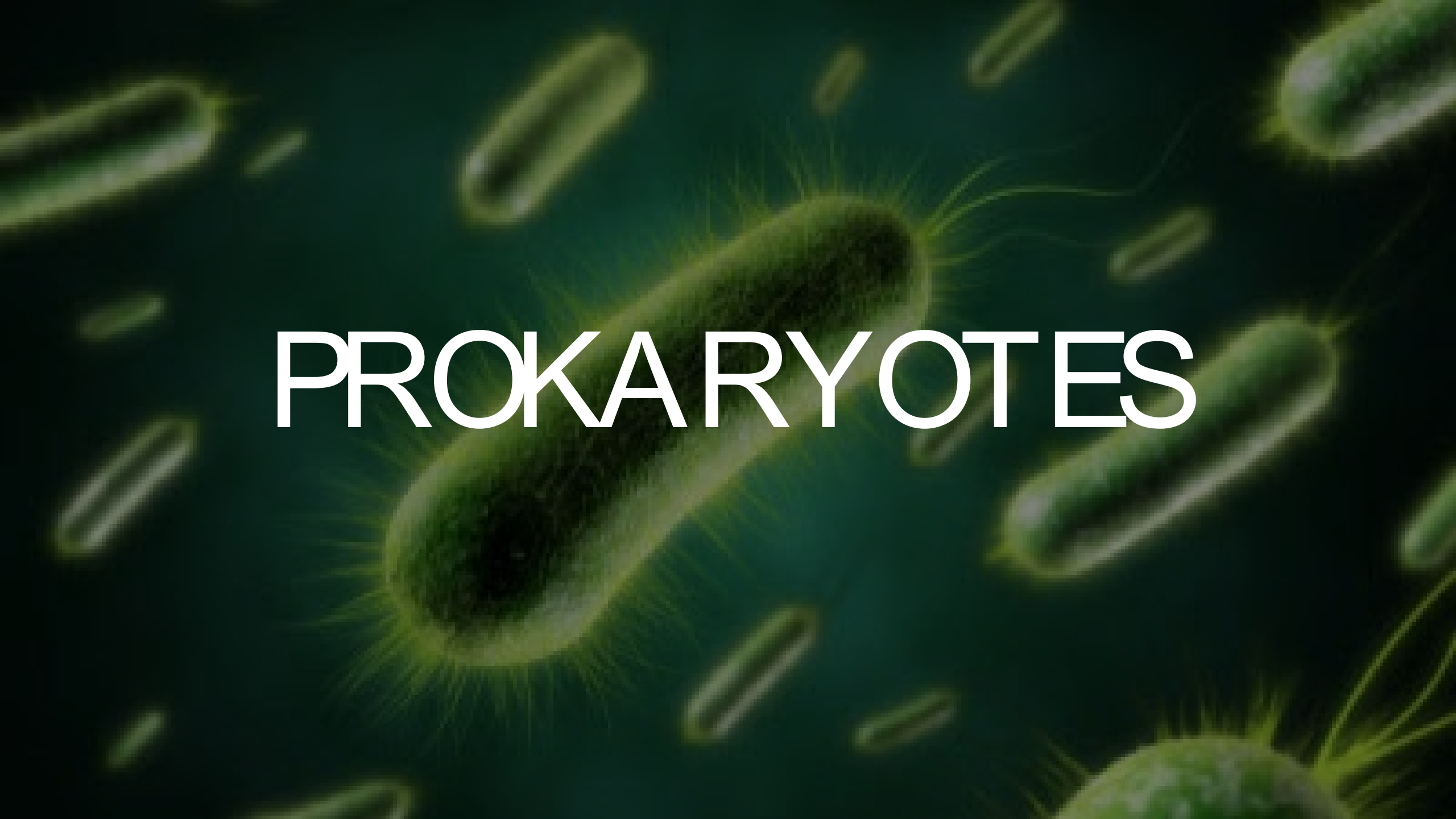
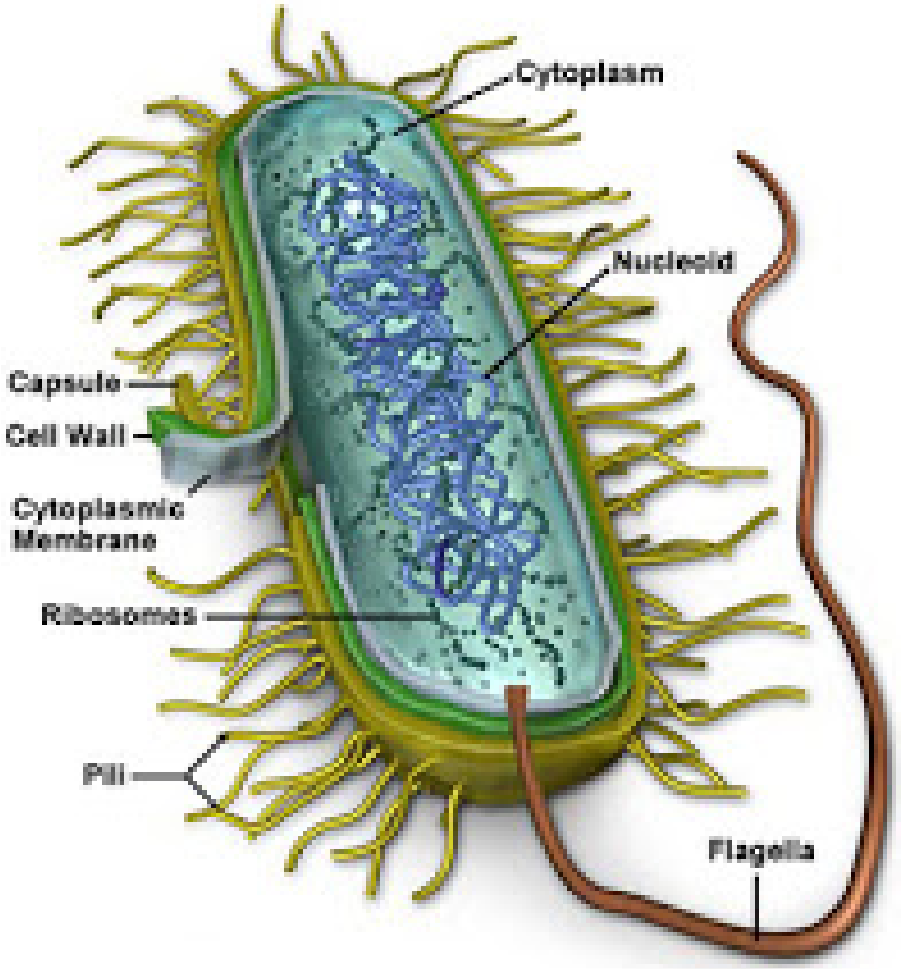
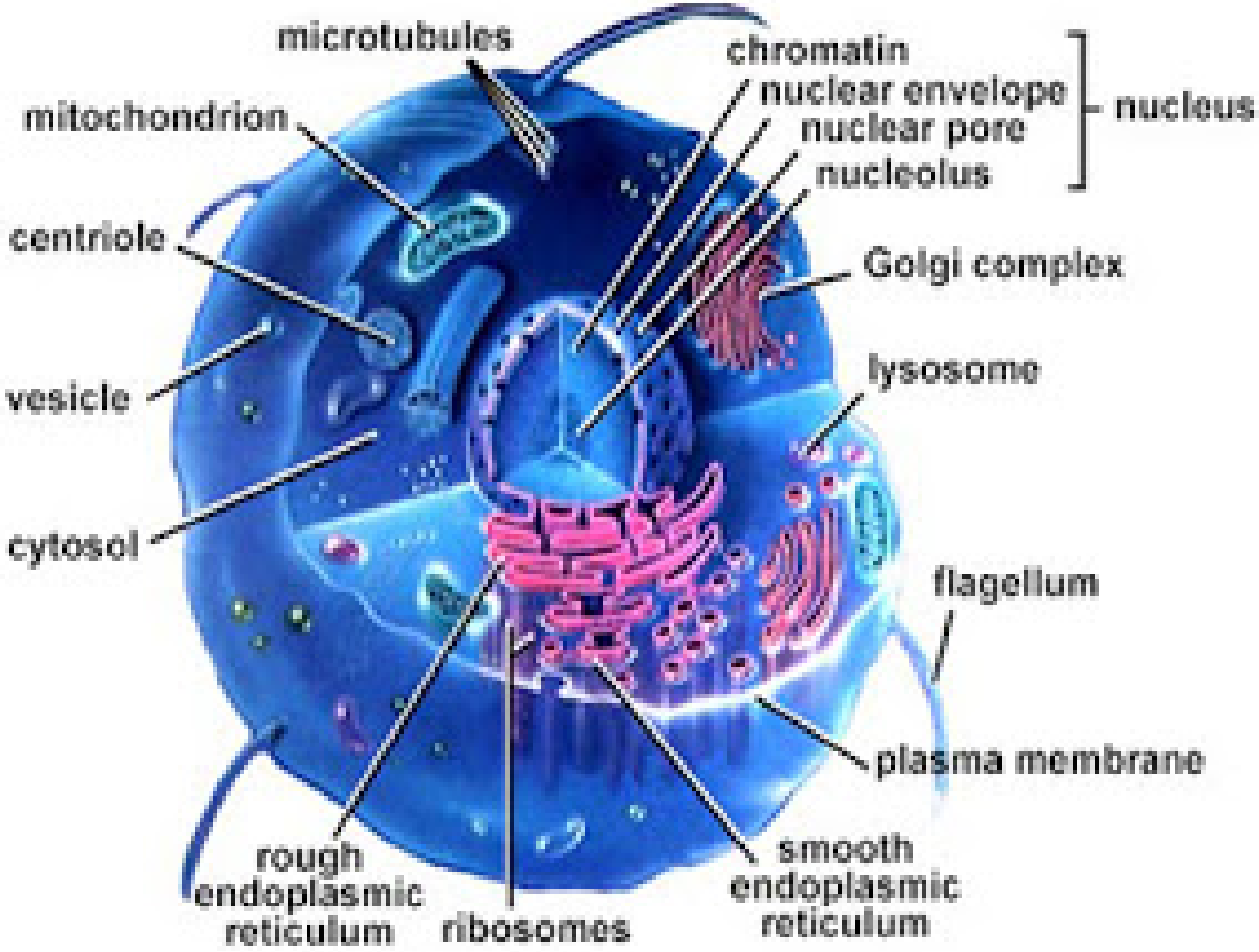
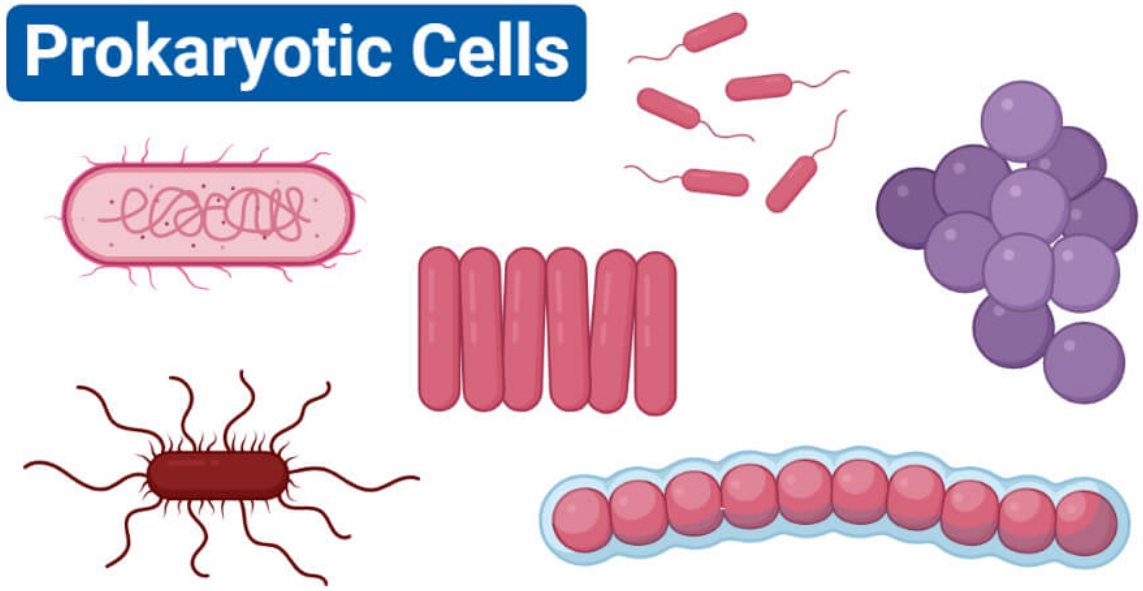

PROKARYOTES

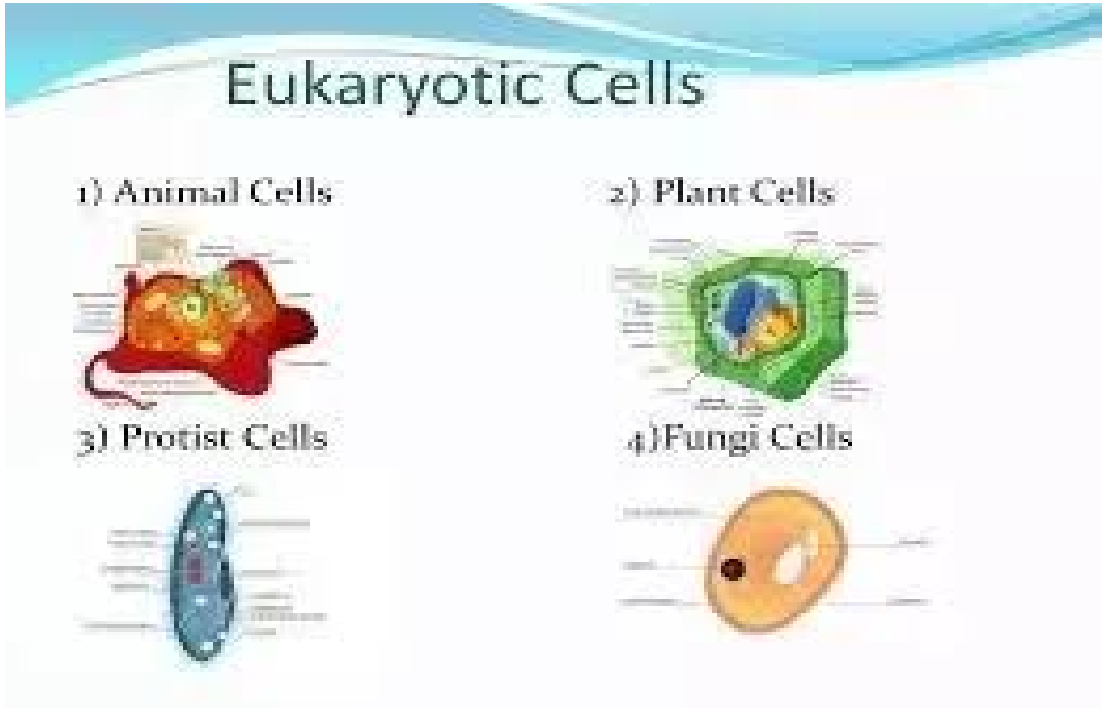


prokaryotic cell
(bacteria)



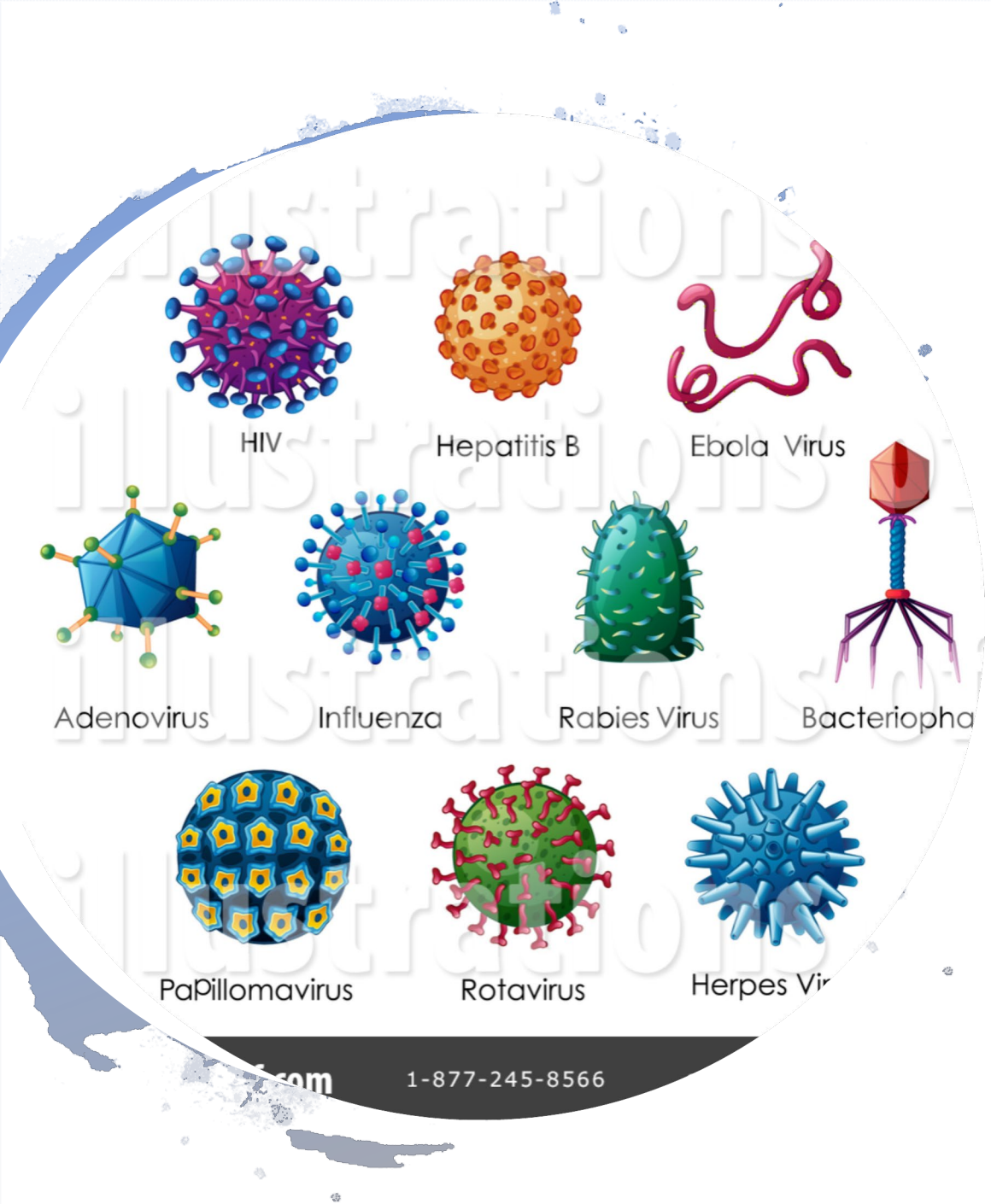
eukaryotic cell
(protists, fungi, animals, plants)





Eukaryotic vs. Prokaryotic Cells

Characteristics	Eukaryotic Cells	Prokaryotic Cells
Definition	Any cell that contains a clearly defined nucleus and membrane bound organelles	Any unicellular organism that does not contain a membrane bound nucleus or organelles
Examples	Animal, plant, fungi, and protist cells	Bacteria and Archaea
Nucleus	Present (membrane bound)	Absent (nucleoid region)
Cell Size	Large (10-100 micrometers)	Small (less than a micrometer to 5 micrometers)
DNA Replication	Highly regulated with selective origins and sequences	Replicates entire genome at once
Organism Type	Usually multicellular	Unicellular
Chromosomes	More than one	One long single loop of DNA and plasmids
Ribosomes	Large	Small
Growth Rate/Generation Time	Slower	Faster
Organelles	Present	Absent
Ability to Store Hereditary Information	All eukaryotes have this ability	All prokaryotes have this ability
Cell Wall	Simple: Present in plants and fungi	Complex: Present in all prokaryotes
Plasma Membrane	Present	Present
Cytoplasm	Present	Present

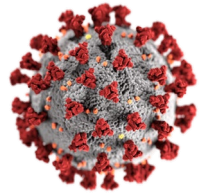


VIRUSES

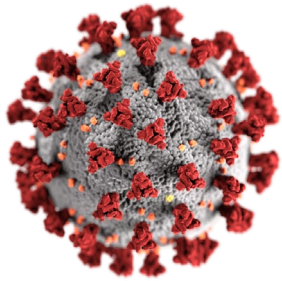
- Viruses are still biologists' puzzle because they **show both living and non- living characters**. Hence viruses are regarded as a separate entity.
- It is not considered in Whittaker's five kingdom classification.
- Viruses are now defined as ultramicroscopic, disease causing intra cellular **obligate parasites**.

Brief history of discovery of virus and Virology:

- Viruses were not known to biologists for a long time due to their ultramicroscopic structure though their presence was apparent by infectious diseases which were proved not due to bacteria.

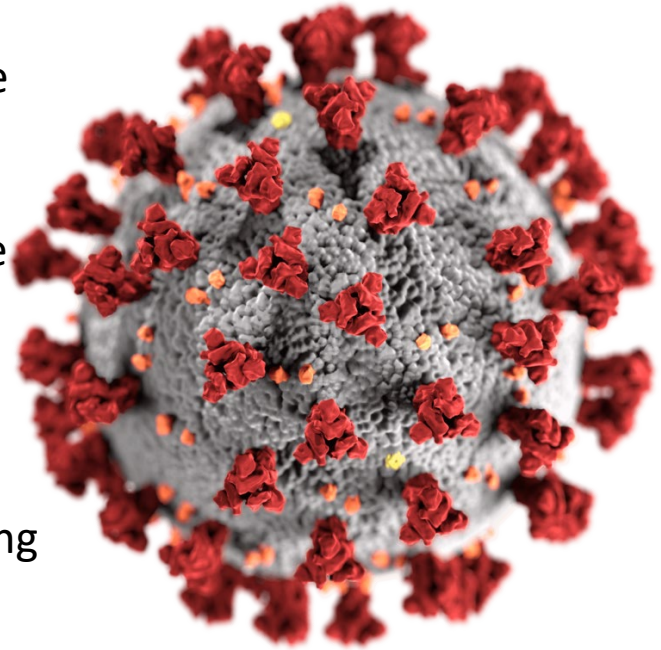


- It attracted the attention of investigators only in the 19th century when a virus called **tobacco mosaic virus (TMV**) caused severe damage to commercially important tobacco crop.



- **Mayer** demonstrated that the disease could be transmitted just by applying the sap of infected leaf to the leaf of healthy plant. He thought that the disease was due to a bacterium.

- It was then the Russian biologist **Iwanowsky** (1892) who demonstrated that the sap of infected leaves even after passing through bacterial filter remained infective, ruling out the bacterium as the causative agent.

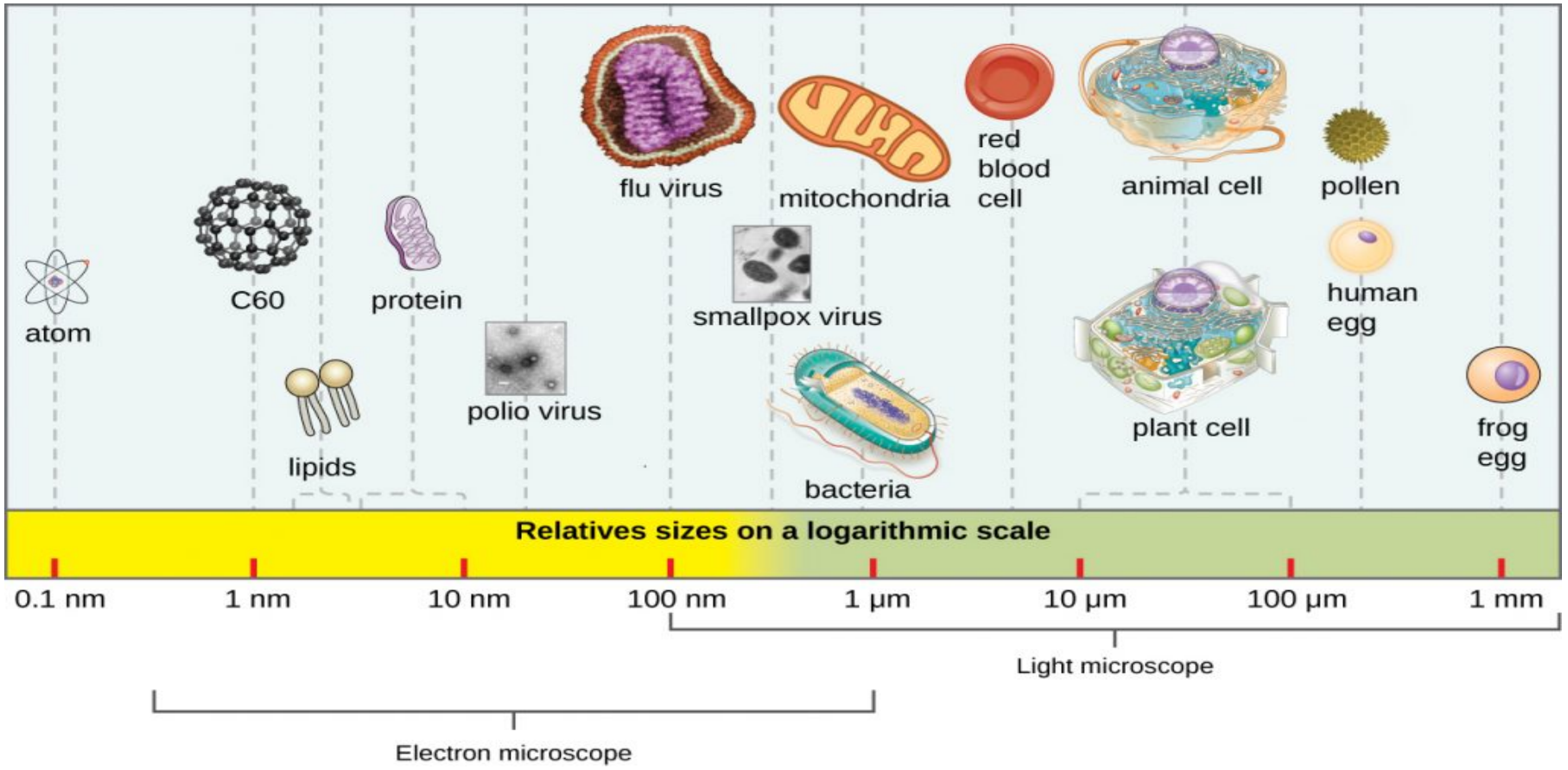


- Dutch microbiologist **Beijerinc**k (1898) confirmed the findings of **Iwanowsky** and called the fluid **"contagium vivum fluidum**" which means contagious living fluid. This was later called virion (poison) and the disease-causing agent as virus.

- **W.M. Stanley** (1935), the American biochemist, isolated virus in crystalline form and demonstrated that even in that state it maintained the infectivity. This marked the beginning of a new branch of science called **virology.**

General Characteristics :

- Viruses are ultramicroscopic and can cause diseases in plants and animals. They are very simple in their structure.
- They are composed of **nucleic acid** surrounded by a **protein coat**. Nucleic acid can be **either RNA or DNA**, but never both.
- They have no cellular organization and have no machinery for any metabolic activity.
- They are obligate intracellular parasites, and they multiply within their host cells. Once outside the host cell they are completely inactive.



Size :

- Viruses are very minute particles that they can be seen only under electron microscope
- They are measured in millimicrons (1 millimicron = 1/1000micron). (1micron – 1/1000 millimetre). Generally they vary from 2.0 mm to 300 mm in size.
- Very small size and ability to pass through bacterial filters are classic attributes of viruses.
- The following methods are used to determine the size of the viruses:

1. Direct observation by using electron microscope.
2. Filtration through membranes of graded porosity: In this method viruses are made to pass through a series of membranes of known pore size, the approximate size of any virus can be measured by determining which membrane allows the virus to pass through and which membrane holds it back.
3. Sedimentation by ultra centrifugation : The relationship between the size and shape of a particle and its rate of sedimentation permits determination of particle size.
4. Comparative measurements: The following data is used for reference:

a. Staphylococcus has a diameter of 1000 mm.
b. Bacteriophage varies in size from 10-100 nm.

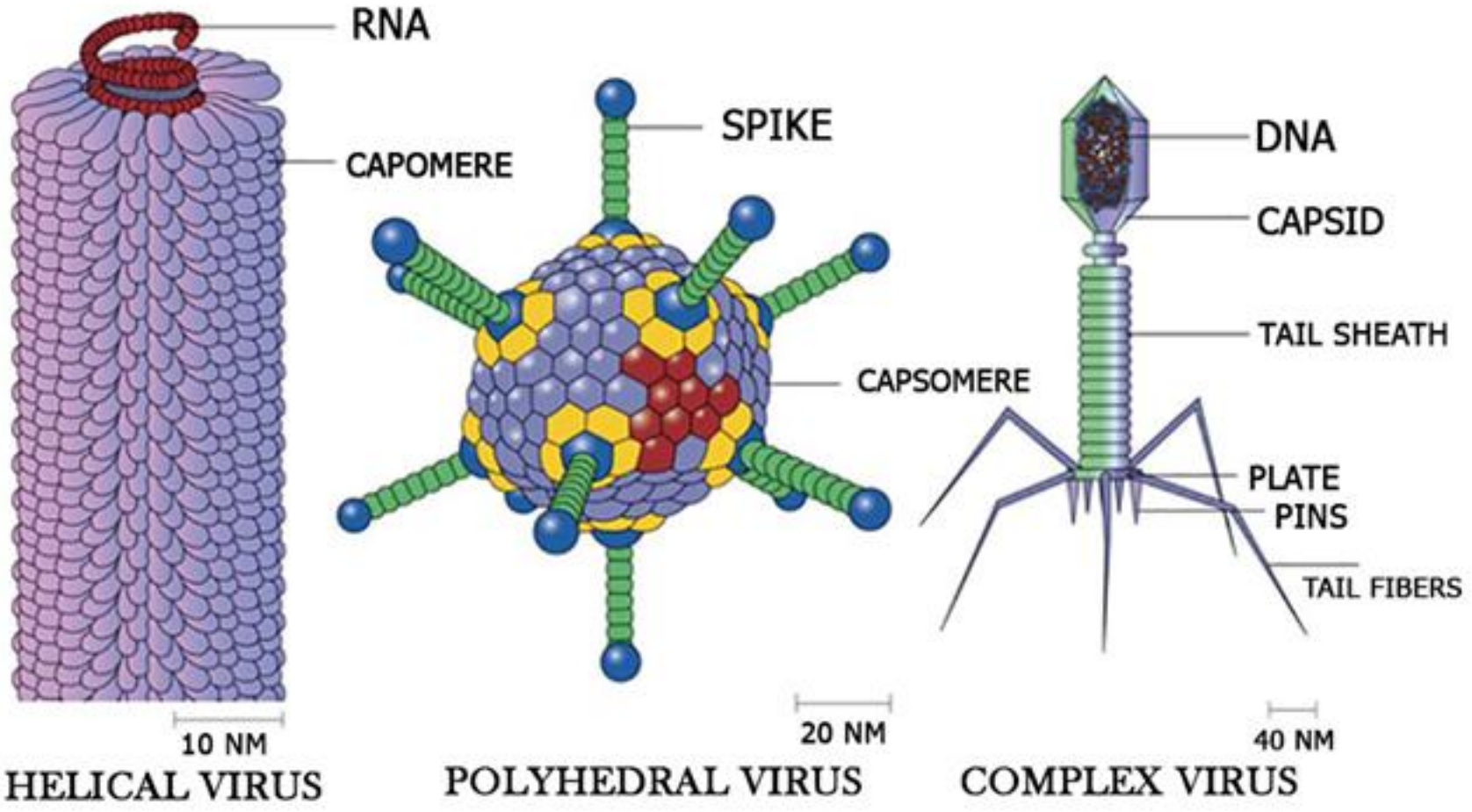
Shape :

Broadly speaking, viruses occur in three main shapes:

1. Cubic symmetry: polyhedral or spherical – e.g. **Adeno virus, HIV**

2. Helical symmetry: e.g. *Tobacco Mosaic virus* (TMV), *Influenza virus*.

3. Complex or atypical e.g. Bacteriophage, Pox virus.



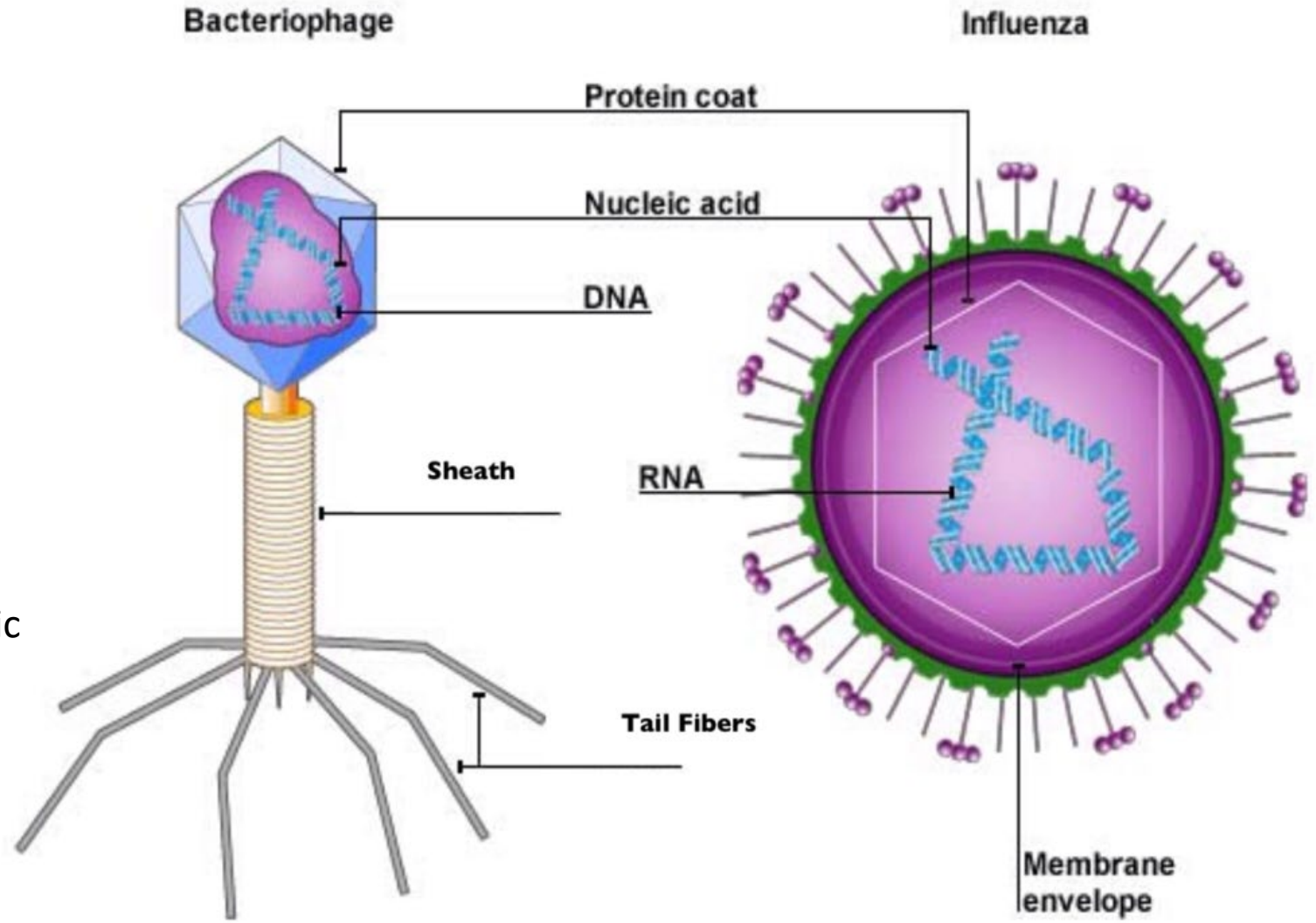
Structure:

- A virus is composed of two major parts:

1.**Capsid** (the protein coat)

2.**Nucleic acid**.

- The capsid is the outer protein coat. It is protective in function. It is often composed of many identical subunits called **capsomeres.**
- Some of the viruses have an outer covering called **envelope** e.g. HIV. They are called enveloped viruses.
- Others are called naked viruses or non-enveloped viruses.
- The capsid is in close contact with the nucleic acid and hence known as **nucleocapsid.**
- The nucleic acid forms the central core. Unlike any living cell, a virus contains either DNA or RNA, but never both. The infective nature of the virus is attributed to the nucleic acid while host specificity is attributed to the protein coat.



Classification of Virus:

- Although viruses are not classified as members of the five kingdoms, they are diverse enough to require their own classification scheme to aid in their study and identification.
- According to the type of the host they infect, viruses are classified mainly into the following four types:

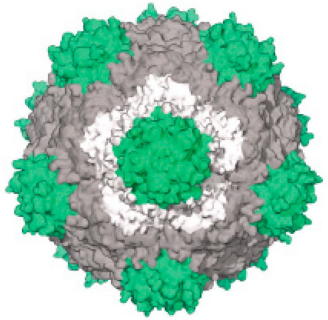
1. **Plant viruses including algal viruses-RNA/DNA**
2. **Animal viruses including human viruses-DNA/RNA**
3. **Fungal viruses(Mycoviruses)-ds RNA**
4. **Bacterial viruses (Bacteriophages) including cyanophages-DNA**

1. Plant virus :

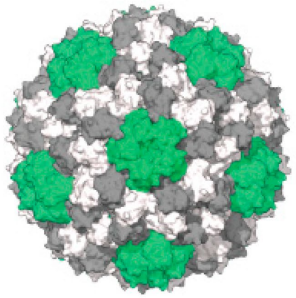
They infect plants and cause diseases. Some common plant viral diseases are:

a. Mosaic diseases of tobacco (TMV), cucumber (CMV), cauliflower.
b. Bunchy top of banana
c. Leaf-roll of potato
d. Spotted wilt of tomato

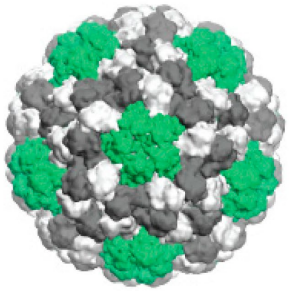
Generally, plant viruses have RNA with the exception of some viruses such as cauliflower mosaic virus which has DNA.



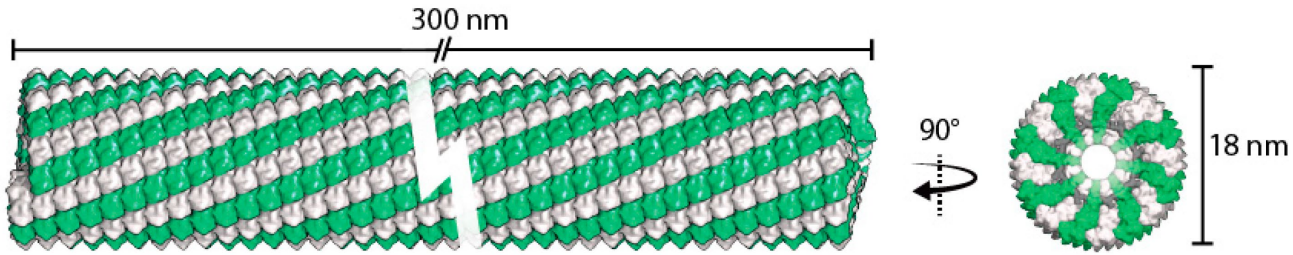
Cowpea Mosaic Virus (CPMV)
icosahedral hetero 120-mer



Cowpea Chlorotic Mottle Virus (CCMV)
icosahedral homo 180-mer



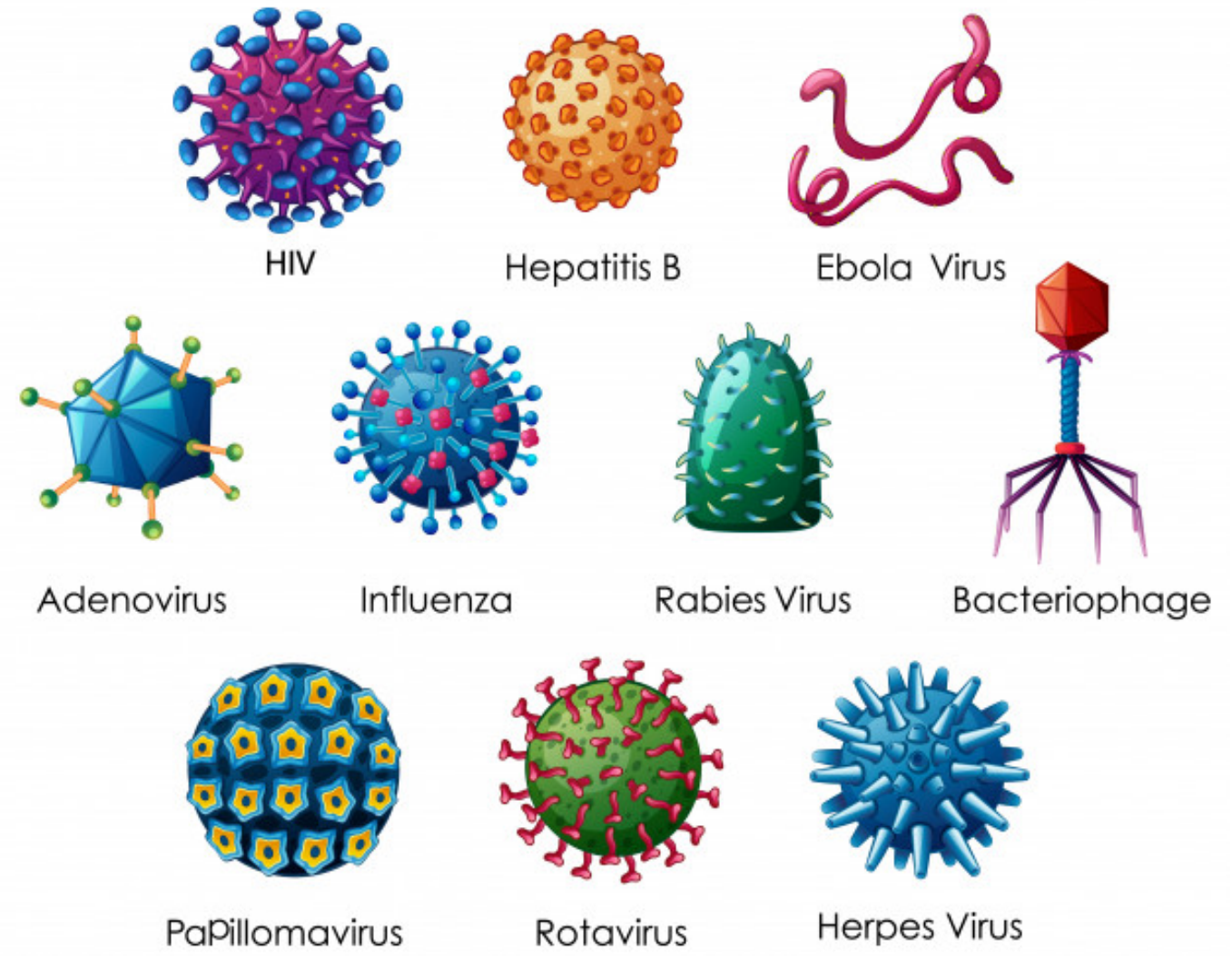
Brome Mosaic Virus (BMV)
icosahedral homo 180-mer



Tobacco Mosaic Virus (TMV)
Helical homo 2130-mer

2. Animal Virus :

- They infect animals and cause diseases.
- The nucleic acid is either DNA or RNA
- Some of the diseases caused by viruses in human beings are: common cold, measles, small pox (now extinct) chicken pox, Jaundice, herpes, hepatitis A B,C,D,E,G, influenza, polio, mumps, rabies, AIDS and SARS.
- Viruses also cause diseases in cattle. eg. Foot and mouth disease. (FMD) in cattle, encephalomyelitis of horse, distemper of dog, rabbies etc.

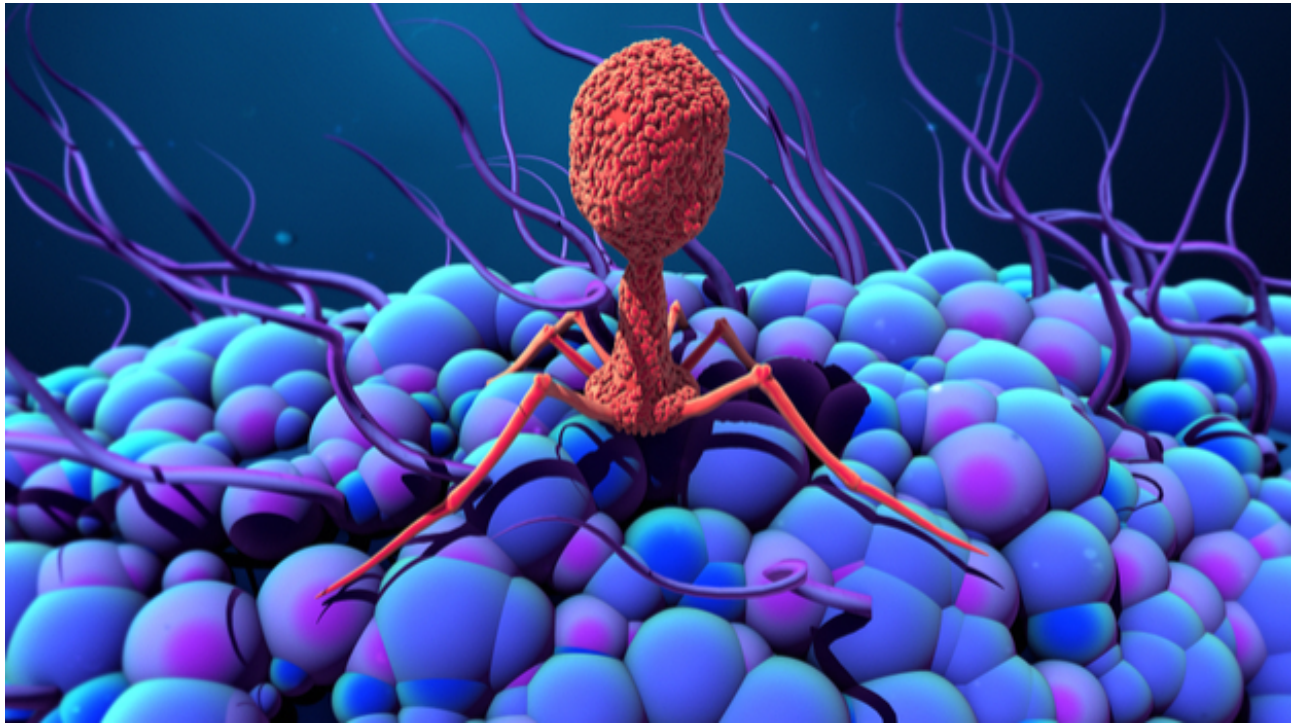


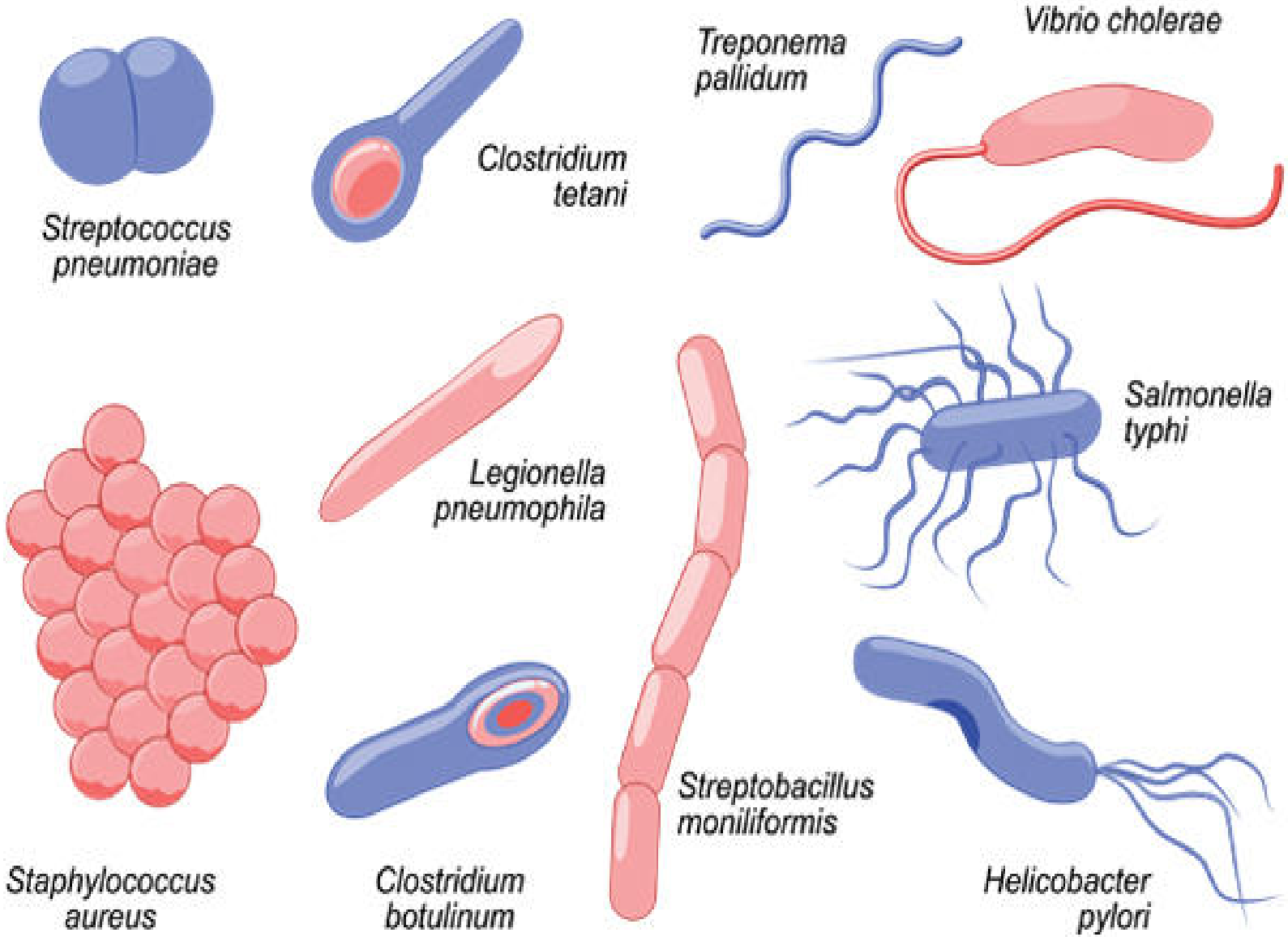
3. Mycophages/ Cyanophages:

- Viruses that cause diseases in fungi are called **Mycophages.**
- Viruses that attack blue green algae/cyanobacteria and cause diseases are called **cyanophages.**

4. Bacteriophages:

- Virus that infects bacteria is called **bacteriophage** or simply **phage**.
- It is tadpole like and the nucleic acid is DNA e.g. T_2 , T_4 , T_6 bacteriophages.

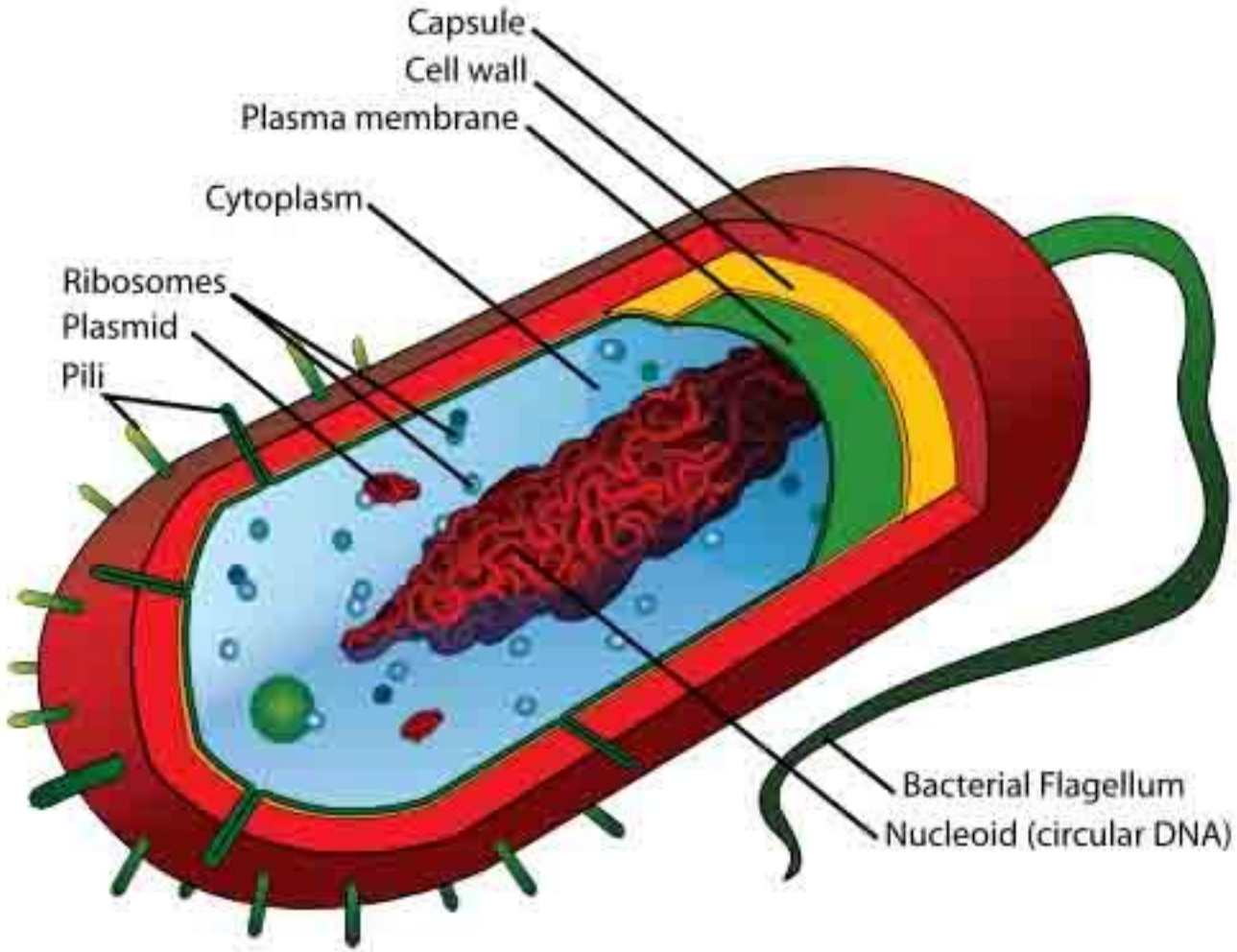



Streptococcus pneumoniae
Clostridium tetani
Treponema pallidum
Vibrio cholerae
Legionella pneumophila
Salmonella typhi
Staphylococcus aureus
Clostridium botulinum
Streptobacillus moniliformis
Helicobacter pylori

BACTERIA

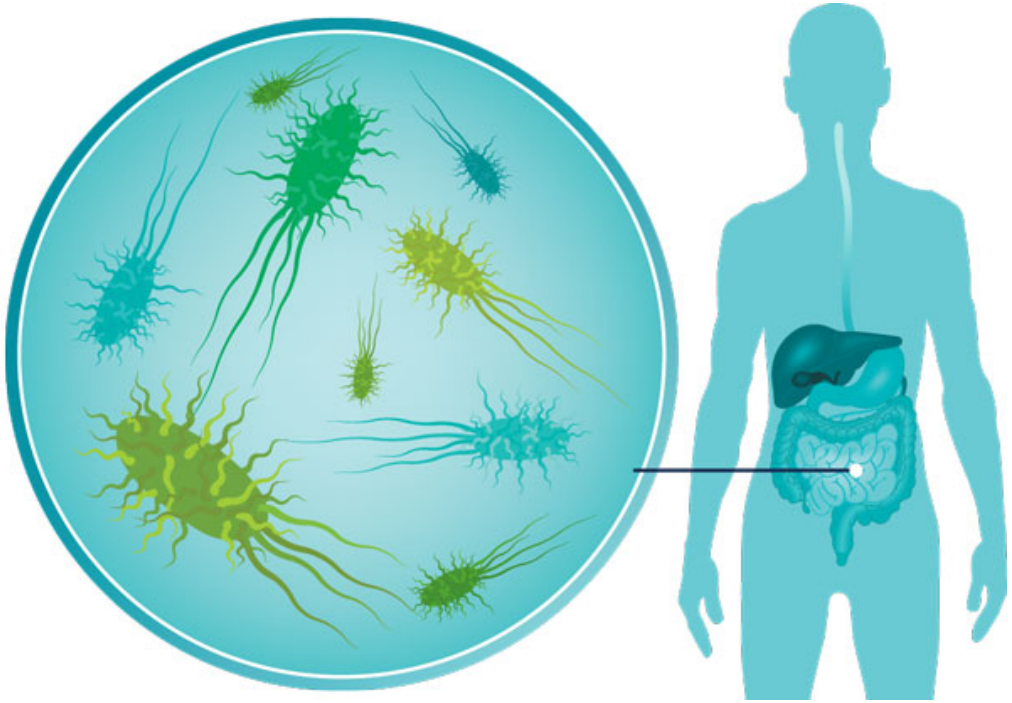
Introduction :

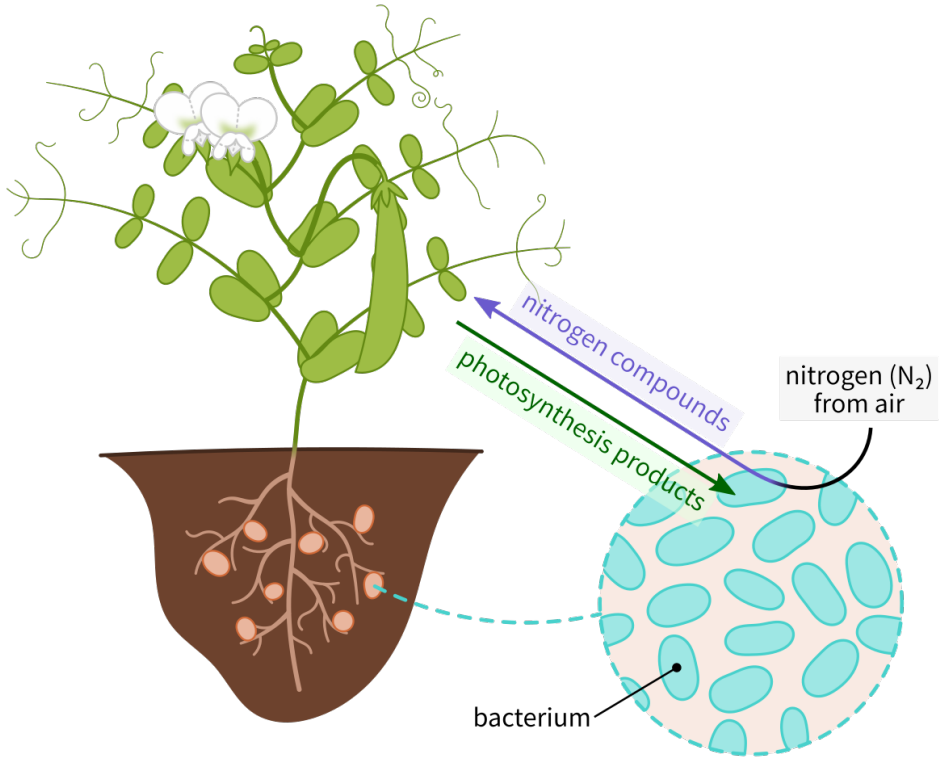
- In 1676 **Anton Van Leeuwenhoek** discovered the microbial world by his simple microscope. It was only after the invention of compound microscope by **Hooke** in 1820, that bacteria came to lime light. These very minute creatures were designated as “small microscopic species” or “ **Infusorial animalcules**”.
- **Louis Pasteur**(1822-95) made a detailed study of bacteria and proposed **germ theory of disease. Robert Koch,** a German microbiologist, was the first scientist to prove the cause and effect relationship between microbes and animal diseases.
- **Ehrenberg**(1829) was the first to use the term **bacterium**.
- The branch of study that deals with bacteria is called **Bacteriology**.
- Bacteria are unicellular organisms and they are prokaryotic, i.e. they do not have a membrane bound nucleus and membrane bound organelles .



Occurrence :

- Bacteria are omnipresent. They are found in all environments, where organic matter is present. They are found in air, water, soil and also in or on the bodies of plants and animals
- Some of the bacteria live as **commensals** (e.g. ***Escherichia coli*** in the human intestine) and some live as **symbionts** (e.g. ***Rhizobium***) in the root nodules of leguminous plants.
- Several of them cause diseases in plants, animals and human beings.
- Size: Bacteria are very small, most being approximately 0.5 to 1 micron in diameter and about 3 to 5 microns in length.



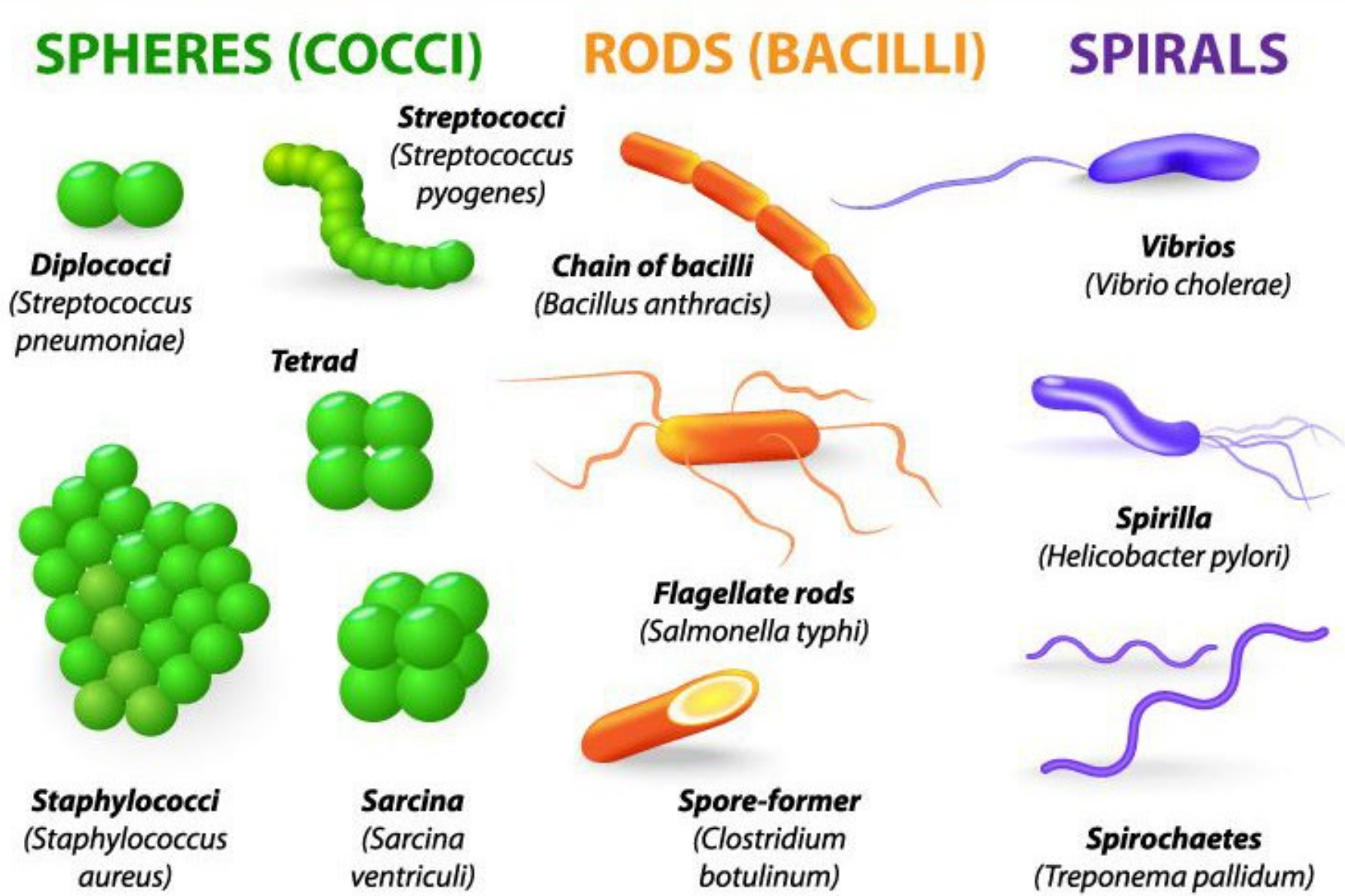


Classification of bacteria based on shape and arrangement :

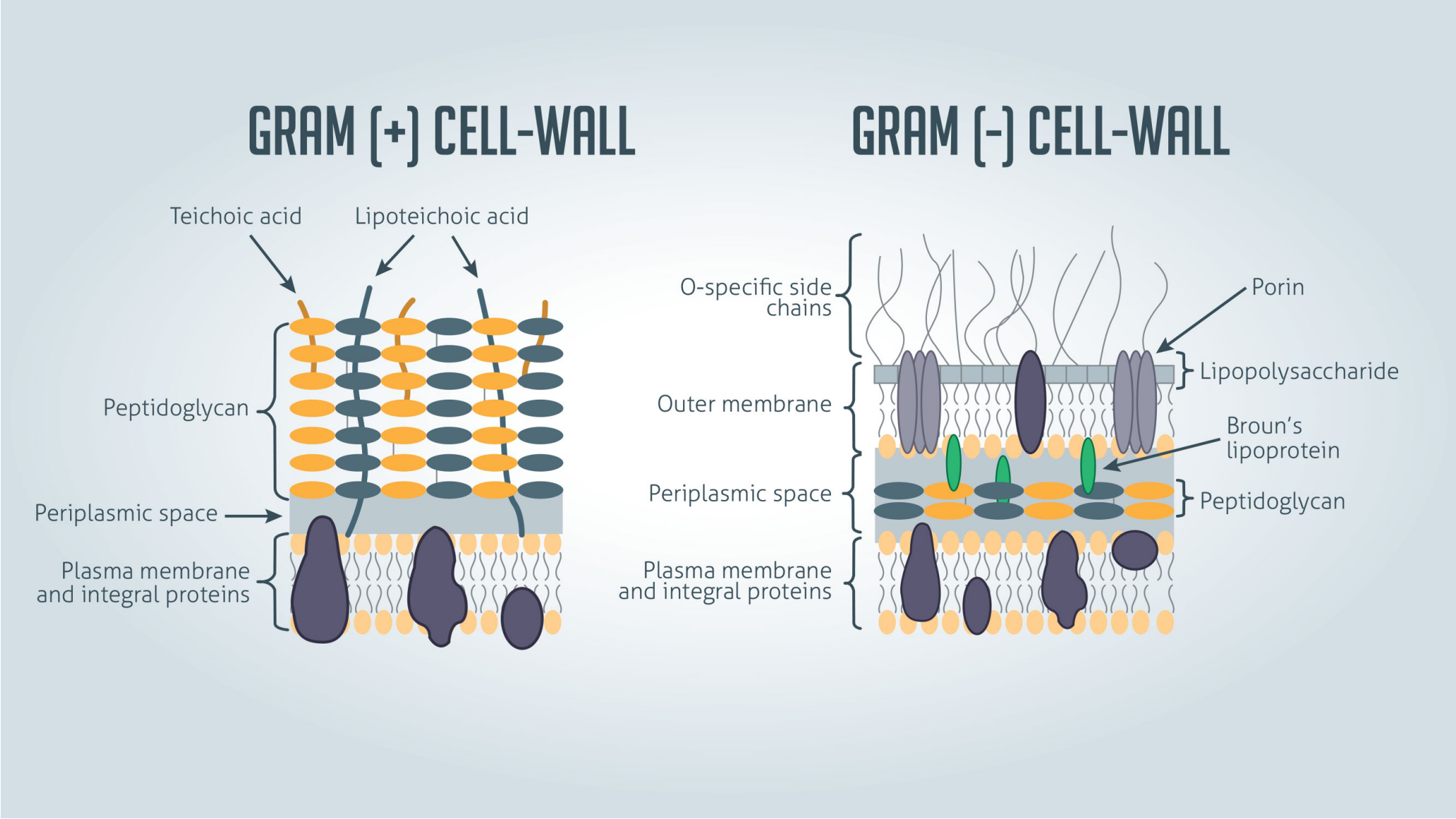
- The rigid bacterial cell wall determines shape of a cell. Typical bacterial cells are spherical (**Cocci**), straight rods (**Bacilli**) or rods that are helically curved (**spirilla),** some bacterial cells are **pleomorphic** ie they can exhibit a variety of shapes eg. ***Arthrobacter***
- Cocci bacteria appear in several characteristic arrangements depending on their plane of division.

- A. **Diplococci:** Cells divide in one plane and remain attached in pairs.
  B. **Streptococci:** cells divide in one plane and remain attached to form chains.
  C. **Tetracocci**: Cells divide in two planes and form group of four cells.
  D. **Staphylococci:** cells divide in three planes, in an irregular pattern, producing bunches of cocci.
  E**. Sarcinae:** cells divide in three planes, in a regular pattern, producing a **cuboidal** arrangement of cells.

- Bacilli forms occur singly or in pairs (**diplobacilli**) or form chains (**streptobacilli**). In ***Corynebacterium diphtheriae*** which is a bacillus species, the cells are arranged side by side like match sticks (**palisade** arrangement)

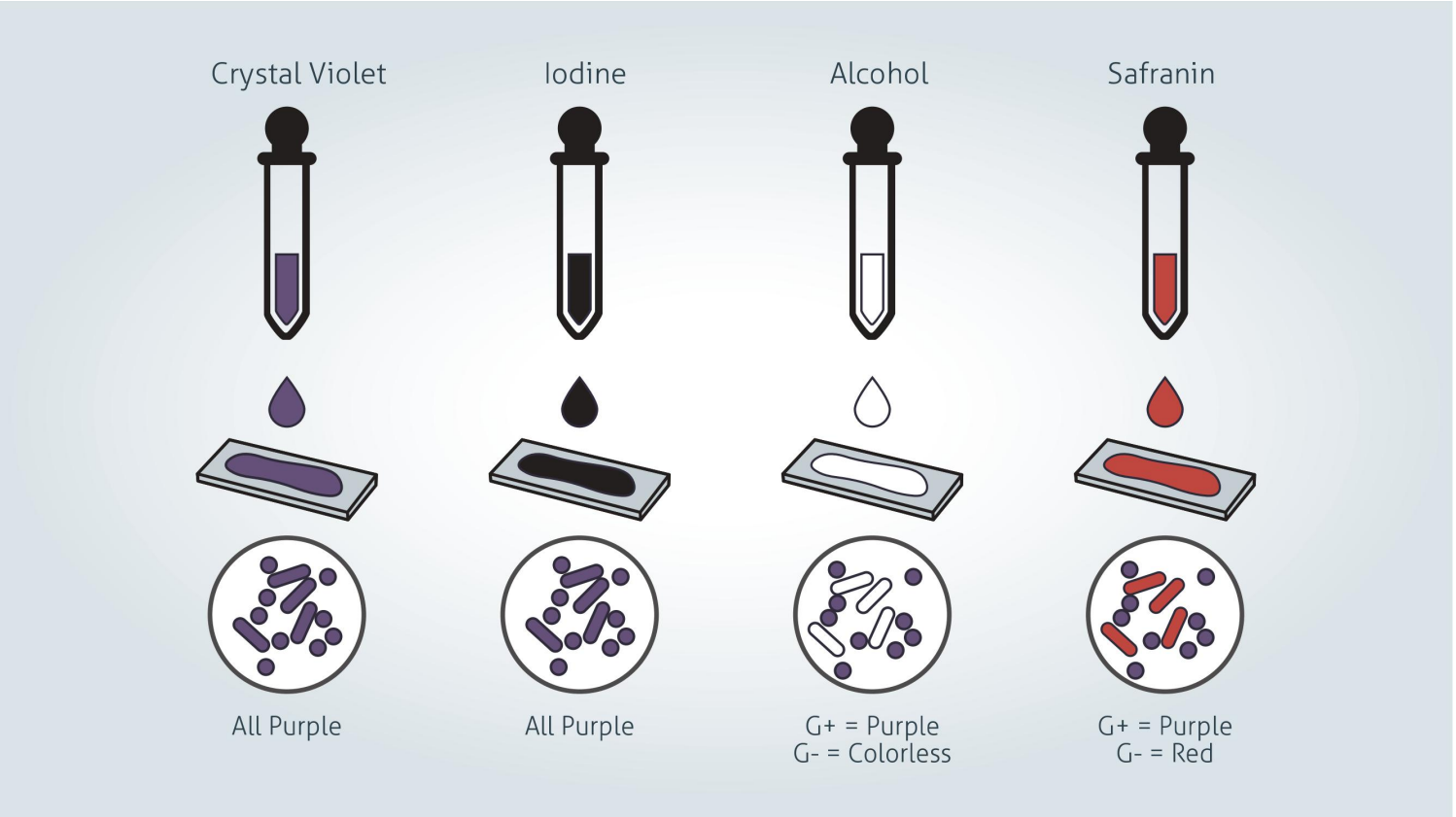

SPHERES (COCCI)
RODS (BACILLI)
SPIRALS
Streptococci
(Streptococcus pyogenes)
Diplococci
(Streptococcus pneumoniae)
Chain of bacilli
(Bacillus anthracis)
Vibrios
(Vibrio cholerae)
Tetrad
Spirilla
(Helicobacter pylori)
Flagellate rods
(Salmonella typhi)
Staphylococci
(Staphylococcus aureus)
Sarcina
(Sarcina ventriculi)
Spore-former
(Clostridium botulinum)
Spirochaetes
(Treponema pallidum)

Classification of bacteria based on cell structure and gram stain :



Gram staining:

- Gram staining is a common technique used to differentiate two large groups of bacteria based on their different cell wall constituents.
- The Gram stain procedure distinguishes between Gram positive and Gram-negative groups by colouring these cells red or violet.
- Gram positive bacteria stain violet due to the presence of a thick layer of peptidoglycan in their cell walls, which retains the crystal violet these cells are stained with.
- Alternatively, Gram negative bacteria stain red, which is attributed to a thinner peptidoglycan wall, which does not retain the crystal violet during the decolouring process.



Procedure for gram - staining:

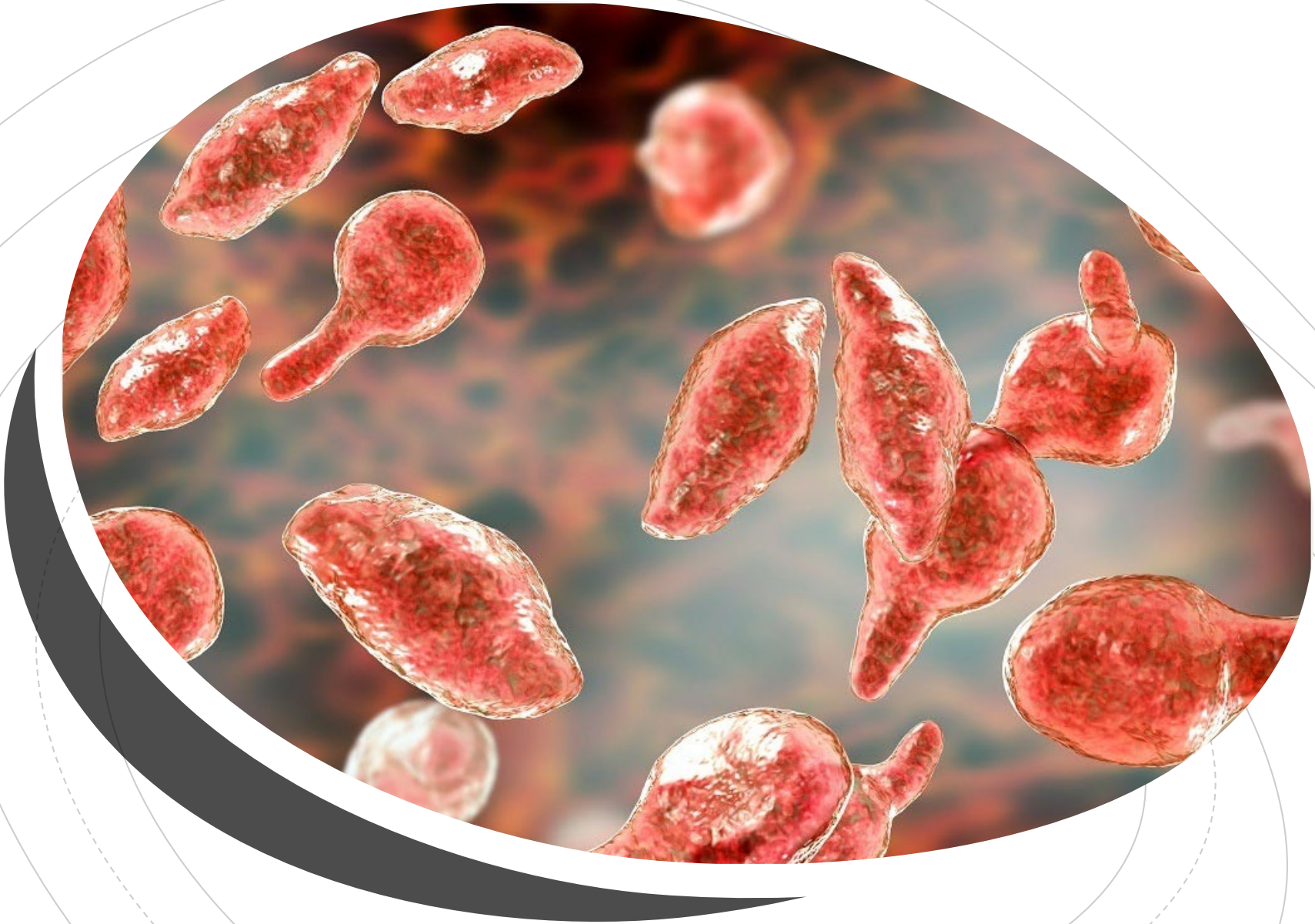
- Gram staining involves three processes: staining with a water-soluble dye called crystal violet, decolorization, and counterstaining, usually with safranine.
- Due to differences in the thickness of a peptidoglycan layer in the cell membrane between Gram positive and Gram negative bacteria, Gram positive bacteria (with a thicker peptidoglycan layer) retain crystal violet stain during the decolorization process, while Gram negative bacteria lose the crystal violet stain and are instead stained by the safranin in the final staining process.
- The process involves three steps:

1. Cells are stained with crystal violet dye. Next, a Gram's iodine solution (iodine and potassium iodide) is added to form a complex between the crystal violet and iodine. This complex is a larger molecule than the original crystal violet stain and iodine and is insoluble in water.

2. A decolouriser such as ethyl alcohol or acetone is added to the sample, which dehydrates the peptidoglycan layer, shrinking and tightening it. The large crystal violet-iodine complex is not able to penetrate this tightened peptidoglycan layer and is thus trapped in the cell in Gram positive bacteria. Conversely, the the outer membrane of Gram-negative bacteria is degraded and the thinner peptidoglycan layer of Gram-negative cells is unable to retain the crystal violet-iodine complex and the color is lost.

3. A counterstain, such as the weakly water-soluble safranin, is added to the sample, staining it red. Since the safranin is lighter than crystal violet, it does not disrupt the purple coloration in Gram positive cells. However, the decolorized Gram-negative cells are stained red.

Characteristic	Gram-positive	Gram-negative
Gram reaction	Retain crystal violet dye and stain dark violet or purple	Can be decolorized to accept counterstain (safranin) and stain red
Peptidoglycan layer	Thick (multilayered) (Fig. 1.6)	Thin (single-layered) (Fig. 1.6)
Teichoic acid	Present in many	Absent
Periplasmic space	Absent	Present
Outer membrane	Absent (Fig. 1.7)	Present (Fig. 1.7)
Lipopolysaccharide (LPS) content	Virtually none	High
Lipid and lipoprotein content	Low (acid fast bacteria have lipids linked to peptidoglycan)	High (due to presence of outer membrane)
Flagellar structure	2 rings in basal bodies	4 rings in basal bodies
Toxins produced	Primarily exotoxins	Primarily endotoxins
Resistance to physical disruption	High	Low
Cell wall disruption by lysozyme	High	Low
Resistance to drying	High	Low
Inhibition by basic dyes	High	Low
Susceptibility to Anionic detergents	High	Low



MYCOPLASMA

Introduction :

- Mycoplasma (plural mycoplasmas or mycoplasmata) is a genus of bacteria that lack a cell wall around their cell membranes.
- They can be parasitic or saprotrophic. Several species are pathogenic in humans, including *M. pneumoniae*, which is an important cause of "walking" pneumonia and other respiratory disorders, and *M. genitalium*, which is believed to be involved in pelvic inflammatory diseases.
- Mycoplasma species are the smallest bacterial cells yet discovered, can survive without oxygen, and come in various shapes. For example, *M. genitalium* is flask-shaped (about 300 x 600 nm), while *M. pneumoniae* is more elongated (about 100 x 1000 nm). Hundreds of mycoplasma species infect animals.

- **Important Characteristics:**

1. Cell wall is absent and plasma membrane forms the outer boundary of the cell.
2. Due to the absence of cell wall, these organisms can change their shape and are pleomorphic.
3. Lack of nucleus and other membrane-bound organelles.
4. Genetic material is a single DNA duplex and is naked.
5. Ribosomes are 70S type.
6. Possess a replicating disc at one end which assist replication process and the separation of the genetic materials.
7. Heterotrophic nutrition. Some live as saprophytes but the majority are parasites of plants and animals. The parasitic nature is due to the inability of mycoplasmal bacteria to synthesise the required growth factor.

1000^m	10^n	Prefix	Symbol	Short scale	Long scale	Decimal
1000^8	10^{24}	yotta-	Y	Septillion	Quadrillion	1 000 000 000 000 000 000 000 000
1000^7	10^{21}	zetta-	Z	Sextillion	Trilliard	1 000 000 000 000 000 000 000
1000^6	10^{18}	exa-	E	Quintillion	Trillion	1 000 000 000 000 000 000
1000^5	10^{15}	peta-	P	Quadrillion	Billiard	1 000 000 000 000 000
1000^4	10^{12}	tera-	T	Trillion	Billion	1 000 000 000 000
1000^3	10^9	giga-	G	Billion	Milliard	1 000 000 000
1000^2	10^6	mega-	M	Million		1 000 000
1000^1	10^3	kilo-	k	Thousand		1 000
$1000^{2/3}$	10^2	hecto-	h	Hundred		100
$1000^{1/3}$	10^1	deca-	da	Ten		10
1000^0	10^0	*(none)*	*(none)*	One		1
$1000^{-1/3}$	10^{-1}	deci-	d	Tenth		0.1
$1000^{-2/3}$	10^{-2}	centi-	c	Hundredth		0.01
1000^{-1}	10^{-3}	milli-	m	Thousandth		0.001
1000^{-2}	10^{-6}	micro-	μ	Millionth		0.000 001
1000^{-3}	10^{-9}	nano-	n	Billionth	Milliardth	0.000 000 001
1000^{-4}	10^{-12}	pico-	p	Trillionth	Billionth	0.000 000 000 001
1000^{-5}	10^{-15}	femto-	f	Quadrillionth	Billiardth	0.000 000 000 000 001
1000^{-6}	10^{-18}	atto-	a	Quintillionth	Trillionth	0.000 000 000 000 000 001
1000^{-7}	10^{-21}	zepto-	z	Sextillionth	Trilliardth	0.000 000 000 000 000 000 001
1000^{-8}	10^{-24}	yocto-	y	Septillionth	Quadrillionth	0.000 000 000 000 000 000 000 001