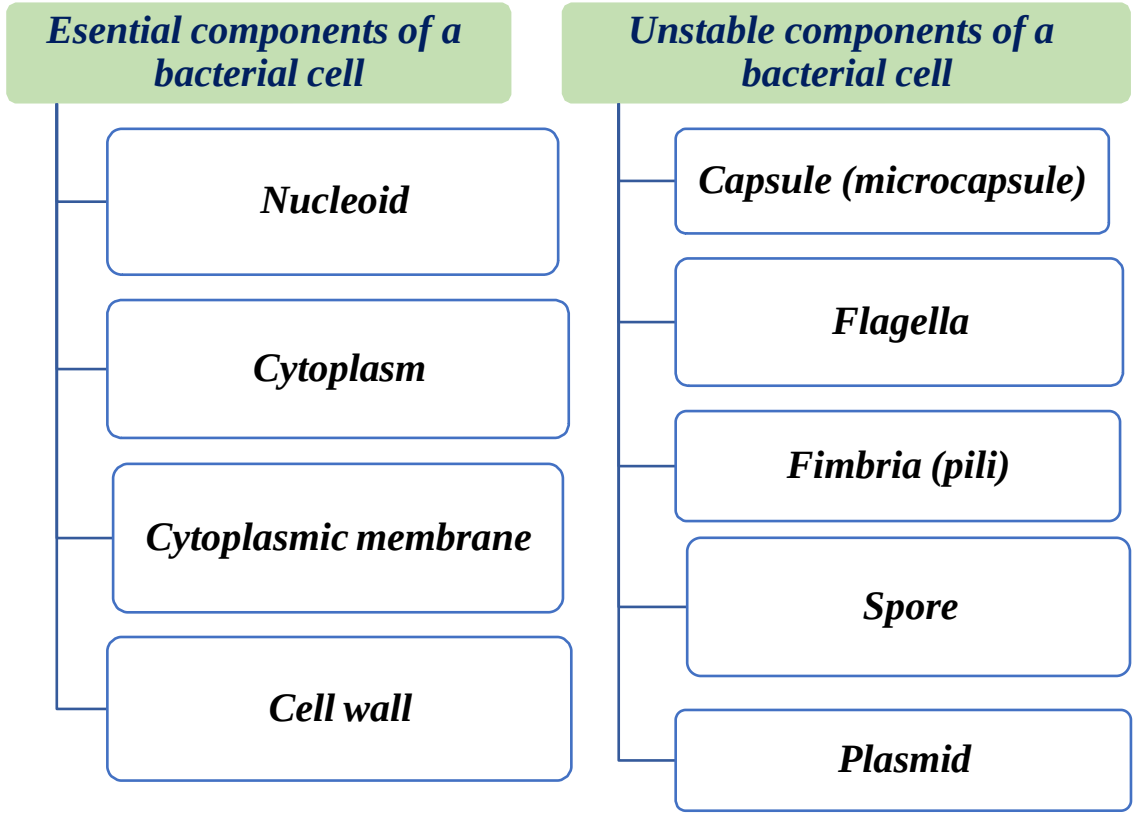
II LECTURE

- Morphology, structure, classification of microorganisms (bacteria, fungi,protozoa and viruses)

Microscopic morphology

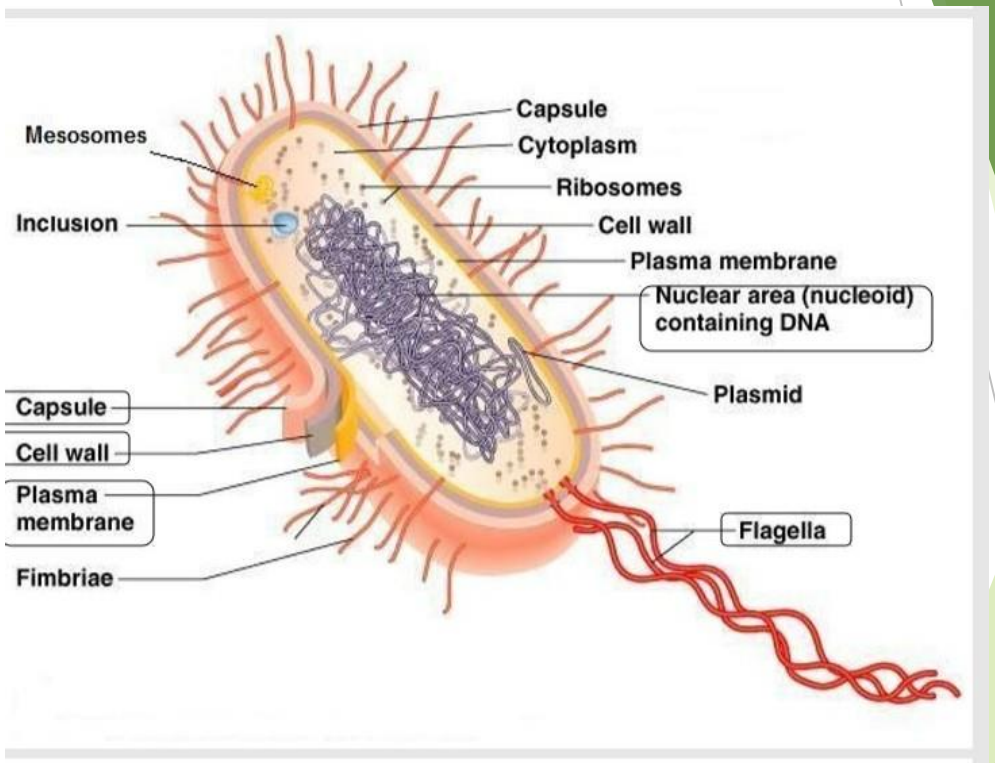
- Cell morphology: rod, coccus, or spirillum
- Cell arrangement: diplococcus, S*treptococcus*,
  - tetrad, sarcina, irregular clusters (*Micrococcus* or
- S*taphycoccus*)
- Special cell structures: flagellum, cilia, spore, capsule

Structure of a bacterial cell



Prokaryotic Cells

- Prokaryotes are molecules surrounded by a membrane and cell wall
- They lack a true nucleus and don’t have membrane bound organelles like mitochondria, etc.
  - large surface-to-volume ratio : nutrients can easily and rapidly reach any part of the cells interior



Anatomy of A Bacterial Cell

Outer layer – two components Rigid cell wall

Cytoplasmic (Cell/ Plasma) membrane – present beneath cell wall

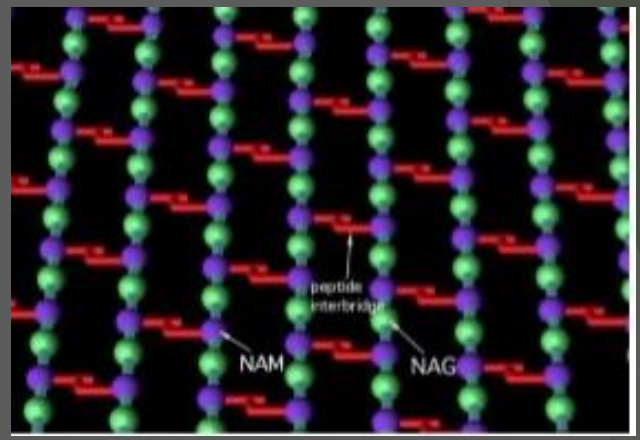
- Cytoplasm – cytoplasmic inclusions, ribosomes, mesosomes, genetic material
- Additional structures –capsule, flagella, fimbriae (pili), spores

Structure & Function of Cell Components

CELL WALL

- Outermost layer, encloses cytoplasm
- Confers shape and rigidity

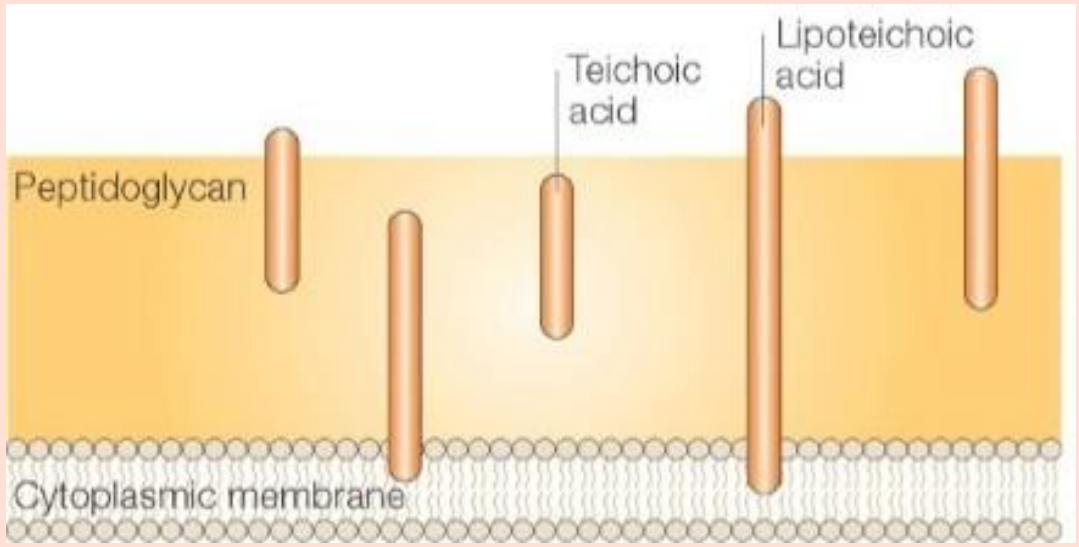
- 2.10 - 25 nm thick
- 3.Composed of peptidoglycan



Cell wall

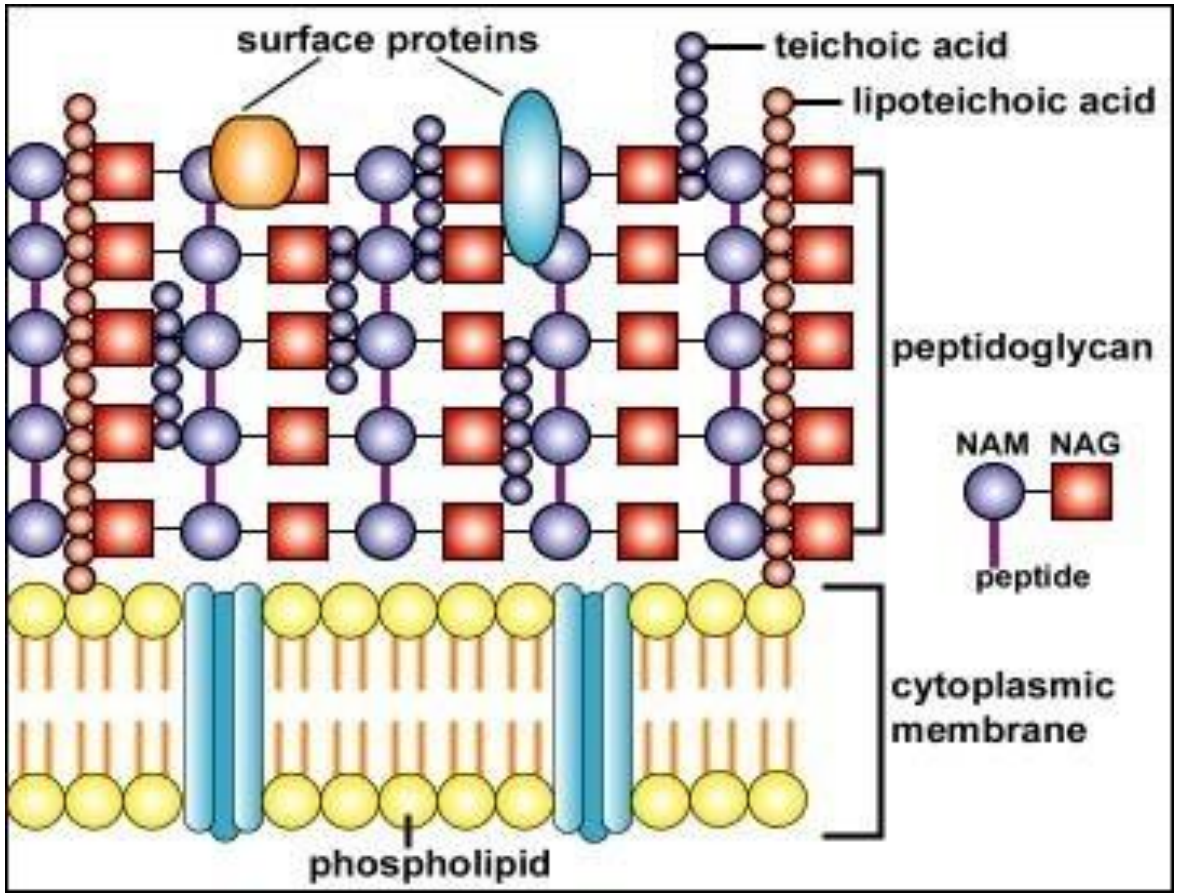
- Chemical nature of the cell wall helps to divide bacteria into 2 broad groups
  - Gram positive
  - Gram negative
- Carries bacterial antigens – important in virulence & immunity – gm – ve cell wall has lipopolysachhrides – fever and necrosis
- Several antibiotics may interfere with cell wall synthesis e.g. Penicillin, Cephalosporins

Gram positive cell wall

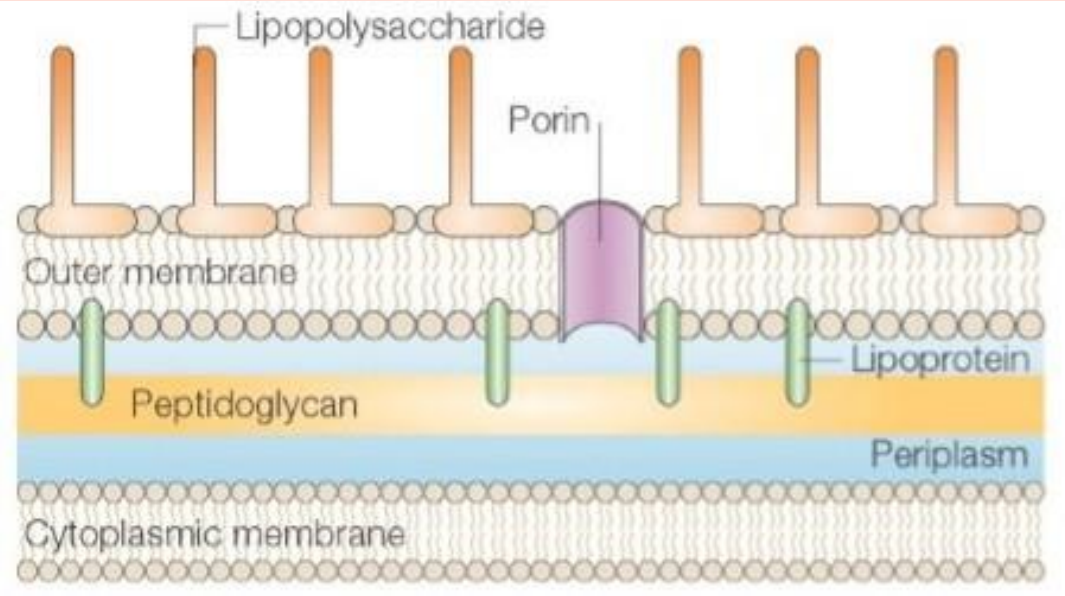


- Gram-positive cell wall is composed
  - of a thick, multilayered peptidoglycan sheath outside of the cytoplasmic membrane
- Teichoic acids
  - are linked to and embedded in the peptidoglycan
- Lipoteichoic acids
  - extend into the cytoplasmic membrane

Gram positive bacterial cell wall

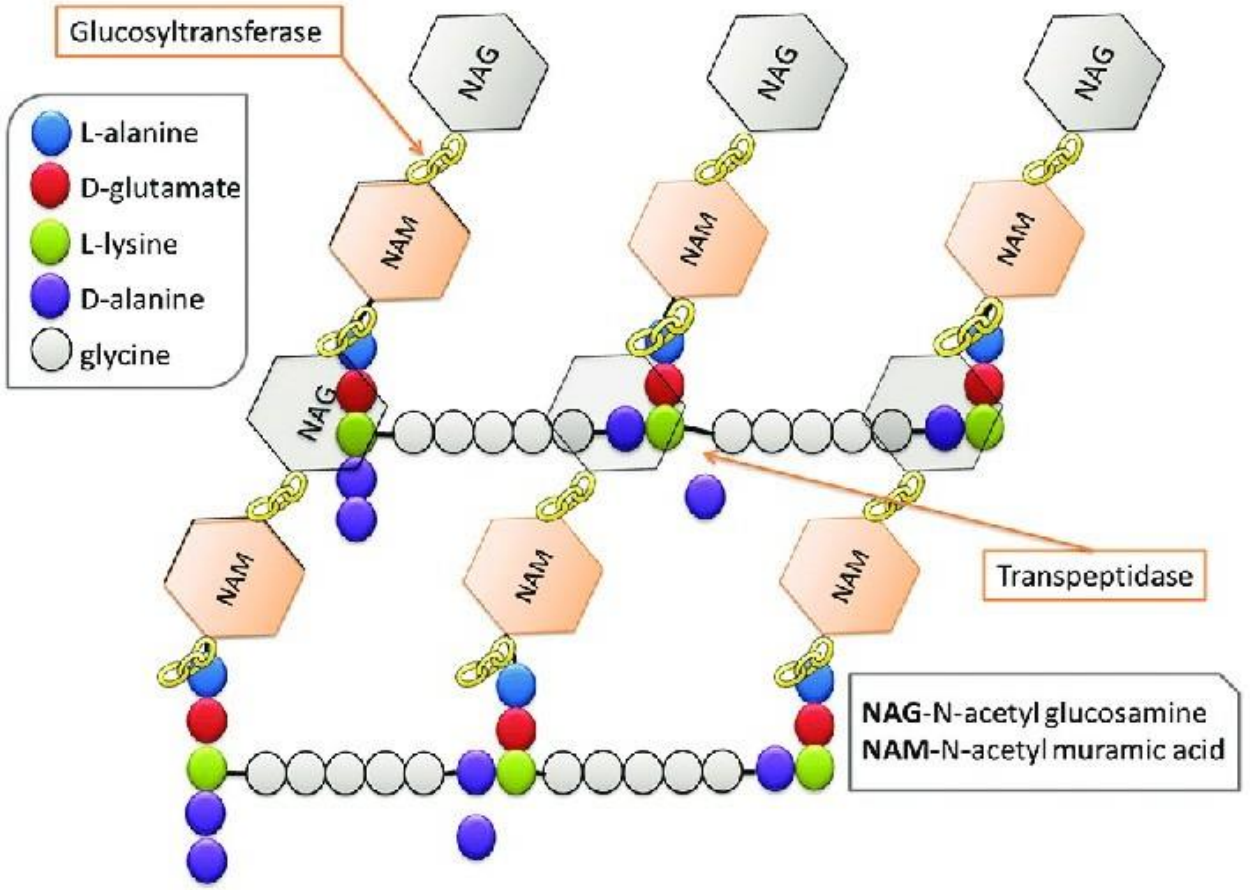


Gram negative cell wall

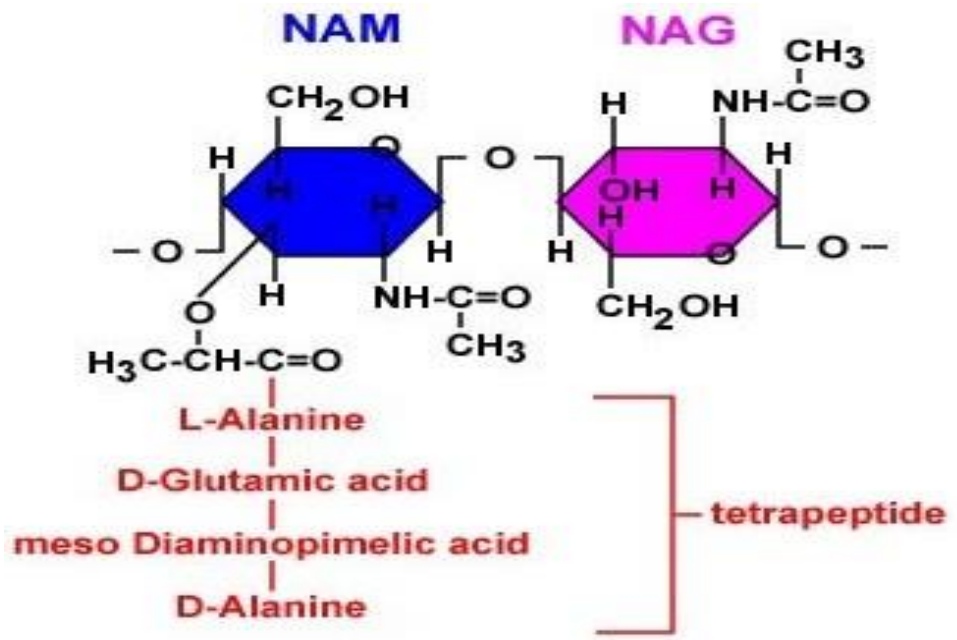


- Gram-negative cell wall is composed of
  - an outer membrane linked to thin, mainly single-layered peptidoglycan by lipoproteins
- The outer membrane includes
  - porins, which allow the passage of small hydrophilic molecules across the membrane
  - lipopolysaccharide molecules that extend into extracellular space

Structure of peptidoglycan

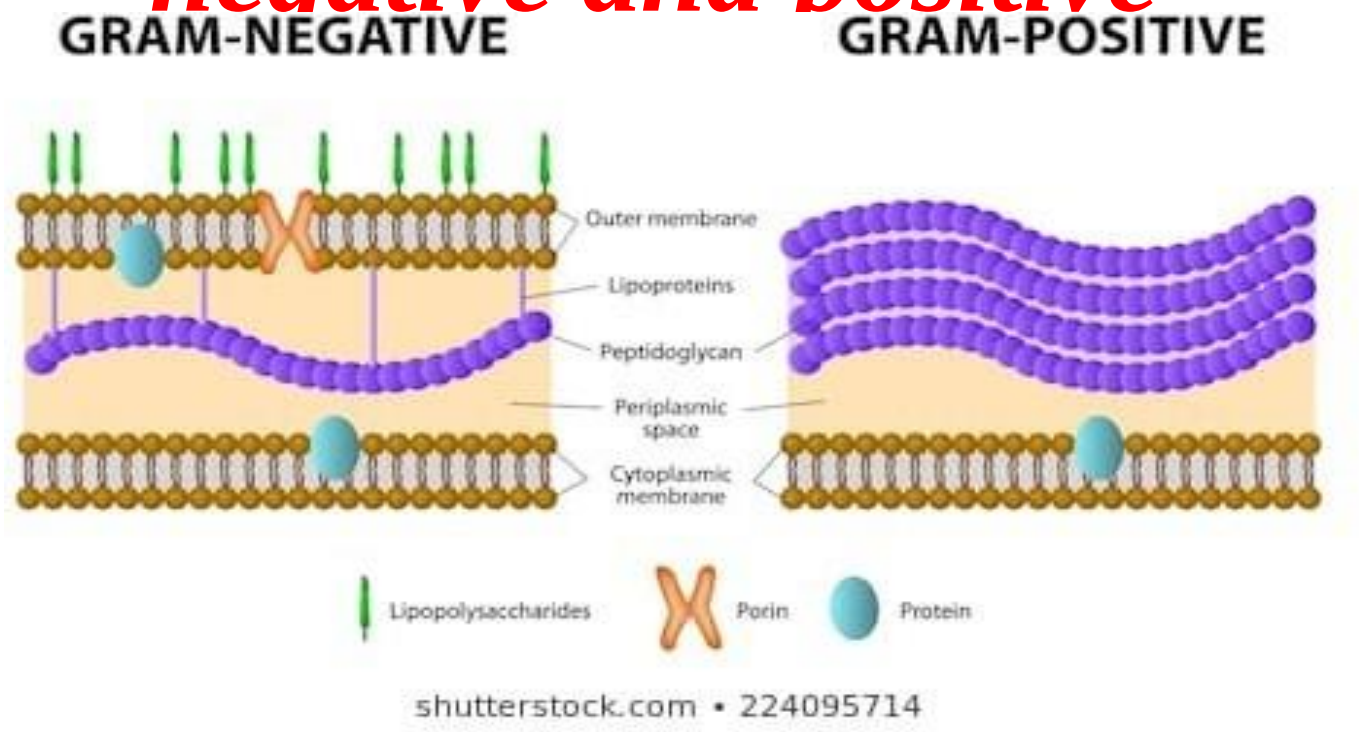


Structure of peptidoglycan

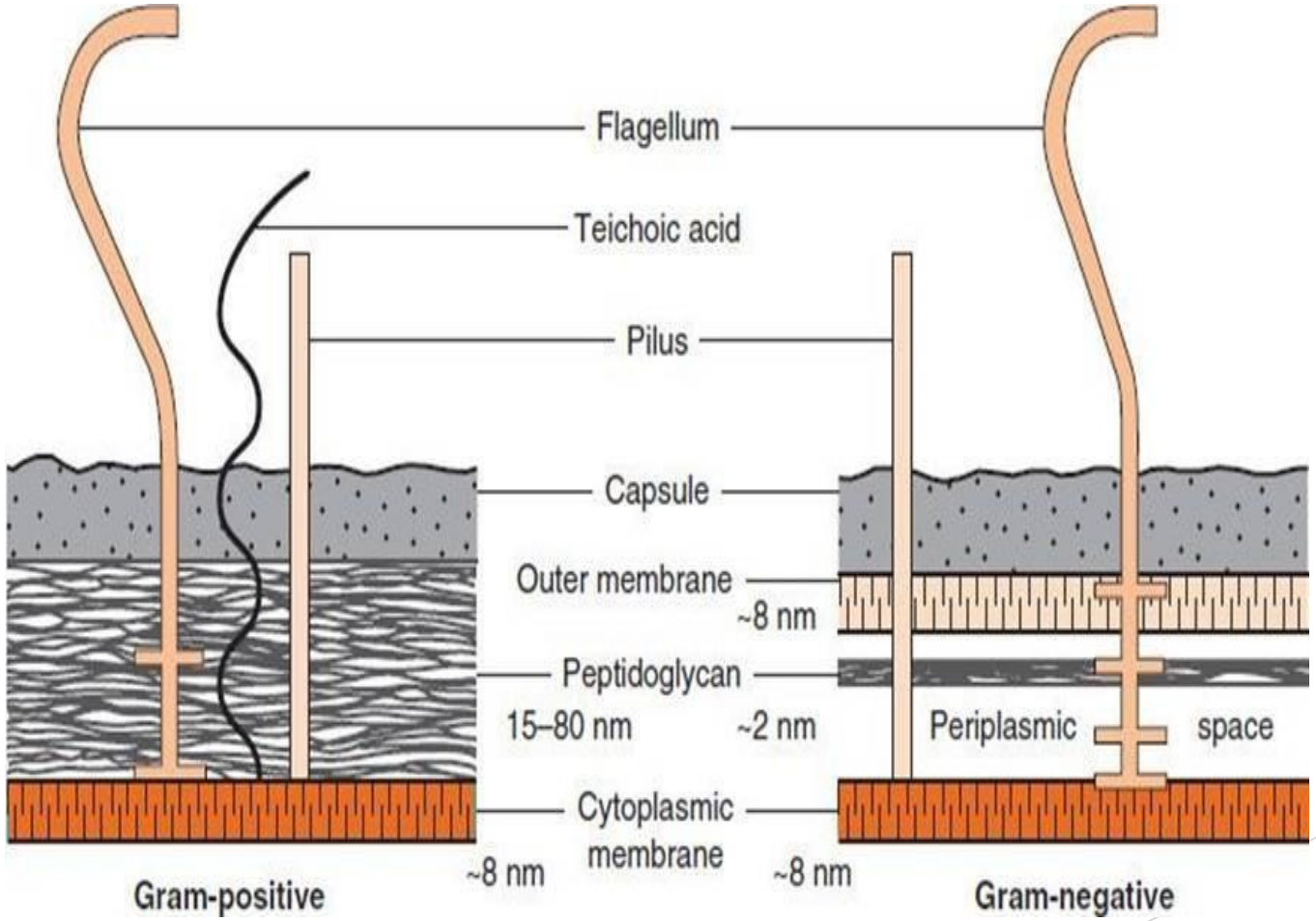


Biologic activity of peptidoglycan

Structure of Gram negative and positive



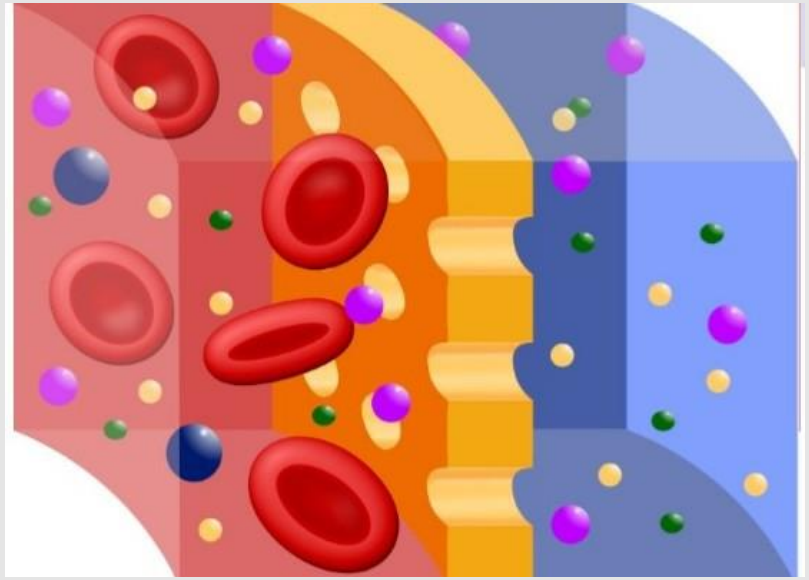
Structure of Gram negative and positive cell wall



Difference between Gram negative and positive cell wall

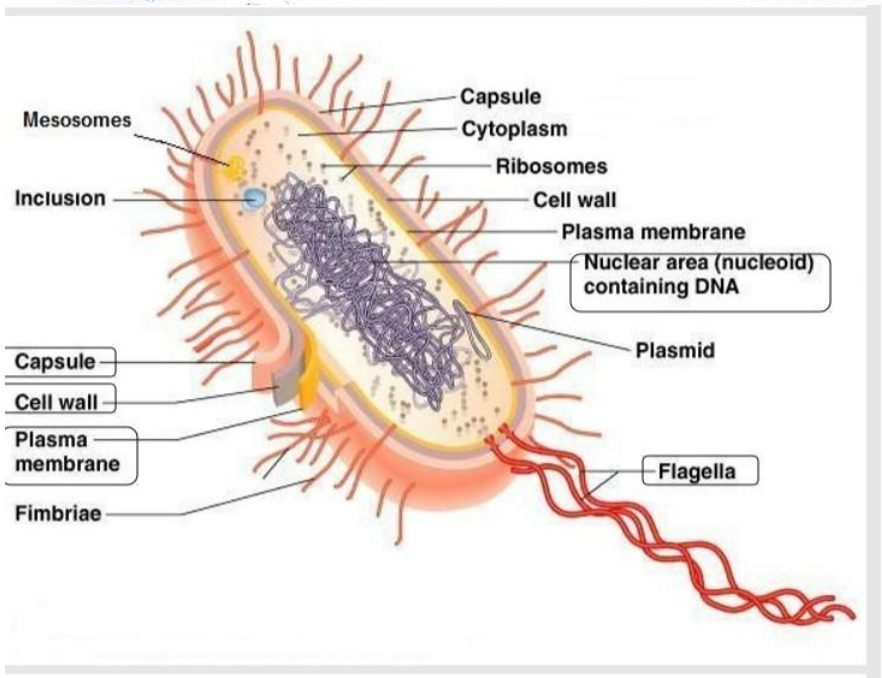
Characteristics	Gram positive	Gram negative
Thickness of the wall	20-80 nm	10 nm
Layer thickness on the wall	1	2
Amount of peptidoglycan	>%50	% 10 -20
Teichoic acid	+	-
Amount of lipids and lipoproteins	%0-3	%58
Amount of proteins	%0	%9
Lipopolysaccharides	%0	%13
Sensitivity to penicillin	+	-
Effect of lysosome	+	-

Cytoplasmic (Plasma) membrane



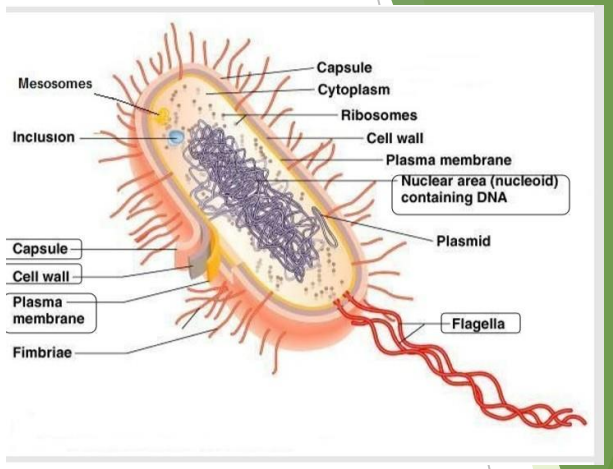
- Thin layer 5-10 nm, separates cell wall from cytoplasm
- Acts as a semipermeable membrane: controls the inflow and outflow of metabolites
- Composed of lipoproteins with small amounts of carbohydrates

Other Cytoplasmic Components



- **Ribosomes** – protein synthesis
- **Mesosomes**
  - Multilaminated structures formed as invaginations of plasma membrane
  - Principal sites of respiratory enzymes
- **Intracytoplasmic inclusions**
  - reserve of energy & phosphate for cell metabolism
  - metachromatic granules in diphtheria bacilli

Nucleus



- No nucleolus
- No nuclear membrane
- Genetic code is determined by specific nucleotide
- Genome
  - single, circular double stranded DNA

Additional Organelles

Plasmid

- Extranuclear genetic elements consisting of DNA
- Transmitted to daughter cells
- Confer certain properties e.g. drug resistance, toxicity

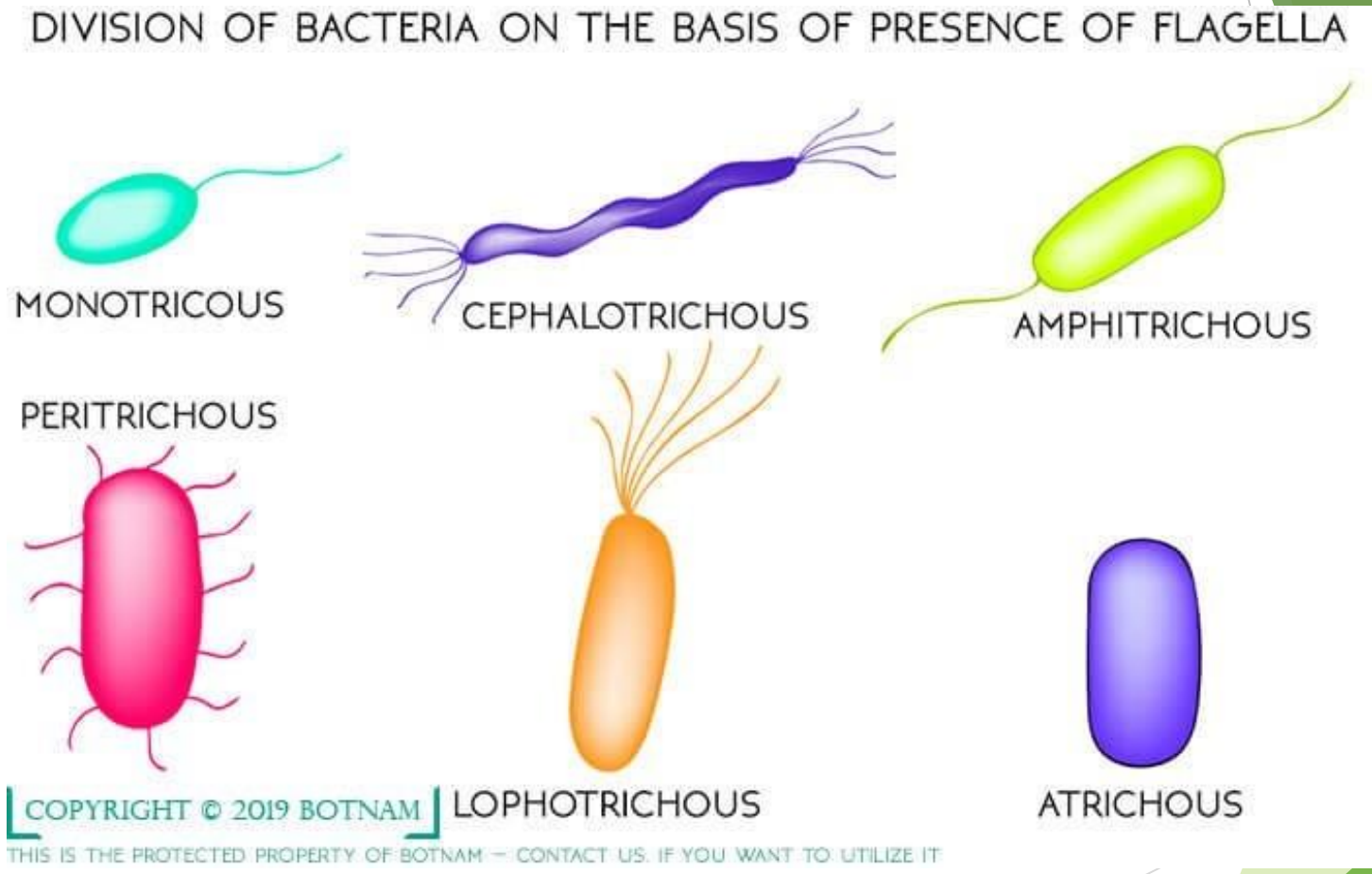
Additional Organelles

Capsule

- Viscous layer secreted around the cell wall
- Polysaccharide / polypeptide in nature
- Capsule – sharply defined structure, antigenic in nature
- Protects bacteria
- Stained by negative staining using India Ink

Flagella

- Flagella – Long (3 to 12 µm), filamentous surface appendages
- Organs of locomotion


DIVISION OF BACTERIA ON THE BASIS OF PRESENCE OF FLAGELLA
MONOTRICOUS
CEPHALOTRICHOUS
AMPHITRICHOUS
PERITRICHOUS
LOPHOTRICHOUS
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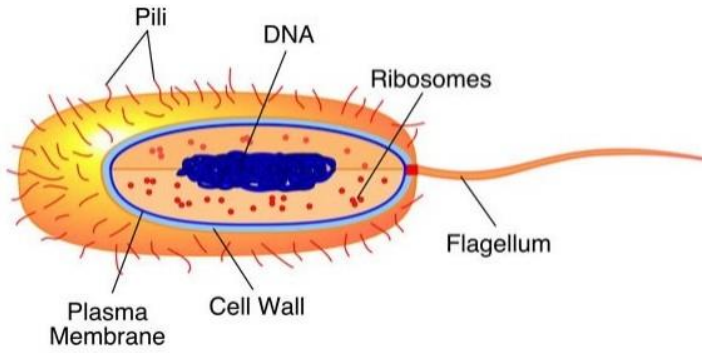
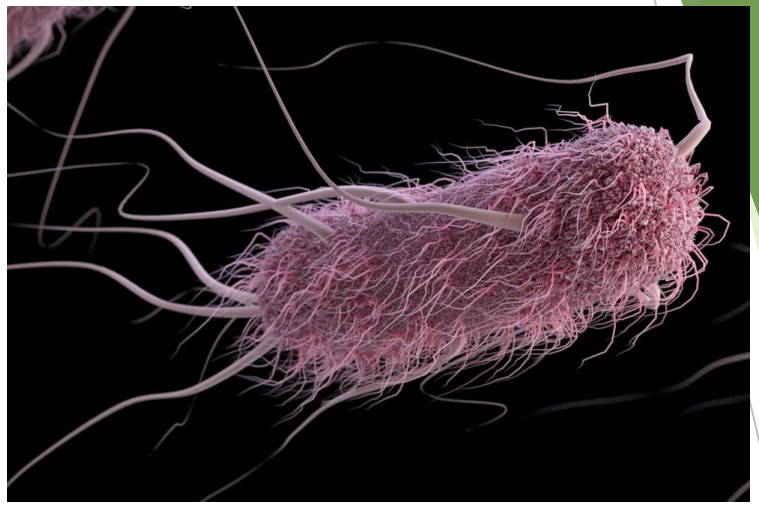
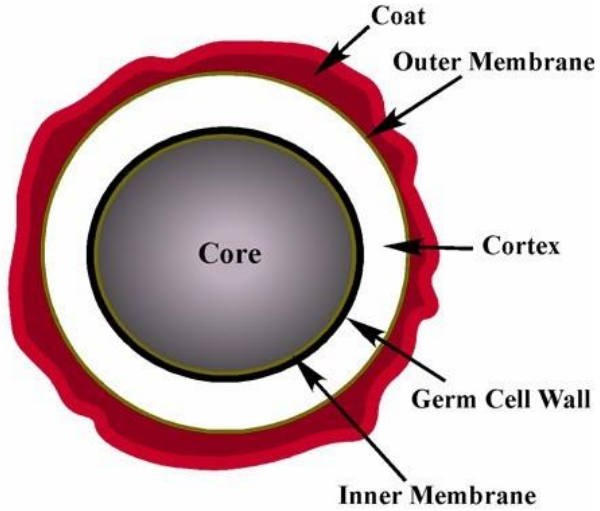




Fimbriae/ Pili

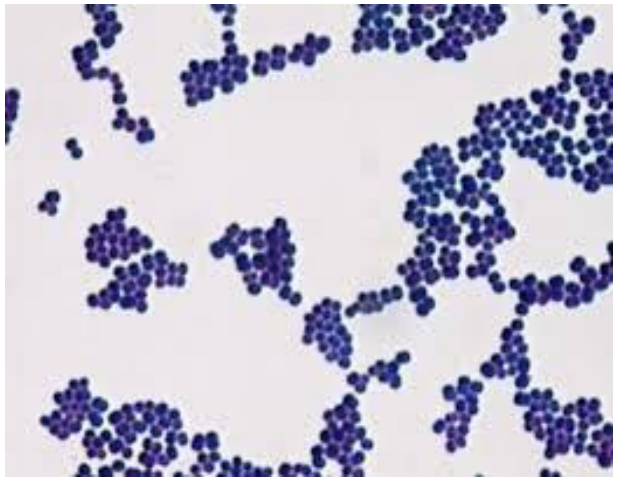
- Fimbriae/ Pili – Thin, hairlike appendages on the surface of many Gram-negative bacteria
- 10-20µ long, acts as organs of adhesion

Spores

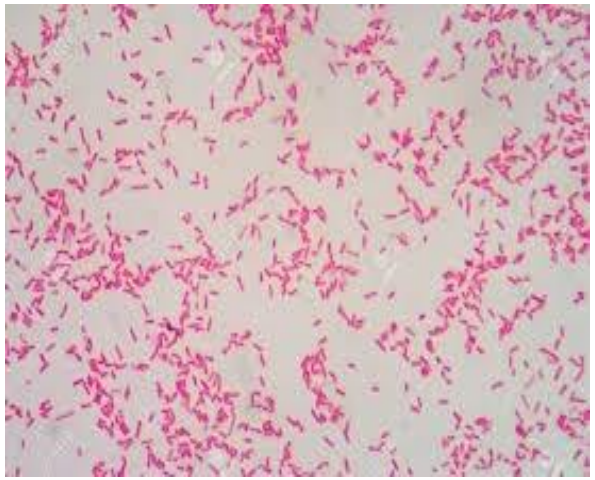


- Highly resistant resting stages formed during adverse environment (depletion of nutrients)
- Formed inside the parent cell, hence called Endospores
- Very resistant to heat, radiation and drying and can remain dormant for hundreds of years.
- Formed by bacteria like *Clostridia*, *Bacillus*

Gram Staining



Gram positive (S.aureus)



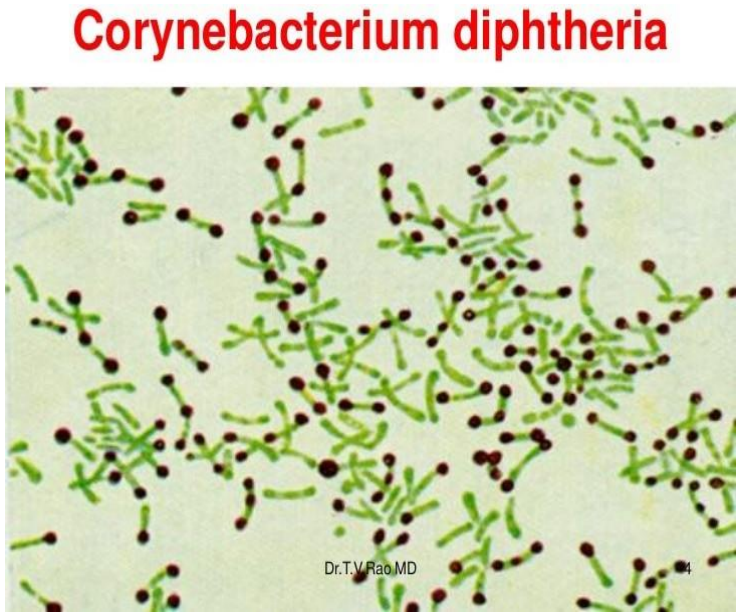
Gram negative (E.coli)

Don`t stained with Gram stain

- ***Mycobacterium* (due to high lipid content in the cell wall)**
- ***Rickettsia ve Chlamydia* (intracellular parasite and very small bacteria)**
- ***Legionella pneumoniae* (don't stained with fuchsin)**
- ***Mollicutes* (lack cell wall-Mycoplasma)**
- ***Treponema pallidum* (very weak)**

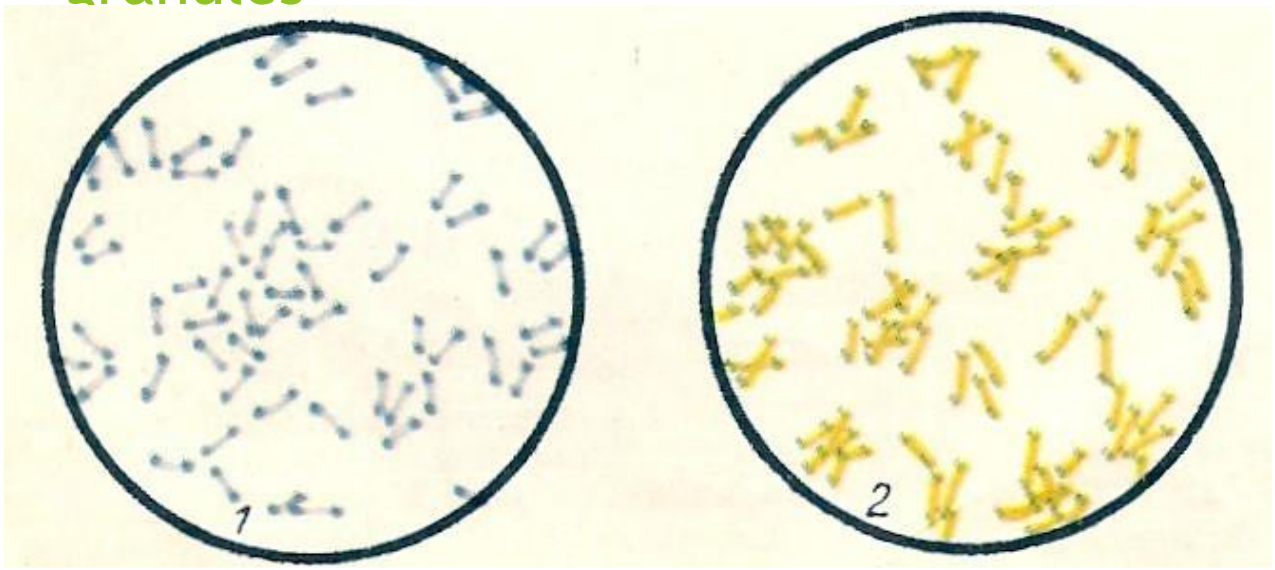
Volutin granules

- ***Polyphosphate granules-metachromatic grains (Babes-Ernest bodies) are found in cornebacteria (Corynebacterium diphteria, etc.), a sign of recognition of these bacteria***
- ***It is determined by Neisser method.***



Neisser staining method

Corynobacterium diphteria – volutin granules



Methylene blue **Neisser method**

microorganisms or microbes

(can't see with naked eye)

bacteria

- good & bad types
- single cell
- eat what's around them
- antibiotics are a bacteria killing bomb!
- vitamin C kills

viruses

- only BAD
- parasite
- 100x smaller than bacteria
- vitamin C kills

fungi

- mold & yeast

algae

- tiny plants

protozoa

multi-cellular & found every-where!

archaea

survive in extreme environ-ments

Some distinctive features of prokaryotes and eukariyotes

Features	Prokaryote cell	Eukaryote cell
Size	1-10 mkm	10-100 mkm
Nucleotide membrane	Absent	Presents
Chromosome	One	several
Histones	Absent	Present
Type of division	Binary	Mitotic
Specialized membrane structure	Absent	Present
Cell wall	Haves peptidoglycan	Haves chitin or cellulose
Steroids of cell	Absent	Present
Ribosome's	70 S	80 S
Anaerobic respiratory	Can be	Usually absent
Nitrogen Fixation	Can be	Cannot be

Typical prokaryote and eukarvote ce¨

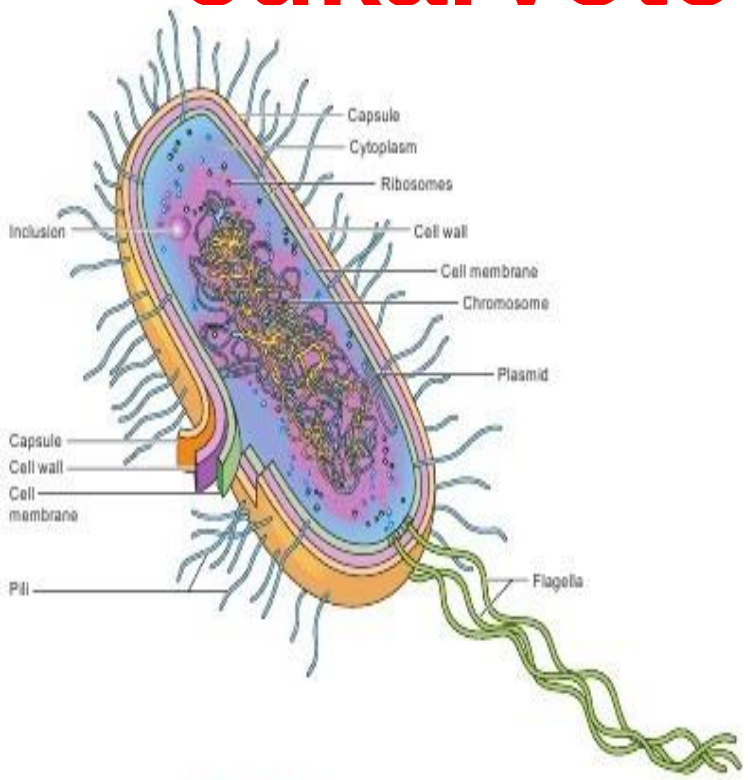


FIGURE 3-6. A typical procaryotic cell.

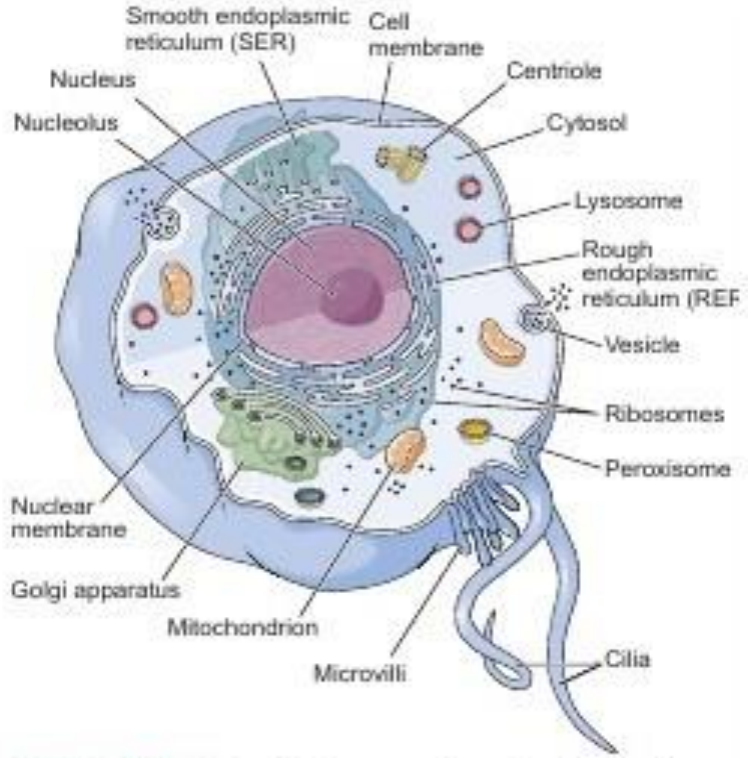
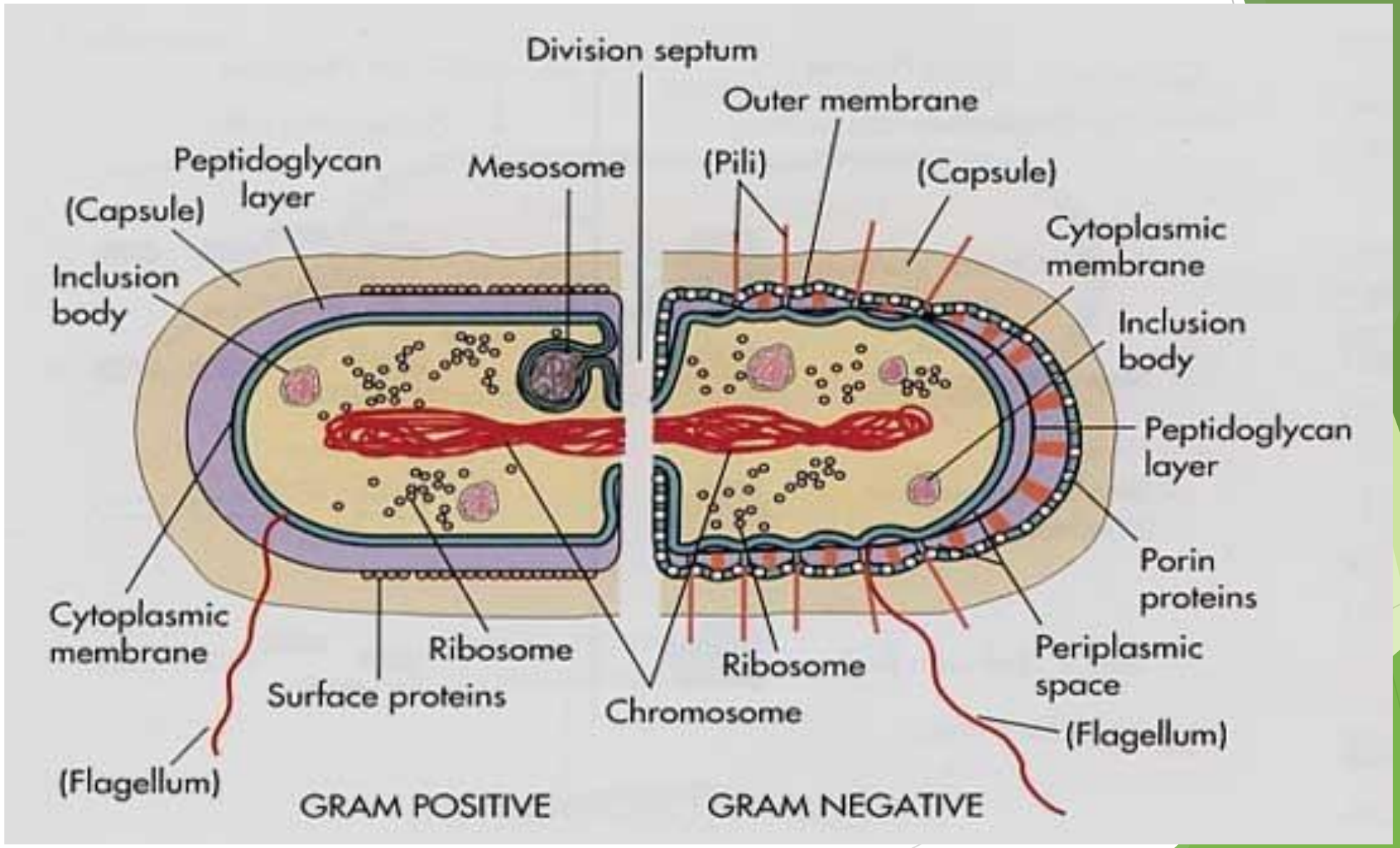
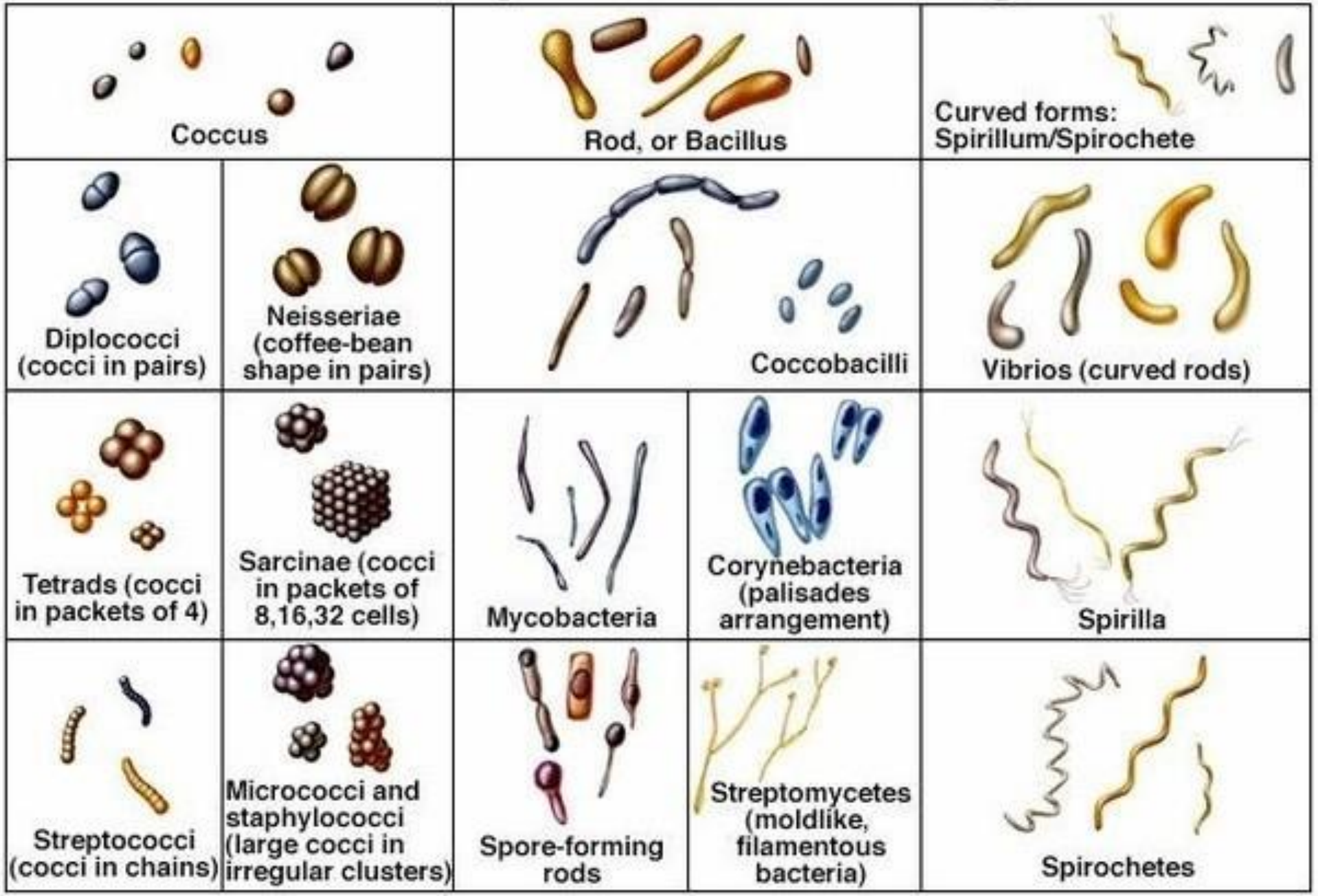


FIGURE 3-2. A typical eucaryotic animal cell. (From Cohen BJ. Memmler's The Human Body in Health and Disease, 11th ed. Philadelphia: Lippincott Williams & Wilkins, 2009.)

Bacteria


Division septum
Outer membrane
Peptidoglycan layer
Mesosome
(Pili)
(Capsule)
(Capsule)
Cytoplasmic membrane
Inclusion body
Inclusion body
Peptidoglycan layer
Porin proteins
Cytoplasmic membrane
Ribosome
Surface proteins
Ribosome
Chromosome
Periplasmic space
(Flagellum)
(Flagellum)
GRAM POSITIVE
GRAM NEGATIVE

Bacterial shapes and arrangements



The sizes of the major form of bacteria's

- Cocciform (0,5-1.5 мкм)
- Rod-shaped (0,3-
- 10 microns)
- Twisted
- (до 20 microns)
- Threadlike (до 10-50
- microns)

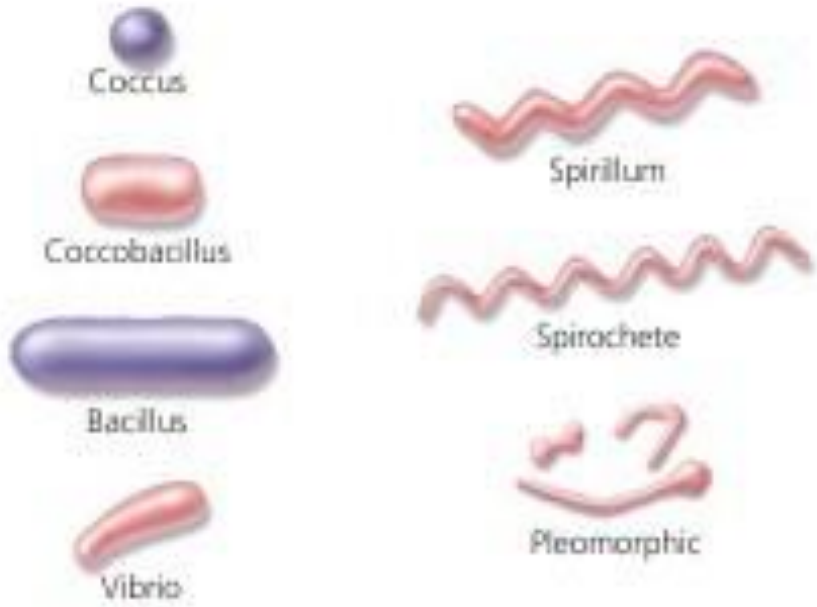


Figure 11.1 Typical prokaryotic morphologies. *What is one difference between a spirillum and a spirochete?*

Cocci-form bacteria. Types of cocci depending on the division plane.

- Micrococci’s
- Dyplococci’s
- Tetracoccis
- Sarcins
- Staphyloccoccus
- Streptococcus

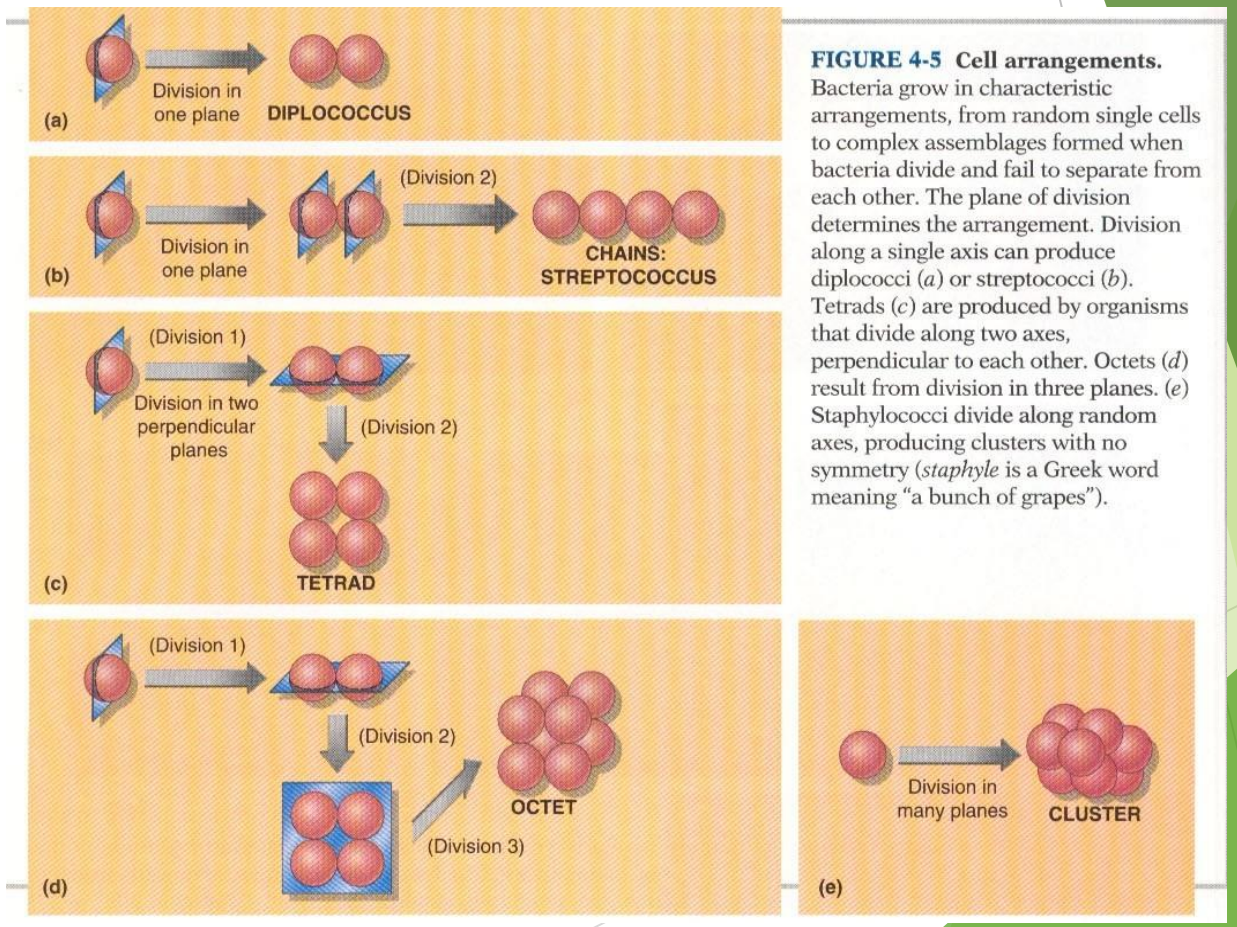


FIGURE 4-5 Cell arrangements. Bacteria grow in characteristic arrangements, from random single cells to complex assemblages formed when bacteria divide and fail to separate from each other. The plane of division determines the arrangement. Division along a single axis can produce diplococci (*a*) or streptococci (*b*). Tetrads (*c*) are produced by organisms that divide along two axes, perpendicular to each other. Octets (*d*) result from division in three planes. (*e*) Staphylococci divide along random axes, producing clusters with no symmetry (*staphyle* is a Greek word meaning “a bunch of grapes”).

Rod shaped bacteria's

- **By the presence of the spore and its size**: bacteria, bacilli. clostridia
- **By size:**

short, medium, long

- **By width:**

thin and thick

- **The shape of the ends of the cell :**

rounded, pointed, cropped, thickened

- **By location:**

single, in pairs, at an angle, chain

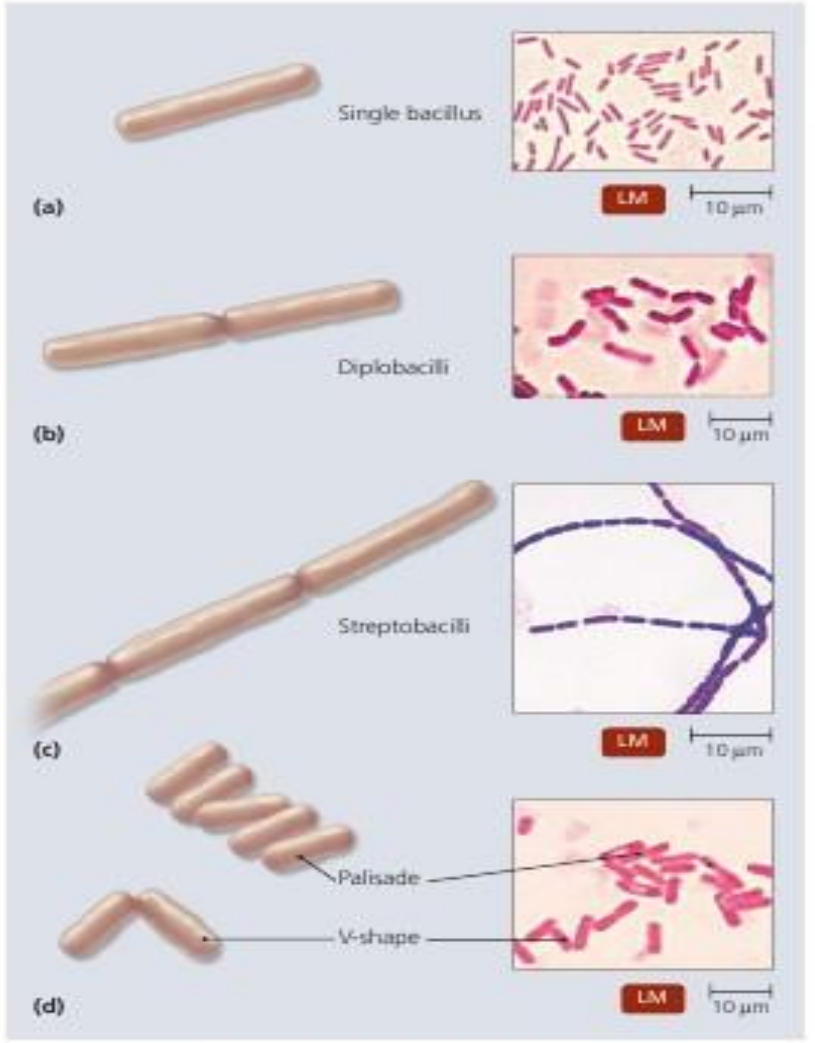


Figure 11.7 Arrangements of bacilli. **(a)** A single bacillus of *Escherichia coli*. **(b)** Diplobacilli in a young culture of *Bacillus cereus*. **(c)** Streptobacilli in an older culture of *Bacillus cereus*. **(d)** V-shape and a palisade of *Corynebacterium diphtheriae*.

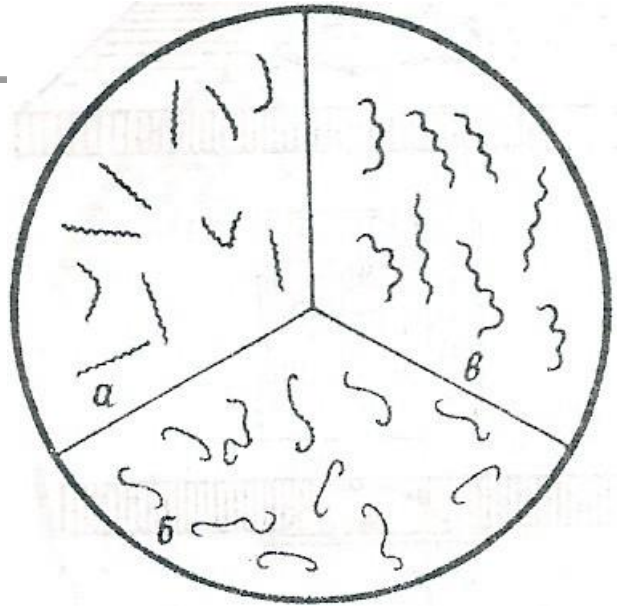
Twisted and threaded bacteria

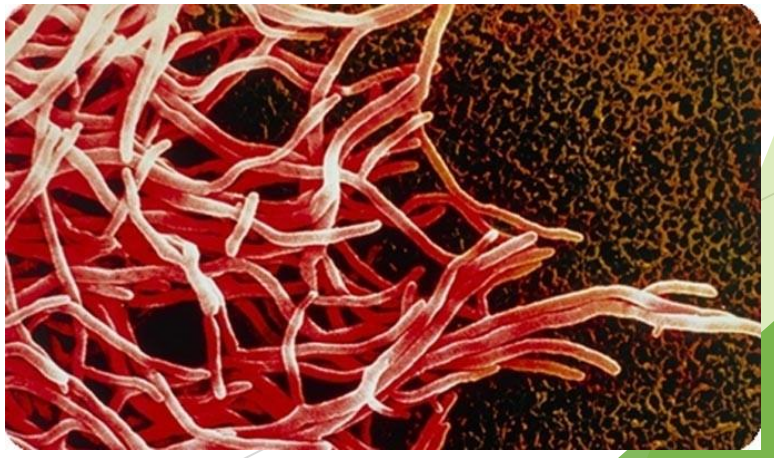
Twisted

- Spirillas
- Spirochetes

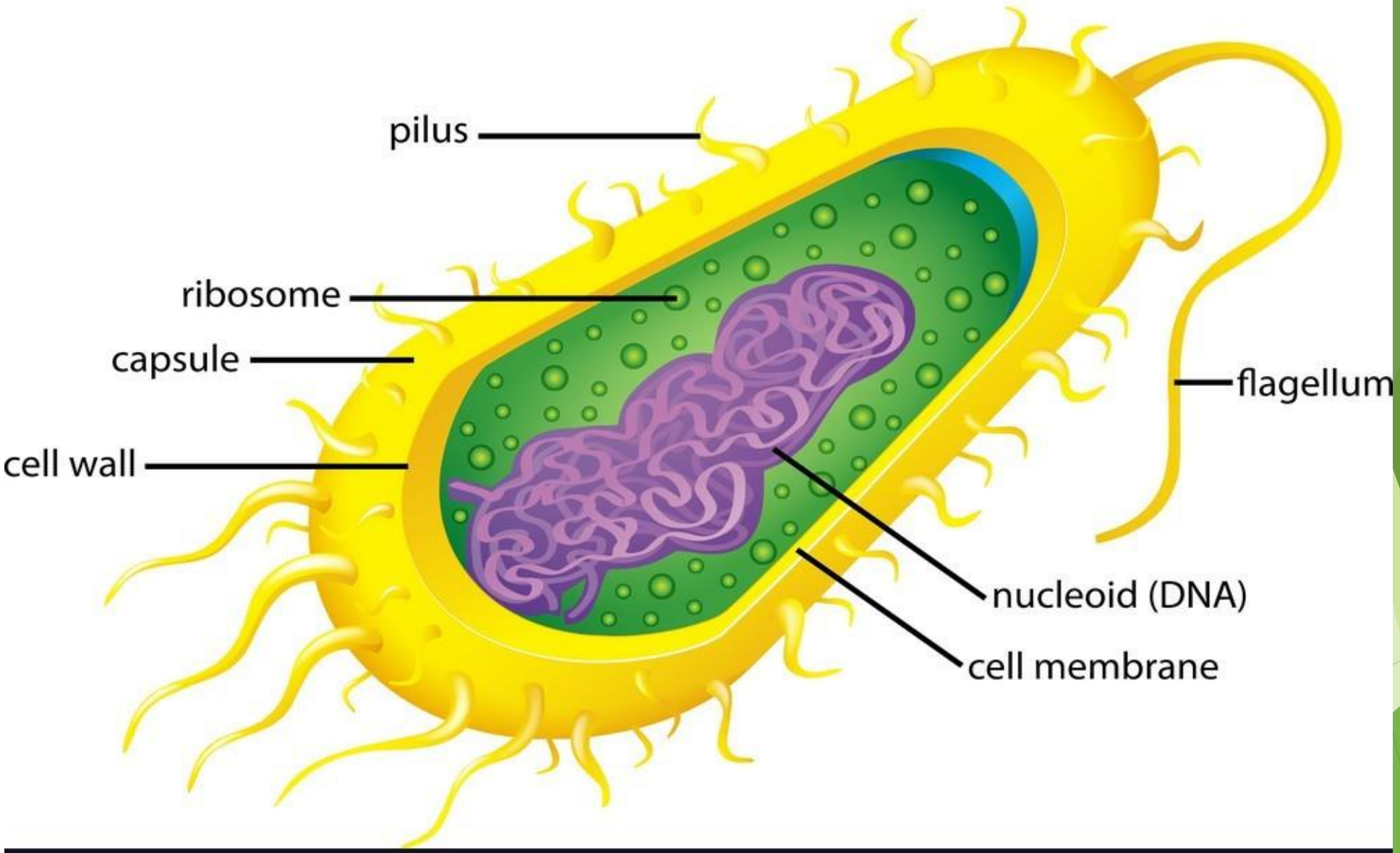
Threaded

- Actinomycetes





Bacteria Cell Anatomy



Structure of bacteria (electronic microphotogram of listeria)

Necleoid of bacterial cell

- A nucleoid in bacteria is a prototype nucleus.
- It does not have a nuclear membrane, nucleolus and histones.
- It is represented by one chromosome.
- It consists of double-stranded DNA, closed in a ring and twisted into a ball.
- In addition to the nucleoid, the carrier of hereditary information are plasmids — circular DNA molecules in the cytoplasm.

Cytoplasm and organelles of a bacterial cell

The cytoplasm is a colloid consisting of soluble proteins,

- RNA, inclusions and ribosomes.

Bacterial ribosomes with a size of 20 nm with a sedimentation constant of 70 S (subunits 50 S and 30

- S).

Ribosomal RNAs (16 S and 23 S) are the most conserved elements of bacteria. Their determination (especially 16 S) is based on the bacterial gene

- systematics.

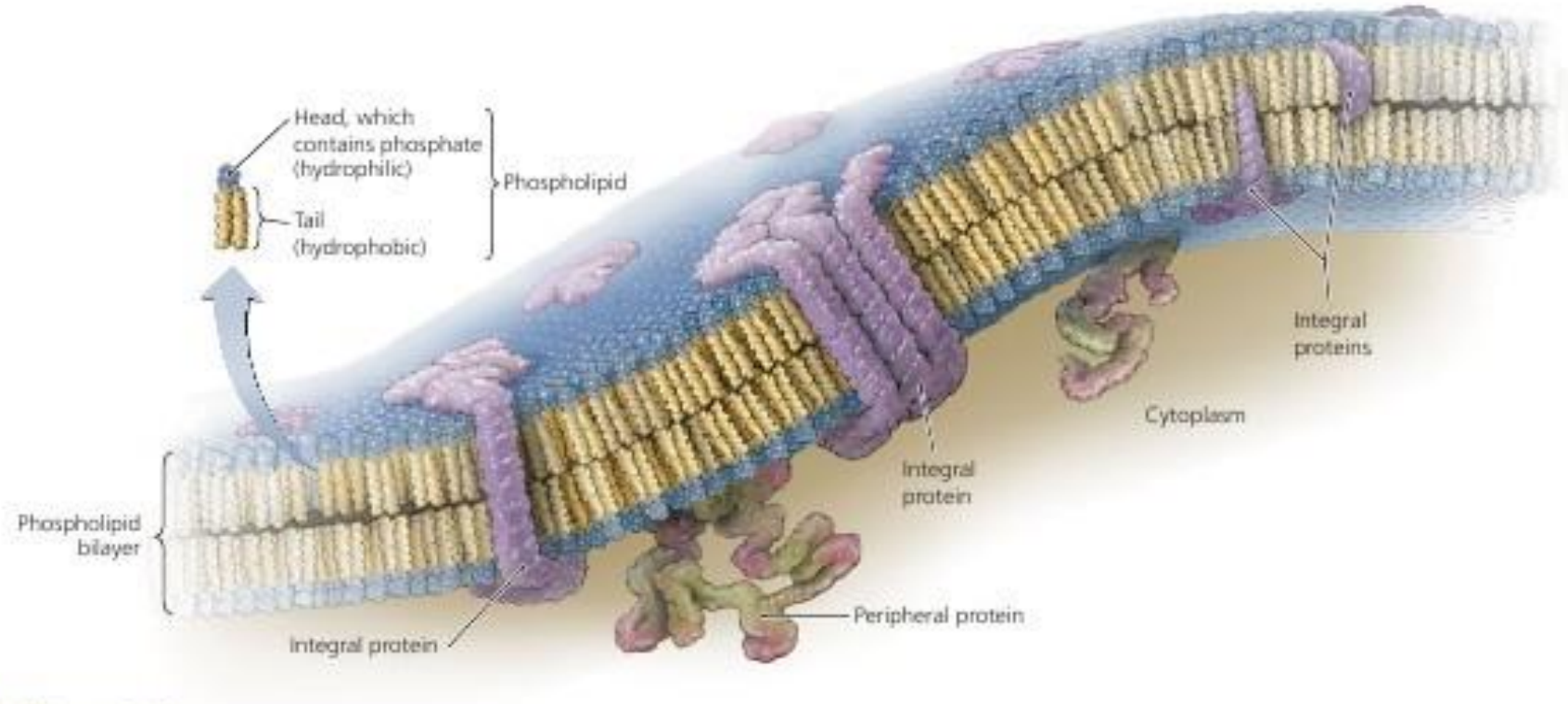
Inclusions (granules of glycogen, polysaccharides, lipids, polyphosphates) are accumulated by the bacterial cell as a supply of nutrient and energy substances.

Bacterial cell membrane

Membrane of bacterial cell consists of:

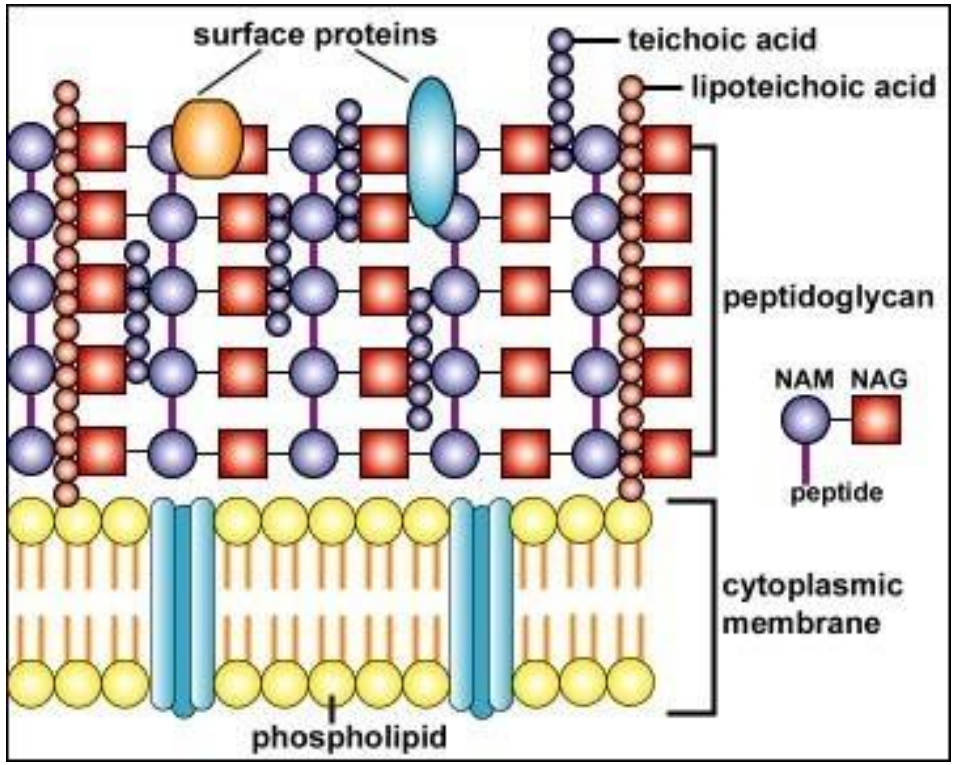
- Cytoplasmic membrane.
- Cell wall (in gram-negative bacteria - with an outer membrane).
- Some bacteria on the outside have an additional structure - the capsule layer.

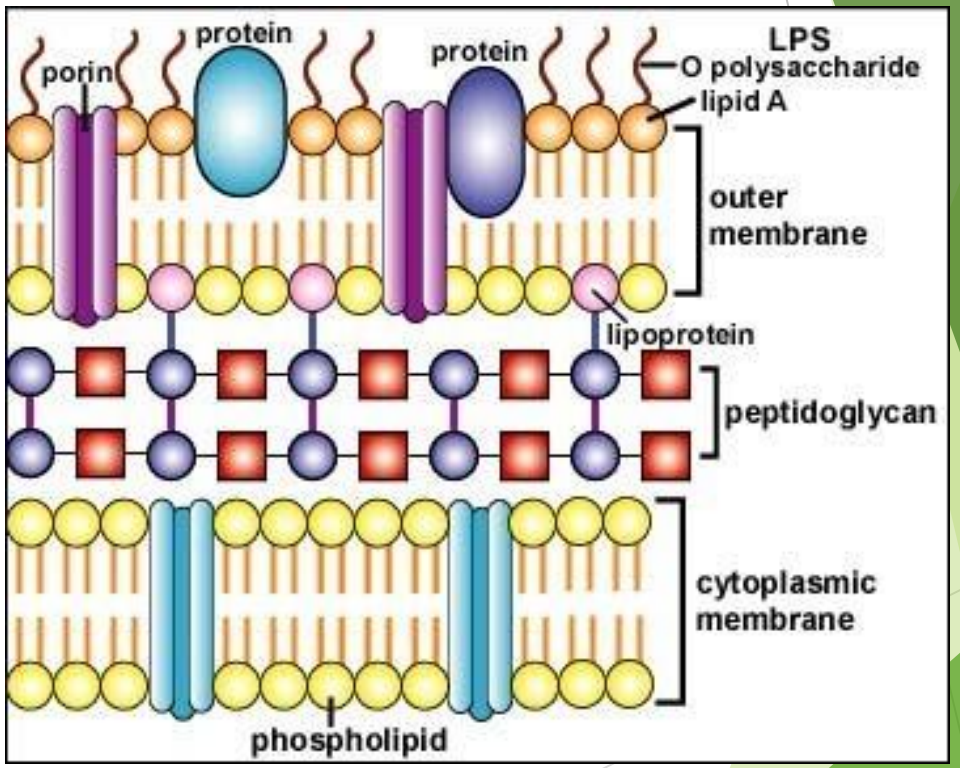
Structure
CPM

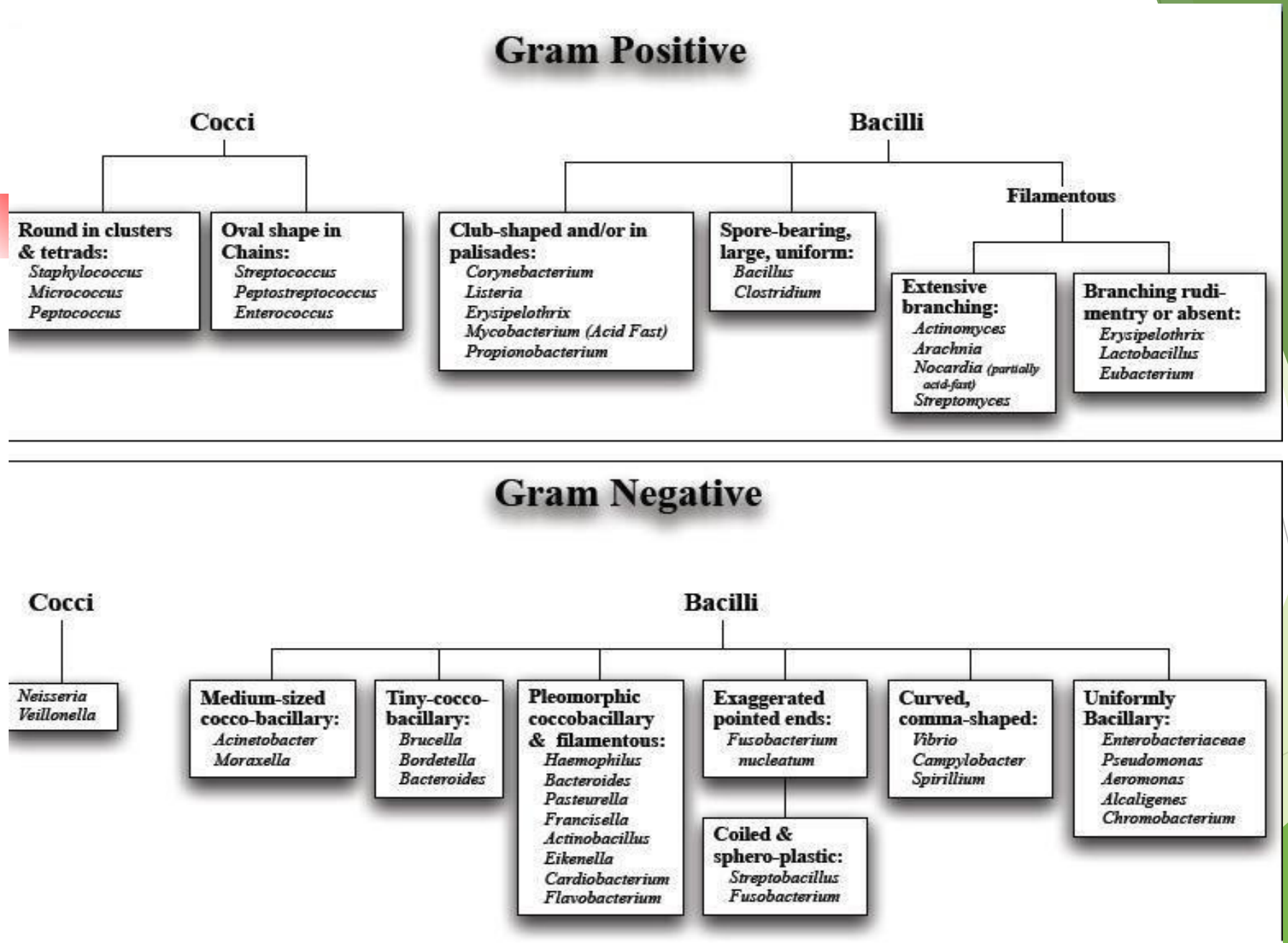


▲ **Figure 3.16**
The structure of a prokaryotic cytoplasmic membrane: a phospholipid bilayer.

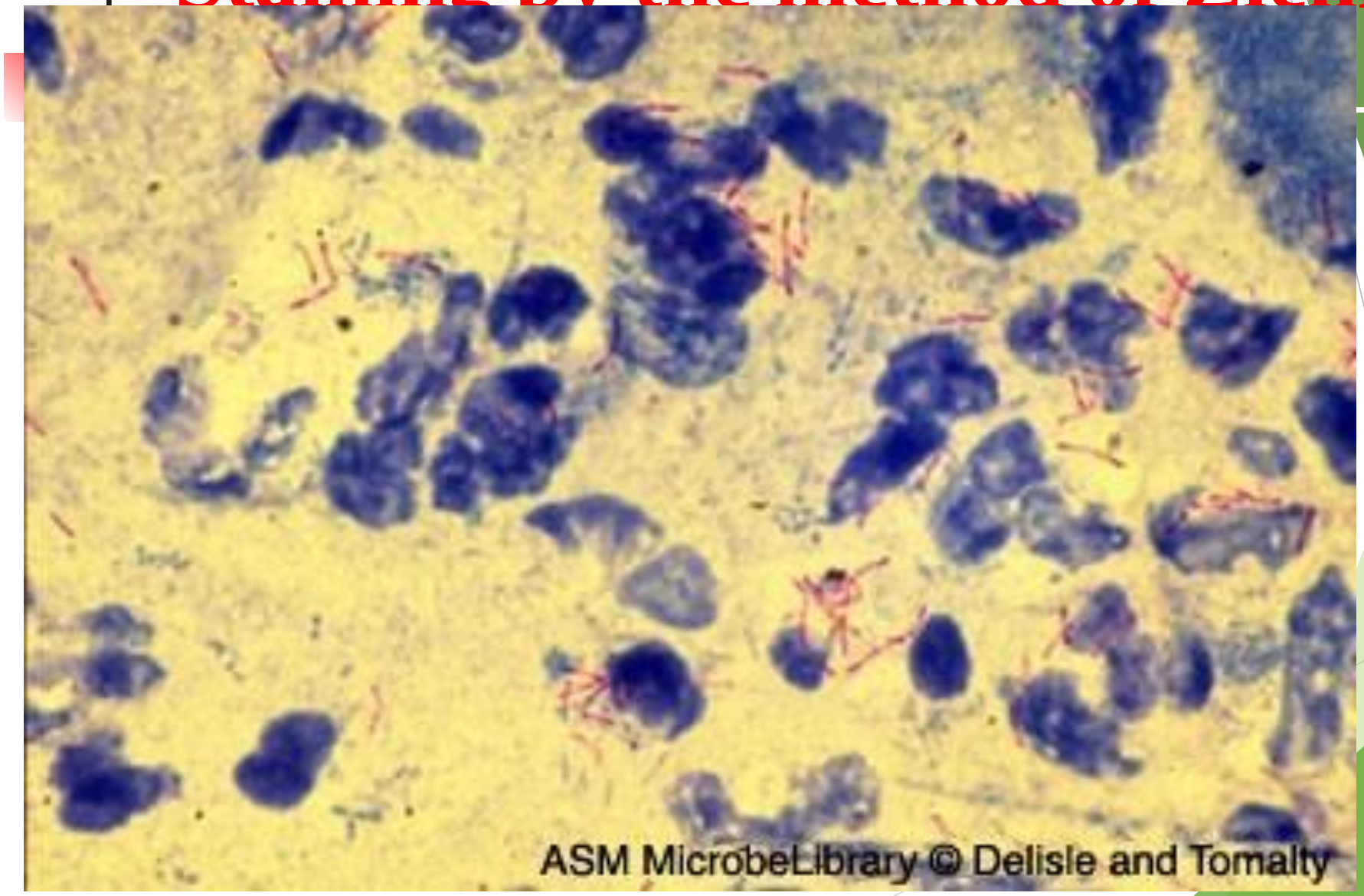
Membrane structure of Gram+ and Gram – of bacteria.






Gram Positive
Cocci
Round in clusters & tetrads:
Staphylococcus
Micrococcus
Peptococcus
Oval shape in Chains:
Streptococcus
Peptostreptococcus
Enterococcus
Bacilli
Club-shaped and/or in palisades:
Corynebacterium
Listeria
Erysipelothrix
Mycobacterium (Acid Fast)
Propionobacterium
Spore-bearing, large, uniform:
Bacillus
Clostridium
Filamentous
Extensive branching:
Actinomyces
Arachnia
Nocardia (partially acid-fast)
Streptomyces
Branching rudimentry or absent:
Erysipelothrix
Lactobacillus
Eubacterium
Gram Negative
Cocci
Neisseria
Veillonella
Bacilli
Medium-sized cocco-bacillary:
Acinetobacter
Moraxella
Tiny-cocco-bacillary:
Brucella
Bordetella
Bacteroides
Pleomorphic coccobacillary & filamentous:
Haemophilus
Bacteroides
Pasteurella
Francisella
Actinobacillus
Eikenella
Cardiobacterium
Flavobacterium
Exaggerated pointed ends:
Fusobacterium nucleatum
Coiled & sphero-plastic:
Streptobacillus
Fusobacterium
Curved, comma-shaped:
Vibrio
Campylobacter
Spirillium
Uniformly Bacillary:
Enterobacteriaceae
Pseudomonas
Aeromonas
Alcaligenes
Chromobacterium

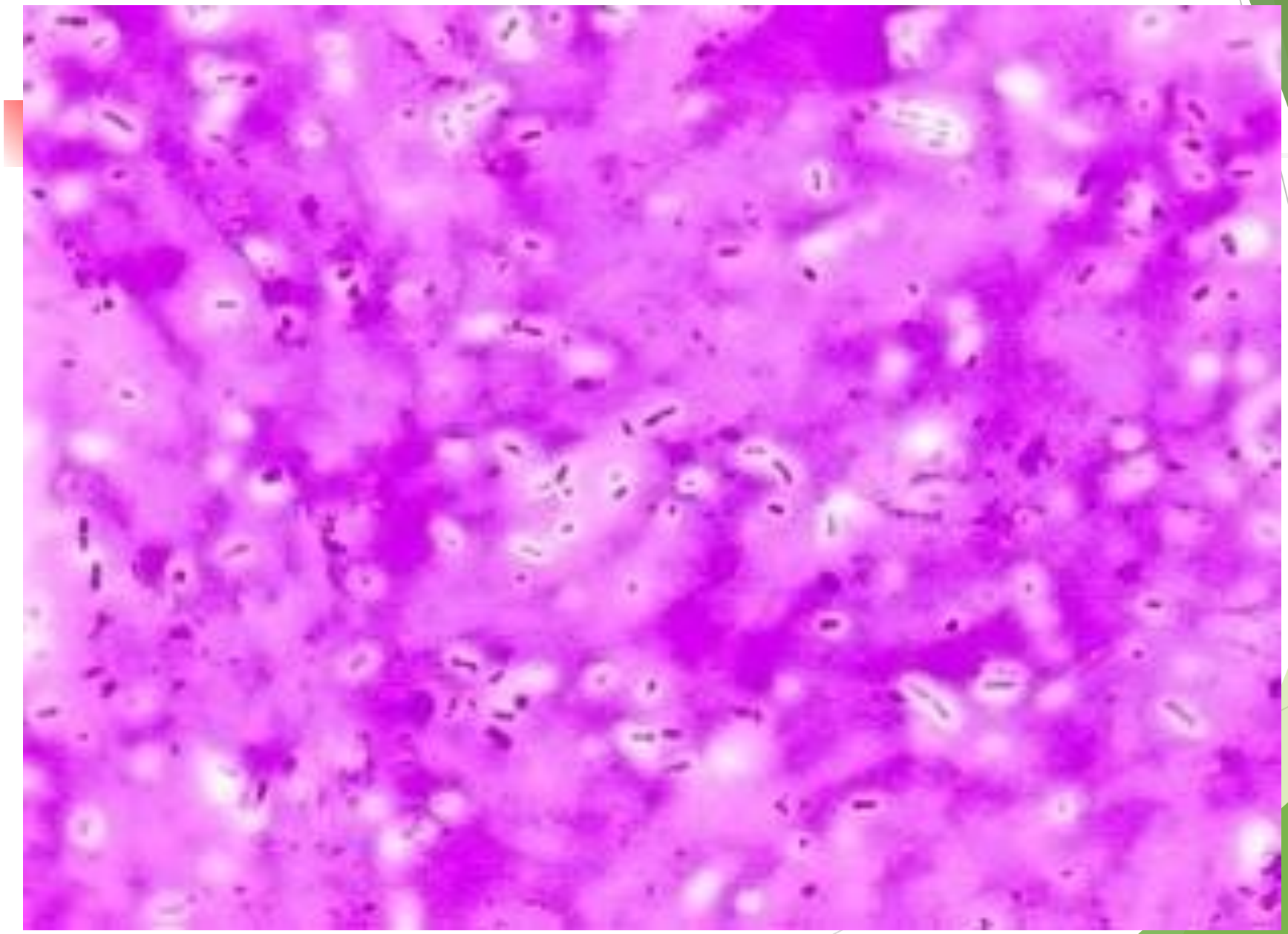
Staining by the method of Ziehl-



Chemical Composition of Capsules

Bacterium	Capsule composition	Structural subunits
Gram-positive Bacteria		
Bacillus anthracis	polypeptide (polyglutamic acid)	D-glutamic acid
Bacillus megaterium	polypeptide and polysaccharide	D-glutamic acid, amino sugars, sugars
Streptococcus mutans	polysaccharide	(dextran) glucose
Streptococcus pneumoniae	polysaccharides	sugars, amino sugars, uronic acids
Streptococcus pyogenes	polysaccharide (hyaluronic acid)	N-acetyl-glucosamine and glucuronic acid
Gram-negative Bacteria		
Acetobacter xylinum	polysaccharide	(cellulose) glucose
Escherichia coli	polysaccharide (colonic acid)	glucose, galactose, fucose glucuronic acid
Pseudomonas aeruginosa	polysaccharide	mannuronic acid
Azotobacter vinelandii	polysaccharide	glucuronic acid
Agrobacterium tumefaciens	polysaccharide	(glucan) glucose

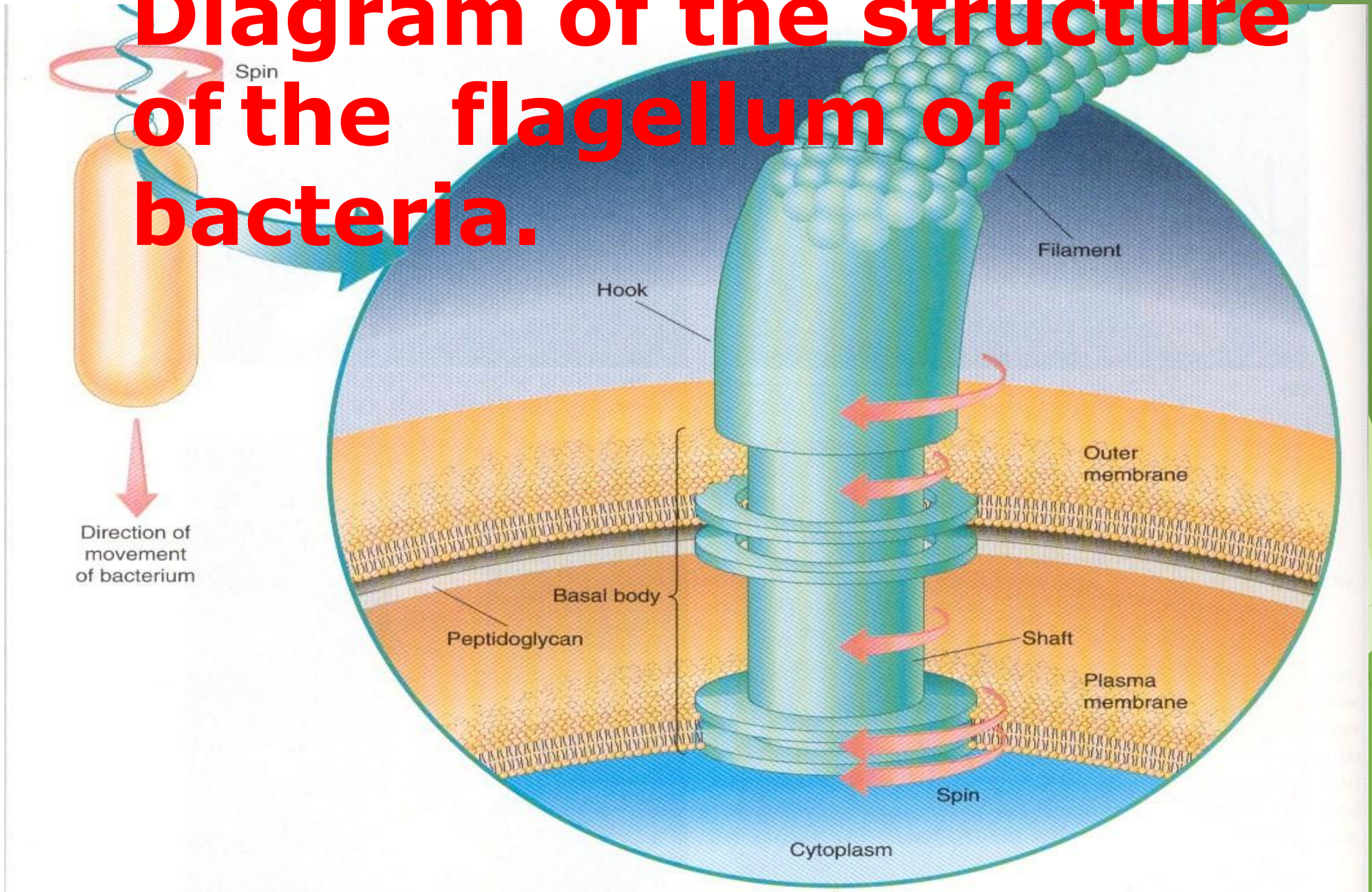
Detection of capsule by the method of Burry-Gins



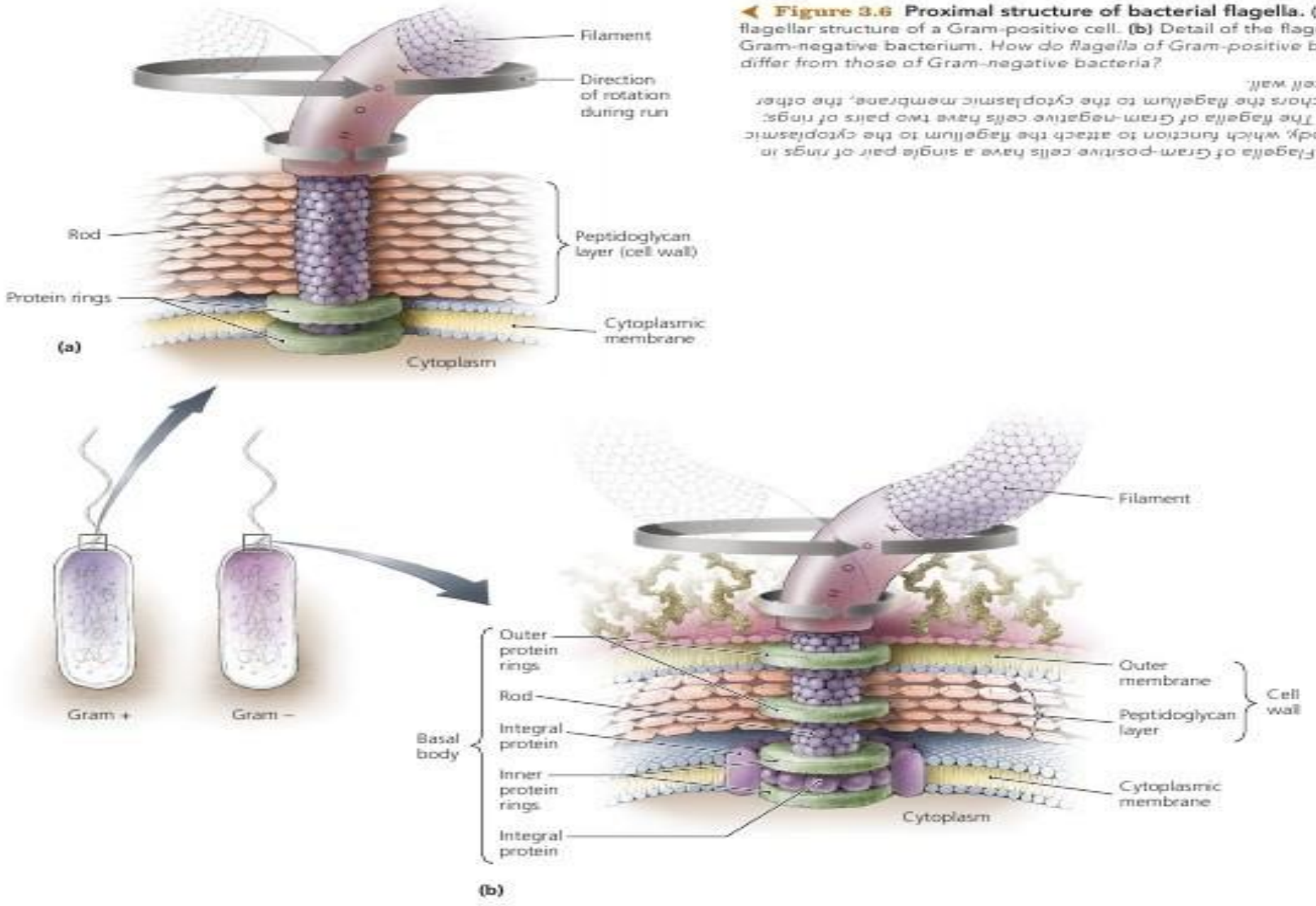
Flagella and fimbriae (drank) in bacteria

▲ **Figure 3.10 Fimbriae.** *Proteus vulgaris* has flagella and fimbriae.

Diagram of the structure of the flagellum of bacteria.



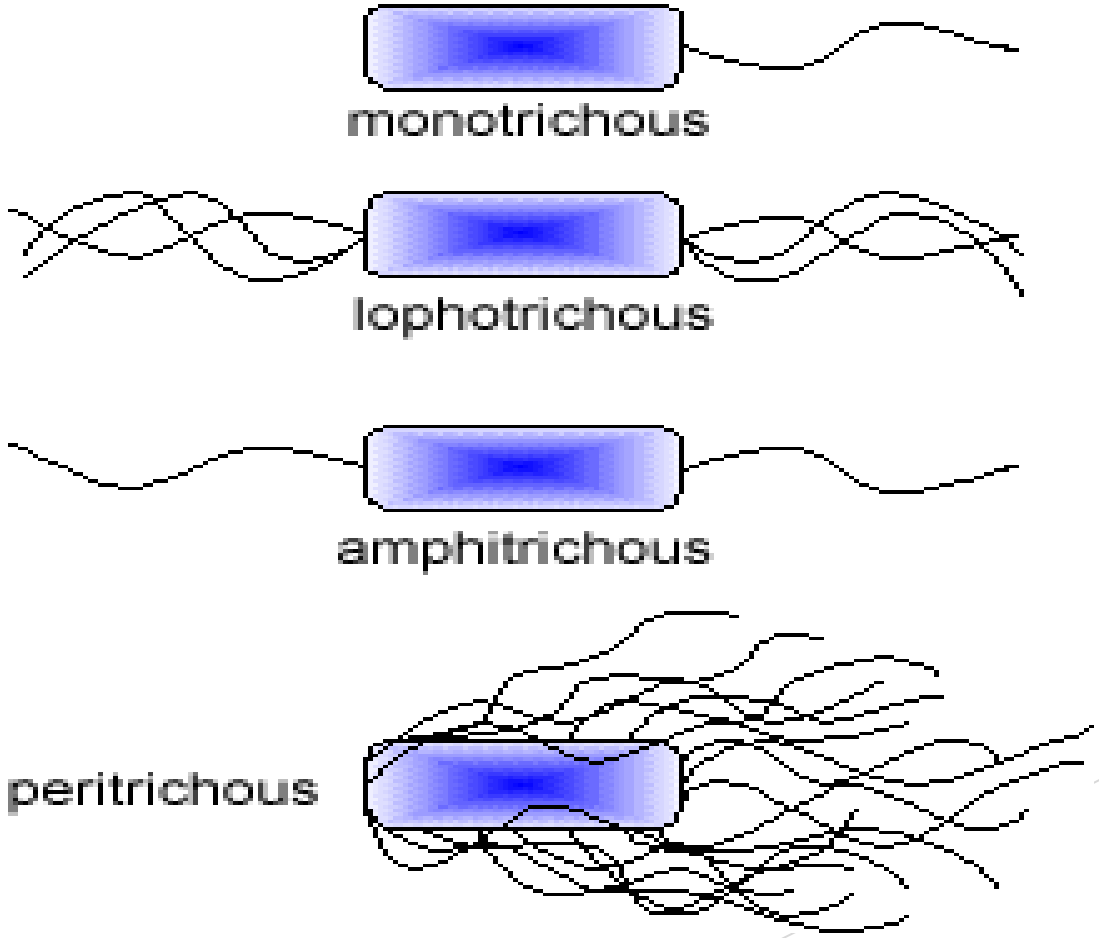
Attachment of flagella in Gr + and



◀ **Figure 3.6 Proximal structure of bacterial flagella.** **(a)** Detail of flagellar structure of a Gram-positive cell. **(b)** Detail of the flagellum of a Gram-negative bacterium. *How do flagella of Gram-positive bacteria differ from those of Gram-negative bacteria?*

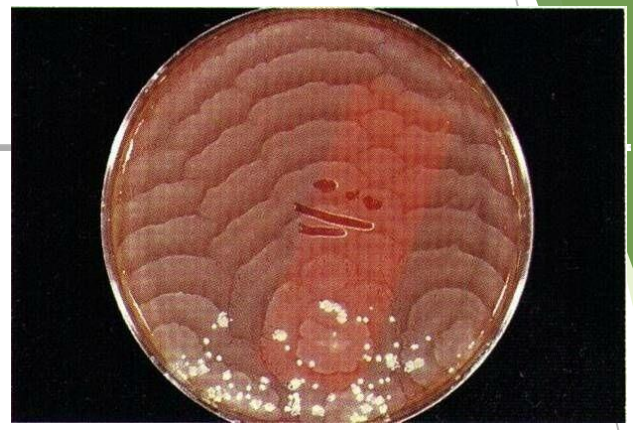
Figure 3.6 Flagella of Gram-positive cells have a single pair of rings in the basal body, which function to attach the flagellum to the cytoplasmic membrane. The flagella of Gram-negative cells have two pairs of rings: one pair anchors the flagellum to the cytoplasmic membrane, the other pair to the cell wall.

Different arrangement of flagella in bacteria.



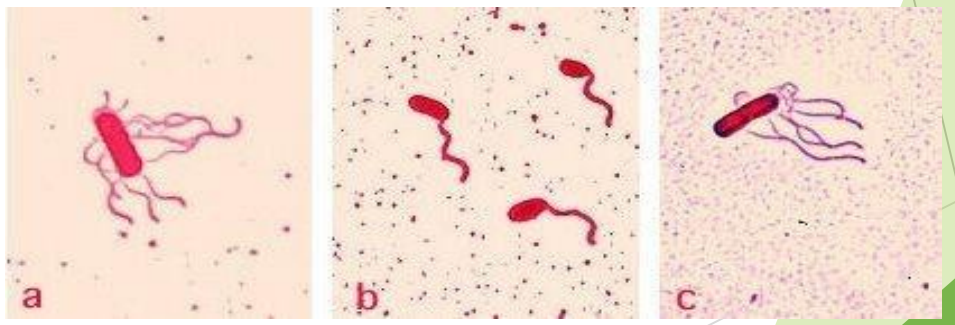
Determination of bacterial motility.

- The phenomenon of swarming in the environment →



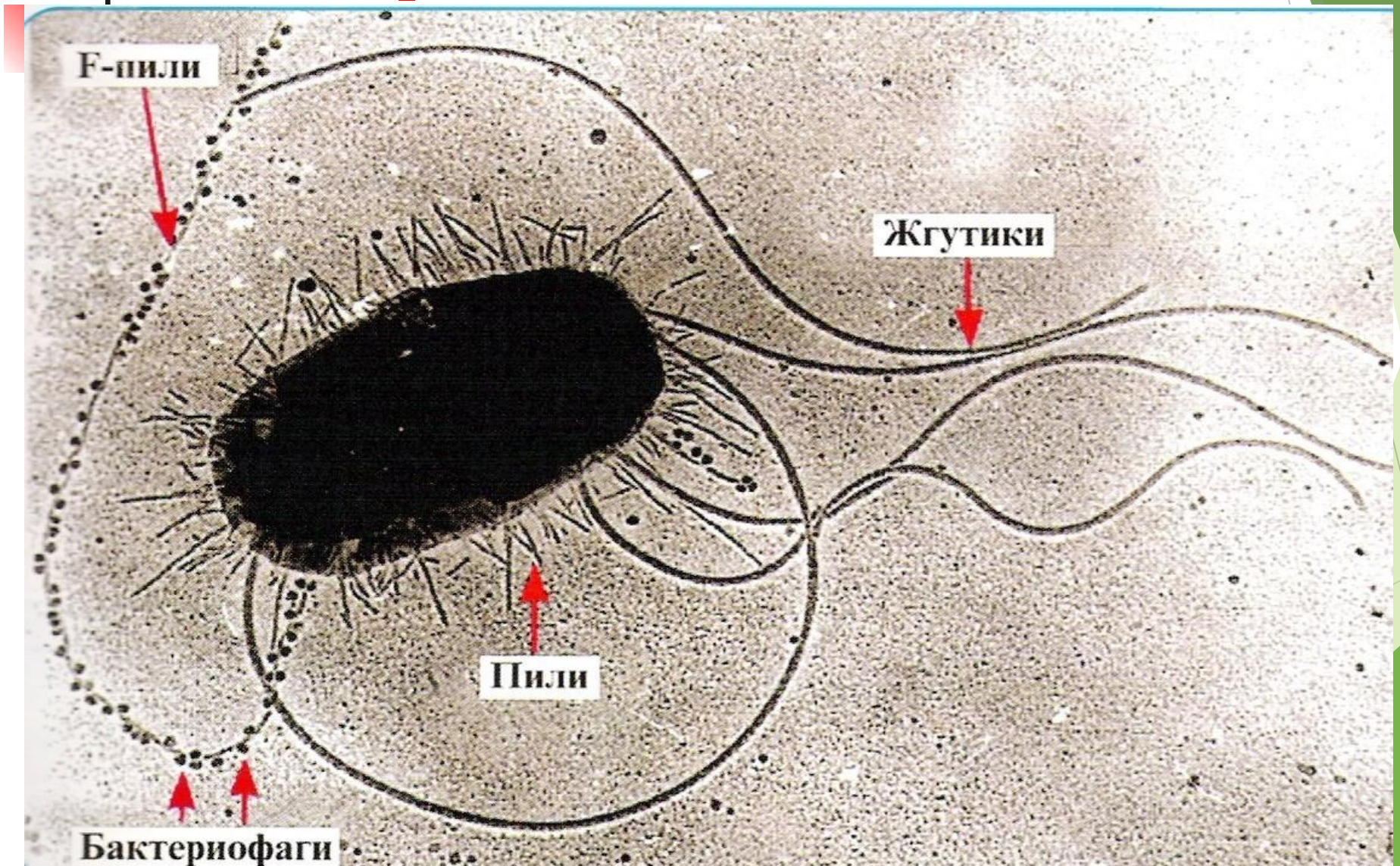
Proteus spp.

- Special stain

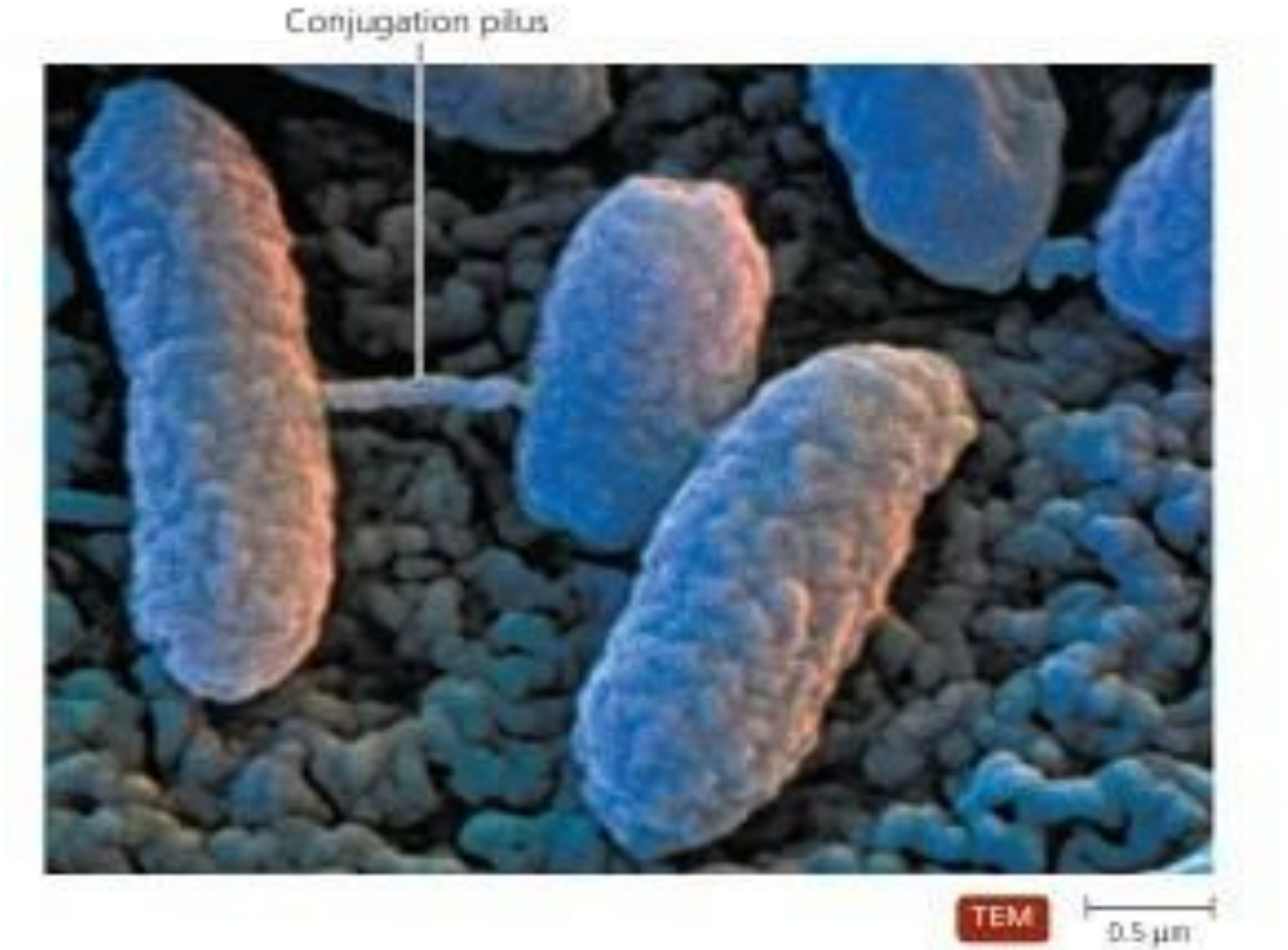


B. cereus **V. cholerae** **B. brevis**

Drank (including F-drank) in bacteria.

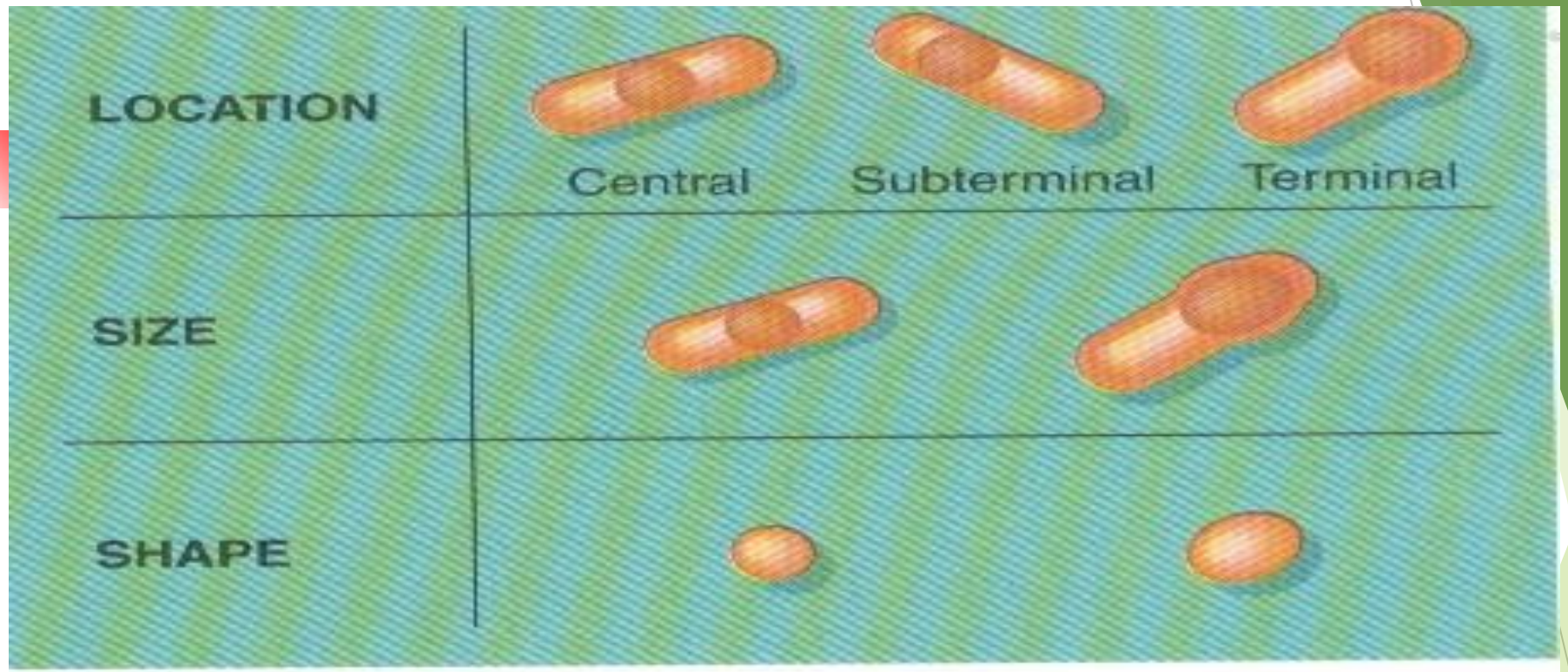


Conjugation drank bacteria.

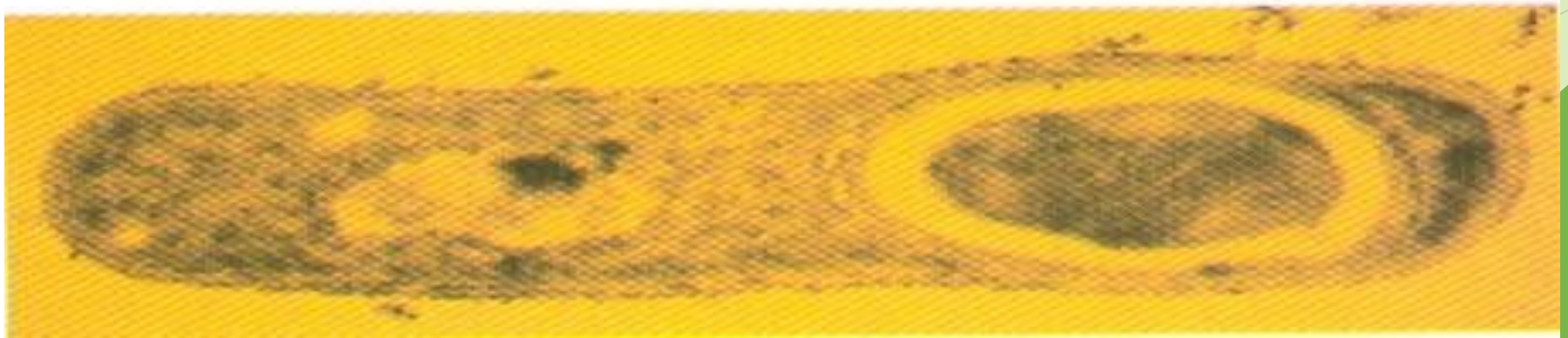


▲ **Figure 3.11 Pili.** Two Salmonella cells are connected by conjugation pili. *How are pili different from bacterial flagella?*

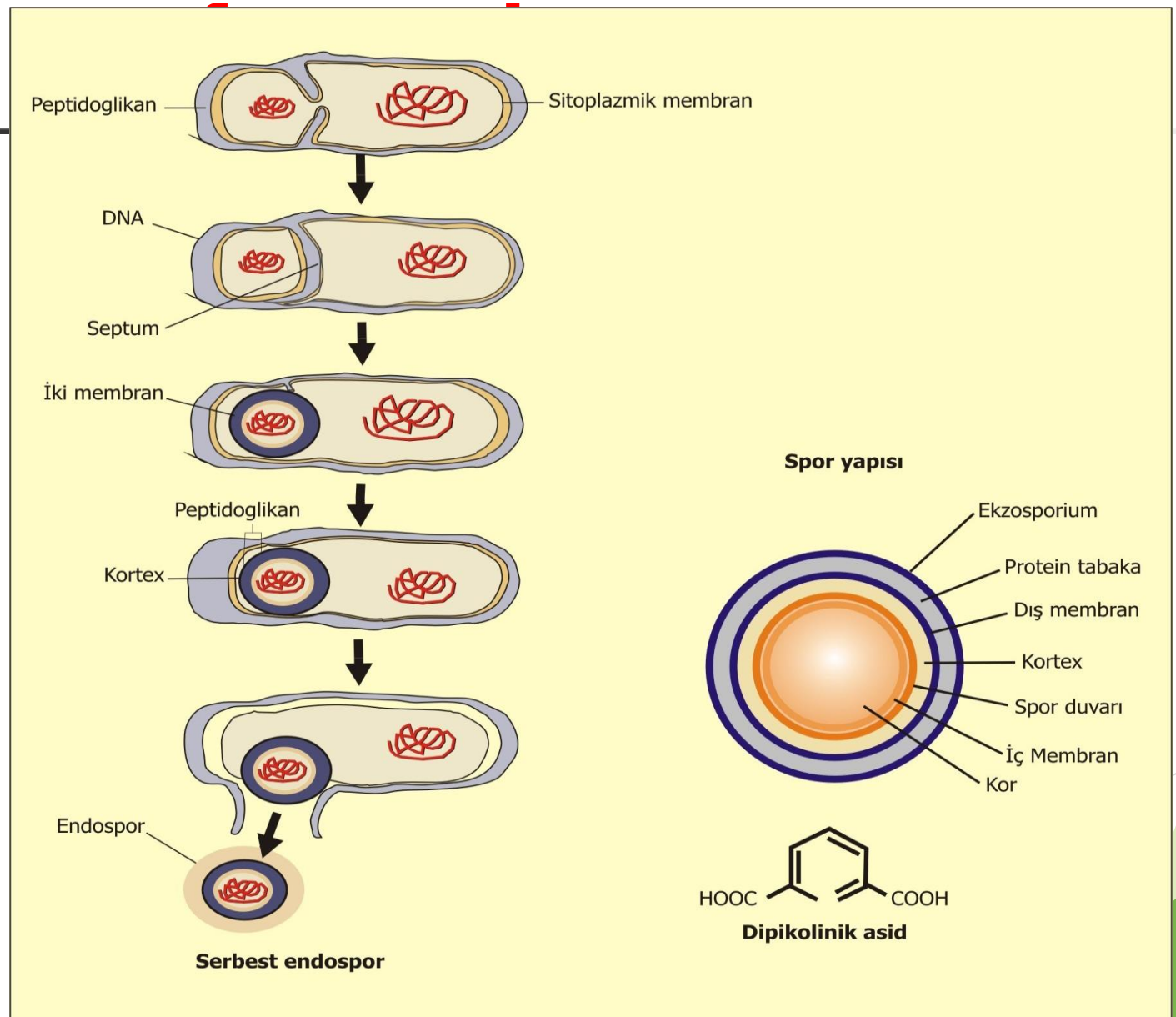
Bacteria spores (sizes and location)



(a)



Stages of spore



Spores of the causative agent of anthrax (method Ozeshko)

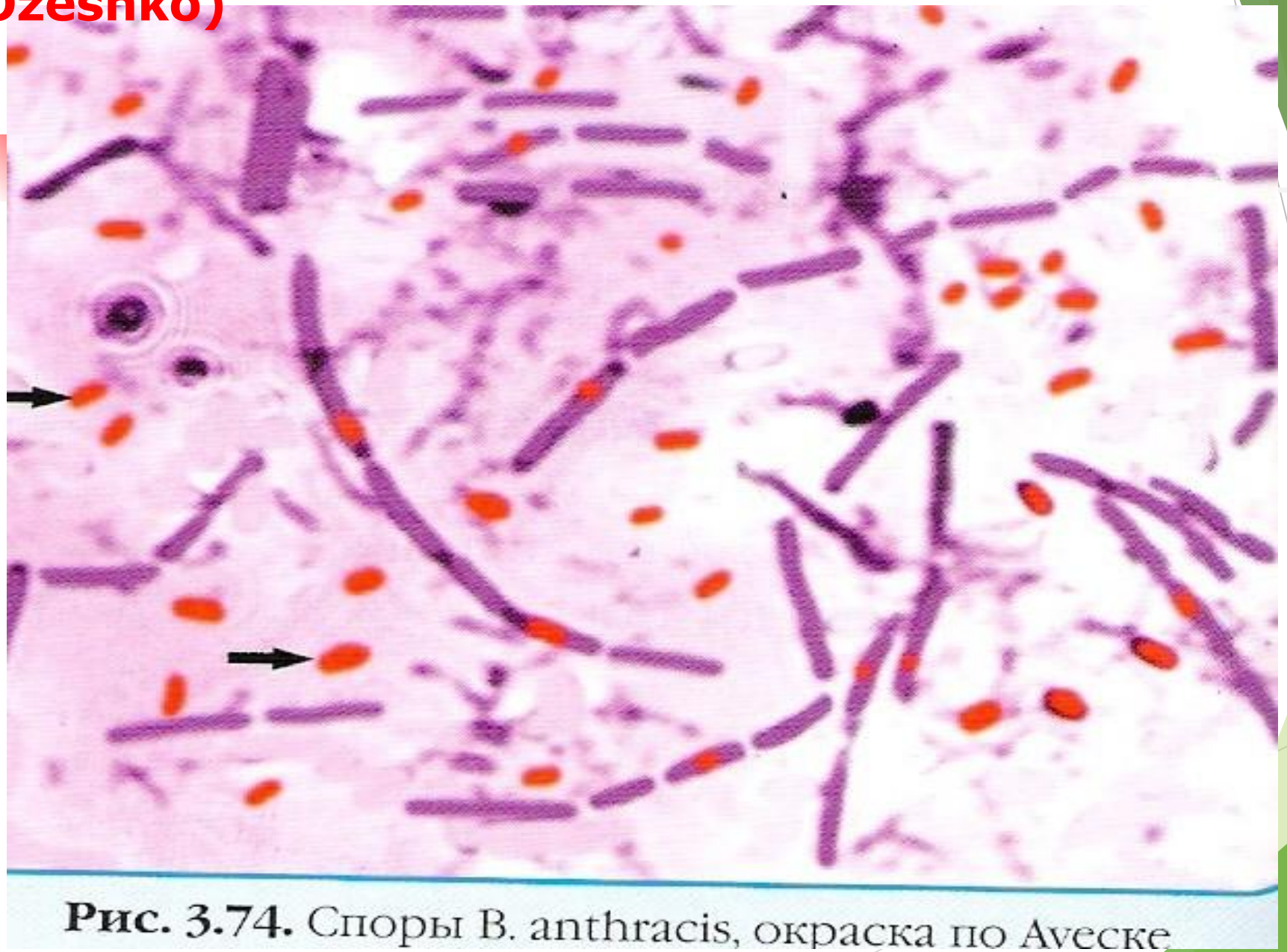


Рис. 3.74. Споры B. anthracis, окраска по Ауеске

Spirochetes

- Thin, mobile, spirally crimped batteries from 3 to 20 microns in length, characterized by mobility due to flexion changes in cells.
- Cells consist of a protoplasmic cylinder intertwined with one or more axial fibrils extending from subterminal attachment disks located at the ends of the cylinder (which brings them closer to the simplest).

Taxonomy of Spirochetes

- Type – Spirochaetes
- Class – Spirochaetes
- Order – Spirochaetales
- Family - Spirochaetaceae

Gender – Spirochaeta

Treponema (more than 10 types of species and subspecies)

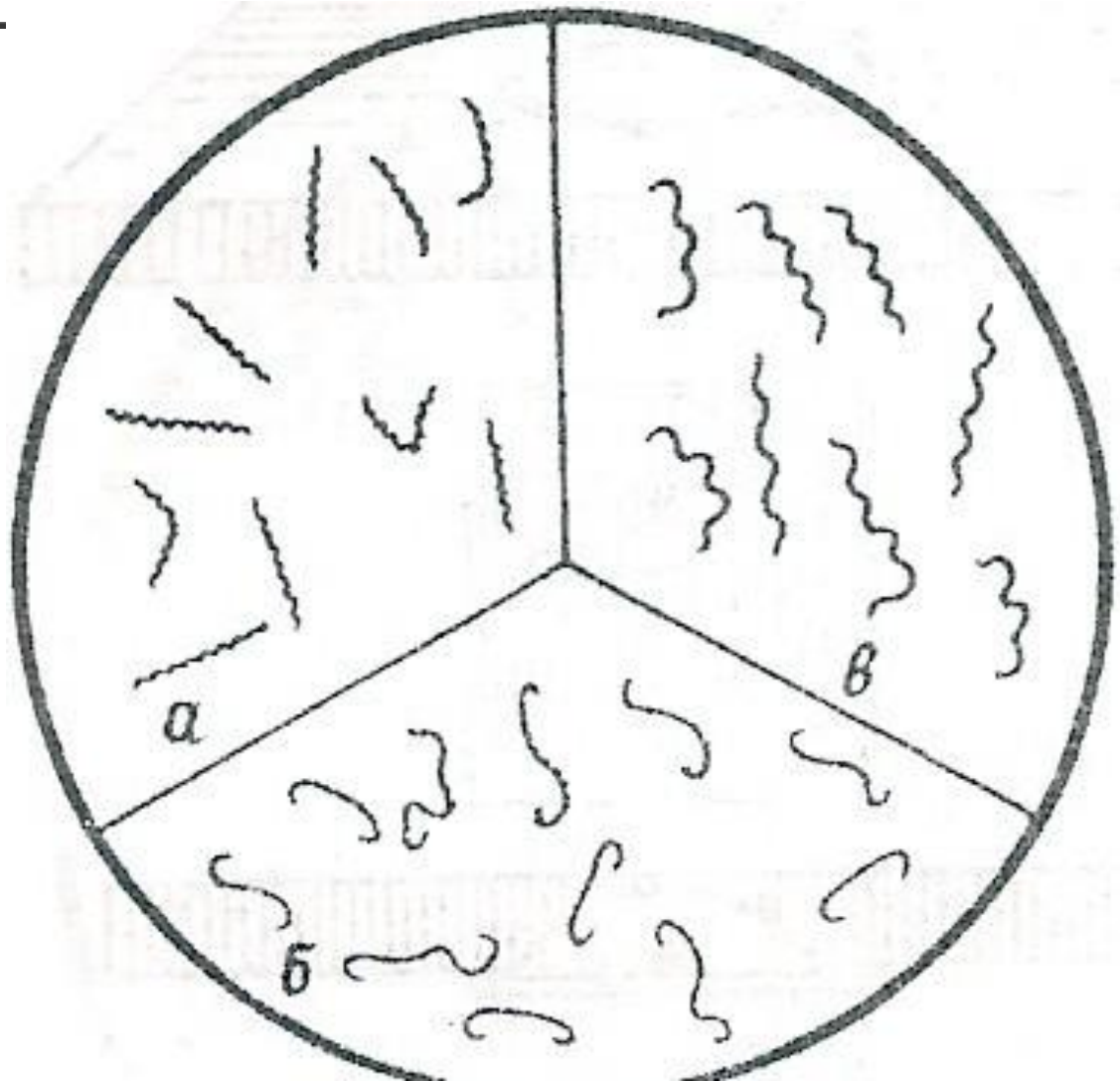
Borrelia (more than 20 species)

- Family – Leptospiraceae

Gender - **Leptospira** (more than 200 serovars)

Spirochetes genders

Leptospira (b) , Borrelia (c) Treponema (a),



Treponema.

Types of treponema pathogen for human beings:

1) **T.pallidum**

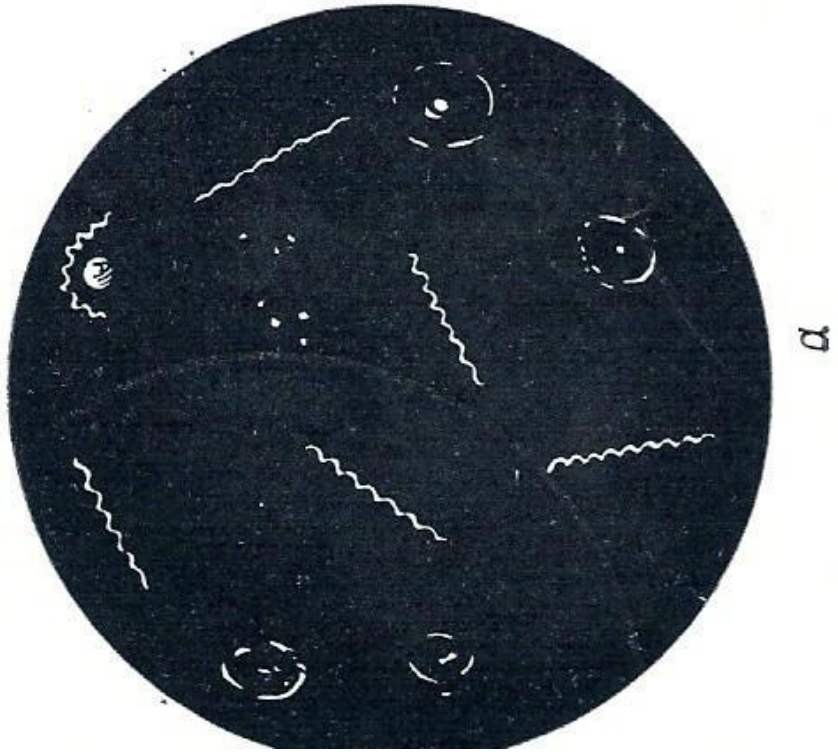
subspecies: pallidum (causative agent of syphilis)
endemicum (begel pathogen)

pertenue (causative agent of frambesia)

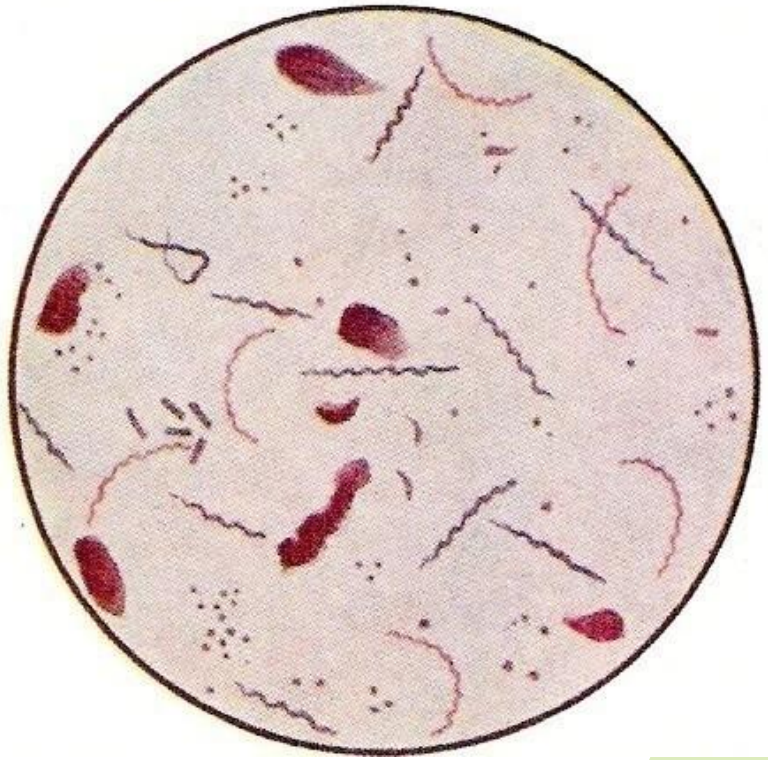
2) **T.carateum** (pint pathogen)

3) **T.vincentii** (together with fusobacteria, the causative agent of ulcerative necrotic tonsillitis Simanovsky-Vincent-Plaut)

Treponema



Dark field microscopy



Staining by the method of Gimzi

Treponema of syphilis (electron micrography)

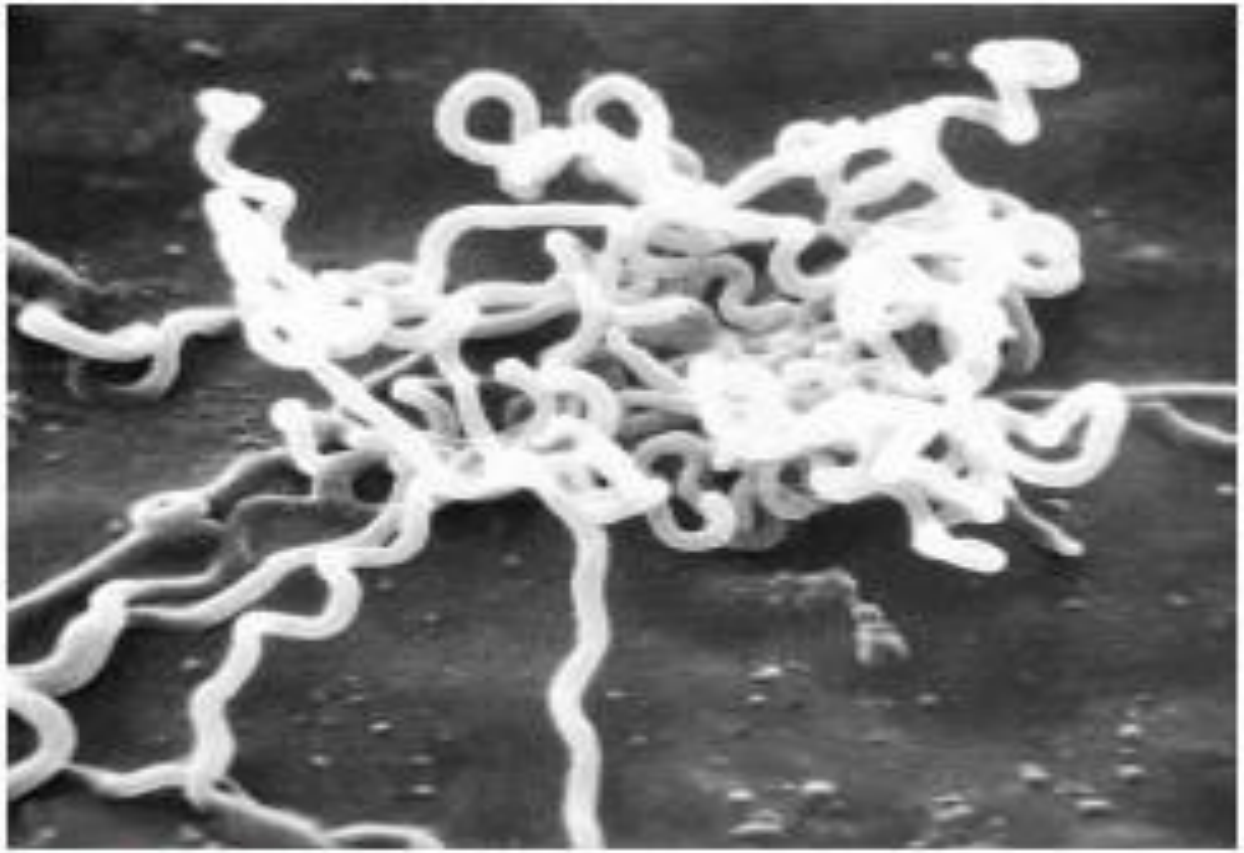


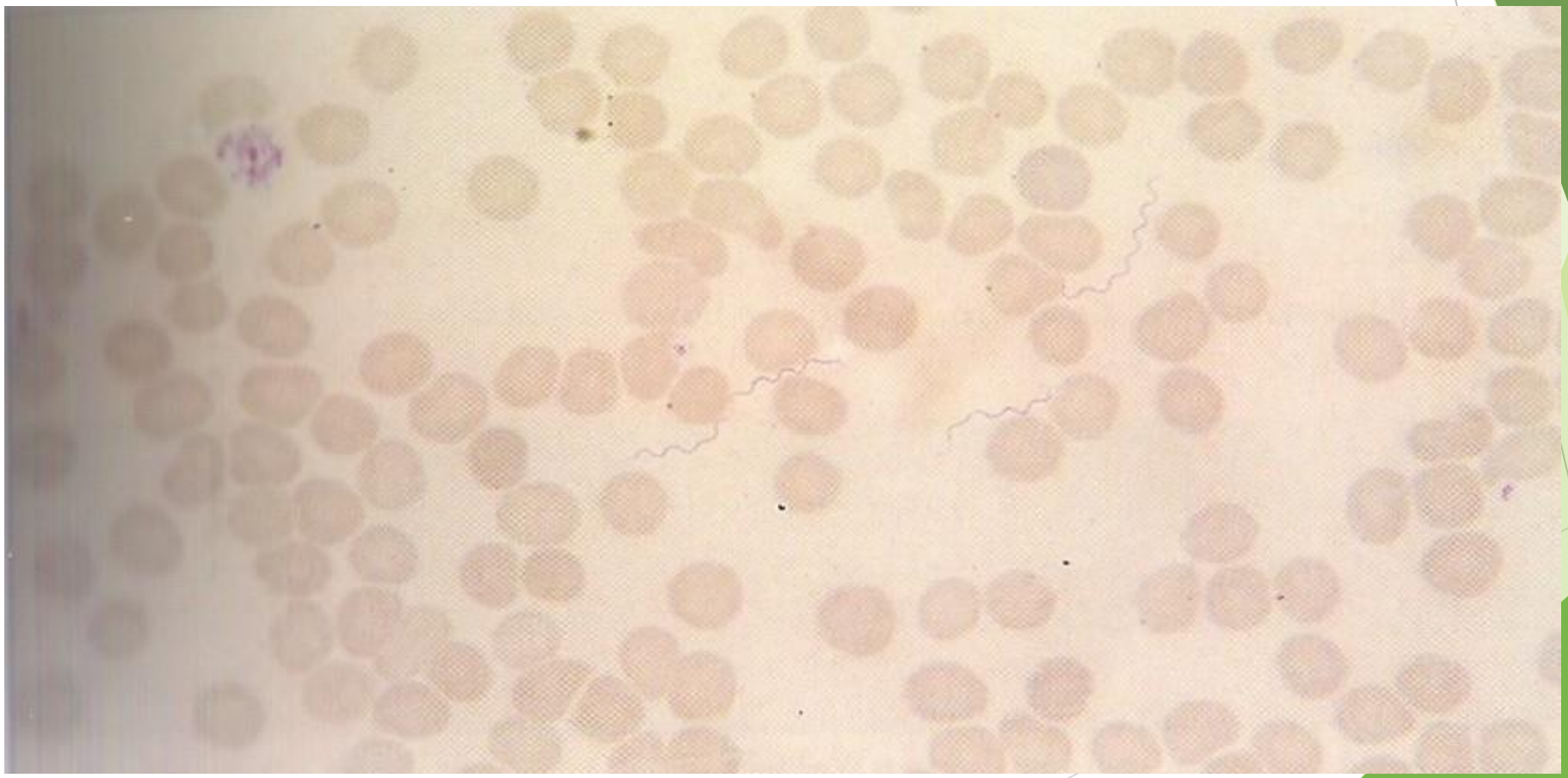
FIGURE 4-18. Scanning electron micrograph of *Treponema pallidum*, the bacterium that causes syphilis. (Courtesy of Dr. David Cox and the Centers for Disease Control and Prevention.)

Borrelia

- **Gender of** Contains more than 20 types, list of which below show the pathogen ones for the human beings:
- **B.recurrentis** -
- causative agent of anthroponous epidemic relapsing fever
- **B.duttoni -** causative agent of zoonotic endemic (tick-borne) relapsing fever
- **B.persica -** causative agent of zoonotic endemic (tick-borne) relapsing fever
- **B.burgdorferi** - Lyme disease pathogen in North America
- **B.garini** - causative agent of Lyme disease on the Euro-Asian continent
- **B.afzelii** - causative agent of Lyme disease on the Euro-Asian continent

Borrelia recurrentis

blood smear (Giemsa stain)



Leptospira

The genus Leptospira contains one species, L.interrhogans, which includes 38 serogroups and more than 200 leptospira serovars.
Leptospira 13 serogroups and 27 serovars are found in the CIS countries.
The most commonly identified leptospira serovars are:

L.icterohaemorrhagiae – causative agent of Vasiliev-Weil disease (icteric leptospirosis)

L.grippotyphosa - causative agent of swamp fever or marsh fever

L. canicola – causative of canine leptospirosis

L.pomona - swine pathogen causative

L.mitis - swine pathogen causative

L.hebdomatis - causative agent of Japanese or 7-day fever

L.autumnalis - causative agent of shin fever or Fort Bragg fever

L.australis - causative agent of Australian or 7-day fever

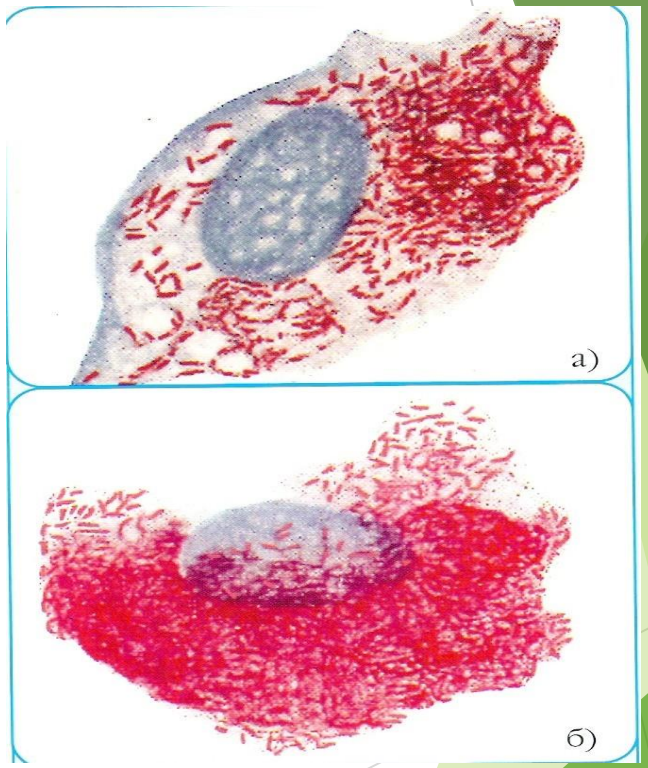
Leptospira (electron

Leptospira interrogans

Rickettsia

.

- Small gram-negative bacteria, obligate intracellular parasites
- The macroergic compounds necessary for their reproduction are obtained from the host cell
- The form is cocci or short sticks with a size of 0.3-2.0 microns, but long sticks and filiform shapes can be found.



Rickettsia inside cell

Taxonomy of ricketsia.

Type – Proteobacteria

Class – Alphaproteobacteria

Genders – **Rickettsia** (causative of typhus and spotted fevers)

Orientia (causative of Tsutsugamushi fever)

Ehrlichia (caus. Ehrlichiosis Sennetsu et al.)

Bartonella (caus. of diseases -cat scratches, trenchfever, etc.)

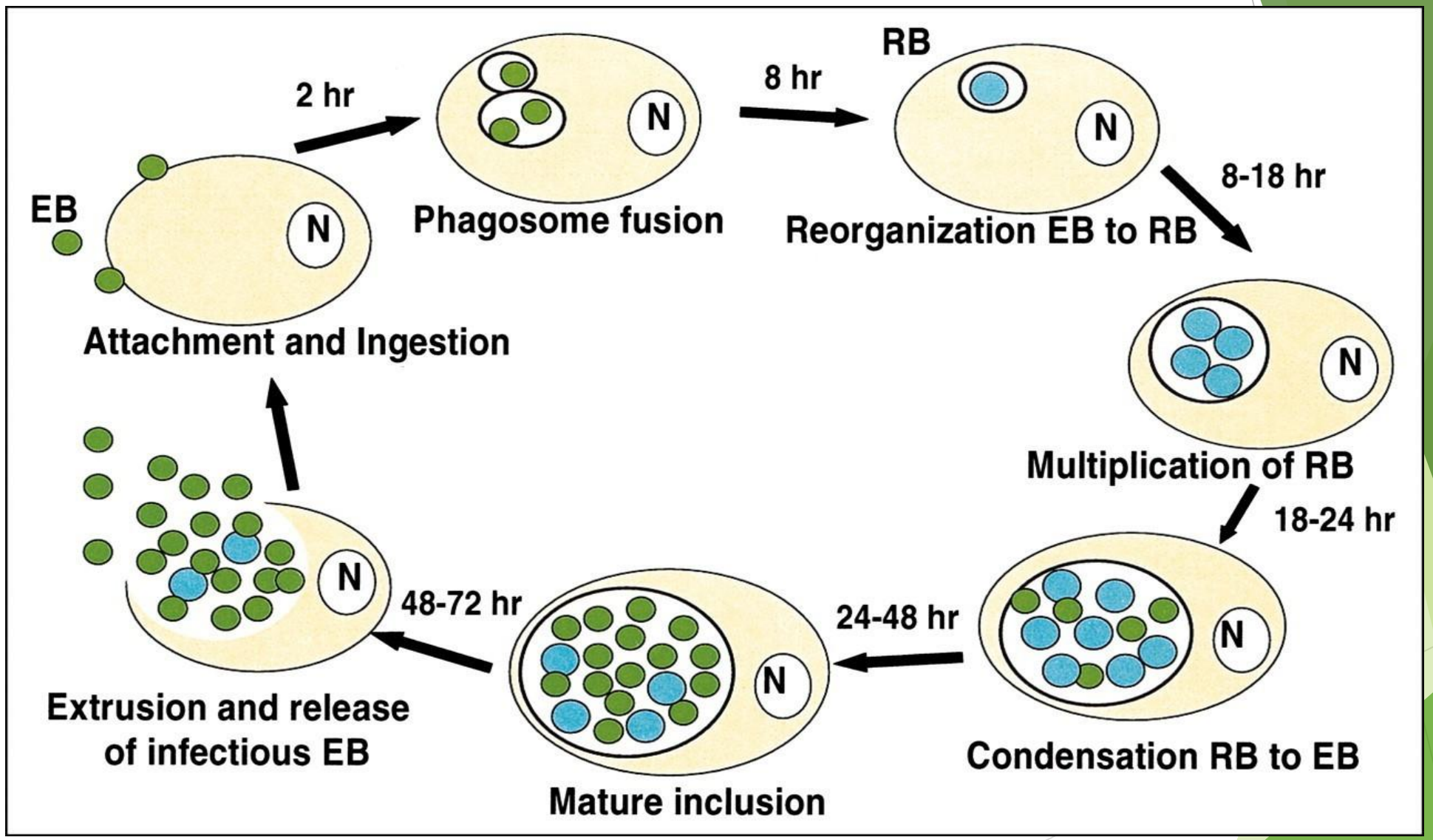
- Class – Gammaproteobacteria

Genders - **Coxiella** (caus. fever ku) For humans are pathogen: **10 types of ricketsia**,

1 type of oriensia, 3 species of Ehrlichia, 5 species of Bartonella and 1 species of coxiella.

Chlamydiae

- Small gram-negative bacteria, obligate intracellular
- parasites with a special development cycle.
- They are energy parasites: they do not synthesize adenosine triphosphate (ATP) and guanosine
- triphosphate (GTP)
- The development cycle includes the stages of elementary (0.2-0.3 μm) and reticular (0.8-1.2 μm)
- bodies
- Almost no N-acetylmuramic acid


EB
N
Attachment and Ingestion
2 hr
N
Phagosome fusion
8 hr
RB
N
Reorganization EB to RB
8-18 hr
N
Multiplication of RB
18-24 hr
N
Condensation RB to EB
24-48 hr
N
Mature inclusion
48-72 hr
N
Extrusion and release
of infectious EB

Taxonomy of Chlamydia

- Type– Chlamydiae
- Class – Chlamydiae
- Gender – **Chlamydia**

  Type - **C.trachomatis** (causative of trachoma, urogenital chlamydia and venereal lymphogranuloma)

  Gender - **Chlamydophila**

  Types – **C.psittaci** (caus. ornithosis)

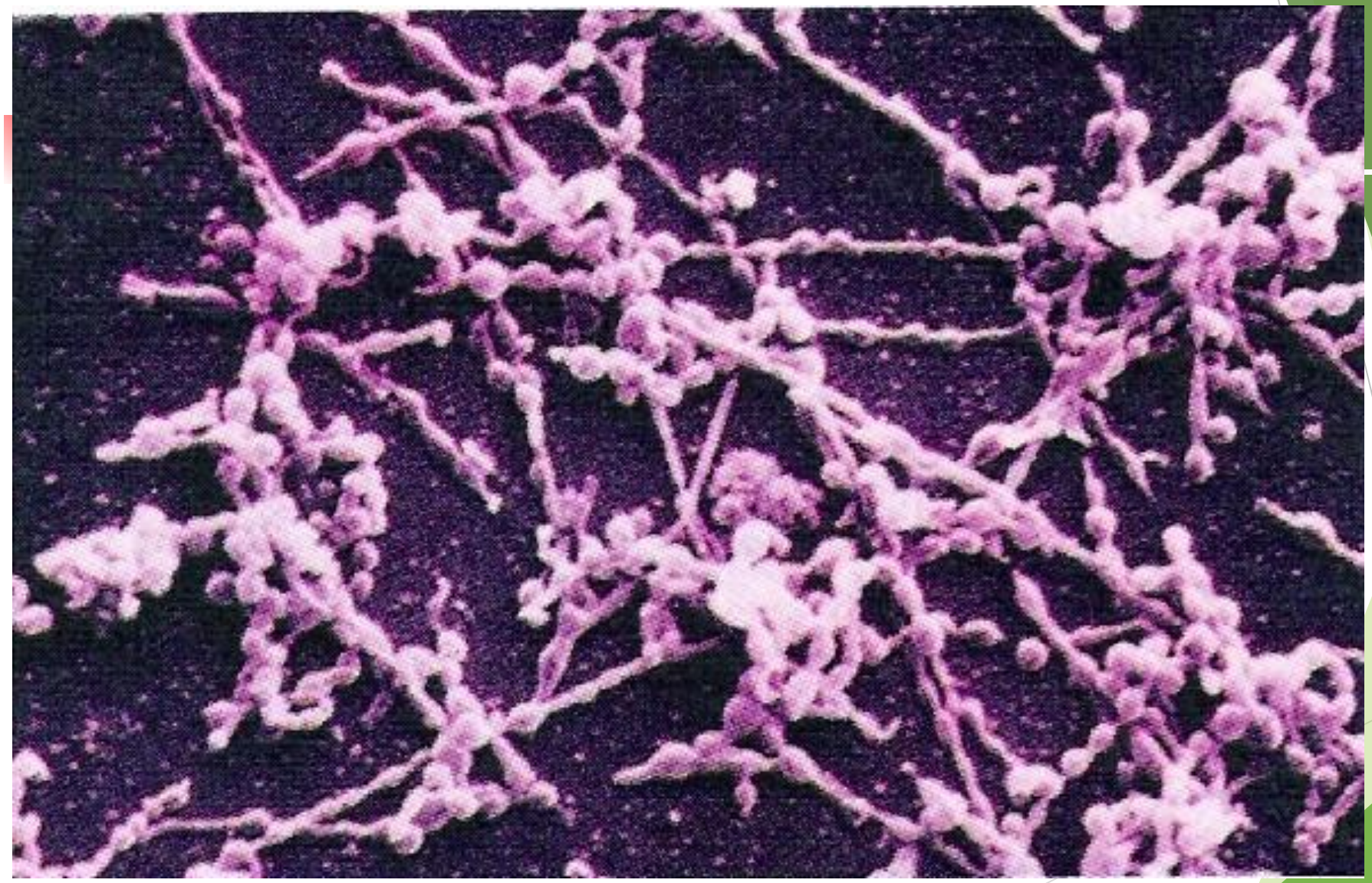
  C.pneumoniae (caus. pneumonia, atherosclerosis, bronchial asthma, etc.)

Mycoplasmas.

- Small gram-negative bacteria, devoid of the cell wall and surrounded only by the cytoplasmic membrane, the main component of lipids of which is cholesterol.
- Due to the absence of a rigid cell wall, they are polymorphic, plastic and osmotically sensitive, resistant to substances that inhibit cell wall synthesis.
- Propagated by binary division, budding, fragmentation of filaments and spherical formations.

They are the smallest among free-living bacteria (0.15-1.0 microns).

Mycoplasmas



Colonies of mycoplasmas

▲ **Figure 11.15 The distinctive "fried egg" appearance of *Mycoplasma* colonies.** This visual feature is unique to this group of bacteria, growing on an agar surface.

Taxonomy of mycoplasmas.

- Type – Firmicutes
- Class - Mollicutes
- Gender – **Mycoplasma**

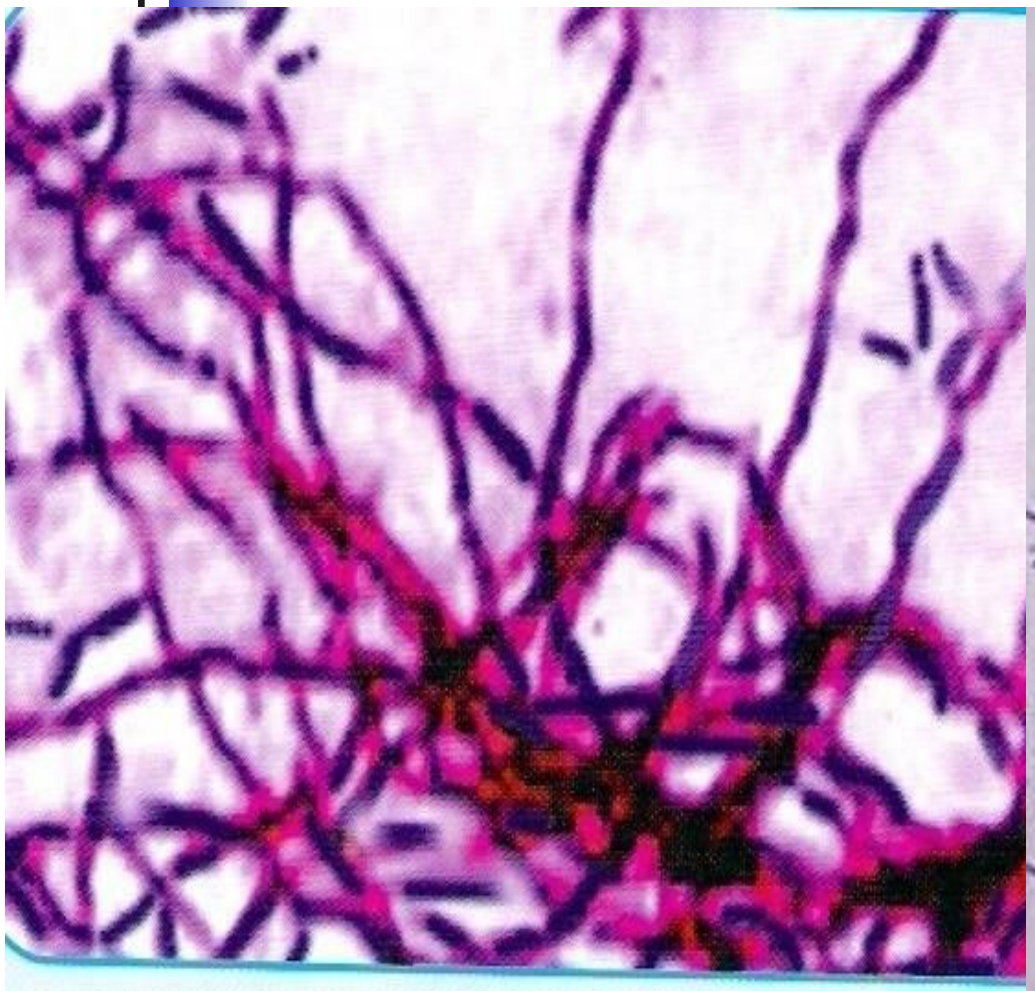
  Types – **M.pneumoniae** (caus. pneumonia), **M.hominis, M.fermentans, M.genitalium** (urogenital mycoplasmas)
- Gender - **Ureaplasma**

  Type – **U.urealyticum** (urogenital mycoplasmas)

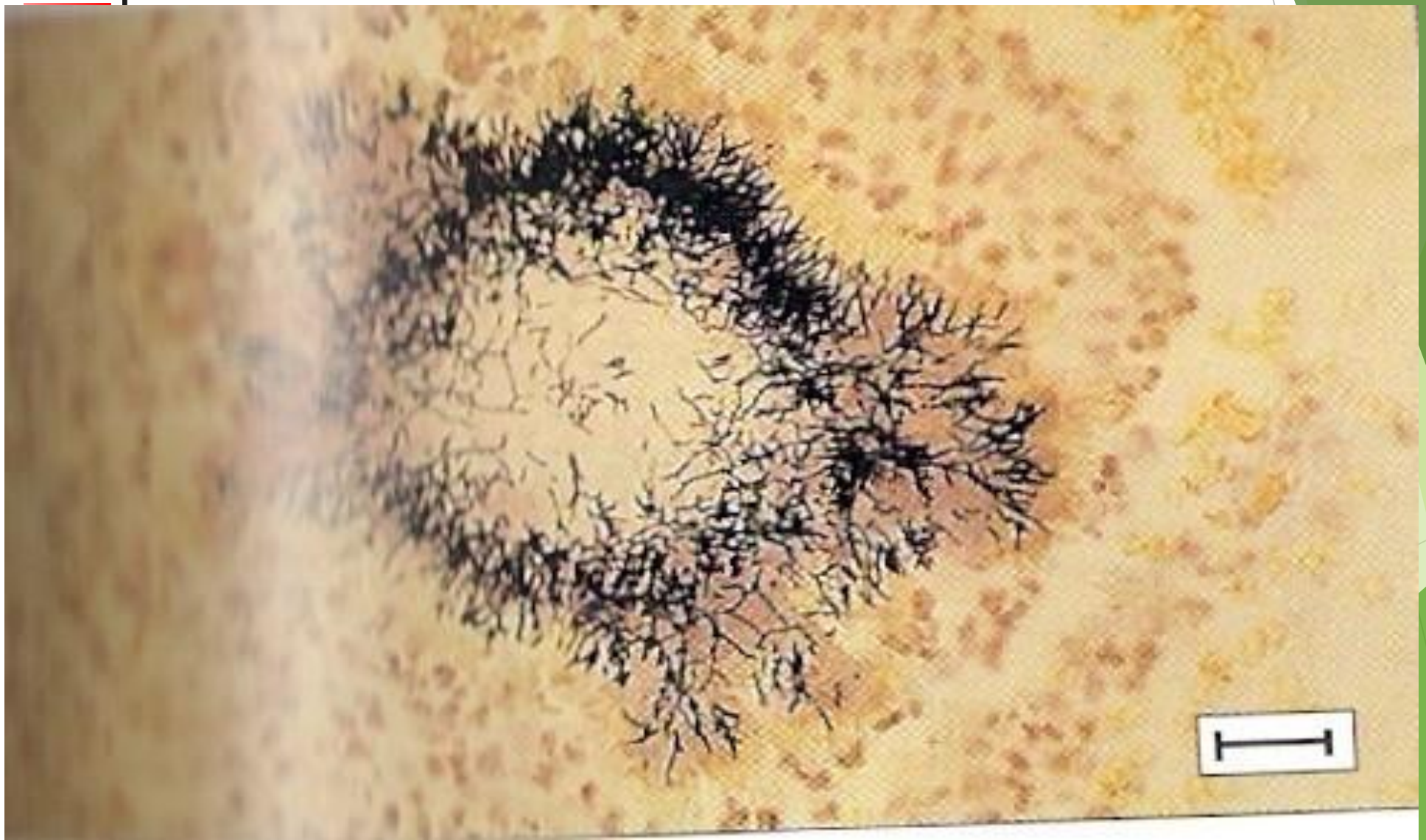
Actinomycetes

- Gram-positive branching filiform or rod-shaped bacteria.
- Like fungi, they form a mycelium, consisting of interwoven thin filaments (hyphae), however, unlike fungi, they do not contain chitin or cellulose in the cell wall.
- Druze form in the affected tissues.

Actinomycetes



Druse (in a smear of pus)



Taxonomy of Actinomycetes

- Type – Actinobakteria
- Class - Actinobakteria
- Gender – **Actinomyces**

  Types - **A.israelii, A.bovis, A. odontolyticus, A.viscosus, A.naeslundii** (pathogens of actinomycosis)

Fungi's

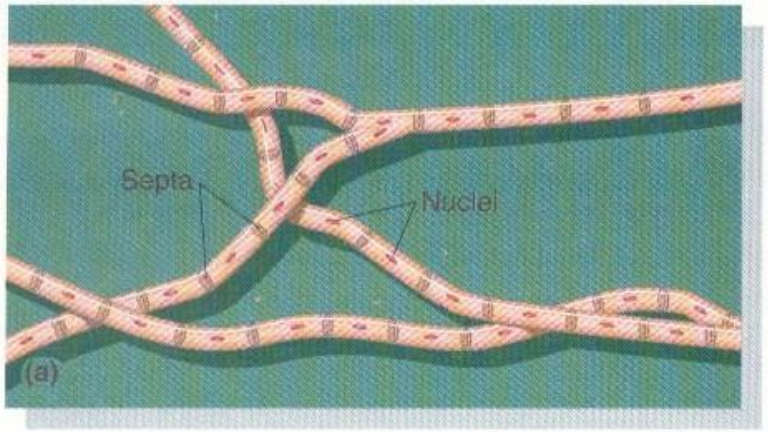
- Single or multicellular chlorophyll-free plant microorganisms
- that are eukaryotic
- Belong to the kingdom of Fungi (Mycetes, Mycota)
- Hyphal (2-100 microns) and yeast (2-5 microns) mushrooms are distinguished.
- By structure - lower (without partitions) and higher (septated)
- By the nature of reproduction - perfect (sexual reproduction) and imperfect (asexual reproduction).

Hyphae fungi.

- Fungi's form thin, windy hyphae that fly into a tomb or mold. The thickness of the hyphae ranges from 2 to 100 microns. They grow into a nutrient substrate, are called vegetative hyphae (nutrition of the fungus), and those growing above the substrate surface are called air and reproductive hyphae (responsible for asexual reproduction)

Hyphae of lower fungi do not have a partition. They are represented by multinucleated cells and are called coenocytic. Hyphae of higher fungi are divided by partitions.

Hyphae's of higher and lower fungi's.



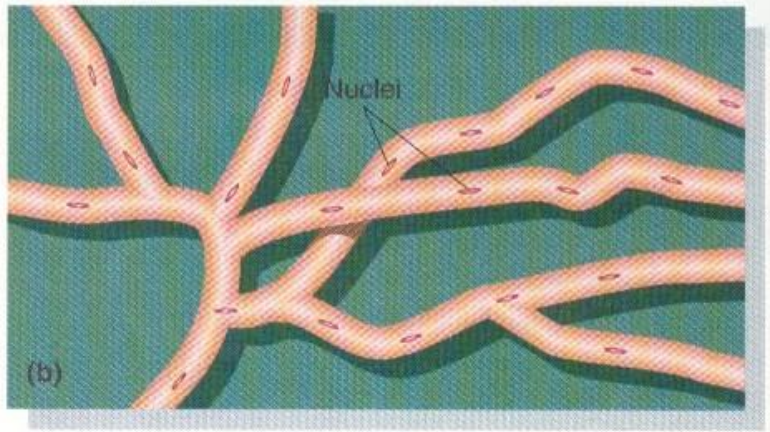


FIGURE 11-4 Characteristic hyphal structures. (*a*) Septate hyphae; (*b*) aseptate hyphae. (Note the absence of septa between nuclei.)

Yeast Fungi.

CHARACTERISTICS OF FUNGI

1. Yeasts

- Unicellular fungi, nonfilamentous, typically oval or spherical cells. Reproduce by mitosis:
  - Fission yeasts: Divide evenly to produce two new cells (*Schizosaccharomyces*).
  - Budding yeasts: Divide unevenly by budding (*Saccharomyces*).

    Budding yeasts can form pseudohypha, a short chain of undetached cells.

    Candida albicans invade tissues through pseudohyphae.
- Yeasts are facultative anaerobes, which allows them to grow in a variety of environments.
  - When oxygen is available, they carry out aerobic respiration.
  - When oxygen is not available, they ferment carbohydrates to produce ethanol and carbon dioxide.

Fungi

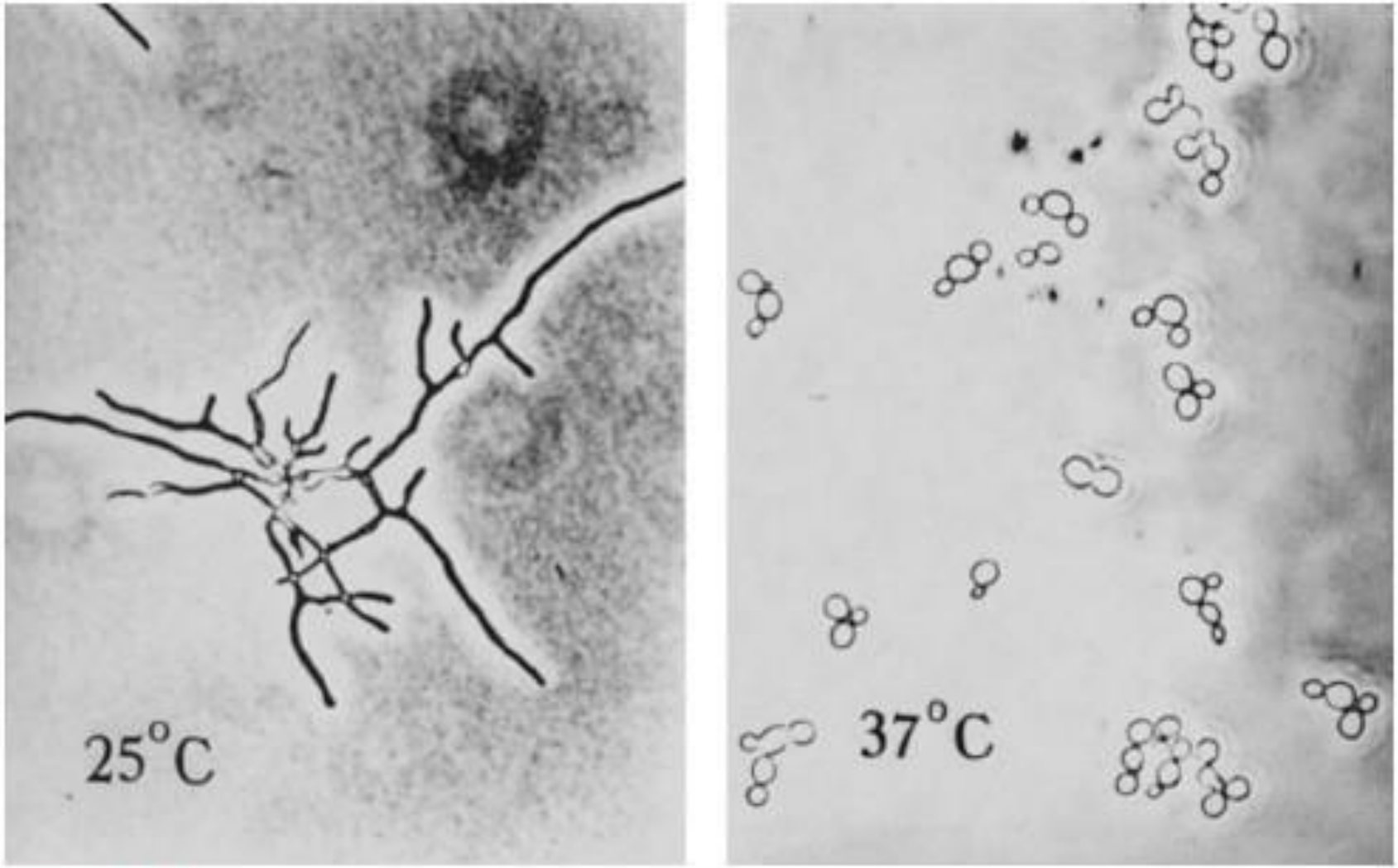


FIGURE 5-13. **Dimorphism.** Photomicrographs illustrating the dimorphic fungus, *H. capsulatum*, being grown at 25°C (left photo) and at 37°C (right photo). (From Schaeter M, et al., eds. Mechanisms of Microbial Disease, 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 1999.)

Multiplication of fungi's

- Sexual reproduction - the formation of germ cells (gametes), the formation of sex spores (zygospores, ascospores, basidiospores);
- Asexual reproduction - budding, hyphae fragmentation, the formation of asexual spores (sporangiospores, conidia: arthroconidia, blastoconidia, chlamydoconidia).

Asexual multiplication of fungi's

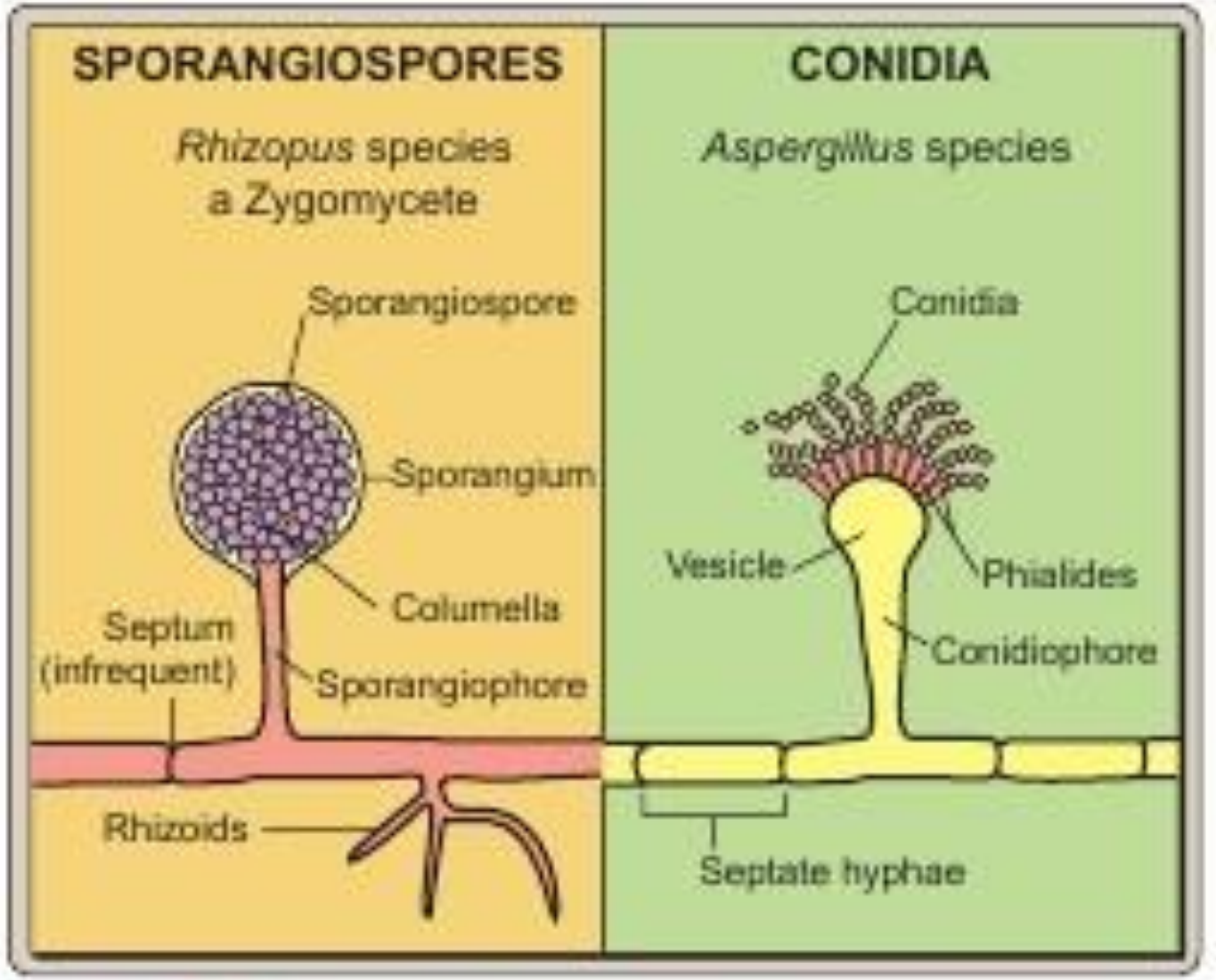


FIGURE 5-7. **Asexual reproduction in *Rhizopus* and *Aspergillus* moulds.** Illustrating the types of structures within and upon which asexual spores are produced.

Types of mushrooms of medical importance.

It is stressed out 3 types of fungi's, which have sexual reproduction, so called complete fungi's: Zygomycota, Ascomycota, Basidiomycota. Apart from them there is conditional, formal type/group- Deiteromycota, which have asexual method of reproduction.

The main groups of fungi's of medical importance

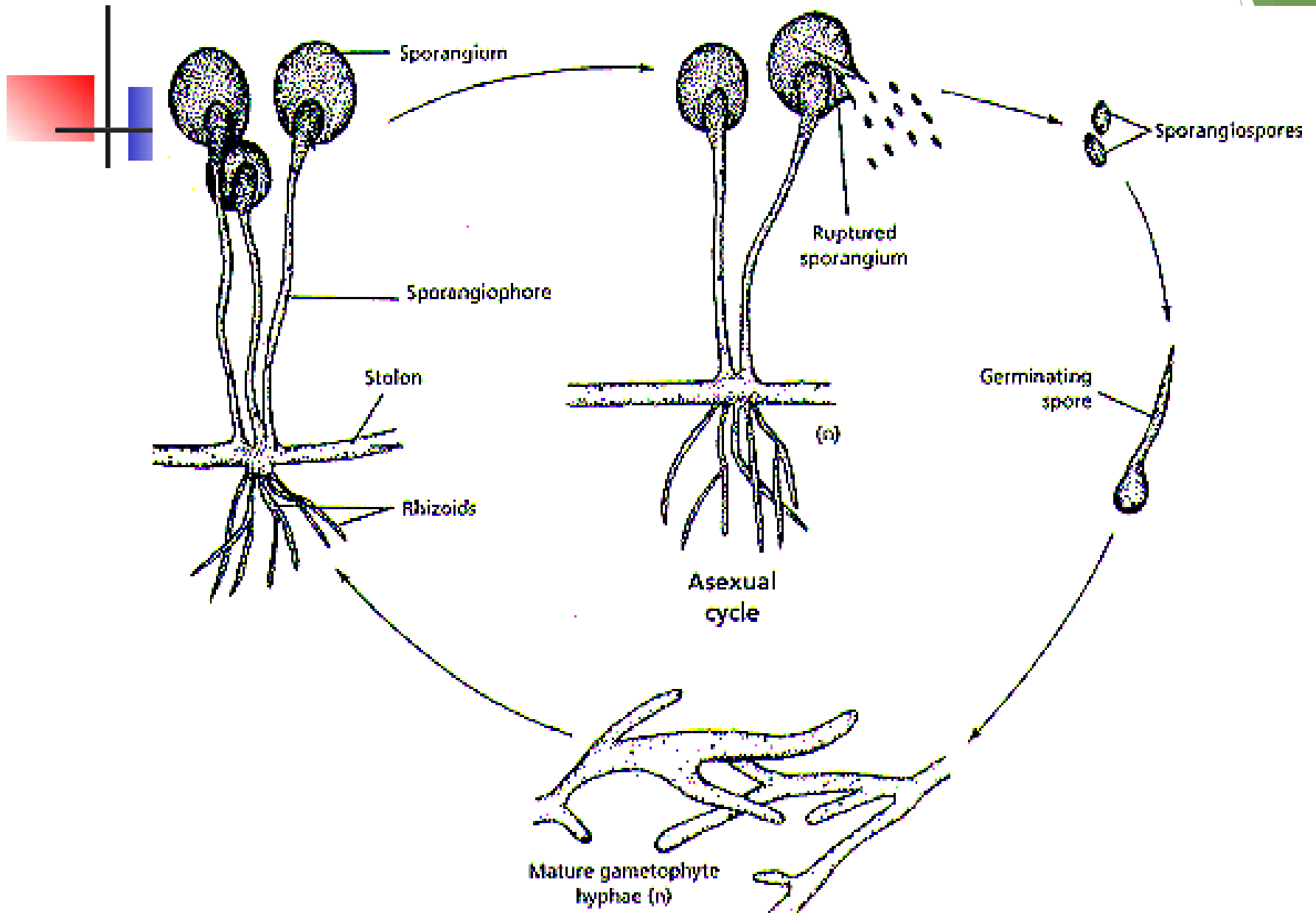
Group	Hyphae	Sexual Spores	Commonly Observed Asexual Spores	Some Medically Important Genera
Zygomycetes	Nonseptate	Zygospores	Sporangiospores	*Mucor* *Rhizopus*
Ascomycetes	Septate	Ascospores	Conidia Arthrospores Blastospores	*Aspergillus* *Histoplasma* *Trichophyton* *Penicillium*
Basidiomycetes	Septate	Basidiospores	Characteristically none	*Cryptococcus* *Amanita* ("death angel" mushroom)
Deuteromycetes	Septate	None	Conidia Arthrospores Blastospores Chlamydospores	*Candida* *Sporothrix* *Coccidioides*

Zygomycetes

- Zygomycetes- belong to lower fungi's. They contain , the representatives of geners like Mucor, Rhizopus

  - Rzizomucor, Absidia, Basidiobolus, Conidiobolus. Spread in the soil and air. Can cause Zygomycetes of lungs, brain and other organs of human being.
  - During asexual reproduction of zygomycetes sporangia are formed on the fruiting hyphae- spherical with a shell containing numerous sporangiospores

Zygomycetes.



Ascomycetes

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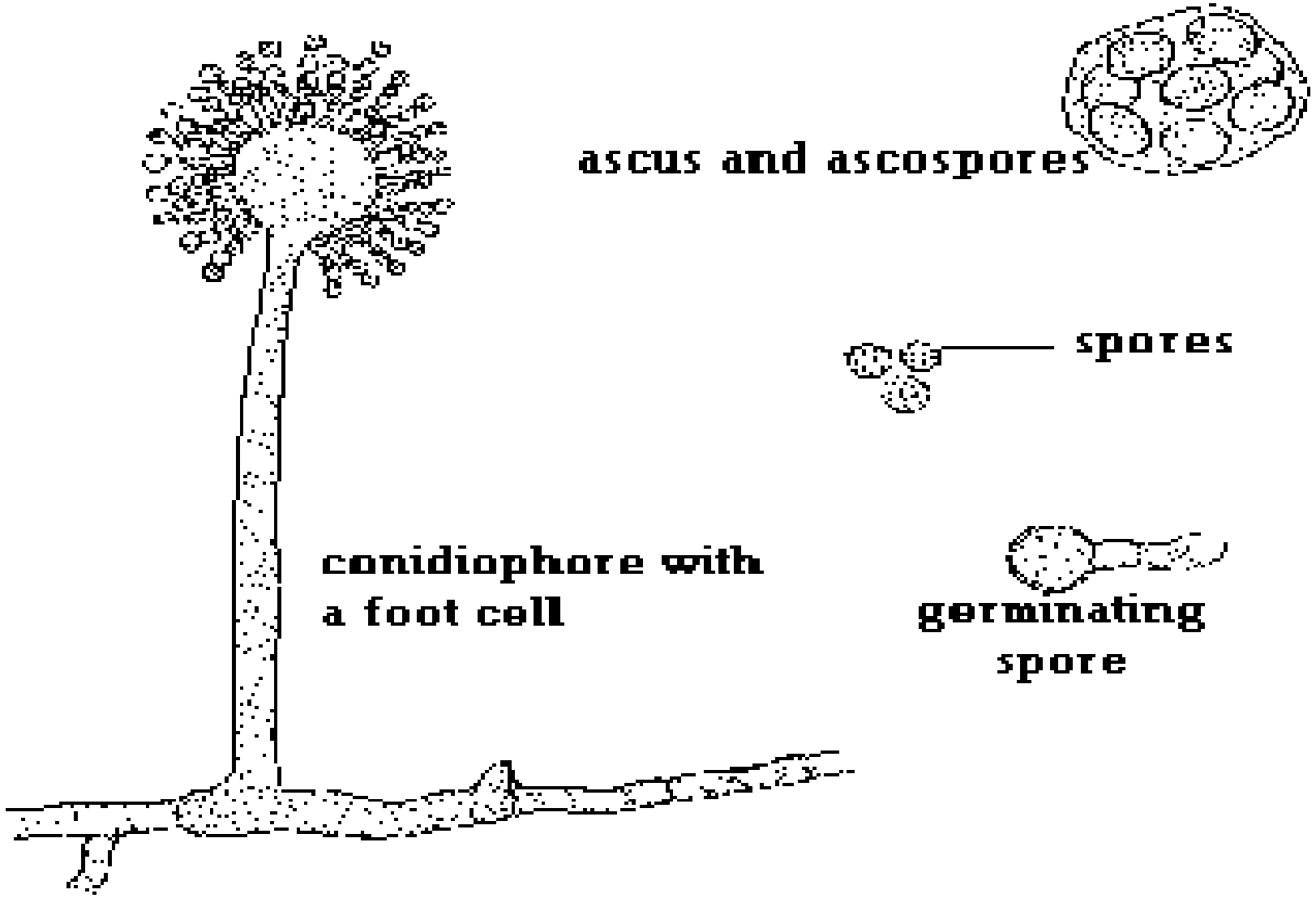
Ascomycetes(marsupial fungi's) have septic mycelium (besides one celled yeasts). Their name they got from bearing- bags which contain 4 or 8 haploid genital spores (Ascospores). Most of the fungis from Aspergillus genre are anamorphs, multiplicate only by asexual method of reproduction, with the help of asexual spores- comidiy's.

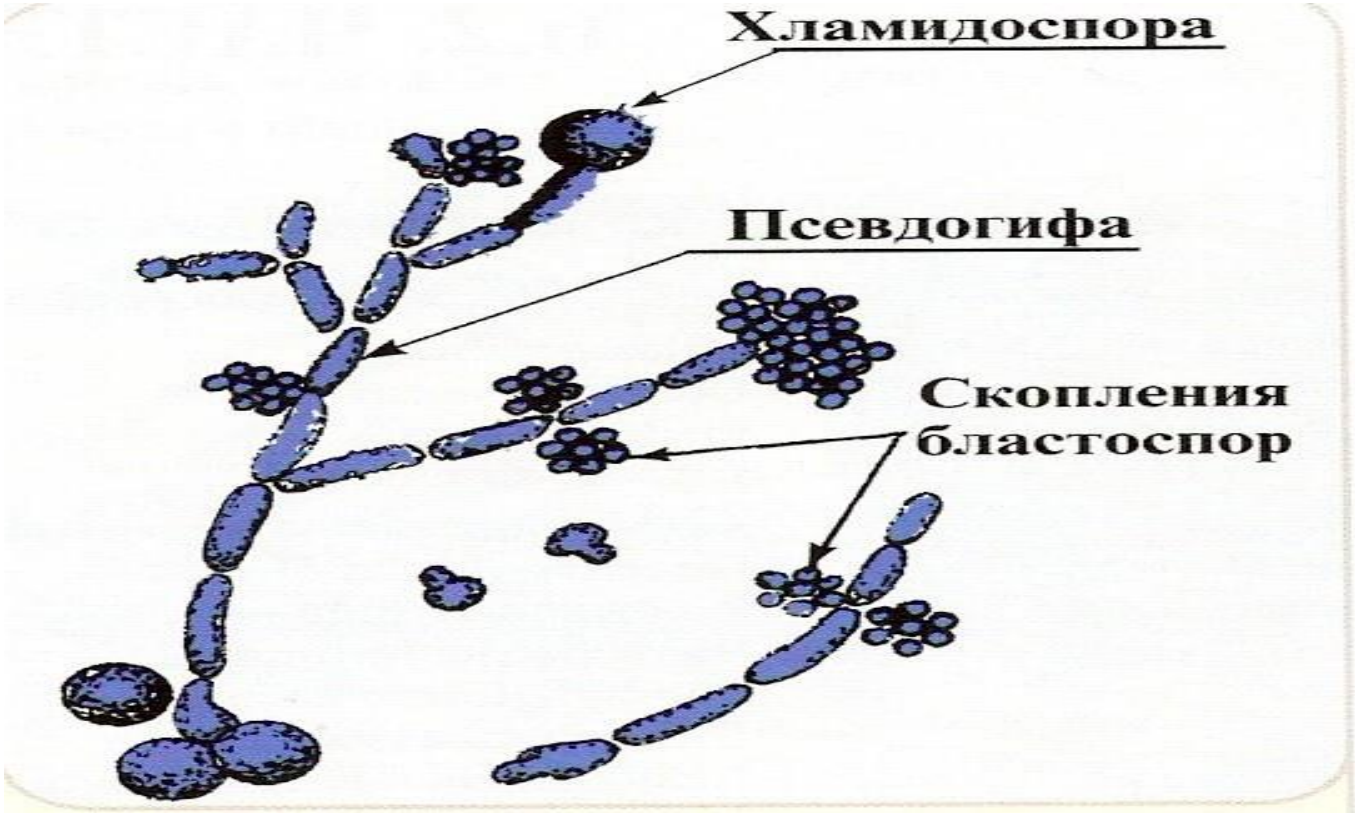
Mold Ascomycetes.



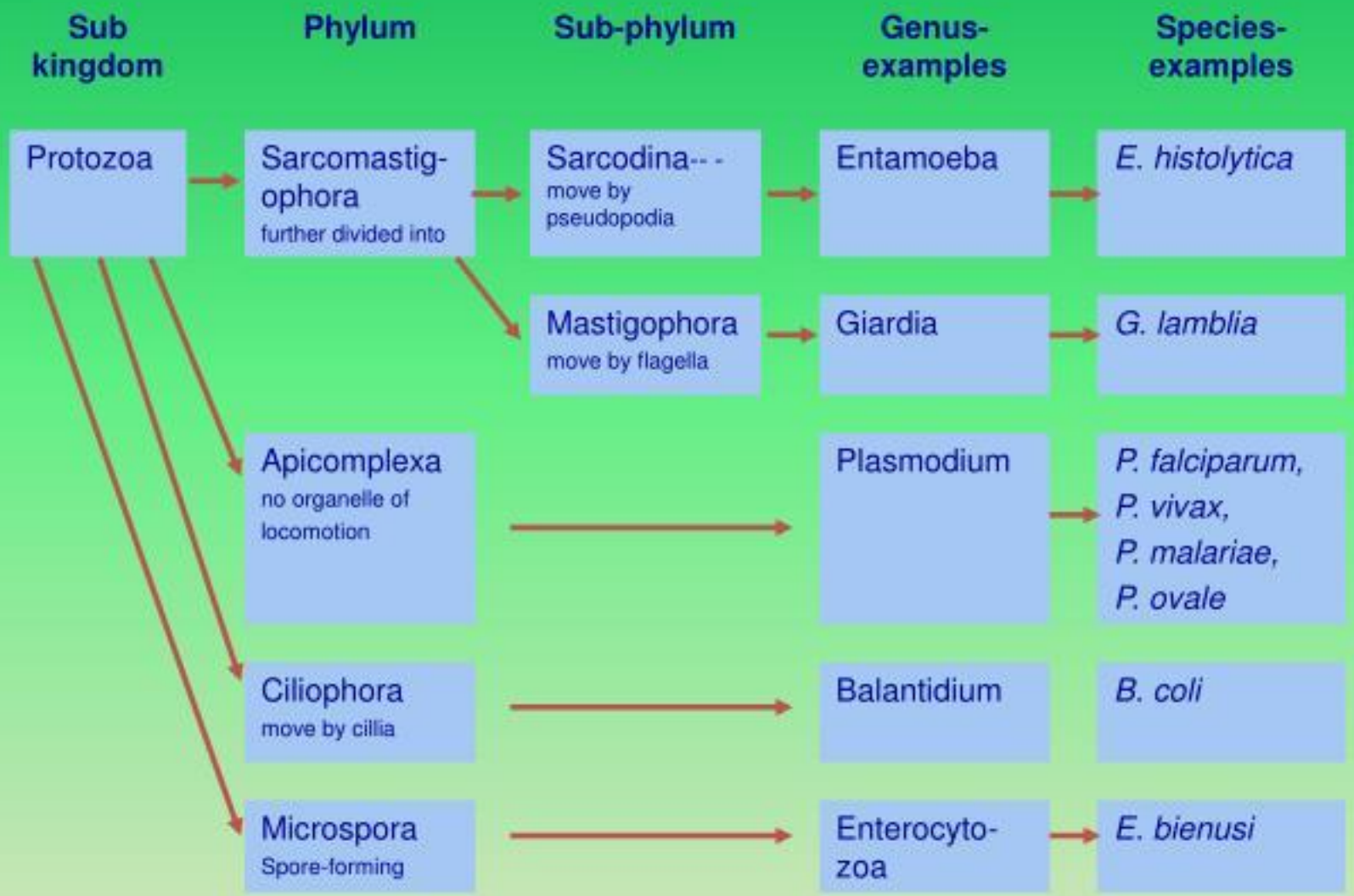
Basidiomycetes

- Basidiomycetes- have septic mycelium. They create genital spores- basidiomycetes by the way of peeling off from basidio- end cells of mycelium, homological asku. Some of the yeast are releted to basidiomycetes, for example Cryptococcus neoformans.

Fungi from deyteromycota class



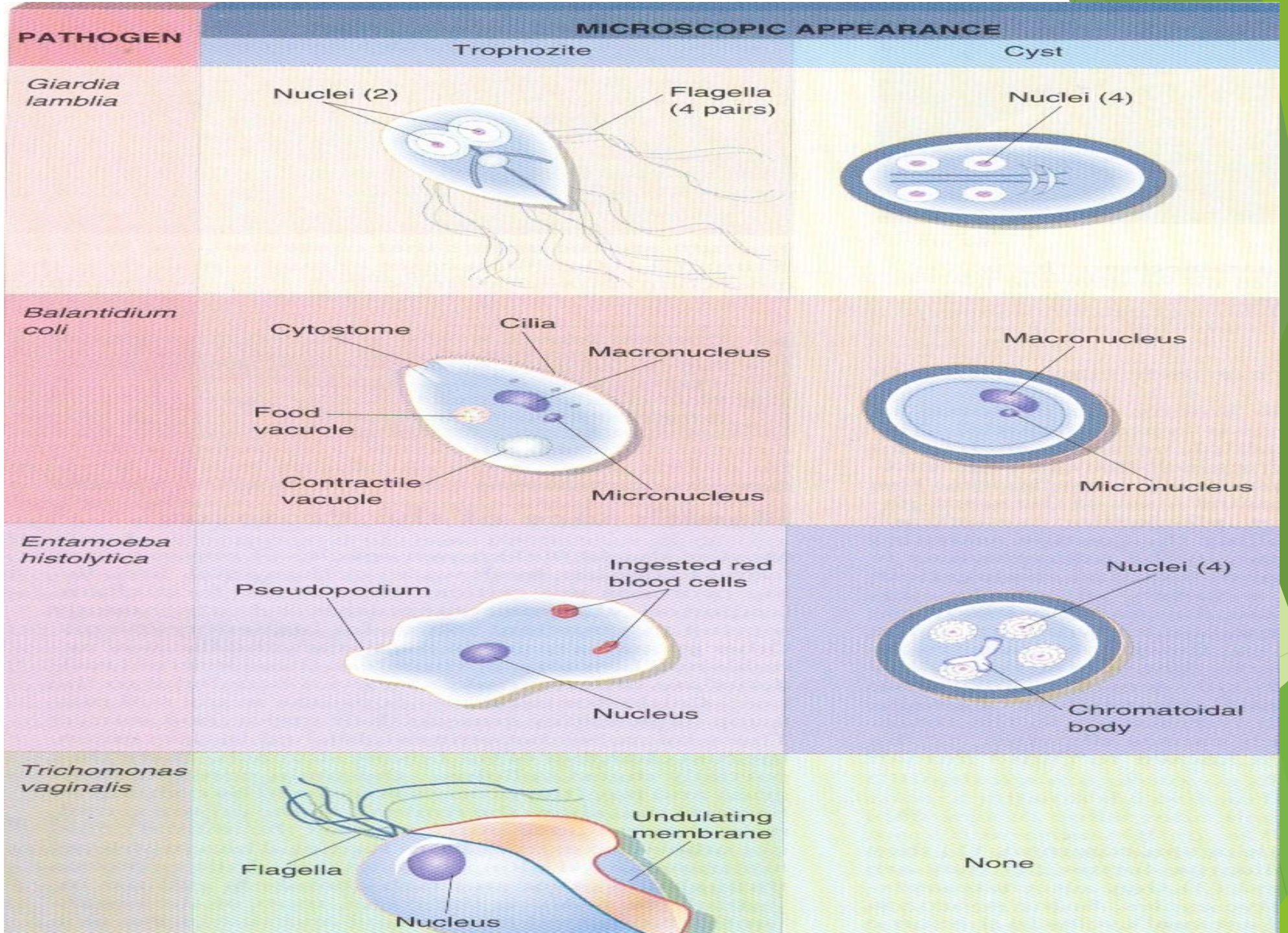
Classification of Protozoa

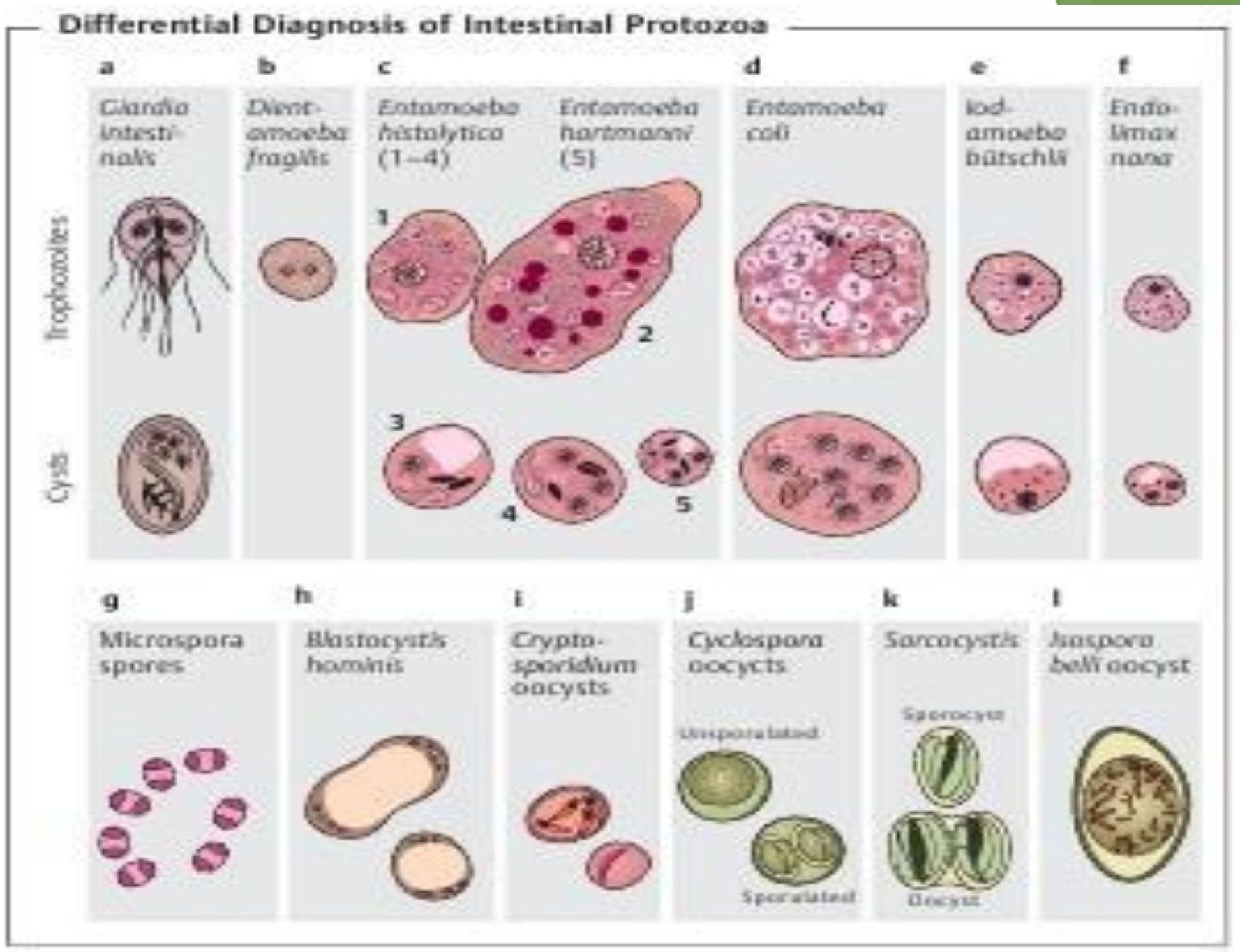


Protozoa

- Some protozoa are parasites.
- Parasitic protozoa break down and absorb nutrients from the body of the host in which they live.
- Many parasitic protozoa are pathogens, such as those that cause:
  - Malaria,
  - Giardiasis,
  - African sleeping sickness,
  - Amebic dysentery

- **Intestinal**
  - Amebiasis ..... *Entamoeba histolytica*
  - Giardiasis .....*Giardia lamblia*
  - Balantidiasis ..... *Balantidium coli*
  - Crytosporidosis ..... *Cryptosporidium parvum*
  - Cyclosporiasis ..... *Cyclospora cayetanensis*
- **Genitourinary tract**
  - Trichomoniasis ..... *Trichomonas vaginalis*
- **Blood and Tissue**
  - Malaria ..... Plasmodium spp
  - Meningoencephalitis ..... *Naegleria fowleri*
  - Toxoplasmosis ..... *Toxoplasma gondii*..... **(Eye)**
- **Cardiovascular system**
  - African Sleeping Sickness ..... *Trypanosoma brucei*..... **(CNS)**
  - Chagas Disease ..... *Trypanosoma cruzi*
- **Skin and mucous membrane**
  - Visceral leishmaniasis(Kala-azar) ... *Leishmania donovani*
  - Cutaneous leishmaniasis ..... *Leishmania topica/braziliensis*


PATHOGEN
MICROSCOPIC APPEARANCE
Trophozite
Cyst
Giardia lamblia
Nuclei (2)
Flagella (4 pairs)
Nuclei (4)
Balantidium coli
Cytostome
Cilia
Macronucleus
Food vacuole
Contractile vacuole
Micronucleus
Macronucleus
Micronucleus
Entamoeba histolytica
Pseudopodium
Ingested red blood cells
Nucleus
Nuclei (4)
Chromatoidal body
Trichomonas vaginalis
Flagella
Undulating membrane
Nucleus
None


Differential Diagnosis of Intestinal Protozoa
a
Giardia intestinalis
b
Dientamoeba fragilis
c
Entamoeba histolytica (1–4)
Entamoeba hartmanni (5)
d
Entamoeba coli
e
Iodamoeba bütschlii
f
Endolimax nana
Trophozoites
Cysts
1
2
3
4
5
g
Microspora spores
h
Blastocystis hominis
i
Cryptosporidium oocysts
j
Cyclospora oocysts
Unsporulated
Sporulated
k
Sarcocystis
Sporocyst
Oocyst
l
Isospora belli oocyst

Viruses

A special group of non-cellular life forms that belong to the kingdom of Vira and have a number of features:

They do not have a cellular structure, they consist of a nucleoid in the form of a nucleic acid and a protein capsid;

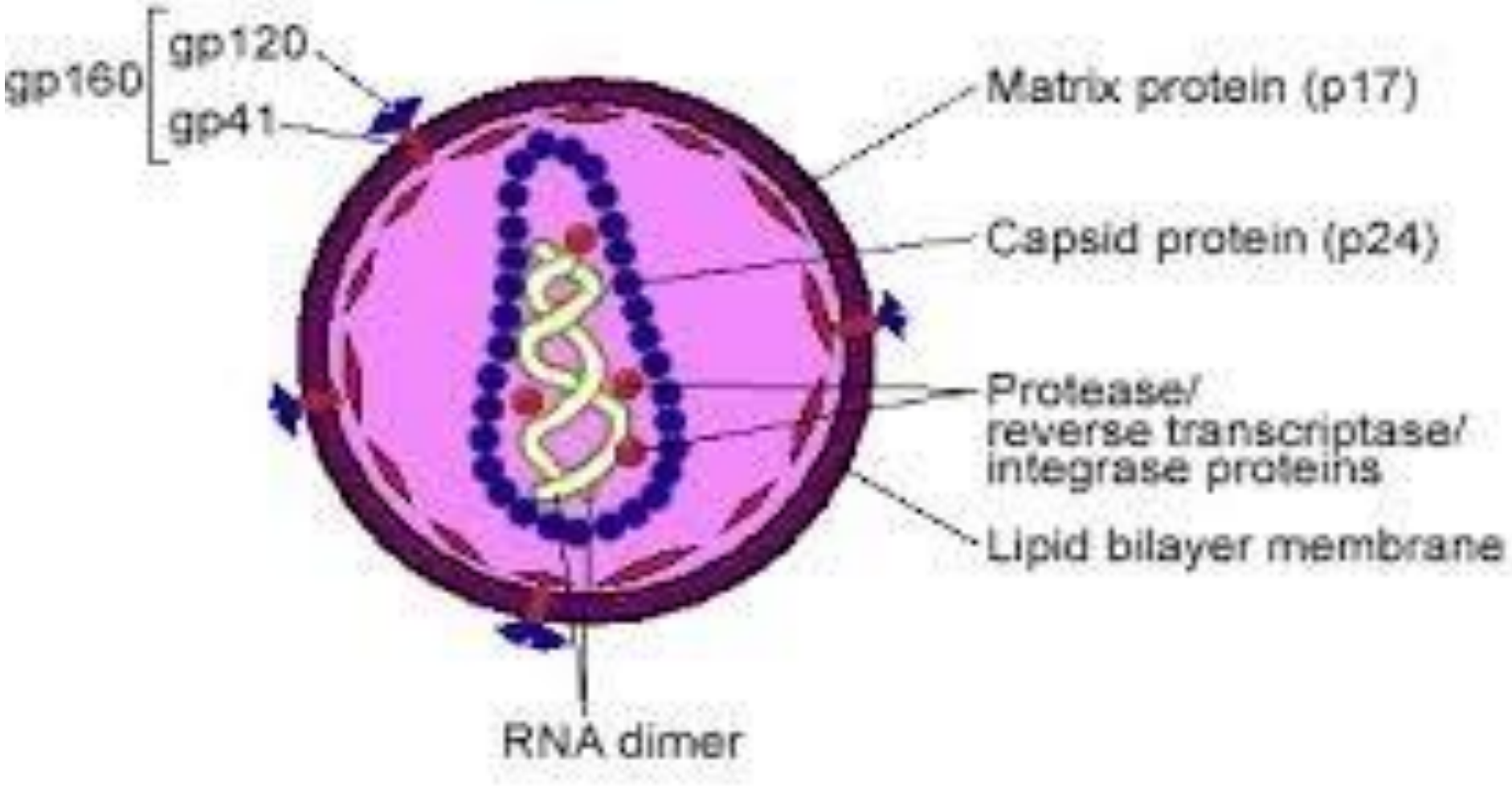
The genetic apparatus of viruses is represented by both DNA and RNA, both of which can be single and double stranded, linear and circular, continuous and fragmented;

They are absolute intracellular parasites at the molecular level that do not have their own protein synthesis systems; reproduce by the disjunctive method of reproduction;

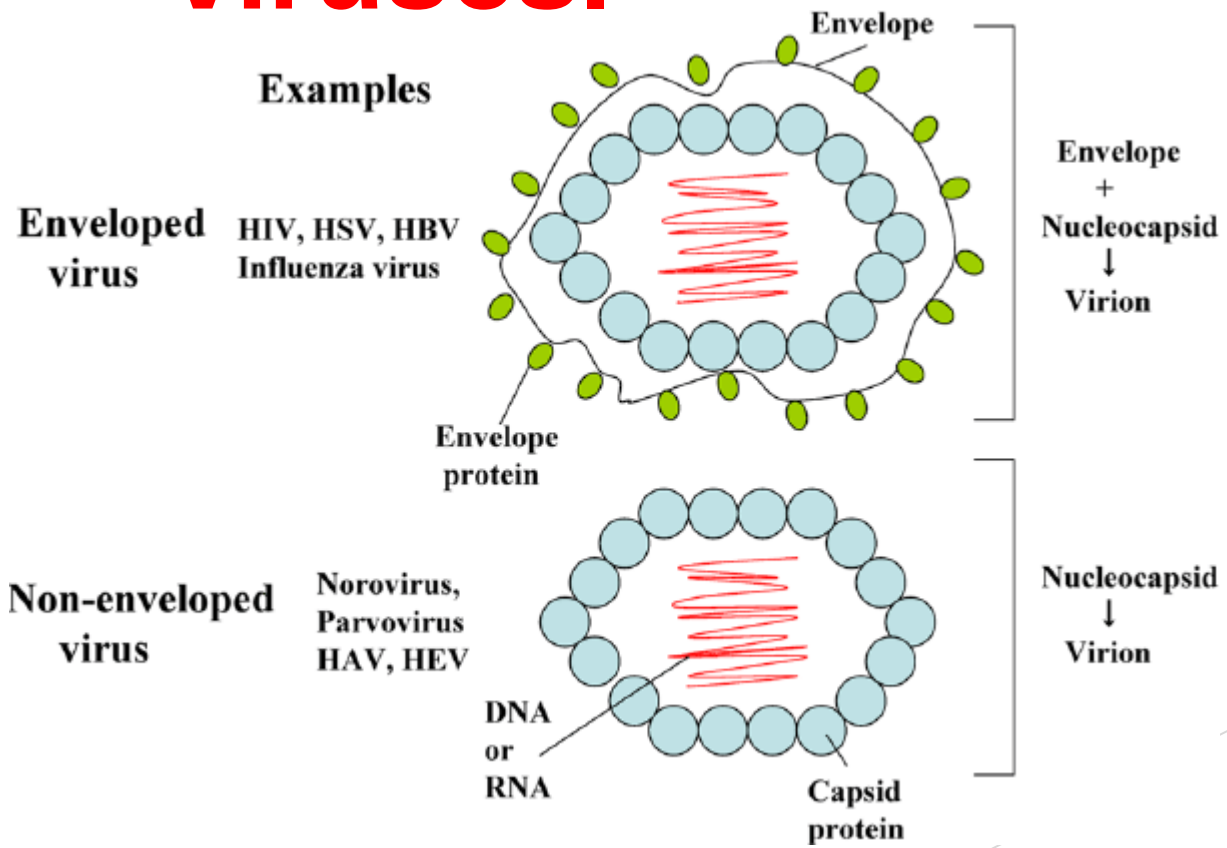
They have very small sizes, calculated in nm (15-350);

Some viruses (plants) can form crystals.

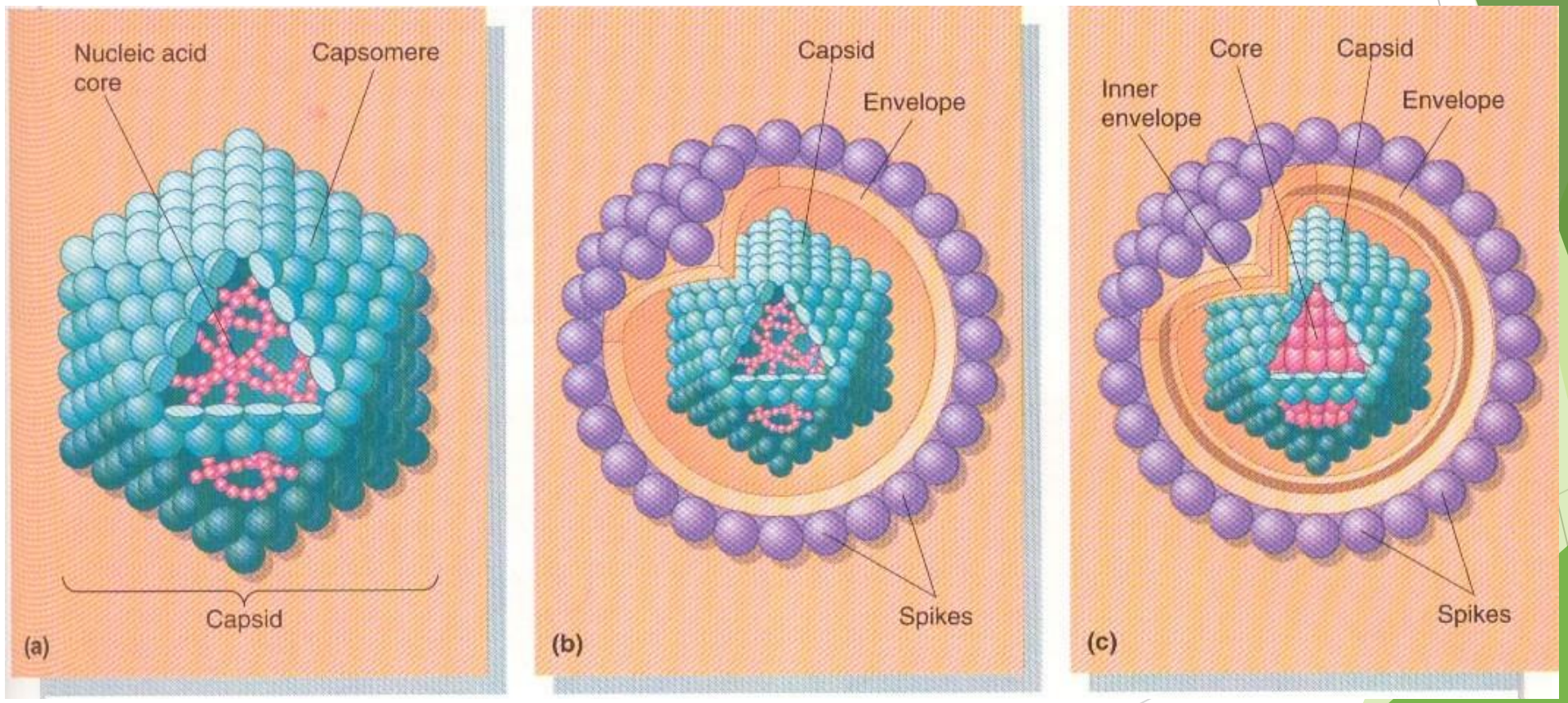
Scheme structure of viral particles



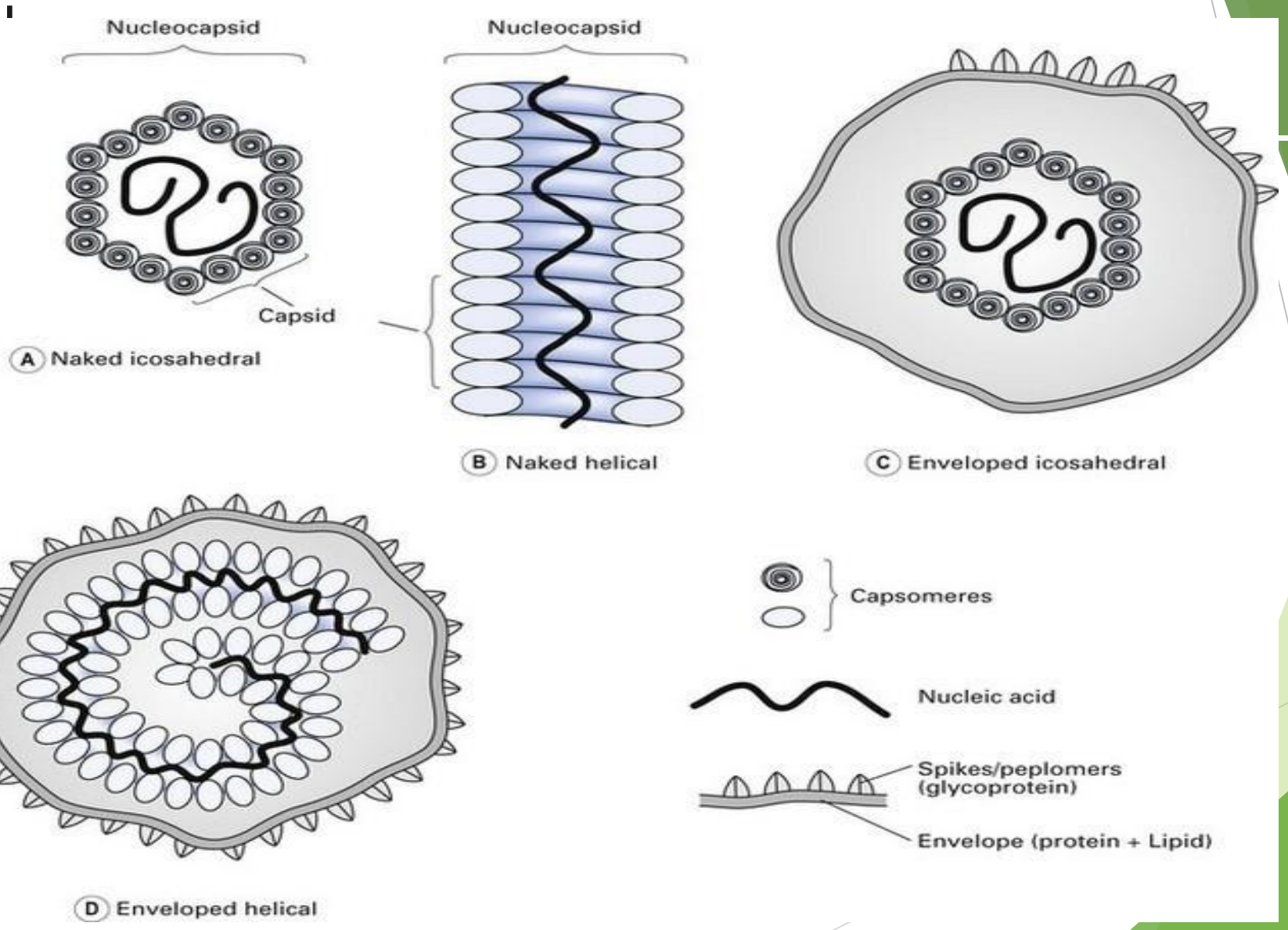
Structure of enveloped and non-enveloped viruses.



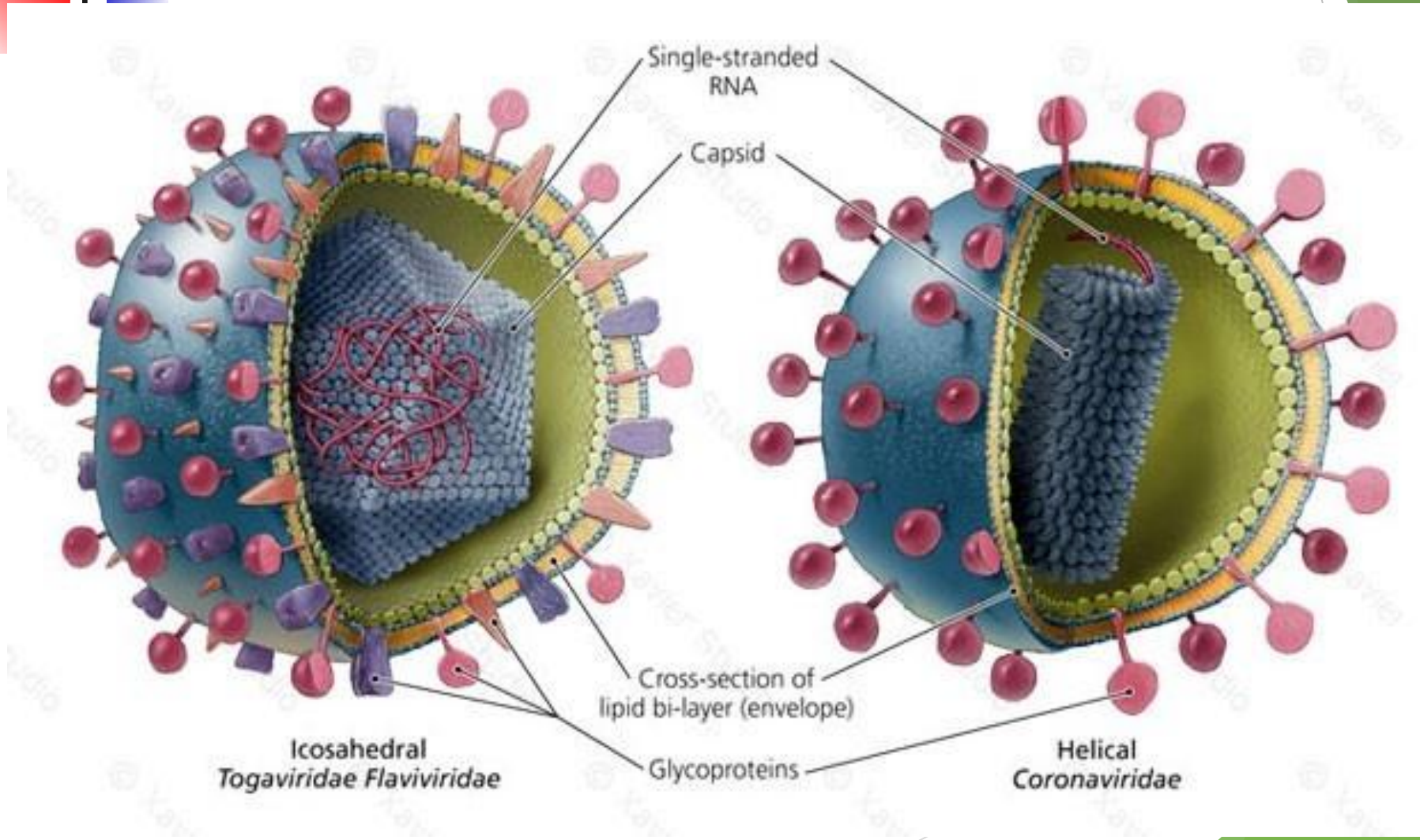
Scheme of the structure of various viruses: simple (a) and complex (b and c)

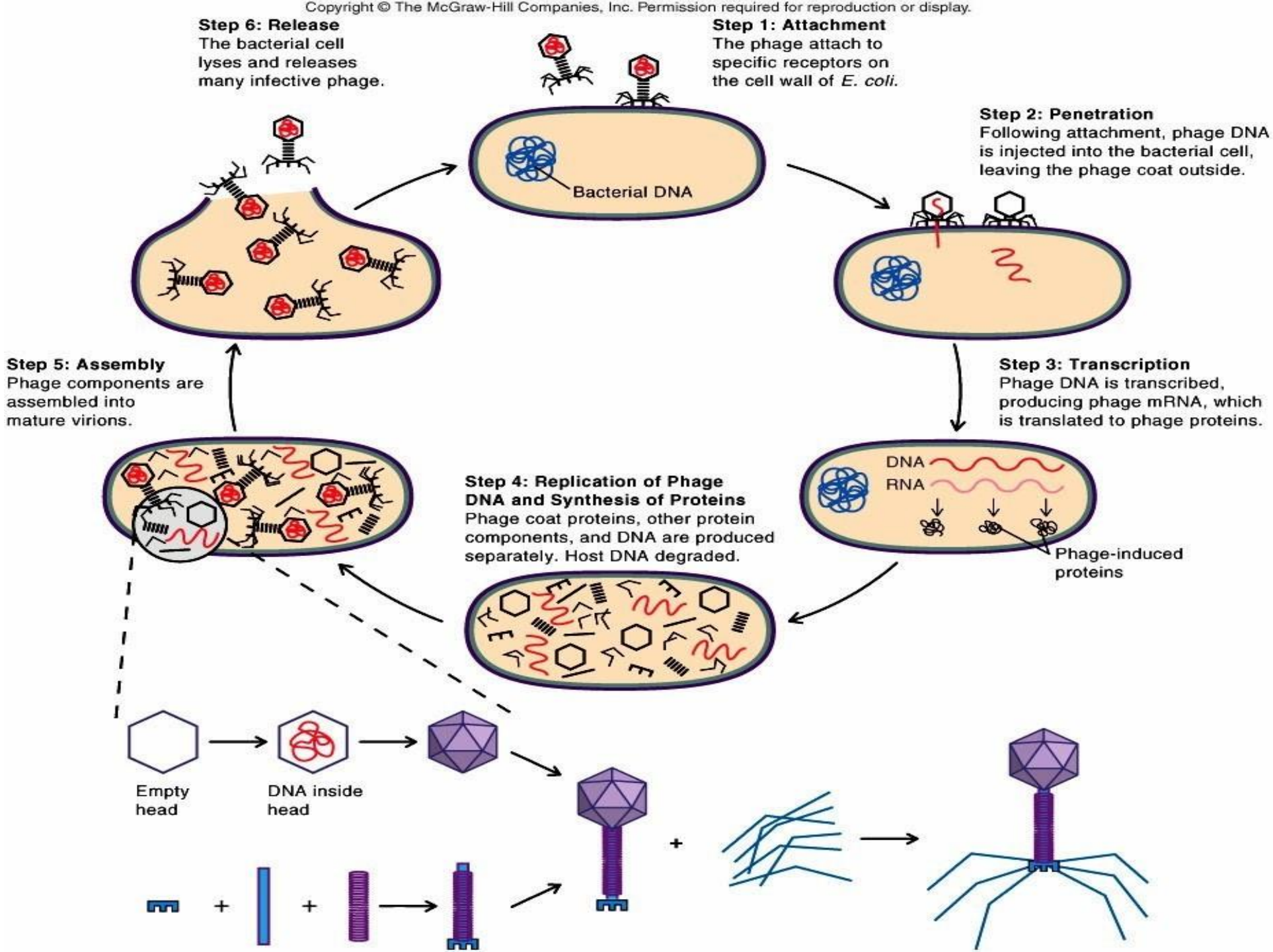


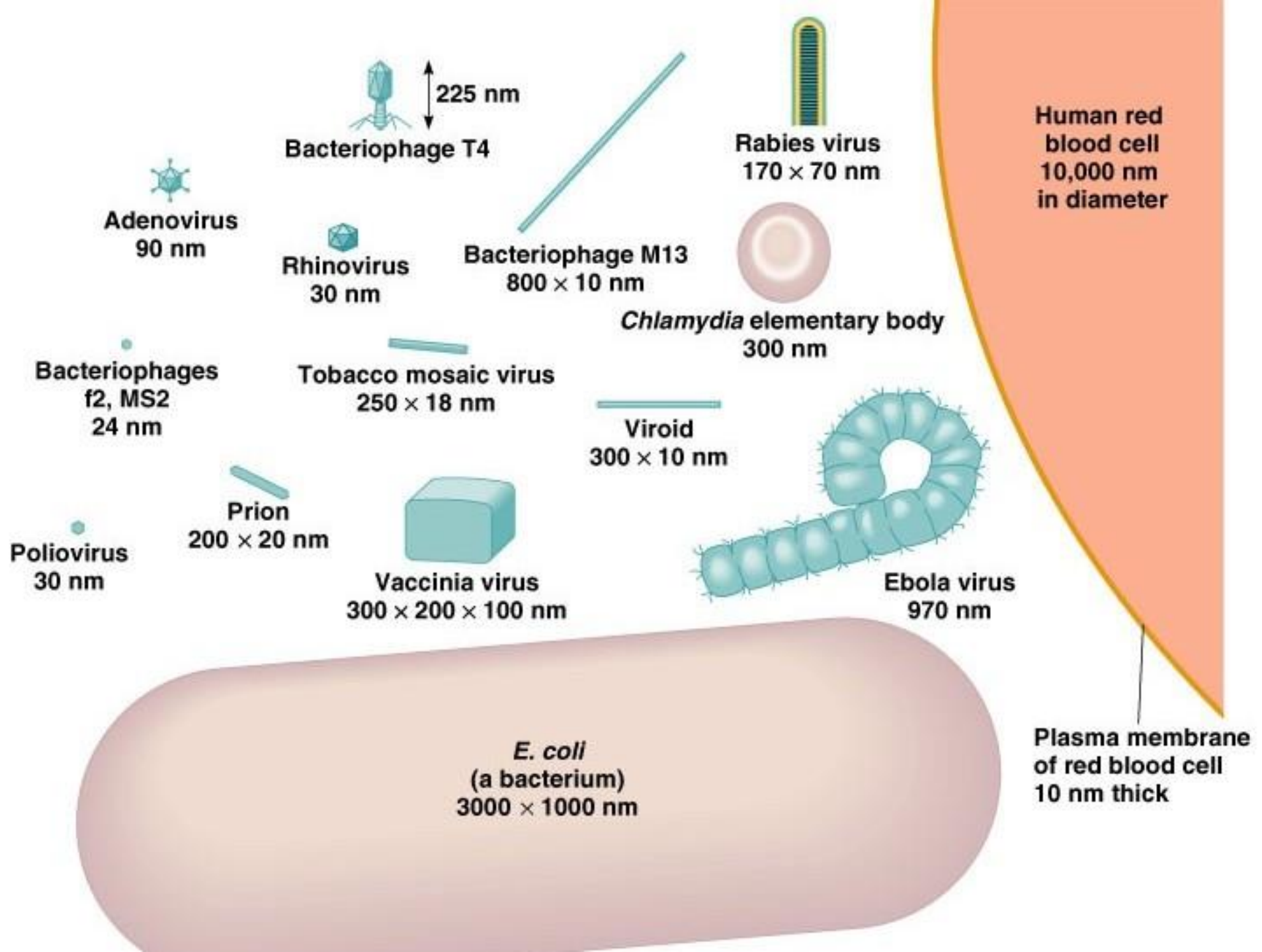
Types of capsid symmetry.



Types of Virion Symmetry.



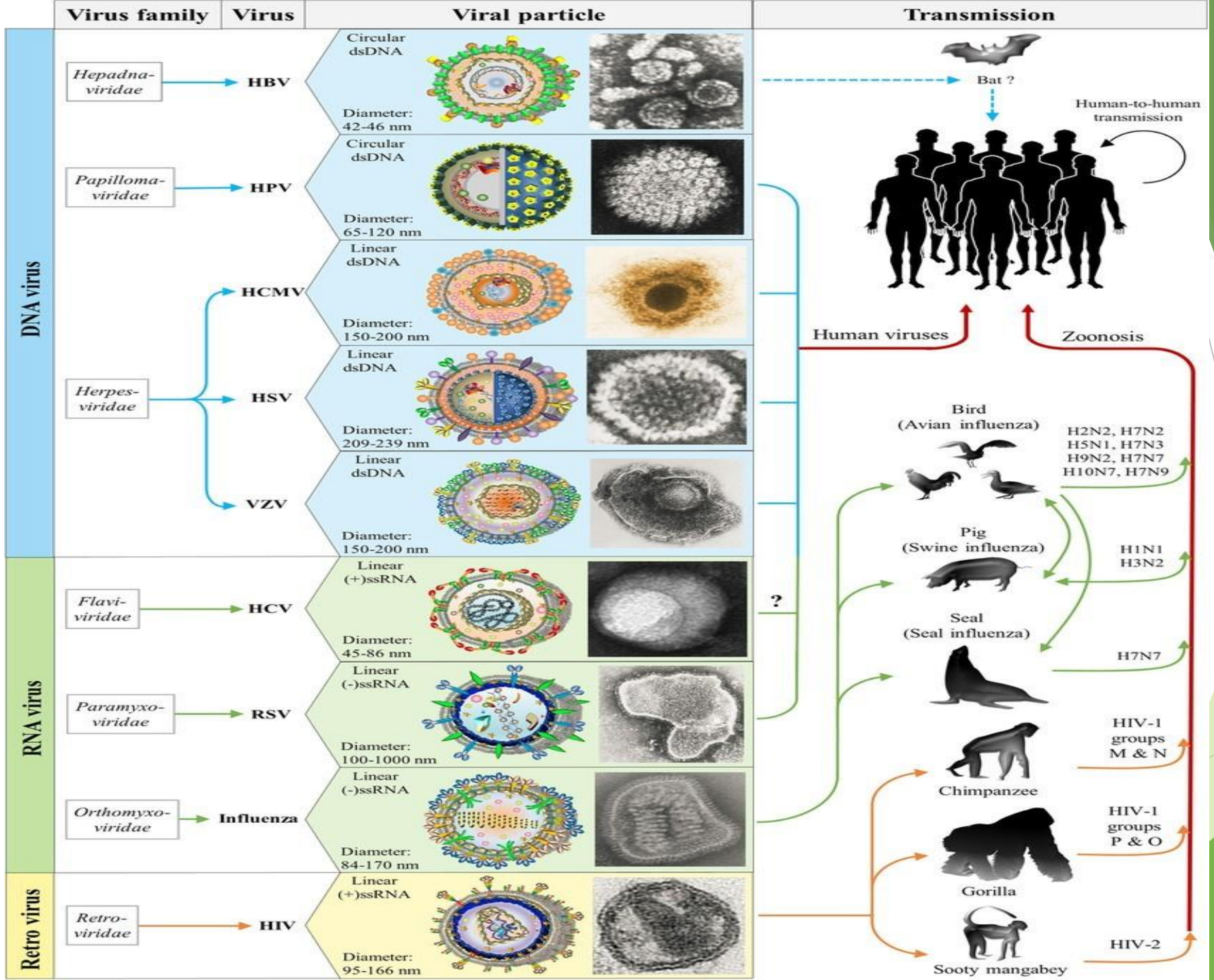



225 nm
Bacteriophage T4
Adenovirus
90 nm
Rhinovirus
30 nm
Bacteriophage M13
800 × 10 nm
Rabies virus
170 × 70 nm
Human red
blood cell
10,000 nm
in diameter
Chlamydia elementary body
300 nm
Bacteriophages
f2, MS2
24 nm
Tobacco mosaic virus
250 × 18 nm
Viroid
300 × 10 nm
Prion
200 × 20 nm
Poliovirus
30 nm
Vaccinia virus
300 × 200 × 100 nm
Ebola virus
970 nm
E. coli
(a bacterium)
3000 × 1000 nm
Plasma membrane
of red blood cell
10 nm thick

Classification principals of the viruses

- Type of nucleic acid, structure, number of threads, molecular weight;
- Morphology of the virion, the number of capsomeres, the type of capsid symmetry, the presence of a shell;
- Virion replication, genetic interactions;
- Antigenic properties;
- The range of susceptible hosts, pathogenicity, geographical prevalence.

Viruses are divided into viruses of vertebrates, invertebrates, plants, bacteria, fungi.


Virus family
Virus
Viral particle
Transmission
DNA virus
RNA virus
Retro virus
Hepadna-viridae
HBV
Papilloma-viridae
HPV
Herpes-viridae
HCMV
HSV
VZV
Flavi-viridae
HCV
Paramyxo-viridae
RSV
Orthomyxo-viridae
Influenza
Retro-viridae
HIV
Circular dsDNA
Diameter: 42-46 nm
Circular dsDNA
Diameter: 65-120 nm
Linear dsDNA
Diameter: 150-200 nm
Linear dsDNA
Diameter: 209-239 nm
Linear dsDNA
Diameter: 150-200 nm
Linear (+)ssRNA
Diameter: 45-86 nm
Linear (-)ssRNA
Diameter: 100-1000 nm
Linear (-)ssRNA
Diameter: 84-170 nm
Linear (+)ssRNA
Diameter: 95-166 nm
?
Bat ?
Human-to-human transmission
Human viruses
Zoonosis
Bird (Avian influenza)
H2N2, H7N2
H5N1, H7N3
H9N2, H7N7
H10N7, H7N9
Pig (Swine influenza)
H1N1
H3N2
Seal (Seal influenza)
H7N7
HIV-1 groups M & N
Chimpanzee
HIV-1 groups P & O
Gorilla
Sooty mangabey
HIV-2

Prions.

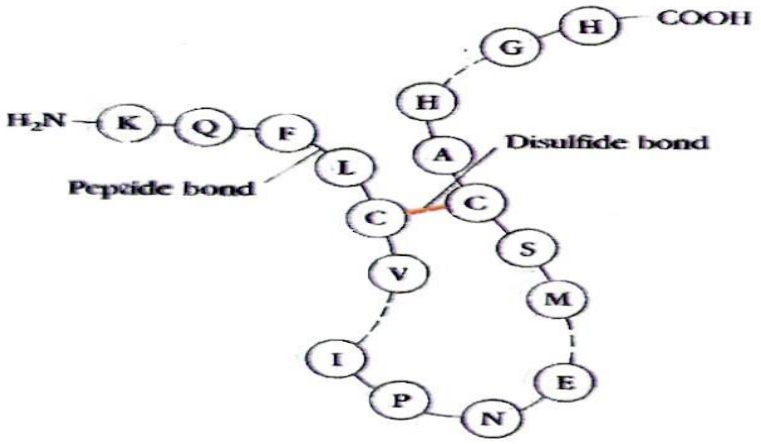
- Low molecular weight, nucleic acid-free proteins that cause transmissible spongiform encephalopathies;

Prions consist of a special protein, which exists in the form of two isomers: the normal cellular prion protein PrPc and the abnormal in PrPSC, which has a secondary structure.

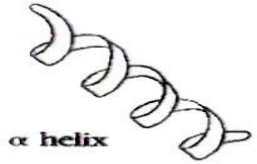
Prions

Prions -are misfolded proteins with the ability to transmit their misfolded shape onto normal variants of the same protein. They characterize several fatal and transmissible neurodegenerative diseases in humans and many other animals. It is not known what causes the normal protein to misfold, but the abnormal three-dimensional structure is suspected of conferring infectious properties, collapsing nearby protein molecules into the same shape. The word *prion* derives from "proteinaceous infectious particle".The hypothesized role of a protein as an infectious agent stands in contrast to all other known infectious agents such as viruses, bacteria, fungi and parasites, all of which contain nucleic acids (DNA, RNA or both).

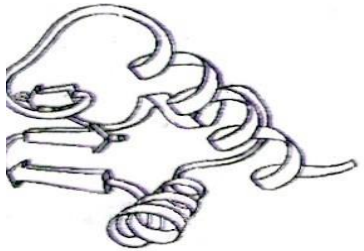
Prion



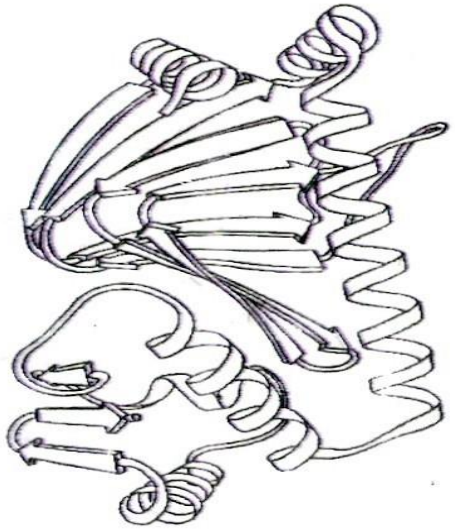
PRIMARY STRUCTURE



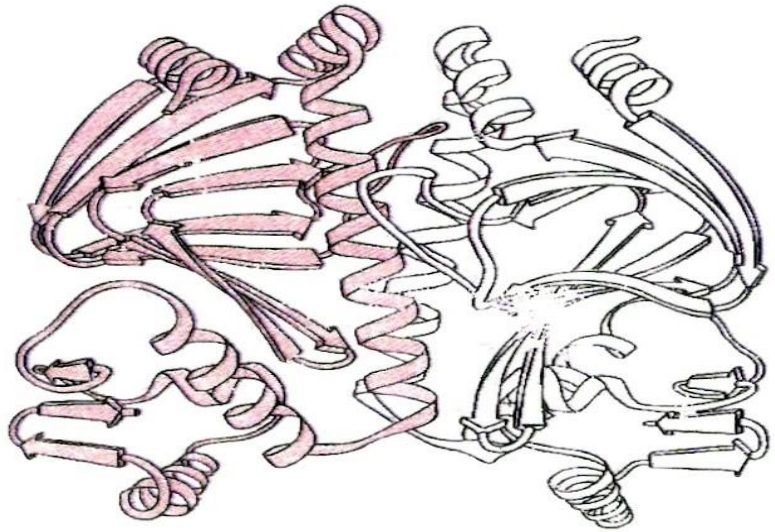
SECONDARY STRUCTURE



Domain

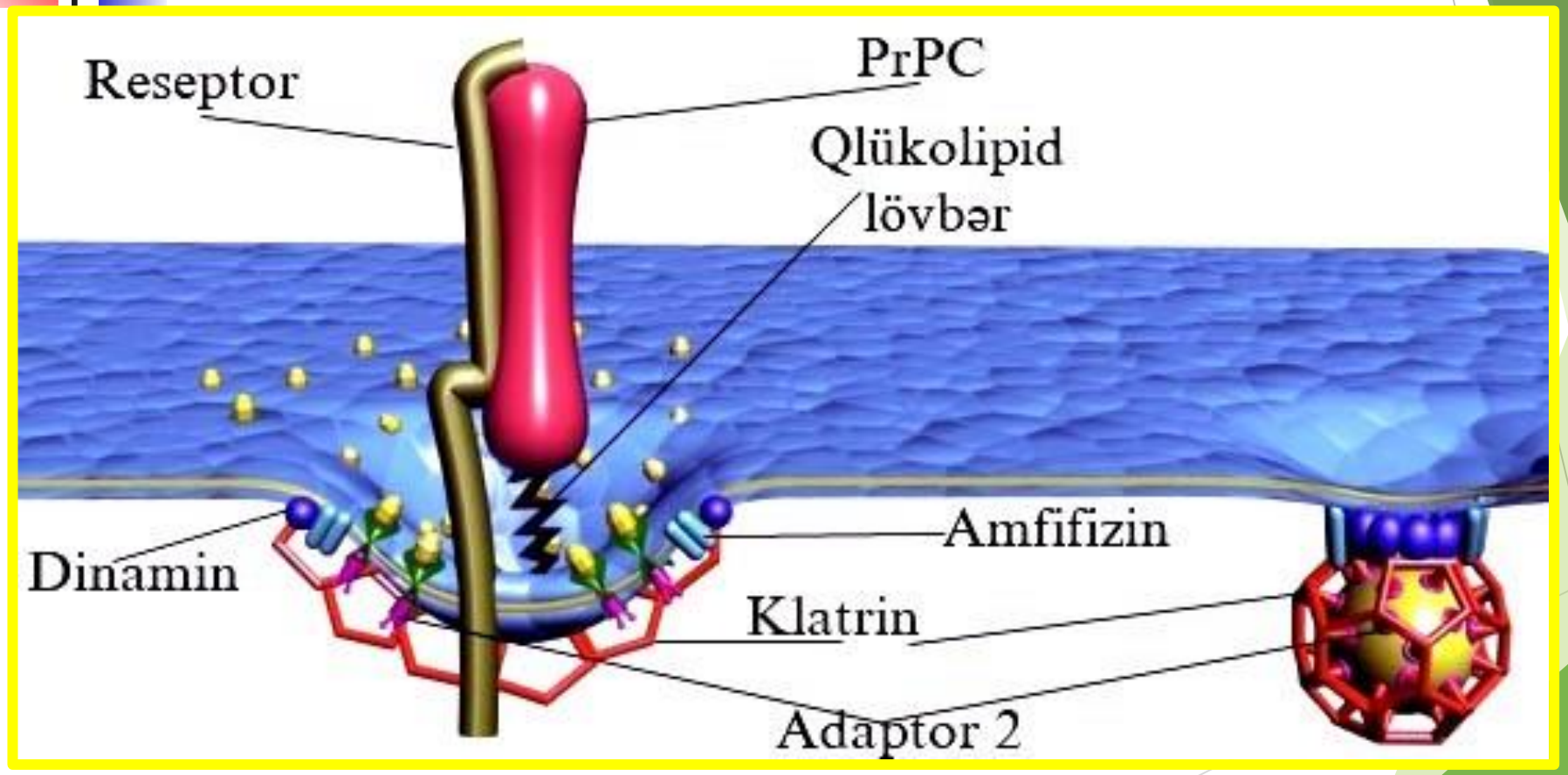


Monomeric polypeptide molecule

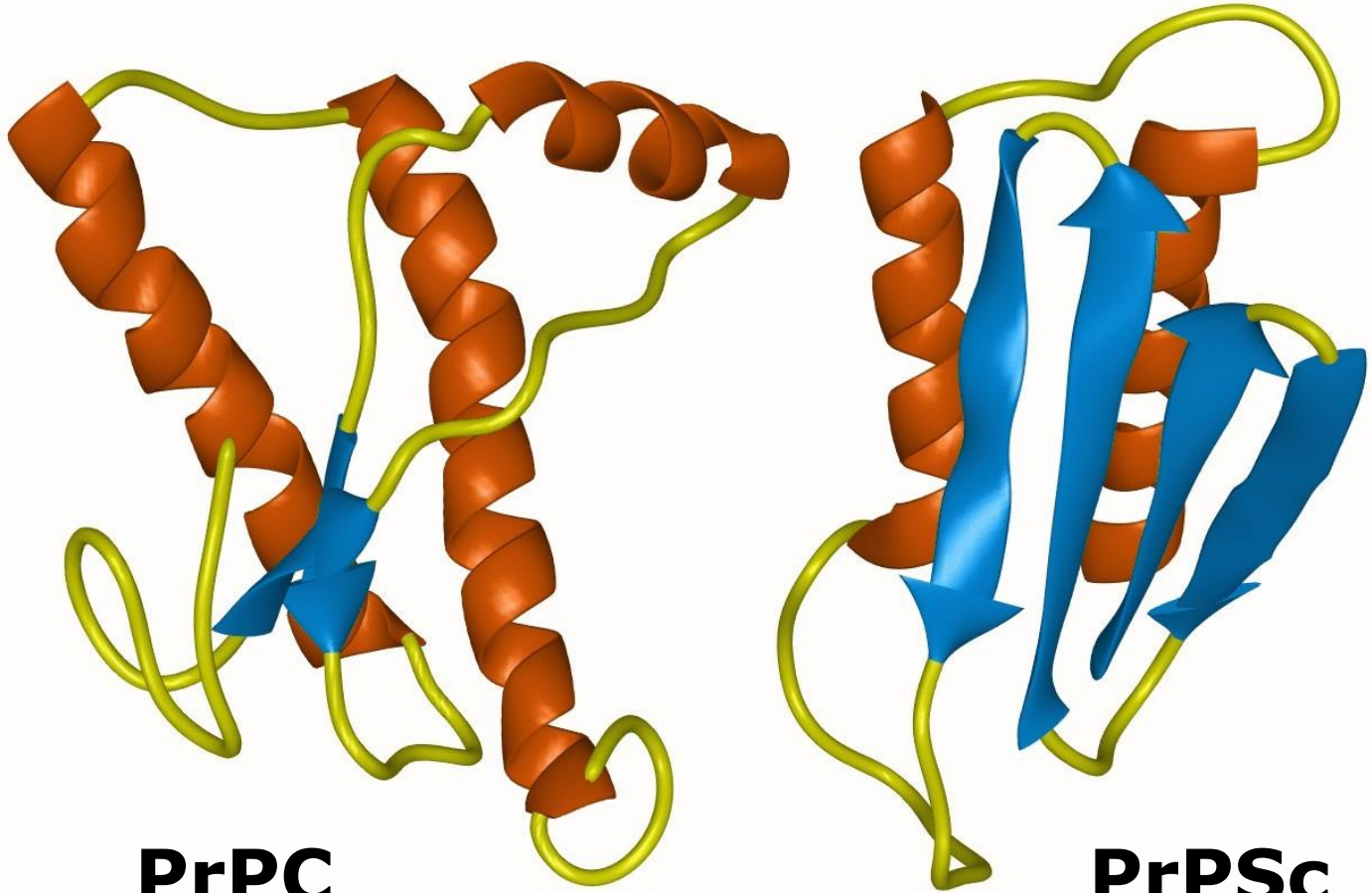


Dimeric protein molecule

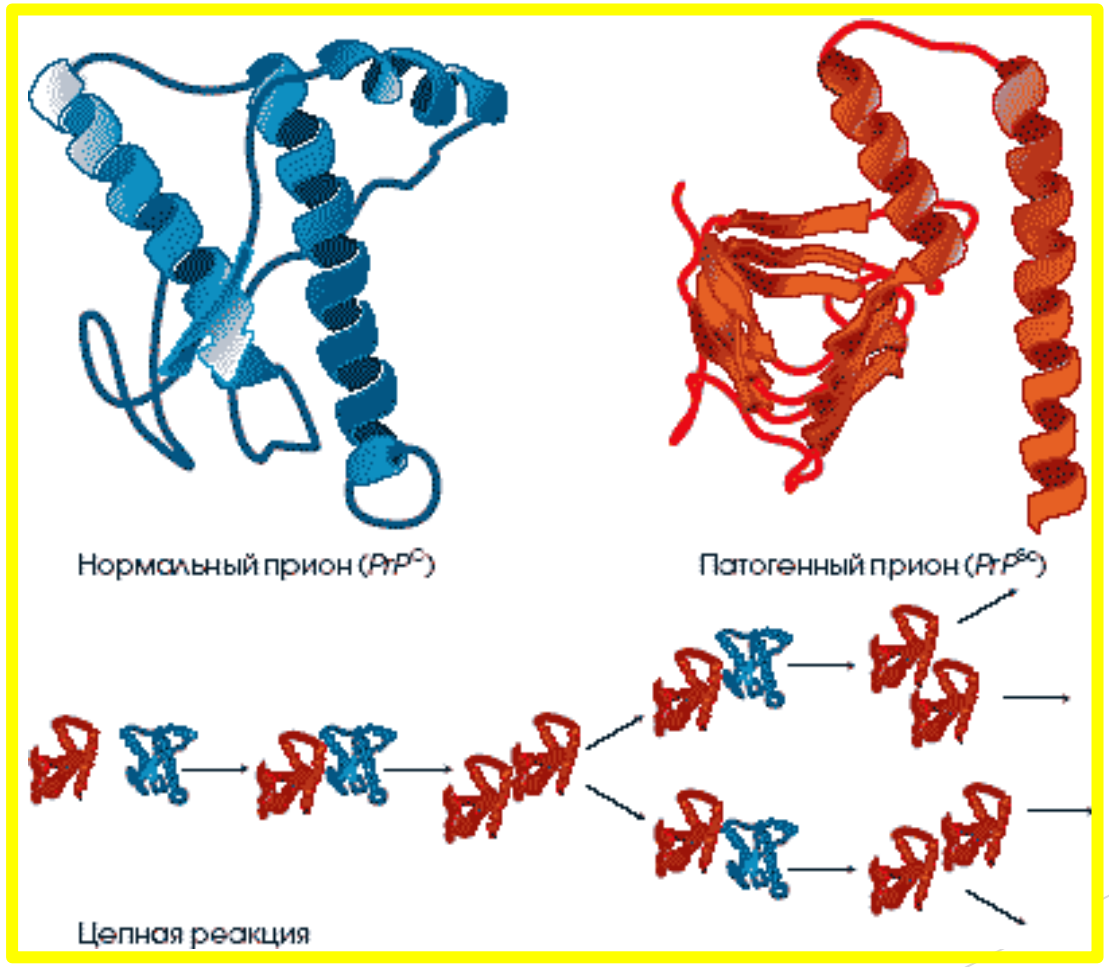
Localization of prions on membrane cell.



The spatial structure of normal and abnormal prions.

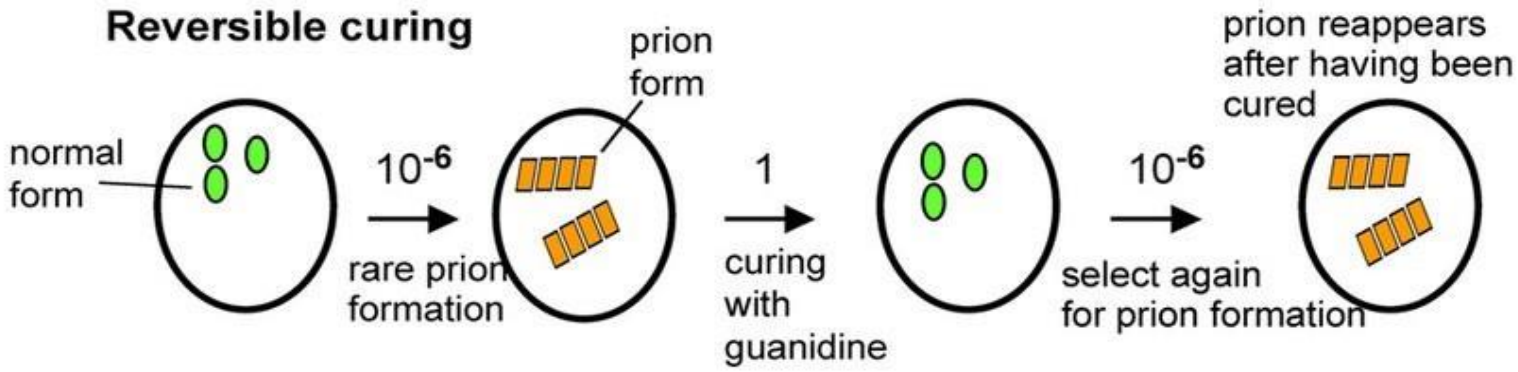


The mechanism for converting PrPc to PrPSC.



Transformation scheme of prions.

Genetic criteria for a prion



Prion protein overproduction increases frequency of prion appearance

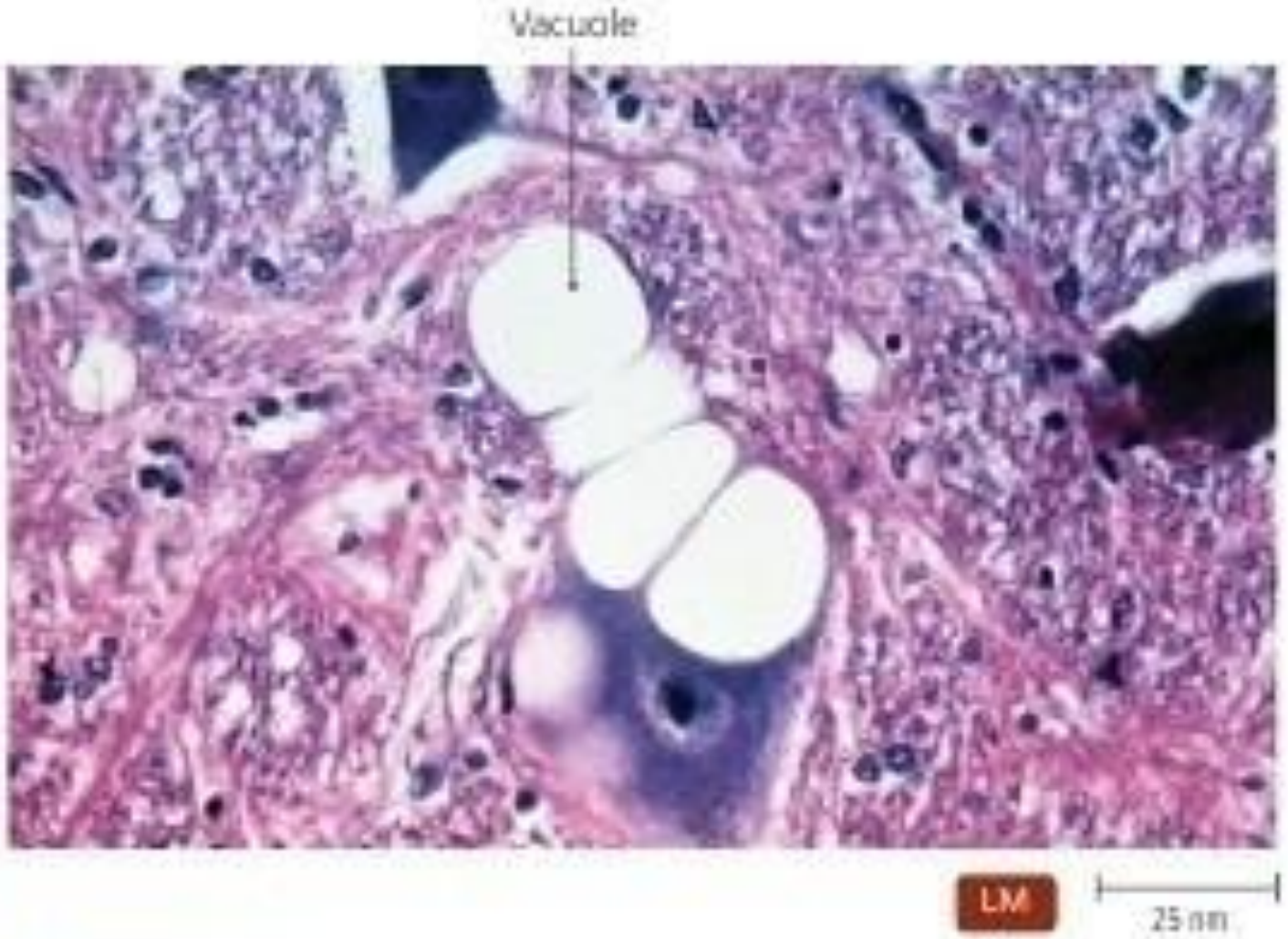
Similar phenotype of prion and mutant in chromosomal gene required for prion propagation

	wild type	prion	prion protein gene mutant
phenotype	+	—	—

Human prion diseases(2)

- Lethal familial insomnia - sleep loss, hyperactivity of the sympathetic system, progressive weakening of autonomic and enlocrine cyclic temporal rhythms; observed in middle-aged people (about 45 years). Gerstmann-Streisler syndrome - slow infection. registered in the UK, USA, Japan and others. It is characterized by degenerative lesions of the central nervous system, which are manifested in the formation of a spongy state, the formation of amyloid plaques throughout the brain.
- Sickness is expressed in the development of slowly progressing ataxia and dementia. Pathogenesis has not been studied. The disease lasts a long time and ends with death.
- Alpers syndrome - a slow prion infection. It is observed mainly in childhood, is characterized by symptoms indicating damage to the
- central nervous system.

Sheep brain with scrapie disease



▲ **Figure 13.23 A brain showing the large vacuoles and spongy appearance typical in prion-induced diseases.** Shown here is the brain of a sheep with the prion disease called scrapie.

Viroids

- Viroids do not have ȧ protein coat and consist only of an infectious RNA molecule. They do not have antigenic properties;
- The viroid molecule is a single stranded circular RNA;
- Viroids have very small sizes: the length of the RNA molecule is 1-10 (-6), it consists of 300-400 nucleotides;
- More than 10 viroids are known that differ in the primary structure of RNA, the circle of affected hosts, and the symptoms of the diseases caused.

Potato Dwarf

▲ **Figure 13.20 The RNA strand of the small potato spindle tuber viroid (PSTV).** Also shown for comparison is the longer DNA genome of bacteriophage T7. *Compare both to the size of a bacterial genome in Figure 13.2. How are viroids similar to and different from viruses?*

Potato affected by viroid.

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