Etege Menen Girls' Boarding Seconday School

Biology Department

Grade 12

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1.1 Type of microorganisms

- **Micro-organism** is a very small organism that can only be seen under a microscope.
- Most microorganism are unicellular
- There are five main groups of micro-organisms. These groups are:
  1) Bacteria
  2) Protozoa
  3) Some fungi
  4) Some algae
  5) Viruses

Bacteria

- Unicellular prokaryotic organisms
- Smaller than the smallest plant and animal cell
- Do not have membrane bounded organelles

Protozoa

- In classification protozoa group under protista
- Have eukaryotic cell
- **Unicellular organisms** that lack a cell wall

- Are animal-like organisms b/c Most of them are motile (able to move), using;
  - **Flagella**; E.g. Giardia
  - **Cilia;** hair like structure E.g. Paramecium.
  - **Pseudopodia;** E.g. Amoeba
- Include organisms such as ***Amoeba, Plasmodium*** (causes malaria), and ***Paramecium.***

Fungi like yeast

- Have eukaryotic cells
- Having heterotrophic mode of nutrition.
- Fungi live as parasitic, saprophytic and mutualistic mode of nutrition
  - **Parasites:** obtain nutrient directly on or in living organisms E.g. ***Candida albicans, Tinea pedis***
  - **Saprophytic:** obtain their nutrition using extracellular digestion by releasing enzyme to break down dead organic matter and absorb the nutrients **E.g. Mucor**
  - **Mutualistic:** live in close association with other organism and both benefit E.g. **mycorrhizal.**

Yeast

Saccharomyces

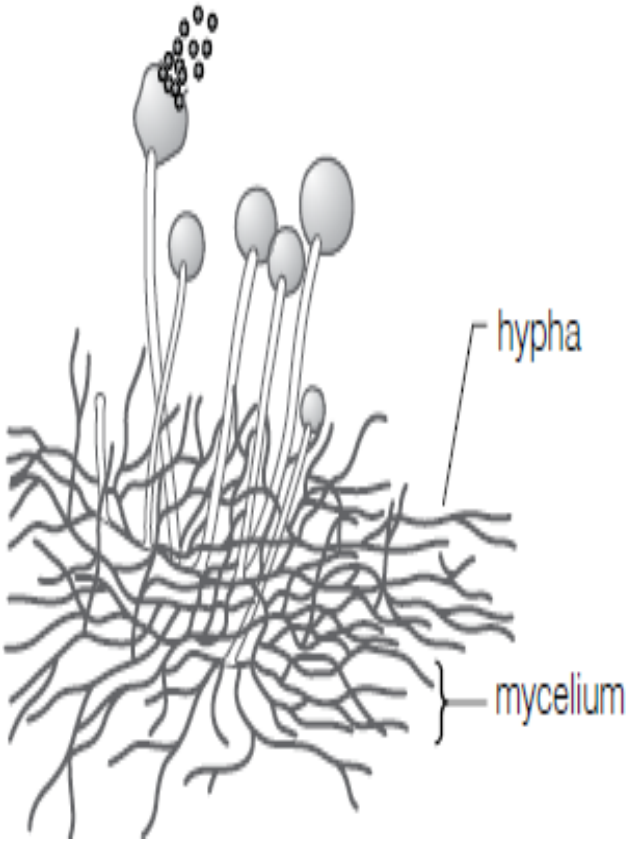


Candida



Fungi….

- Fungi cell wall mainly composed of **chitin** (**non cellulose cell wall**).
- Fungi body made up of thread like structure called **hyphae** which form a **mycelium**
- Fungi do not have true roots, stems and leaves.
- Fungi do not have chloroplast so they are non-photosynthetic.
  - Include **brewer's yeast** and **baker's yeast** (***Saccharomyces***)
  - As well as the **yeast-like organism** that causes thrush in humans (***Candida***).



Algae

- Simple autotrophic organisms.
- Algae are a diverse group of photosynthetic organism
- Have eukaryotic cells
- Unicellular or multicellular
- Algae provide food for fish and other larger organisms.
- Highly productive of oxygen and organic matter then terrestrial plant
- Some unicellular algae are **motile** – they can move.

  E.g. Chlamydomonas, which has two flagella

Viruses

- Viruses are infectious agent found in all life forms.
- Virus is **not even a cell (they are acellular),** they lack nucleus, cytoplasm and other major organelles.
- For these reason viruse cannot independently carryout any of the life processes.
- They can only reproduce inside other cells (**obligate intracellular parasite** to bacteria, plants and animals)
- Have **genetic material** either DNA or RNA surrounded by a protein coat
- Example **Bacteriophages** are viruses that parasitise bacteria, **tobacco mosaic virus.**

1.2 BACTERIA

- Organisms which **belong to kingdom monera**
- Have cell wall made of **peptidoglycan** (non cellulose cell wall)
- Have **prokaryotic cell structure**
  - Do not have membrane bounded organelle such as chloroplast, mitochondria, Golgi bodies etc
- All are unicellular

1.2.1 Bacterial cell structure

- **Common structure found in all bacteria**
  - **Call wall ;** made from a substance called **peptidoglycan** (also called **Murein**)
  - **Cytoplasm**
  - **Cell membrane**
  - **Ribosome**
  - **DNA**

Some other structure found only in few bacteria

- **Capsule**; protect against drying, harsh chemicals and host WBC
- **Flagella**; use to move the cell
- **Endospore;** used bacteria to resist heat, Ultra violet radiation and Chemical disinfectant
- **Plasmid;** self-replicating loop of DNA
- **Pili**; used to
  - transfer genetic material from one bacteria to another
  - help bacteria to adhere to host cell

Type of cell

Prokaryotic cell

- Small cell Size (**1 µm to 10 µm**)
- Nucleus absent
- Genetic material a **continuous loop DNA**, **no protein histone** to form chromosomes Have a circular DNA called plasmid
- Fundamentally **unicellular cell form**
- **Reproduce asexually by binary fission. Sexually by conjugation**

Eukaryotic cell

- Large cell Size (**10 to 100 µm**
- Nucleus present
- Genetic material have **liner DNA in a protein histone** to form chromosomes
- The majority are **multicellular cell form**
- Performing **true sexual reproduction** and also show **asexual reproduction**

Type of cell…

Prokaryotic cell

- **Cell wall** made up of **Murein** (**peptidoglycan**)
- **Respiration** takes place in the **mesosomes of cell membrane**
- Do not contain membrane bounded organelle
- Very **simple flagella** structure and lack microtubules
- Small **ribosomes (70S)**

Eukaryotic cell

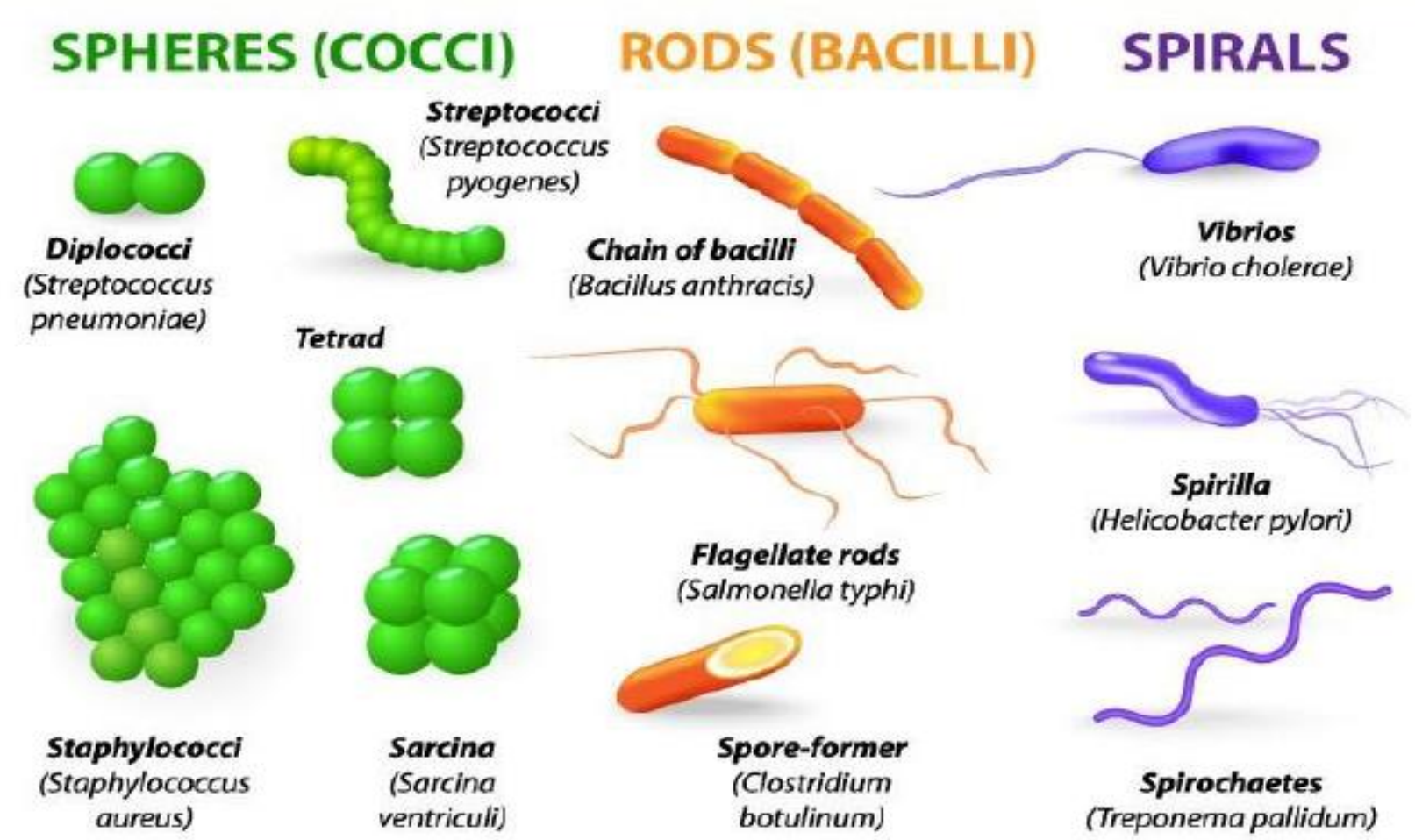
- Plant **cell wall** made up of **cellulose**
- **Respiration** takes place in **mitochondria**
- Have membrane bonded organelle
- **Complex flagella** structure with **9+2 microtubules**
- Large **ribosomes (80s)**

1.2.2 Bacterial classification

1. Bacterial cells have three main shapes:

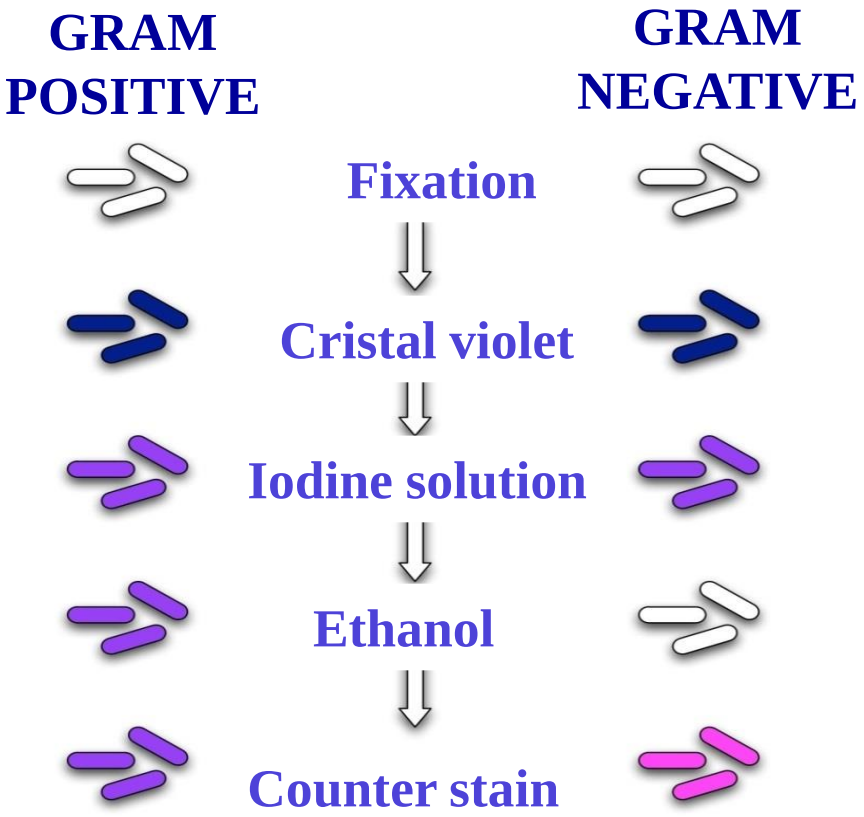
- **Cocci** (singular, coccus) – spherical bacteria
  - **Diplococci.** e.g. *Streptococcus pneumonia*
  - **Streptococci.** e.g. *Streptococcus pyogenes*
  - **Staphylococci** e.*g. Staphylococcus aurous*
- **Bacilli** (singular, bacillus) – rod-shaped bacteria
  - **Chain of bacilli** e.g. *Bacillus anthraces*
  - **Flagellate rods** e.g. *Salmonella typhi*
  - **Spore forming** e.g. *Clostridium botulinum*
- **Spiral** – spiral or corkscrew-shaped bacteria
  - **Spirilla:** e.g. *Helicobacter pylori*
  - **Spirochetes:** e.g. *Treponema palladium*

Bacterial shapes…..



2. Based on staining property-Gram stain

- Gram staining is a deferential staining technique used to classify bacteria into gram positive and negative based on its staining property



Stages of gram stain

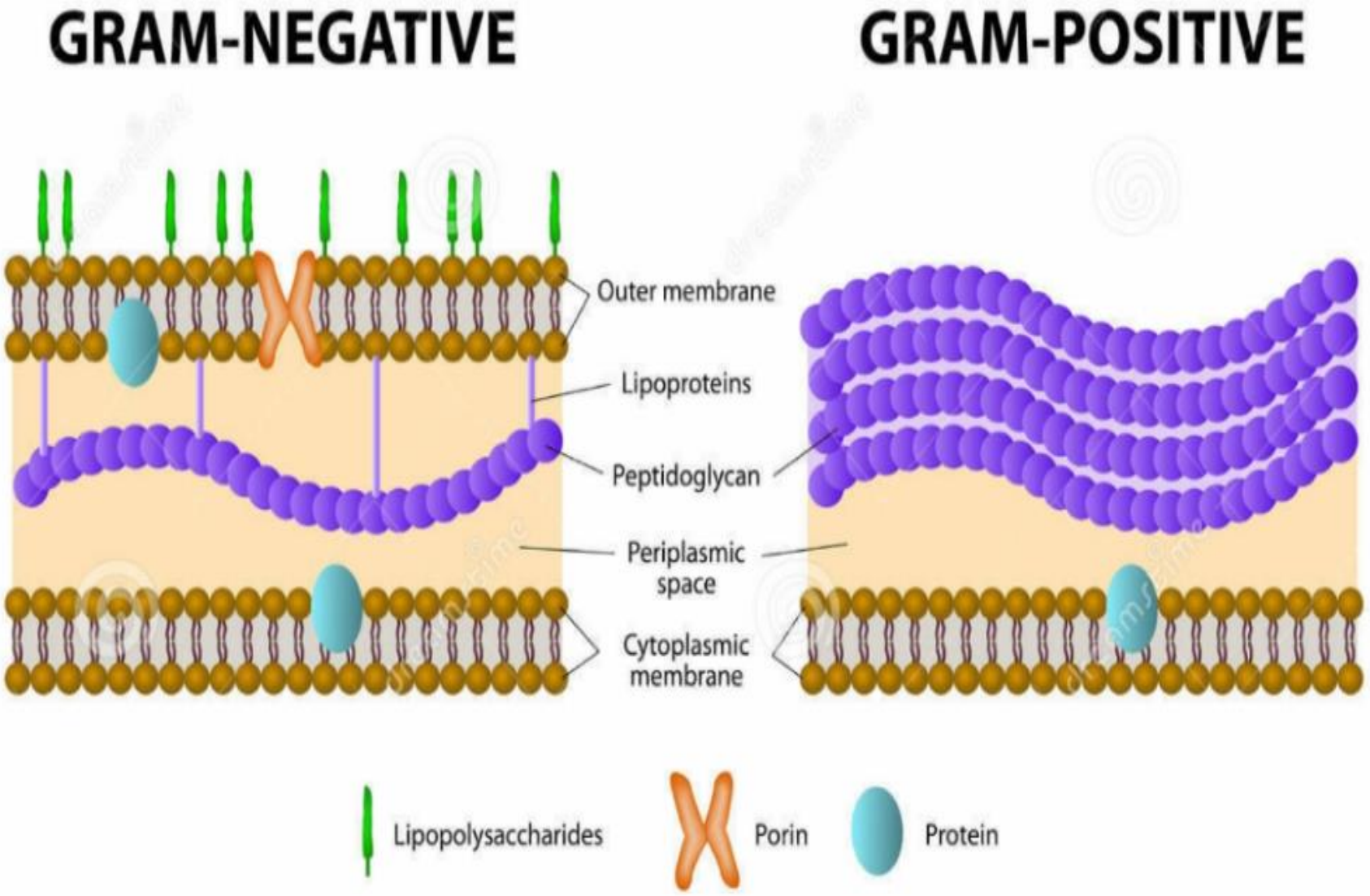
- **Smear**
- **Fixation:**
- **Cristal violet** /purple color/; primary stain
- **Iodine solution;** as a mordant /to form iodine--violet complex/
- **Decolorized** by **ethanol**
- **Counter stain** or secondary stain **Safranin** /pink color/;

Gram positive

- Stained **purple** by gram stain
- **Keep the color of primary stain** /crystal violet/ not decolorized
- Have **thick cell wall**
- No membrane outside cell wall
- Do **not produce endotoxin**
- **More susceptible** to antibiotics and disinfectants
- E.g., Mycobacterium tuberculosis

Gram negative

- Stain **pink** by gram stain
- **Primary stain decolorized by ethanol** and take the color of secondary stain safranin
- **Cell wall is thinner**
- Have **lipopolysaccharide** outside cell wall
- **Produce endotoxin**
- **Less susceptible** to antibiotics and disinfectants
- E.g., Escherichia coli


GRAM-NEGATIVE
GRAM-POSITIVE
Outer membrane
Lipoproteins
Peptidoglycan
Periplasmic space
Cytoplasmic membrane
Lipopolysaccharides
Porin
Protein

1.3 The ecology and uses of bacteria

- Bacteria are important because they:
  1. Cause diseases
  2. Recycle nutrients such as carbon, nitrogen and sulphur through ecosystems
  3. Used in industrial processes

1.3.1 The role of bacteria and other microorganisms in causing diseases

- **Germ theory** states that disease can be caused by micro-organisms.
- Organisms that cause disease are called **pathogens**
- Disease caused by a pathogens such as bacteria, viruse, protozoa are called **infectious disease**
- **Louis Pasteur, Joseph Lister** and **Robert Koch** involved in the development of germ theory.

The role of bacteria….

- **Pasteur** showed that micro-organisms in the air caused wine to go ‘sour’.
  - Develop **immunization technique** and **vaccine** for **rabies**
  - Disprove the theory of spontaneous generation
- **Lister** showed that **carbolic acid (phenol)** acted as **a disinfectant** and prevented disease in bones following surgery **(antiseptic technique in surgery).**
- **Robert Koch** identified the micro-organisms that cause **tuberculosis** and **cholera**

Koch's postulates

- **Robert Koch stated the following main postulates**
  1) Micro-organism must always be present when the disease is present
  2) Micro-organism can be isolated from an infected person and grown in culture.
  3) Introducing cultured micro-organisms into a healthy host result in the disease.
  4) It can isolate the micro-organism from this newly infected host and grow it in culture.

How micro-organisms cause disease?

- **Bacteria** ***cause disease by:***
  - release toxins that affect cells as they multiply
  - some bacteria invade in the tissue of organs, causing physical damage
  - E.g. **Pneumonia, Cholera, Tuberculosis, Tetanus, Typhoid, Chancroids**
- **Viruses** ***cause disease by:***
  - enter cells and take over the 'metabolic machinery' of these cells.
  - E.g. **Influenza ('flu), AIDS, Measles, Common cold, Ebola, Yellow fever**

How micro-organisms…

- **Fungi** ***cause disease by:***
  - secrete enzymes that digest substances in the tissues where they grow.
  - secreting toxins.
  - causing an allergic reaction
  - E.g. **Athlete's foot, farmer's lung, Thrush**
- **Protozoa** ***cause disease by:***
  - have no set pattern of causing disease.
  - E.g. **Malaria, sleeping sickness, Amoebic dysentery**

How are disease-causing micro-organisms transmitted?

- **Reservoir of infection**
  - **Any person, animal, plant, soil or substance** in which infectious agents normally live, grow and multiplies
  - The reservoir is the **principal habitat** where infectious agents lives and multiplies
  - Reservoir are **origin of infectious substance** transmitted to human or other host
  - **People** acting as the reservoir of infection are sometimes called **carriers of the disease**

Reservoir of infection …

1) **Human reservoir** are reservoir for many diseases, including **common cold, diphtheria** and others
2) **Animal reservoirs**;
   - for example: **chickens** are reservoir for **salmonella** infections;
   - **Mosquito** are reservoir for **malaria**
3) **Environmental reservoir**
   - **Soil;** the reservoir for ***Clostridium tetani*** which cause tetanus
   - **Water;** the reservoir for ***legionella pneumphila*** which cause **Legionnaire's disease, amoeba, *Virio cholera*,** which cause **cholera,** etc.
   - **Food** ; the reservoir for many diseases including **typhoid**
   - **Contaminated objects**; contact infections such as HIV/AIDS and **trachoma**
   - **Air**; the reservoir for **pneumonia, tuberculosis,** etc

Reservoir of infection …

- Infectious agents may be transmuted from its natural reservoir to a susceptible host in different way
  - **Direct:** infectious agents is transmitted from a reservoir to a susceptible host by **direct contact or droplets infection**
  - **Indirect:** the transfer of an infection agents from a reservoir to a host by **suspended air particles, inanimate object** (food, water, blood, fomites) or **animal victors**

Root of transmission of disease

1. Droplet infection

- It is respiratory disease
- Transmitted through air droplets
- Examples **Common cold, 'flu, Pneumonia, Tuberculosis**

2. Contaminated water

- Water born disease (infect gut)
- Example **cholera, typhoid fever**

3. Contaminated food

- Food born disease (infect gut)
- Example **salmonellosis, typhoid fever, Listeriosis, botulism**

4. Direct contact

- Skin infection
- **Athlete's foot, Ringworm**

Root of transmission…

5. **Sexual intercourse /venereal disease/**
   - Infecting sex organs
   - transmitted by;
     - direct body contact, such **candidiasis**
     - Semen or vaginal secretions, such as **AIDS.**
     - Saliva, such as **syphilis.**
   - **Example** ***candidiasis, Syphilis, AIDS,*** **Gonorrhea**

6. **Animal vectors**
   - Spread through the bites of insects.
   - Mosquitoes spread malaria
   - Tsetse flies spread sleeping sickness.
   - Example **malaria, sleeping sickness**

Types of disease

- The World Health Organization's definition of **health** is "a state of complete physical, mental and social well-being".

A. Infectious or communicable disease

- Disease caused by pathogens. E.g., **Syphilis, pneumonia, Malaria,**

B. Non infectious or Non-communicable disease

1. Human induced diseases

- Diseases that arise as a result of a person's **lifestyle or working conditions.**
- **E.g., Many cancers, Heart disease, Fibrosis,**

2. Degenerative diseases

- Diseases result from deterioration of body structure with **ageing** process
- E.g. **Arthritis** (inflammation of joints) , **Atherosclerosis** (Blood vessels become blocked by deposit of fat) , **Alzheimer's diseases** (Memory disorder)

Types of disease…

3. Genetic diseases

- Diseases that result from genetic defect
- E.g., **Hemophilia** and **Sickle-cell anemia**

4. Deficiency diseases

- Diseases that result from a lack of a nutrient in our diet.
- E.g. **Scurvy** and **Kwashiorkor**

5. Social diseases

- A conditions that result from social activities
- May lead to socially unacceptable behavior
- E.g. **Alcoholism** and **Drug addiction,**

Types of disease…

6. **Functional diseases**
   - Abnormal change in the function of an organ
   - Without being any obvious damage or physical sign of disease in the organ.
   - E.g. Heart disease, **Irritable Bowel Syndrome** (IBS), **Myalgic Encephalopathy** (ME)

- **Multifactorial disease:** it is an illness that is caused by the action of many factors. E.g. atherosclerosis classified as degenerative, genetic and life style disease

1.3.2. The role of bacteria in an ecosystem

- The role of bacteria in recycling minerals through ecosystems

The nitrogen cycle

- The element nitrogen is found in many important organic molecules in all living organisms. These include:
  - Proteins
  - DNA
  - RNA
  - ATP
- **Bacteria** decompose protein in dead **bodies (detritus)** into simpler molecule

The nitrogen cycle…..

- Nitrogen cycle involves several types of microorganisms.
- **Ammonifying** conversion of protein in dead body into ammonium ions (NH4)
  - Protein $\longrightarrow$ NH_4
- **Nitrogen-fixing bacteria**, conversion of elemental nitrogen into ammonium ion
  - $N_2 \xrightarrow{\textit{Rhizobium}} NH_3$
- **Nitrifying bacteria**, ammonium ion **(NH_4^+)** oxidised into nitrates **(NO^-_3)**
  - $NH_3 \xrightarrow{\textit{Nitrosomonas}} NO^-_2 \xrightarrow{\textit{Nitrobacter}} NO^-_3$
- **Denitrifying bacteria,** reduction of nitrates in soil into elemental nitrogen
  - $\textbf{\textit{NO}}_{\textbf{3}} \xrightarrow{\textbf{\textit{Pseudomonas}}} \mathbf{N_2}$

Sulphur cycle

- Sulphur is a component of amino acid such as methionine and cysteine.
- Sulphur cycle is a collective process by which sulphur cycles from organism and environment
- Sulphur cycle involves the following process.

1) **Decomposition**
   - **Desulphovibrio** decompose proteins of dead matter and release sulfur as **hydrogen sulphide** in anaerobic condition.
2) **Oxidation of hydrogen sulphide**
   - **Photosynthetic sulphur bacteria** oxidise **hydrogen sulphide** is oxidised to release **sulphur** in anaerobic condition..
3) **Oxidation of Sulphur**
   - **Non-photosynthetic sulphur** bacteria such as **thiobacillus** oxidised **sulphur to sulphate ions** in aerobic condition.

Sulphur cycle…

- The accumulation of sulphur and nitrogen oxide in the atmosphere cause acid rain
- Burning of fossil fuels release sulphur and nitrogen oxide which are the main cause of acid rain. Which results in:
  - Acidification of soil
  - Acidification of lakes

1.3.3 Role of bacteria in industrial processes

1. Food and beverage fermentation

- Bacteria and other micro-organisms used to make:
  - Bread
  - Alcohol
  - Irgo or yoghurt
  - Vinegar as well as many other products.

2. Production of vinegar

- Vinegar is a dilute solution of ethanoic acid in water.
- The alcohol in the beer, wine or cider is oxidised to ethanoic acid by ***Acetobacter bacteria***
- Vinegar is used in two main ways:
  - To flavour foods
  - To preserve foods
- Keeping foods in vinegar **(pickling)** is a good way of preserving food

3. Producing antibiotics

- The first antibiotics **penicillin,** come from fungi (penicillium).
- Genetically modified bacteria are also used to produce:
  - Insulin
  - Human growth hormone
  - Antibiotics
  - Enzymes for washing powders
  - Human vaccines, such as the vaccine against hepatitis B

4. Sewage treatment

- Microorganisms play a significant role in sewage treatment. There are two methods:
  - **The percolating filter method,** (trickling filter); Removal of polluting organic matter through filtration. **How?**
  - **The activated sludge method:** decomposition and removal of organic matter. **How?**

1.3.4. How bacteria genetically modified?

- **Genetic engineering** is a technique of changing the organism character by inserting a new gene from other organism
- The main tools used in genetic engineering
  - **Restriction endonuclease;** are enzyme used to cut DNA at a specific sequence
  - **DNA Ligase**; are enzyme used to insert gene into molecules
  - **Vector;** used to transfer a recombinant gene into host organism. E.g. **plasmid** (Circular DNA found only in bacteria), **bacteriophages**
- **What are the main stages of genetic engineering?**

How bacteria genetically modified…

- The organism that have had a foreign gene added to them are called **transgenic organism** **or** **genetically modified organism**
- Genetically modified crops develop a new trait. Such as
  - Resistance to infectious disease
  - Resistance to animal pests
  - A longer shelf-life before decaying
- **Agrobacterium tumefaciens,** can be used to transfer foreign gene into genome of many plant. **How?**
- **Gene gun** is used to transfer foreign gene into **maize, tobacco, carrots, soybean and apple.**

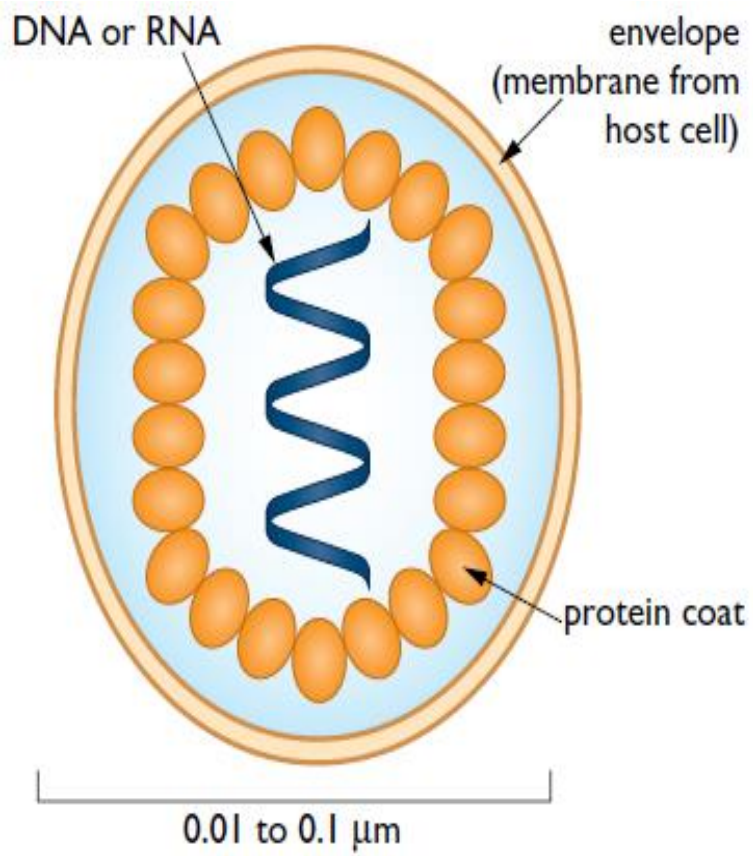
4.VIRUSE

1.4.1Nature of viruse

- Virus are not cellular (acellular)
- Not like prokaryotic or eukaryotic cell
- Viruses cannot carry out any of the life processes independently
- They can only reproduce inside other cells.
- So all are **obligate intracellular parasites.**
- Only reproduce inside host cell.
- Smaller than the smallest bacterium

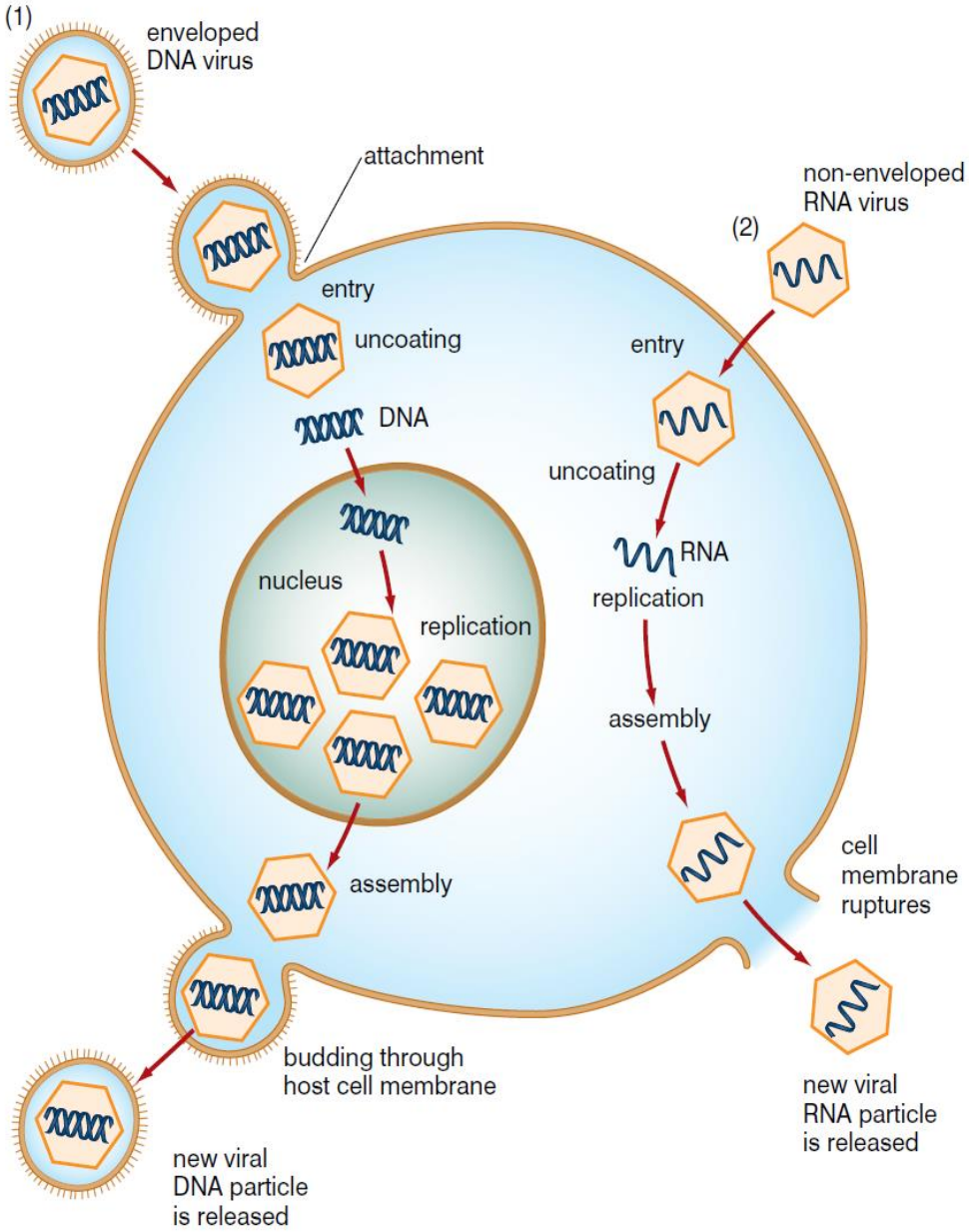
Nature of viruse…

- The particle of a virus contain at **least two components:**
  - **A protein** shell or capsid
  - DNA or RNA as the **genetic material**
- **Some** also have:
  - An **envelope** outside capsoid
  - **Enzyme** inside capsoid



Virus lie between life and non-life forms

- **Characteristics of life virus perform**
  - Have **genetic material** either DNA or RNA
  - Have **protein** (capsoid)
  - Viral DNA has gene to synthesis **enzyme** inside host cell
- **Characteristics of life virus do not perform**
  - **No record of metabolism**
  - Lack ability to generate their own energy
  - Virus do not feed, grow, respire, move or get rid of metabolic waste



Stage of viruse infection

1. **Attachment-** on the surface of host cells
2. **Penetration/entry**- injection into cytoplasm of host cells
3. **Uncoating**
4. **Replication**- inside nucleus (DNA viruse) & inside cytoplasm (RNA virus)
5. **Assembly**
6. **Budding off** or **membrane rapture**
7. **Release of new virus-** out of the host cells

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1.4.2 Types of viruses

- Based on th**e nature of their genetic material** and the **way in which it is expressed**. These groups are:

1. DNA virus;

- Genetic information stored in the form of DNA
- DNA virus replicate itself and control the synthesis of viral proteins
- DNA is quite a stable molecule, is not very reactive with other molecules, and replicates very accurately.
- Viral genome replication of DNA viruse
  - DNA ⟶ DNA
- E.g. **Herpes simplex** (causes cold sores), **Bacteriophages**

2. RNA viruse;

- The only one contains genetic information the form of RNA
- RNA is quite unstable and makes frequent mistakes during copying.
- Unstable nature of RNA allows RNA viruses to evolve far more rapidly than DNA viruses,
- Viral genome replication of RNA Viruse
  - RNA ⟶ RNA
- E.g. **H_1N_1 virus** (causes swine flu), **TMV** (Tobacco mosaic viruse)

3. Retrovirus

- An RNA virus that converts its genetic information from RNA into DNA, this process is called **reverse transcription;**
- Enable the viruse to inject its genetic material into the host cell.
- Viral genome replication of retrovirus
- RNA ⟶ DNA ⟶ RNA
- E.g. HIV

Viruses can also be classified by the type of organism they infect:

- Animal-infecting viruses
- Plant-infecting viruses
- Bacteria-infecting viruses – these are called **bacteriophages**

1.4.3 Viruse replication

1) Lytic life cycle

- Infection cause the host cell burst and release new viruse
- Lytic cycle is the life cycle of bacteriophages
- The host bacteria undergoes lysis and release many new phages
- Viruse that kill infected host are called **Virulent virus**

Lytic cycle have five phase

1) **Attachment** on receptor cite
2) **Viruse inject** its DNA
3) **disintegration** host DNA and synthesis
4) **Assembly** of viral DNA and protein coat into new viruse
5) **The host cell burst** and release new viruse

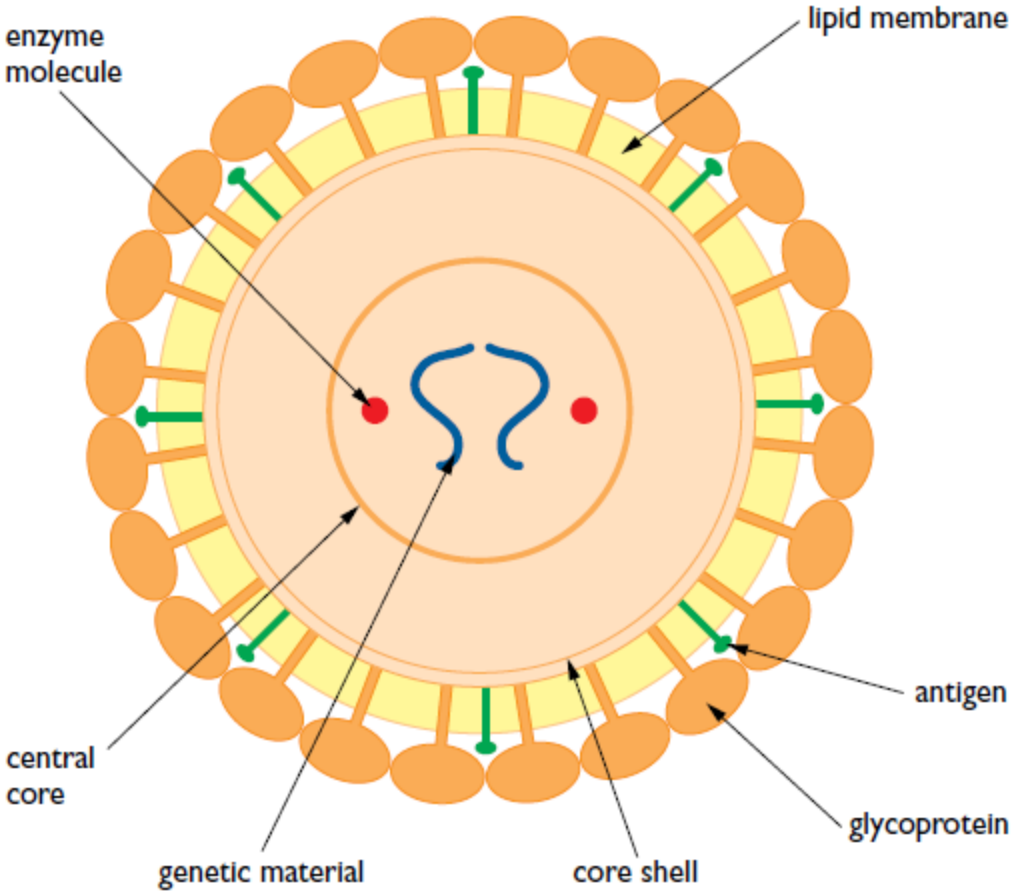
Viruse replication…

- **Lysogenic cycle**
  - Viral **DNA integrates** itself into host DNA without causing immediate destruction
  - The DNA segment that is integrated into host cell genome is called **prophage**
  - Viruse that can reproduce without killing the host are called **temperate viruse**
- **Chronic release cycle**
  - **I**nfection cause the viruse released by exocytosis through plasma membrane

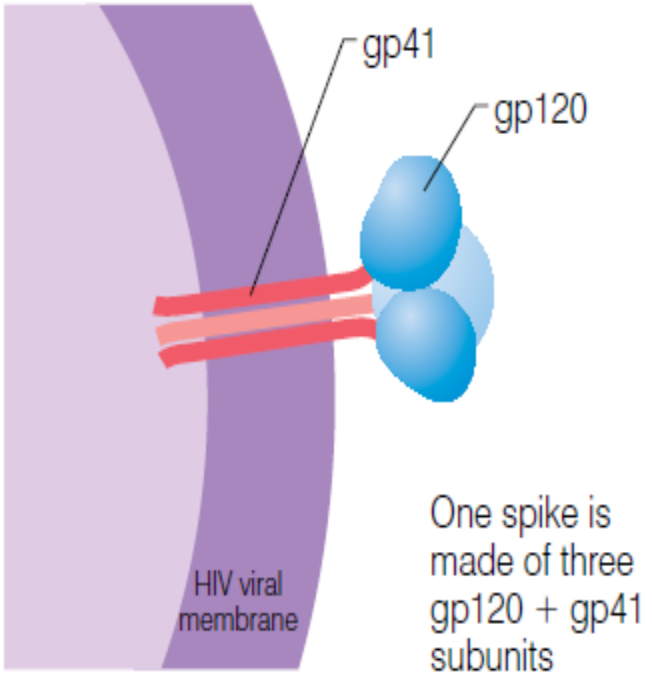
1.4.4 HIV and AIDS

- Human Immunodeficiency Virus or **HIV** is one of the retroviruses.
- HIV has RNA as its genetic material.
- RNA transcribed to DNA by the enzyme **reverse transcriptase**
- HIV targets **CD4 lymphocytes** or **T-helper cells**,
- HIV has spikes on its surface, made up of a head **gp120** attached to **gp41.**
- The spikes attach to CD4 cells
- Besides the T-helper cells, **macrophages** also contain CD4 cells

Structure of HIV



HIV spikes



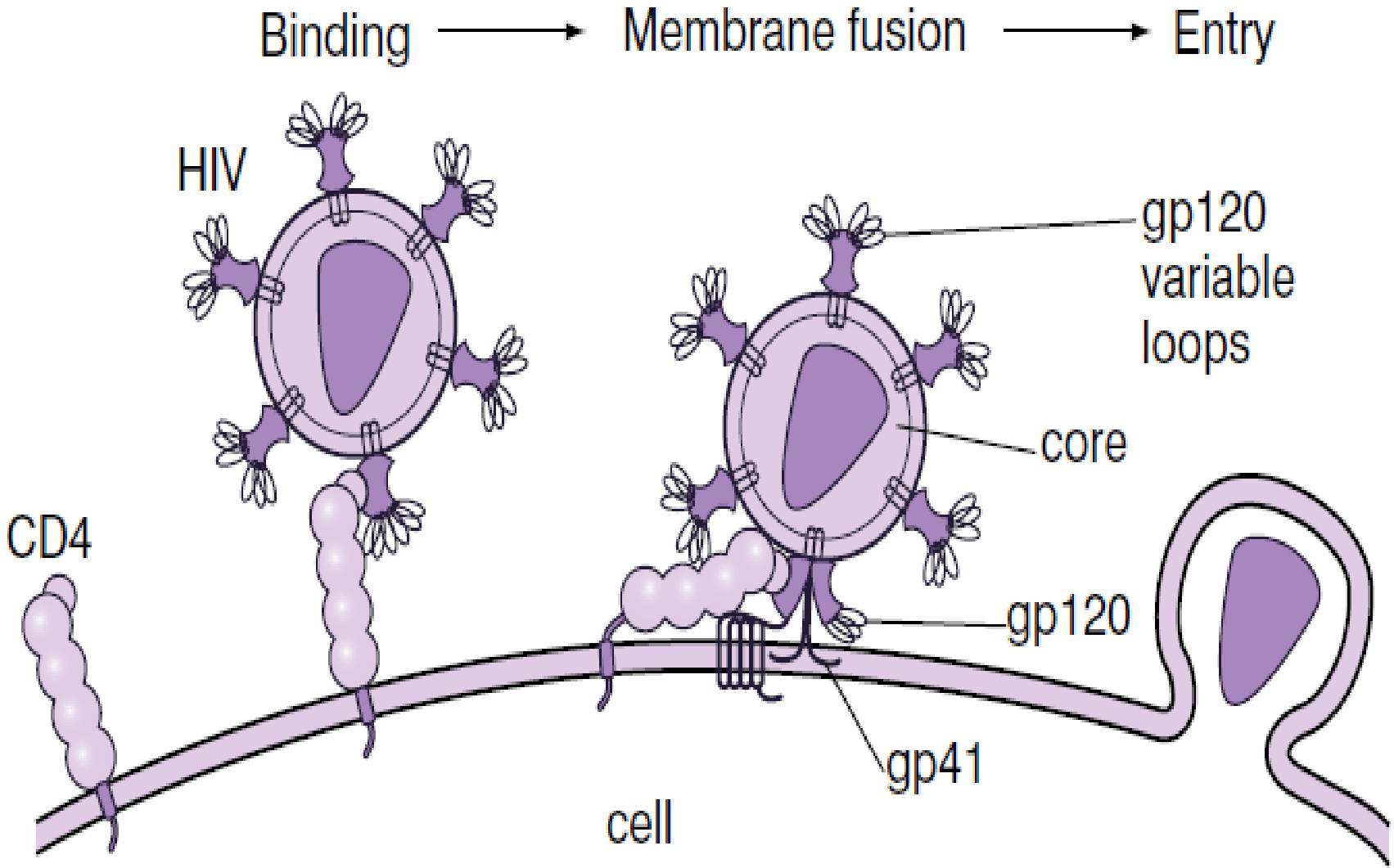
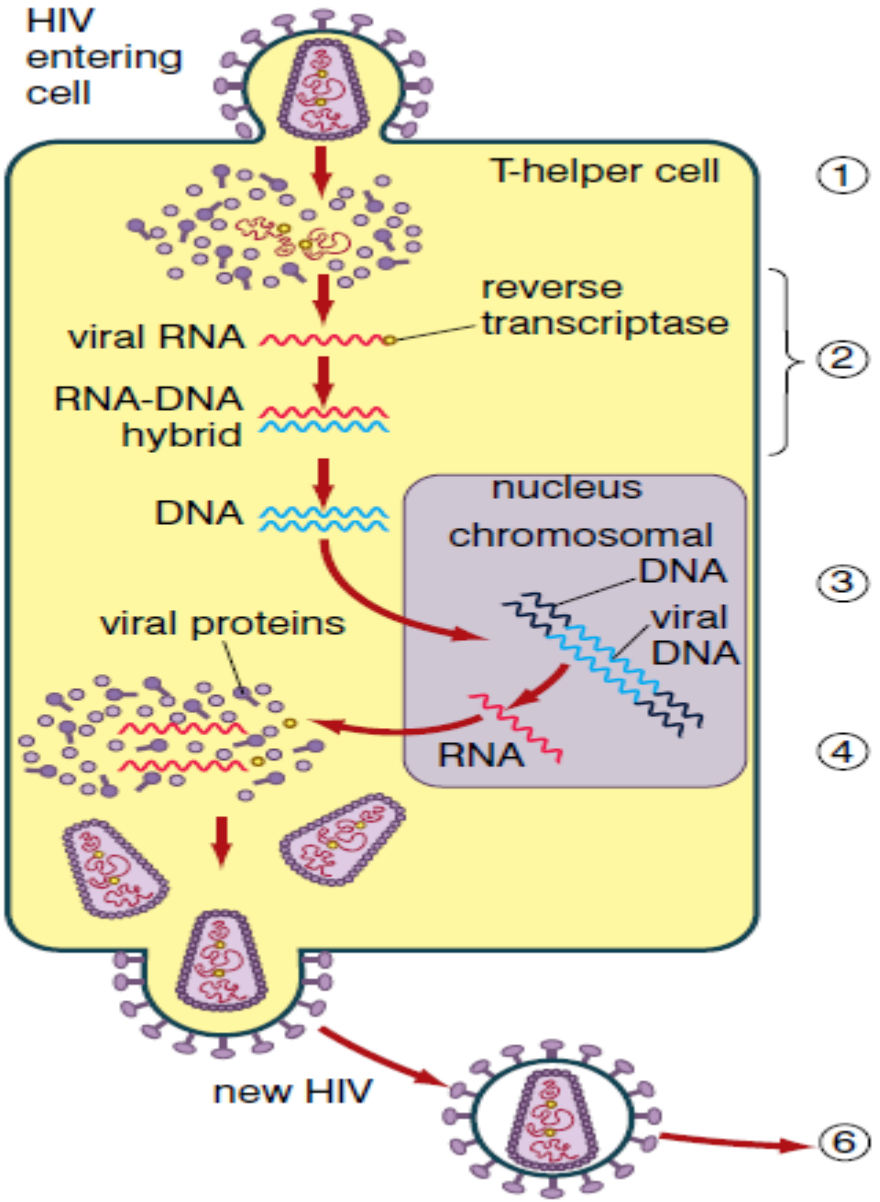


Figure: HIV infection CD4 lymphocyte cell

How does HIV reproduce and cause AIDS?

1. **Binding (binding of gp120 of HIV to CD4)**
   - A glycoprotein on the surface of HIV binds to CD4 receptors of the immune cell and RNA is released into the immune cell.
2. **Reverse transcription**
   - Viral RNA is into DNA by a viral enzyme, **Reverse transcriptase**
3. **Integration**
   - Viral DNA enters the cell nucleus, incorporates into the cell's own DNA
4. **Transcriptions and translation**
   - The viral DNA is transcribed to viral RNA, which starts producing viral proteins, including the enzymes reverse transcriptase, protease
5. **Viral assembly**
   - Protease cuts protein chains into a new HIV particles
   - Viral particle assembled and released by 'budding' from the cell membrane to infect other T-helper cells



① **Entry:**

② **Reverse transcription:**

③ **Integration:.**

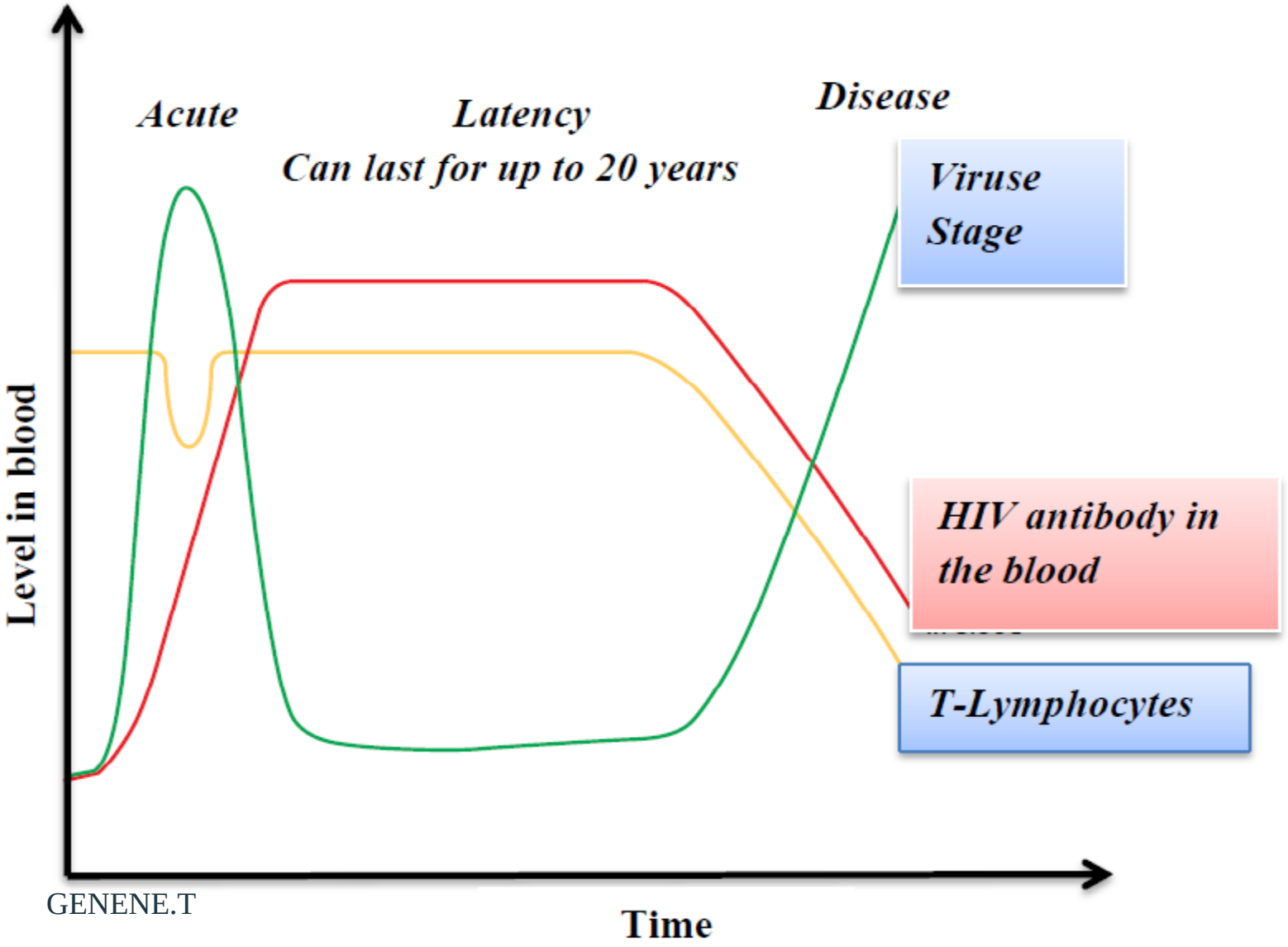
④ **Transcription and translation**

5 **Assembly**

Stage of HIV infection

- **Acute stage;**
  - Soon after infection
  - Viruse replicates and the number of CD4 lymphocytes reduced
  - The white blood cell starts to produce antibody against HIV
- **Latency stage (asymptomatic stage)**
  - The viral load remains stable
  - The period when the body keep replacing CD4 lymphocyte cell
- **Disease stage**
  - The viral load is high
  - CD4 count is abnormally low and opportunistic disease occur
  - Including pneumonia and tuberculosis together with rare cancers like **Kaposi's sarcoma.**

Stage of HIV infection…



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Can AIDS be treated?

- **Why a vaccine for AIDS would be ineffective?**
  - The virus mutates (changes) regularly
  - live attenuated (harmless) vaccine may re-acquire their virulence
  - HIV is a retrovirus and once RNA is converted to DNA, it can remain hidden in the host cell DNA for many years
- Although there is no cure for AIDS, there are a number of drugs called **anti-retroviral drugs** that slow down the progression infection to AIDS.

Anti-retroviral drugs

1. Entry inhibitors

- Prevent the binding of CD4 of the T-helper cell gp120 of HIV

2. Nucleotide reverse transcriptase inhibitors (NRTI's)

- Prevent reverse transcription by faulty versions of nucleotides used by HIV to convert RNA into DNA.

2. Non-nucleotide reverse transcriptase inhibitors (NNRTI's)

- Attach to the enzyme reverse transcriptase **and** preventing it from converting RNA to DNA

3. Integrase inhibitors

- Prevent the joining of viral DNA into the human genome

4. Protease inhibitors

- preventing the assembly of new virus particles by action of protease enzyme

- **High Activity Anti-Retroviral Treatment** (**HAART**) using anti-retro viral drugs in combination to act on different stages of the HIV life cycle.
  - The main advantage of HAART breaking the life cycle of HIV in different stages
- **Students expected to discusses social and economic impact of AIDS**