General Microbiology

TIU
Second year

Prof. Dr. Sewgil S. Anwer

Lec 1-5

2025-2026

References:

Text Books:

-Microbiology (Principle and Exploration).
Jacquelyn G. Black- 5th edition

- Microbiology Experiments (fourth edition)

A health Science perspective John Kleyn- Mary Bicknell

- Microbiology (A human perspective). Fourth edition Nester, Anderson , PEARSALL

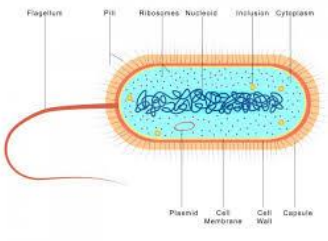
Weekly course outline

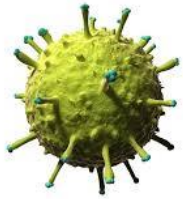
Lec. No.	**Subject Title**
1	Introduction to microbiology , new concept in microbiology , Scope and Importance of Microbiology in Nursing
2.	Microbial cell structure -Cell wall of bacteria - Gram positive and gram negative bacteria
3.	Microbial cell structure and functions –bacteria
4.	Microbial cell structure and functions - Fungi, algae and viruses, protozoa

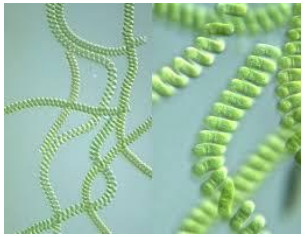
5-6	Microbial growth and population, microbial counting methods
7-8	Antimicrobial activity ,Antibiotic, Classification of antibiotic, resistance to antibiotic
9	Food microbiology
10-11	water and soil microbiology
12	**Review and discussion**

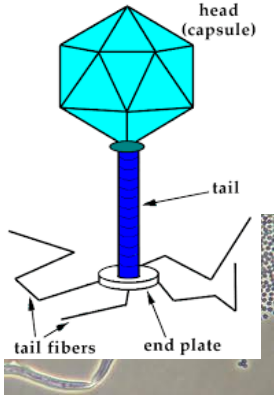
What is Microbiology?

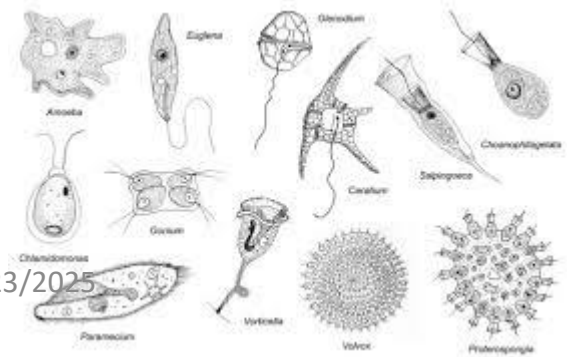
Microbiology: - Is the science which study the living microorganism of microscopic size, which include the following: bacteria, fungi, viruses, algae and protozoa.











- Microbes and microorganisms

Both terms include all organisms that are too small to be seen without a microscope.

- Most of us thinks microorganisms are harmful, but it is not true. Most of the microorganisms are harmless.

Harmful

Harmless

Harmful Effects of microorganisms

1. Cause Diseases to animal and plant (air ,water and food born disease)
2. Spoilage of food, Food poisoning
3. Damage substratum

Beneficial (helpful) microorganisms

Microorganisms are used in the production of beneficial material such as antibiotics, dairy products (yoghurt), ethanol, vitamins, and proteins.

- Use in removal of undesirable products

History of Microbiology

A. Anton van Leeuwenhoek: was the first microbiologist and the first person to observe bacteria using a single-lens microscope of his own design.

B. Louis Pasteur (1822–1895): Pasteur developed a process (today known as pasteurization) to kill microbes. pasteurization is accomplished by heating liquids to 63 to 65 C for 30 minutes or to 73 to 75 C for 15 seconds.

C. Robert Koch (1843–1910): was a pioneer in medical microbiology and worked in cholera, anthrax and tuberculosis. He was awarded a Nobel prize in 1905 (Koch's postulates) he set out criteria to test.

D. Alexander Fleming (1929): Discovered penicillin.

E. Francesco Redi Italian physician, naturalist and biologist. "Father of Modern parasitology".

- Microbiology has many applied area:-

1. **Bacteriology-** The study of bacteria.
2. **Virology:** The study of viruses.
3. **Mycology:** The study of fungi.
4. **Parasitology:** The study of parasites.
5. **Immunology:** The study of the immune system.
6. **Environmental Microbiology:** The study of microorganisms in the environment.
7. **Industrial Microbiology:** The use of microorganisms in industrial processes.
8. **Medical Microbiology:** The study of microorganisms that cause diseases in humans.
9. **Food Microbiology:** The study of microorganisms in food.
10. **Agricultural Microbiology:** The study of microorganisms in agriculture.
11. **Microbial Genetics:** The study of the genetics of microorganisms.
12. **Pharmaceutical Microbiology:** The study of microorganisms in the development of pharmaceuticals.

The study of microbiology includes:-

1. The distribution of microorganism in nature.
2. The relationship to each other and other living organisms.
3. The effect of microorganisms on animal, plant, and human being.
4. The ability of microorganism to make physical and chemical effects in their environment.
5. The reaction of microorganism to chemical and physical agents.

Scope and Importance of Microbiology in Nursing

- **Understanding Disease Causation**

  Nurses learn how microorganisms cause diseases

- **Infection Prevention and Control**

  Knowledge of microbiology equips nurses to follow proper aseptic techniques and prevent hospital-acquired infections (HAIs).

- **Proper Specimen Collection**

  Nurses must understand how to collect, handle, and transport clinical specimens to avoid contamination and ensure accurate lab results.

- **Guiding Antibiotic Use**

  Nurses support antibiotic stewardship by understanding microbial resistance and ensuring proper medication administration.

- **Effective Sterilization and Disinfection**

  Helps in maintaining sterile environments, cleaning equipment, and preventing cross-contamination.

- **Understanding Body's Immune Response**

  Nurses use this knowledge to monitor patients' immune status, especially in immunocompromised or vaccinated individuals.

- **Patient Education**

  Nurses educate patients about infectious diseases, hygiene, vaccination, and preventive measures.

- **Assisting in Diagnostic Procedures**

  Nurses play a role in tests like Gram staining, culture sensitivity, and rapid diagnostic tests by knowing their purpose and interpretation basics.

- **Management of Isolation Techniques**

  Helps nurses implement standard and transmission-based precautions (airborne, droplet, contact).

Microbiota or Normal microflora:

Microbiota: refers to the community of microorganisms such as bacteria, viruses, fungi, and archaeathat live on and within the specific area of humans, animals body, as well as in various environments like soil, water, and air

- **Probiotics:** Live beneficial bacteria that are consumed through supplements or fermented foods, intended to enhance the microbiota's balance.

- **Prebiotics:** Non-digestible food components (like fiber) that stimulate the growth and activity of beneficial microorganisms in the gut

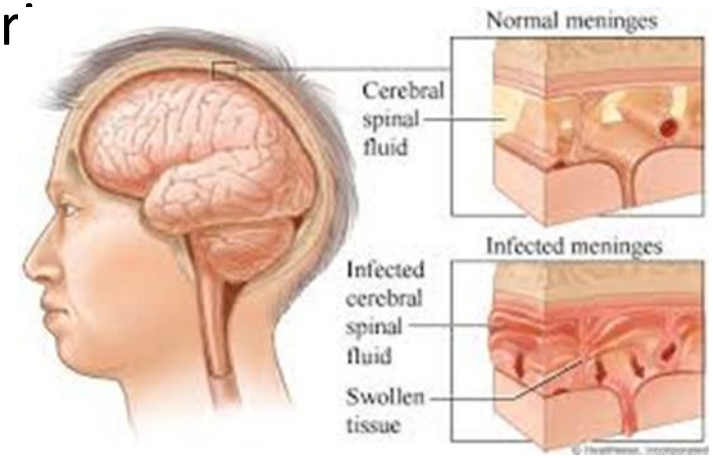
The normal microflora is present :

- skin, upper respiratory tract, oral cavity, intestine, especially large intestine, vaginal tract.
- Very little normal flora in eyes and stomach.

The normal microflora is absent in:

- Sterile tissue in a healthy human, the internal tissues such as blood, brain, muscle, cerebrospinal fluid, meninges and lower respiratory tract are normally free of microorganisms.

One fourth of fecal weight is made of bacter



The human microbiota consists of thousands of different species of
1-Bacteria- E.coli,
2- Viruses- Bacteriophage and some sp.of papilloma virus,
3-Fungi -Candida albicans,
4-Archaea- Methanosphaera stadtmanae).

Distribution in the Body

- **Gut Microbiota:** The gut contains about 100 trillion bacteria, which is the largest concentration of microbes in the body.

- **Skin Microbiota:** about 1 million bacteria per square centimeter of skin. The total number of microbes on the skin is estimated to be around 1 trillion.

- **Oral Microbiota:** billions of bacteria residing on the teeth, gums, and tongue. There are around 700 different species in the oral cavity.

- **Respiratory and Urogenital Tract:** These areas also contain significant microbial populations, although the numbers are lower compared to the gut and skin.

Beneficial effects of (microbiota) normal flora:

1- Competing with invaders for space and nutrients.
2- Producing compounds (bacteriocins) which kill other bacteria.
3- lowering the pH, so that other bacteria can not grow.
4-In addition; normal flora help us in other ways eg
Producing vitamins we are not able to produce such as vitamin **k** produced by *E. coli*
5-Help digest food
6-Help the development of the immune system.

Note: Antibiotic treatment of bacterial infection also killed beneficial bacteria.

Infection

- **Infection:** the invasion and multiplication of microorganisms such as bacteria, viruses and parasites, that are not normally present within the body. An infection may cause no symptoms and it may be cause symptoms.

- Infection is caused by microorganism.
- The microorganisms may be a bacteria, a virus, a parasite or a fungus.
- Microorganisms that live naturally in the body are not considered infection.
- - difference between sign and symptoms:

Stages of Infection

Incubation period

organisms growing and multiplying

Prodromal stage

person is most infectious, vague and nonspecific signs of disease

Full stage of illness

presence of specific signs and symptoms of disease

Convalescent period

recovery from the infection

Infection and Disease
Chain of Infection

- **Infectious agent** – the microorganism (bacteria, virus, fungus, parasite)
- **Reservoir** – where the organism lives (e.g., humans, animals, water)
- **Portal of exit** – how the pathogen leaves the reservoir (e.g., coughing, wounds)
- **Mode of transmission** – how it spreads (e.g., direct contact, droplets, contaminated instruments)
- **Portal of entry** – how it enters a new host (e.g., broken skin, mucous membranes)
- **Susceptible host** – someone at risk of infection (e.g., elderly, immunocompromised, infants)

. Types of Infections

a. Local Infection

•Infection is limited to a small area (e.g., skin boil or abscess).

•Symptoms: redness, swelling, heat, pain.

b. Systemic Infection

•The infection spreads throughout the body, often via the bloodstream.

•Examples: sepsis, bacteremia.

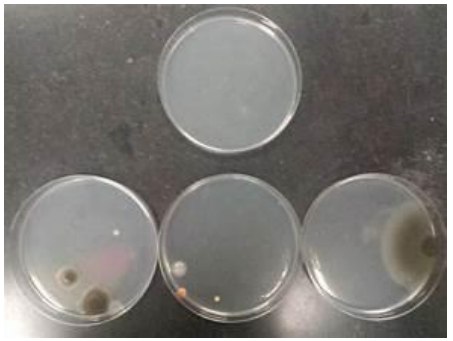
•Symptoms: fever, chills, fatigue, low blood pressure.

c. Nosocomial (Hospital-Acquired) Infection

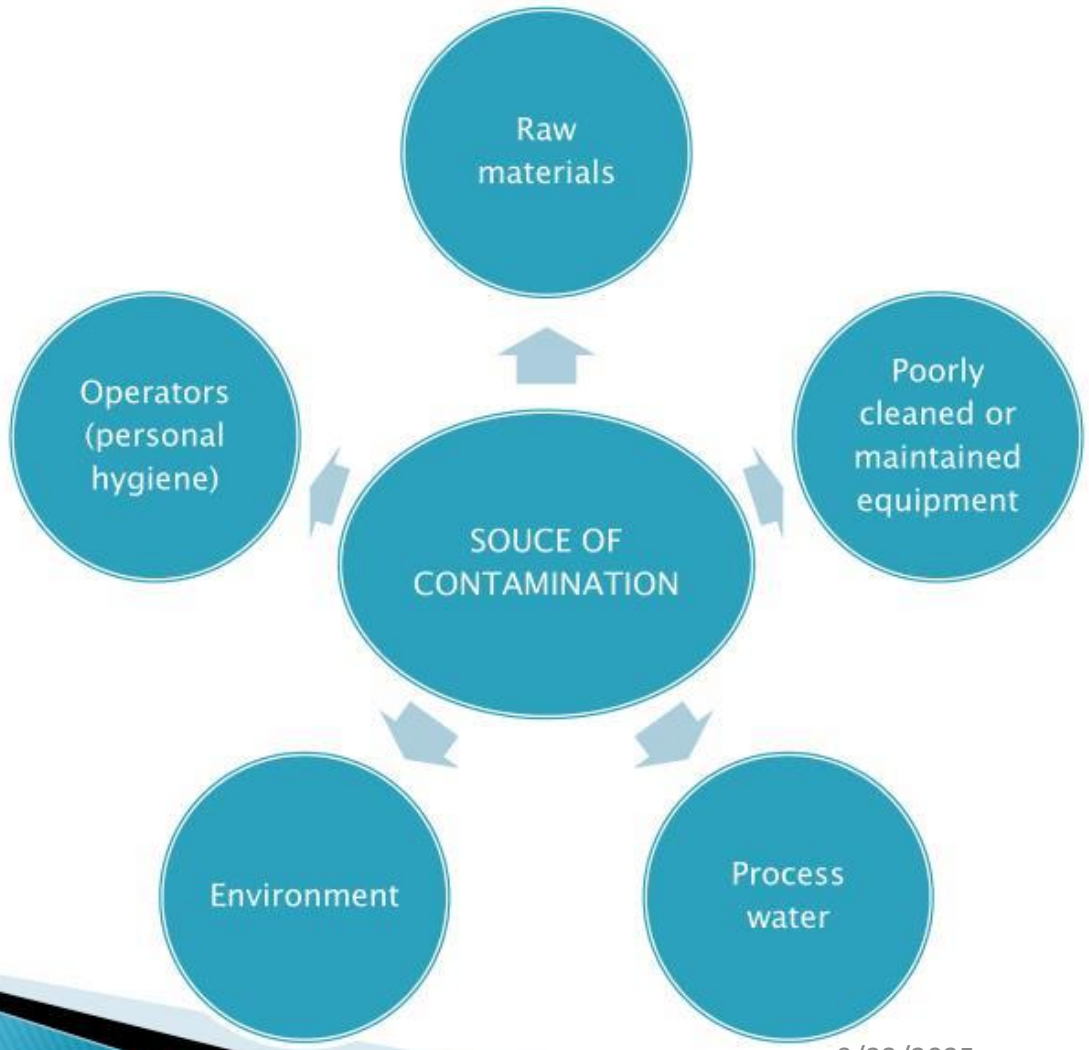
Acquired in a healthcare setting after admissionCommon types: UTI (catheter), surgical site infections, pneumonia (ventilator-associated)Often caused by resistant organisms like MRSA or Klebsiella

Contamination

- Presence of an organism in a culture that was not in the sample when taken.
- E.g. a culture of blood contaminated with an organism from the skin.
- Sample contaminated in the lab.



SOURCE OF CONTAMINATIONS



Relationship among microorganisms

There are many different types of relationship that the body can have with the microorganisms:

1- **Mutualism:** A symbiotic relationship in which both species benefits.
2- **Commensalism:** A symbiotic relationship in which one species benefits and the other species is neither helped nor harmed.
3- **Parasitism:** A symbiotic relationship in which one species benefits and the other species is harmed.

Does fetus is considered a parasite?

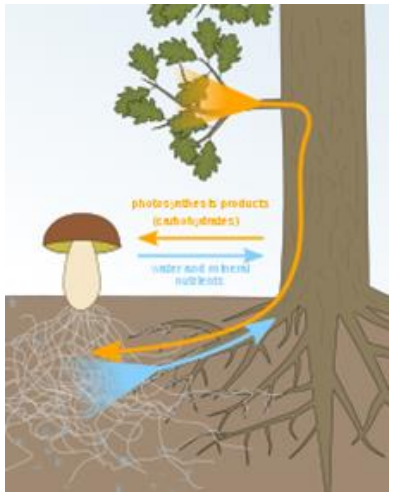
Example of microbial community

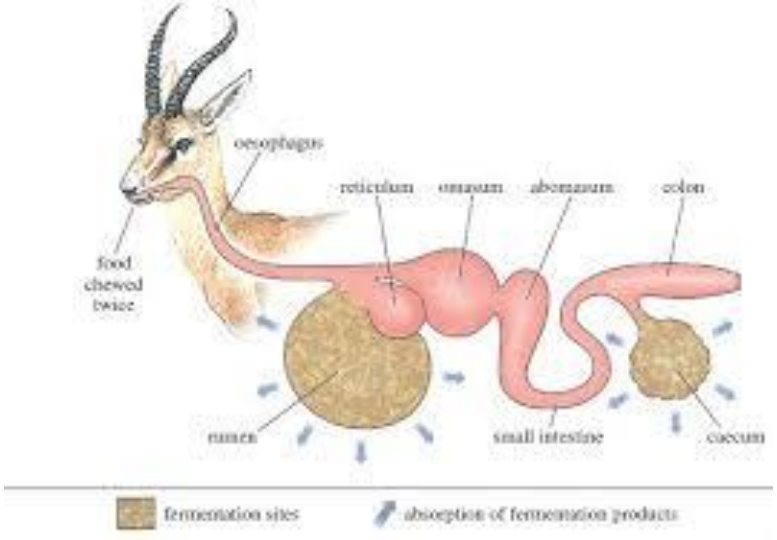
Mycorrhiza- Fungal symbiotic association with plants which helps plants to absorb phosphorus from soil.

-microorganism – termite relationship – the protozoa breakdown cellulose and release acetate which can be absorbed and used by the termite •

-The rumen of ruminants are filled with microorganisms and they help breakdown the plant material the animals eat

Examples of commensalism are where the waste products of one organism is utilized by another.


photosynthesis products
(carbohydrates)
water and mineral
nutrients


oesophagus
reticulum
omasum
abomasum
colon
food
chewed
twice
rumen
small intestine
caecum
fermentation sites
absorption of fermentation products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Classification of Organisms

What is the meaning of classification and Why do Scientists classify?

Classification is the process of grouping things based on their similarities.
Biologists use classification to organize living things into groups so that the organisms are easier to study.

The Scientific study of how living things are classified is called Taxonomy.

Scientists use a classification system to **study**, **compare** and **identify living things**.

information

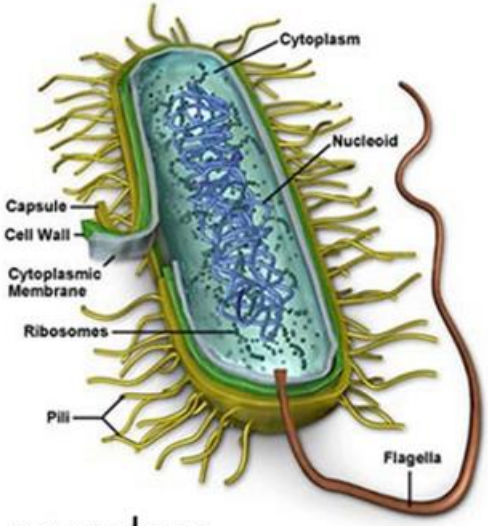
Domain	Bacteria
Phylum	Proteobacteria
Class	Gammaproteobacteria
Order	Enterobacterales
Family	Enterobacteriaceae
Genus	*Escherichia*
Species	*E. coli*

Level of Classification

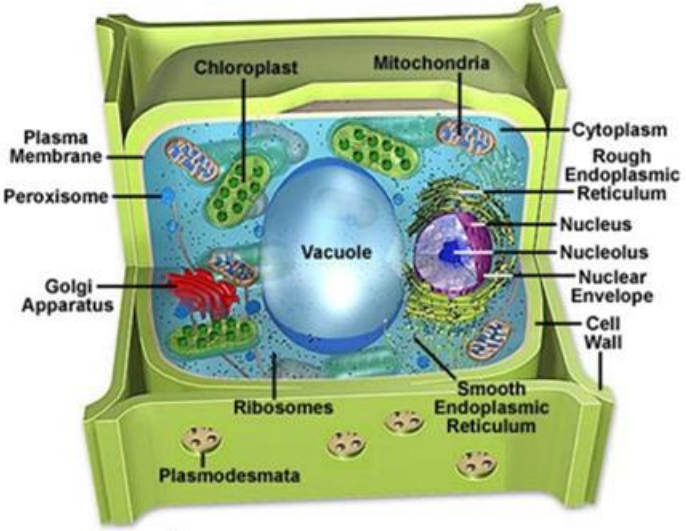
- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

Animalia
Chordata
Mammalia
Primates
Hominidae
Homo
Homo sapiens

Prokaryotic vs. Eukaryotic



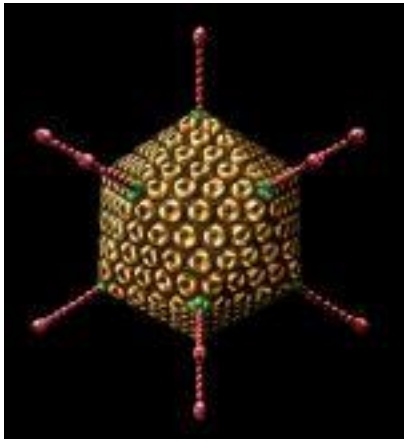
- no nucleus
- no membrane enclosed organelles
- single chromosome
- no streaming in the cytoplasm
- cell division without mitosis
- simple flagella
- smaller ribosomes
- simple cytoskeleton
- no cellulose in cell walls
- no histone proteins



- nucleus
- membrane enclosed organelle
- chromosomes in pairs
- streaming in the cytoplasm
- cell division by mitosis
- complex flagella
- larger ribosomes
- complex cytoskeleton
- cellulose in cell walls
- DNA bound to histone proteins

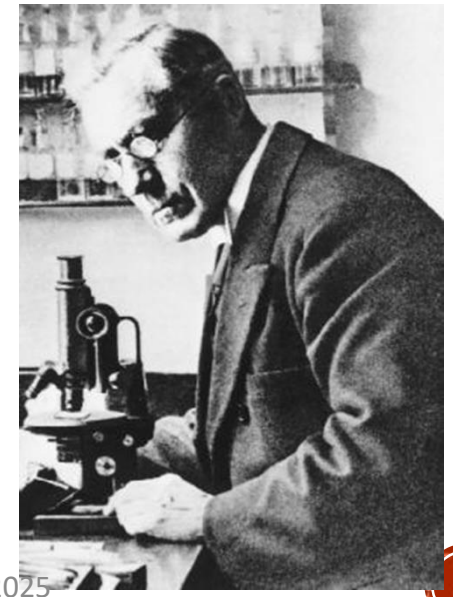
MEMBER OF MICROORGANISMS-
A-VIRUS

- A virus is a non-cellular particle made up of genetic material and protein that can invade living cells.



•Beijerinck (1897) coined the Latin name “virus” meaning poison

•He studied filtered plant juices & found they caused healthy plants to become sick



CHARACTERISTICS

1. Small size:

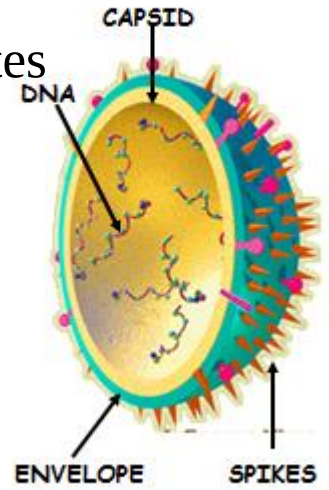
- The smallest infectious agents (20-300 nm in diameter)
- Bacteria (300-1000nm); RBC (7500nm)

2. Genome:

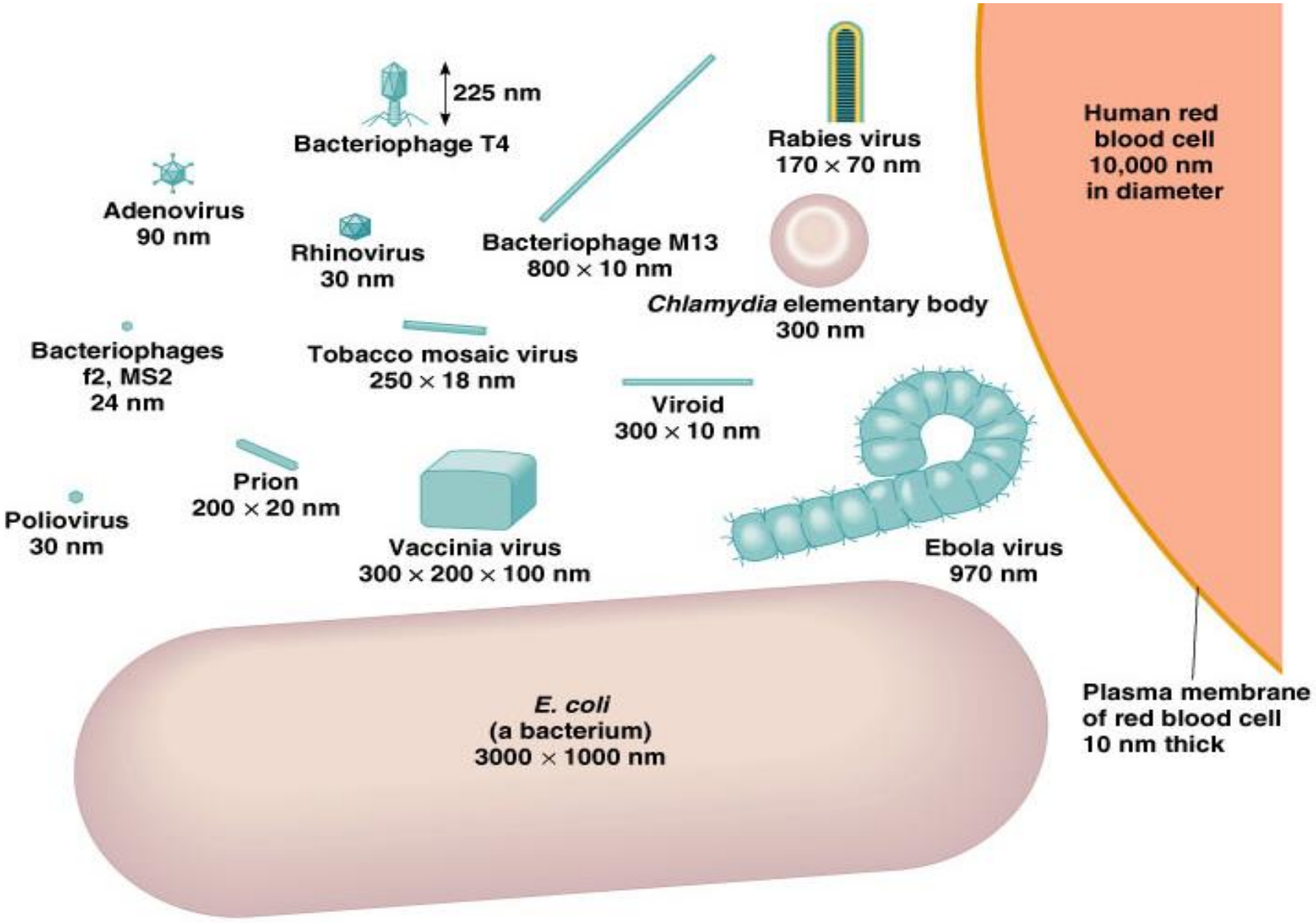
- Either DNA or RNA

3. Metabolically inert:

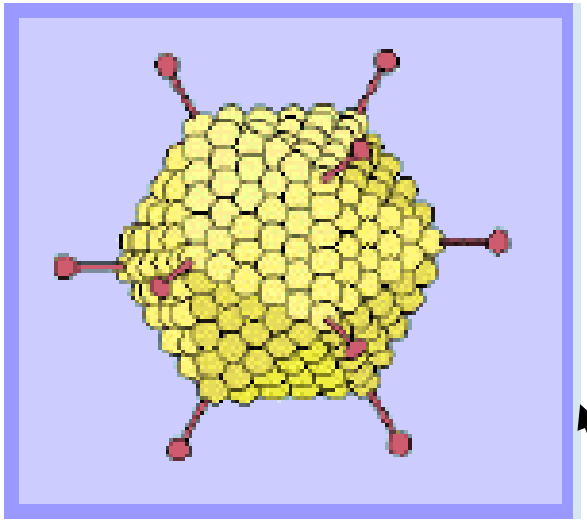
- Do not posses active protein synthesizing apparatus
- Do not have a nucleus, cytoplasm, mitochondria or ribosomes
- No metabolic activity outside host: obligate intracellular parasites
- Can replicate only inside living cells; NOT on inanimate media

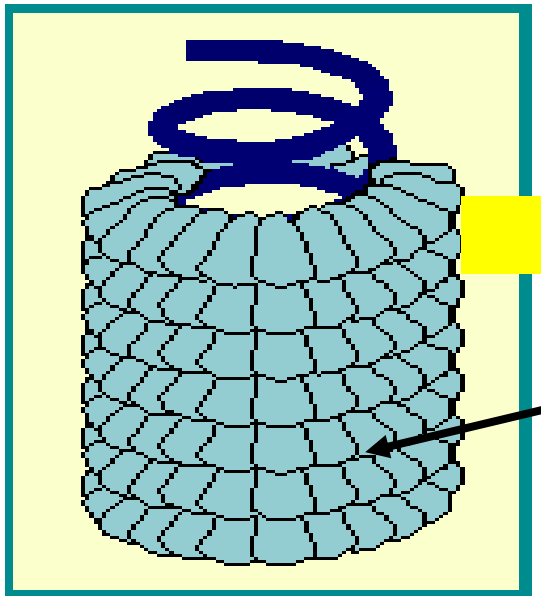


SIZE OF VIRUSES



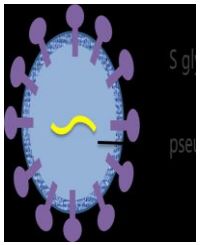
- **Capsid:** protein coat surrounding the genome
  - Provides structural symmetry
  - Participates in attachment to susceptible host
  - Facilitates transfer of viral nucleic acid in to host cell
  - Protects the viral genome from nucleases in blood stream
- **Capsomeres:** the structural units making up capsid: consist of one or several proteins





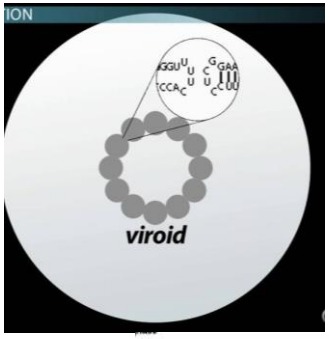
Pseudovirions

- Contain host cell DNA instead of viral DNA within the capsid
- Can infect cells but do not replicate.



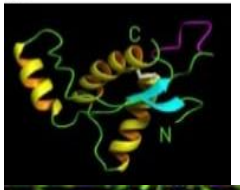
Viroids

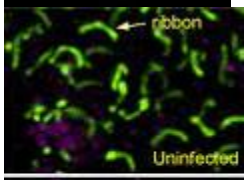
- Are infectious agents that consist only of naked RNA without any protective layer such as a protein coat.
- Cause several plant diseases but are not implicated in human diseases (Potato spindle tuber viroid)

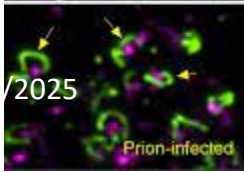


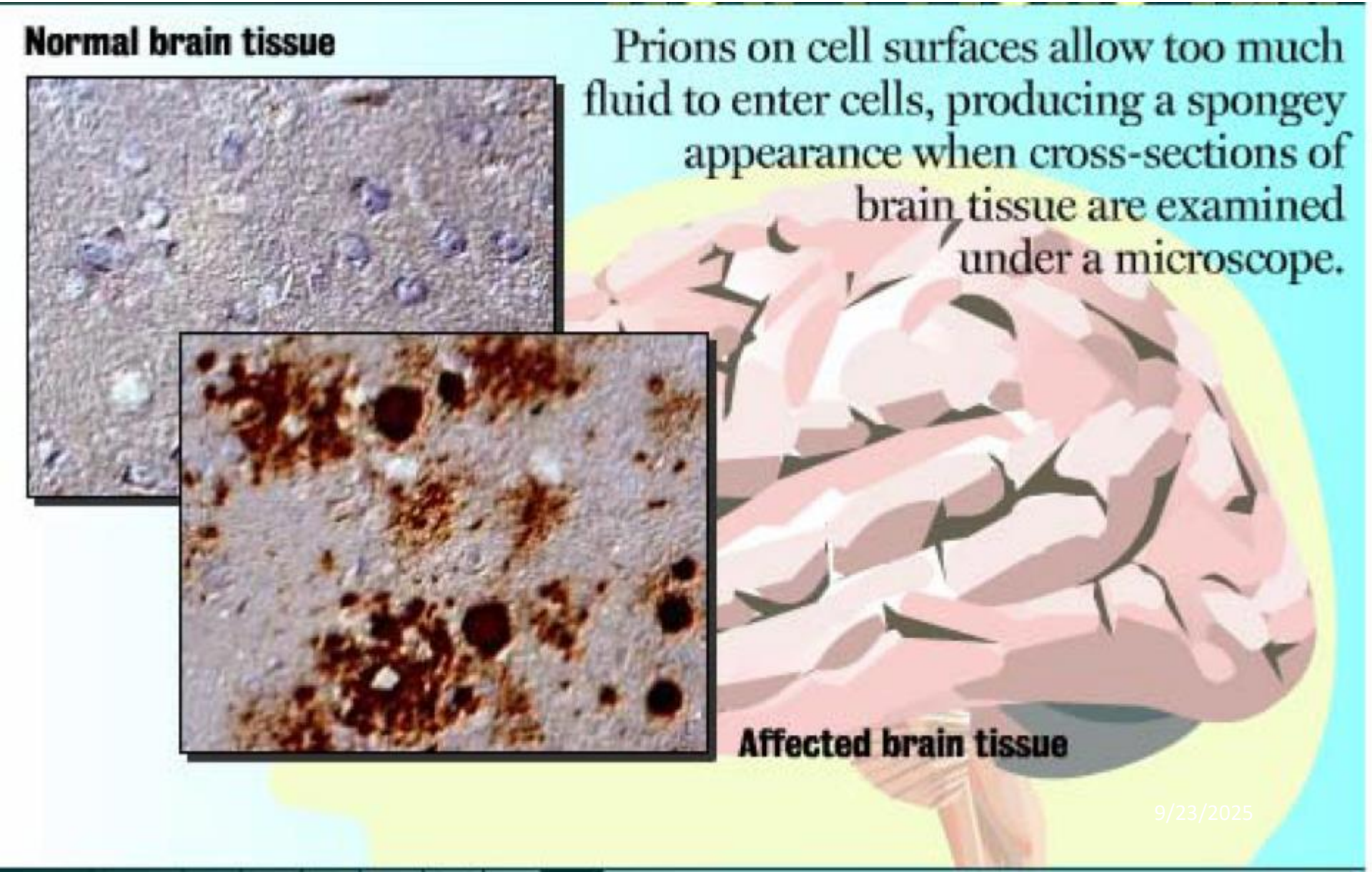
Prions

- A prion is a type of protein that can trigger normal proteins in the brain to fold abnormally. Prion diseases can affect both humans and animals and are sometimes spread to humans by infected meat products.
- The most common form of prion disease that affects humans is Creutzfeldt-Jakob disease (CJD).

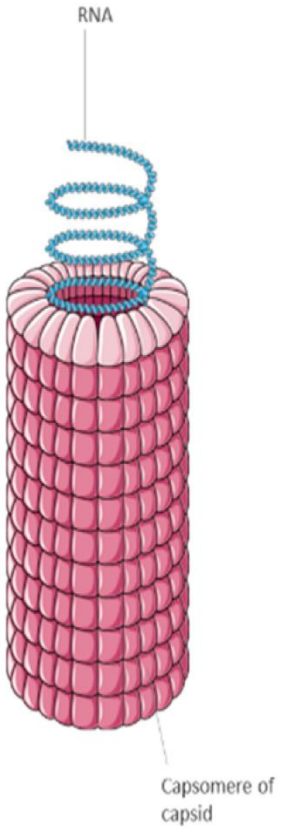






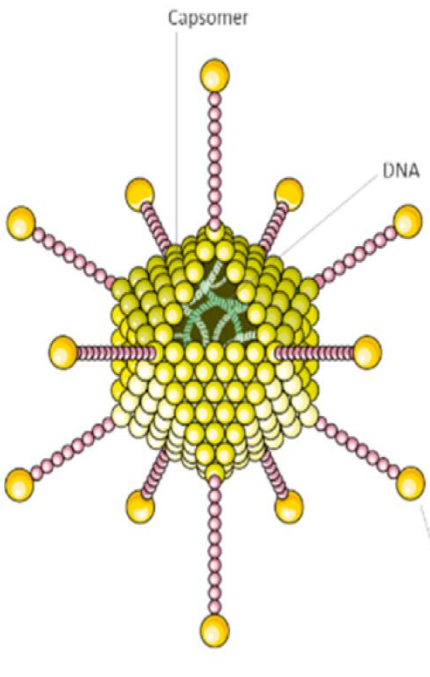

Normal brain tissue
Prions on cell surfaces allow too much fluid to enter cells, producing a spongey appearance when cross-sections of brain tissue are examined under a microscope.
Affected brain tissue

Viral shapes



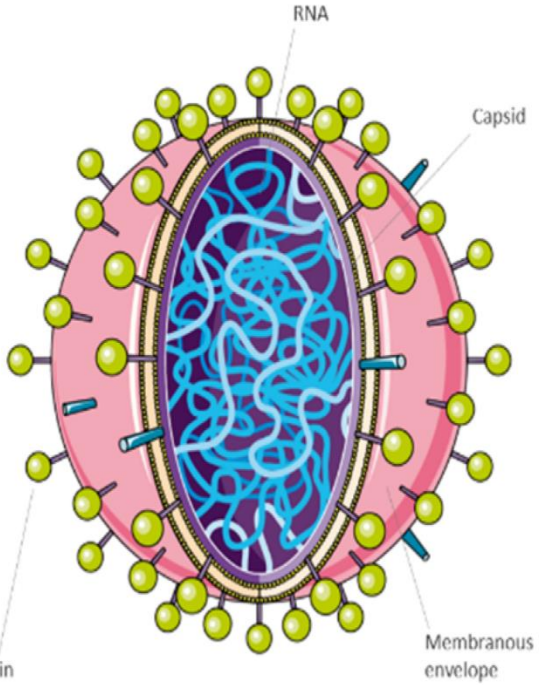
HELICAL

Tobacco Mosaic Virus



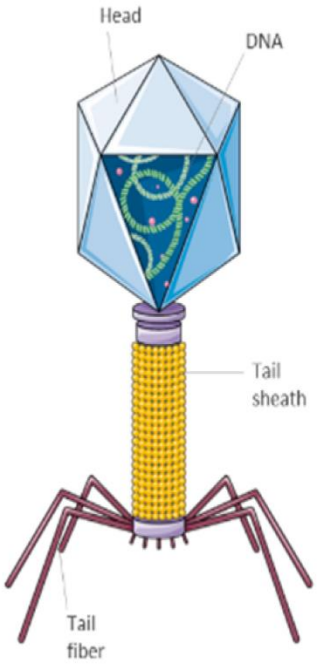
POLYHEDRAL

Adenovirus



SPHERICAL

Influenza Virus



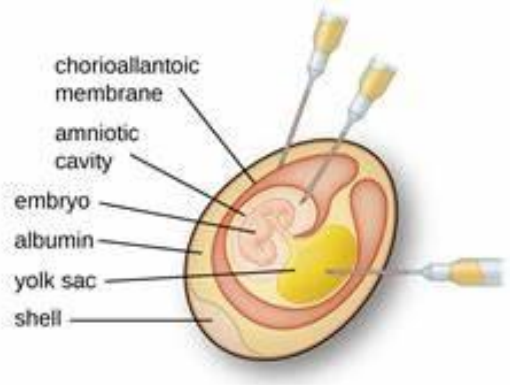
COMPLEX

Bacteriophage

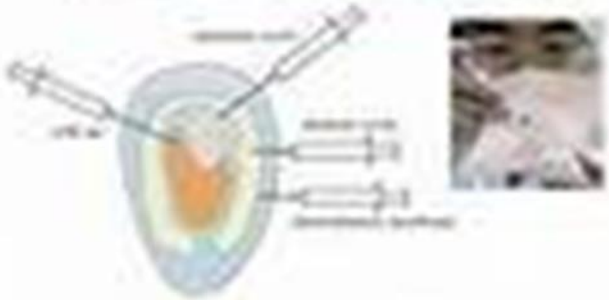
Cultivation of viruses:

need living cells, living hosts, Tissue cultures, embryonated eggs,

(a)



(b)

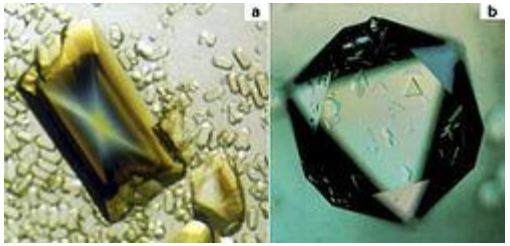


Q/ Are there non-parasitic viruses?

A/All viruses are obligate intracellular parasites, meaning that they depend on a host cell to complete their life cycle. A virus does not have its own metabolism.

Q/ What is the crystallization of a virus? What is the importance of this process?

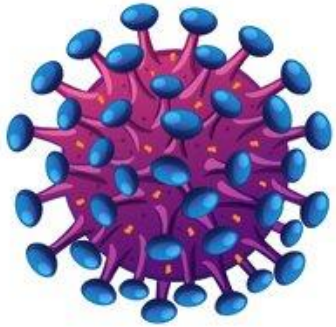
A/ Crystallization is the process of the transformation of viral components into organized solid particles.
The crystallization of biological macromolecules, including viral components, is used to study structural characteristics, through X-rays or laser beams.



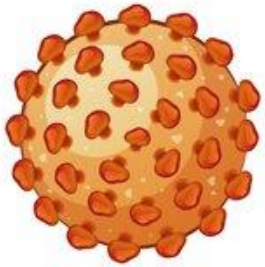
Q/What are the main human diseases caused by viruses?

A/ Among diseases caused by viruses are the common cold, the flu, mumps, smallpox (considered eradicated nowadays), rubella, measles, AIDS, viral hepatitis, papillomatosis (HPV infection), rabies, dengue fever, yellow fever, poliomyelitis (a disease almost eradicated in developed countries), hemorrhagic fever from the Ebola virus and SARS (severe acute respiratory syndrome), COVID-19

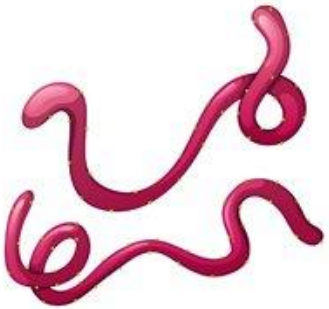
Viruses also cause many other diseases in animals and plants.



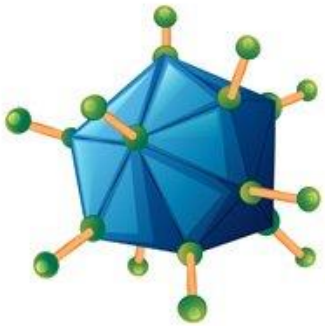
HIV



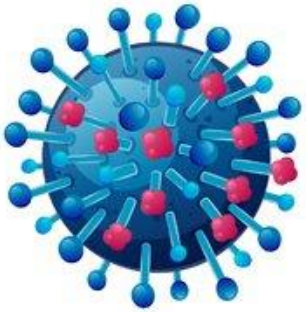
Hepatitis B



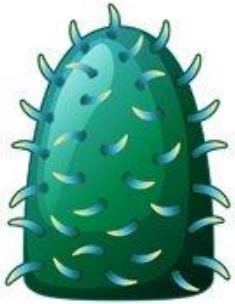
Ebola Virus



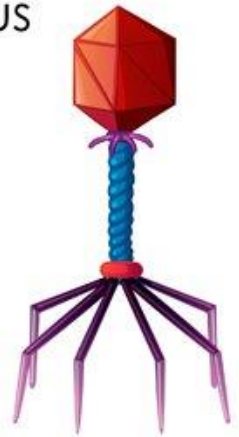
Adenovirus



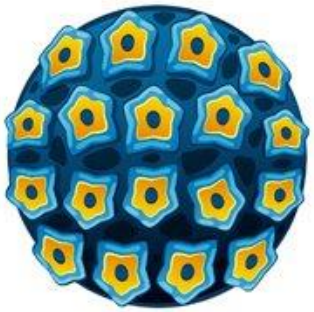
Influenza



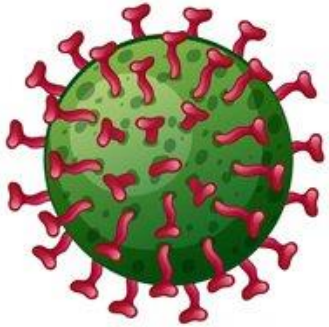
Rabies Virus



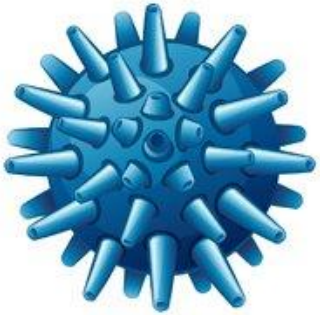
Bacteriophage



Papillomavirus

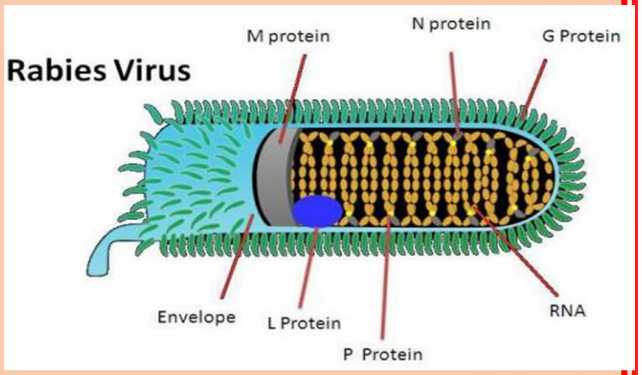


Rotavirus



Herpes Virus

RABIES



Etiology

- Rabies is a deadly, zoonotic, neurologic disease.
- Bullet-shaped, enveloped RNA virus that belongs to the Rhabdoviridae family
- Readily inactivated by a variety of disinfectants, soaps, ultraviolet light, and heat.
- **Presence of virus in the saliva indicates that the CNS has been infected.**
- Dogs most often contract rabies through the bite of another infected animal, which introduces saliva containing the virus into flesh and nerves

Host affected

- All warm-blooded animals
- Highly susceptible hosts include wolves, foxes, coyotes, jackals, dogs, cattle, raccoons, skunks, bats, and mongooses.
- Moderately susceptible hosts include cats, ferrets, primates, sheep, goats, and horses.

Mode of transmission

- Biting, with inoculation of saliva containing the virus
- Large majority of the cases occur after a dog bite
- Other routes of transmission ***corneal or solid-organ transplantation*** in human patients
- Aerosol transmission, such as that occurring within caves containing large numbers of bats
- Ingestion of infected tissues or milk
- Dogs, wild carnivores, and bats are considered the main natural reservoirs of rabies virus.

Signs and symptoms may include

- Fever
- Headache
- Nausea
- Vomiting
- Agitation
- Anxiety
- Confusion
- Hyperactivity
- Difficulty swallowing
- Excessive salivation
- Fear brought on by attempts to drink fluids because of difficulty swallowing water
- Fear brought on by air blown on the face
- Hallucinations
- Insomnia
- Partial paralysis

DIAGNOSIS

-According to historical data and clinical manifestations

-Immunofluorescence microscopy on fresh brain tissue (medulla oblongata and cerebellum), facilitating direct visual observation of a specific antigen-antibody interaction, is the preferred diagnostic method.

-Molecular diagnostics, encompassing real-time polymerase chain reaction (PCR)

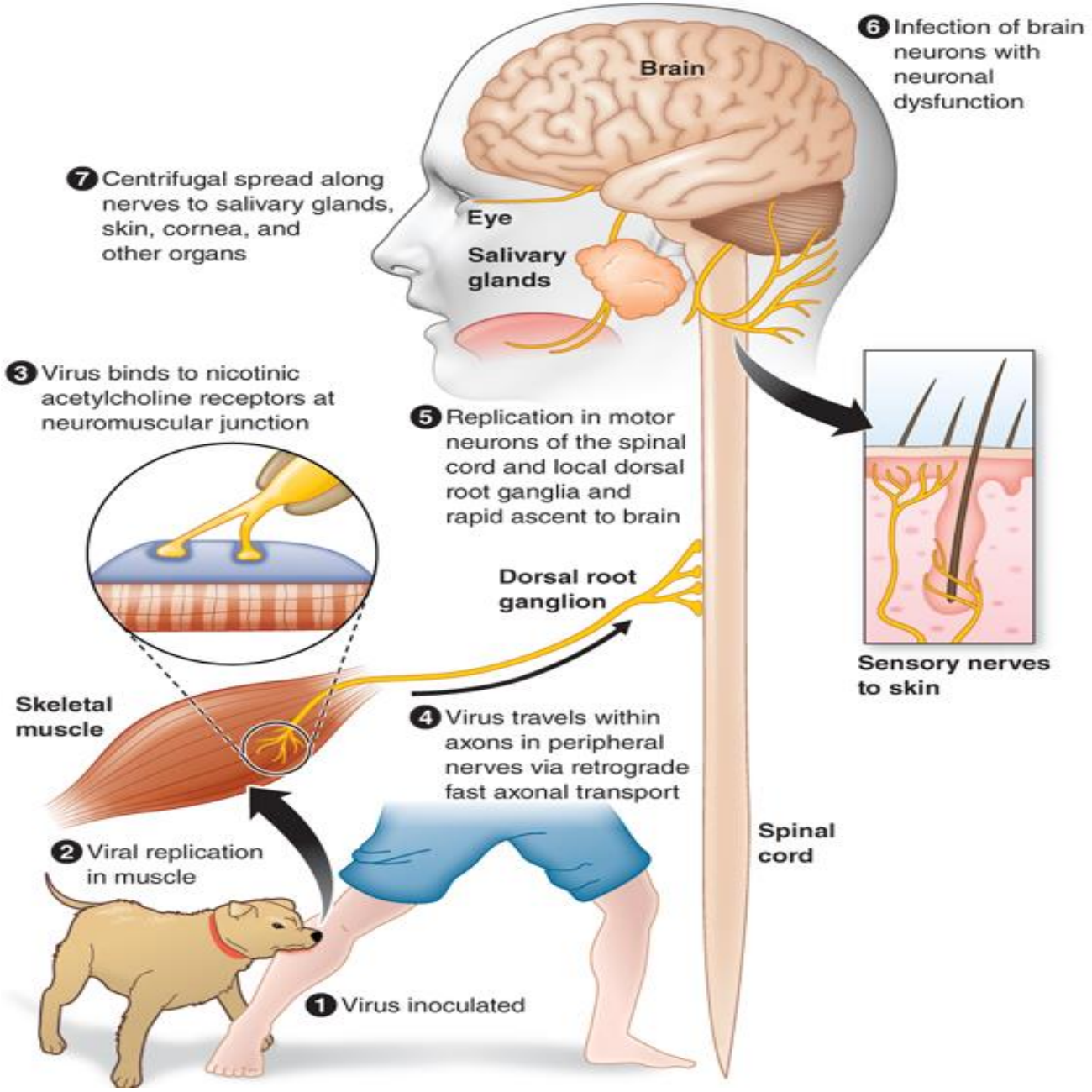
-The WHO advocates for techniques to detect rabies virus antigens, amplicons, and antibodies.

Treatment

- Management of wound
- Cauterization or application of oil, turmeric etc on should be avoided
- Not stitched the wound at least within 24-48 hr of injury
- Tetanus toxoid and Antibiotics for wound healing.

Prevention and Control

- All dogs and cats should be vaccinated for rabies at 3 or 4 months of age (depending on state legislation), with a booster dose 1 year later, then every 3 years with approved inactivated vaccines, or annually with recombinant vaccines
- Dogs and cats less than 1 year of age are not considered immunized until 28 days after the initial vaccination
- Oral vaccinia-vectored recombinant rabies vaccines, used in wild animals such as raccoons, coyotes, and gray foxes


6 Infection of brain neurons with neuronal dysfunction
Brain
7 Centrifugal spread along nerves to salivary glands, skin, cornea, and other organs
Eye
Salivary glands
3 Virus binds to nicotinic acetylcholine receptors at neuromuscular junction
5 Replication in motor neurons of the spinal cord and local dorsal root ganglia and rapid ascent to brain
Dorsal root ganglion
Sensory nerves to skin
Skeletal muscle
4 Virus travels within axons in peripheral nerves via retrograde fast axonal transport
Spinal cord
2 Viral replication in muscle
1 Virus inoculated

Hydrophobia – A symptom of rabies where the patient develops a fear of drinking water due to painful muscle spasms in the throat.

Post-exposure prophylaxis (PEP) – A treatment given after possible rabies exposure, including wound cleaning, vaccination, and sometimes rabies immunoglobulin.

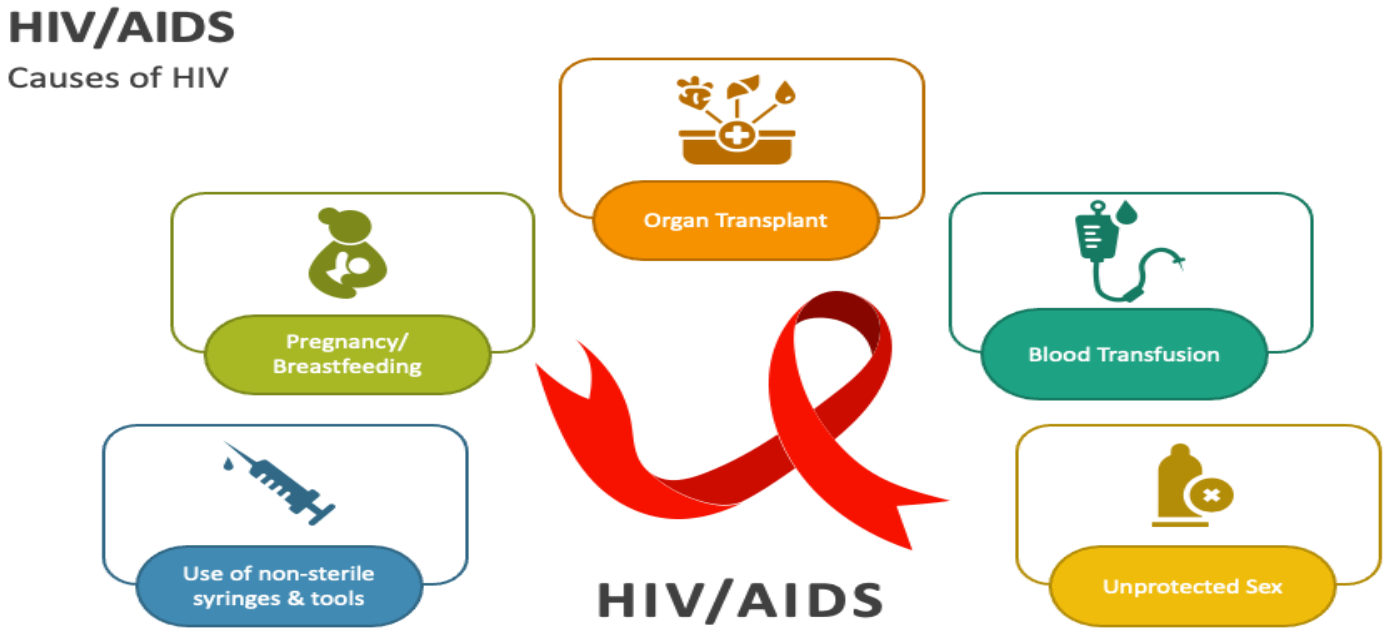
Incubation period – The time between exposure to the rabies virus and the appearance of symptoms.

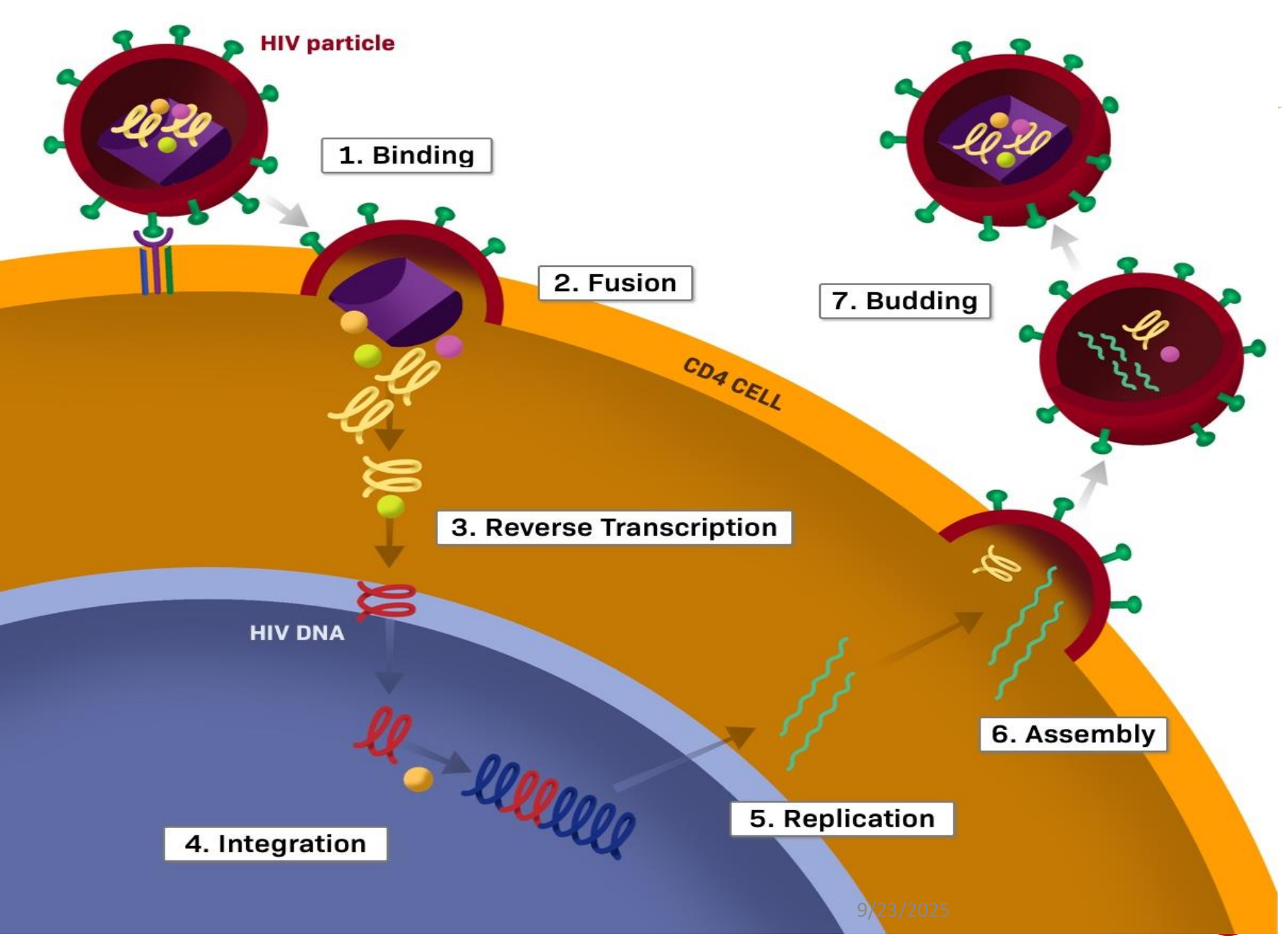
Rabies vaccine – An injection that stimulates the immune system to protect against rabies infection, used for both pre- and post-exposure prevention.

AIDS

AIDS is the late stage of HIV infection that occurs when the body's immune system is badly damaged because of the virus.

A virus spread through body fluids and affects specific cells of the immune system, called CD4 cells or T cells.

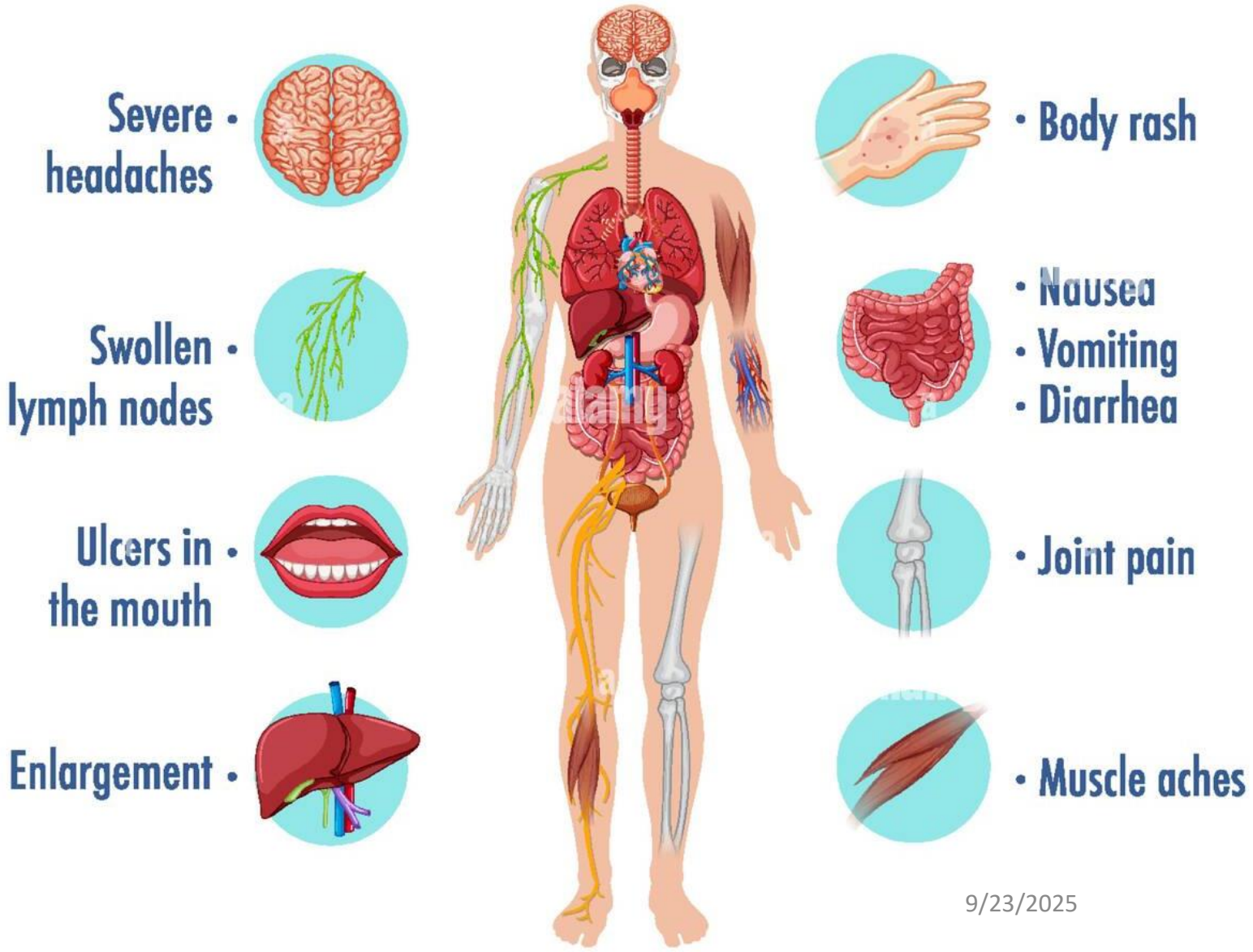



HIV particle
1. Binding
2. Fusion
CD4 CELL
3. Reverse Transcription
HIV DNA
4. Integration
5. Replication
6. Assembly
7. Budding

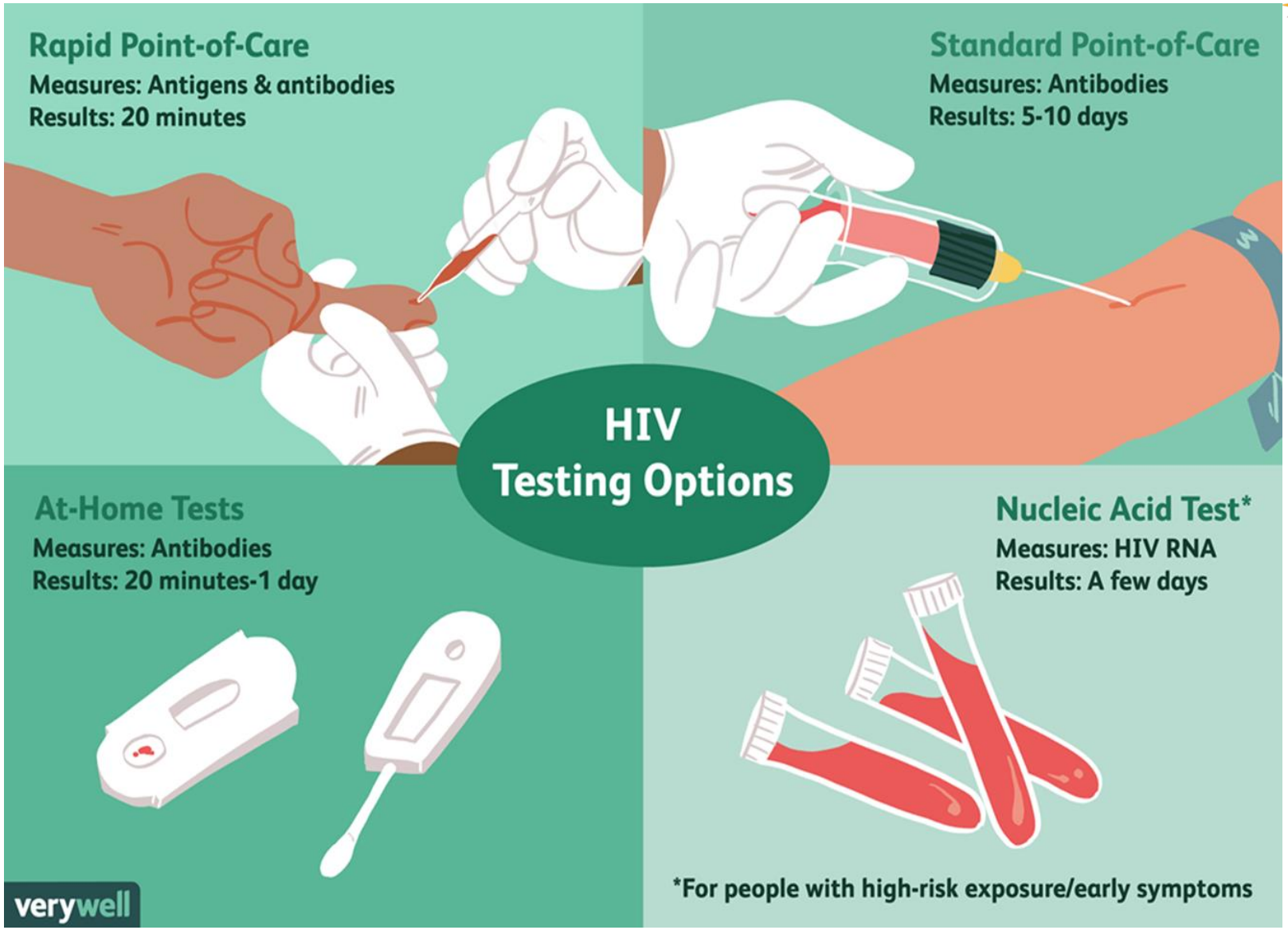
INFORMATION

•**Step 1: Attachment** occurs when the GP120 protein projections make contact and bind with a CD4 receptor. In addition, there is also binding with certain co-receptors called **CCR5 or CXCR4** to gain entry into the cell.
•**Step 2: Fusion** occurs when the virus becomes united with the cell and dumps its content into the cell, which is genetic material (RNA) and enzymes (unpacks it "suitcase").
•**Step 3: Reverse transcription –** Now it's time to set up shop with the goal of getting into the cell's nucleus and becoming integrated with the cell! Therefore, the single strand of viral RNA needs to turn into viral DNA. The HIV virus brought along with it an enzyme called **reverse transcriptase**. This enzyme causes the viral RNA to turn into double stranded DNA. This viral DNA moves into the nucleus of the cell.
•**Step 4: Integrate –** Once inside the nucleus it needs to hijack the cell's DNA (hence become part of it so it can take control, produce more HIV virus, and kill the cell). To do this, the HIV DNA strand releases another enzyme called integrase, which allows it to become part of the cell's DNA. So, it's now integrated into the cell's DNA.
•**Step 5: Replicate –** Now that the HIV's DNA is in control, it starts to use the parts of the hijacked cell to make long chains of the virus.
•**Step 6: Assembly –** These long chains and other viral material are being assembled and start to move toward the cell's surface.
•**Step 7: Budding –** The assembled parts start to grow (hence bud) off the cell wall.
•**Step 8: Maturity –** Once it has completely grown off the cell's surface, it pops off. Then protease (an enzyme that cuts the long chain of virus prepping it for maturity) completes its job of maturing the viral material, and a new mature virus is born. The cell that the HIV virus hijacked dies, and this new mature HIV virus has a mission of finding another cell victim with a CD4 receptor. It then starts the whole process again.

SYMPTOMS OF HIV INFECTION



Diagnosis


Rapid Point-of-Care
Measures: Antigens & antibodies
Results: 20 minutes
Standard Point-of-Care
Measures: Antibodies
Results: 5-10 days
HIV
Testing Options
At-Home Tests
Measures: Antibodies
Results: 20 minutes-1 day
Nucleic Acid Test*
Measures: HIV RNA
Results: A few days
*For people with high-risk exposure/early symptoms
verywell

Transmission of HIV

HIV is not transmitted by

- Coughing, sneezing
- Insect bites
- Touching, hugging
- Water, food
- Kissing
- Public baths
- Handshakes
- Work or school contact
- Using telephones
- Sharing cups, glasses, plates, or other utensils

Question and answers

"I'm HIV-positive, now my life is OVER." – ✗ False.With current treatments (ART), people living with HIV can have long, healthy lives and prevent transmission.

"I CAN get HIV by being around people who are HIV-positive." – ✗ False. HIV is not spread through casual contact like hugging, sharing food, or being near someone.

"I would NOT be able to tell if my partner or I were HIV-positive." – ✓ True.HIV often shows no symptoms for years, so only testing can confirm infection.

"I CANNOT get HIV from mosquitos." – ✓ True.HIV cannot survive or replicate in insects; mosquitoes do not transmit HIV.

"I'm straight and don't inject drugs, so I CANNOT get HIV." – ✗ False.Anyone can get HIV through unprotected sex, regardless of sexual orientation, or other blood-to-blood contact.

"My partner and I are both HIV-positive, so there is NO NEED to use condoms." – ✗ False.Condoms can prevent transmission of other STIs and different HIV strains (including drug-resistant ones).

	Virus	Living Cell
Structure	RNA or DNA core (center), protein coat (capsid)	Cell membrane, cytoplasm, genetic material, organelles
Reproduction	Copies itself only inside host cell--REPLICATION	Asexual or Sexual
Genetic Material	DNA or RNA	DNA and RNA
Growth and Development	-	YES—Multicellular Organisms
Obtain and Use Energy	-	YES
Response to Environment	-	YES

Prokaryotic cell structure

- Prokaryotic cells are about 10 times smaller than eukaryotic cells.

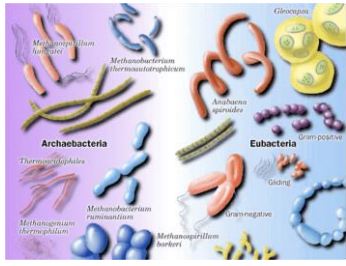
- Prokaryotes are very simple cells when compare with eukaryotic cells and yet they are able to perform the necessary processes of life.
- Reproduction of prokaryotic cells is by **binary fission** (the simple division of one cell into two cells, after DNA replication and the formation of separating membrane and cell wall)

- Prokaryotic cells: **bacteria** and **archae**

- Do **not have true nucleus** or other **membrane-bound organelles** (Mitochondria, Golgi apparatus …)

ARCHAEBACTERIA

- These can easily survive under very harsh conditions such as, The cell membranes of the Archaebacteria are composed of lipids.
- **Characteristics of Archaebacteria**
- **Cell Wall:** No peptidoglycan; composed of different polymers.
- **Membrane Lipids:** Ether-linked lipids instead of ester-linked.
- **Genetic Machinery:** More similar to eukaryotes than bacteria, e.g., RNA polymerase and ribosomes.



Types of Archaebacteria and Their Environments

- **Methanogens:** Produce methane; found in guts of animals and marshes.
- **Halophiles:** Thrive in high salt concentrations; found in salt mines and salt lakes.
- **Thermophiles:** Live in high-temperature environments; found in hot springs and hydrothermal vents.
- **Acidophiles:** Thrive in acidic conditions; found in acid mine drainage and acidic hot springs.

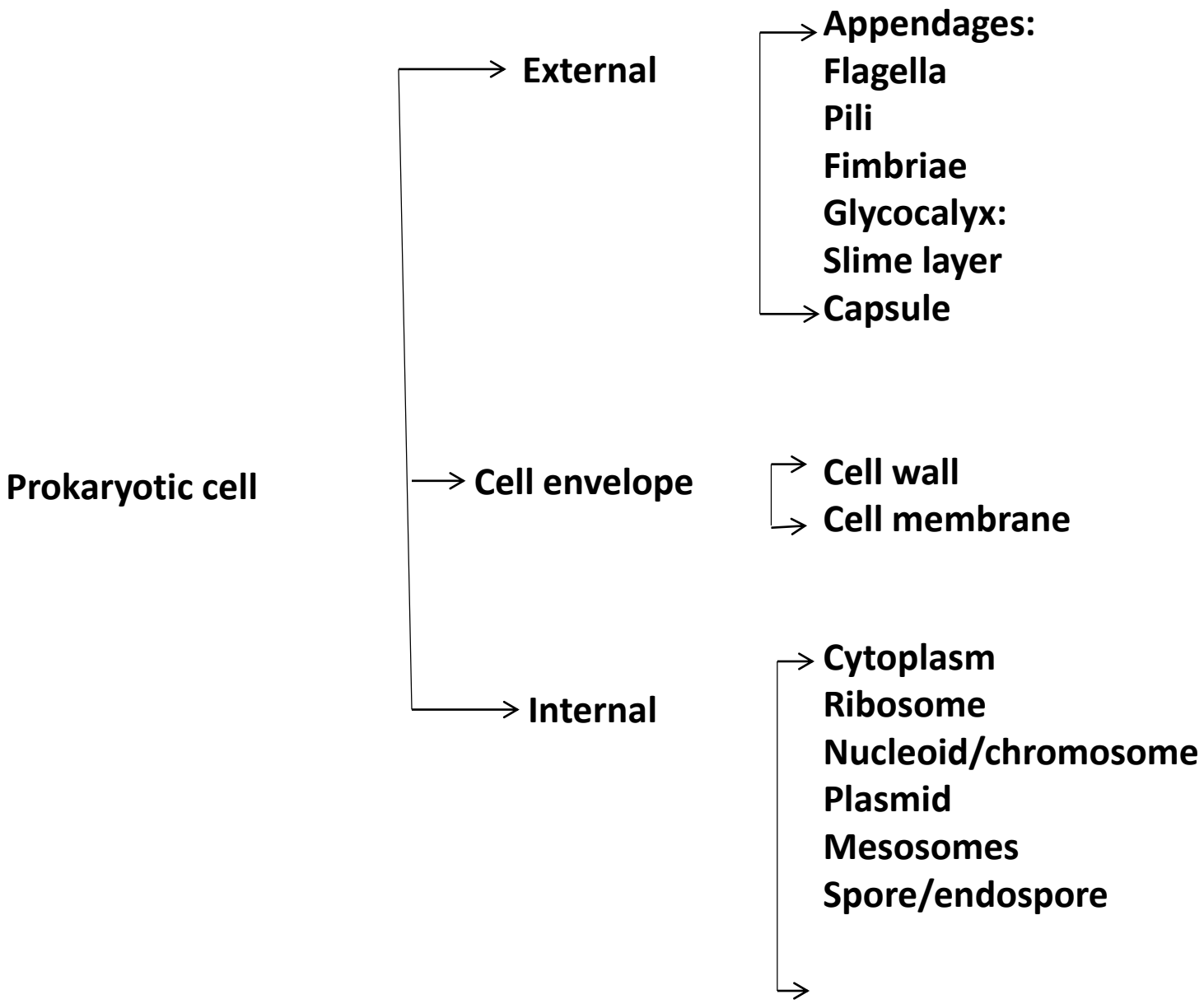
Bacteria

Important characteristics:

- Prokaryotic
- Unicellular
- Simple internal structure
- Grow on artificial laboratory media
- Reproduction by binary fission

Practical significance:

- Some cause diseases
- Some perform role in natural cycling of elements and increase soil fertility.
- Manufacture of valuable compounds in industry.


Prokaryotic cell
External
Appendages:
Flagella
Pili
Fimbriae
Glycocalyx:
Slime layer
Capsule
Cell envelope
Cell wall
Cell membrane
Internal
Cytoplasm
Ribosome
Nucleoid/chromosome
Plasmid
Mesosomes
Spore/endospore

Structures common to all bacterial cells

- Cell membrane
- Cytoplasm
- Ribosomes
- One (or a few) chromosomes

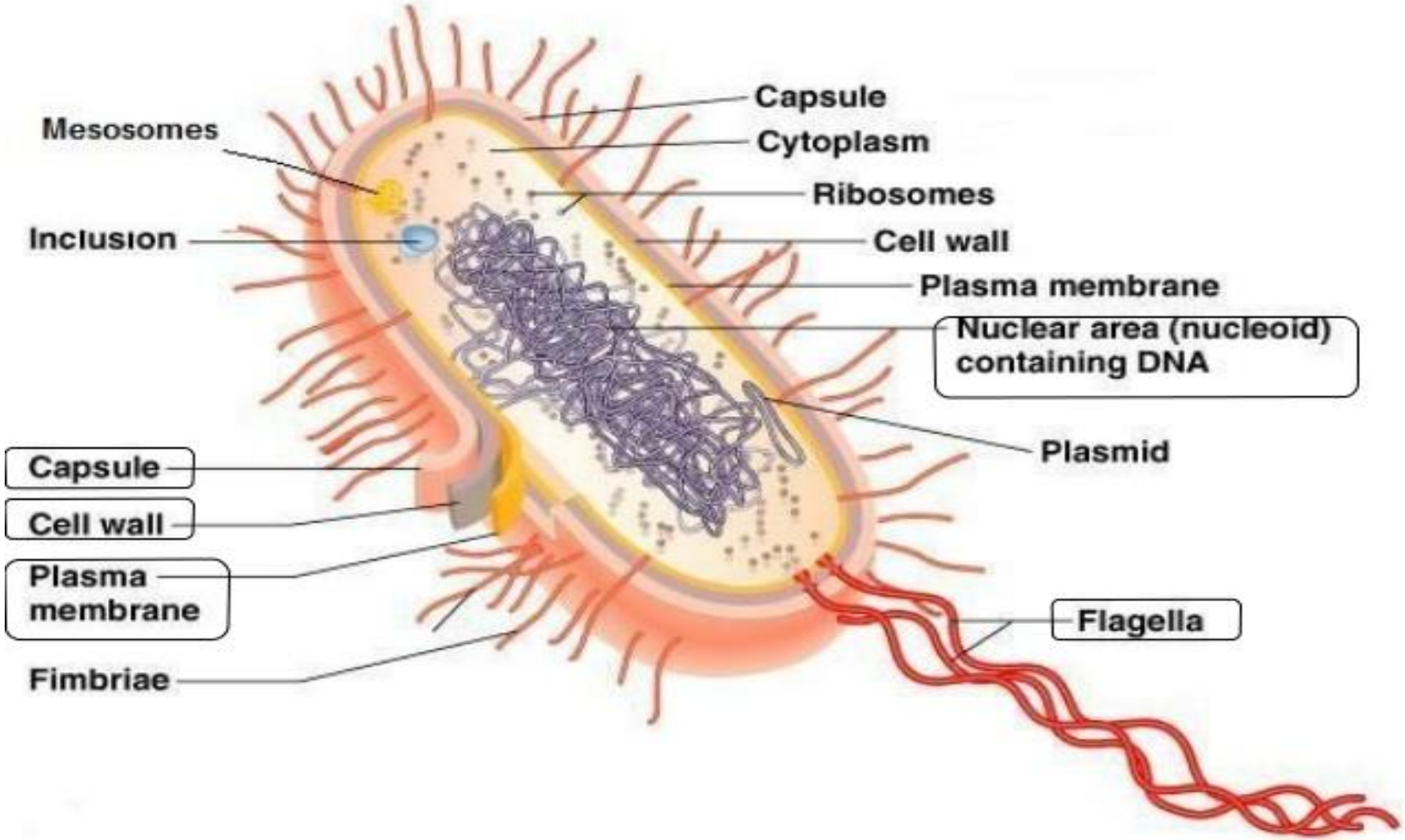
Structures found in most bacterial cells

- Cell wall
- Surface coating or glycocalyx

Structures found in some bacterial cells

- Flagella
- Pili
- Fimbriae
- Capsules
- Slime layers
- Inclusions
- Actin cytoskeleton
- Endospores

Prokaryotic cell structures



- **Bacteria…..**
- All the action takes place in the cytosol or cytoplasmic membrane

Bacteria also lacks true membrane bound nucleus and nucleolus.

The bacterial nucleus is known as nucleoid.

Most bacteria possess peptidoglycan, a unique polymer that makes its synthesis peptidoglycan is a good target for antibiotics.

Protein synthesis takes place in the cytosol with structurally different ribosome's

When bacteria coloured with gram stain they may be gram positive (purple coloure) or gram negative (pink colour)

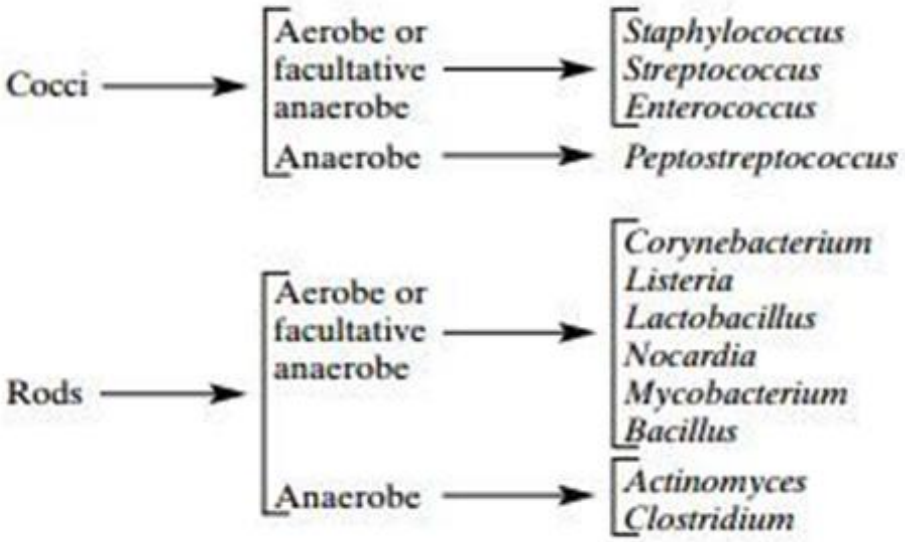
Gram Staining :

This differential staining procedure separates most bacteria into two groups on the basis of cell wall composition:

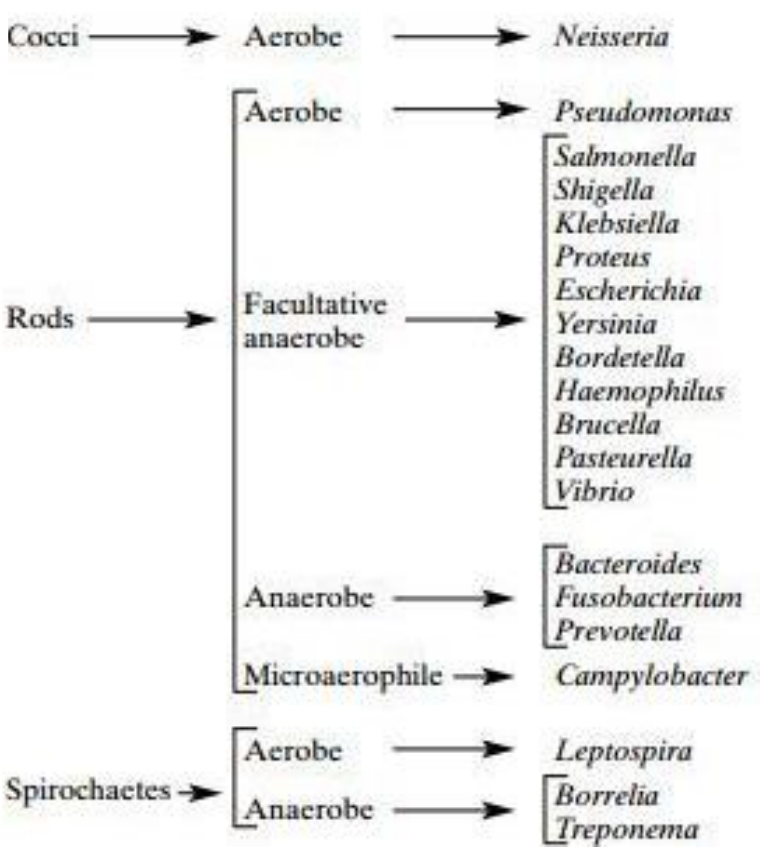
1.Gram positive bacteria (thick layer of peptidoglycan-90% of cell wall)- **stains purple**

2-Gram negative bacteria (thin layer of peptidoglycan-10% of cell wall and high lipid content) –**stains red/pink**

GRAM POSITIVE BACTERIA



GRAM NEGATIVE BACTERIA



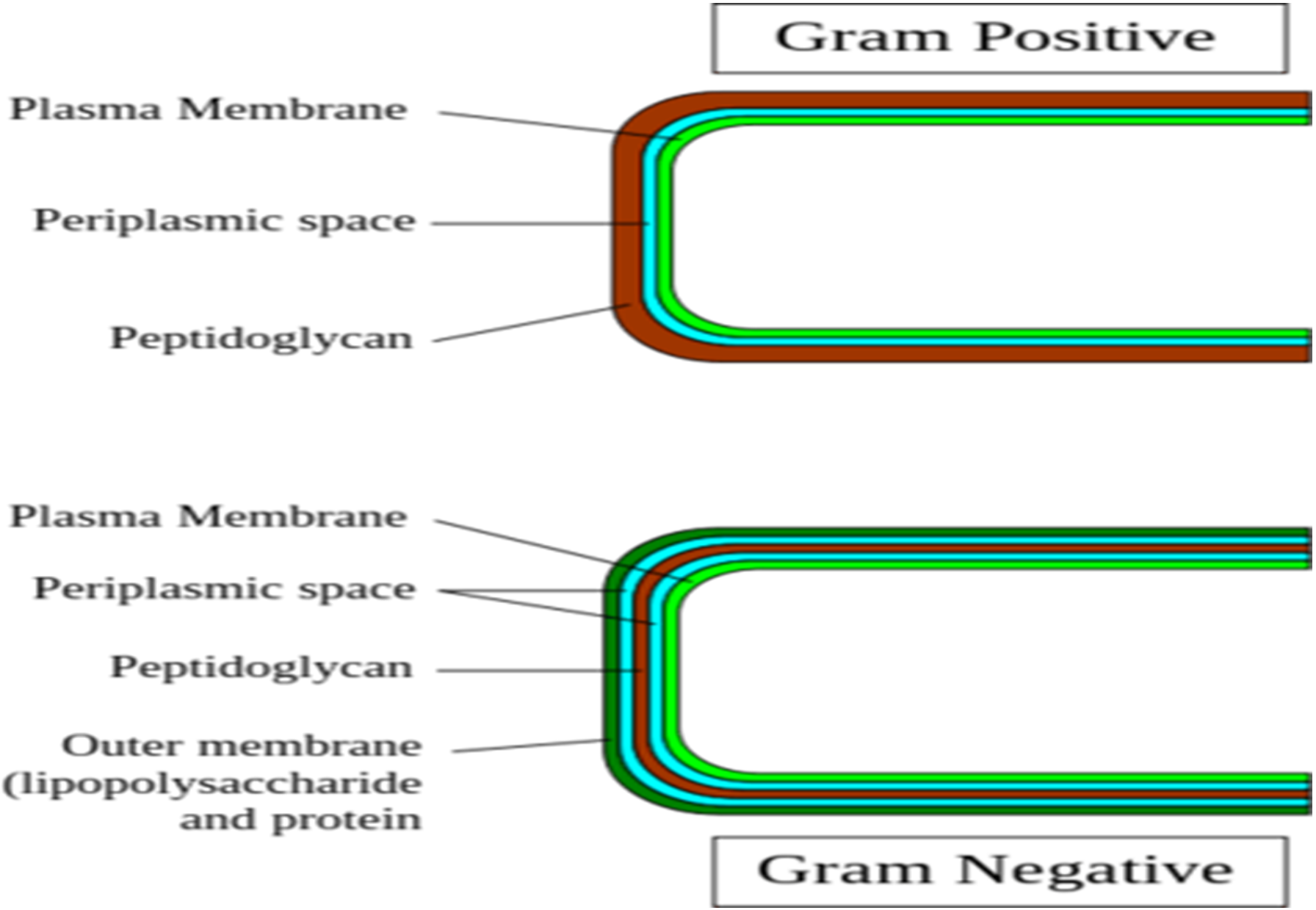
Principle of Gram Staining

When the bacteria is stained with primary stain Crystal Violet and fixed by the mordant, some of the bacteria are able to retain the primary stain and some are decolorized by alcohol.

- **The cell walls of gram positive** bacteria have a thick layer of protein-sugar complexes called peptidoglycan and lipid content is low. Decolorizing the cell causes this thick cell wall to dehydrate and shrink, which closes the pores in the cell wall and prevents the stain from exiting the cell. So the ethanol cannot remove the Crystal Violet-Iodine complex that is bound to the thick layer of peptidoglycan of gram positive bacteria and appears blue or purple in colour.

In case of gram negative bacteria, cell wall also takes up the CV-Iodine complex but due to the thin layer of peptidoglycan and thick outer layer which is formed of lipids, CV-Iodine complex gets washed off. When they are exposed to alcohol, decolorizer dissolves the lipids in the cell walls, which allows the crystal violet-iodine complex to leach out of the cells. Then when again stained with safranin, they take the stain and appears red in color.

Cell wall composition

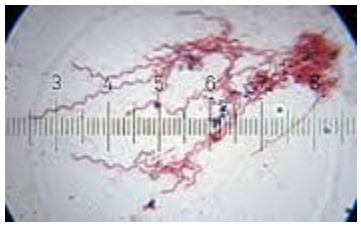


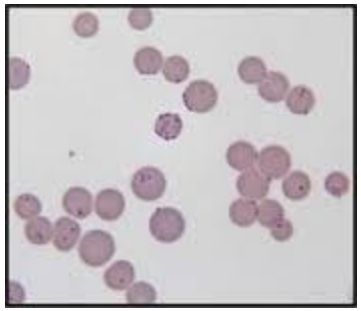
Nearly all clinically important bacteria can be detected using Gram staining method the only exceptions being those organisms;

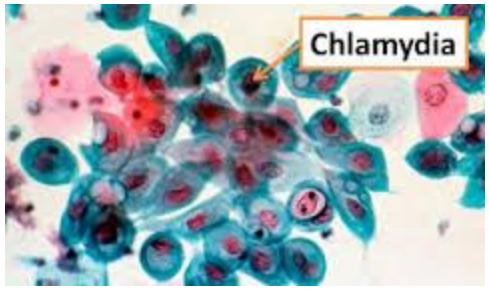
-That exists almost exclusively within host cells i.e. Intracellular bacteria (e.g., Chlamydia)

-Those that lack a cell wall (e.g., Mycoplasma)

- Those of insufficient dimensions to be resolved by light microscopy (e.g., Spirochetes)







Variations in Gram Reaction:

A-Gram positive bacteria may lose their ability to retain crystal violet and stain Gram negatively for the following reasons:

1. Cell wall damage of bacteria due to antibiotic therapy or excessive heat fixation of the smear.
2. Over- decolorization of the smear
3. Use of an Iodine solution which is too old, i.e. yellow instead of brown in color (always store in a brown glass or other light opaque container).
4. Smear has been prepared from an old culture.

B-When smear is too thick, Gram negative bacteria may not be fully decolorized during decolorization steps and appear as Gram positive bacteria.

The differences between Gram positive and negative bacteria:

Gram Positive Bacteria	Gram Negative Bacteria
The bacteria remain colored with Gram staining even after washing with alcohol or acetone.	The bacteria do not retain the stain when washed with alcohol or acetone.
Outer membrane is absent.	Outer membrane is present.
Cell wall is 20-30 nm thick.	Cell wall is 8-12 nm thick.
The lipid content in the wall is very low.	The lipid content in the wall is 20-30%.
A few pathogenic bacteria belong to Gram positive group.	Most of the pathogenic bacteria belong to Gram negative group.

Questions

What color would a Gram negative cell be if you forgot to wash with ethanol and why?

What color would Gram negative cell be if you forgot to stain it with safranin and why?

What specific structure of the bacteria is absorbing the crystal violet dye and how is this structure different between Gram negative and Gram positive bacteria?

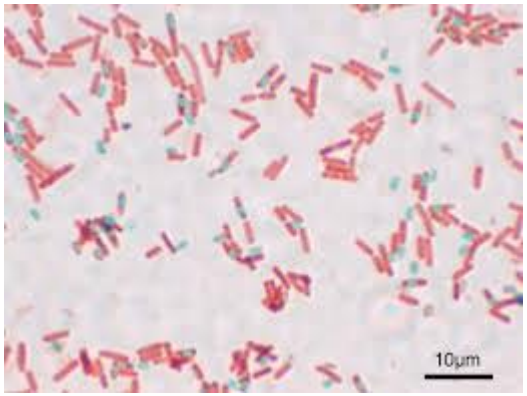
Difference between Gram positive and Gram negative bacteria

Gram positive bacteria	Gram negative bacteria
Simple cell wall	More complex cell wall
Thick peptidoglycan cell wall layer	Thin peptidoglycan cell wall layer
No outer lipopolysaccharide wall layer	outer lipopolysaccharide wall layer
Retain crystal violat/iodine	Retain safranin
Appear (Blue/Purple)	Appear (Pink/Red)

Endospore

An endospore is a dormant, tough, and non-reproductive structure produced by certain bacteria. consisting of the DNA genome, some small amount of cytoplasm, and a specialized coating that confers resistance to heat, radiation, and other harsh external conditions.

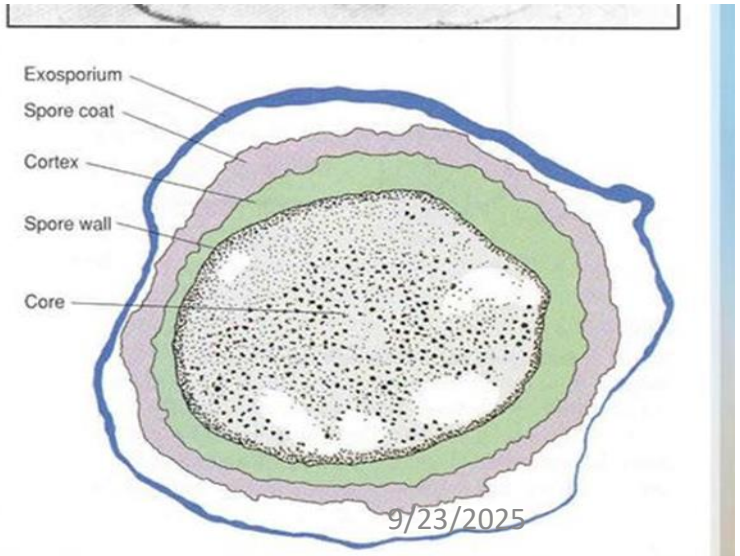
- Formed inside the parent cell, hence called endospores
- Very resistant to heat, radiation and drying
- Formed by bacteria like Clostridia, Bacillus



Life cycle of endospores

- Have two phase life cycle:
- **Vegetative cell-** metabolically active and growing
- **Endospores**- when exposed to adverse environmental conditions, capable of high resistance and very long term survival
- **Sporulation**- formation of endospores
- Not a means of **reproduction**
- **Germination** – return of spore to vegetative growth

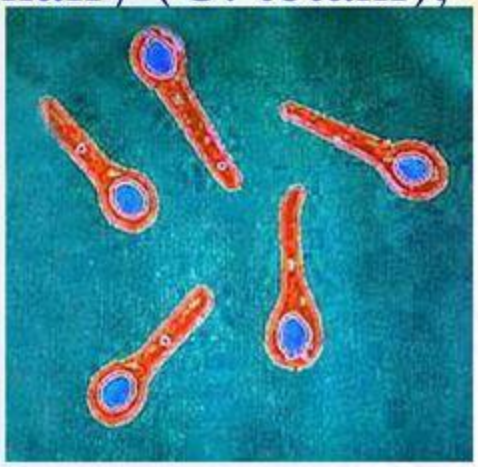
- Structure
  - Core / Cytoplasm
  - Plasma membrane
  - Core wall/ spore wall
  - Cortex
  - Spore coat
  - Exosporium



Spores are located:

1) Centrally (B. anthracis);

2) Terminally (C. tetani);



3) Subterminally (C. botulinum, C. perfringens)

How do bacteria acquire their energy and nutrients?

- **Photoautotrophs** :photosynthetic bacteria change solar energy to chemical energy and produce CHO with O2(Cyanobacteria).

- **Chemoautotrophs**

  oxidize inorganic compounds - nitrogen, sulfur, hydrogen…

- **Heterotrophs**

  - live on plant and animal matter
  - decomposers and pathogens

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  oxidize inorganic compounds - nitrogen, sulfur, hydrogen…

- **Heterotrophs**

  - live on plant and animal matter
  - decomposers and pathogens

Preservation and Maintenance of pure culture:

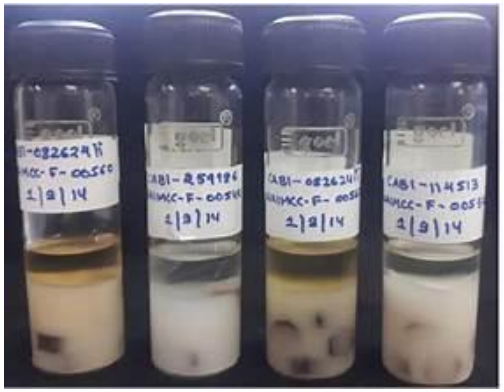
1- Slant or Petri dish

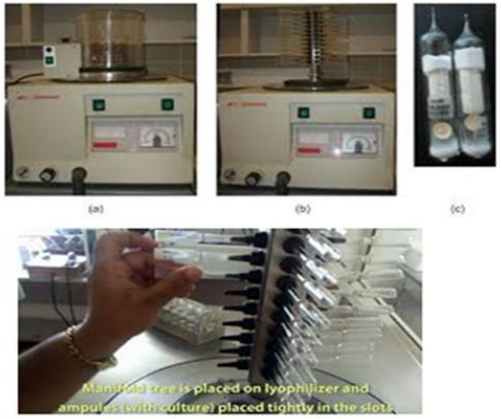
2- Oil cover slant "liquid paraffin“

3- Freezing by use of liquid nitrogen method of(-196 and – 150°C)

4-Storage by dehydration

5- Lyophilization "freeze-drying





Fungi:

- The study of fungi is called **mycology**
- Fungi are diverse and widespread
- They are essential for well-being of most terrestrial ecosystems because the **break down organic material** and **recycle vital nutrients**

Fungi include:

Yeast, mold, mushroom and toadstools, puffballs,

etc.

Micro fungi include **Yeast and mold**

Characteristics of fungi:

1- Fungi are eukaryotic microorganisms, heterotrophic, they do not have chlorophyll.

2-Most are multicellular except unicellular yeast.

3- They are surround by a true **cell wall** except for slime mold. Cell wall are made of **chitin**.

5- The fungal colony may be a mass of yeast cell or it may be a filamentous as mold

6- Reproduce sexually and asexually; Asexually by spores, Sexually by mating of hyphae filaments

Yeast:

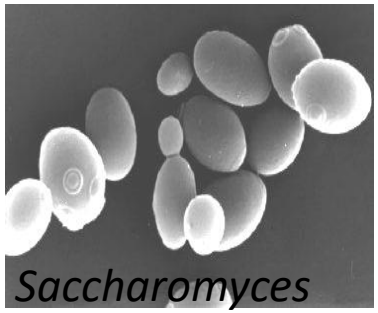
-Yeast are unicellular organisms about 5 to 10 times larger than bacteria.

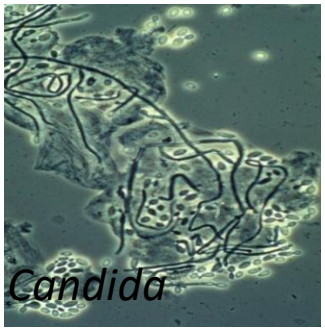
-The shape is commonly egg shaped, but some are elongated and some are spherical.

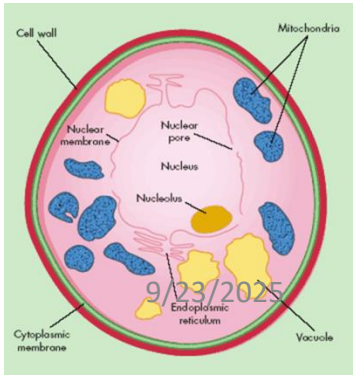
-The yeast cell have no flagellum or other organelles of locomotion.

-Most yeast reproduce asexually by a process called budding.

-Some yeasts may also undergo sexual reproduction


Saccharomyces


Candida



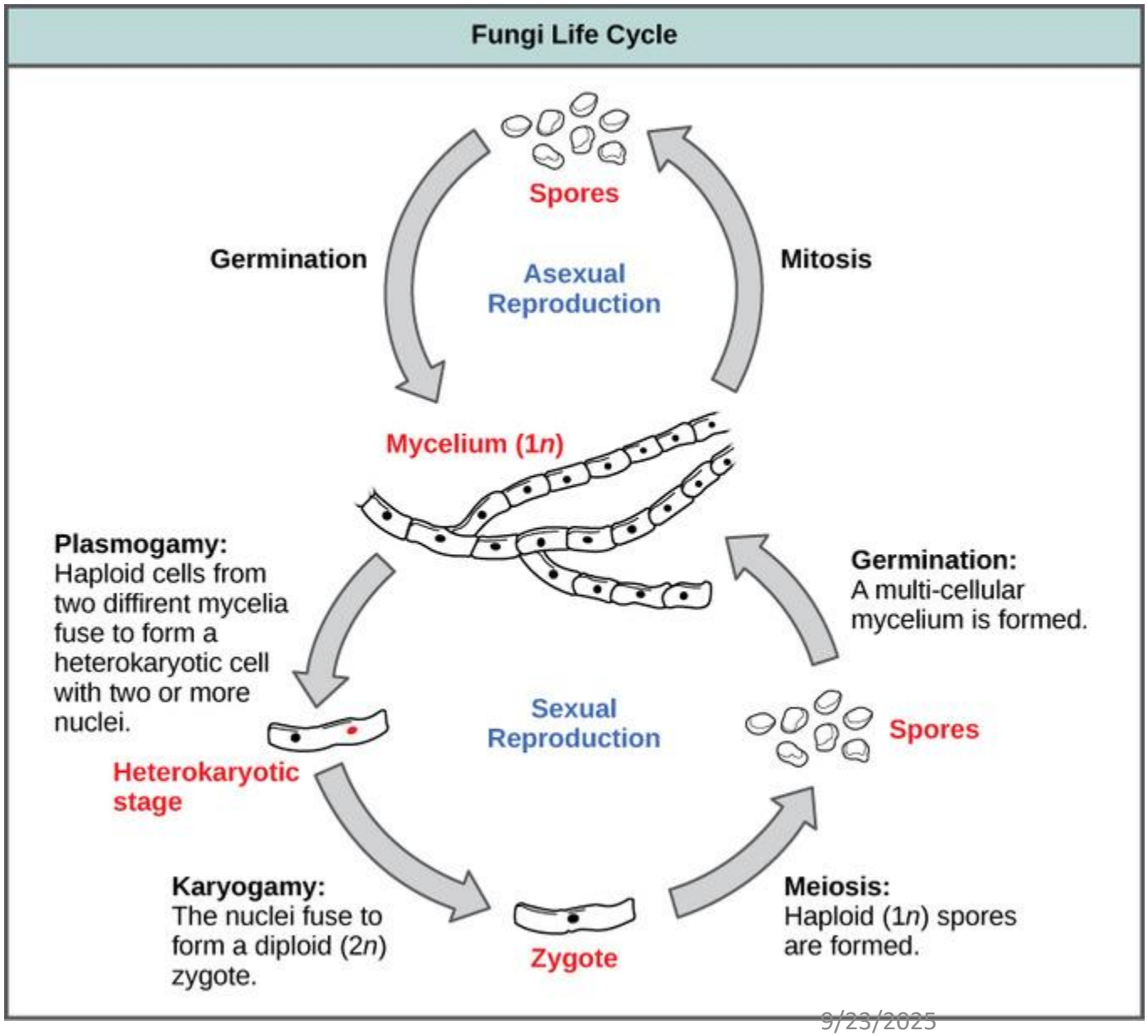
Mold:

- Molds are the major fungal organisms that can be seen by the naked eye.
- Thallus (body) of a mold or fleshy fungus consist of long filaments of cells joined together, these filaments are called **hyphae**
- Many hyphae together form a thick mass called a mycelium

MOLD FORM OF FUNGI, REPRODUCE BY RELEASING SPORES THAT ARE PRODUCED EITHER SEXUALLY OR ASEXUALLY

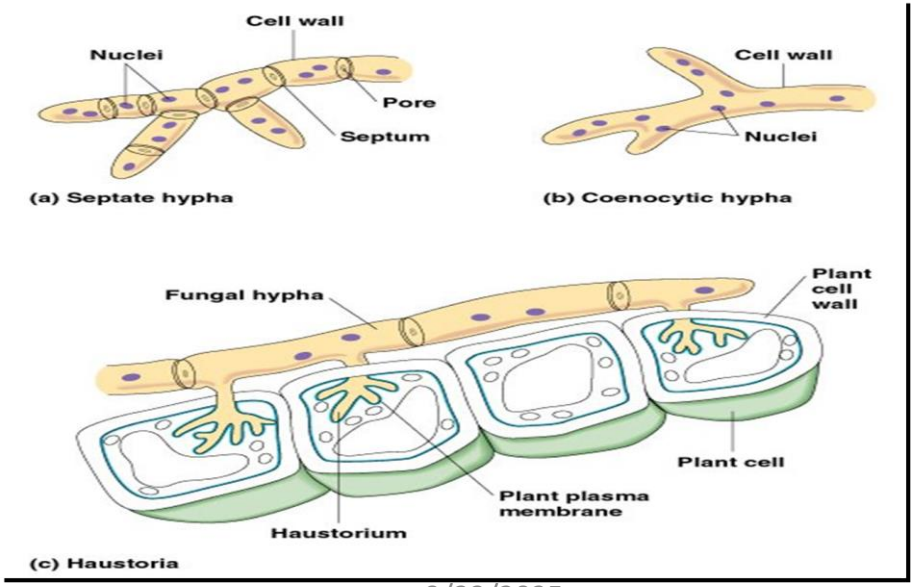
- Produced either sexually (by meiosis) or asexually (by mitosis)
  - In favourable conditions, fungi generally clone themselves by producing enormous numbers of spores asexually
  - Spores are the agent of dispersal responsible for geographic distribution of fungi:

    Carried by wind or water. Germinate in moist places with appropriate substrata
  - For many fungi, sexual reproduction only occurs as a contingency - results in greater genetic diversity


Fungi Life Cycle
Spores
Germination
Asexual Reproduction
Mitosis
Mycelium (1n)
Plasmogamy:
Haploid cells from two diffirent mycelia fuse to form a heterokaryotic cell with two or more nuclei.
Germination:
A multi-cellular mycelium is formed.
Sexual Reproduction
Spores
Heterokaryotic stage
Karyogamy:
The nuclei fuse to form a diploid (2n) zygote.
Meiosis:
Haploid (1n) spores are formed.
Zygote

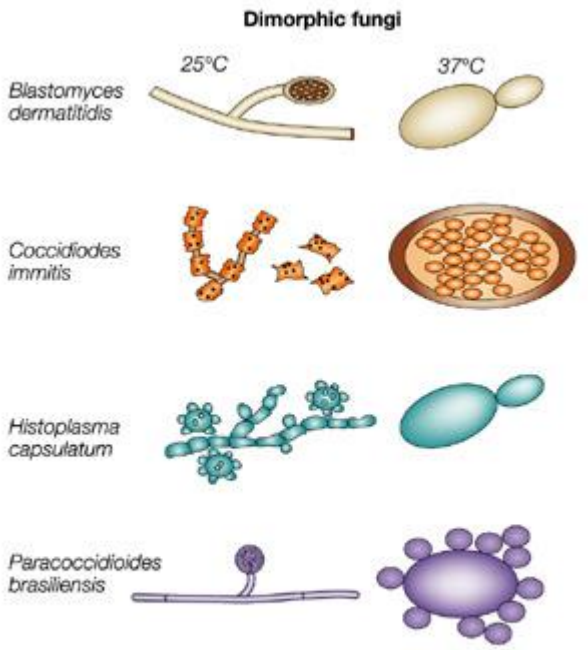
Fungal hyphae may be septate or aseptate

- Hyphae of septate fungi are divided into cells by cross walls called **septa**
- Hyphae of **aseptate** fungi lack cross walls (**coenocytic**)
- Parasitic fungi have modified hyphae called **haustoria**, which penetrate the host tissue but remain outside cell membrane



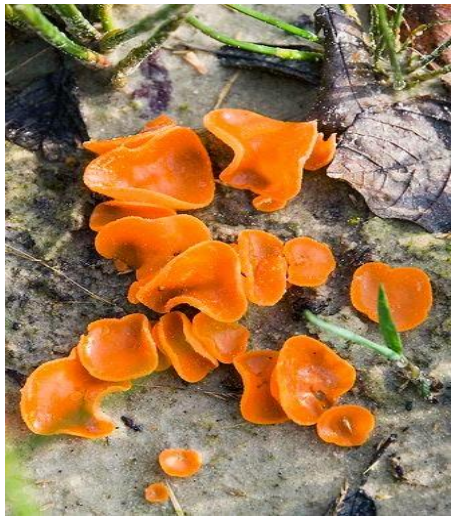
Morphological classification

1. Yeasts
2. Yeast-like fungi
3. Filamentous fungi (molds)
4. Dimorphic fungi



Systematic classification

1. Zygomycetes
2. Ascomycetes reproduce sexually
3. Basidiomycetes
4. Deuteromycetes (fungi imperfect)




Deuteromycetes
Encarta Encyclopedia, Andrew McClenaghan/Science Source/Photo Researchers, Inc.

Fungi Nutrition

-Heterotrophs depend on other organisms for food
-Unlike animals, fungi do not ingest their food
Instead they digest food outside their bodies and then absorb it
-Many feed by absorbing nutrients from decaying matter in the soil (decomposers)
-Others live as parasites, absorbing nutrients from their hosts

Beneficial Effects of Fungi

* Decomposition - nutrient and carbon recycling.
* Biosynthetic factories. Can be used to produce drugs, antibiotics, alcohol, acids, food (e.g., fermented products, mushrooms).
* Model organisms for biochemical and genetic studies.

Harmful Effects of Fungi

* Destruction of food, lumber, paper, and cloth.
* Animal and human diseases, including allergies.
* Toxins produced by poisonous mushrooms and within food (e.g., grain, cheese, etc.).
* Plant diseases.

-Algae (microalgae)

- Algae are autotrophic, diverse group of eukaryotic organisms, ranging from unicellular to multicellular forms.exept Cyanobacteria(Blue green algae) are Prokayotic
- Aquatic (fresh water and marine) and terrestrial environment.
- They also occur in moist stones, soils, wood, on snow and on ice.

Marine Algae

Algae on wood

The Form of Algae

Algae exhibit great diversity in organization of plant body.

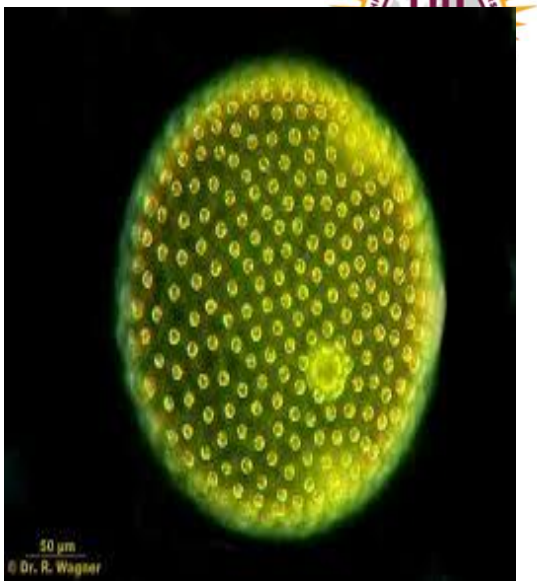
- Unicellular — Motile e.g. *Chlamydomonas*
  Non-motile e.g. *Chlorella*

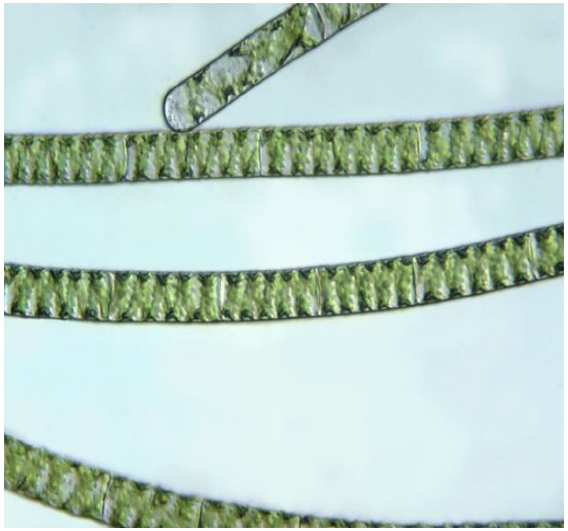
- Colonial e.g. *Volvox*

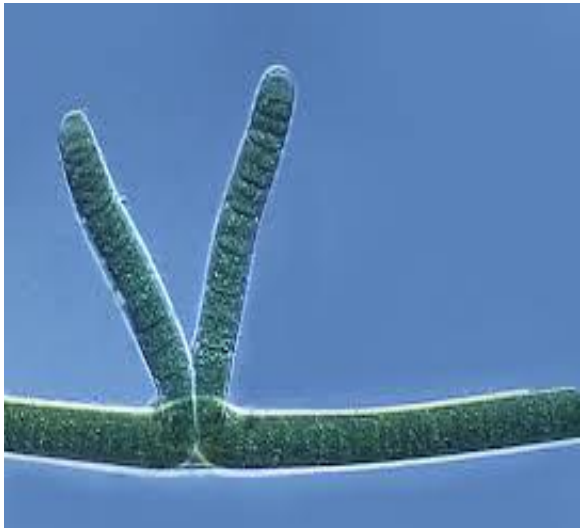
- Filamentous — Simple or un branched e.g. *Ulothrix*
  Branched e.g. *Sytonema*

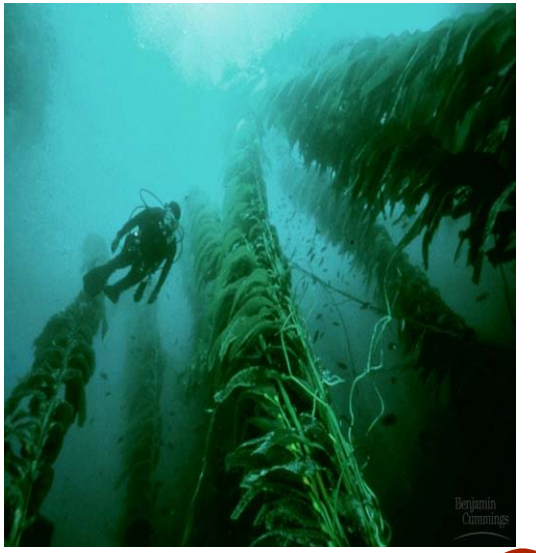
- Dendroid means tree like. e.g. *Prasinocladus*

Shapes of Algae









Reproduction in Algae

1. Vegetative reproduction is by fragmentation.
2. Asexual reproduction is by the production of different types of spores, the most common being the **zoospores.**
3. Sexual reproduction takes place through fusion of two gametes. Gametes may be isogamy or anisogamy or oogamy.

Classification of Algae based on

- Color
- Type of chlorophyll
- Food storage substance
- Cell wall composition

Advantages of Algae

- Source of food
- Used as biofertilizer
- Sewage treatment
- Alternative to chemical dyes and colouring agents
- Commercial uses Agar

LICHENS

- Symbiosis of algae with fungal hyphae
- The alga:
  - Provides fungus with food
  - May fix nitrogen
- Fungus provides good environment for growth:
  - Hyphal mass absorbs minerals and protects algae

Protozoa and parasites

Characteristics of Protozoan Phyla

1.They are unicellular with some colonial and multicellular stages.

2.Most are microscopic.

3.All symmetries are present within members of the group.

4.No germ layers are present.

5.No organs or tissues are formed, but specialized organelles serve many of these functions.

6.They include free-living, mutualistic, commensal and parasitic forms.

7.They move by pseudopodia, flagella, cilia and they can direct cell movements.

8. Most are naked, but some have a simple endoskeleton or exoskeleton.

All types of nutrition are present: autotrophic, heterotrophic and saprozoic.

10. They can be aquatic or terrestrial.

11. Reproduction is asexual by fission, budding or cysts; or sexual by conjugation or syngamy of gametes.

THE PROTOZOA

The Phylum Protozoa is classified into four subdivisions according to the methods of locomotion.

- The amoebae (Sarcodina) move by means of pseudopodia.
- The flagellates (Mastigophora) typically move by long, whip like flagella.
- The ciliates (Ciliata) are propelled by rows of cilia that beat with a synchronized wavelike motion.
- The sporozoans (Sporozoa) lack specialized organelles of motility.

- **Parasite -** one animal deriving its sustenance from another without making compensation. The uncompensated animal is the host.
- **Parasitology -** the science or study of host-parasite relationships.
- **Medical parasitology** - study of parasites which infect humans.
- **Host** - the partner providing food and/or protection. Some parasites require more than one host to complete their life cycle; Or may not require a host during some stage(s).
- **Vector -** “carrier” of a parasite from one host to another. Often an insect.

A SUCCESSFUL PARASITE

- **A parasite is successful -** when it is in delicate balance with the host. If the balance is upset, the host may destroy or expel the parasite; If the host is overly damaged, it may die - as will the parasite.

- **Parasitology is important -** because this balance is not always maintained.

PARASITIC DAMAGE TO HOST:

- **Trauma -** damage to tissues, intestine, liver, eye.
- **Lytic action -** activity of enzymes elaborated by organism.
- **Tissue response -** localized inflammation, eosinophilia.
- **Blood loss -** heavy infection with hookworm may cause anemia.
- **Secondary infections -** weakened host susceptible to bacterial infection, etc.

Transmission:

- **mostly person-to-person,**
- **fecal-oral route; fecally contaminated food or water; other means include sexual transmission, insect bites or insect feces.**
  - **Trophozoite - the motile vegetative stage; multiplies via binary fission; colonizes host.**
  - **Cyst - the inactive, non-motile, infective stage; survives the environment or is a dormant stage of a protozoan that helps to survive in unfavorable environmental conditions.**
  - **due to the presence of a cyst wall. Cysts do not multiply, however, some organisms divide within the cyst wall.**

Protozoan Disease: (information)

1- Giardiasis: Giardiasis is caused by the parasite known as *Giardia intestinalis*.

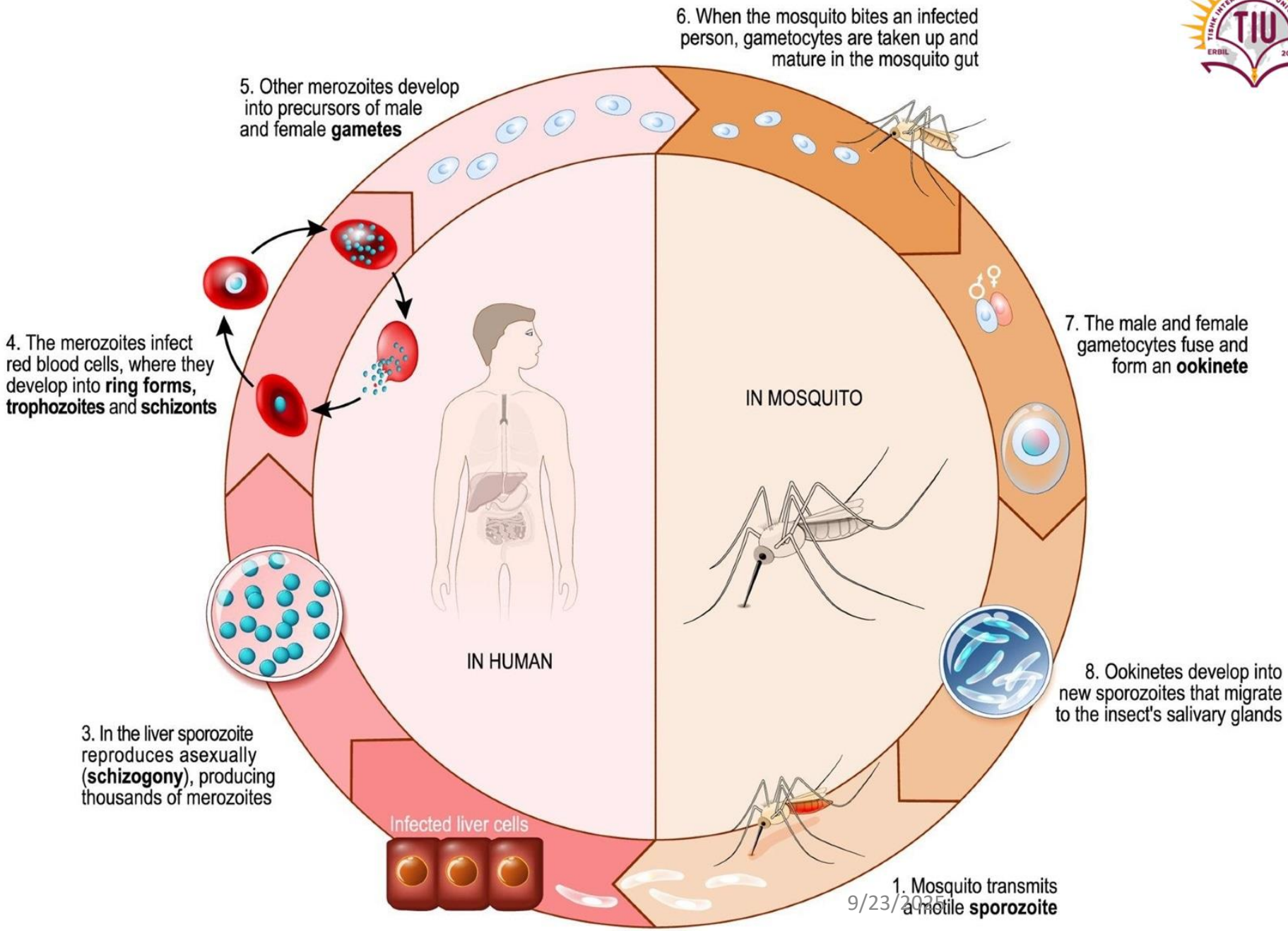
2- African Sleeping Sickness: African sleeping sickness is caused by protozoa in the Trypanosoma genus. skin rash, slurred speech and difficulty talking and walking.

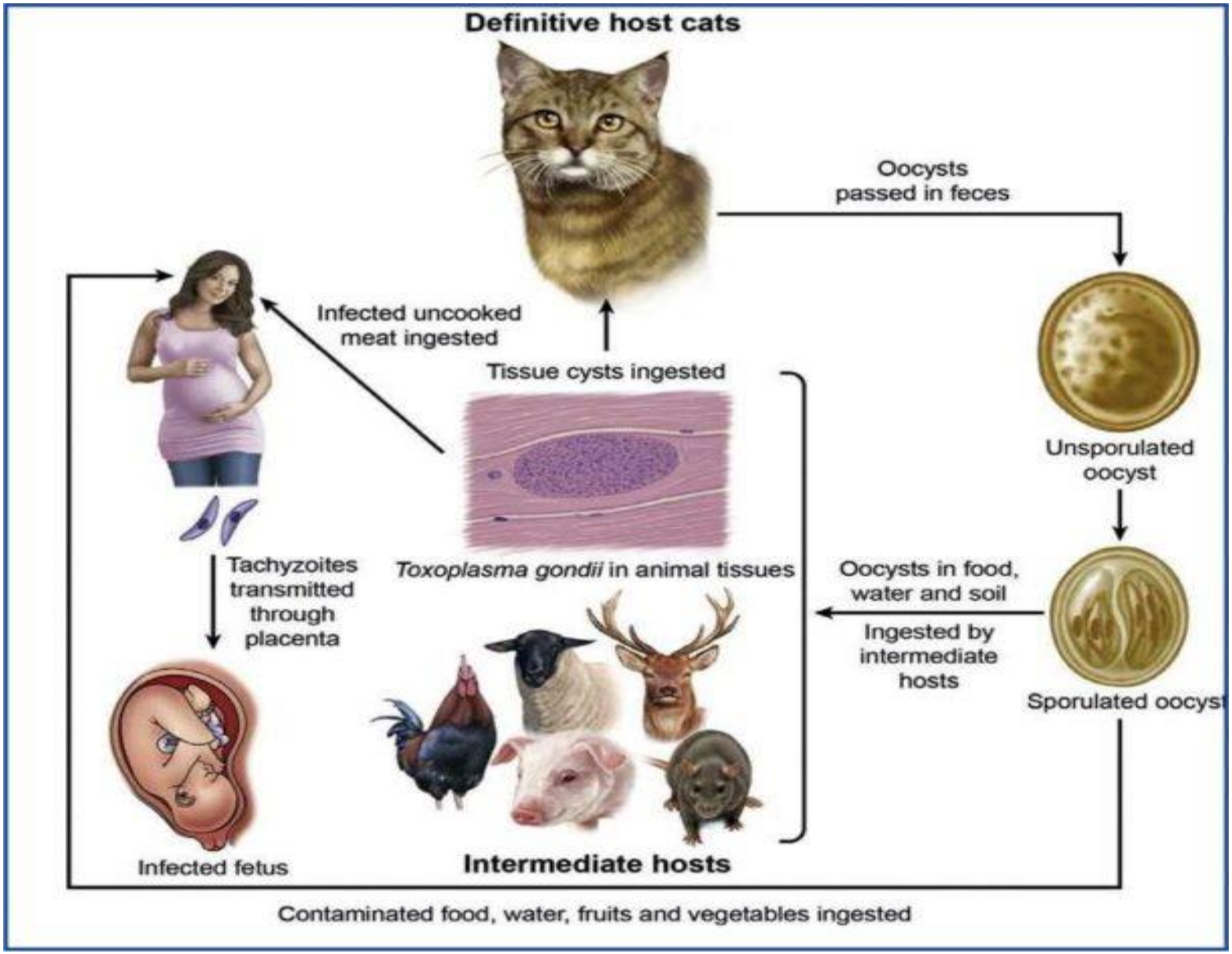
3-Leishmaniasis: Leishmaniasis is caused by the Leishmania parasite.

4- Toxoplasmosis is caused by an organism known as Toxoplasma gondii.

5- Malaria is spread by mosquitoes that are infected by the parasites Plasmodium falciparum.

6-Babesiosis is caused by the Babesia parasite, which is carried by ticks.


6. When the mosquito bites an infected person, gametocytes are taken up and mature in the mosquito gut
5. Other merozoites develop into precursors of male and female gametes
4. The merozoites infect red blood cells, where they develop into ring forms, trophozoites and schizonts
IN MOSQUITO
7. The male and female gametocytes fuse and form an ookinete
IN HUMAN
8. Ookinetes develop into new sporozoites that migrate to the insect's salivary glands
3. In the liver sporozoite reproduces asexually (schizogony), producing thousands of merozoites
Infected liver cells
1. Mosquito transmits a motile sporozoite
2. A sporozoite travels


Definitive host cats
Oocysts passed in feces
Infected uncooked meat ingested
Tissue cysts ingested
Unsporulated oocyst
Tachyzoites transmitted through placenta
Toxoplasma gondii in animal tissues
Oocysts in food, water and soil
Ingested by intermediate hosts
Sporulated oocyst
Infected fetus
Intermediate hosts
Contaminated food, water, fruits and vegetables ingested

- **Question and Discussion**