



Life and Health Science

Xingyi MA

Professor, School of Science

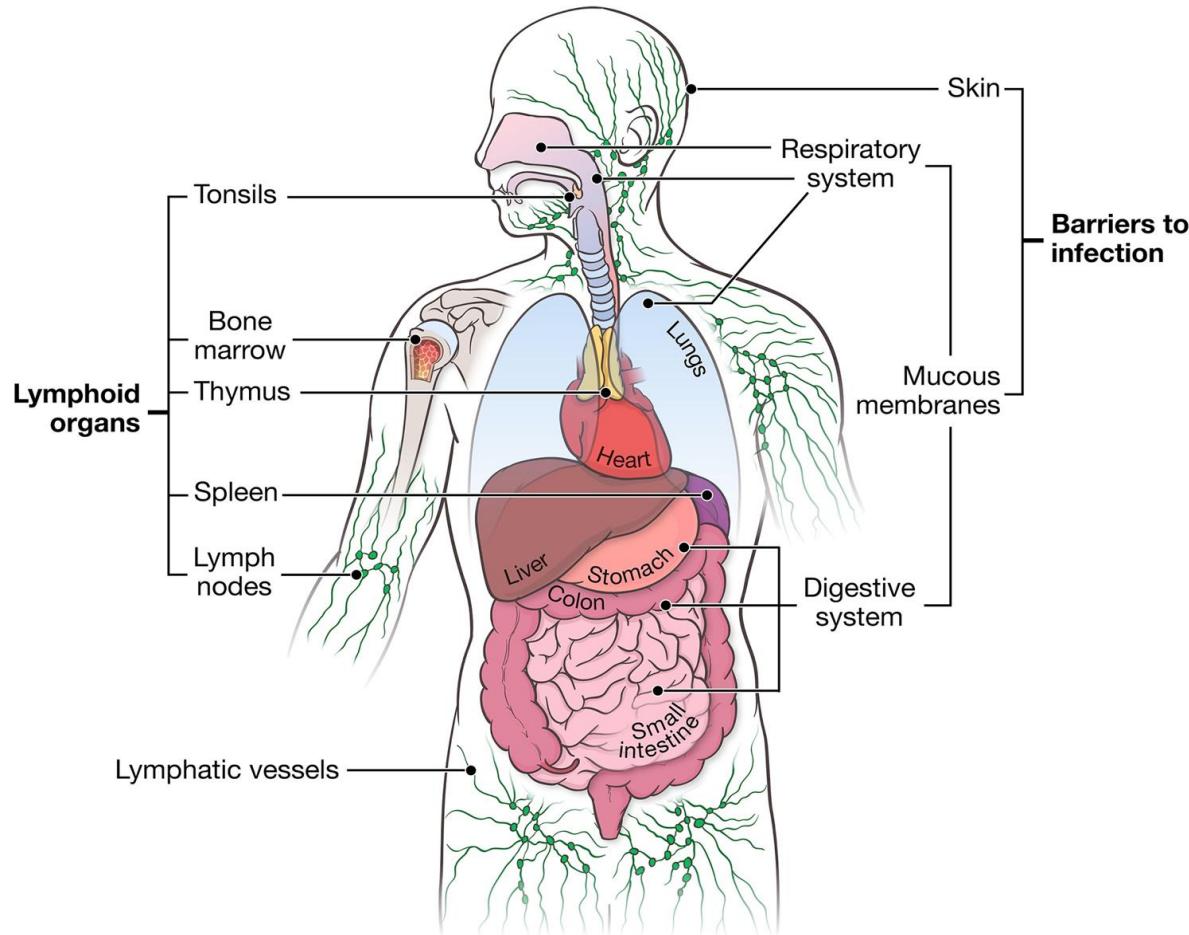
Email: LifeHealthScience@yeah.net

Chapter 12: Health and diseases

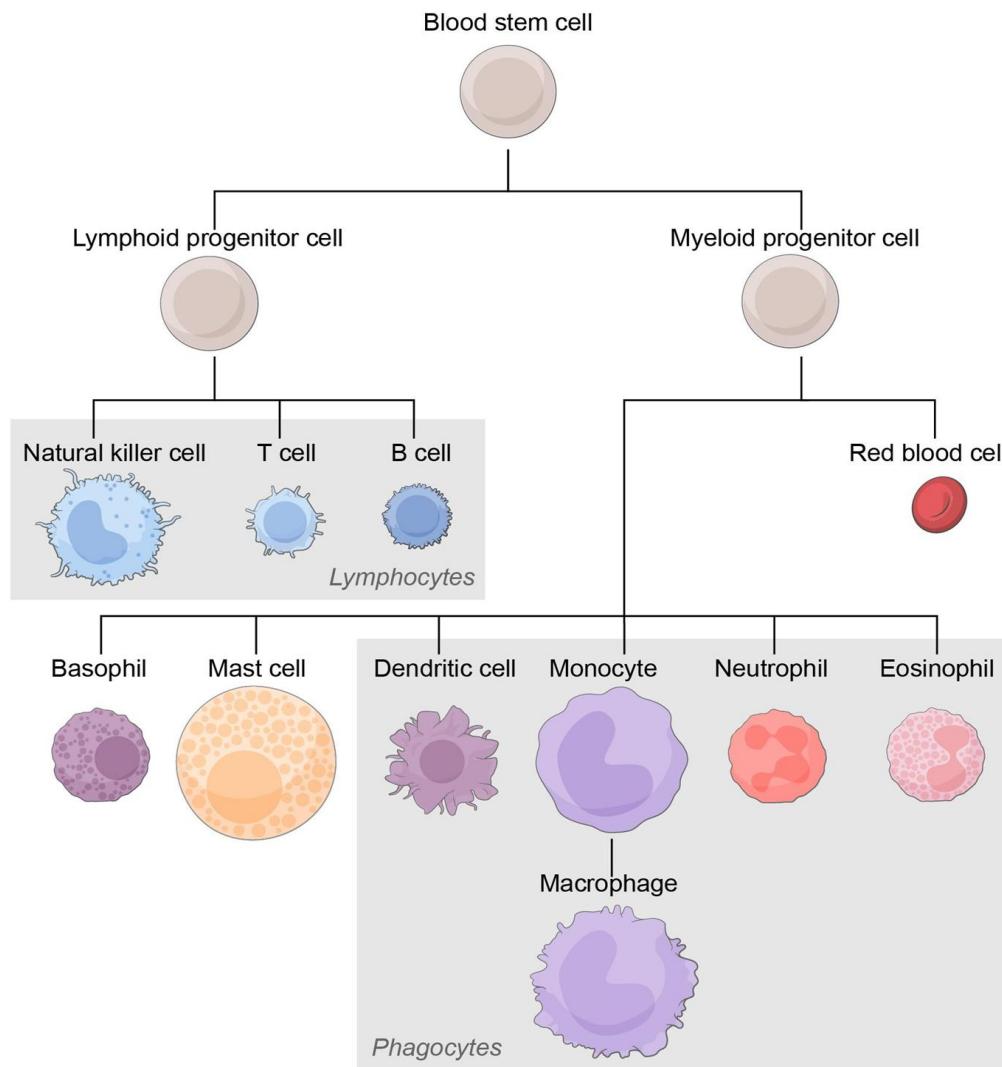
- Human immune and defense system
- Major causes of diseases and pathogens
- Introduction and prevention of serious diseases
- Stay healthy and live a quality life

Human immune and defense system

- Innate Immunity or Natural or Non-specific Immunity
- Acquired Immunity or Adaptive Immunity.



Members of immune cell



Innate Immunity

Immunity present in an organism by birth.

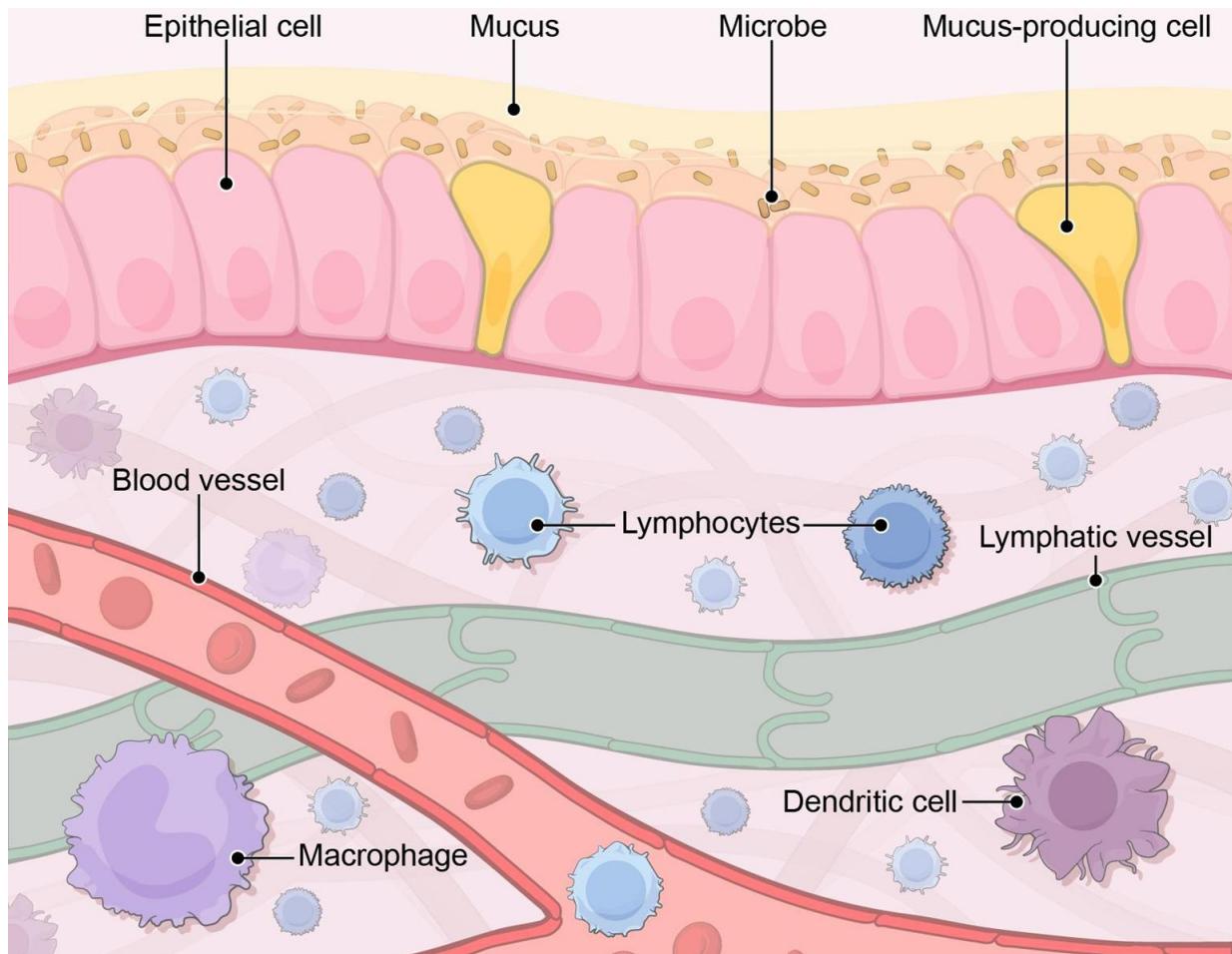
Barriers

- **Physical barrier**

Skin, body hair,
respiratory tract.

- **Physiological
barriers**

Saliva, tear



Innate Immunity

Immunity present in an organism by birth.

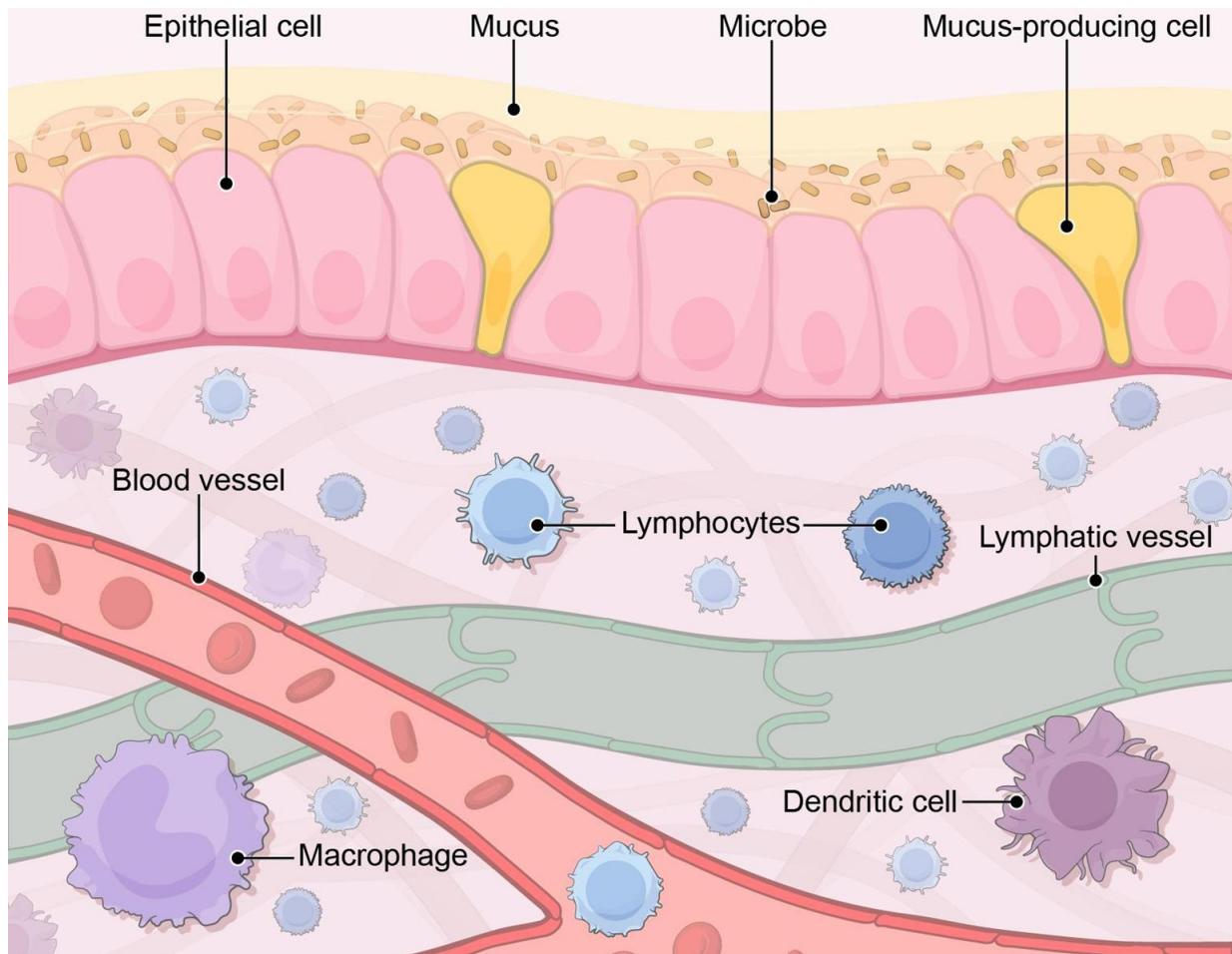
Barriers

- Cellular barrier

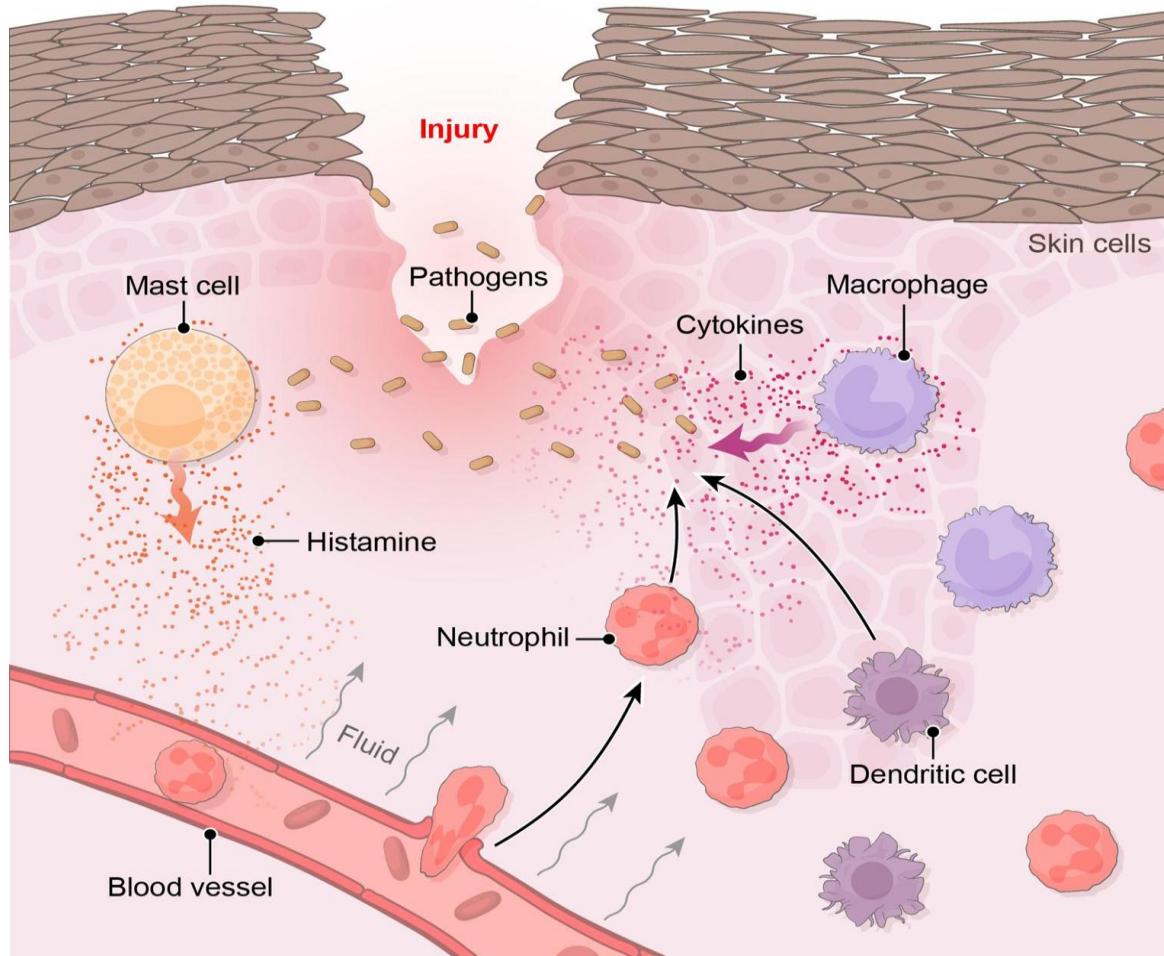
Macrophages,
neutrophils, natural
killer cells

- Cytokine barriers

Interferons



Inflammation-innate immunity

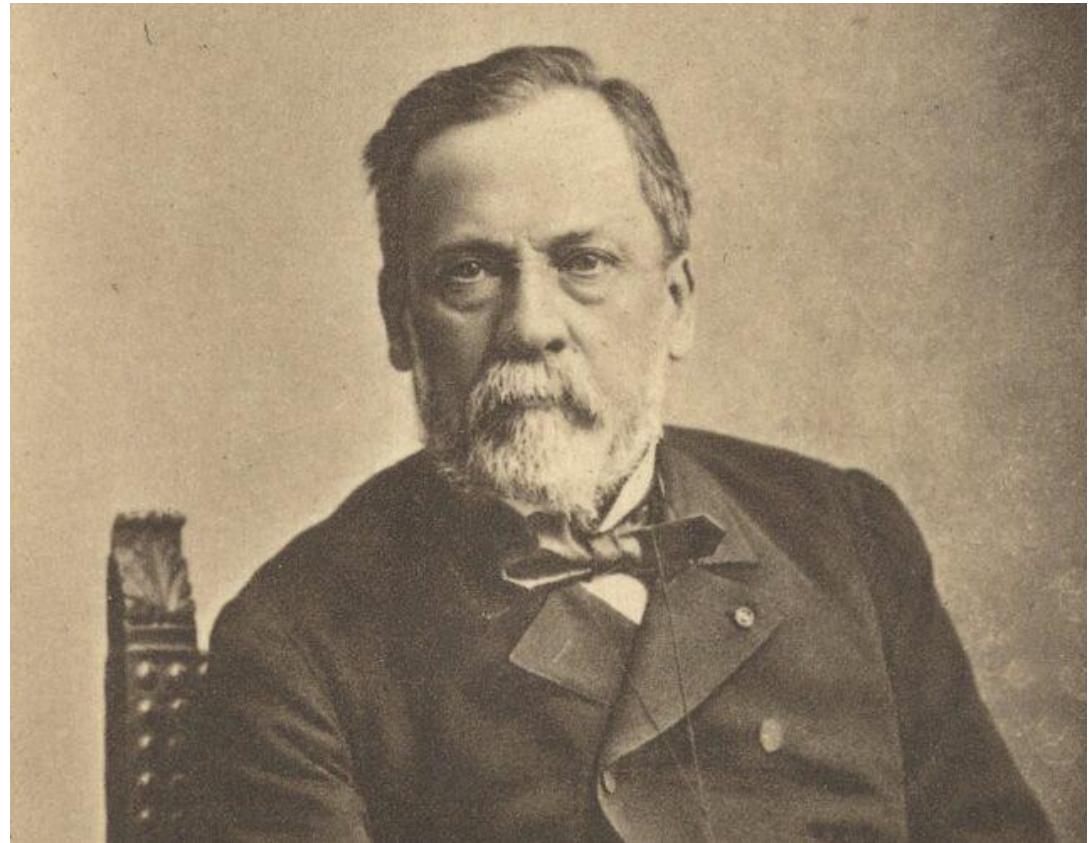


Acquired immunity

Immunity that our body acquires or gains over time.

1776, England,
doctor, Jenner

Smallpox morbidity
was decrease to
70%.



Acquired immunity

Two types

➤ Humoral Immune Response

Mediated by B-lymphocyte, depend on the action of antibody.

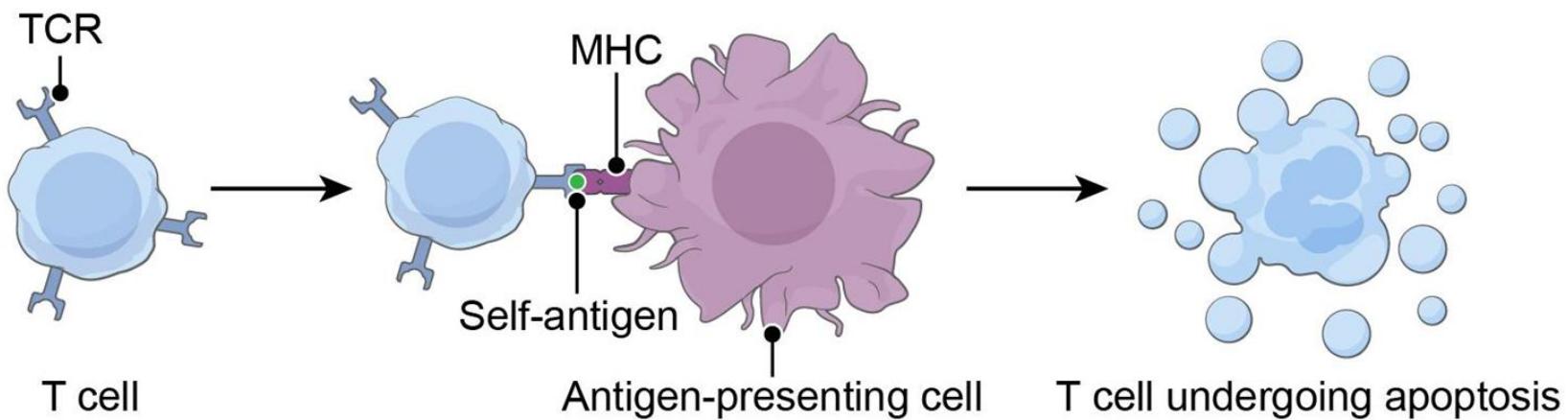
➤ Cell-mediated Immune Response

Mediated by T-lymphocyte.

Major histocompatibility complex (MHC)

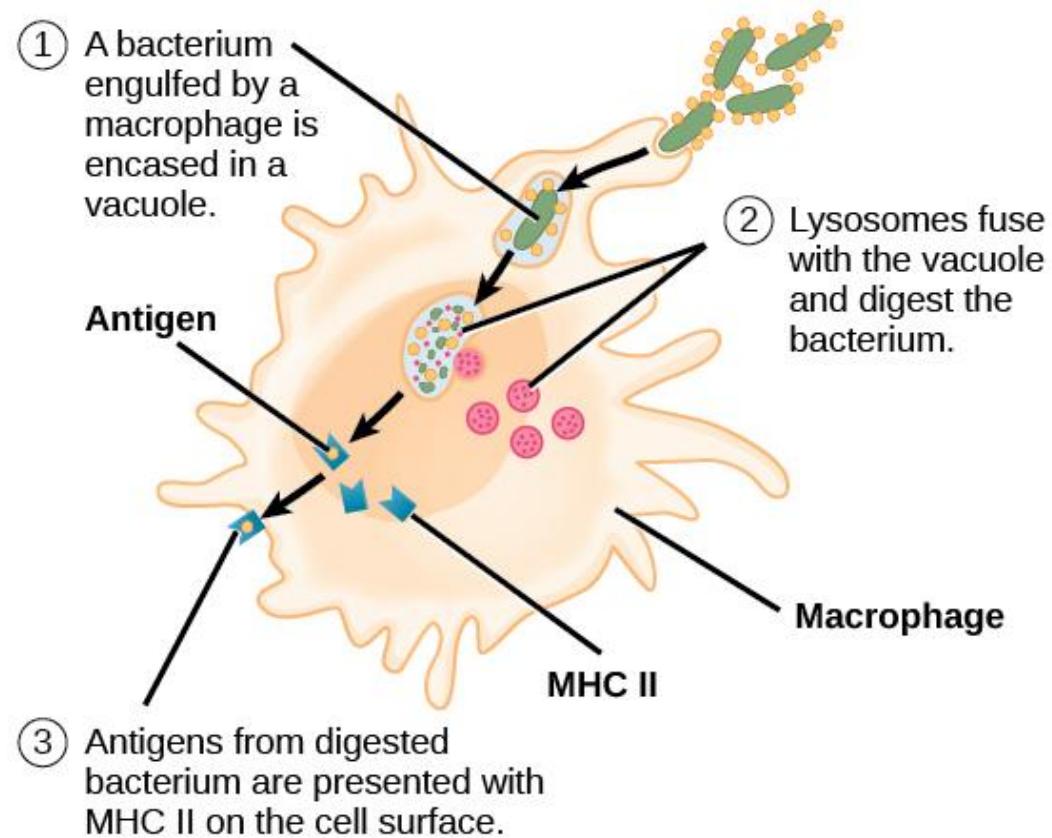
MHC class 1: express in some nucleated cells and platelet.

MHC class 2: normally occurs only on "professional" antigen-presenting cells (APCs): macrophages, B cells, and especially dendritic cells (DCs)

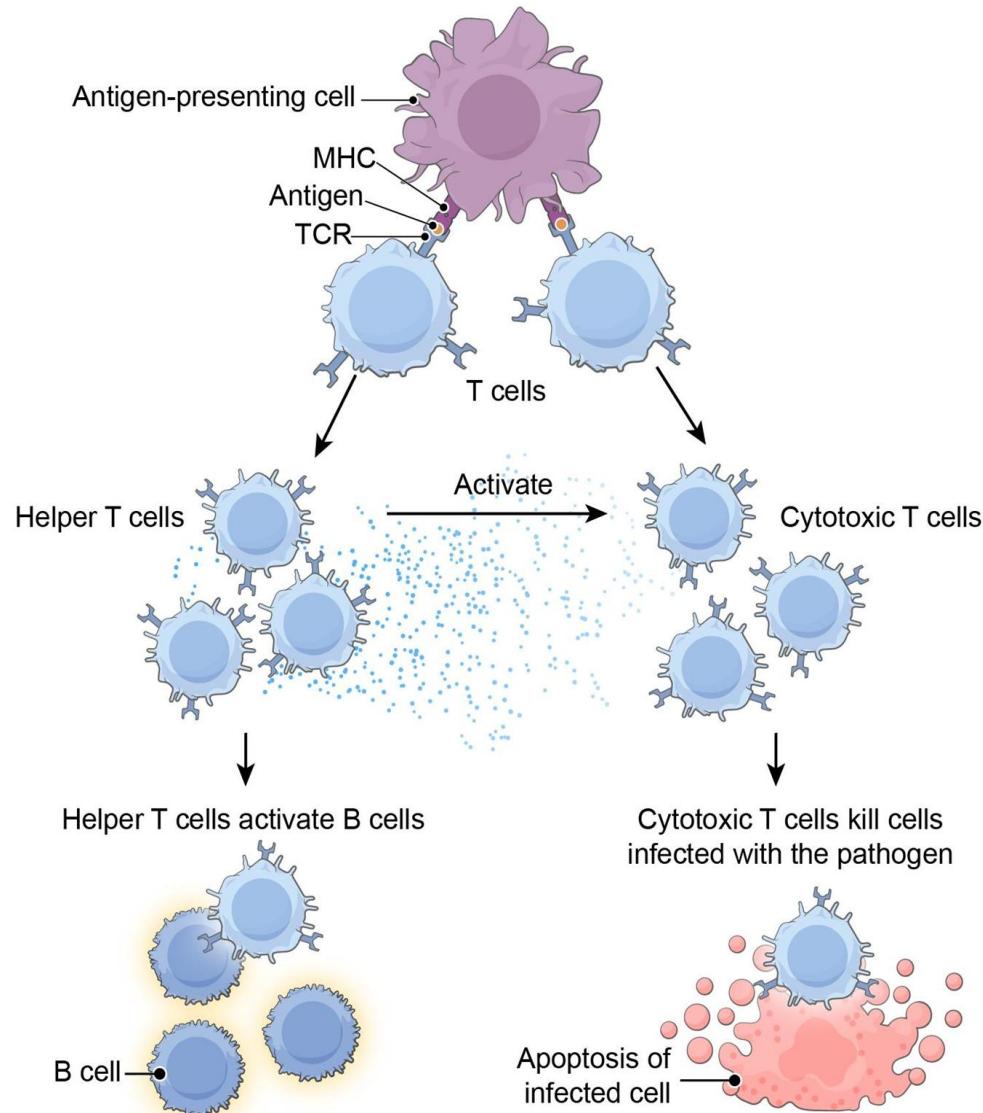


Antigen-Presenting Cells (APC)

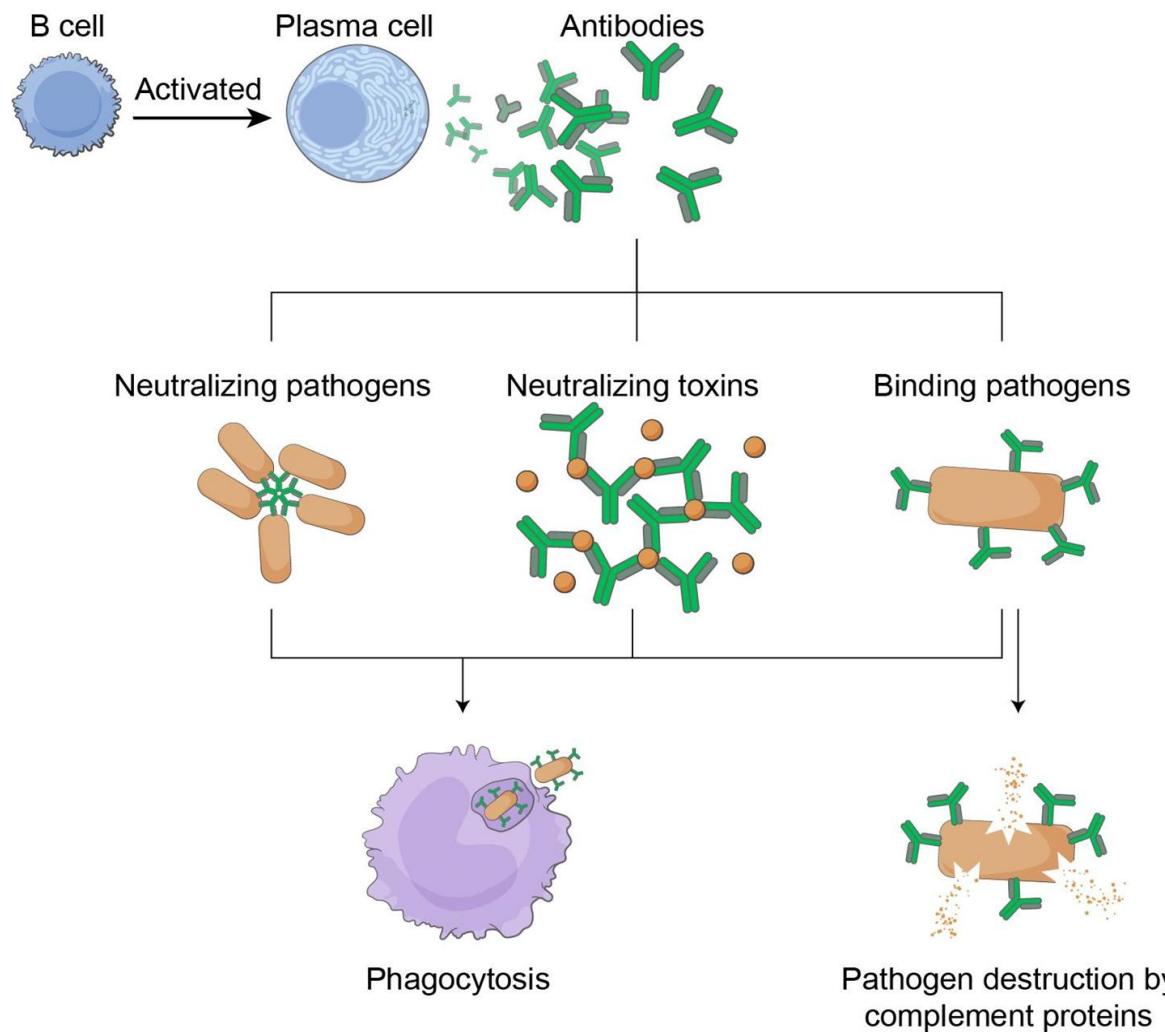
Immune cell that detects, engulfs, and informs the adaptive immune response about an infection, i.e. DC, macrophage cell.



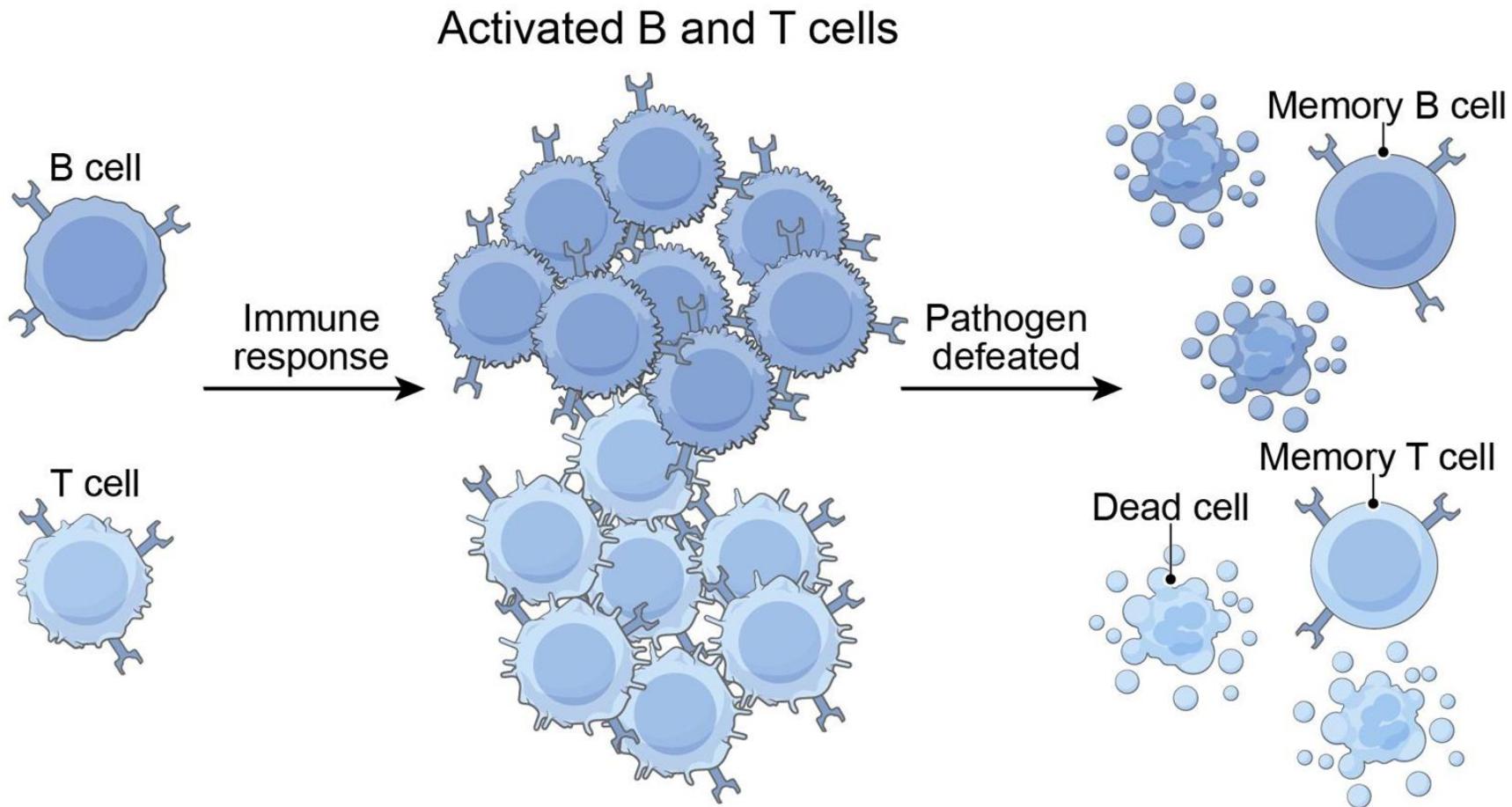
Cell-mediated immune response



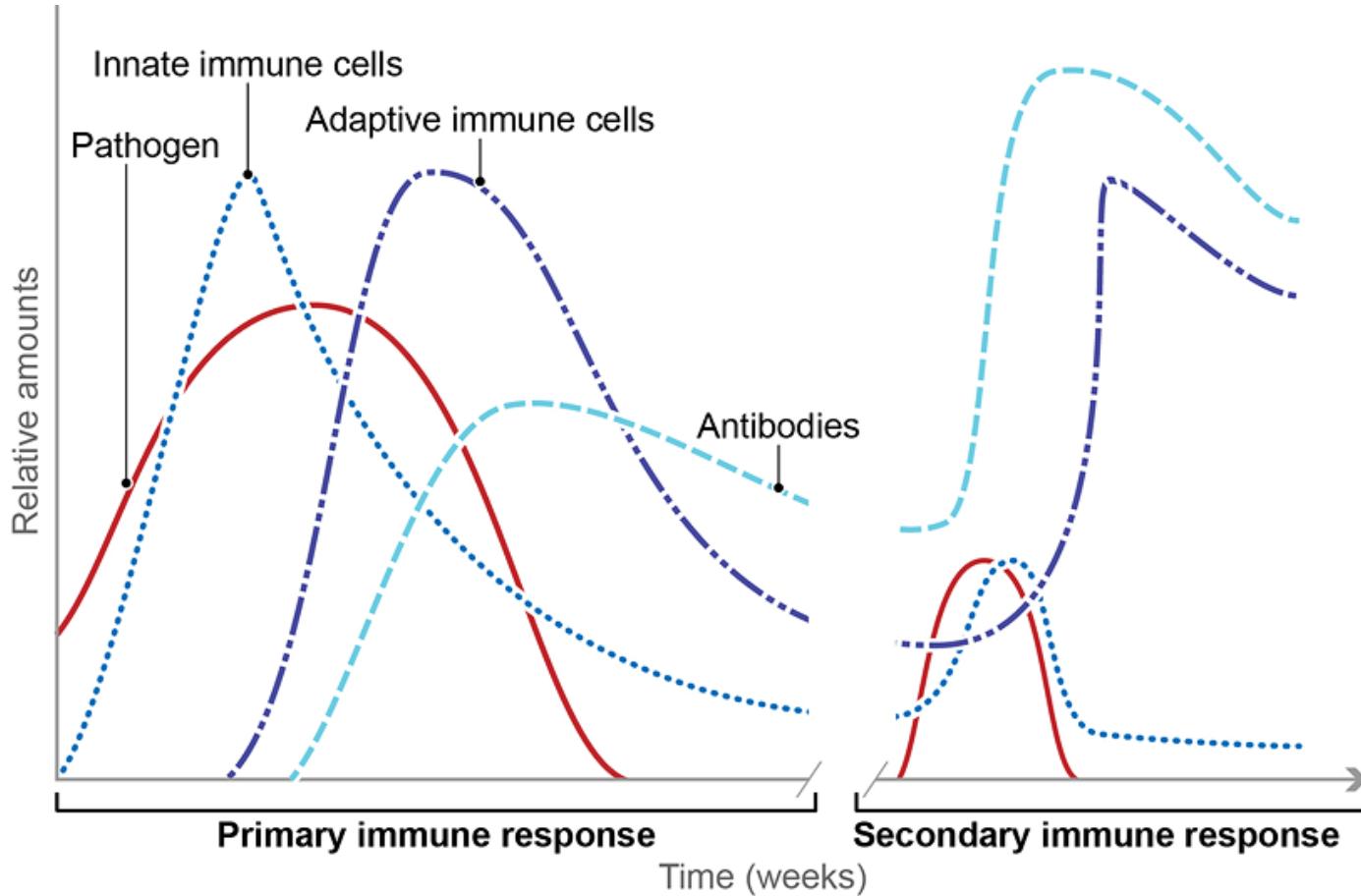
Humoral immune response



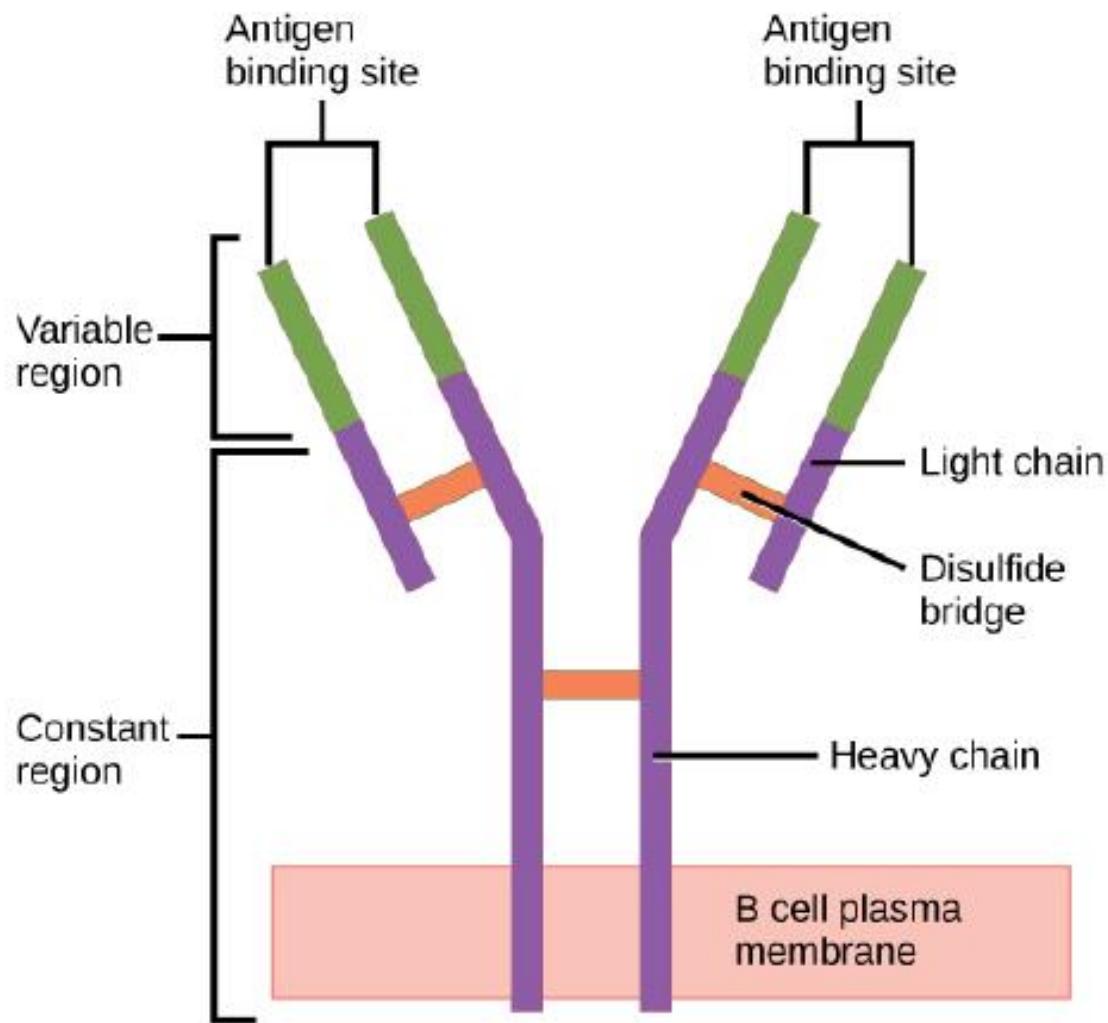
Immunological Memory



Immune responses



Structure of antibodies



Functions of different antibodies

IgA: populate the saliva, tears, breast milk, and mucus. Protect against pathogens

IgD: part of B cell receptor. Activate basophils and mast cells.

IgE: protect against parasitics worm. Responsible for allergic reactions.

IgG: secreted by plasma cells in the blood. Able to cross the placenta into fetus.

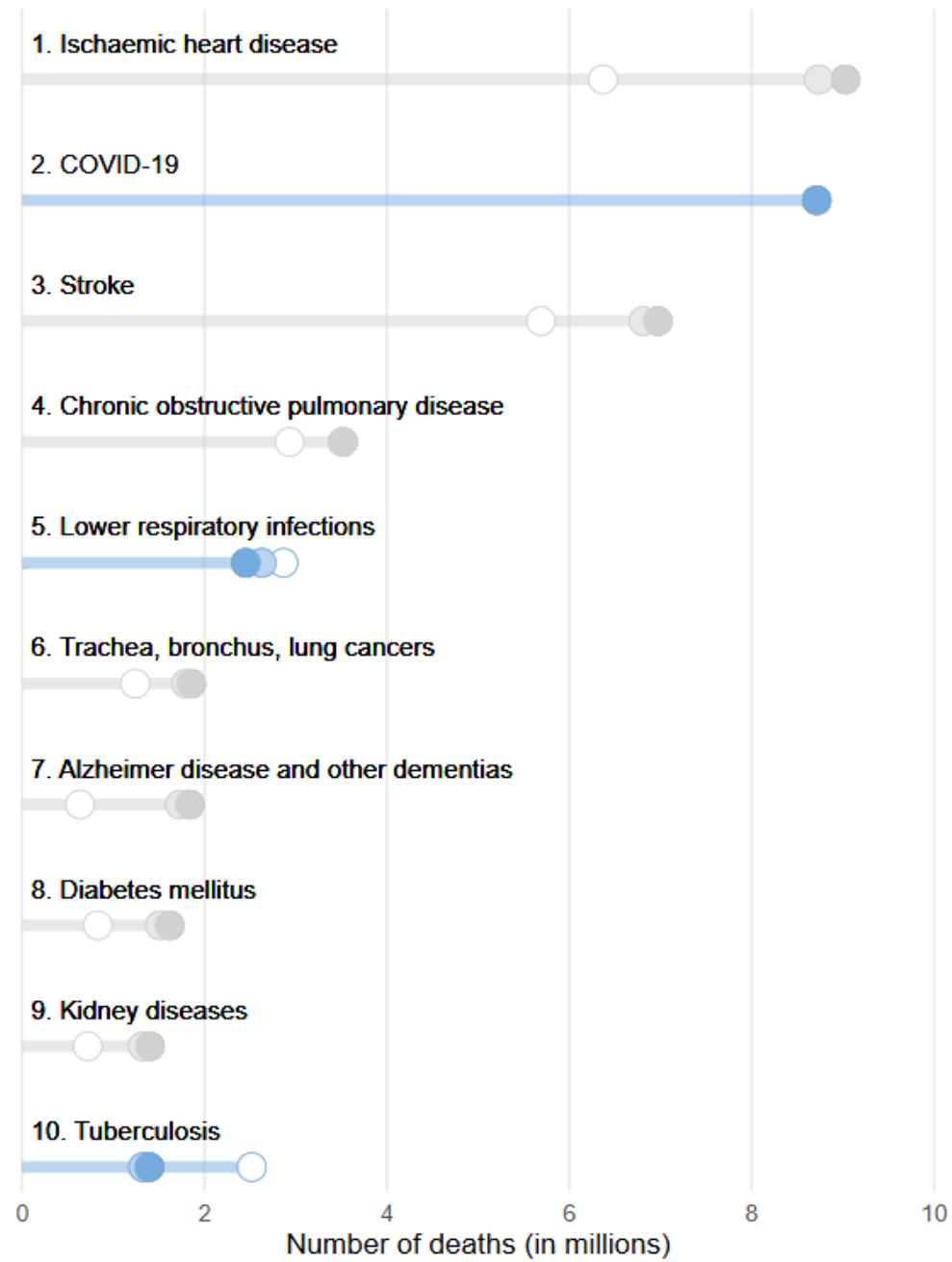
IgM: may be attached to the surface of a B cell or secreted into the blood. Responsible for early stages of immunity.

Major causes of diseases and pathogens

Major causes of diseases and pathogens

- Generally, traditional views hold that diseases occur when pathogenic factors act on the body, disrupting homeostasis and leading to damage in metabolism, function, and structure, while also triggering the body's response to injury.
- Some modern molecular medicine perspectives suggest that diseases result from the response of genes within cells to pathogenic signals via cell receptors and signaling pathways, leading to mutations in the structure or function of specific proteins.
- Causes of diseases, including biological infectious factors, genetic factors, immune factors, physical factors, chemical factors, and psychological factors.

Statistics of major causes of diseases



Pathogens, are the primary and most common causative factors of disease.

- There are many types of infectious pathogens, with the main ones including bacteria, viruses, fungi, mycoplasma, and protozoa.
- The characteristics of infectious diseases include:

Living Pathogens

Infectious or Contagious

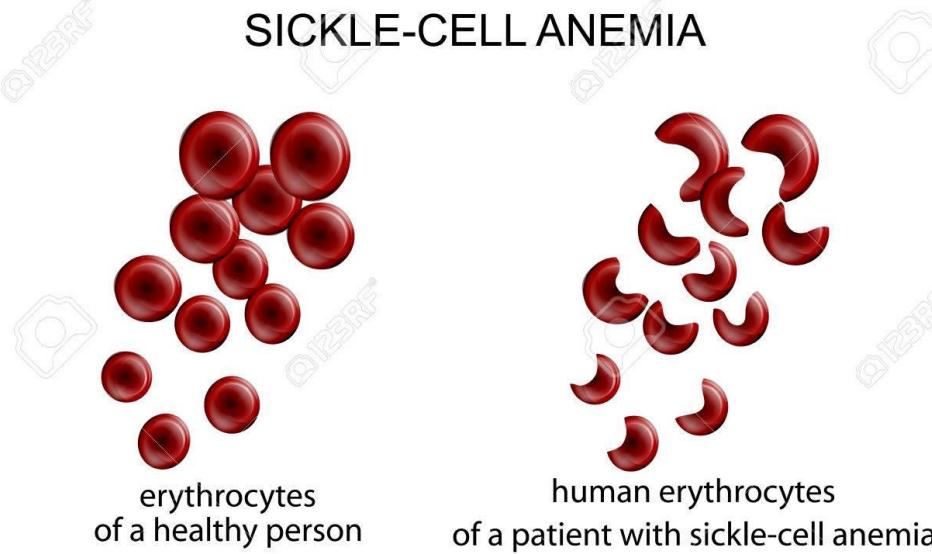
Epidemic, Endemic, and Seasonal

Immunogenicity

Epidemic Potential.

Chromosomal abnormalities and gene mutations can directly lead to hereditary diseases

- Examples of chromosomal abnormalities include congenital intellectual disability and sickle cell anemia.



Immune factors

- Diseases caused by immune factors in humans mainly fall into three categories:

Immunodeficiency Diseases

Autoimmune Diseases

Allergic Reactions

Physical and chemical causative factors

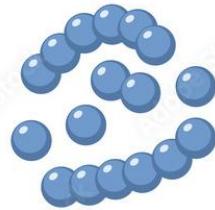
- **Physical Causative Factors:** These include violence, traffic accidents, natural disasters, occupational injuries, extreme temperatures or pressures, noise, electric currents, ultraviolet light, lasers, and radiation.
- **Chemical Causative Factors:** These include strong acids, strong bases, chemical toxins, biological toxins, abnormal medications, and toxic or harmful substances in the environment.

Bacteria

- Bacteria are a group of small, simple, prokaryotic single-celled organisms. They can be classified based on their shape into three main categories: cocci (spherical), bacilli (rod-shaped), and spirilla (spiral-shaped).

Basic Shapes of Bacterial Cell

Spherical



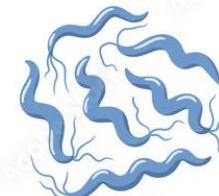
Cocci

Rod-shaped



Bacilli

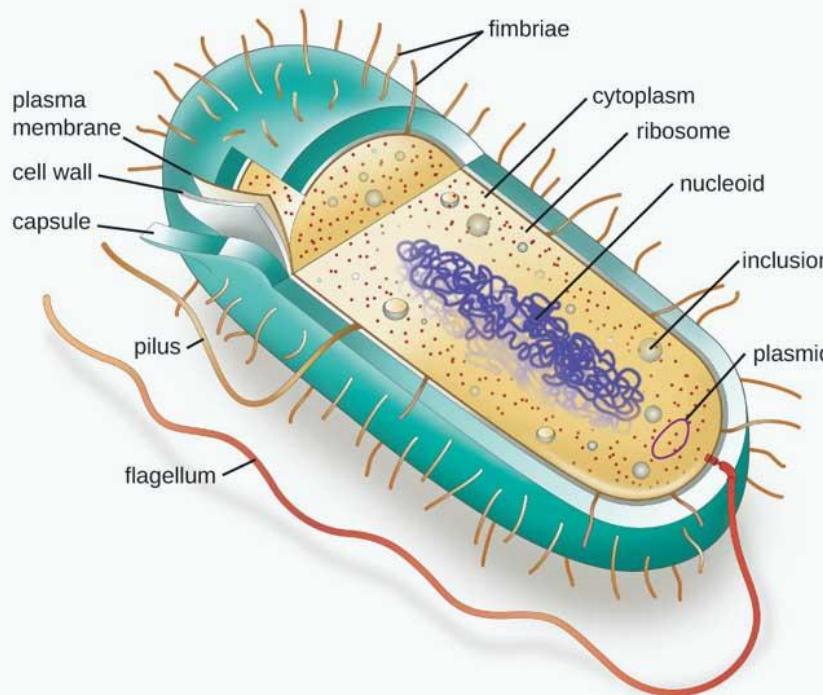
Spiral



Spirillum

Bacteria

- The basic structure of bacterial cells includes : the cell wall, cell membrane, cytoplasm, and nucleoid. Some bacteria also possess specialized structures such as capsules, flagella, pili, and endospores.



Bacteria

- The outermost layer of bacteria is the cell wall, primarily composed of peptidoglycan. This structure is formed by alternating N-acetylglucosamine and N-acetylmuramic acid linked by short peptides to create a mesh-like framework.
- Classifies bacteria into Gram-positive and Gram-negative groups.

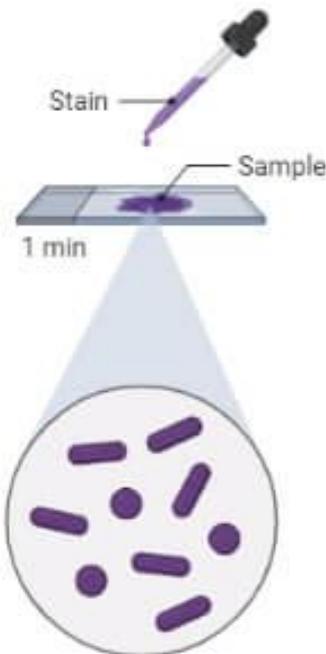
Bacteria

Gram staining

Step 1

Crystal violet

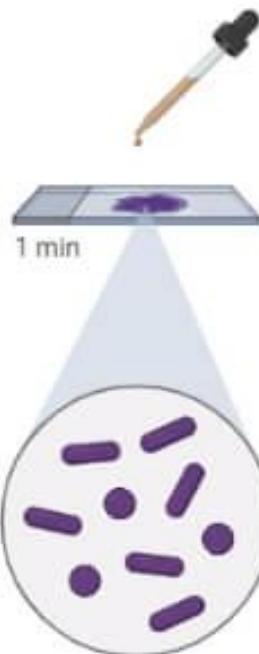
Primary stain added to specimen smear.



Step 2

Iodine

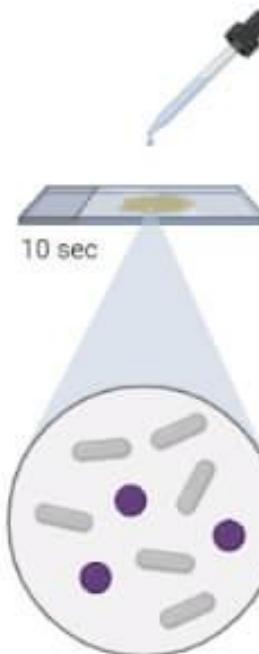
Mordant makes dye less soluble so it adheres to cell walls.



Step 3

Alcohol

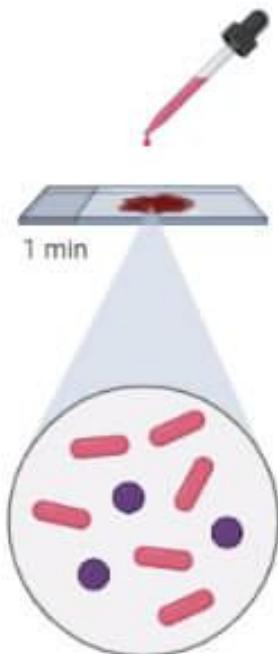
Decolorizer washes away stain from gram (-) cell walls.



Step 4

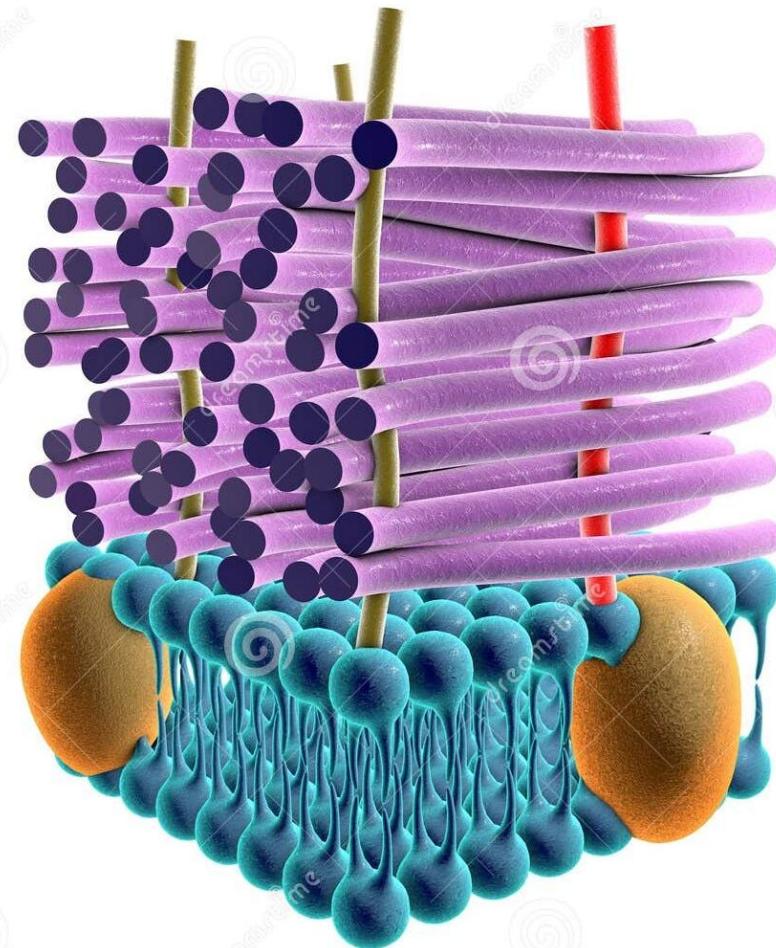
Safranin

Counterstain allows dye adherence to gram (-) cell walls.



Bacteria

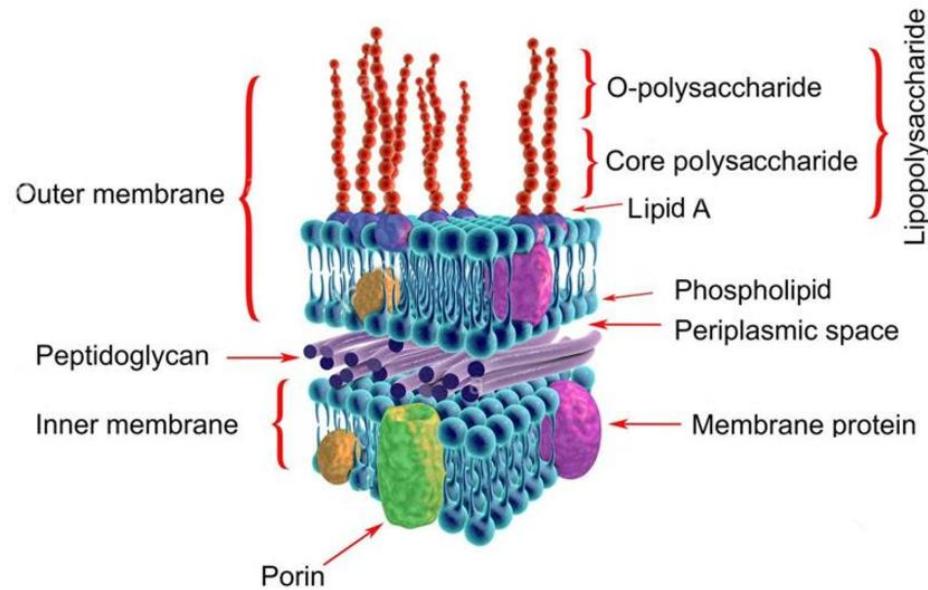
- Gram positive:
thicker cell wall,
containing a large
amount of
peptidoglycan and
teichoic acids with
closely woven
mesh structures.



Bacteria

Gram negative

- A thinner cell wall with less peptidoglycan and a more loosely woven mesh.
- An outer membrane layer composed of lipopolysaccharides and lipoproteins outside the peptidoglycan layer.



Bacterial Nutrition Types

- Chemoheterotrophy: Bacteria obtain energy and carbon sources by consuming organic matter.
- Chemoautotrophy: Bacteria use CO_2 as a carbon source and derive energy from simple inorganic substances like H_2S , NH_3 , or Fe^{2+} .
- Photoautotrophy: Bacteria harness light energy to synthesize organic matter from CO_2 and obtain energy.
- Photoheterotrophy: Bacteria absorb light energy while using organic matter as a carbon source.

- **Reproduction and Cultivation**
- Bacteria reproduce through cell division, which is a key characteristic that enables rapid proliferation.
- Most bacteria can be artificially cultured, and this artificial cultivation is widely applied in scientific research and industrial production.
- **Natural Distribution and Pathogenicity**
- Bacteria are widely distributed in nature.
- Pathogenic bacteria are those that cause physiological dysfunction in the host through infection.

Culturing of bacteria



Bacteria toxin

- **Exotoxins:** These are toxic proteins secreted by bacteria into their environment, often causing damage to the host's cells or tissues.
- **Endotoxins:** These are components of the bacterial cell wall, specifically lipopolysaccharides (LPS) found in Gram-negative bacteria, which can trigger strong immune responses when released into the host's bloodstream.

Exotoxin

- Exotoxins have selective toxic effects on the organs and tissues of the host, and they are generally highly potent. Examples include:
- **Diphtheria toxin:** Causes damage primarily to the heart and nervous system.
- **Tetanus toxin:** Affects the nervous system, leading to muscle spasms and rigidity.
- **Anthrax toxin:** Disrupts cellular processes and can lead to severe systemic effects.
- These toxins can cause significant harm even in very small amounts due to their high toxicity.

Endotoxin

- Endotoxins are typically composed of three parts: O-specific polysaccharides, a non-specific core polysaccharide, and lipid A. They are highly heat-resistant and usually require heating at 160° C for 2 to 4 hours to be inactivated.
- The toxic effects of endotoxins are generally weaker than those of exotoxins, but they can still trigger significant physiological responses, including:

Fever,

Leukocytosis (increased white blood cell count)

Shock

Coagulation responses

- These reactions can lead to serious health complications, particularly in cases of severe infection.

Route of pathogen infecting human

- Airborne Transmission and Respiratory Infections
- Gastrointestinal Infections
- Contact Infections
- Wound Infections
- Some pathogenic bacteria can infect through multiple routes listed above.

Antibiotics

Antibiotics are substances that inhibit the growth of or kill bacteria. They are widely used in medicine to treat bacterial infections.

- **Bactericidal Antibiotics:** These kill bacteria directly. Examples include:
 - Penicillin (e.g., amoxicillin)
 - Cephalosporins
- **Bacteriostatic Antibiotics:** These inhibit bacterial growth and reproduction without necessarily killing them. Examples include:
 - Tetracyclines
 - Macrolides (e.g., erythromycin)

Antibiotics Mechanism of Action

- **Cell Wall Synthesis Inhibition:** Antibiotics like penicillin's disrupt the formation of the bacterial cell wall.
- **Protein Synthesis Inhibition:** Some antibiotics target the bacterial ribosomes, preventing protein production.
- **Nucleic Acid Synthesis Inhibition:** Certain antibiotics interfere with DNA or RNA synthesis.
- **Metabolic Pathway Inhibition:** Some antibiotics block essential metabolic pathways in bacteria.

Antibiotics Resistance

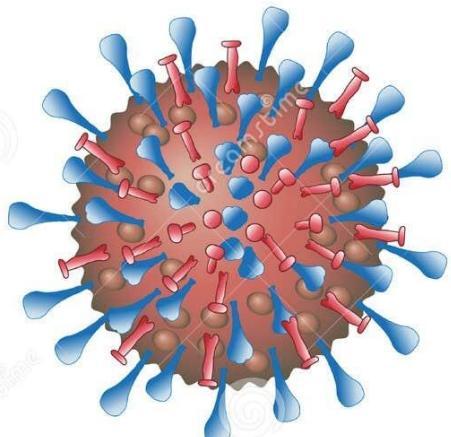
- The misuse and overuse of antibiotics have led to antibiotic resistance, making some bacterial infections harder to treat. This occurs through various mechanisms, including:
- Genetic mutations in bacteria
- Horizontal gene transfer
- Enzymatic degradation of antibiotics

Virus

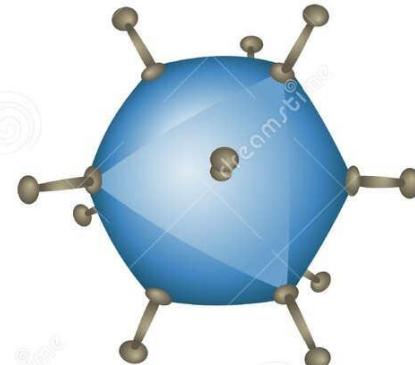
- Viruses are a class of extremely small, simple structures composed of a protein coat surrounding a single nucleic acid, often referred to as "parasitic chemical particles."
- They lack a cellular structure and cannot reproduce independently; instead, they proliferate by replicating within host cells.

Characteristics of Viruses

- **Varied Shapes and Sizes:** Viruses exhibit a wide range of shapes and sizes.
- **Basic Structure:** The fundamental structure of a virus particle generally consists of nucleic acid (either DNA or RNA) enclosed within a protein coat, known as the capsid.
- **Nucleic Acid Type:** Each virus contains only one type of nucleic acid, which can be:
 - **Linear or Circular**
 - **Single-stranded or Double-stranded**



Influenza



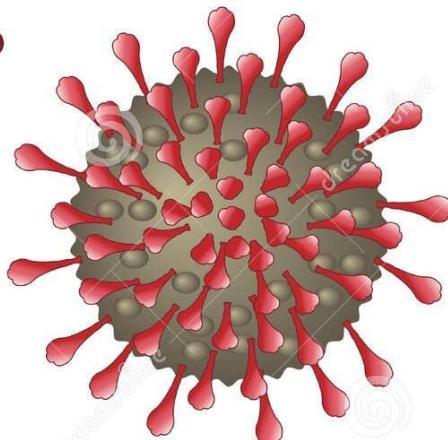
Adenovirus



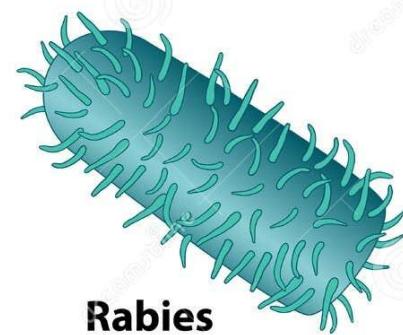
Bacteriophage



Ebola



Coronavirus



Rabies

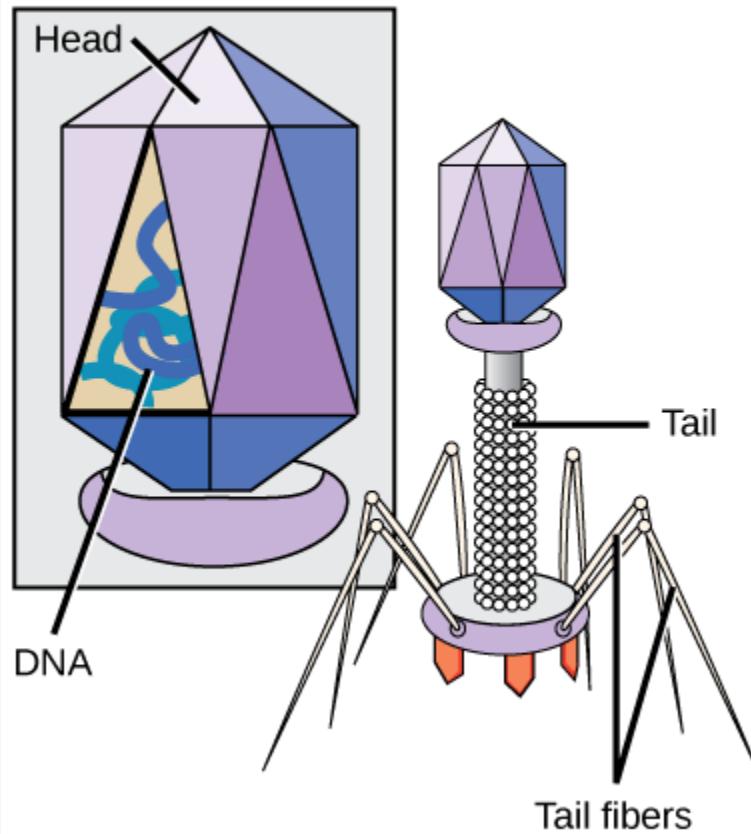
Replication

- Viruses cannot reproduce on their own. They must enter a host cell and utilize the host's molecular genetic machinery to replicate.

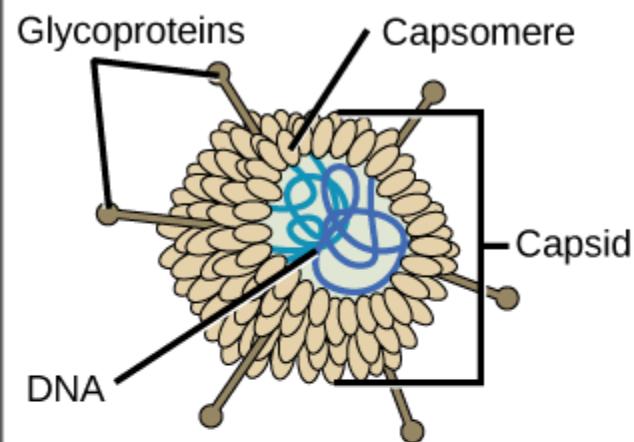
Host Specificity

- Each virus can only infect specific hosts. Viruses that infect bacteria are specifically known as **bacteriophages**.

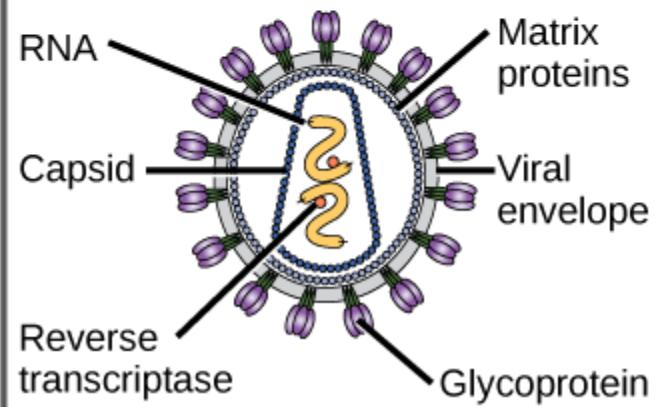
Bacteriophage T4



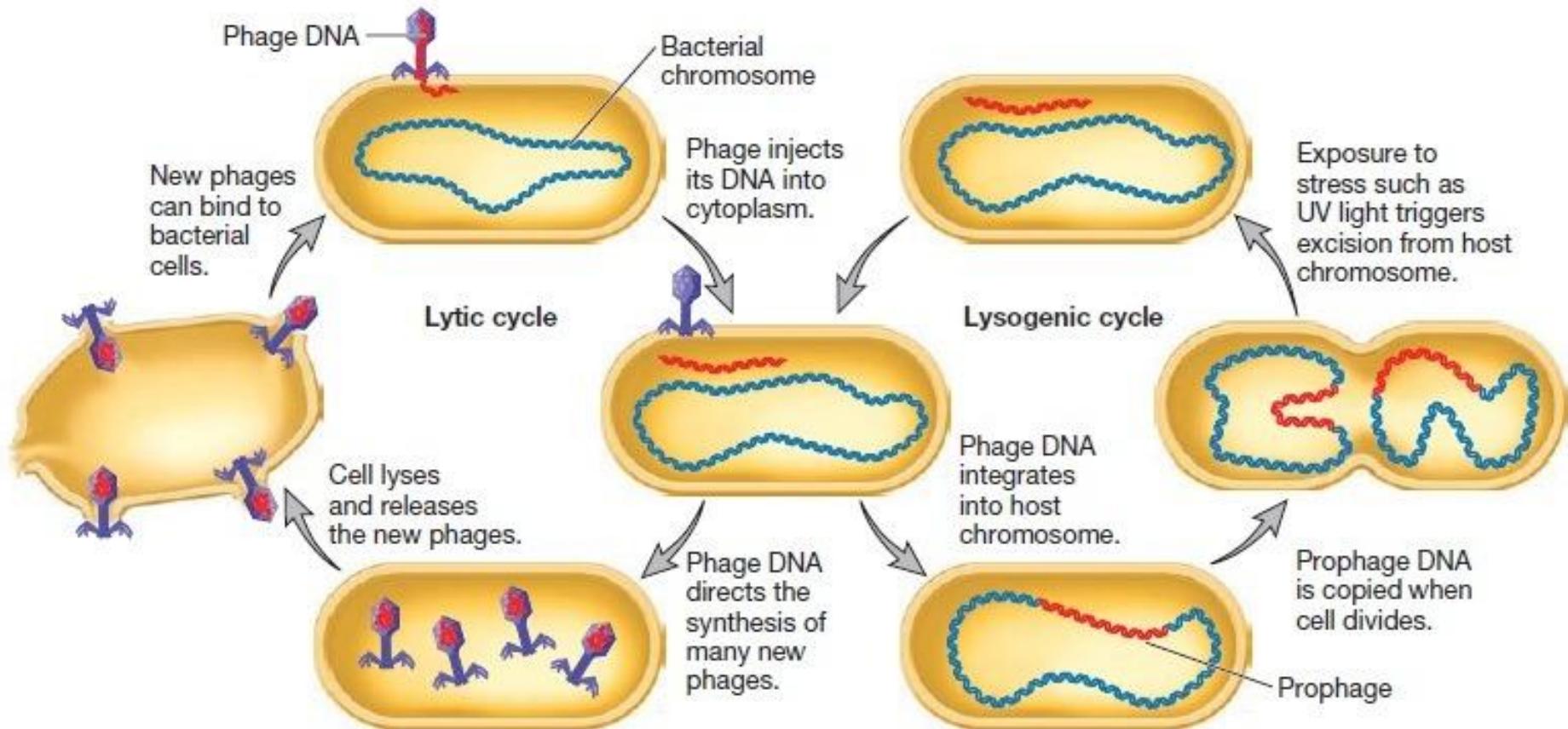
Adenovirus



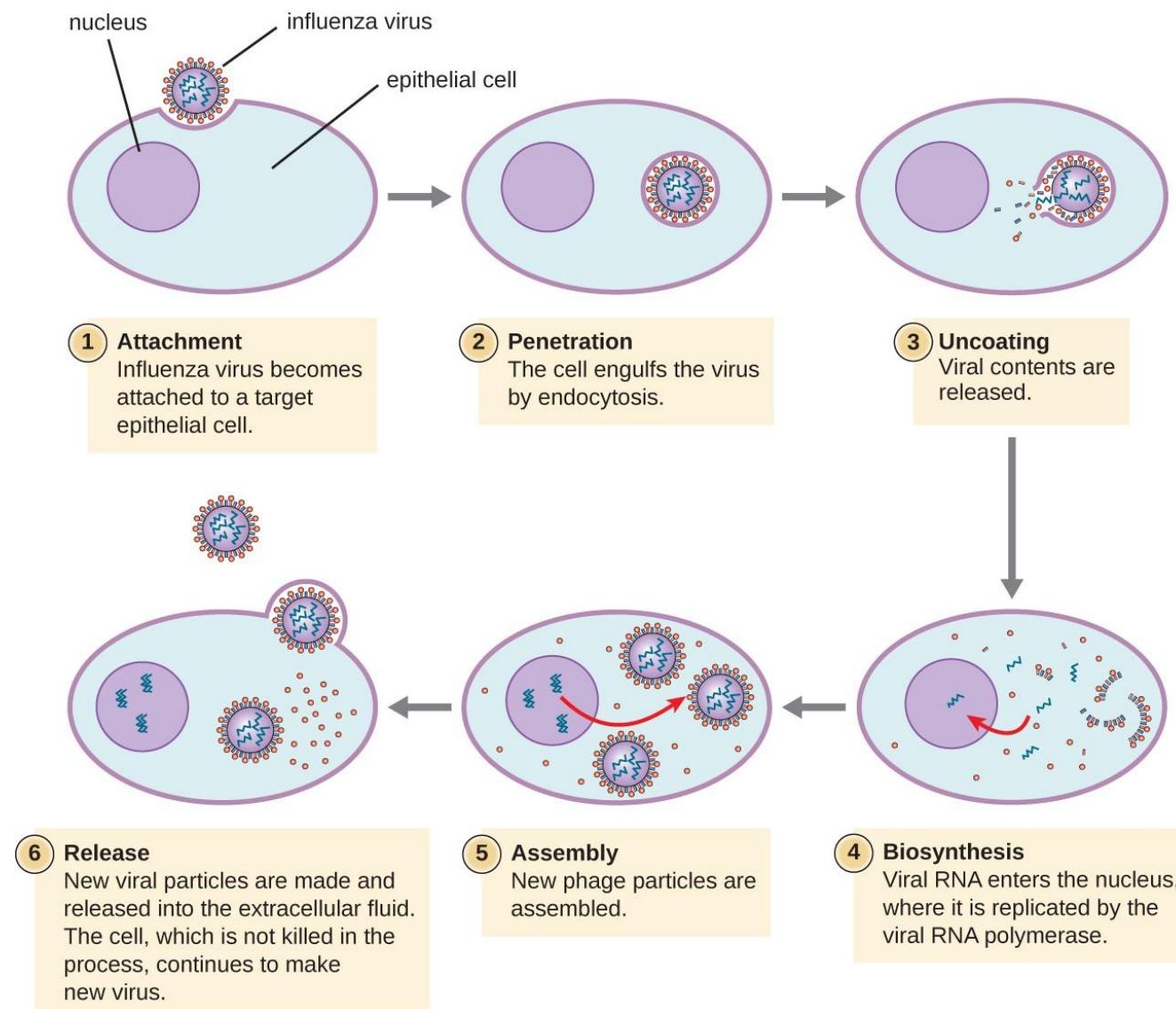
HIV retrovirus



T4 Bacteriophage Replication Process: Lytic Cycle



Influenza Virus Replication Process: Lysogenic Cycle



Viroid

- **Definition:** Viroids are small, circular RNA molecules that lack a protein coat. They consist solely of a single strand of RNA.
- **Host:** Most known viroids infect plant cells and can cause various diseases in economically important plants, leading to significant agricultural losses.
- **Mechanism:** Viroids disrupt normal plant cellular processes by interfering with RNA transcription and replication.

Prions

- **Definition:** Prions are infectious protein particles, They do not contain nucleic acids (DNA or RNA).
- **Characteristics:** Prions are misfolded proteins that can induce other normal proteins in the brain to misfold, leading to neurodegenerative diseases.
- **Diseases:** Prions are associated with several serious conditions, such as:
 - **Bovine Spongiform Encephalopathy (BSE),** commonly known as "mad cow disease."
 - **Creutzfeldt-Jakob Disease (CJD)** in humans.

Introduction and prevention of serious diseases

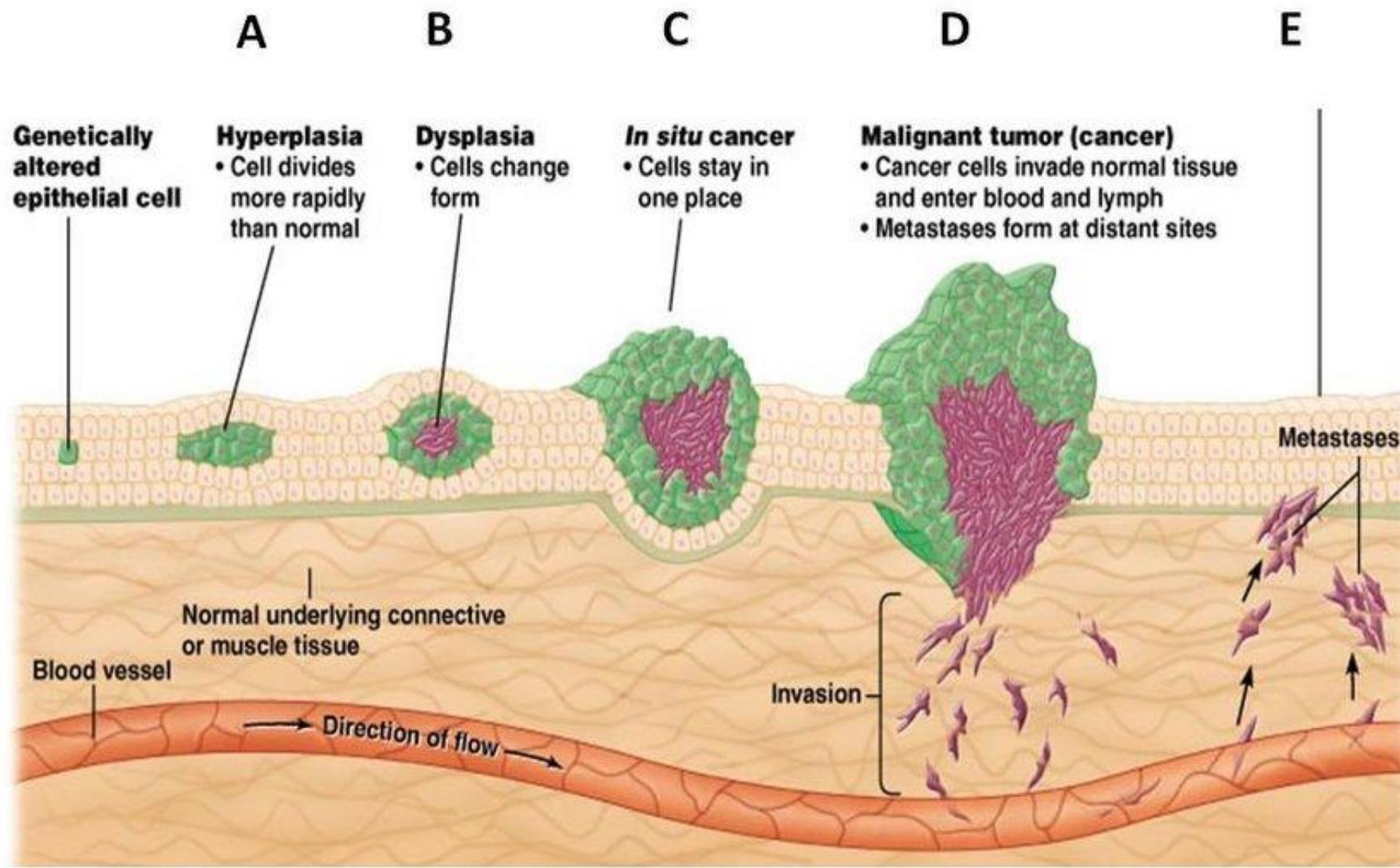
Cancer

Cancer, also known as malignant tumors, occurs when normal cell growth and division become uncontrolled, leading to the formation of abnormal cell masses, or tumors, that continue to grow.

Characteristics of Cancer

- **Tumor Cell Division:** The daughter cells produced by the division of tumor cells are also cancerous.
- **Metastasis:** Tumor cells can spread to other parts of the body through lymphatic vessels and blood vessels, forming new tumors.
- **Impact on Organ Function:** The growth and spread of tumors severely damage the structure and function of tissues and organs, ultimately leading to death.

Cancer Development



Chemical Carcinogens

Key factors contributing to the development of cancer include:

- **Chemical Carcinogens:** Substances in the environment that can cause cancer.
- **Radiation:** Both ionizing and non-ionizing radiation can lead to cancer.
- **Viruses:** Certain viruses are linked to the development of specific cancers.

Causes of Cancer

Key factors contributing to the development of cancer include:

- **Chemical Carcinogens:** Substances in the environment that can cause cancer.
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Causes of Cancer

Key factors contributing to the development of cancer include:

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Proto-oncogenes

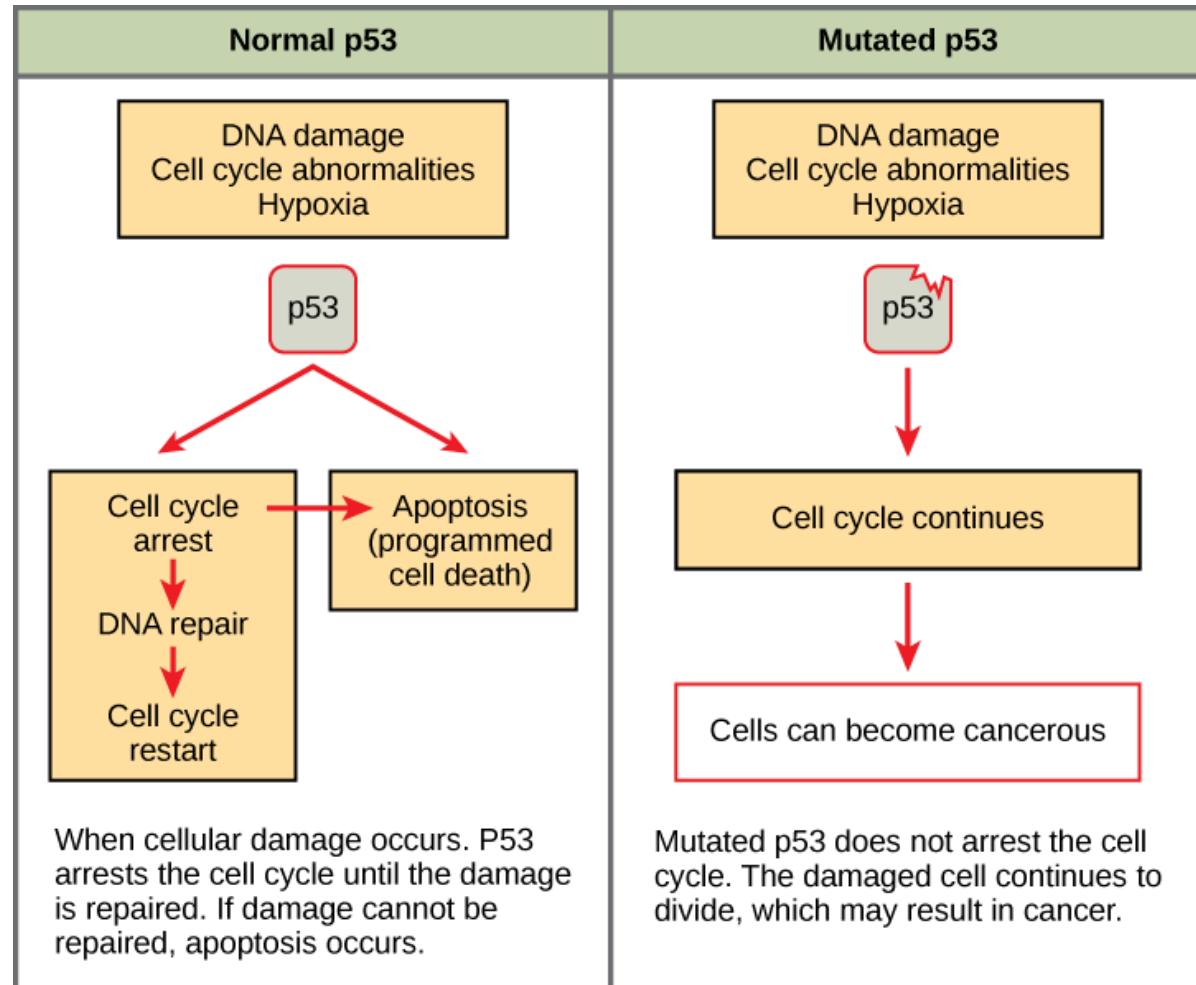
Oncogenes in humans and other animal cells originate from proto-oncogenes. Proto-oncogenes are genes that regulate and control cell growth, division, and the cell cycle.

There are four types of mutations that can convert proto-oncogenes into oncogenes:

- Gene Amplification and Enhancement:
- Chromosomal Translocation
- Gene Transposition
- Point Mutation

Tumor Suppressor Genes

Genes that encode proteins to prevent uncontrolled cell division are known as **tumor suppressor genes**. Mutations that inactivate or reduce the expression of these genes can lead to cancer. The **p53 gene** was the first identified tumor suppressor gene, discovered in 1979.

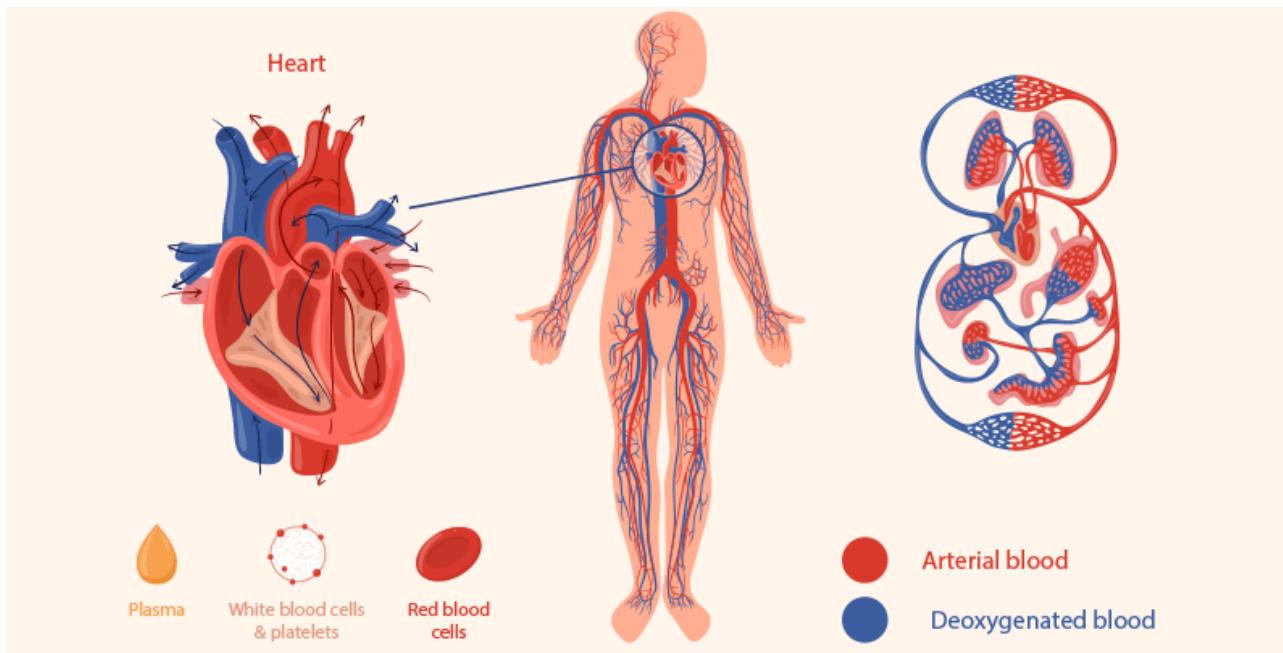


Multifactorial Nature of Cancer

- The development of cancer is multifactorial and closely related to the activation or mutation of various genes, including oncogenes, tumor suppressor genes, and apoptosis-related genes. The onset of cancer is often a complex process involving the accumulation of multiple mutations over time.

Cardiovascular Diseases

The heart and blood vessels form the circulatory system, which is essential for transporting blood throughout the body. The blood supply to the heart itself is primarily provided by the **coronary arteries**. The blood vessels connected to the heart are classified into three main types: arteries, veins and capillaries.



Cardiovascular Diseases

- Cardiovascular diseases, particularly **hypertension** (high blood pressure) and **atherosclerosis**, remain the most common and severe health issues globally.

Hypertension

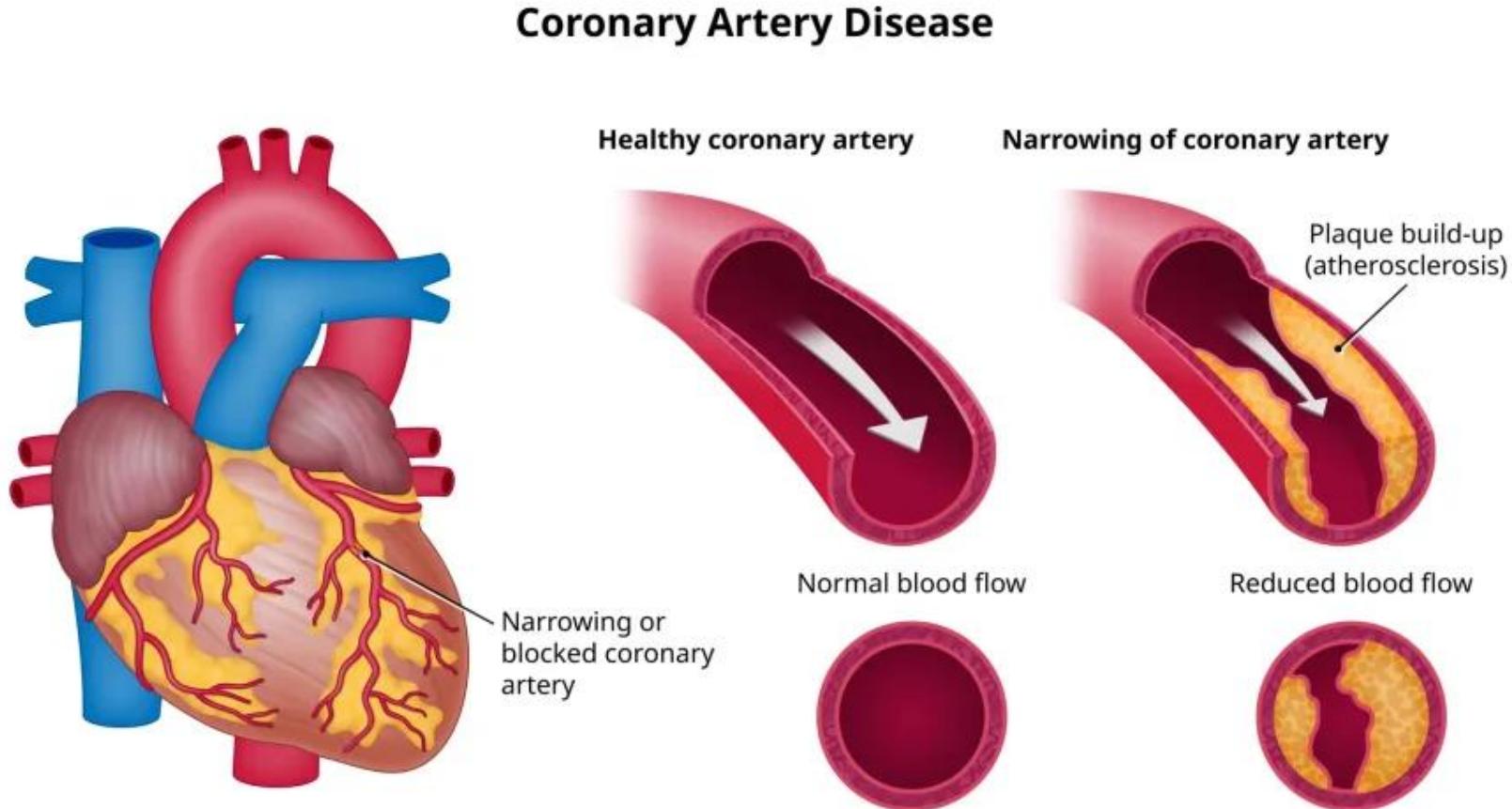
- Hypertension is characterized by elevated arterial blood pressure. Key points include:
- **Systolic Pressure:** The highest pressure in the arteries during heart contraction (systole).
- **Diastolic Pressure:** The lowest pressure in the arteries during heart relaxation (diastole).

Cardiovascular Diseases-Atherosclerosis

Atherosclerosis: buildup of lipids and fibrous materials within the inner walls of arteries.

- Several factors directly contribute to the development of coronary heart disease, including: elevated blood lipids, obesity, hypertension
- Prevention Strategies: balanced diet, regular physical activity, lifestyle modifications

Coronary Artery Disease



AIDS (Acquired Immunodeficiency Syndrome)

- **AIDS** (Acquired Immunodeficiency Syndrome) was first confirmed in 1981. It is caused by the **Human Immunodeficiency Virus (HIV)**, which attacks the body's immune system.
- **Infection Rates:** As of 2021, approximately **38 million** people worldwide are living with HIV, with an estimated **36 million** deaths attributed to AIDS-related illnesses since the epidemic began.

Transmission and Health Threat

- HIV spreads primarily through unprotected sexual contact, sharing needles, and from mother to child during childbirth or breastfeeding.
- The virus specifically targets **CD4+ T cells**, which are essential for a functioning immune response, leading to a gradual decline in immune function and increased susceptibility to infections and certain cancers.

Current Challenges and Advances

- **Treatment:** While antiretroviral therapy (ART) can effectively manage HIV infection, improving quality of life and extending life expectancy, there is still no definitive cure.
- **Vaccine Research:** Research is ongoing for an effective HIV vaccine, with various clinical trials being conducted.
- **Global Health Threat:** HIV/AIDS remains a significant public health challenge, with disparities in access to care and treatment in different regions of the world

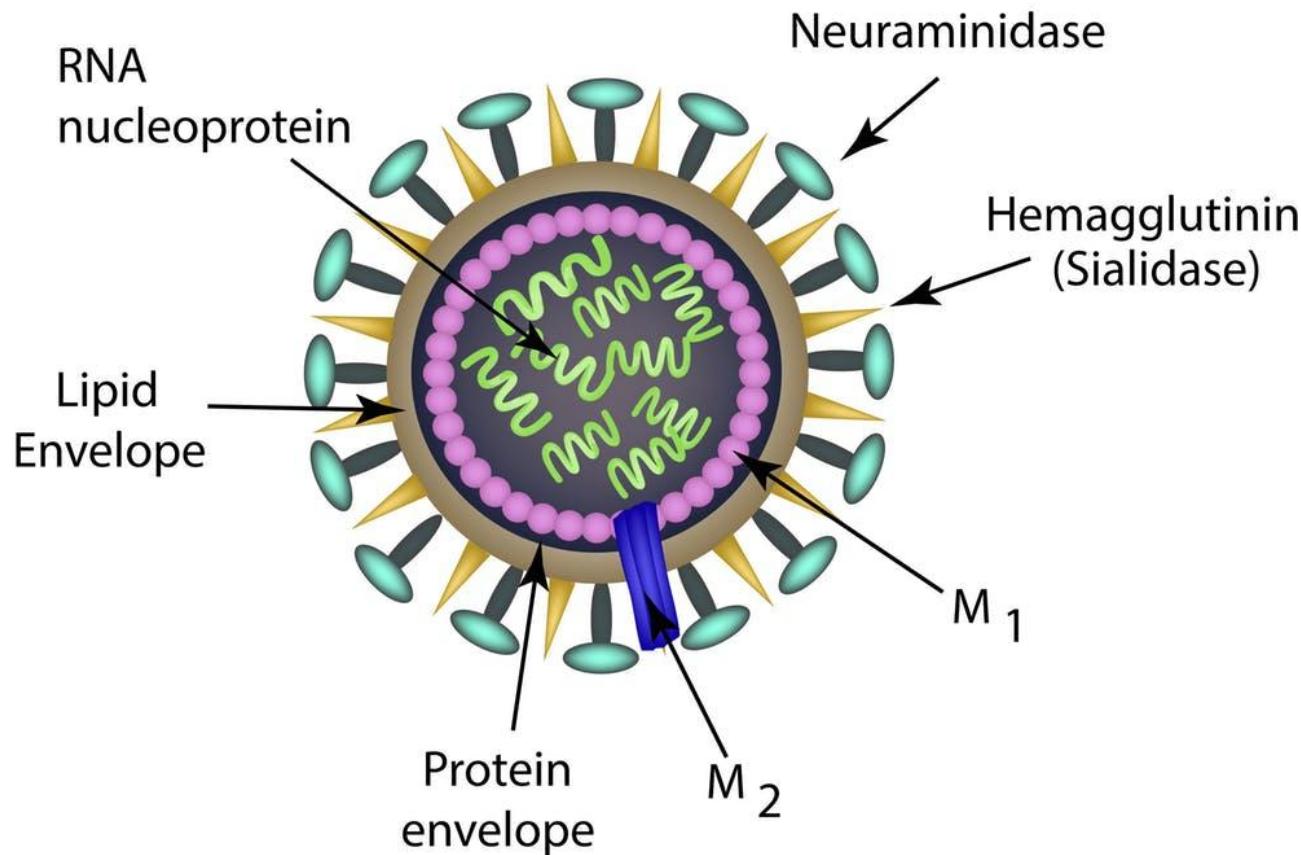
Infectious Diseases-1

- **Influenza**, commonly known as the flu, is an acute respiratory infectious disease characterized by high incidence, strong transmissibility, rapid spread, and a short incubation period.
- **Type A**: Frequently undergoes mutations and is responsible for most seasonal flu epidemics and pandemics.
- **Type B**: Generally causes seasonal epidemics but is less common than Type A.
- **Type C**: Typically causes mild respiratory illness and is not associated with epidemics.

Transmission and Infection

- **Transmission:** Influenza primarily spreads through respiratory droplets when an infected person coughs, sneezes, or talks.
- **Infection Process:** Once the virus enters the respiratory tract, it adheres to the epithelial cells of the mucosa, where it rapidly replicates.

Structure Model of Influenza A Virus

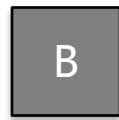


Which of the following characteristics contribute to the strong resistance of *Mycobacterium tuberculosis* to drying and phagocytosis? (Select all that apply)



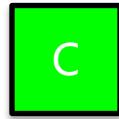
A

Rich lipid content in the cell wall



B

Presence of flagella



C

Branching rod structure



D

Ability to form spores

Prevention and Treatment

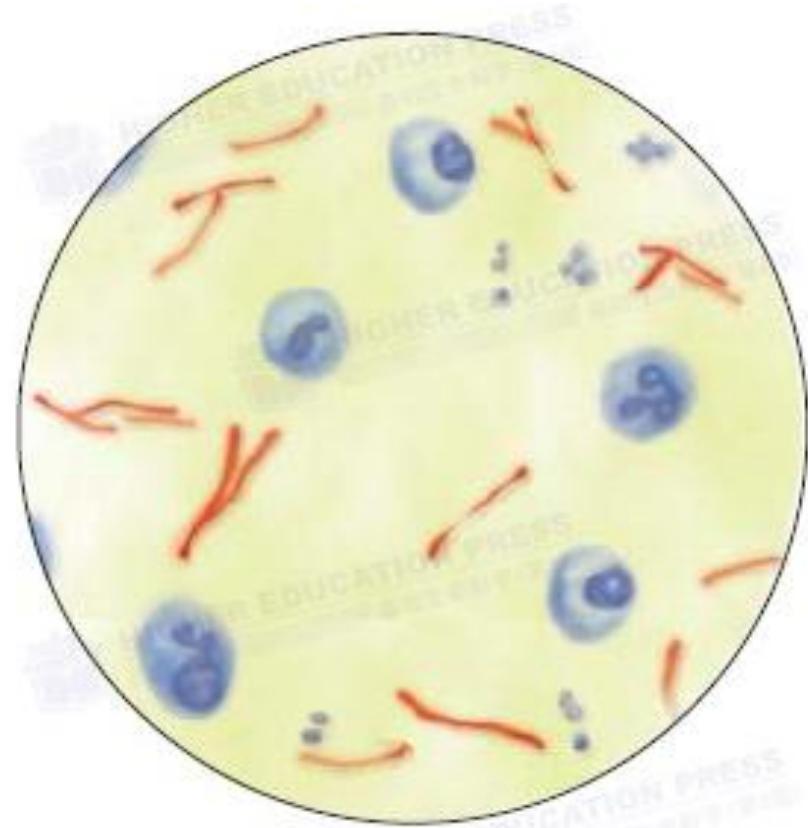
- **Prevention and Treatment**
- Vaccination
- No Specific Treatment: Currently, there is no specific antiviral treatment for influenza, although some antiviral medications can help alleviate symptoms and shorten the duration of illness if taken early.

Infectious Diseases-2

- **Tuberculosis (TB)** is primarily characterized by pulmonary tuberculosis, which is most commonly caused by respiratory infections. The causative agent of TB is *Mycobacterium tuberculosis*, commonly known as the tuberculosis bacillus.

Infectious Diseases-2

- *Mycobacterium tuberculosis* appears as slender, slightly curved rods that often arrange in branching structures. The cell wall of the tuberculosis bacillus is rich in lipids, which gives it a strong resistance to drying. Additionally, the lipids in the cell wall help the bacillus resist phagocytosis by human immune cells.



Infectious Diseases-2

- The pathogen primarily spreads through the respiratory tract, with chronic pulmonary tuberculosis patients who have prolonged bacterial shedding being the main source of infection.
- There are four common types of pulmonary tuberculosis:

Primary TB

Disseminated TB

Infiltrative TB

Chronic Fibrocavitary TB

Infectious Diseases-2

- Vaccination with the Bacillus Calmette-Guérin (BCG) vaccine is an effective measure for preventing tuberculosis among susceptible populations.
- Maintaining environmental and personal hygiene, refraining from spitting in public, and practicing meal separation can also help prevent the spread of tuberculosis.

Infectious Diseases-3

- **Viral hepatitis** refers to a group of systemic diseases primarily caused by hepatitis viruses, characterized by liver damage. These infections can lead to inflammation of the liver and may result in a range of symptoms and complications, including jaundice, fatigue, abdominal pain, and liver dysfunction. The most common types of hepatitis viruses include:

Hepatitis A Virus (HAV)

Hepatitis B Virus (HBV)

Hepatitis C Virus (HCV)

Hepatitis D Virus (HDV)

Hepatitis E Virus (HEV)

Infectious Diseases-3

- **Hepatitis A Virus (HAV)**
- **Structure:** Hepatitis A virus is a spherical RNA virus.
- **Clinical Presentation:** Hepatitis A usually manifests as acute hepatitis, with a predominance of jaundice.
- **Immune Response:** Patients infected with HAV produce IgM and IgG antibodies, which can provide protection against reinfection and may persist for several years.

Infectious Diseases-3

- **Hepatitis B Virus (HBV)**
- **Structure:** Hepatitis B virus is a spherical DNA virus.
- **Mechanism of Infection:** HBV does not directly cause inflammation or necrosis of liver cells; instead, it triggers an immune response.
- **Immune Response:** Cytotoxic T lymphocytes work to eliminate HBV, but in the process, they can also damage liver cells.

Infectious Diseases-3

- **Prevention**
- Interrupting the transmission routes of hepatitis viruses is a key strategy for preventing hepatitis infections. This includes vaccination, practicing safe hygiene, and implementing measures to reduce the risk of transmission.

Infectious Diseases-4

- **Atypical pneumonia** refers to a type of pneumonia that is often caused by pathogens other than the typical bacteria responsible for common pneumonia. One significant cause of atypical pneumonia is **Severe Acute Respiratory Syndrome (SARS)**, which is caused by a novel coronavirus.

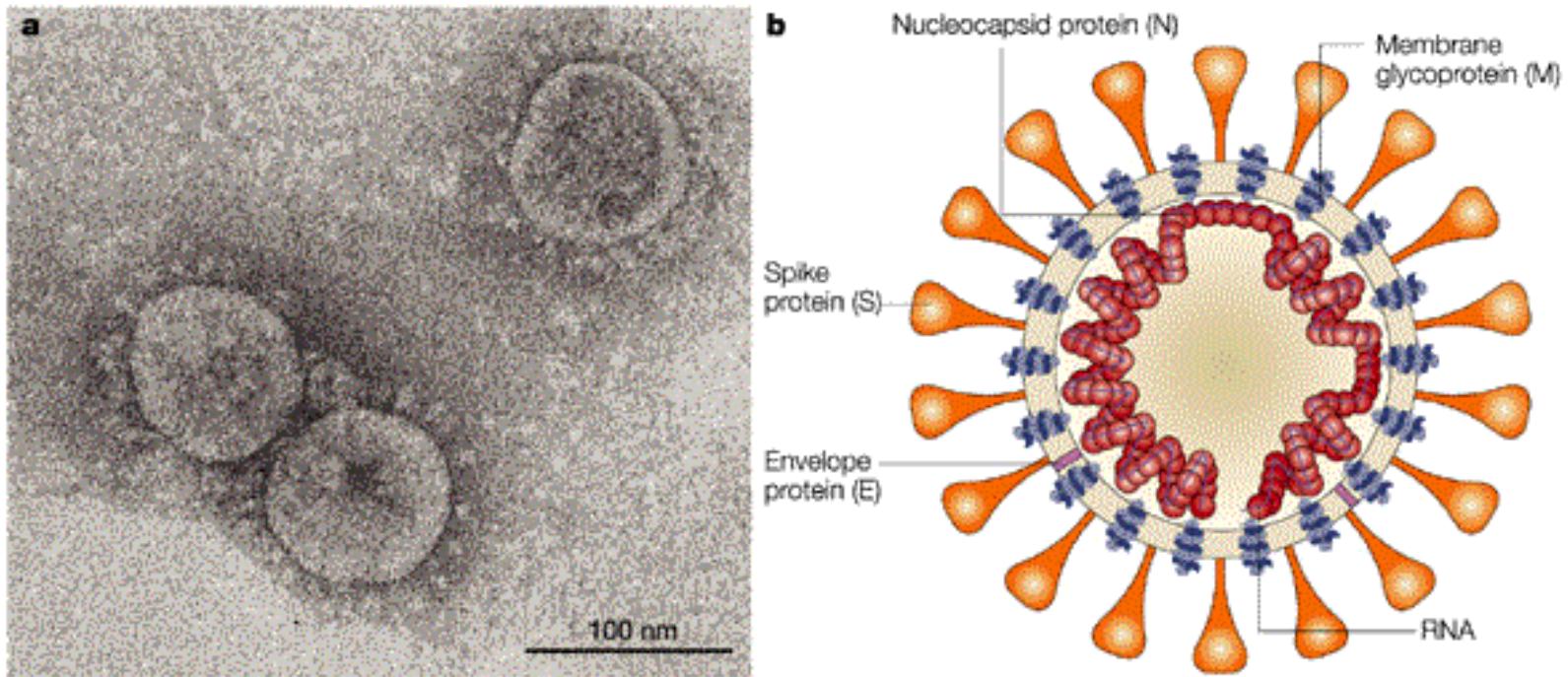
Infectious Diseases-4

- **Pathogen:** SARS is caused by the SARS coronavirus (SARS-CoV).
- **Transmission:** The virus spreads through respiratory droplets, contact with infected surfaces, and close contact with infected individuals.
- **Symptoms:** Common symptoms include fever, cough, difficulty breathing, and atypical pneumonia, which may present with less severe symptoms compared to typical bacterial pneumonia.
- **Complications:** Severe cases can lead to acute respiratory distress syndrome (ARDS), requiring hospitalization and intensive care.

Preventive measures for atypical pneumonia

- Promote Indoor Air Circulation
- Maintain Environmental and Personal Hygiene
- Hand Hygiene
- Physical Activity
- Avoid Crowded Places
- Limit Contact with Infected Individuals

Morphology of the SARS coronavirus



Nature Reviews | Microbiology

Stay healthy and live a quality life

Concept of Health and Quality of Life Assessment

- Health is commonly defined by the World Health Organization (WHO) as a state of complete physical, mental, and social well-being, not merely the absence of disease or infirmity. This holistic view emphasizes that health encompasses various dimensions, including:
- **Physical Health:** The proper functioning of bodily systems and the absence of illness or injury.
- **Mental Health:** Psychological well-being, including emotional stability, cognitive functioning, and the ability to cope with stress.
- **Social Health:** The capacity to form satisfying interpersonal relationships and adapt to social situations.

Quality of Life Assessment

- Quality of life (QoL) is a broad concept that reflects an individual's overall well-being and satisfaction in life. It encompasses various factors, including:
- **Physical Well-Being:** Health status, physical functioning, and the presence of pain or discomfort.
- **Psychological Well-Being:** Emotional health, life satisfaction, and mental functioning.
- **Social Relationships:** Support networks, social interactions, and community engagement.
- **Environment:** Living conditions, safety, and access to resources and services.
- **Spiritual Well-Being:** Personal beliefs and values that provide meaning and purpose in life.

Assessment Tools

- Quality of life can be assessed using various tools and questionnaires, such as:
- **SF-36 (Short Form 36 Health Survey):** Measures health-related quality of life across multiple dimensions.
- **WHOQOL (World Health Organization Quality of Life):** A comprehensive tool assessing different aspects of quality of life.
- **EQ-5D:** A standardized instrument for measuring health outcomes.

The Key to Health is in Your Hands

- To enhance quality of life and promote physical health, consider the following key aspects:
- **1. Balanced Diet**
- **Body Mass Index (BMI):** The formula to calculate BMI is:
$$f = w/h^2$$
- where f is the BMI, w represents weight in kg, and h is height in meters (m).

Healthy Eating Pyramid: Focus on a variety of nutritious foods

- **2. Regular Exercise**
- **3. Avoid Smoking and Limit Alcohol**
- **4. Psychological Balance**
- **5. Personal and Environmental Hygiene**

HEALTHY EATING PYRAMID

BALANCED DIET

