Semester 4/ Infection and Immunity Module

Session 1 / Lecture 2

An Introduction to Microbes

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AIMS & Learning Outcomes

Objectives:

- Describe the “ microbial world.

- Describe the key features of microorganisms (bacteria, viruses parasites and fungi), and broadly how they are classified.

- The main antimicrobial classes and their mechanisms of action.
- The principles of choosing antimicrobials for particular infections.

Objective Number 1:

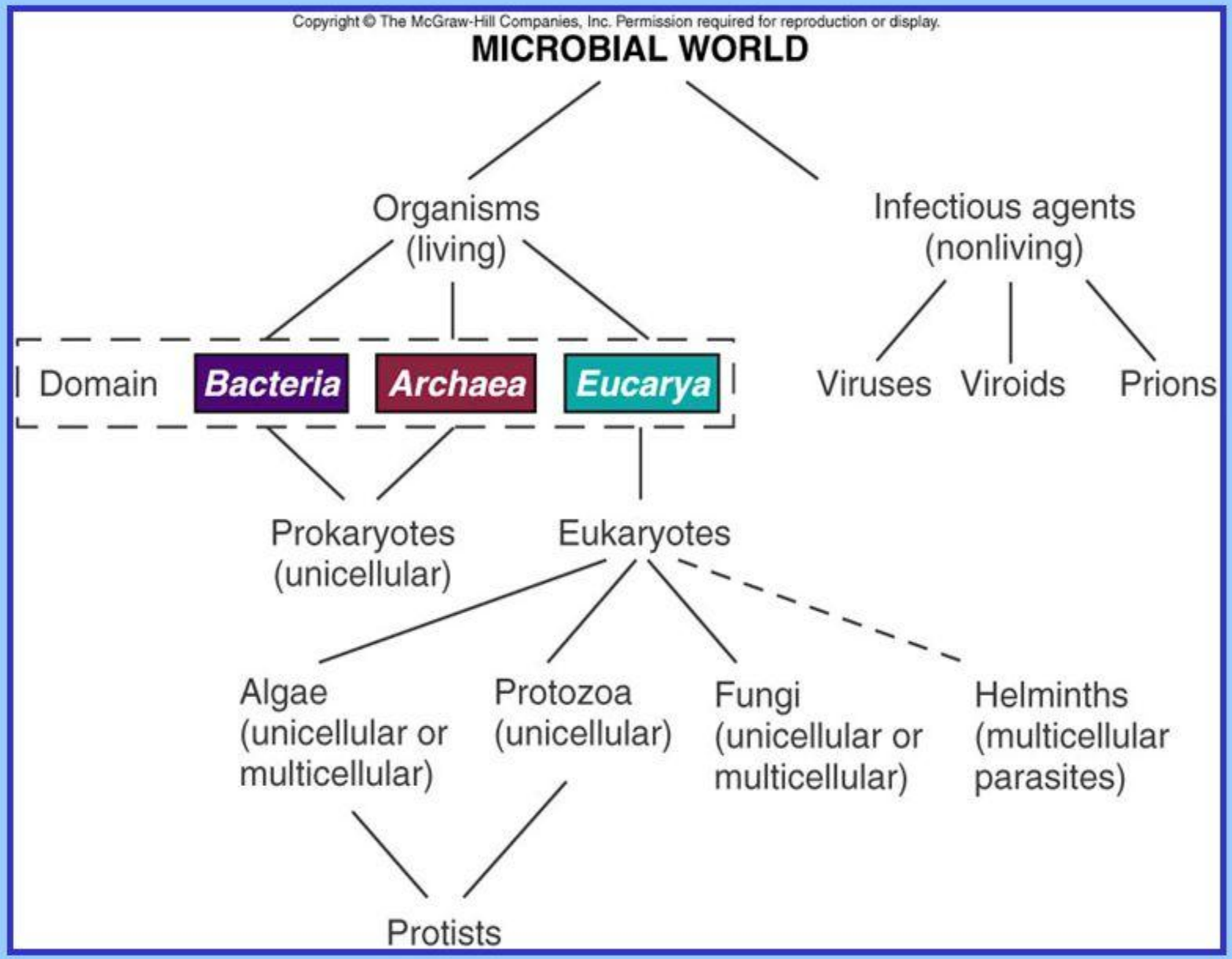
- Describe the “ microbial world ”.

Overview

A brief summary of micro-organisms causing human diseases:

- **Viruses**
- **Bacteria**
- **Parasites**
- **Fungi**

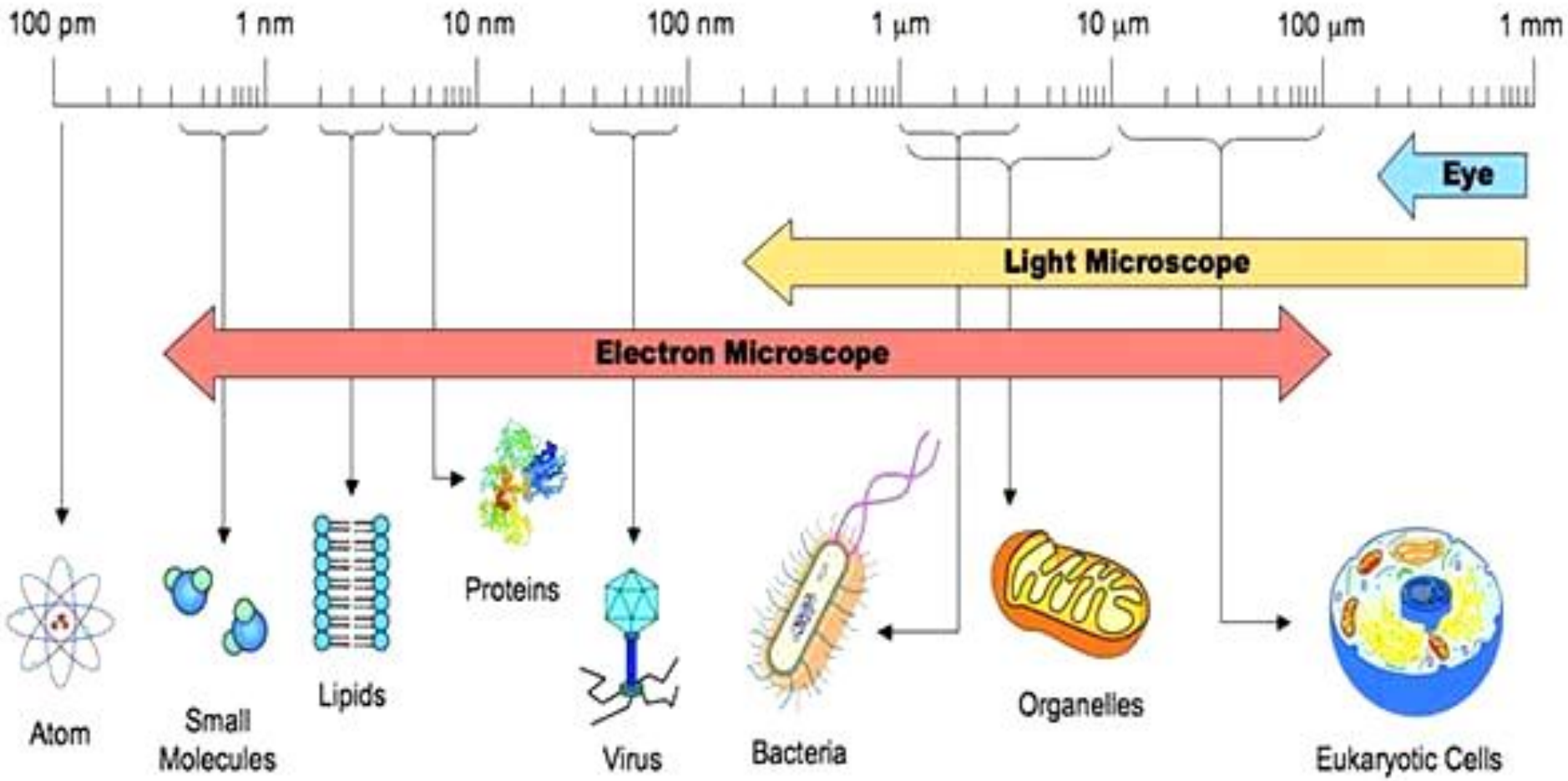
Relationship of Microbes



Distinctive Features of Prokaryotic and Eukaryotic Cells

Characteristics	Prokaryotic Cells	Eukaryotic Cells
Range of cell size	0.5 - 10 µm	10-100 µm
Nucleus	Absent	Present, bounded by nuclear envelope
Chromosome	Usually a single, circular	Multiple, linear
Cell wall	Usually present many contain peptidoglycan (absent in ***Mycoplasma***)	Only Present in (plants and fungi), No peptidoglycan (cellulose, chitin in some)
Plasma membrane	No carbohydrates, most lack sterols	Carbohydrates and sterols present
Membrane-bound organelles	None	Present examples: mitochondria and endoplasmic reticulum
Ribosome	70S	80S (70S in organelles)
Organisms	Bacteria	Fungi, plants and animals

The size of micro-organisms

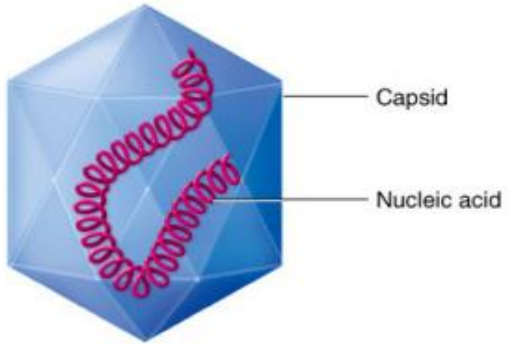


Objective Number 2:

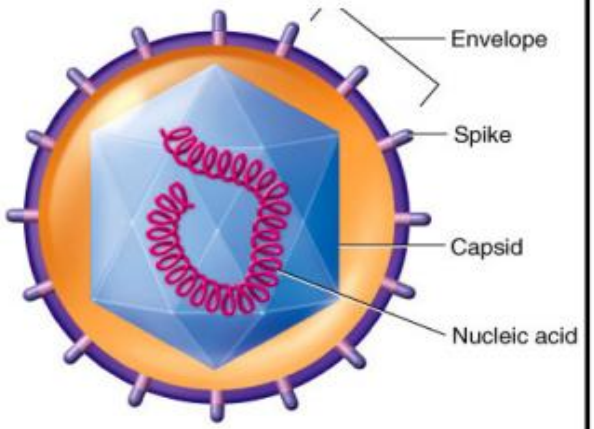
- Describe the key features of microorganisms (bacteria, viruses parasites and fungi), and broadly how they are classified.

Viruses

There are two major structures of viruses called the naked nucleocapsid virus and the enveloped virus



(a) **Naked Nucleocapsid Virus**



(b) **Enveloped Virus**

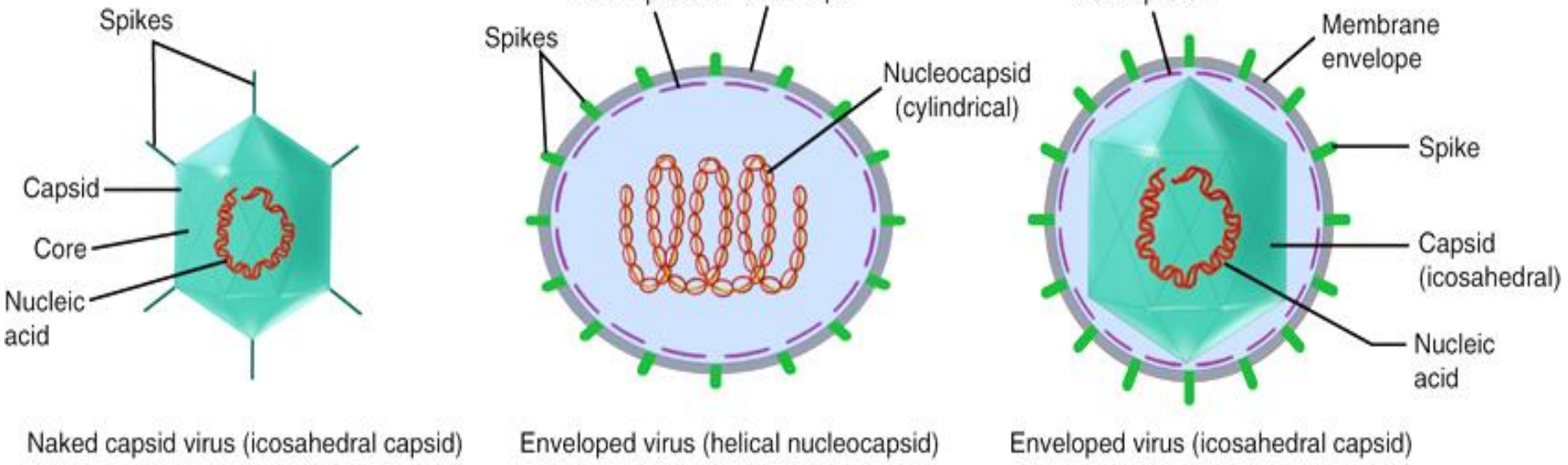
NAKED **Enveloped**

a) Non-enveloped viruses/ Naked Viruses = viruses whose capsids are not covered by an envelope

b) Sometimes, Capsid covered with envelope

- **SPIKES** = carbohydrate-protein complexes (glycoproteins) that project from the envelope
  - Can be used to attach to host cell

Viruses


Spikes
Capsid
Core
Nucleic acid
Naked capsid virus (icosahedral capsid)
Membrane envelope
Matrix protein
Spikes
Nucleocapsid (cylindrical)
Enveloped virus (helical nucleocapsid)
Matrix protein
Membrane envelope
Spike
Capsid (icosahedral)
Nucleic acid
Enveloped virus (icosahedral capsid)

Classification of viruses

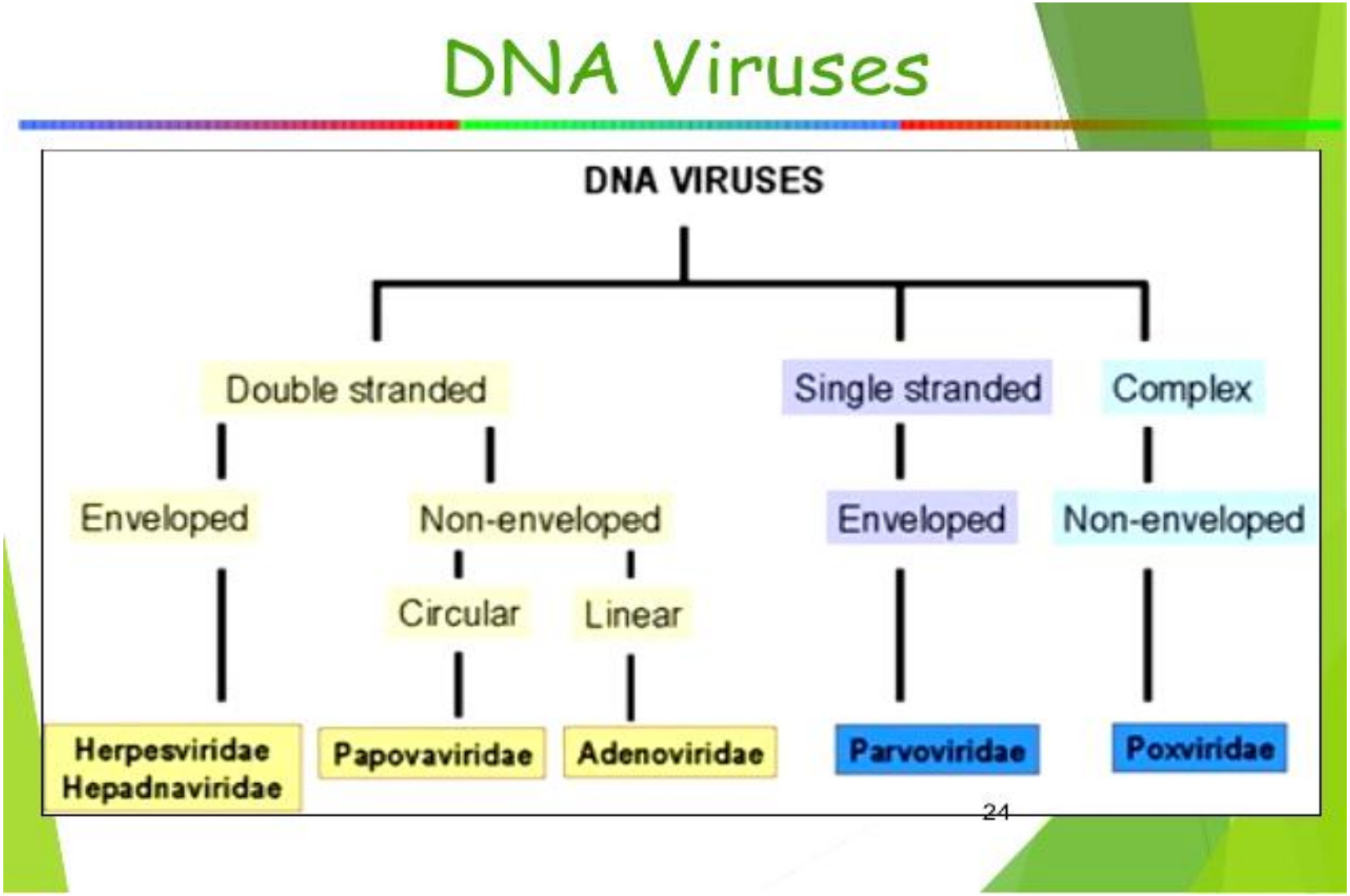
- Genome Type (DNA or RNA)

- Size

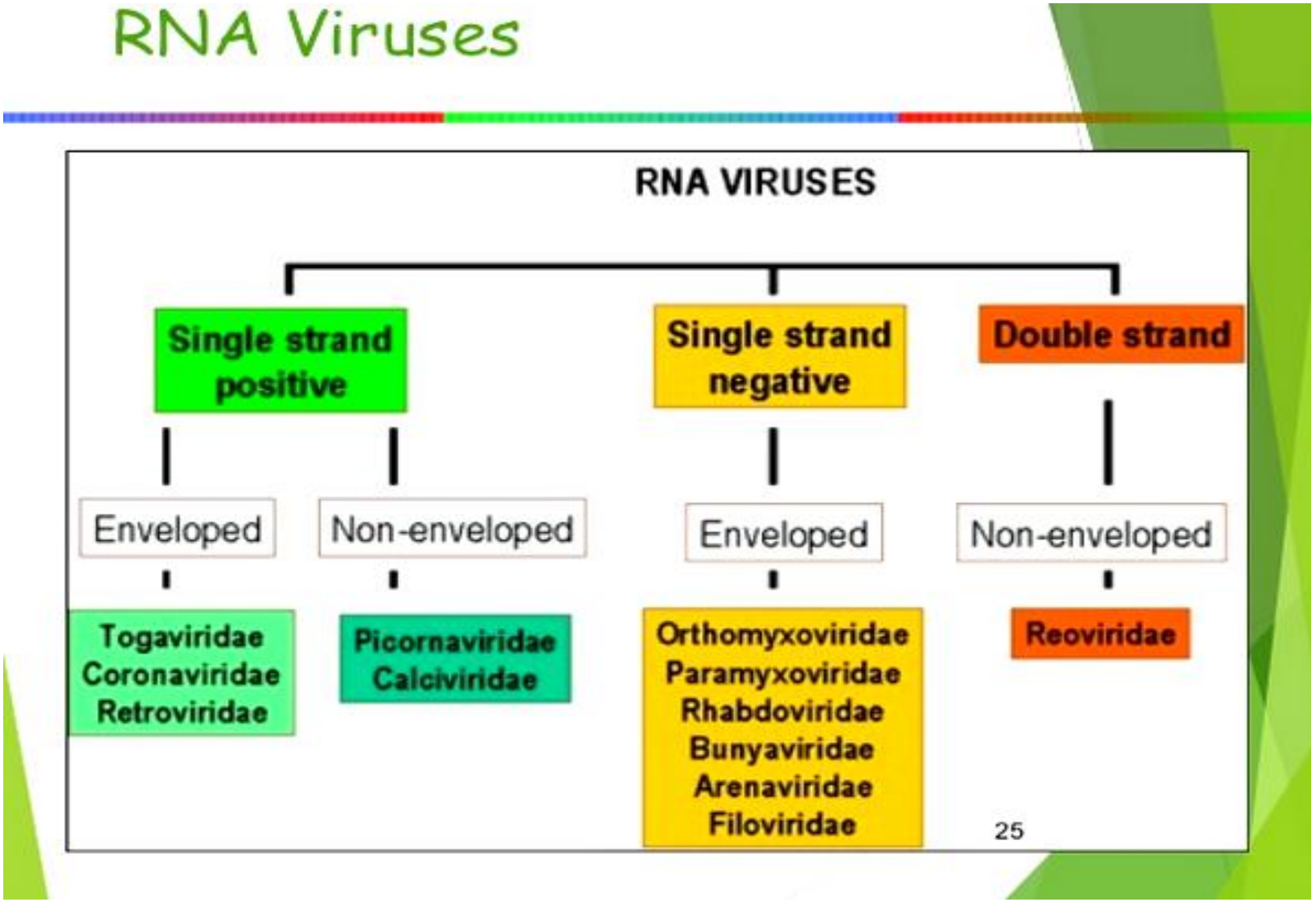
- Morphology

- Means of Replication

Classification of viruses according to Genome Type (DNA or RNA) :

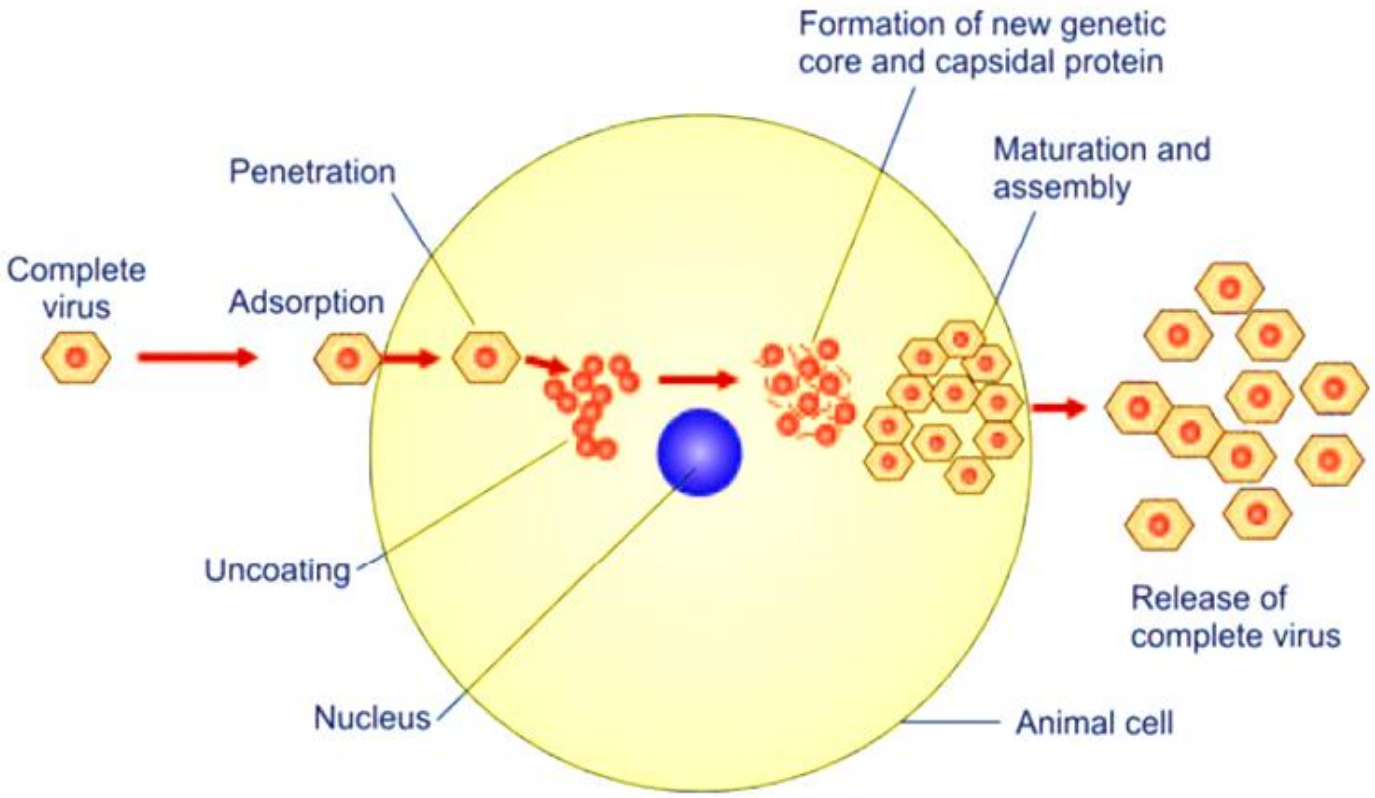


Classification of viruses according to Genome Type (DNA or RNA) :

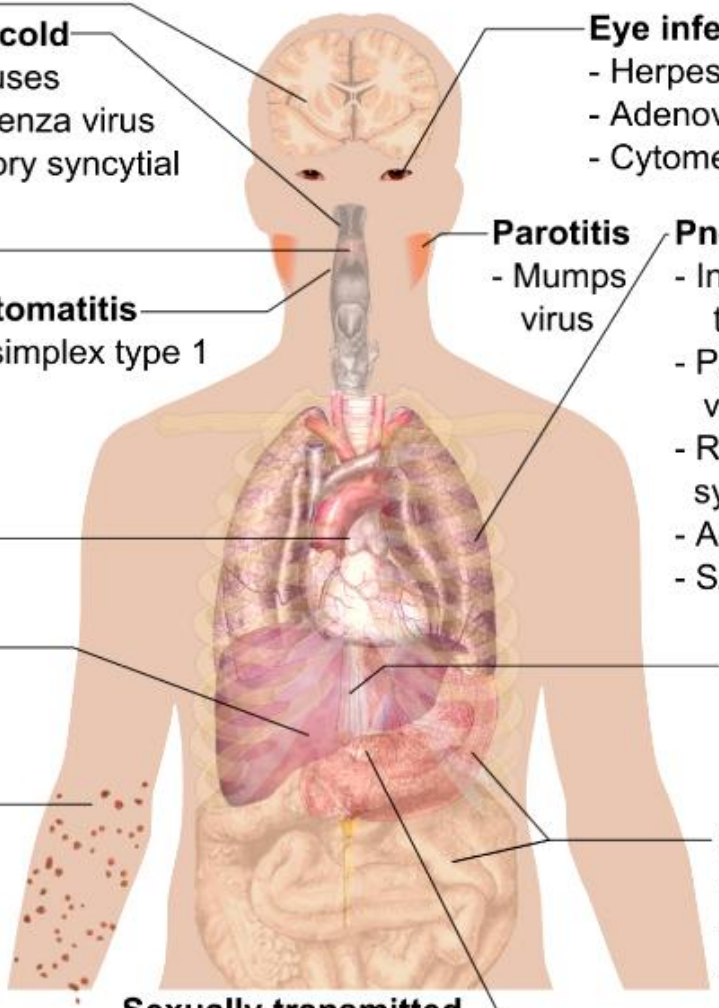


Key steps in viral replication cycle:

1 – Attachment & Adsorption
2 - Penetration
3 - Uncoating
4 – Genome Replication
5- Maturation
6- Assembly
7- Release



Overview of Viral Infections



Encephalitis/ meningitis
- JC virus
- Measles
- LCM virus
- Arbovirus
- Rabies

Common cold
- Rhinoviruses
- Parainfluenza virus
- Respiratory syncytial virus

Eye infections
- Herpes simplex virus
- Adenovirus
- Cytomegalovirus

Parotitis
- Mumps virus

Pneumonia
- Influenza virus types A and B
- Parainfluenza virus
- Respiratory syncytial virus
- Adenovirus
- SARS coronavirus

Pharyngitis
- Adenovirus
- Epstein-Barr virus
- Cytomegalovirus

Gingivostomatitis
- Herpes simplex type 1

Cardiovascular
- Coxsackie B virus

Hepatitis
- Hepatitis virus types A, B, C, D, and E

Myelitis
- Poliovirus
- HTLV-I

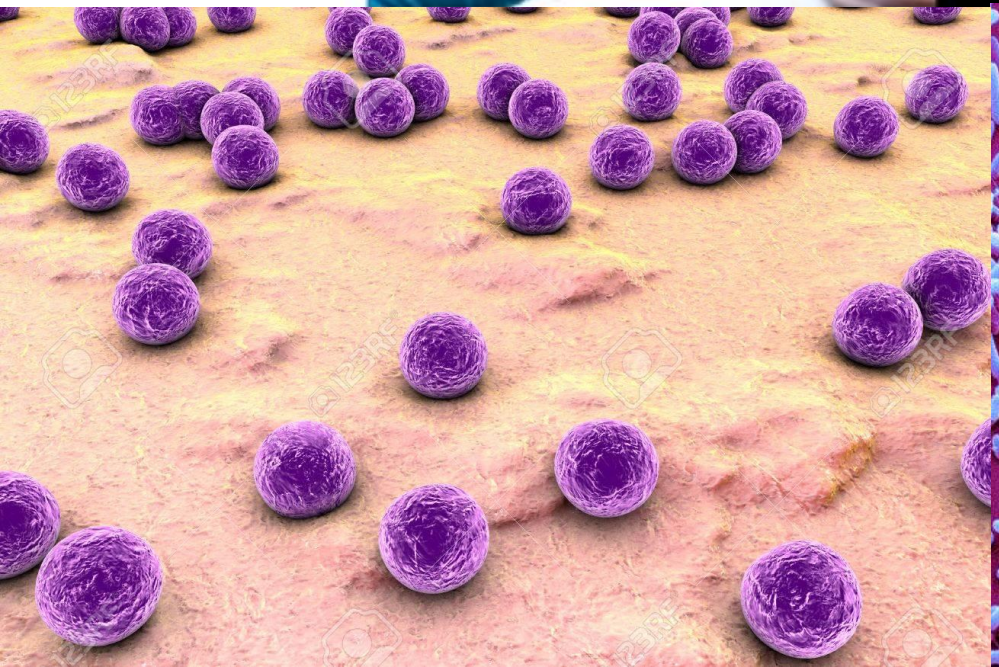
Skin infections
- Varicella-zoster virus
- Human herpesvirus 6
- Smallpox
- Molluscum contagiosum
- Human papillomavirus
- Parvovirus B19
- Rubella
- Measles
- Coxsackie A virus

Gastroenteritis
- Adenovirus
- Rotavirus
- Norovirus
- Astrovirus
- Coronavirus

Sexually transmitted diseases
- Herpes simplex type 2
- Human papillomavirus
- HIV

Pancreatitis
- Coxsackie B virus

Bacteria



Bacteria Definition

• Bactria are prokaryotic microorganisms, simple unicellular (single cell) microscopic organisms, that lack nuclei and other organized cell structures of Eukaryotes .

• Several bacterial species are pathogenic (capable of causing disease), most are non-infectious, and many beneficial have a critical roles in decay, fermentation, nutrient recycling, and nitrogen fixation.

• Can be measured in Micron or Micrometer (μm)

1 μm =10^{-3} mm

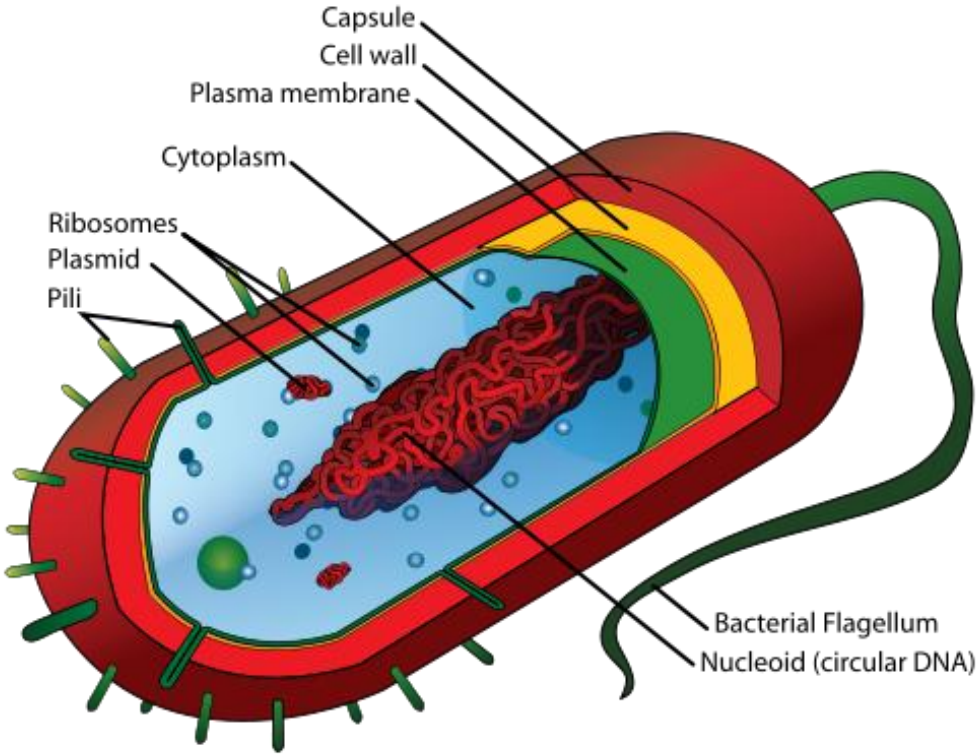
Bacterial Structure

• Essential Structures :

- Cell wall
- Cell membrane
- Cytoplasm
- Nuclear material

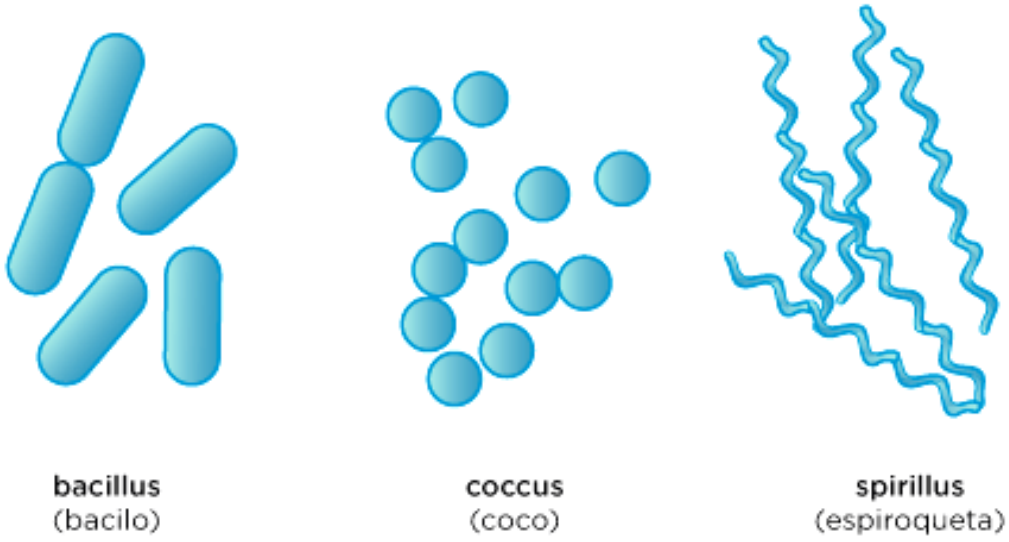
• Specific Structures :

- Capsule
- Flagella
- Pili
- Endospores (spores)



Shape of Bacteria (Morphology)

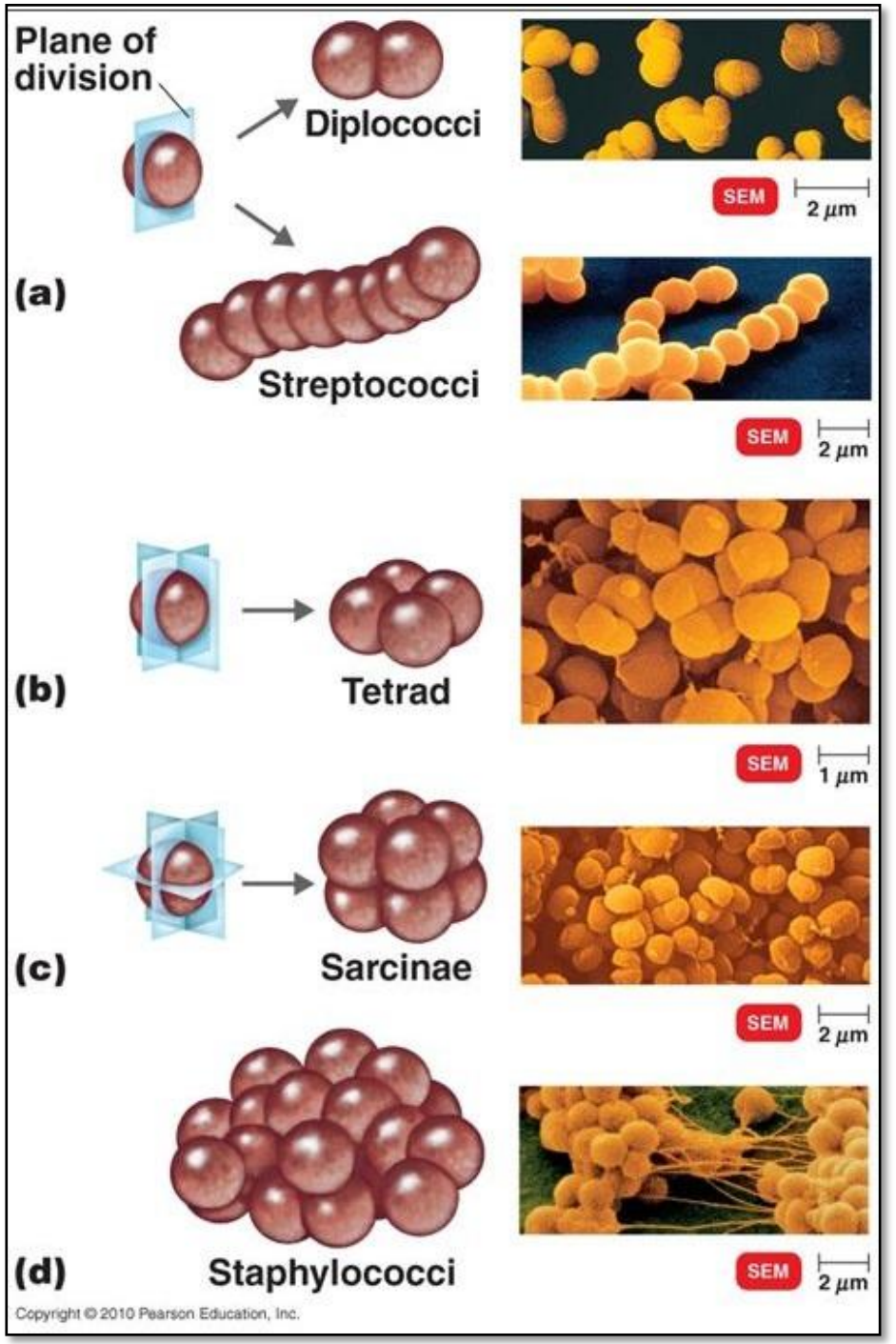
- **Spherical or round (Cocci, *single* Coccus)**
- **Rods (Bacilli, *sing*le Bacillus)**
- **Spiral or twisted (Spiral, *sing*le spirillus)**



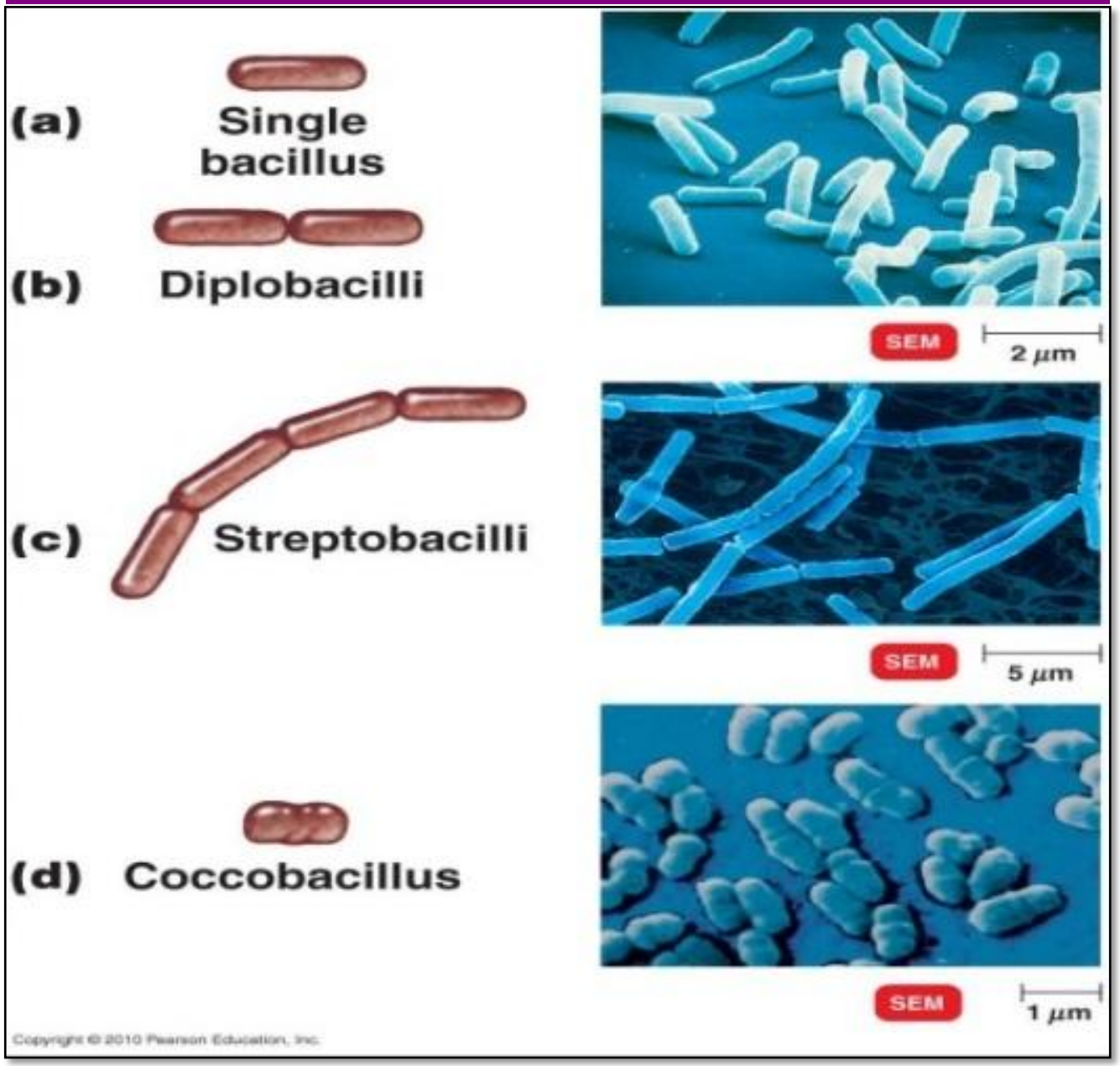
Bacteria can also have different arrangements of cells:

Arrangements of cocci

- Diplococci : cells remain in pairs after dividing .
- Streptococci : cells remain in chains after dividing.
- Tetrad : cells remain in groups of four and divide in two planes.
- Sarcinae : cells remain in groups of eight and divide in three planes.
- Staphylococci : cells remain in clusters and divide in multiple planes.

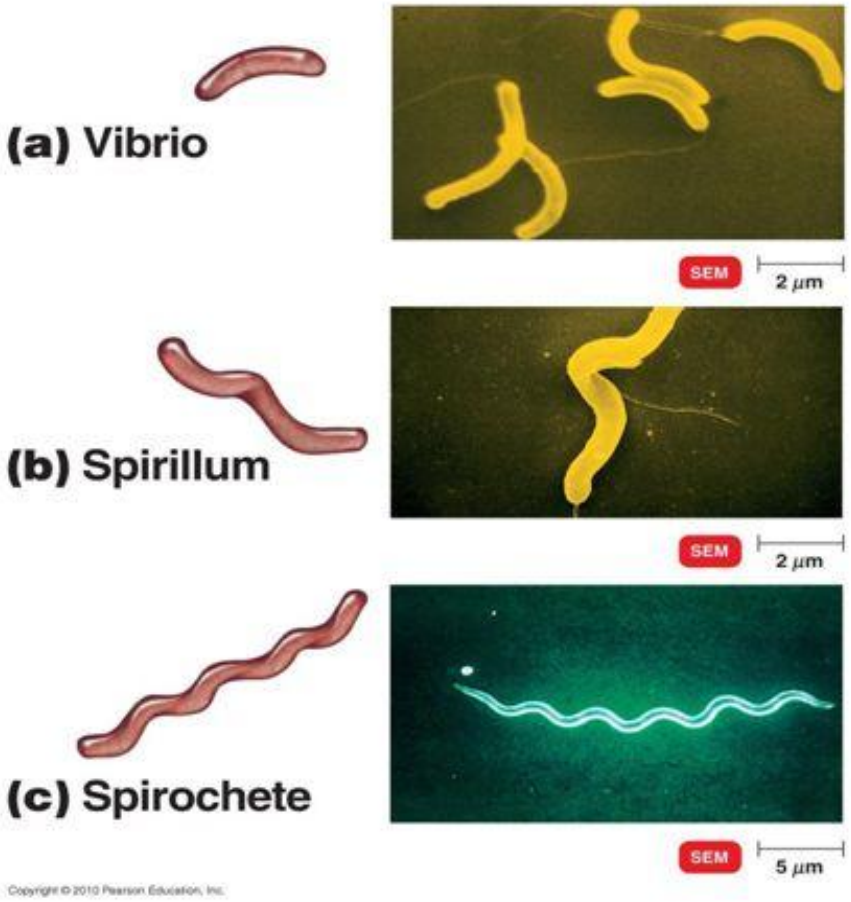


Arrangements of Bacilli



Spiral-shaped bacteria

- Spiral bacteria have one or more twists
  - Bacteria that look like curved rods are called vibrios
  - Spiralla have a helical shape like a corkscrew and fairly rigid bodies
    - Use flagella to move
  - Spirochetes are helical and flexible
    - Move via means of axial filaments



Classification of bacteria according to :

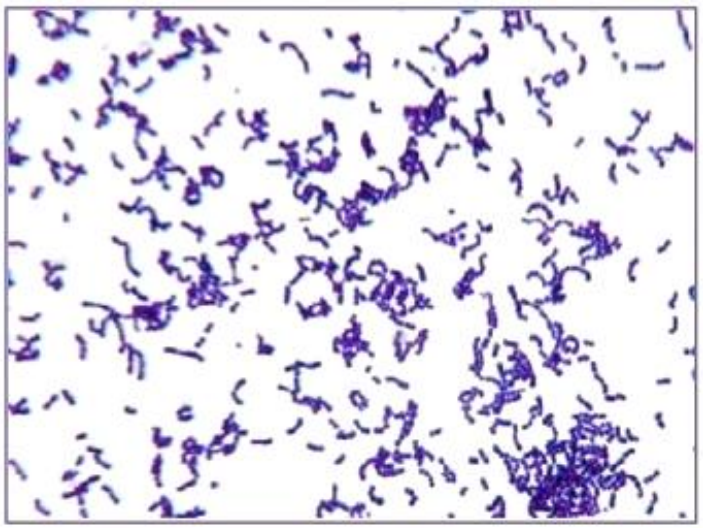
- Morphology
- Staining reaction (Gram's stain & acid fast stain)
- Anatomical features (capsule, flagella, spore)
- Cultural characteristics
- Environmental factors (temperature, oxygen dependence, PH, salt concentration, atmospheric pressure)
- Nutrition (autotrophs & heterotrophs)
- Motility
- pathogenicity
- Sensitivity to antibiotics

Cell Envelope

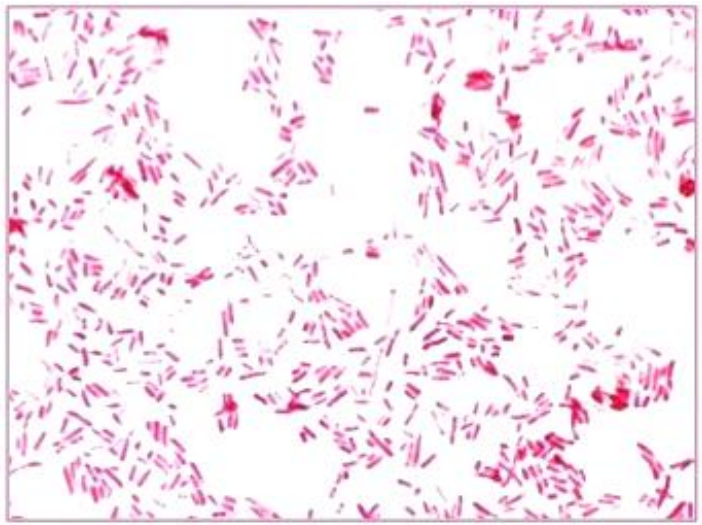
- The cell envelope may be defined as the cell membrane and cell wall.

- Usually, bacterial cell envelopes fall into two major categories: Gram positive and Gram negative.

- This is based on Gram staining characteristics that reflect major structural differences between the two bacterial groups.

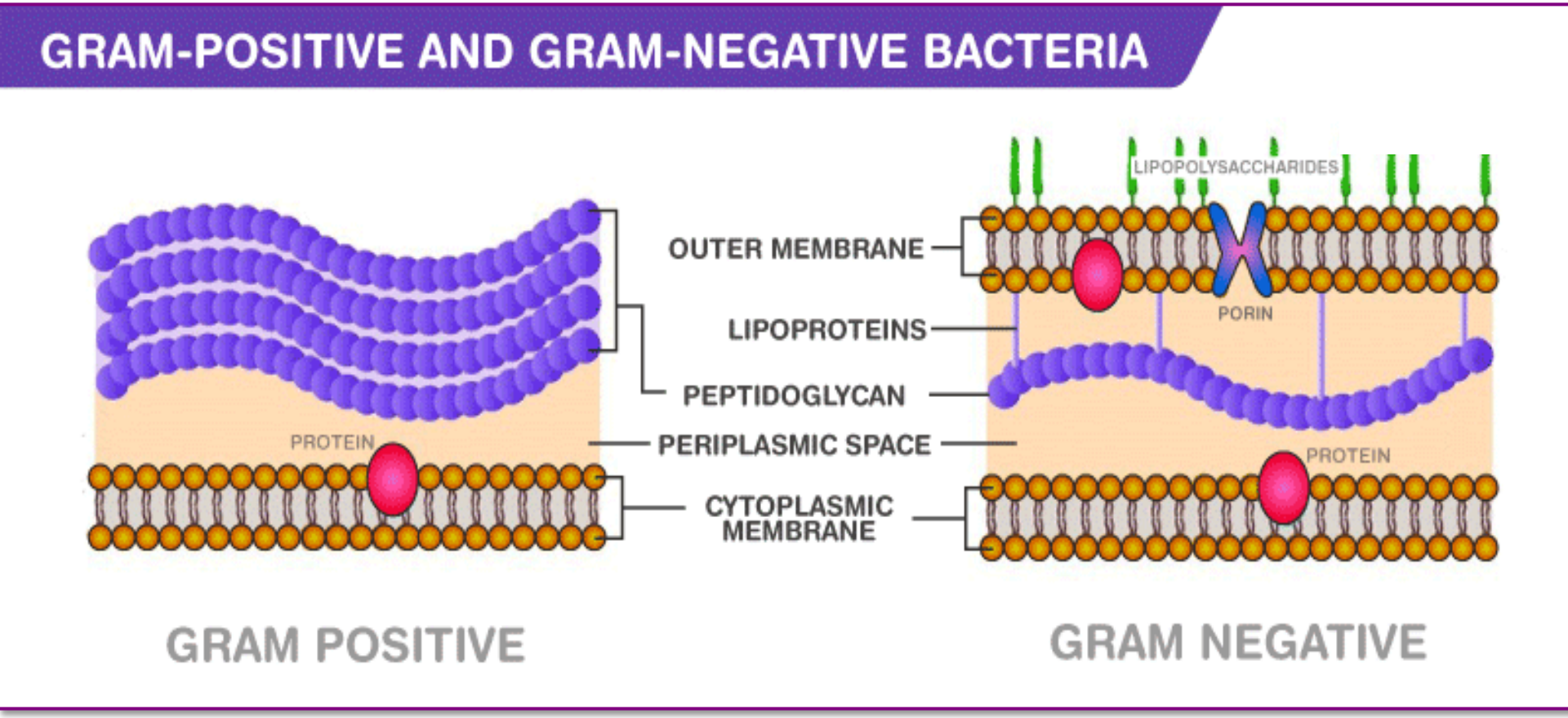


Gram-Positive Bacteria



Gram-Negative Bacteria

Bacterial Cell Wall



Peptidoglycan is found in all bacteria except *Chlamydia* and *Mycoplasma*.

Examples of Medically Important Bacteria

Gram (+) cocci

- *Staphylococcus aureus*
- *Staphylococcus epidermidis*
- *Staphylococcus saprophyticus*
- *Streptococcus mutans*
- *Streptococcus pneumoniae*
- *Streptococcus pyogenes*

Gram (–) cocci

- *Neisseria gonorrhoeae*
- *Neisseria meningitides*
- *Acinetobacter species*

Gram (+) bacilli

- *Bacillus anthracis*
- *Bacillus cereus*
- *Corynebacterium diphtheriae*

Gram (–) bacilli

- *Escherichia coli*
- *Salmonella typhi*
- *Campylobacter jejuni*
- *Shigella sonnei*
- *Vibrio cholerae*
- *Klebsiella pneumoniae*
- *Helicobacter pylori*

Bacterial Virulence Factors

Enzymatic Virulence Factors

Examples:

- Coagluase (*Staphylococcus aureus*)
- Streptokinase (*Streptococcus pyogenes*)
- Hyaluronidase (Many pathogens)
- Collagenase (Many pathogens)
- Leucocidin (Many pathogens)
- Hemolysin (Many pathogens)

Bacterial Virulence Factors

Adhesion Factors

Examples:

- Protein A (*Staphylococcus aureus*)

- Protein M (*Streptococcus pyogenes*)

Bacterial Virulence Factors

Exotoxins

Classes of exotoxins: Neurotoxic, cytotoxic, or enterotoxic:

- Neurotoxins: Interfere with proper synaptic transmissions in neurons

- Cytotoxins: Inhibit specific cellular activities, such as protein synthesis.

- Enterotoxins: Interfere with water reabsorption in the large intestine; irritate the lining of the gastrointestinal tract

Endotoxins

- Endotoxin is composed of Lipid A: Part of the lipopolysaccharide layer.

Comparison between Exotoxins and Endotoxins

	Comparison of Properties	
Property	**Exotoxin**	**Endotoxin**
Source	Certain species of gram-positive and gram-negative bacteria	Cell wall of gram-negative bacteria
Secreted from cell	Yes	No
Chemistry	Polypeptide	Lipopolysaccharide
Location of genes	Plasmid or bacteriophage	Bacterial chromosome
Toxicity	High (fatal dose on the order of 1 μg)	Low (fatal dose on the order of hundreds of micrograms)
Clinical effects	Various effects (see text)	Fever, shock
Mode of action	Various modes (see text)	Includes TNF and interleukin-1
Antigenicity	Induces high-titer antibodies called antitoxins	Poorly antigenic
Vaccines	Toxoids used as vaccines	No toxoids formed and no vaccine available
Heat stability	Destroyed rapidly at 60°C (except staphylococcal enterotoxin)	Stable at 100°C for 1 hour
Typical diseases	Tetanus, botulism, diphtheria	Meningococcemia, sepsis by gram-negative rods

Parasites

- **Protozoa (single-celled)**
  - *Giardia lamblia*
  - *Cryptosporidium parvum*
  - *Plasmodium falciparum*
  - *Trypanosoma cruzi*

- **Helminths (worms, multi-cellular)**
  - Roundworms (e.g *Enterobius vermicularis*)
  - Tapeworms (e.g. *Taenia saginata*)
  - Flukes (e.g. *Schistosoma mansoni*)

Fungi

- **Yeasts (single-celled)**
  - Candida albicans
  - Cryptococcus neoformans

- **Molds (multicellular)**
  - Aspergillus *species*
  - Dermatophytes (ringworm, athlete's foot)

Objective Number 3 & 4:

- The main antimicrobial classes and their mechanisms of action.
- The principles of choosing antimicrobials for particular infections.

Antimicrobials

Agents are chemical substances that can kill or suppress the growth of microorganisms.

Antimicrobials are classified according to the type of infections into:

- Antibacterial agents - Bacterial infections.
- Antiviral agents – Viral infections.
- Antifungal agents – Fingal infactions.
- Antiprotozoal agents – Protozoal infections.
- Antimycobacterial - Mycobacterial infections.
- Antihelminthic – Helminthiasis.

Mechanisms of Action

- Cell wall synthesis inhibitors.
- Alteration of cell membrane function.
- Protein synthesis inhibitors.
- Nucleic acid synthesis inhibitors.
- Metabolic pathways inhibitors.

The principles of choosing antimicrobials agents

Selection of the most appropriate antimicrobial agent requires knowing :

1) the organism's identity.
2) the organism's susceptibility to a particular agent.
3) the site of the infection.
4) patient factors e.g. age, weight, pregnancy, hepatic and renal status, etc.
5) the safety of the agent.
6) the cost of therapy.

Dr.Niran Kadhim AL-Rubaey 2018 – 2019