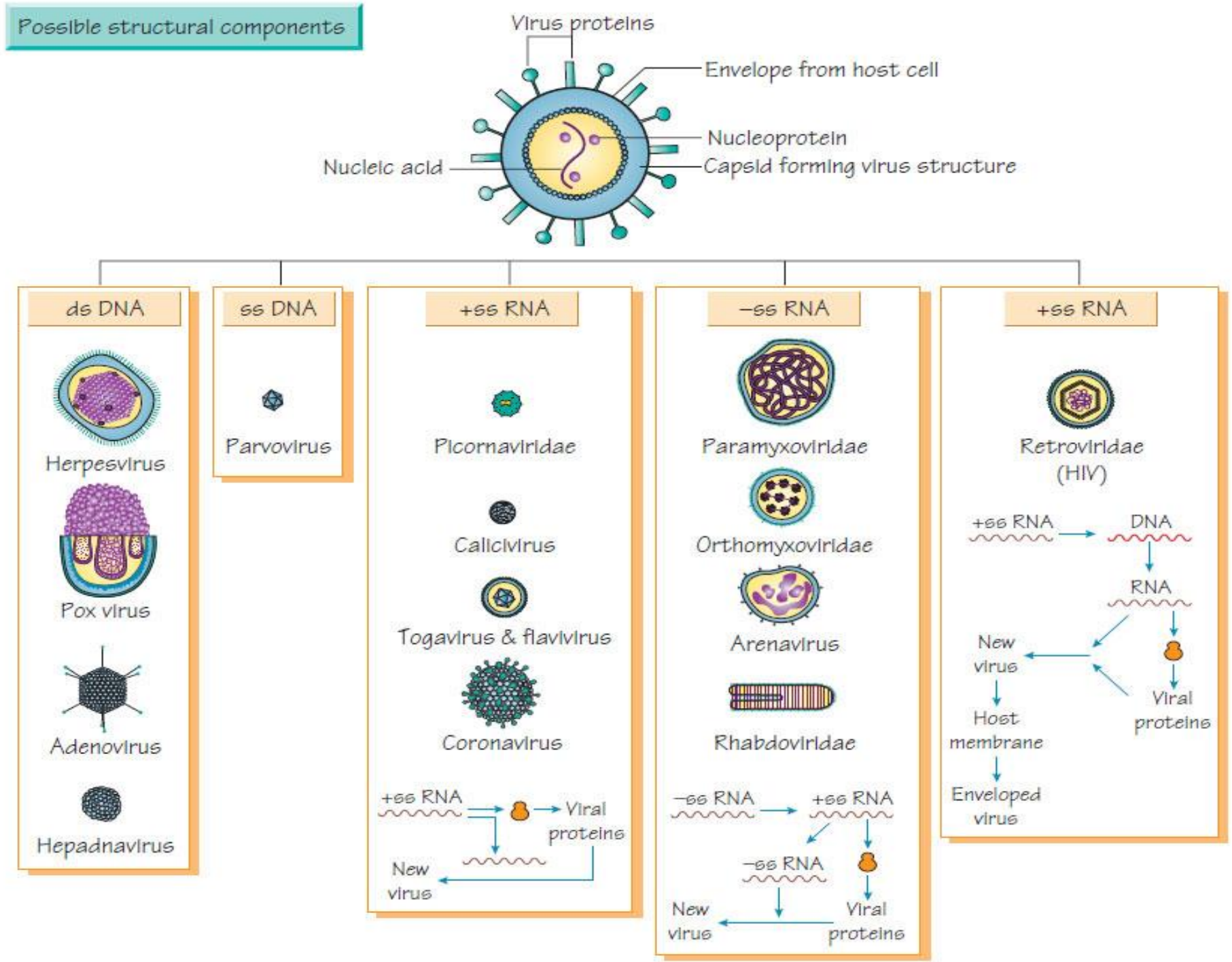


The chemical composition of the virion

- The virion consists of nucleic acid and proteins. Therefore, viruses, based on the chemical composition, can be attributed to nucleoproteins.
- Complicated viruses have a supercapsid of a lipid nature.
- Viruses have virus-specific enzymes necessary for reproduction in the host cell.

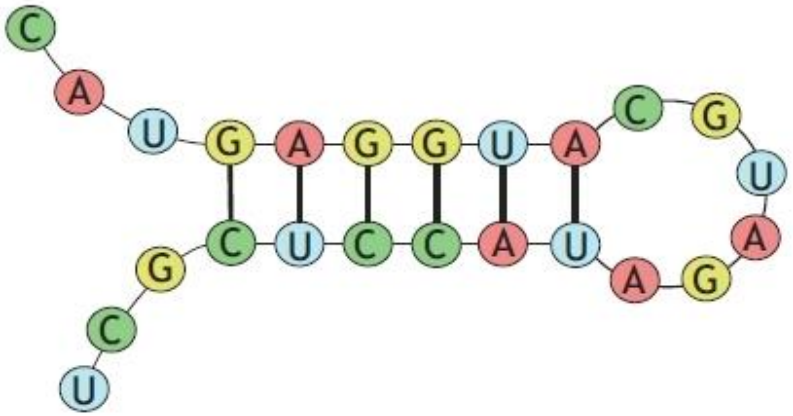
Nucleic acids (DNA)

- Viral DNA can be double-stranded circular (eg, in papillomavirus and polyomaviruses) and linear forms (eg, in herpesviruses)
- Some viruses have single-stranded DNA (for example, parvoviruses).
- The molecular weight of viral DNA is 106-108 D.
- Their molecular weight is 10-100 times less than the mass of bacterial DNA.


Possible structural components
Virus proteins
Envelope from host cell
Nucleoprotein
Nucleic acid
Capsid forming virus structure
ds DNA
Herpesvirus
Pox virus
Adenovirus
Hepadnavirus
ss DNA
Parvovirus
+ss RNA
Picornaviridae
Calicivirus
Togavirus & flavivirus
Coronavirus
+ss RNA
Viral proteins
New virus
−ss RNA
Paramyxoviridae
Orthomyxoviridae
Arenavirus
Rhabdoviridae
−ss RNA
+ss RNA
−ss RNA
New virus
Viral proteins
+ss RNA
Retroviridae (HIV)
+ss RNA
DNA
RNA
New virus
Viral proteins
Host membrane
Enveloped virus

Direct and inverted repeating sequences

- *Viral DNA has a unique nucleotide sequence, with identical nucleotide sequences occurring once, but straight or inverted repeating nucleotide sequences can be found at the ends of viral DNA.*
- *Their presence ensures the ability of the DNA molecule to close into a ring.*



Nucleic acids (RNA)

- *Viral RNA is mostly single-stranded, but can also be double-stranded (such as in reoviruses).*
- *Some viruses have segmented RNA (for example, influenza virus, reoviruses). The presence of segments leads to an increase in the coding capacity of the genome.*

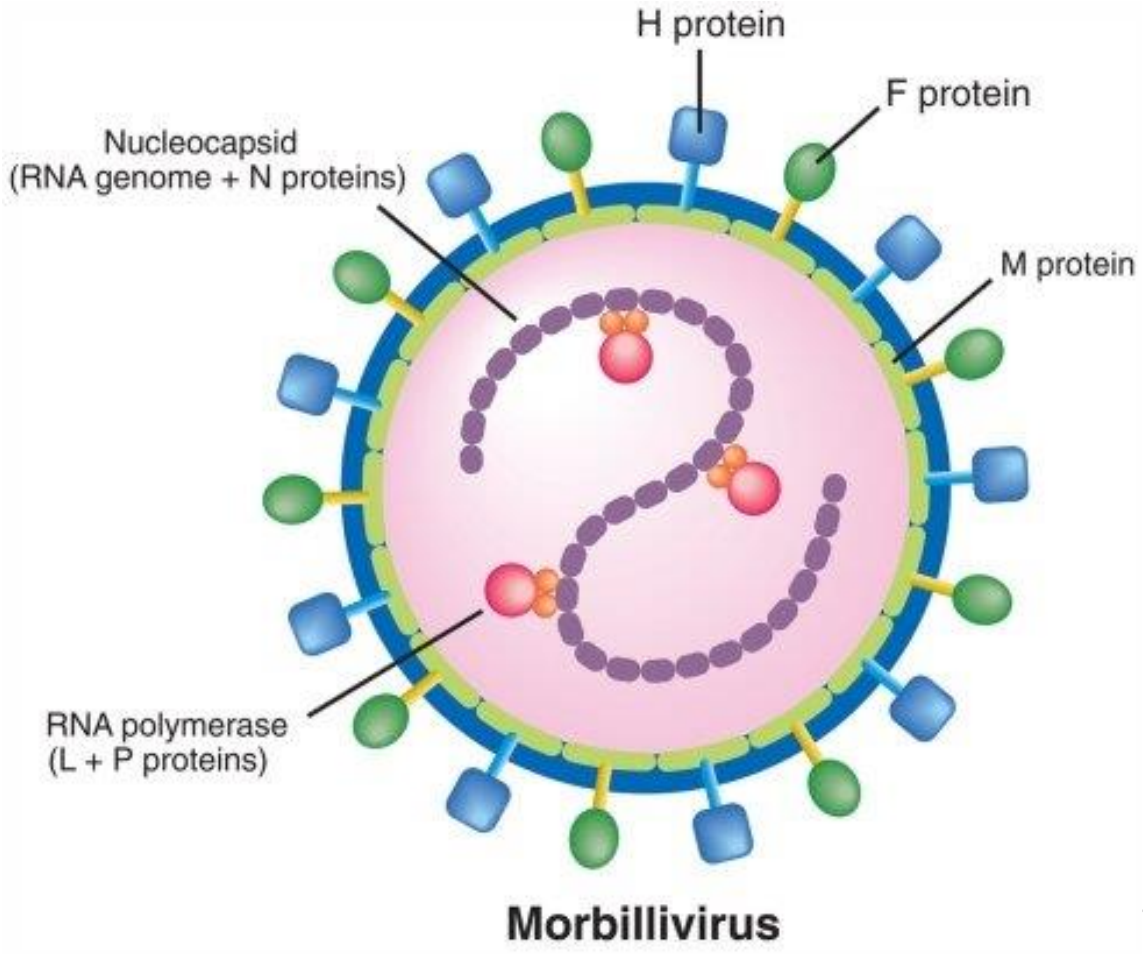
Viral RNAs are divided into the following groups:

- *The plus-strands of RNA of some viruses are capable of translating genetic information on the ribosomes of a virus-infected cell, i.e. perform mRNA functions. These are positive genome viruses.*
- *RNA minus strands are not capable of translating genetic information directly on ribosomes, i.e. they cannot function as mRNA. These are genome negative viruses.*

Virus proteins

- Structural and non-structural proteins (enzymes)
- The capsid shell of viruses is made up of proteins (capsomeres)
- Proteins are also part of the supercapsid of complexly organized viruses (glycoprotein spikes)
- Under the shell of some complex viruses there is a matrix M-protein, which forms a layer on the inner surface of the supercapsid and facilitates its interaction with nucleocapsid proteins, which is important for self-assembly of virions.

Measles virus ultrastructure



Modern principles of virus classification

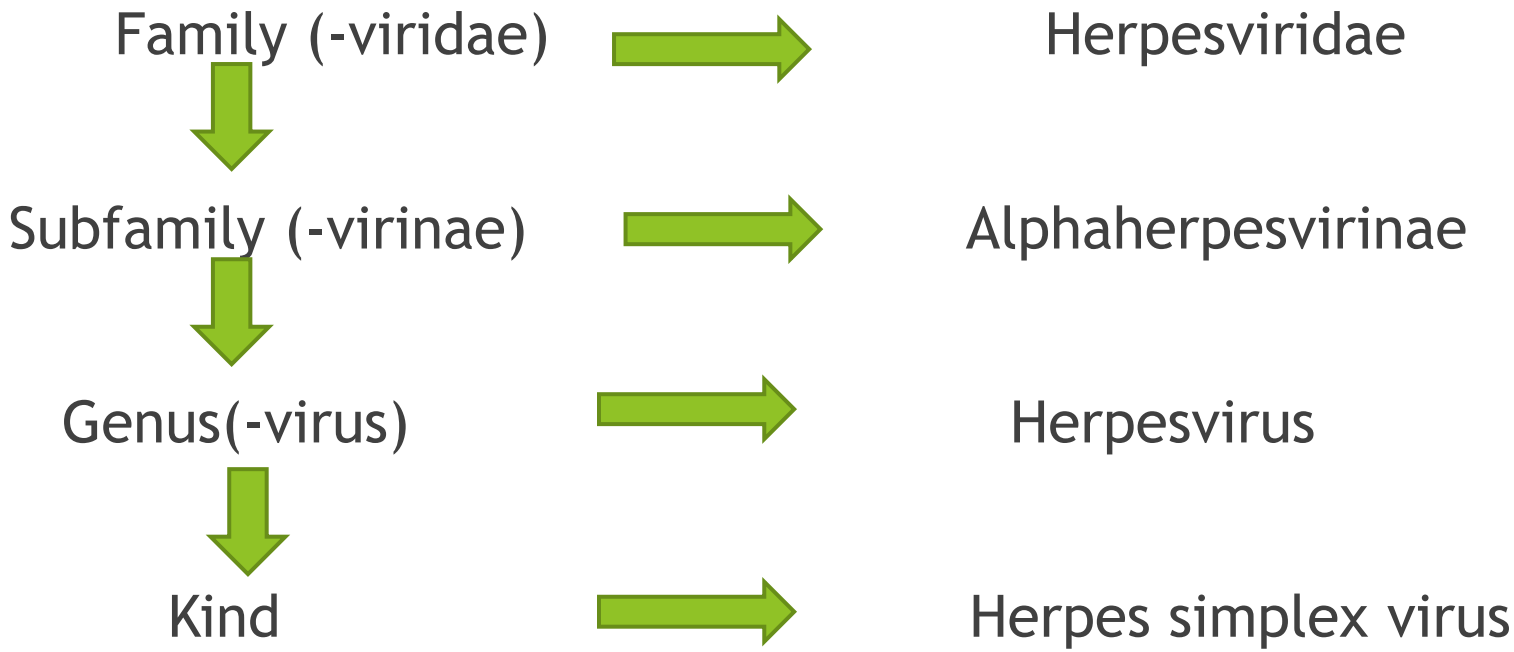
The classification of viruses is based on the following categories:

1. Morphology, sizes and shapes
2. The presence of a shell (supercapsid)
3. Symmetry type of nucleocapsid
4. Features of nucleic acid: molecular weight, type, its structure, number of strands, etc.

Classification of viruses

- According to the type of nucleic acid, viruses are divided into 2 groups:
- RNA-containing
- DNA containing

Nomenclature of viruses



RNA containing viruses

Family	Representatives
Picornaviridae	Viruses of poliomyelitis, hepatitis A, etc.
Togaviridae	Rubella virus, etc.
Flaviviridae	Hepatitis C, yellow fever, Japanese encephalitis, etc.
Caliciviridae	Viruses of gastroenteritis
Coronaviridae	Human coronaviruses, SARS virus, COVİD-19
Retroviridae	AIDS virus
Filoviridae	Viruses Marburg, Ebola
Bunyaviridae	Hemorrhagic fever viruses, etc.
Arenaviridae	Lymphocytic choriomeningitis virus.
Orthomyxoviridae	Influenza viruses
Paramyxoviridae	Measles, parainfluenza, mumps viruses
Rhabdoviridae	Rabies viruses, etc.
Reoviridae	Human rotaviruses, etc.

DNA containing viruses

Family	Representatives
Parvoviridae	Human parvoviruses
Polyomaviridae	Human parvoviruses
Papillomaviridae	Human parvoviruses
Adenoviridae	Human adenoviruses
Herpesviridae	HSV, CMV and oth.
Poxviridae	Variola virus
Hepadnaviridae	Hepatitis virus B