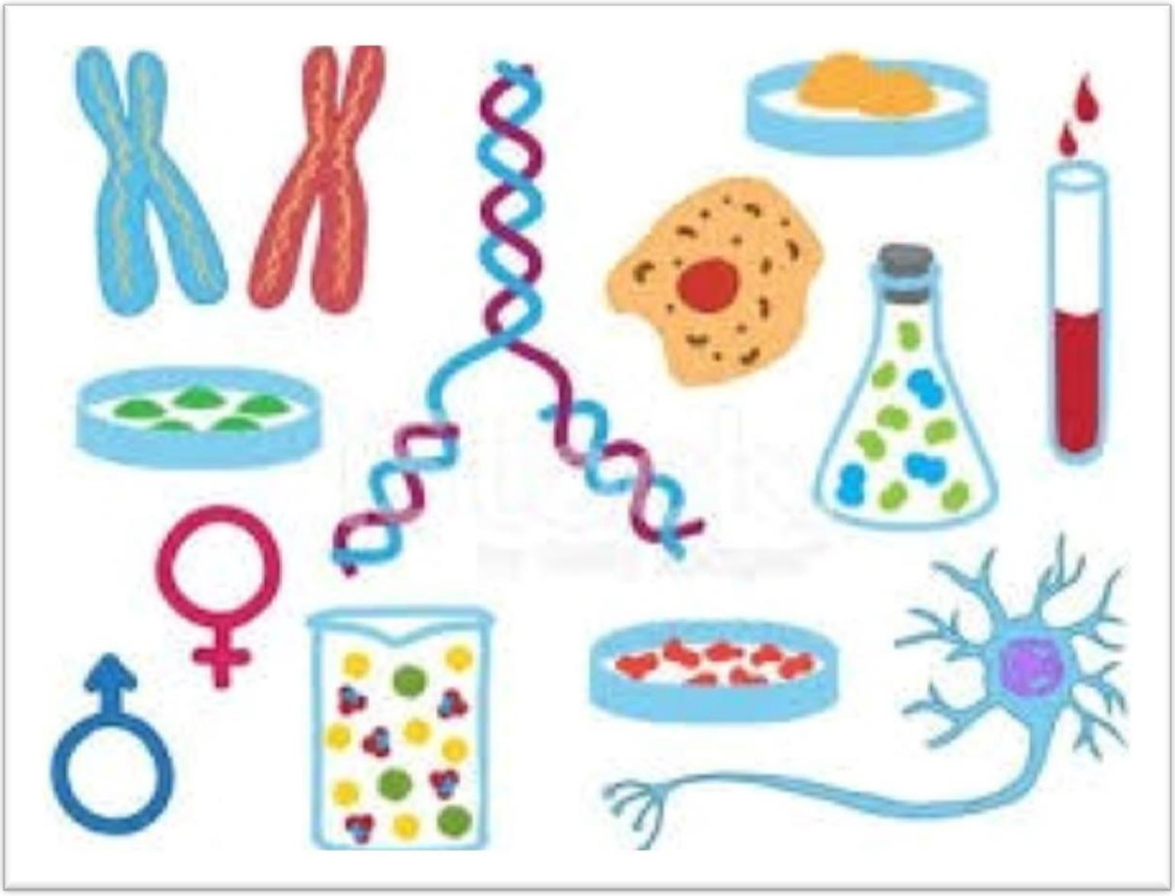
GOVERNMENT COLLEGE (A), RAJAHMUNDRY

DEPARTMENT OF MICROBIOLOGY



FIRST YEAR

Course-2

SEMESTER – 1

APPLIED BIOLOGY

Semester – 1

Course: 2 **INTRODUCTION TO APPLIED BIOLOGY**

Hours/Week: 5

Credit s: 4

Learning objectives

The student will be able to learn the foundations and principles of microbiology, immunology, biochemistry, biotechnology, analytical tools, quantitative methods, and bioinformatics.

Learning Outcomes

1. Learn the history, ultrastructure, diversity and importance of microorganisms.
2. Understand the structure and functions of macromolecules.
3. Knowledge on biotechnology principles and its applications in food and medicine.
4. Outline the techniques, tools and their uses in diagnosis and therapy.
5. Demonstrate the bioinformatics and statistical tools in comprehending the complex biological data.

Unit 1: Essentials of Microbiology and Immunology

1.1. History and Major Milestones of Microbiology; Contributions of Edward Jenner, Louis Pasteur, Robert Koch and Joseph Lister.

1.2. Groups of Microorganisms – Structure and characteristics of Bacteria, Fungi, Archaea and Virus.

1.3. Applications of microorganisms in – Food, Agriculture, Environment, and Industry.

1.4. Immune system – Immunity, types of immunity, cells and organs of immune system.

Unit 2: Essentials of Biochemistry

2.1. Biomolecules I – Carbohydrates, Lipids.

2.2. Biomolecules II – Amino acids & Proteins.

2.3. Biomolecules III – Nucleic acids -DNA and RNA.

2.4. Basics of Metabolism – Anabolism and catabolism.

Unit 3: Essentials of Biotechnology

3.1. History, scope, and significance of biotechnology. Applications of biotechnology in Plant, Animal, Industrial and Pharmaceutical sciences.

3.2. Environmental Biotechnology – Bioremediation and Biofuels, Biofertilizers and Biopesticides.

3.3. Genetic engineering – Gene manipulation using restriction enzymes and cloning vectors; Physical, chemical, and biological methods of gene transfer.

3.4. Transgenic plants – Stress tolerant plants (biotic stress – BT cotton, abiotic stress – salt tolerance). Transgenic animals – Animal and disease models.

Unit 4: Analytical Tools and techniques in biology – Applications

4.1. Applications in forensics – PCR and DNA fingerprinting

4.2. Immunological techniques – Immunoblotting and ELISA.

4.3. Monoclonal antibodies – Applications in diagnosis and therapy.

4.4. Eugenics and Gene therapy

Unit 5: Biostatistics and Bioinformatics

5.1. Data collection and sampling. Measures of central tendency – Mean, Median, Mode.

5.2. Measures of dispersion – range, standard deviation and variance. Probability and tests of significance.

5.3. Introduction, Genomics, Proteomics, types of Biological data, biological databases- NCBI, EBI, Gen Bank; Protein 3D structures, Sequence alignment

5.4. Accessing Nucleic Acid and Protein databases, NCBI Genome Workbench

REFERENCES

1. Gerard J., Tortora, Berdell R. Funke, Christine L. Case., 2016. Microbiology: An Introduction. 11th Edition. Pearson publications, London, England.
2. Micale, J. Pelczar Jr., E.C.S. Chan., Noel R. Kraig., 2002. Pelczar Microbiology. 5th Edition. McGraw Education, New York, USA.
3. Sathyanarayana U., Chakrapani, U., 2013. Biochemistry. 4th Edition. Elsevier publishers.
4. Jain J.L., Sunjay Jain, Nitin Jain, 2000. Fundamentals of Biochemistry. S. Chand publishers, New Delhi, India.
5. R.C. Dubey, 2014. Advanced Biotechnology. S. Chand Publishers, New Delhi, India.
6. Colin Ratledge, Bjorn, Kristiansen, 2008. Basic Biotechnology. 3rd Edition. Cambridge Publishers.
7. U. Sathyanarayana, 2005. Biotechnology. 1st Edition. Books and Allied Publishers pvt. ltd., Kolkata.
8. Upadhyay, Upadhyay and Nath. 2016. Biophysical Chemistry, Principles and Techniques. Himalaya Publishing House.
9. Arthur M. Lesk. Introduction to Bioinformatics. 5th Edition. Oxford publishers.
10. AP Kulkarni, 2020. Basics of Biostatistics. 2nd Edition. CBS publishers.

ACTIVITIES

1. Identification of given organism as harmful or beneficial.
2. Observation of microorganisms from house dust under microscope.
3. Finding microorganism from pond water.
4. Visit to a microbiology industry or biotech company.

5. Visit to a waste water treatment plant.
6. Retrieving a DNA or protein sequence of a gene’
7. Performing a BLAST analysis for DNA and protein.
8. Problems on biostatistics.
9. Field trip and awareness programs on environmental pollution by different types of wastes and hazardous materials.
10. Demonstration on basic biotechnology lab equipment.
11. Preparation of 3D models of genetic engineering techniques.
12. Preparation of 3D models of transgenic plants and animals.

[**NOTE**: In the colleges where there is availability of faculty for microbiology and biotechnology, those chapters need to be handled by microbiology and biotechnology faculty. In other colleges, the above topics shall be dealt by Botany and Zoology faculty]

UNIT-1

EDWARD JENNER

Edward Jenner was an English country doctor who introduced the vaccine for *smallpox*. Jenner is often called "the father of immunology"
Smallpox is a deadly disease caused by the **variola virus**. It causes painful lesions that leave disfiguring scars on the skin of people who survive and can also cause blindness. It caused horrible facial disfigurement

It was also common knowledge that dairymaids were often immune to smallpox.

This was because they were exposed to **cowpox**, a similar virus that affects cows.

In humans, it causes a much milder version of smallpox. If the dairymaids got cowpox, they would be immune to smallpox afterwards, because the antibodies their bodies had made against the cowpox virus would also work against the smallpox virus.

The story involves a dairymaid called Sarah Nelmes, an eight-year-old boy called James Phipps and a cow known as Blossom.

Sarah came to Jenner in **1796** with a rash on her right hand and he diagnosed .

Sarah told Jenner that one of cow called Blossom had recently been infected with cowpox.

Sarah's pustules were on the part of the right hand that handled the animal's teats.

Jenner took some pus from Sarah's hand and scratched it into the arm of young *James Phipps*s, the son of his gardener.

The lad became mildly ill but recovered, confirming that cowpox can be transmitted from person to person.

Several days later, Jenner exposed the boy to smallpox. Much to Jenner's relief, the boy survived and . He was found to be immune.
this known as vaccination – a name taken from the Latin word vacca, meaning a cow.

Jenner called his new method '*vaccination*' after the Latin word for cow (*vacca*).
But Jenner had no explanation for why this method worked - no-one could see the virus with the *microscopes* of the time.
He submitted a paper to the Royal Society the following year.
In 1853, 30 years after Jenner's death, smallpox vaccination was made compulsory in England and Wales.

LOUIS PASTEUR

Louis Pasteur was a French microbiologist and chemist . He is known for his discoveries of rabies ,anthrax ,chicken cholera vaccines , microbial fermentation and pasteurization. Louis Pasteur is regarded as the father of Modern Microbiology.

GERM THEORY OF FERMENTATION

Pasteur proved that fermentation is caused by a microorganism. Using this knowledge he saved French wine industry.

GERM THEORY OF DISEASE

Germ theory states that many diseases were caused by the presence of microorganisms .He discovered various infectious diseases such as staphylococcus, streptococcus and pneumococcus

BIOGENESIS

Disapproved Spontaneous generation theory and gave law of biogenesis. He rejected the theory of spontaneous generation by his swan neck experiment. He proposed that life existed from pre-existing life

PASTEURISATION

He gave the pasteurization technique of food preservation. First it was for wine and beer later it was applied for milk preservation . It involved heating at 55 degree Celsius. This process was named as pasteurisation.

RABIES VACCINE

He discovered anti rabies vaccine. It was first used for Joseph Meister, a boy bitten by a rabid animal. The boy survived . the rabies vaccine became a success.

PEBRINE SILKWORM DISEASE

He worked on protecting the Silk Industry. He studied that infection was transmitted by parasites and showed how infected worms should be isolated and destroyed.

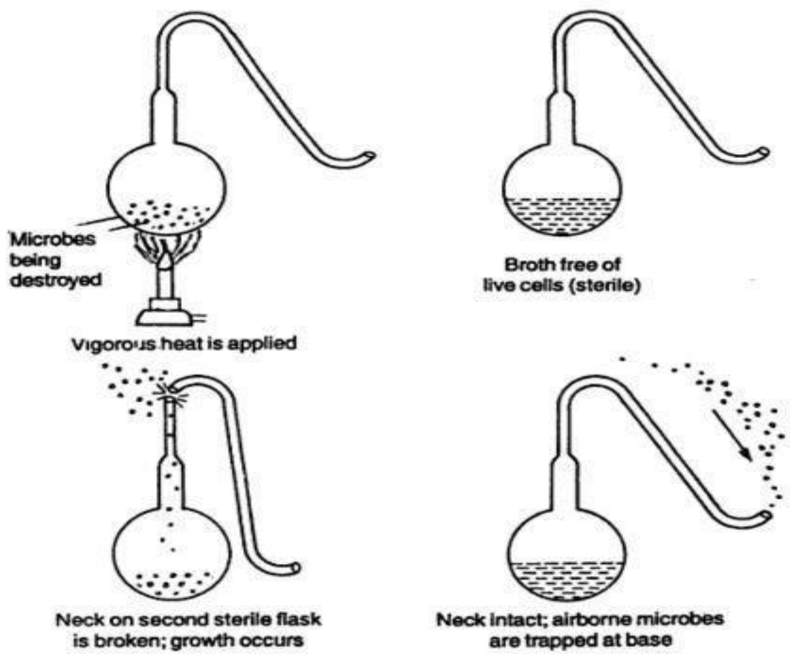
CHICKEN CHOLERA VACCINE

Pasteur injected some Cholera bacteria (old culture) into his chickens. The birds fell ill, but did not die. Later they were inoculated with fresh culture but became resistant to cholera infection. Pasteur realised that weakened strains of a pathogen (attenuated culture) could help animals develop immunity and in this way made chicken cholera vaccine.

ANTHRAX VACCINE

Anthrax is a disease caused by *Bacillus anthracis*. This bacteria was discovered by Robert Koch. Louis made the vaccination for anthrax

Pasteur's Experiment



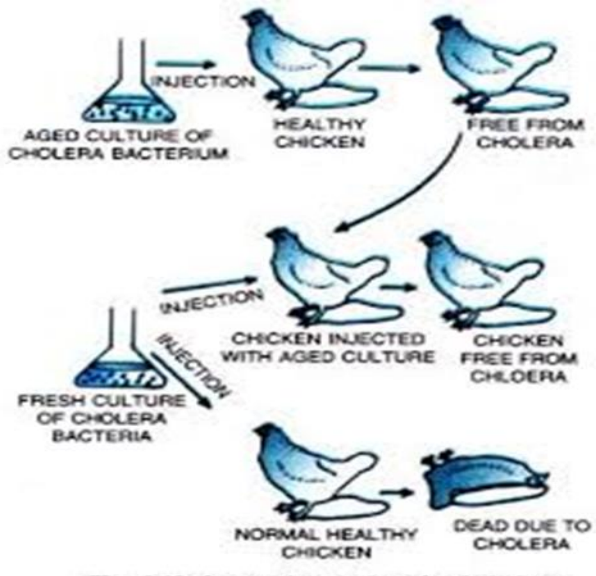
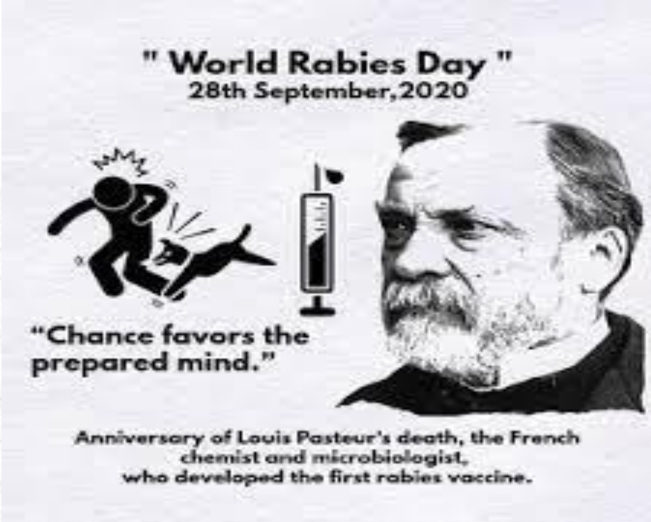
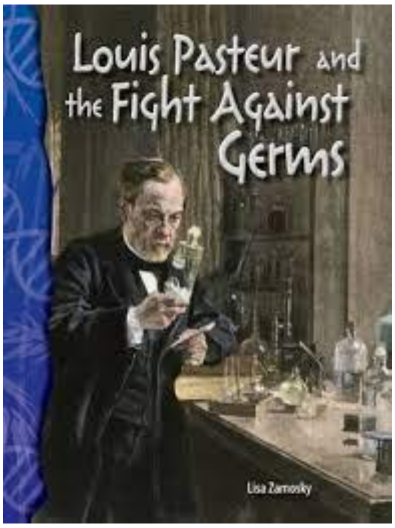
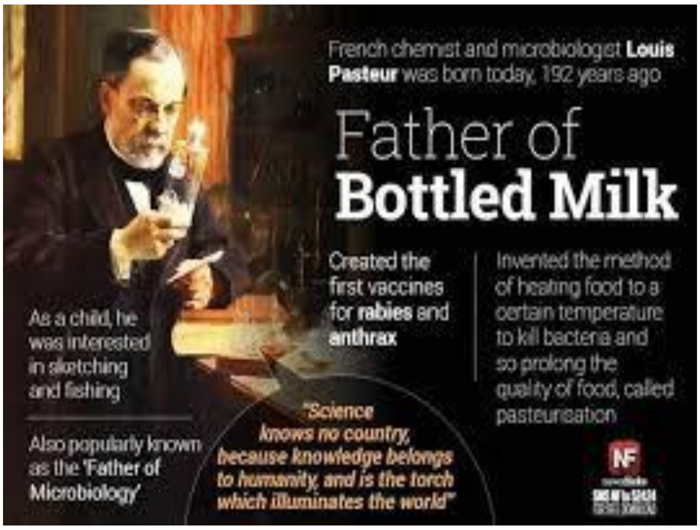


Fig. 8.13. Immunity against fowl-cholera.


" World Rabies Day "
28th September,2020
"Chance favors the prepared mind."
Anniversary of Louis Pasteur's death, the French chemist and microbiologist, who developed the first rabies vaccine.


Louis Pasteur and the Fight Against Germs
Lisa Zamosky


French chemist and microbiologist Louis Pasteur was born today, 192 years ago
Father of Bottled Milk
Created the first vaccines for rabies and anthrax
Invented the method of heating food to a certain temperature to kill bacteria and so prolong the quality of food, called pasteurisation
As a child, he was interested in sketching and fishing
Also popularly known as the 'Father of Microbiology'
"Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world"

Bacteria

Bacteria are single celled microbes. They have prokaryotic cell structure. They do not have nucleus and other cell organelles. The genetic information is contained in a single loop of DNA. Some bacteria have an extra circle of genetic material called a plasmid.

HABITAT

Bacteria are found in everywhere on Earth such as Soil, Rock, Oceans, and snow. Some live on the skin of animals and humans. Most are found in the large intestine of humans & animals.

Bacteria come in a wide variety of shapes. They are

- Coccus (Circle Or Spherical)
- Bacillus (Rod-Like)
- Spiral
- Filamentous

They can exist as single cells, in pairs, chains or clusters.

Bacteria Reproduction

Bacteria single-celled prokaryotic organisms. They mostly reproduce by binary fission.

Binary Fission

Bacteria reproduce by binary fission. In this process the bacterium, which is a single cell, divides into two identical daughter cells.

BACTERIAL CELL STRUCTURE

Bacteria are single celled microbes. They have prokaryotic cell structure. They do not have nucleus and other cell organelles. The genetic information is contained in a single loop of DNA. Some bacteria have an extra circle of genetic material called a plasmid.

- A procaryotic **cell** has five essential structural components (invariant):
    - **Cell Wall**
    - **Cell Membrane**
    - **Cytoplasm**
    - **A Nucleoid (DNA)**
    - **Ribosomes**
- **Cell Wall -** Each bacterium is enclosed by a rigid cell wall composed of peptidoglycan.The wall gives the cell its shape and surrounds the cytoplasmic

membrane. Peptidoglycan is made up of a polysaccharide backbone consisting of alternating N-Acetylmuramic acid (NAM) and N-acetylglucosamine (NAG) .

- **Cytoplasm -** The cytoplasm of bacterial cells is where the functions for cell growth, metabolism, and replication are carried out. It is a gel-like matrix composed of 80 % water, enzymes, nutrients, wastes, and gases and contains cell structures such as ribosomes, a chromosome, and plasmids.
- **Cytoplasmic Membrane -** The plasma membrane or bacterial cytoplasmic membrane is composed of a phospholipid bilayer . it **encloses** the interior of the bacterium and regulates the flow of materials in and out of the cell.
- **Nucleoid -** The nucleoid is a region of cytoplasm where the chromosomal DNA is located. It is not a membrane bound nucleus, but simply an area of the cytoplasm where the strands of DNA are found. Most bacteria have a single, circular chromosome that is responsible for replication.
- **Ribosomes** – they are found in the bacterial cytoplasm. the ribosome is the site of protein synthesis . All prokaryotes have 70S ribosomes .

EXTERNAL STRUCTURES (variant)

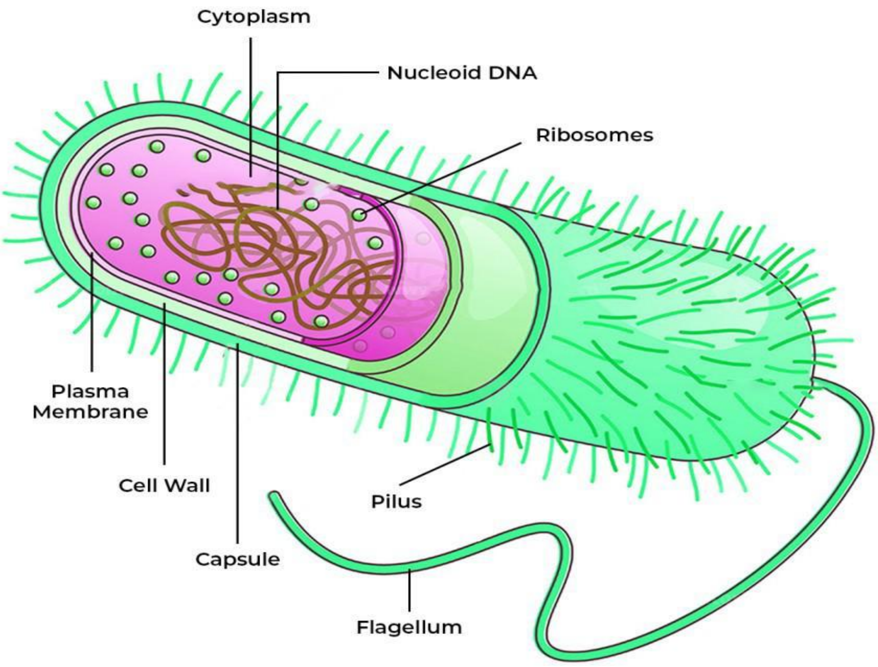
- **Fimbriae** are protein tubes that extend out from the outer membrane . They are short in length and present in high numbers about the entire bacterial cell surface. Fimbriae function in the attachment of a bacterium to a surface.

- **Pili -** Many species of bacteria have pili , small hair like projections emerging from the outside cell surface. These help the bacteria in attaching to other cells and surfaces, such as teeth, intestines, and rocks.
- **Flagella -** Flagella are whip-like structures protruding from the bacterial cell wall and are responsible for bacterial motility (i.e. movement).
- **Glycocalyx** / Capsules

Many bacteria secrete extracellular polymers outside of their cell walls called glycocalyx. These polymers are usually composed of polysaccharides and sometimes protein. They are structures that help protect bacteria from phagocytosis and desiccation.

Intracellular membranes (mesosomes)

Some bacteria contain intracellular membranes in addition to cytoplasmic membrane called mesosomes,. Examples of bacteria containing intracellular membranes are phototrophs, nitrifying bacteria .


Cytoplasm
Nucleoid DNA
Ribosomes
Plasma Membrane
Cell Wall
Pilus
Capsule
Flagellum

Characteristics of Bacteria

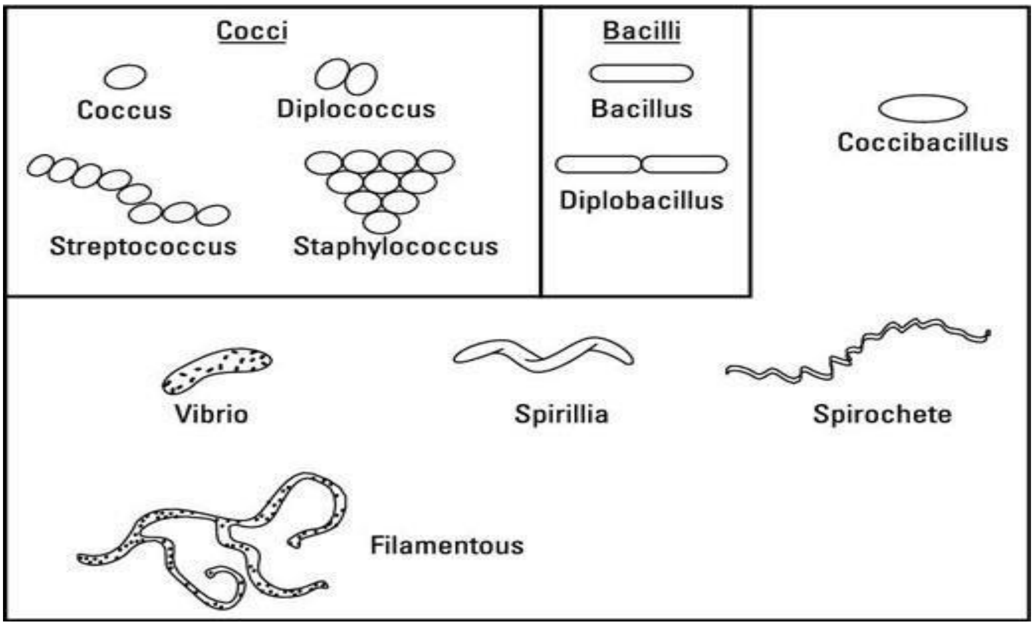
Bacteria are Prokaryotic , single-celled organisms found everywhere—soil, water, air, and even inside the human body. They can be both helpful (e.g., gut bacteria) and harmful (e.g., causing infections).

- DNA pieces that carry special traits, like antibiotic resistance.

2. **Flagella (optional):**
   - Tail-like structures that help bacteria move.
   - Example: Salmonella uses flagella to swim.
3. **Pili or Fimbriae (optional):**

Characteristics of Bacteria

1. **Size:**
   - Very small, usually 1–5 micrometers.
2. **Shapes:**
   - **Coccus (round):** Example: *Streptococcus* (causes throat infections).
   - **Bacillus (rod-shaped):** Example: *Escherichia coli* (E. coli) in the gut.
   - **Spirillum (spiral-shaped):** Example: *Helicobacter pylori* (causes stomach ulcers).
3. **Reproduction:**
   - Reproduce quickly by **binary fission** (splitting into two).
4. **Nutrition:**
   - Some bacteria make their own food (*autotrophs*), like *Cyanobacteria*.
   - Others feed on organic matter (*heterotrophs*), like *Lactobacillus* in yogurt.
5. **Habitat:**
   - Found in extreme environments like hot springs, deep oceans, or even human intestines.
6. **Helpful or Harmful:**
   - **Helpful bacteria:** *Lactobacillus* (makes yogurt), *Rhizobium* (helps plants fix nitrogen).
   - **Harmful bacteria:** *Mycobacterium tuberculosis* (causes tuberculosis), *Salmonella* (causes food poisoning).


Cocci
Coccus
Diplococcus
Streptococcus
Staphylococcus
Bacilli
Bacillus
Diplobacillus
Coccibacillus
Vibrio
Spirillia
Spirochete
Filamentous

Structure and Characteristics of Archaebacteria

Archaebacteria are ancient microorganisms that live in extreme environments. They are a type of prokaryote, meaning they lack a true nucleus.

Structure of Archaebacteria

1. **Cell Wall:**
    - Made of unique molecules (not peptidoglycan like bacteria).
    - Provides strength and protection.
2. **Cell Membrane:**
    - Contains unique lipids that help them survive extreme conditions (like high heat or salt).
3. **Cytoplasm:**
    - Contains enzymes and ribosomes needed for survival.
4. **DNA (Genetic Material):**
    - A single circular chromosome found in the nucleoid region (not enclosed in a nucleus).
5. **Ribosomes:**
    - Similar to bacterial ribosomes but slightly different in structure and function.
6. **Flagella (Optional):**
    - Tail-like structures for movement in liquid environments.

Characteristics of Archaebacteria

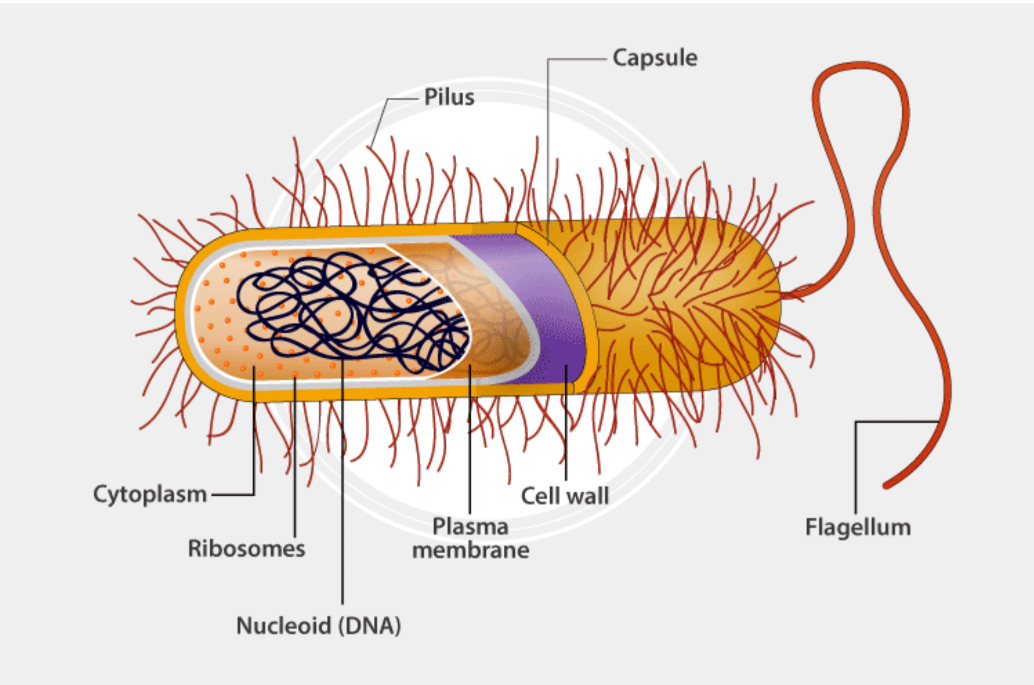
1. **Prokaryotic:**
    - Lack a nucleus and membrane-bound organelles.
2. **Extreme Environment Lovers:**
    - Live in harsh conditions like hot springs, salty lakes, or deep-sea vents.
    - Example:
        - *Thermophiles:* Thrive in high heat.
        - *Halophiles:* Survive in salty areas.
        - *Methanogens:* Produce methane gas in oxygen-free environments (e.g., swamps).
3. **Unique Cell Wall and Membrane:**
    - Their cell wall composition and membrane lipids are different from bacteria, making them resistant to harsh conditions.
4. **Non-pathogenic:**
    - Do not cause diseases in humans or animals.
5. **Diverse Metabolism:**

- Can use unusual energy sources like hydrogen gas, sulfur, or methane.

6. **Reproduction:**
   - Multiply by binary fission (simple splitting), budding, or fragmentation.

Examples of Archaebacteria:

1. *Halobacterium:* Found in salt lakes.
2. *Thermoplasma:* Lives in hot and acidic environments.
3. *Methanobacterium:* Produces methane gas in oxygen-free zones like cow intestines.



STRUCTURE AND CHARACTERISTICS OF VIRUSES

A virus are very small infectious particle that can only survive and multiply inside a living host cell. Viruses are much smaller than bacteria and are considered non-living outside of a host.

Structure of a Virus

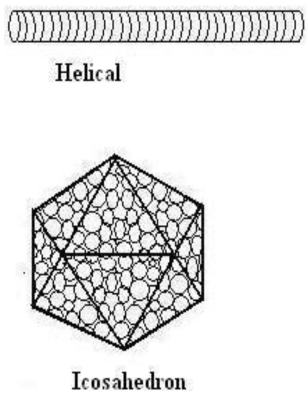
1. **Genetic Material (Core):**
   - Contains DNA or RNA (not both).

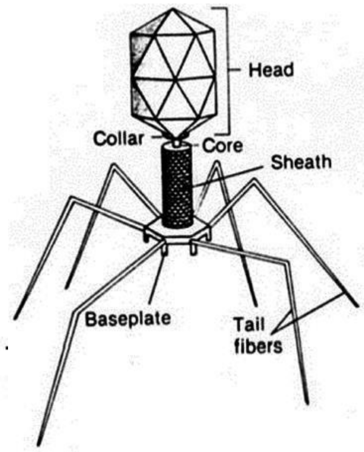
- Carries the instructions for making new viruses.
- Example:
    - DNA viruses: Herpesvirus.
    - RNA viruses: Coronavirus.

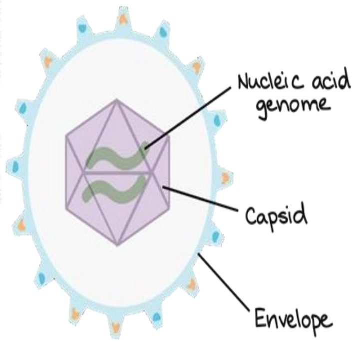
2. **Capsid (Protein Coat):**
    - A protective shell made of proteins.
    - Gives the virus its shape.
    - Helps the virus attach to host cells.
3. **Envelope (Optional):**
    - Some viruses have an outer lipid layer derived from the host cell membrane.
    - Example: Influenza virus (enveloped virus).
4. **Spikes (Optional):**
    - Protein projections on the surface of some viruses.
    - Help the virus attach to and enter host cells.
    - Example: Coronavirus has spike proteins.

Characteristics of Viruses

1. **Non-living Outside a Host:**
    - Cannot grow, reproduce, or perform metabolism on their own.
    - Require a host cell to replicate.
2. **Small Size:**
    - Range from 20 to 300 nanometers (nm).
    - Example: Poliovirus is about 30 nm.
3. **Specificity:**
    - Infect specific host cells (e.g., human cells, plant cells, bacteria).
    - Example: HIV infects human immune cells.
4. **Rapid Multiplication:**
    - Multiply quickly inside host cells by hijacking the host's machinery.
5. **Variety of Shapes:**
    - **Helical:** Example: Tobacco mosaic virus.
    - **Icosahedral (spherical):** Example: Adenovirus.
    - **Complex:** Example: Bacteriophage (infects bacteria).
6. **Mutation Ability:**
    - Can change their genetic material to adapt and evade immune responses.
    - Example: Flu virus mutates frequently, requiring new vaccines each year.







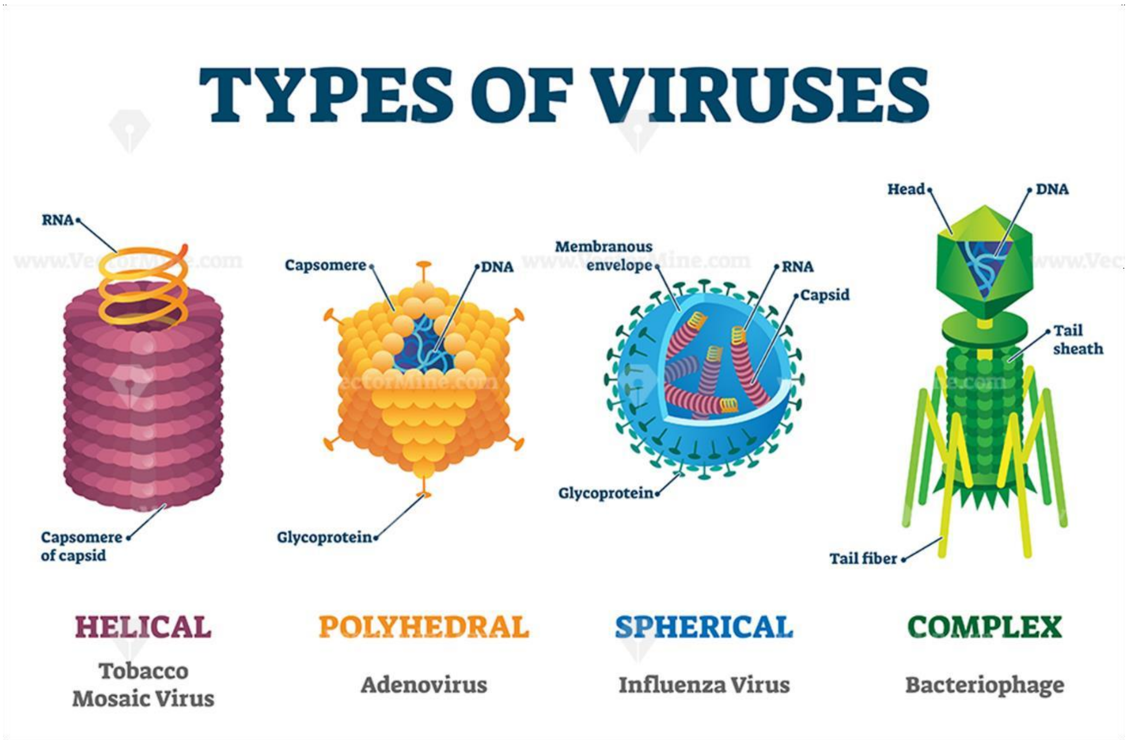
Based on the type of host, there are four different types of viruses:

ANIMAL VIRUSES -These viruses infect the animal cells. Examples- Rabies Virus, Poliovirus, Herpes virus, HIV, Corona virus etc.

PLANT VIRUSES -These viruses infect the cells of plants. Examples -Potato Virus, Tobacco Mosaic Virus, Beet Yellow Virus, and Turnip Yellow Virus, Etc.

BACTERIOPHAGE -The virus which infects bacterial cells is known as Bacteriophage. There are many varieties of bacteriophages, such as DNA virus, RNA virus, λ page, T2,T4 etc.

INSECT VIRUS -The virus which infects insects is known as Insect virus. These viruses are used as a biocontrol agent in agriculture. Ascovirus virions and Entomopox virus are best examples for insect virus.


TYPES OF VIRUSES
RNA
Capsomere of capsid
HELICAL
Tobacco Mosaic Virus
Capsomere
DNA
Glycoprotein
POLYHEDRAL
Adenovirus
Membranous envelope
RNA
Capsid
Glycoprotein
SPHERICAL
Influenza Virus
Head
DNA
Tail sheath
Tail fiber
COMPLEX
Bacteriophage

IMMUNITY

Immunity is defined as resistance to infections. The immune system defends our body against invaders, such as viruses, bacteria, and foreign bodies,

Two major kinds of mechanisms that protect the-body:

1 **Natural/Innate/Nonspecific immunity**
2 **Acquired/ Adaptive/ Specific immunity**

NATURAL/INNATE/NONSPECIFIC IMMUNITY

It is defined as sum of all the naturally occurring defense mechanisms that protect from infections. It is present from birth.

Some of Non-Specific Defense Mechanisms are

1. Intact Skin
2. Mucus membranes
3. Physiological processes
4. Lysozyme
5. Phagocytosis
6. Complement system
7. Interferons
8. Inflammatory response
9. Natural killer cells
10. Fever

1. **Intact Skin-** it is a physical barrier and retards growth of bacteria because of the following factors:
   - Dry
   - Acidic pH
   - Salty
   - Multiple Layers of tightly packed dead cells filled with wax & Keratin
   - Secretions of Sebaceous glands have Fatty acids & lactic acid which have antibacterial & antifungal

2. **Mucus membranes** – Lines up all systems that open to outside of body

They Secretes mucus which is thick, sticky & traps pathogens. Many mucus membranes have cilia which move mucus out of system.In the nose Nasal Hairs help trap pathogens

3.**Physiological processes** –

- Coughing & sneezing drives out pathogens & dust
- Ear wax or cerumen traps dust particles and kills bacteria & insects
- Stomach lining secretes gastric juices which Contains HCL and enzymes that are highly acidic (ph~1.2-3.0) & kill and dissolve most bacteria & toxins
- Washing action of tears & continual blinking flushes & wipes away pathogens from eye.

- Saliva in mouth flushes of bacteria to stomach
- Urine flushes bacteria entering urethra
- Vaginal secretions flush & traps pathogens in mucus. Acidity inhibits bacterial growth.

4. **Lysozyme** is an enzyme found in Tears, Saliva, Sweat & Tissue Fluid attacks bacteria by dissolving the cell walls of many bacteria. Lysozyme in tears kills and dissolves some bacteria. Lysozyme is also found in sweat, saliva, & nasal secretions

5. **Phagocytosis** - it is a type of defense mechanism in which some WBCs called Phagocytes eat/engulf bacteria or other foreign particles. Neutrophils &Macrophages are best examples of phagocytes.

6. **Complement system-**. It is made up of a number of plasma proteins that become active after antigen and antibody reaction.
Functions - Lysis- it kills the Microbes, Damaged cells & Foreign Bodies by forming Membrane Attack Complex. Opsonisation- it increases the rate of phagocytosis.

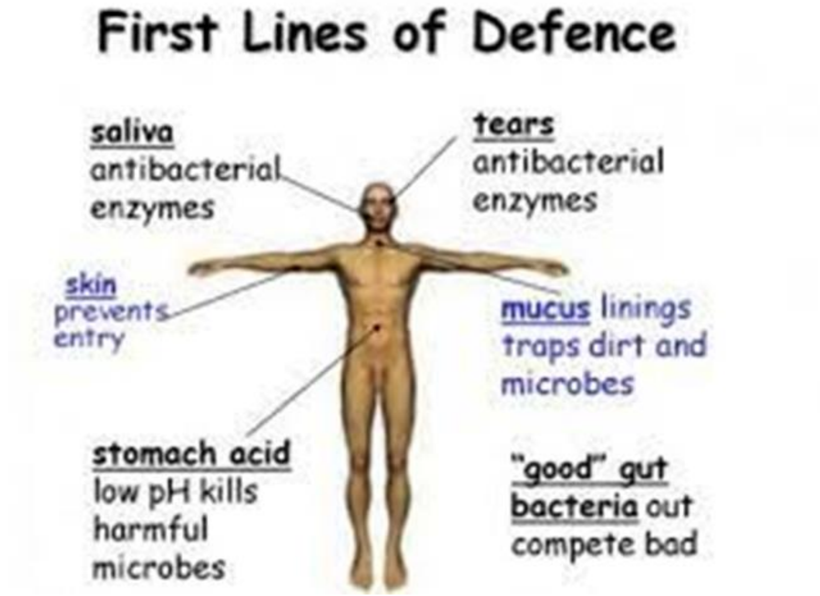
7 **Interferons -** they are Antiviral Proteins or Glycoproteins secreted by virally infected cells. Interferons are antiviral agents as they inhibit viral replications.

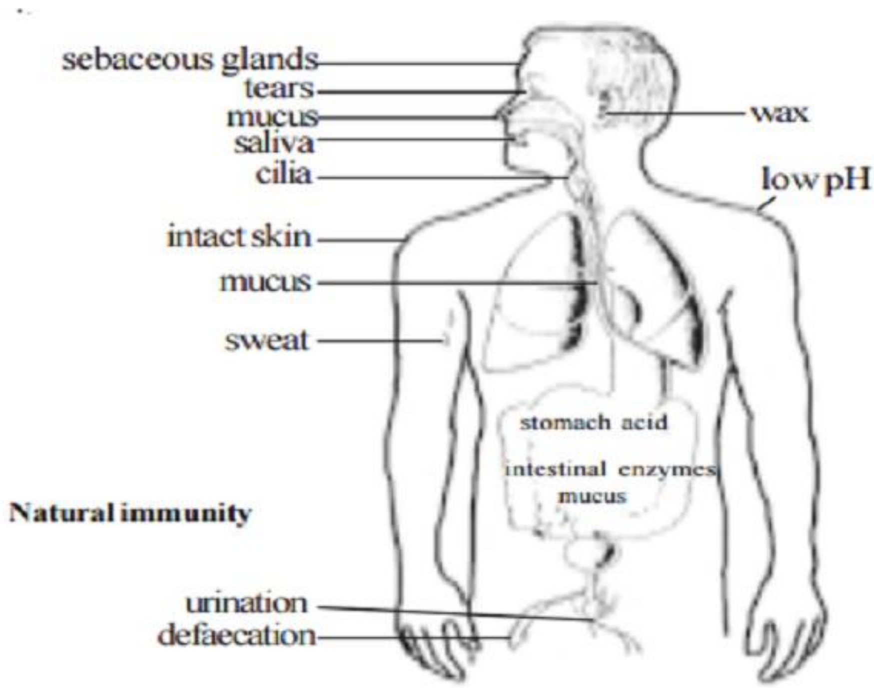
8 **Inflammatory response**
Inflammation is a response triggered by damage to living tissues. It is a defense mechanism that protects from infection and injury. Its purpose is to to heal the body.
It is characterised by:-

- Redness
- Pain
- Heat
- Swelling &Sometimes Loss Of Function

9 **Natural Killer Cells-** These Cells Kill Cancer & Virally Infected cells. These cells also secrete Cytokines that are Antiviral & Inflammatory.

10 **Fever -** It occurs when a Bacteria or Virus invade body. Increase in temperature Inhibits growth of some pathogens and Speed metabolism, enzymatic reactions and thus helps speed Innate & Acquired Immunity.


First Lines of Defence
saliva
antibacterial
enzymes
tears
antibacterial
enzymes
skin
prevents
entry
mucus linings
traps dirt and
microbes
stomach acid
low pH kills
harmful
microbes
"good" gut
bacteria out
compete bad


sebaceous glands
tears
mucus
saliva
cilia
intact skin
mucus
sweat
wax
low pH
stomach acid
intestinal enzymes
mucus
Natural immunity
urination
defaecation

ACQUIRED IMMUNITY

Acquired immunity is the defense system your body develops after being exposed to a disease or receiving a vaccine. It is specific, meaning it targets particular germs (like bacteria or viruses) and remembers them for the future.

Types of Acquired Immunity:

1. **Active Immunity -** Your body makes its own antibodies to fight off infections.

- **Naturally:** After you recover from an illness (e.g., chickenpox).
- **Artificially:** After getting a vaccine (e.g., polio vaccine).
    - **Example:** If you get measles once, your body "remembers" the virus and protects you from getting it again.

2. Passive Immunity -Your body gets ready-made antibodies from an outside source.

- **Naturally:** From a mother to her baby through breast milk or the placenta.
- **Artificially:** Through antibody injections (e.g., rabies treatment).
    - **Example:** A newborn baby gets protection from its mother's antibodies.

Key Features of Acquired Immunity:

1. **Specific:**
    - Targets specific pathogens (e.g., flu virus).
2. **Memory:**
    - The body remembers germs for faster defense if they attack again.
    - **Example:** Vaccines work by "teaching" the immune system to remember germs.
3. **Slow to Develop:**
    - It takes time for the immune system to recognize and respond to new germs.
4. **Long-lasting Protection:**
    - Especially in active immunity, the body can stay protected for years or even a lifetime.

Examples of Acquired Immunity in Action:

1. Recovering from chickenpox makes you immune to it later.
2. Getting a COVID-19 vaccine protects against severe infection.
3. A baby being protected from infections by antibodies in breast milk.
4. Receiving an injection of antivenom after a snake bite.
5. Developing immunity to the flu after catching it once.

****

ACTIVE AND PASSIVE IMMUNITY

Immunity is the ability of the body to fight infections and stay healthy. It can be developed in two ways: **active immunity** (body produces its own defense) or **passive immunity** (ready-made defenses are provided).

1. Active Immunity

The body produces its own antibodies to fight an infection or a vaccine.

Key Features:

- Long-lasting (sometimes for life).
- Takes time to develop because the immune system needs to learn to recognize and attack the pathogen.

Types of Active Immunity:

1. **Natural Active Immunity:**
    - Happens when you recover from an infection.
    - **Example:** Getting chickenpox and becoming immune to it.
2. **Artificial Active Immunity:**
    - Happens after vaccination. The vaccine contains weakened or dead germs that train your immune system.
    - **Example:** Getting a tetanus or polio vaccine.

2. Passive Immunity

The body is given ready-made antibodies instead of producing them.

Key Features:

- Provides immediate protection.
- Short-term immunity (lasts only a few weeks or months).

Types of Passive Immunity:

1. **Natural Passive Immunity:**
   - Happens naturally when antibodies are passed from mother to baby.
   - **Example:** A baby getting antibodies through breast milk or the placenta.
2. **Artificial Passive Immunity:**
   - Happens through antibody injections.
   - **Example:** Receiving an antivenom for a snake bite or antibodies for rabies treatment.

Comparison Table:

Feature	Active Immunity	Passive Immunity
Source	Body makes its own antibodies.	Ready-made antibodies are given.
Time to Develop	Takes time to develop.	Immediate protection.
Duration	Long-lasting (can be lifelong).	Short-term (weeks to months).
Examples	Vaccines, recovering from infections.	Antivenom, maternal antibodies.

Examples in Everyday Life:

- **Active Immunity:**
  1. Recovering from measles and becoming immune.
  2. Getting a flu vaccine to avoid seasonal flu.
- **Passive Immunity:**
  1. A newborn baby getting immune protection from the mother's breast milk.
  2. Receiving antibodies for COVID-19 in emergency treatments.

****

PRIMARY AND SECONDARY LYMPHOID ORGANS

Lymphoid organs are part of the immune system. They produce and support immune cells like lymphocytes (B-cells and T-cells).

1. Primary Lymphoid Organs

These are where lymphocytes (immune cells) are **formed and matured**.

- **Examples:**
    1. **Bone Marrow:**
        - Found inside bones.
        - Produces all blood cells, including B-cells and immature T-cells.
        - B-cells mature here.
    2. **Thymus:**
        - Located in the chest, above the heart.
        - Immature T-cells travel here to mature.

2. Secondary Lymphoid Organs

These are where **mature lymphocytes** gather and respond to infections.Trap pathogens and activate immune cells.

- **Examples:**
    1. **Lymph Nodes:**
        - Small, bean-shaped structures found throughout the body.
        - Trap pathogens from lymph (fluid) and activate immune cells.
    2. **Spleen:**
        - Located in the abdomen.
        - Filters blood, removes old red blood cells, and traps blood-borne pathogens.
    3. **Tonsils:**
        - Located at the back of the throat.
        - Trap pathogens from air or food.
    4. **Peyer's Patches:**
        - Found in the small intestine.
        - Monitor gut bacteria and pathogens.

CELLS OF THE IMMUNE SYSTEM

The immune system uses different types of cells to protect the body from infections and diseases. These cells work together to identify, attack, and remember harmful pathogens like bacteria, viruses, and fungi.

1. Lymphocytes

Recognize and remember specific pathogens.

Types:

B-cells:

- Produced in the bone marrow.
- Make antibodies to fight infections.
- **Example:** B-cells produce antibodies against the flu virus.

T-cells: Mature in the thymus.

- Types of T-cells:
- **Helper T-cells:** Activate other immune cells.
- **Cytotoxic T-cells:** Kill infected cells.
- **Example:** T-cells destroy virus-infected cells like those with COVID-19.

2. Phagocytes

- Eat (engulf) and destroy pathogens.
- **Types:**
    1. **Macrophages:**
        - Found in tissues.
        - Act as scavengers and signal other immune cells.
        - **Example:** Macrophages clean up dead cells in wounds.
    2. **Neutrophils:**
        - First responders to infections.
        - Quickly destroy bacteria and fungi.
        - **Example:** Fight bacterial infections like pneumonia.
    3. **Dendritic Cells:**
        - Capture pathogens and present them to lymphocytes.
        - **Example:** Help activate T-cells against a virus.

3. Natural Killer (NK) Cells

- Kill infected or cancerous cells without needing prior activation.

- **Example:** Destroy tumor cells or cells infected by viruses.

4. Mast Cells

- Release chemicals (like histamine) to trigger inflammation and fight allergens.
- **Example:** Cause swelling and itching in allergic reactions (e.g., after a bee sting).

5. Eosinophils and Basophils

- Defend against parasites and play a role in allergic responses.
- **Example:** Fight worm infections or contribute to asthma.

UNIT -2

CARBOHYDRATES

Carbohydrates are a group of organic compounds occurring in living tissues and foods in the form of starch, cellulose, and sugars.

Carbohydrates consist of carbon, hydrogen, and oxygen.The general structure is $(CH_2O)_n$. The term carbohydrate is a combination of the "hydrates of carbon". The ratio of oxygen and hydrogen in carbohydrates is the same as in water i.e. 2:1. Carbohydrates break down in the to release energy.

They are mainly classified into four groups:

- **Monosaccharides**
- **Disaccharides**
- **oligosaccharides**
- **Polysaccharides**

MONOSACCHARIDES

- they cannot be further hydrolyzed. They have only one simple sugar.
- They possess a free aldehyde or ketone group.
- The general formula is $C_n(H2O)_n$or $C_nH_{2n}O_n$.
- Examples are Glucose, Fructose, Erythrulose, Ribulose.
- They have either Aldehyde or Ketone Group

Carbon Chain Length.

- Trioses. They have 3 carbons in them ex Gylceraldehyde
- Tetroses. They have 4 carbons in them ex Erythrose
- Pentoses. They have 5 carbons in them. ex Ribose
- Hexoses. They have 6 carbons in them. ex Glucose

DISACCHARIDES

- Disaccharides have two molecules of sugars on hydrolysis.
- They are joined by glycosidic linkage.
- The general formula of disaccharides is $C_n(H2O)_{n-}$
- Examples : Disaccharides include sucrose, lactose, maltose etc.
- Sucrose is one of the most common disaccharides .
- Maltose and Lactose (also known as milk sugar) are other two important disaccharides.

OLIGOSACCHARIDES

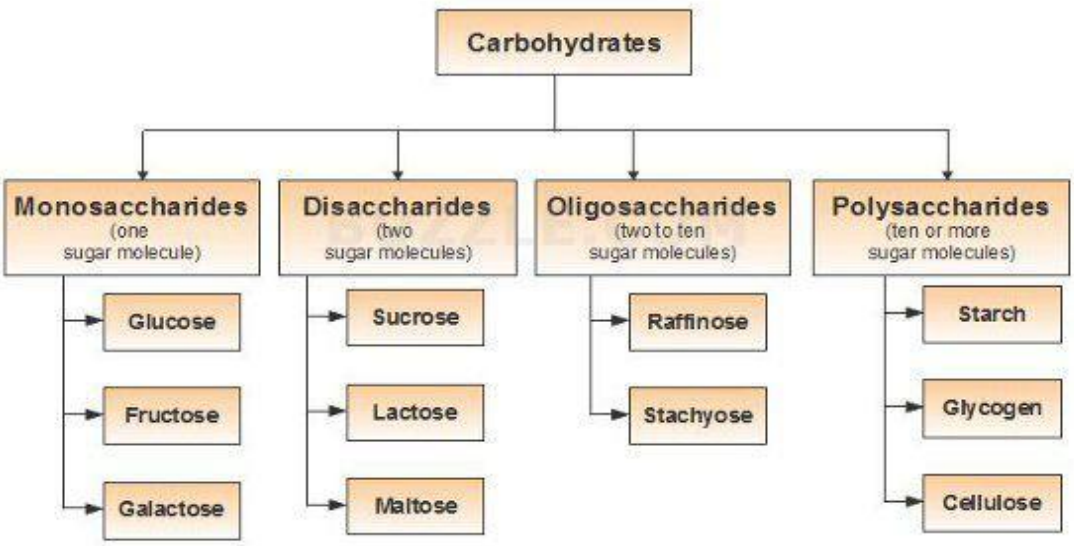
- Oligosaccharides are compound sugars that yield 2 to 10 molecules of a monosaccharides on hydrolysis.
- The monosachharide units are joined by glycosidic linkage.
- Oligosaccharides yielding 3 or 4 monosaccharides are known as trisaccharides and tetrasaccharides.

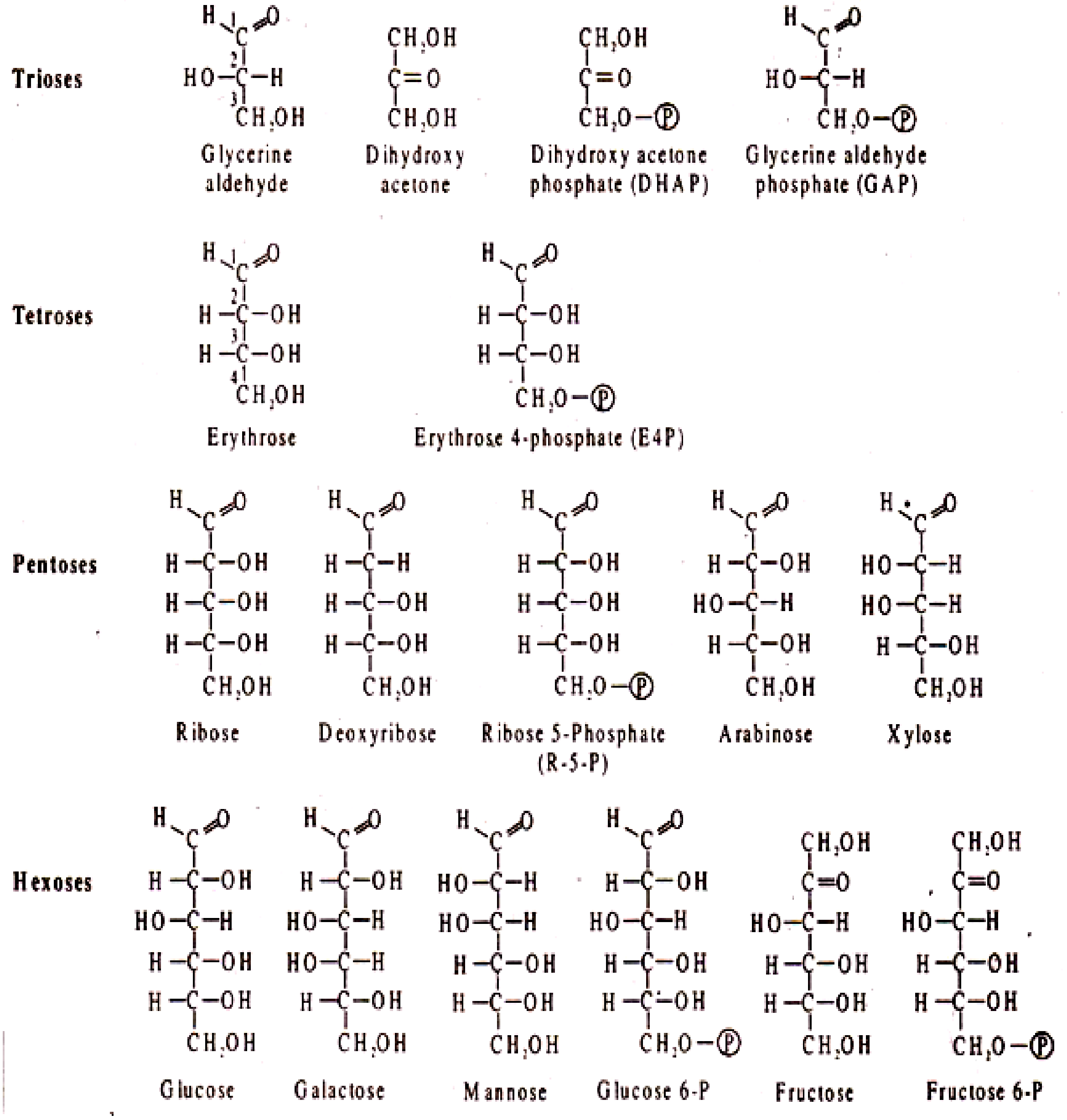
- examples are Raffinose, Rabinose.

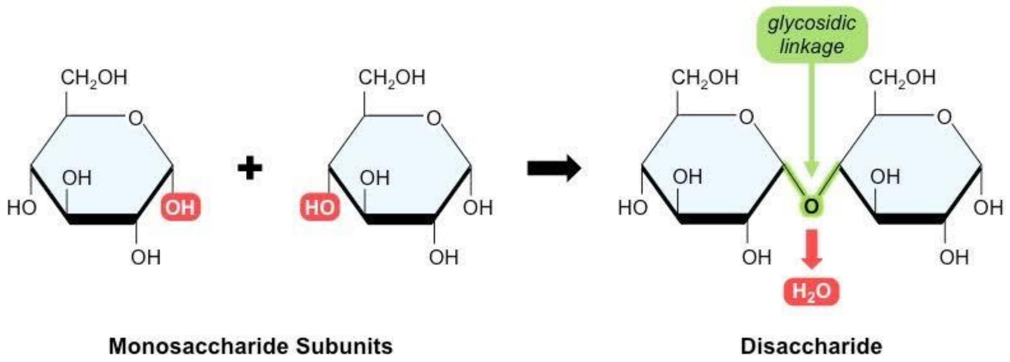
POLYSACCHARIDES

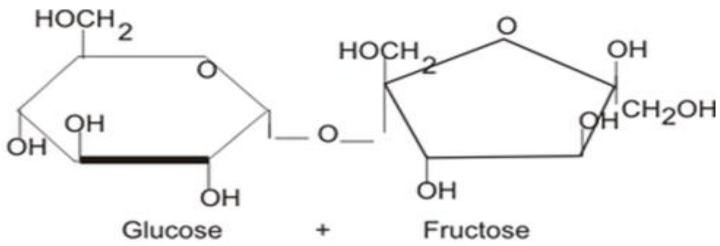
- Polysaccharides yield more than 10 molecules of monosaccharides on hydrolysis.
- They have Structural functions and the storage of energy.
- They maybe **homopolysaccharides**e, containing monosaccharides of the same type or **heteropolysaccharides** i.e., monosaccharides of different types.
- Example of Homopolysaccharides are starch, glycogen, cellulose, pectin.
    - Heteropolysaccharides are Hyaluronic acid, Chondrotin.

Classification of Carbohydrates

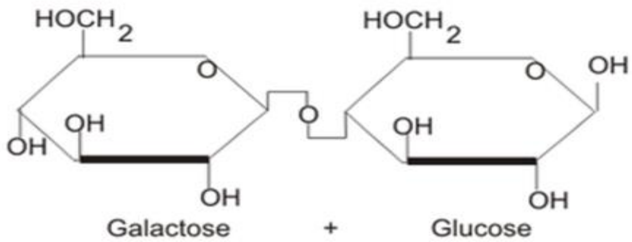



Trioses
Glycerine aldehyde
Dihydroxy acetone
Dihydroxy acetone phosphate (DHAP)
Glycerine aldehyde phosphate (GAP)
Tetroses
Erythrose
Erythrose 4-phosphate (E4P)
Pentoses
Ribose
Deoxyribose
Ribose 5-Phosphate (R-5-P)
Arabinose
Xylose
Hexoses
Glucose
Galactose
Mannose
Glucose 6-P
Fructose
Fructose 6-P

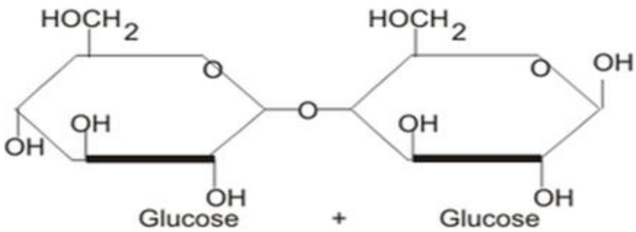

glycosidic linkage
Monosaccharide Subunits
Disaccharide



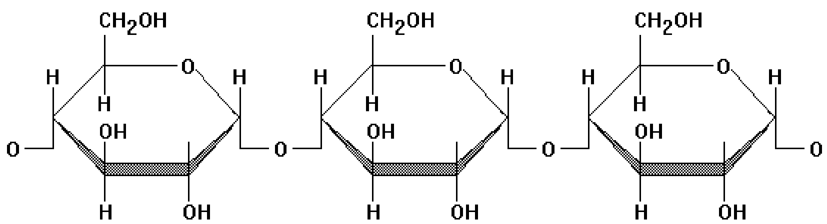
Sucrose



Lactose



Maltose



PROTEINS

Proteins are made of amino acids . Proteins are important part of organisms and participate in every process within cells.

Proteins are made from amino acids. A peptide bond is formed between two amino acids.

Depending on Structure proteins can be divided into three types:

- ***Primary structure***: it is made up of amino acid linked by peptide bonds in a linear sequence.

- ***Secondary structure***: it is made up of regularly repeating structures such as the alpha helix, beta sheet . It is stabilized by hydrogen bonds.

- ***Tertiary structure***: it is the overall shape of a single protein molecule and the spatial relationship of the secondary structures to one another. Tertiary structure is held by hydrophobic core and salt bridges, hydrogen bonds, disulfide bonds.The tertiary structure is what controls the basic function of the protein.

- ***Quaternary structure***:it is the structure formed by several *protein subunits*, which function as a single protein complex.

Proteins can be divided into three main classes,:

1. **Globular Proteins**: Almost all globular proteins are soluble and many are enzymes.Example of globular proteins are :
    - **Antibodies,**
    - **Serum Albumin**
    - **Haemoglobin**.

2. **Fibrous Proteins**: Fibrous proteins are physically tough and insoluble in water and in dilute salt solutions.they are the basic structural elements in the connective tissues is higher animal. Examples are:
    - **Collagen** -found in tendons and bone matrix
    - **Keratin** -the protein component of hair, nails, feathers, hooves.

3. **Membrane Proteins :** Membrane proteins serve as receptors or provide channels for polar or charged molecules to pass through the cell membrane.

Functions of proteins:

1.) Proteins as Enzymes. : catalyze all the reactions in the body**. Ex hexokinase.**

2.) Storage Proteins: help in storage of energy and food material .

- **Ovalbumin-**Egg Protein
- **Casein**—Milk Protein

3.) Protective proteins: protects body against infections and injury.

- **Antibodies** ,**Fibrinogen** and **Thrombin** .

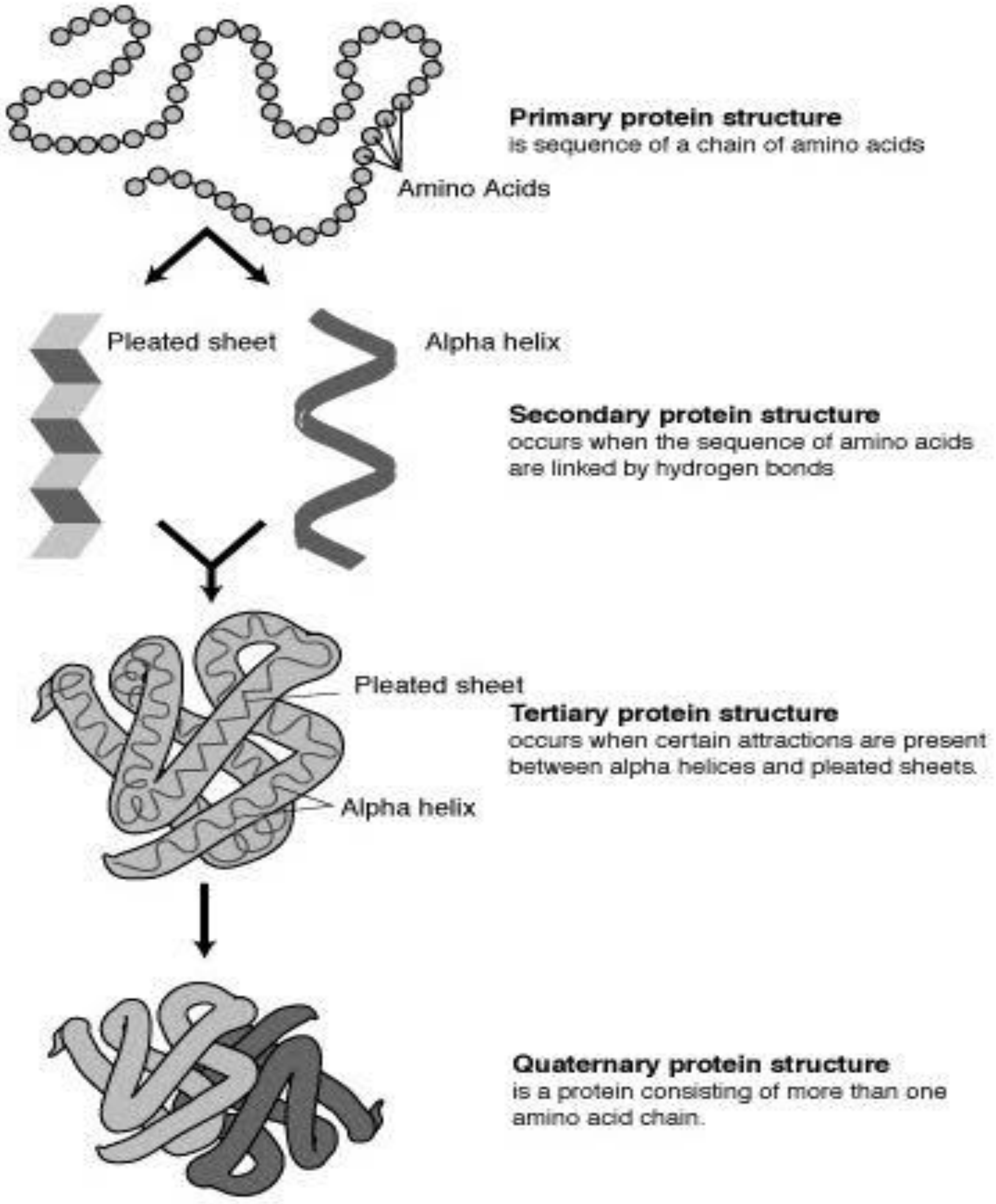
4.) Transport proteins: helps in transport.

- **Haemoglobin** – transports oxygen
- **Myoglobin** – transports oxygen in muscles
- **Serum albumin -** transports fatty acids in blood.

5.) **Contractile proteins** : helps in movement. Example is **Actin** and **Myosin**
6.) **Proteins as Harmones**: example is **Insulin** – glucose metabolism
7.) Structural proteins – they make stiff and rigidity biological components. Most structural proteins are fibrous proteins . Example are **Actin and Tubulin .** **Collagen** and **Elastin.** Keratin is found hair, nails, feathers, hooves.

8.) Some Proteins are Toxins : Snake venom ,Diphtheria toxin .

9.) Many Proteins function in Cell signaling and ligand binding.


Primary protein structure
is sequence of a chain of amino acids
Amino Acids
Pleated sheet
Alpha helix
Secondary protein structure
occurs when the sequence of amino acids
are linked by hydrogen bonds
Pleated sheet
Tertiary protein structure
occurs when certain attractions are present
between alpha helices and pleated sheets.
Alpha helix
Quaternary protein structure
is a protein consisting of more than one
amino acid chain.

NUCLEIC ACID

Nucleic acids are molecules that allow organisms to transfer genetic information from one generation to the next. There are two types of nucleic acids:

- **Deoxyribonucleic Acid (DNA)**
- **Ribonucleic Acid (RNA).**

DNA

- DNA is essential to all living forms.
- It contains the genetic information
- It is used in the development and functioning of all living organisms.
- It carry genetic information are called the genes.
- It is made of two chains of polynucleotides.

RNA

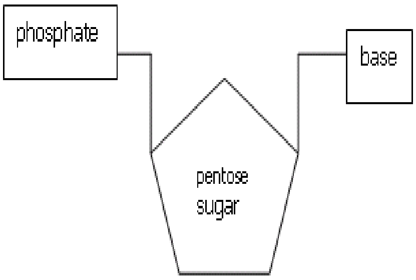
- It converts genetic information from genes into amino acid sequences of protein.
- RNA exists as a single stranded molecule.
- In some viruses, RNA is the genetic material.
- There are 3 types of RNA.
- **Messenger RNA (mRNA)** is the RNA copy of the DNA message produced during DNA transcription. Messenger RNA is translated to form proteins.
- **Transfer RNA (tRNA)** has a three dimensional shape and is necessary for the translation of mRNA in protein synthesis.
- **Ribosomal RNA (rRNA**) is a component of ribosomes and is also involved in protein synthesis.

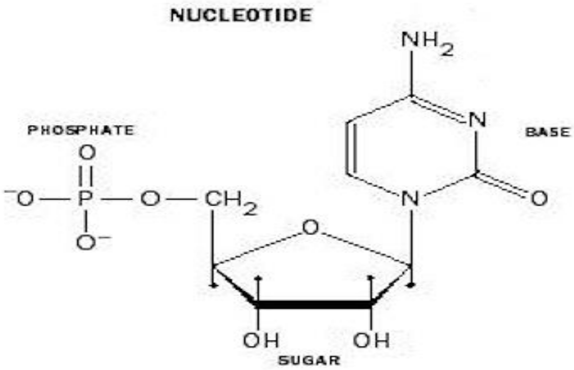
NUCLEOTIDES

Nucleotides are the building blocks of Nucleic acids. Nucleotides contain three parts:

- A Five-Carbon Sugar
- A Nitrogenous Base
- A Phosphate Group

The sugar is joined to the nitrogenous base by Glycosidic bond . The sugar is joined to the phosphate by ester bond.





Nucleotides are linked together to form polynucleotide chains. Nucleotides are joined to one another by covalent bonds between the phosphate of one and the sugar of another. These linkages are called Phosphodiester bonds. Phosphodiester bonds form the sugar-phosphate backbone of both DNA and RNA.

SUGAR -

The **sugar** in a nucleotide is a 5-carbon atom sugar in its ring form.

It will either be **ribose in RNA** or **deoxyribose in DNA**.

The "deoxy" means that the ribose molecule has lost an oxygen. In a nucleotide, sugar forms a Glycosidic Bond with the nitrogenous base at 1 ‘ position . It forms an Ester Bond with phosphate at 5’ position.

NITROGENOUS BASE -

The nitrogenous base is the central information carrying part of the nucleotide structure. There are two types of Nitrogenous Bases Purines and Pyrimidines.

Adenine

Adenine is a purine. it has a double-ringed structure. In DNA, adenine bonds with thymine. In RNA, adenine bonds with uracil.

Guanine

Guanine is a purine. It has a double ring. It bonds with cytosine in both DNA and RNA. Guanine binds to cytosine through three hydrogen bonds.

Cytosine

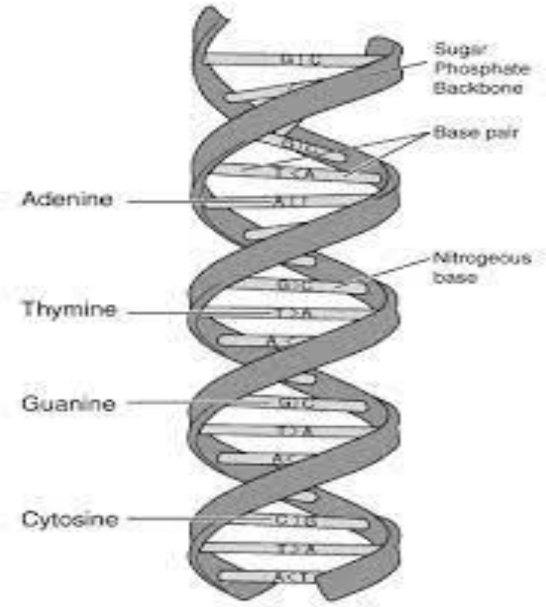
Cytosine is a pyrimidine nucleotide. It has only one ring in its structure. Cytosine bonds with guanine in both DNA and RNA. Bonding with the nucleotide guanine, the two make a strong pair.

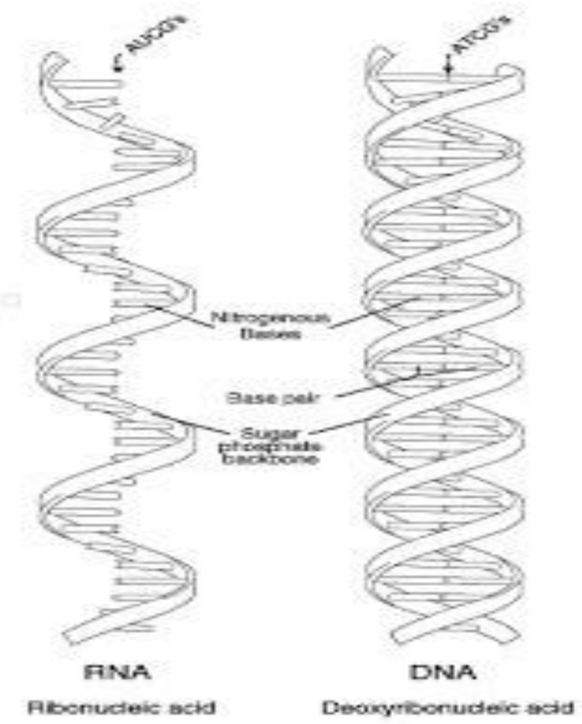
Thymine

Thymine is a pyrimidine and has one ring. It bonds with adenine in DNA. Thymine is not found in RNA. In DNA, it forms only two hydrogen bonds with adenine, making them the weaker pair.

Uracil
Uracil is also a pyrimidine and has one ring . It is found only in RNA and not found in DNA. In RNA it forms only two hydrogen bonds with adenine .

PHOSPHATE GROUP -
A phosphate group is formed by a phosphorus atom with four oxygen atoms around it.





Lipids
Lipids are fats and oils that are important for storing energy, building cell membranes, and protecting the body. They are made of carbon, hydrogen, and oxygen.

Classification of Lipids

Lipids are grouped into different types based on their structure and function. Here's an easy classification:

1. Simple Lipids

- Made of fatty acids and alcohol.
- **Examples:**
  - **Fats:** Found in butter, cheese, and body fat (solid at room temperature).
  - **Oils:** Found in olive oil, sunflower oil, and fish oil (liquid at room temperature).
  - **Waxes:** Found on fruits (apple skin) and in beeswax (used in candles).

2. Compound Lipids

- Made of fatty acids, alcohol, and other molecules like phosphorus or sugars.
- **Examples:**
  - **Phospholipids:** Found in egg yolk and soy; they make up cell membranes.
  - **Glycolipids:** Found in the brain and nerve cells, involved in cell communication.

3. Derived Lipids

- These are made from simple or compound lipids.
- **Examples:**
  - **Steroids:** Cholesterol, which helps make hormones like estrogen and testosterone.
  - **Fatty acids:** Omega-3 from fish, which is good for the heart.
  - **Vitamins:** Fat-soluble vitamins like Vitamin A, D, E, and K.

Functions of Lipids:

- **Energy Storage:** Lipids store long-term energy (e.g., body fat).
- **Insulation:** Fat under the skin keeps the body warm.
- **Protection:** Lipids cushion organs.
- **Cell Structure:** Phospholipids help build cell membranes.
- **Hormones:** Steroids are used to make hormones.

Metabolism, Catabolism, and Anabolism

Metabolism
Metabolism includes all chemical reactions in the body to keep it alive. It is divided into two processes: **Catabolism** (breaking down) and **Anabolism** (building up).

Catabolism (Breaking Down)
Catabolism is the process of breaking down larger molecules into smaller ones to release energy.

Examples of Catabolism:

1. **Digestion of carbohydrates:** Breaking down starch into glucose.
2. **Protein breakdown:** Proteins are broken into amino acids during digestion.
3. **Fat breakdown:** Fats are broken into fatty acids and glycerol for energy.
4. **Cellular respiration:** Glucose is broken down into carbon dioxide and water to produce energy (ATP).
5. **Breaking muscle glycogen:** During exercise, stored glycogen in muscles is broken into glucose for energy.

Anabolism (Building Up)
Anabolism is the process of building larger molecules from smaller ones, requiring energy.

Examples of Anabolism:

1. **Protein synthesis:** Using amino acids to build proteins for muscles.
2. **DNA synthesis:** Creating new DNA strands from nucleotides during cell division.
3. **Fat storage:** Converting excess glucose into fats for long-term storage.
4. **Bone growth:** Using minerals like calcium to build stronger bones.
5. **Repair of tissues:** Healing wounds by producing new cells and tissues.

UNIT 3

Ancient Biotechnology –It refers to the traditional methods humans used to use living organisms for their benefit.

Examples:

1. **Fermentation**:
    - Making bread, beer, and wine by using yeast.
    - Example: Egyptians used yeast to make bread.
2. **Selective Breeding**:
    - Choosing the best plants or animals for reproduction to improve their traits.
    - Example: Farmers selecting high-yield wheat for planting.
3. **Agriculture**:
    - Cultivating crops and domesticating animals.
    - Example: Ancient people growing rice and wheat.

Modern Biotechnology – It involves using advanced scientific techniques, like DNA technology, genetic engineering, and molecular biology, to manipulate living organisms for specific purposes.

Examples:

1. **Genetically Modified Organisms (GMOs)**:
    - Altering crops to make them resistant to pests or increase nutrition.
    - Example: Golden rice with added Vitamin A.
2. **Medical Biotechnology**:
    - Producing medicines like insulin using genetically engineered bacteria.
    - Example: Bacteria producing human insulin for diabetes patients.
3. **Cloning**:
    - Creating a genetically identical copy of an organism.
    - Example: Dolly the sheep, the first cloned mammal.

Scope of Biotechnology

1. **Healthcare**:
   Biotechnology is used to develop medicines like vaccines and antibiotics.
   Example: Making insulin for diabetes treatment.
2. **Agriculture**:
   Helps improve crop yield, pest resistance, and drought tolerance.
   Example: Genetically modified (GM) crops like Bt cotton resist pests.

3. **Food Industry**:
   Used to improve food quality, taste, and shelf life.
   Example: Making yogurt or cheese using bacteria.
4. **Environment**:
   Used to clean pollution and manage waste.
   Example: Bioremediation, where bacteria are used to clean oil spills.
5. **Industrial Use**:
   Produces enzymes and biofuels to reduce reliance on fossil fuels.
   Example: Making bioethanol from sugarcane.
6. **Research**:
   Advances in genetics, molecular biology, and cloning.
   Example: Mapping the human genome.

Significance of Biotechnology

1. **Better Healthcare**:
   Helps in early disease diagnosis and targeted treatments.
   Example: Vaccines for COVID-19 were developed using biotechnology.
2. **Sustainable Agriculture**:
   Ensures food security by improving crop productivity.
   Example: Golden rice, enriched with Vitamin A, prevents deficiency.
3. **Environmental Protection**:
   Reduces pollution and promotes eco-friendly processes.
   Example: Using biofertilizers instead of chemical ones.
4. **Economic Growth**:
   Creates jobs in research, pharmaceuticals, and agriculture sectors.
   Example: Biotech companies contributing to the economy.
5. **Improved Livelihood**:
   Helps farmers by providing better seeds and reducing losses.
   Example: Pest-resistant crops save money on pesticides.

Biotechnology is a tool to solve real-world problems and improve quality of life in sustainable ways!

****

Applications of biotechnology in Plant, Animal, Industrial and Pharmaceutical sciences

Applications of Biotechnology

1. In Plant Science

Biotechnology helps improve crops for better yield, disease resistance, and quality.

Examples:

- **Genetically Modified (GM) Crops**:
  - BT Cotton: Resistant to pests like bollworms.
  - Golden Rice: Enriched with Vitamin A to fight malnutrition.
- **Tissue Culture**: Growing disease-free plants from a single cell.
  - Example: Banana and sugarcane farming.

2. In Animal Science

Biotechnology enhances animal breeding, health, and productivity.

Examples:

- **Cloning**: Producing identical animals.
  - Example: Dolly the sheep.
- **Animal Vaccines**: Developing vaccines for diseases like foot-and-mouth disease.
- **Transgenic Animals**: Animals modified to produce useful substances.
  - Example: Cows that produce milk with human proteins for medicinal use.

3. In Industrial Science

Biotechnology is used to create products like enzymes, biofuels, and chemicals in industries.

Examples:

- **Enzyme Production**:
  - Using microbes to make enzymes for detergents (e.g., protease for cleaning stains).
- **Biofuels**:
  - Producing ethanol from sugarcane or corn for renewable energy.
- **Bioplastics**:
  - Making eco-friendly plastics from plants or bacteria.

4. In Pharmaceutical Science

Biotechnology is used to develop medicines, vaccines, and diagnostic tools.

Examples:

- **Insulin Production**:
  - Genetically modified bacteria produce human insulin for diabetes patients.
- **Vaccines**:
  - Example: Hepatitis B vaccine made using recombinant DNA technology.
- **Monoclonal Antibodies**:
  - Used in cancer treatment and COVID-19 therapy.

****

Environmental Biotechnology: Bioremediation

Definition:
Bioremediation is the use of living organisms, like bacteria, fungi, or plants, to clean up pollutants from the environment, such as soil, water, or air.

Procedure:

- Microorganisms break down harmful substances into non-toxic forms.
- Plants can absorb or trap pollutants from soil or water.

Types of Bioremediation

1. **In-Situ Bioremediation**
   - Cleaning pollutants directly at the site.
   - Example: Treating oil spills in the ocean using bacteria.
2. **Ex-Situ Bioremediation**
   - Removing polluted material and cleaning it elsewhere.
   - Example: Contaminated soil taken to a bioreactor for treatment.

Examples

1. **Oil Spill Clean-up**
   - Bacteria like *Pseudomonas* digest oil in water.
   - Example: Using microbes to clean the Gulf of Mexico oil spill.
2. **Heavy Metal Removal**

- Plants like sunflowers absorb metals like lead or arsenic from the soil.
- Example: Sunflowers used near nuclear disaster sites (e.g., Chernobyl).

3. **Plastic Degradation**
   - Fungi or bacteria break down plastic waste.
   - Example: *Ideonella sakaiensis* bacteria degrade PET plastics.
4. **Wastewater Treatment**
   - Microbes purify sewage water by breaking down organic pollutants.
   - Example: Using anaerobic bacteria in water treatment plants.

Benefits of Bioremediation

- Eco-friendly and natural process.
- Cost-effective compared to chemical methods.
- Reduces pollution without causing harm to the environment.

Limitations

- May take a long time.
- Not all pollutants can be treated using bioremediation.
- Effectiveness depends on environmental conditions like temperature and pH.

Conclusion

Bioremediation is an essential tool for cleaning up environmental pollution using natural methods, offering a sustainable solution for a healthier planet.

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Environmental Biotechnology: Biofuels

Definition:
Biofuels are renewable fuels made from biological materials like plants, algae, or organic waste. They are an eco-friendly alternative to fossil fuels like petrol and diesel.

Types of Biofuels

1. **Bioethanol**
    - Made by fermenting sugar or starch from crops like sugarcane, corn, or wheat using yeast.
    - **Example**: Ethanol blended with petrol (E10 fuel) to reduce emissions.
2. **Biodiesel**
    - Produced from vegetable oils (soybean, sunflower) or animal fats through a chemical process.
    - **Example**: Biodiesel used in trucks and buses.
3. **Biogas**
    - Created by breaking down organic waste (like food scraps or manure) in the absence of oxygen.
    - **Example**: Biogas used for cooking or as electricity in rural areas.
4. **Algal Biofuels**
    - Made from algae that produce oil, which can be converted into biodiesel or bioethanol.
    - **Example**: Algal biofuel for aviation or cars.

Advantages of Biofuels

- **Renewable**: Made from plants or waste, unlike limited fossil fuels.
- **Eco-Friendly**: Reduces greenhouse gas emissions and pollution.
- **Waste Utilization**: Converts agricultural and organic waste into useful energy.

Limitations of Biofuels

- Requires large amounts of land and water to grow biofuel crops.
- Can compete with food production (e.g., using corn for fuel instead of food).
- Processing and transport may still produce some emissions.

Examples of Biofuel Use

1. **In Transportation**

   - Brazil: Cars run on ethanol made from sugarcane.
   - Europe: Trucks use biodiesel made from rapeseed oil.
2. **In Rural Areas**
   - Biogas plants provide clean cooking fuel and electricity in villages.
3. **Future Innovations**
   - Algal biofuel research aims to create high-yield, sustainable fuels.

Conclusion

Biofuels are a promising alternative to fossil fuels, offering a cleaner, renewable, and sustainable energy source. With proper management, they can significantly reduce environmental pollution and energy dependency.

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BIOFERTILIZERS AND BIOPESTICIDES

Biofertilizers: Natural fertilizers that use living microorganisms to improve soil fertility and plant growth.

Biopesticides: Biological substances or organisms used to control pests, diseases, and weeds without harming the environment.

Biofertilizers

Microorganisms in biofertilizers fix nutrients like nitrogen, solubilize phosphorus, or improve soil quality, helping plants grow better.

Examples:

Types of Biofertilizers

1. **Nitrogen-Fixing Biofertilizers**
   - These biofertilizers have microorganisms that convert atmospheric nitrogen into a form plants can absorb.
   - Examples:
     - *Rhizobium* (used in legume crops like peas and beans)
     - *Azotobacter* (used in cereals like wheat and rice)
2. **Phosphate-Solubilizing Biofertilizers**
   - They release enzymes to convert insoluble phosphate into soluble forms, making it available for plants.
   - Examples:
     - *Pseudomonas*
     - *Bacillus*

3. **Potassium-Mobilizing Biofertilizers**
    - Help in making potassium from the soil easily absorbable for plants.
    - Examples:
        - *Frateuria aurantia*
        - *Bacillus mucilaginosus*
4. **Cyanobacterial Biofertilizers**
    - These are blue-green algae that fix atmospheric nitrogen and improve soil fertility.
    - Examples:
        - *Anabaena*
        - *Nostoc*
5. **Mycorrhizal Biofertilizers**
    - Symbiotic fungi that increase water and nutrient uptake in plants.
    - Examples:
        - *Glomus* (used in tree and crop farming)
        - *Acaulospora*
6. **Compost-Inoculants**
    - Microbes that decompose organic waste into nutrient-rich compost.
    - Examples:
        - *Cellulomonas*
        - *Aspergillus*

These biofertilizers improve soil fertility naturally, reducing the need for chemical fertilizers.

Benefits of Biofertilizers

- Increases soil fertility naturally.
- Reduces the use of chemical fertilizers.
- Eco-friendly and sustainable.

Biopesticides

Biopesticides use natural organisms or compounds to kill pests, control diseases, or manage weeds without harming crops, soil, or humans.

Types and Examples:

Types of Biopesticides

1. **Microbial Biopesticides**
    - Made from microorganisms like bacteria, fungi, or viruses that target specific pests.

    - Examples:
        - *Bacillus thuringiensis* (Bt): Effective against caterpillars.
        - *Trichoderma* spp.: Controls fungal diseases in plants.
2. **Botanical Biopesticides**
    - Derived from plant extracts and are toxic to pests but safe for humans and the environment.
    - Examples:
        - Neem oil (*Azadirachta indica*): Effective against insects like aphids and whiteflies.
        - Pyrethrin (from *Chrysanthemum* flowers): Kills mosquitoes and flies.
3. **Biochemical Biopesticides**
    - Contain natural compounds like pheromones or hormones to disrupt pest behavior.
    - Examples:
        - Insect pheromones: Used in traps to confuse pests like moths.
        - Plant growth regulators: Prevent insects from molting or reproducing.
4. **Predatory or Parasitic Biopesticides**
    - Use natural enemies of pests to control their population.
    - Examples:
        - Ladybugs: Feed on aphids.
        - Parasitic wasps (*Trichogramma* spp.): Attack and kill insect eggs.

Biopesticides are eco-friendly and promote sustainable pest management.

Benefits of Biopesticides

- Safe for humans, animals, and beneficial insects.
- Biodegradable, leaving no harmful residues.
- Reduces the reliance on chemical pesticides.

Limitations

- May take longer to show results compared to chemical alternatives.
- Effectiveness depends on environmental conditions.

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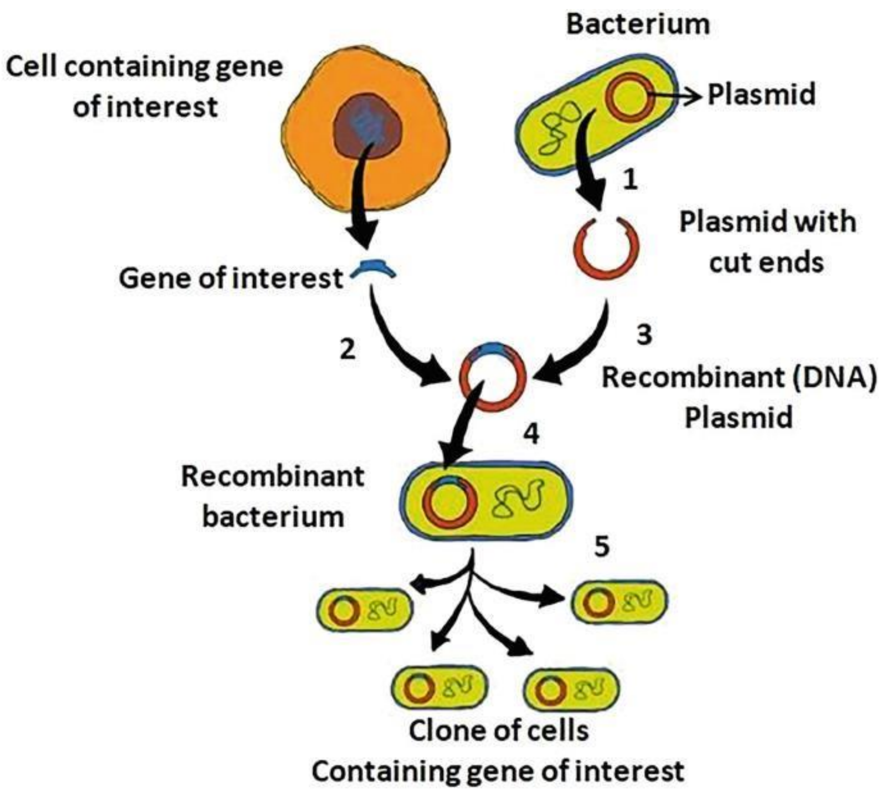
GENETIC ENGINEERING

Genetic engineering involves modifying an organism's DNA to introduce new traits or remove undesirable ones. It uses tools like restriction enzymes and cloning vectors for manipulating genes.

Important Steps in Gene Cloning

1. **Isolation of the Gene of Interest**
    - The desired gene is identified and isolated from the organism's DNA.
    - Example: Extracting the insulin gene from human DNA.
2. **Cutting DNA with Restriction Enzymes**
    - Special enzymes (restriction enzymes) cut DNA at specific sequences to create fragments.
    - Example: *EcoRI* cuts DNA to isolate the insulin gene.
3. **Inserting the Gene into a Vector**
    - The gene of interest is inserted into a DNA carrier called a vector (like a plasmid).
    - Example: Human insulin gene is inserted into the plasmid of *Escherichia coli*.
4. **Introduction into a Host Cell (Transformation)**
    - The recombinant DNA (vector + gene) is introduced into a host organism (like bacteria).
    - Example: The modified plasmid is introduced into *E. coli* cells.
5. **Selection of Transformed Cells**
    - Cells that have successfully taken up the recombinant DNA are identified and separated.
    - Example: Using antibiotic resistance markers to select *E. coli* with the plasmid.
6. **Replication and Expression**
    - The host cell replicates the recombinant DNA and expresses the desired protein.
    - Example: *E. coli* produces human insulin, which is later purified for use.

Gene cloning allows for large-scale production of important proteins like insulin and vaccines.



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Methods of Gene Transfer

Physical Methods

1. **Microinjection**:
   - A fine needle injects DNA directly into a cell.
   - **Example**: DNA injected into an animal egg for research.
2. **Gene Gun (Biolistics)**:
   - Shoots tiny particles coated with DNA into plant cells.
   - **Example**: Creating genetically modified (GM) crops like golden rice.
3. **Electroporation**:
   - An electric field creates pores in the cell membrane to let DNA enter.
   - **Example**: Introducing genes into bacteria or animal cells.

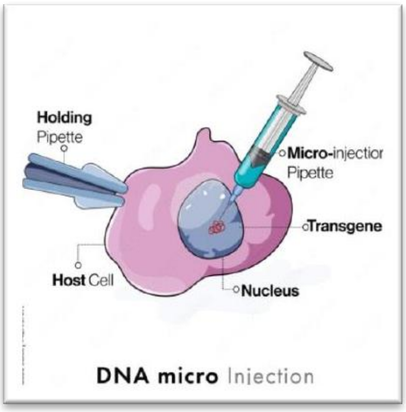
Chemical Methods

- Chemicals like calcium chloride make cell membranes permeable to DNA.

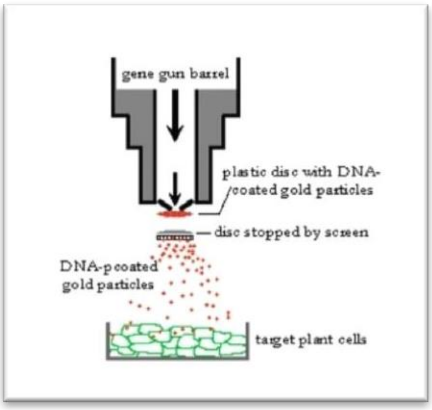
- **Example**: Introducing plasmid DNA into *E. coli* bacteria using calcium chloride.

Biological Methods

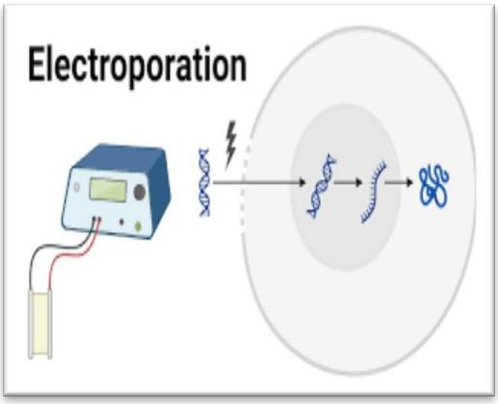
1. **Agrobacterium-Mediated Gene Transfer**:
   - A bacterium (*Agrobacterium tumefaciens*) naturally transfers DNA into plant cells.
   - **Example**: Creating pest-resistant cotton (BT cotton).
2. **Viral Vectors**:
   - Viruses are modified to carry desired genes into animal or plant cells.
   - **Example**: Gene therapy to treat genetic disorders in humans.

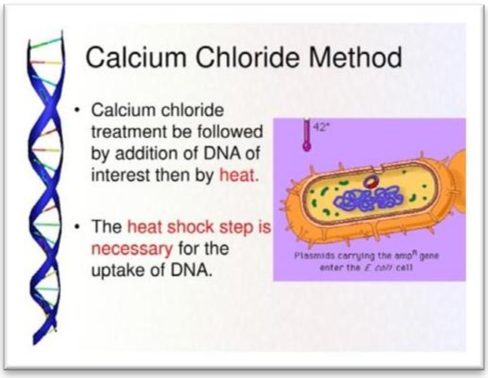


Microinjection

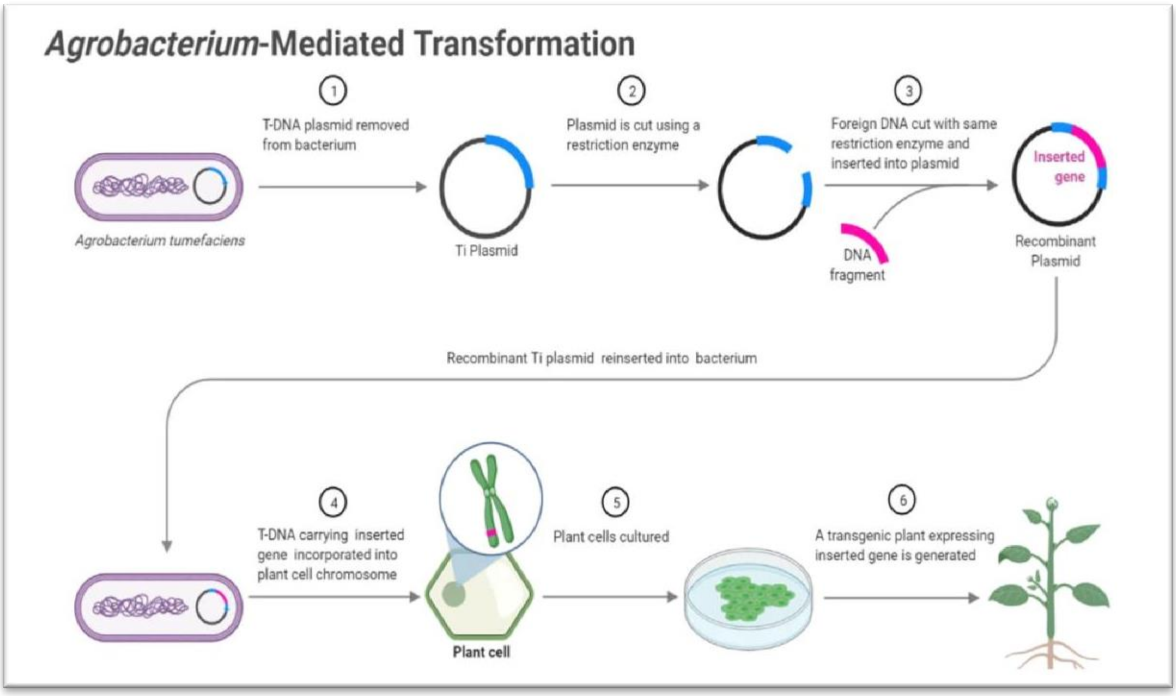


Gene Gun

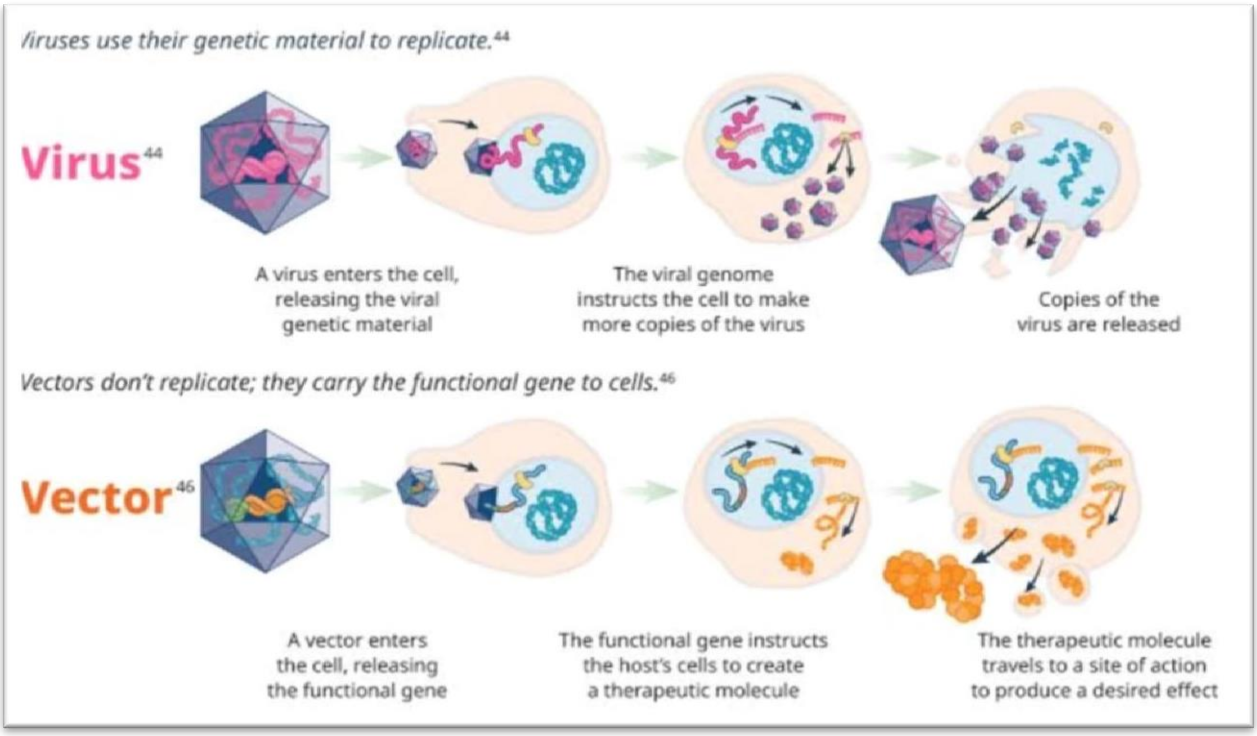




Electroporation Calcium chloride



Agrobacterium tumefaciens



Viral Vectors

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TRANSGENIC PLANTS AND ANIMALS

Transgenic Plants: Plants that have been genetically modified by inserting a gene from another organism to improve traits like pest resistance or nutrition.

Transgenic Animals: Animals that carry a gene from another species to enhance desired traits or for research purposes.

TRANSGENIC PLANTS

Procedure:

1. A useful gene is identified (e.g., for pest resistance).
2. The gene is inserted into the plant's DNA using techniques like gene guns.
3. The modified plant is grown and tested for the desired traits.

Examples:

1. **BT Cotton**:
    - Contains a gene from *Bacillus thuringiensis* (Bt), a bacterium.
    - Produces a protein toxic to pests like bollworms but safe for humans.
2. **Golden Rice**:
    - Enriched with Vitamin A by adding genes from daffodils and bacteria.
    - Reduces Vitamin A deficiency.
3. **Herbicide-Resistant Soybeans**:
    - Modified to survive herbicides, making weed control easier for farmers.

Benefits:

- Pest and disease resistance.
- Improved nutritional content.
- Reduced reliance on chemical pesticides and herbicides.

Limitations:

- Concerns about environmental impact (e.g., harm to non-target species).
- Possible resistance in pests.

TRANSGENIC ANIMALS

Procedure:

1. A desired gene is identified (e.g., for faster growth).
2. The gene is inserted into the animal's DNA using microinjection or viral vectors.
3. The animal is bred to produce offspring with the new trait.

Examples:

1. **Dolly the Sheep**:
    - First cloned animal.
2. **Transgenic Cows**:
    - Modified to produce milk with human proteins like lactoferrin, which boosts immunity.
3. **GloFish**:
    - Fish modified with jellyfish genes to glow under UV light. Used for research and as pets.
4. **Fast-Growing Salmon**:
    - Modified with growth hormone genes to grow faster than normal salmon.

Benefits:

- Improved productivity (e.g., faster growth, better milk production).
- Producing human medicines (e.g., insulin in transgenic goats).
- Advanced research on diseases and treatments.

Limitations:

- Ethical concerns about modifying animals.
- Potential risks to ecosystems if transgenic animals escape into the wild.

UNIT-4

Applications in Forensics: PCR and DNA Fingerprinting

Forensic science uses biotechnology techniques like **PCR** and **DNA fingerprinting** to solve crimes, identify individuals, and settle disputes like paternity cases.

1. Polymerase Chain Reaction (PCR)

PCR is a technique to amplify (make many copies of) a specific DNA segment from a tiny sample.

Procedure:

1. A small DNA sample (e.g., from hair, blood, or skin) is collected.
2. PCR creates millions of copies of the DNA in just a few hours.
3. This amplified DNA is used for analysis.

Important Steps in PCR

1. **Denaturation (Heating):**
   The DNA is heated to **94–98°C** to separate its two strands, like unzipping a zipper.
2. **Annealing (Primer Binding):**
   The temperature is lowered to **50–65°C** so **primers** (short DNA pieces) can stick to specific parts of the single strands.
3. **Extension (Building DNA):**
   The temperature is set to **72°C**, and an enzyme called **Taq polymerase** adds DNA building blocks (nucleotides) to create new DNA strands.

These steps are repeated multiple times to make millions of copies of the DNA.

Example in Forensics:

- A single drop of blood from a crime scene is used to amplify the suspect's DNA for comparison.

Advantages:

- Works with very small or degraded samples.
- Quick and highly sensitive.

2. DNA Fingerprinting

DNA fingerprinting is a method to identify individuals based on their unique

DNA patterns.

Procedure:

1. DNA is extracted from samples like blood, saliva, or hair.
2. Specific regions of DNA are analyzed to create a unique pattern.
3. These patterns are compared to match suspects or identify individuals.

Steps:

1. Collect DNA samples.
2. Cut DNA into fragments using restriction enzymes.
3. Separate fragments using a technique called **gel electrophoresis**.
4. Compare the DNA patterns (like barcodes).

Example in Forensics:

- Matching DNA from a crime scene to a suspect's DNA to prove their involvement.
- Identifying victims in natural disasters by comparing their DNA to family members.

Applications in Forensics

1. **Crime Solving**:
    - DNA from a crime scene (e.g., blood or skin cells) can confirm a suspect's presence.
    - Example: Matching a suspect’s DNA with samples found on a weapon.
2. **Paternity Tests**:
    - DNA fingerprinting can determine the biological parent of a child.
    - Example: Comparing the child’s DNA with potential parents.
3. **Identifying Remains**:
    - Used in disasters to identify bodies through DNA comparisons.
    - Example: Identifying victims of plane crashes.
4. **Exonerating Innocent People**:
    - DNA evidence can prove a person's innocence in wrongful convictions.

Advantages of PCR and DNA Fingerprinting

- Highly accurate and reliable.
- Can work with old, degraded, or tiny samples.
- Unique for every individual (except identical twins).

Limitations:

- Requires careful handling to avoid contamination.
- Costly equipment and expertise needed.

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Immunological Techniques: Immunoblotting and ELISA

Immunological techniques are methods used to detect, measure, and analyze specific proteins or antibodies in biological samples. **Immunoblotting** and **ELISA** are widely used in research, medicine, and diagnostics.

1. Immunoblotting (Western Blotting)

Immunoblotting, or Western blotting, is a technique used to detect specific proteins in a sample.

Procedure:

1. **Sample Preparation**: Proteins are extracted from a sample (e.g., blood, tissue).
2. **Gel Electrophoresis**: Proteins are separated based on size by running them on a gel.
3. **Transfer**: The proteins are transferred to a membrane (like paper) for analysis.
4. **Detection**: Antibodies specific to the protein of interest are added. These antibodies bind to the target protein, and a color or light signal is produced to show its presence.

Example:

- **HIV Testing**: Western blot is used to confirm the presence of HIV proteins in a patient's sample.

2. ELISA (Enzyme-Linked Immunosorbent Assay)

ELISA is a method to detect and measure specific antibodies or proteins in blood or other biological samples.

Procedure:

1. A plate is coated with a specific antigen or antibody.
2. The sample is added, and if the target protein or antibody is present, it binds to the plate.
3. An enzyme-linked antibody is added, which binds to the target.
4. A chemical substrate is added, producing a color change if the target is present.
5. The intensity of the color indicates the quantity of the target.

Types of ELISA:

1. **Direct ELISA**: Detects the target protein directly using an enzyme-linked antibody.
2. **Indirect ELISA**: Detects antibodies by using an enzyme-linked secondary antibody.

Example:

- **COVID-19 Testing**: ELISA is used to detect antibodies against the coronavirus in blood samples.

Applications of Immunoblotting and ELISA

1. **Medical Diagnostics**:
   - Western blot for confirming diseases like HIV or Lyme disease.
   - ELISA for diagnosing infections, allergies, or autoimmune diseases.
2. **Vaccine Development**:
   - ELISA checks the effectiveness of vaccines by measuring antibody levels.
3. **Protein Analysis**:
   - Western blotting is used in research to study protein expression in cells or tissues.
4. **Food Safety**:
   - ELISA detects allergens (like peanuts) in food products.

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MONOCLONAL ANTIBODIES

Monoclonal antibodies (mAbs) are identical antibodies produced by a single type of immune cell. They are useful for diagnosing and treating diseases.

Procedure

1. **Immunization**: A mouse is injected with a specific antigen (the target protein).
2. **Harvesting Cells**: The mouse's spleen cells, which produce antibodies, are collected.
3. **Fusion**: These spleen cells are fused with myeloma (cancer) cells to create hybrid cells called **hybridomas**.
4. **Selection**: Hybridomas that produce the desired antibody are selected and cloned.

5. **Production**: The cloned cells are cultured to produce large quantities of monoclonal antibodies.

Applications of Monoclonal Antibodies

1. Diagnosis

Monoclonal antibodies are used to detect diseases quickly and accurately.

Examples:

- **Blood grouping:** Monoclonal antibodies are used in blood grouping.
- **Pregnancy Tests**: mAbs detect the hormone hCG in urine.
- **Cancer Detection**: Monoclonal antibodies labelled with radioactive substances or dyes bind to cancer cells, helping locate tumours.
- **Disease Testing**: Detects viruses like HIV or COVID-19 by identifying specific antigens.

2. Therapy

Monoclonal antibodies are used to treat various diseases by targeting specific molecules involved in the disease process.

Examples:

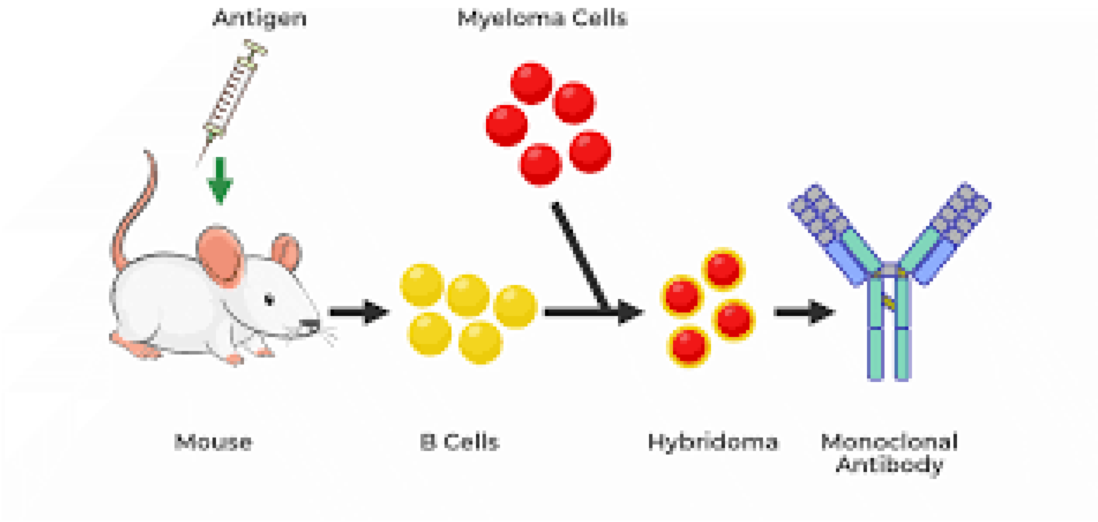
1. **Cancer Treatment**:
    - mAbs like *Trastuzumab* (Herceptin) target HER2, a protein overexpressed in some breast cancers, blocking tumor growth.
2. **Autoimmune Diseases**:
    - *Infliximab* targets is used to treat rheumatoid arthritis.
3. **Infectious Diseases**:
    - mAbs can neutralize viruses like Ebola by blocking their ability to infect cells.
4. **Allergy Treatment**:
    - *Omalizumab* reduces allergic reactions by targeting IgE antibodies.
5. **Organ Transplants**:
    - mAbs prevent organ rejection by suppressing the immune system.

Advantages of Monoclonal Antibodies

- Highly specific: They only target disease-causing molecules.
- Fewer side effects compared to traditional treatments.
- Versatile: Used in both diagnostics and therapies.

Limitations

- Expensive to produce.
- May cause allergic reactions or side effects.
- Limited effectiveness in some diseases due to resistance.



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EUGENICS AND GENE THERAPY

Eugenics: A concept focused on improving the genetic quality of humans by encouraging desirable traits and reducing undesirable ones.

Gene Therapy: A modern technique to treat or prevent diseases by altering a person's genes.

1. Eugenics

Types of Eugenics:

1. **Positive Eugenics** -
   - Encouraging reproduction among people with desirable traits (e.g., intelligence, health).
   - Example: Providing incentives for healthy individuals to have children.

2. **Negative Eugenics**:
    - Preventing reproduction among people with undesirable traits (e.g., genetic diseases).
    - Example: Sterilization programs (historically used, now considered unethical).

Applications:

- Historically used to control hereditary diseases like Huntington's disease.
- Today, ethical concerns have largely discredited eugenics.

Limitations and Ethical Issues:

- Violates human rights by discriminating against people with certain traits.
- Misused in history for harmful practices, such as forced sterilizations and racial discrimination.

2. Gene Therapy

Gene therapy involves fixing or replacing faulty genes to treat genetic disorders.

Procedure:

1. Identify the faulty gene causing the disease.
2. Replace, repair, or add a healthy copy of the gene using a vector (often a virus).
3. Introduce the modified gene into the patient's cells.

Types of Gene Therapy:

1. **Somatic Gene Therapy**:
    - Targets body cells. Changes do not pass to offspring.
    - Example: Treating cystic fibrosis by introducing a healthy gene into lung cells.
2. **Germline Gene Therapy**:
    - Targets reproductive cells. Changes can pass to offspring.
    - Example: Preventing inherited diseases like sickle cell anemia (not widely used due to ethical concerns).

Applications of Gene Therapy:

1. **Treating Genetic Disorders**:

- Example: *SCID (Severe Combined Immunodeficiency)*: "Bubble boy disease" is treated by adding a functional gene to the immune cells.

2. **Cancer Treatment**:
   - Example: CAR-T therapy modifies immune cells to attack cancer cells.
3. **Inherited Blindness**:
   - Example: *Luxturna*, a gene therapy for certain types of inherited retinal diseases, restores vision.
4. **Hemophilia**:
   - Gene therapy introduces a gene to produce clotting factors, reducing the need for frequent treatments.

Advantages of Gene Therapy:

- Targets the root cause of diseases.
- Provides potential cures for previously untreatable conditions.
- Reduces the need for lifelong medications or surgeries.

Limitations:

- Expensive and technically complex.
- Risk of immune reactions or unintended effects.
- Ethical concerns, especially with germline therapy.

Conclusion

While eugenics is a controversial and outdated practice, gene therapy is a promising modern approach to treating genetic disorders. Gene therapy focuses on improving individual health offering hope for many diseases.

UNIT-5

Data Collection and Sampling

Definition:
Data collection is the process of gathering information or observations to analyze and make decisions. Sampling involves selecting a smaller group (sample) from a larger population to study.

1. Types of Data Collection Methods

1. **Primary Data**: Collected directly by the researcher.
   - Examples: Surveys, interviews, experiments.

2. **Secondary Data**: Collected by someone else but used by the researcher.
    - Examples: Reports, books, online databases.

2. Types of Sampling Methods

1. **Random Sampling**:
    - Every individual in the population has an equal chance of being selected.
    - Example: Drawing names from a hat.
2. **Systematic Sampling**:
    - Selecting every nth person from a list.
    - Example: Choosing every 10th customer entering a store.
3. **Stratified Sampling**:
    - Dividing the population into groups (strata) and sampling from each group.
    - Example: Dividing students by grade and selecting a few from each grade.
4. **Cluster Sampling**:
    - Dividing the population into clusters and randomly selecting entire clusters.
    - Example: Selecting specific neighborhoods in a city for a survey.
5. **Convenience Sampling**:
    - Selecting individuals who are easy to access.
    - Example: Asking friends to participate in a survey.

Explain Measures of Central Tendency: Mean, Median, and Mode

Measures of central tendency help summarize a set of data by identifying a central or typical value. The three most common measures are **Mean**, **Median**, and **Mode**.

1. MEAN (AVERAGE)
The mean is the total of all values divided by the number of values.
Formula:

$$\text{Mean} = \frac{\text{Sum of all values}}{\text{Number of values}}$$

Steps:
1. Add all the values together.
2. Divide the total by the number of values.

Example:
- Numbers: 10, 20, 30, 40, 50

- Total = 10+20+30+40+50 = 150
- Mean = 150 /5=30

Uses:

- Calculating the average marks of students in a class.

2. MEDIAN

The median is the middle value of a dataset when arranged in order.

Steps:

1. Arrange the data in ascending order.
2. If there are an odd number of values, the median is the middle one.
3. If there's an **even** number of values, the median is the average of the two middle values.

Examples:

1. **Odd Set**:
   - Data: 5, 10, 15, 20, 25
   - Median = 15 (middle value).
2. **Even Set**:
   - Data: 10, 20, 30, 40
   - Median = $\frac{20+30}{2}=25$

Uses:

- Useful when data has extreme values (outliers), e.g., finding the middle income in a population.

---

3. MODE

The mode is the value that appears most frequently in a dataset.

Steps:

1. Identify the number that repeats the most.
2. If no number repeats, there is no mode.

Examples:

1. Data: 2, 4, 4, 6, 8
   - Mode = 4 (appears twice).
2. Data: 1, 2, 3, 4
   - No mode (all values appear once).

Uses:

- Finding the most popular category, e.g., the most common shoe size sold in a store.

Comparison of Mean, Median, and Mode

Measure	Best Used When	Example
Mean	Data is evenly distributed without extreme values.	Average age in a group.
Median	Data has outliers or is skewed.	Median house price in a city.
Mode	Identifying the most common value.	Most frequent survey response.

Conclusion

Mean, median, and mode are essential tools in statistics to summarize data. Each measure is suitable for different situations, helping us understand trends and patterns in the data.

****

Measures of Dispersion: Range, Standard Deviation, and Variance

Measures of dispersion tell us how spread out the data is, helping to understand the variability in a dataset. The three common measures are **Range**, **Variance**, and **Standard Deviation**.

1. RANGE
The range is the difference between the largest and smallest values in a dataset.
Formula:
Range=Maximum Value−Minimum Value
Steps:

1. Identify the largest value.
2. Identify the smallest value.
3. Subtract the smallest value from the largest.

Example:

- Data: 5, 10, 15, 20, 25
- Range = 25−5= 20.

Uses:

- Quick way to understand the spread of data, like temperature variations in a week.

---

2. VARIANCE
Variance measures how far each value in the dataset is from the mean. It tells us the "average" of these squared differences.
Formula:

$$\text{Variance}(\sigma 2) = \frac{\sum(\text{Value}-\text{Mean})^2}{\text{Number of values}}$$

Steps:

1. Find the mean of the dataset.
2. Subtract the mean from each value and square the result.
3. Find the average of the squared differences.

Example:

- Data: 10, 12, 14, 16
- Mean = $\frac{10+12+14+16}{4}$=13
- 13410+12+14+16=13.

Differences: (10−13)2 =9, (12−13)2= =1, (14−13)2=1 =1, (16−13)2=9

- Differences: $(10-13)^2$=9$(10 - 13)^2$ = 9$(10-13)^2$=9$(16-13)^2$=9.
- Variance = $\frac{9+1+1+9 \quad + 5}{4}$
- **Uses**:
- Used in finance to measure the risk of investments.

---

3. STANDARD DEVIATION

The standard deviation is the square root of variance. It shows how much the values deviate, on average, from the mean.

Formula:

Standard Deviation(σ)=Variance\

Steps:

1. Calculate the variance.
2. Take the square root of the variance.

Example:

- From the above example, Variance = 5.
- Standard Deviation = 5≈2.24

Uses:

- Understanding the consistency of data, like checking how consistent exam scores are in a class.

Comparison of Range, Variance, and Standard Deviation

Measure	Definition	Best Used When	Example
Range	Difference between max and min values.	For quick understanding of data spread.	Range of rainfall in a week.
Variance	Average of squared differences from mean.	For detailed variability analysis.	Variance in stock prices over a month.
Standard Deviation	Square root of variance.	To interpret spread in original units.	SD of students' marks in an exam.

Conclusion

Measures of dispersion like range, variance, and standard deviation help us understand how spread out the data is. While the range is simple, variance and standard deviation give a more detailed picture of variability in the dataset.

****

Probability and Tests of Significance

Probability is the measure of how likely an event is to happen.

Tests of significance are statistical tests used to determine whether the results of an experiment or survey are meaningful or if they could have occurred by chance.

1. Probability

Probability is the likelihood or chance of an event happening. It ranges from 0 (impossible) to 1 (certain).

Formula:

$$\text{Probability(P)} = \frac{\text{Number of favorable outcomes}}{\text{Total number of possible}}$$

Steps:

1. Count the number of favorable outcomes.
2. Count the total number of possible outcomes.
3. Divide the number of favorable outcomes by the total number of possible outcomes.

Example:

- You have a bag with 3 red balls and 2 blue balls.
- The probability of drawing a red ball:
  - Favorable outcomes = 3 (red balls).
  - Total outcomes = 5 (total balls).
  - Probability = 3/5=0.6
  - So, there is a 60% chance of drawing a red ball.

Types of Probability:

- **Simple Probability**: As shown in the example above.
- **Conditional Probability**: Probability of an event given that another event has occurred.
- **Independent Probability**: Probability of two events occurring together, where one event does not affect the other.

---

2. Tests of Significance

Definition:
A test of significance helps determine if the results from an experiment or study are due to chance or if they are statistically meaningful.

The most common test is the **hypothesis test**.

---

3. Steps in Hypothesis Testing

1. **State the Hypothesis**:
   - **Null Hypothesis (H_0)**: Assumes no effect or no difference.
   - **Alternative Hypothesis (H_1)**: Assumes there is an effect or a difference.
   - Example: H_0: There is no difference in average test scores between two groups.
     H_1: There is a difference in average test scores between two groups.
2. **Choose the Significance Level (α)**:
   - Common choice: 0.05 (5%).
   - This means there's a 5% chance of concluding that there's an effect when there isn't one (Type I error).
3. **Calculate the Test Statistic**:
   - Based on the data, calculate a test statistic (e.g., t-test, z-test) to compare the observed data with what is expected under the null hypothesis.
4. **Make a Decision**:
   - If the p-value (probability value) is less than or equal to the significance level (α), reject the null hypothesis (H_0).
   - If the p-value is greater than α, fail to reject the null hypothesis.

4. Common Tests of Significance

1. **t-test**:
    - Used to compare the means of two groups.
    - Example: Comparing the test scores of two different classes.
2. **z-test**:
    - Used when the sample size is large (usually $n > 30$) and you know the population standard deviation.
    - Example: Checking if the average height of a group of people is different from the national average height.
3. **Chi-Square Test**:
    - Used to compare observed and expected frequencies in categorical data.
    - Example: Testing if there is a relationship between gender and voting preference.
4. **ANOVA (Analysis of Variance)**:
    - Used to compare the means of more than two groups.
    - Example: Comparing the effectiveness of three different diets on weight loss.

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5. P-value and Conclusion

The **p-value** helps to decide if the results are statistically significant.

- **P-value ≤ 0.05**: The result is statistically significant (reject H_0).
- **P-value > 0.05**: The result is not statistically significant (fail to reject H_0).

Example of a Hypothesis Test

- **Problem**: You want to test if a new teaching method improves student performance.
- **Step 1**:
    - Null hypothesis (H_0): The new teaching method does not improve student performance.
    - Alternative hypothesis (H_1): The new teaching method improves student performance.
- **Step 2**:
    - Set $\alpha = 0.05$ (5%).

- **Step 3**:
  - Collect data from two groups of students: one using the old method and one using the new method.
  - Perform a t-test to compare the average scores.
- **Step 4**:
  - If the p-value is less than 0.05, reject H_0 and conclude that the new teaching method has an effect. If the p-value is greater than 0.05, fail to reject H_0 and conclude that there's no significant difference.

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Define Genomics and Proteomics. Explain the difference between Genomics and Proteomics and enlist their uses.

1. Genomics

Definition:
Genomics is the study of the genome, which is the complete set of an organism's DNA, including all its genes. It focuses on understanding genes, their functions, and their interactions.

Examples:

- Scientists study the **human genome** to identify genes linked to diseases like cancer or diabetes.
- Farmers use genomics to develop **drought-resistant crops** by identifying genes that help plants survive in dry conditions.

Applications:

1. **Medicine**: Detecting genetic disorders and personalizing treatments (e.g., identifying the **BRCA1 gene** for breast cancer risk).
2. **Agriculture**: Creating better crops like **Bt cotton**, which resists pests.
3. **Gene Therapy**: Treating diseases by correcting faulty genes (e.g., using **CRISPR** for genetic editing).

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2. Proteomics

Definition:
Proteomics is the study of all the proteins produced by an organism. Proteins perform most of the tasks in a cell, such as building structures, sending signals, and speeding up chemical reactions.

Examples:

- Researchers study the protein **hemoglobin** to understand how it carries oxygen in the blood.
- Proteomics helps identify proteins involved in diseases like **cancer**, allowing for targeted treatments.

Applications:

1. **Disease Diagnosis**: Finding proteins that signal specific diseases (e.g., **PSA** for prostate cancer).
2. **Drug Development**: Designing drugs that target harmful proteins (e.g., targeting the **HER2 protein** in breast cancer).
3. **Personalized Medicine**: Tailoring treatments based on a patient's unique protein profile.

Key Differences

Genomics	Proteomics
Focuses on the **genes** and **DNA** in an organism.	Focuses on the **proteins** produced from genes.
Studies the **genome** (all the DNA).	Studies the **proteome** (all the proteins).
Key for understanding genetic diseases and inheritance.	Key for understanding how cells and tissues function.
Uses DNA sequencing and gene mapping.	Uses techniques like mass spectrometry to study proteins.

In Short:

Genomics helps understand the genetic code and its role in health and disease.

Proteomics focuses on proteins, which are the working molecules in cells, to understand their functions and interactions.

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Write Notes on Biological Databases: NCBI, EBI, and GenBank

1. NCBI (National Center for Biotechnology Information)

- A U.S.-based organization that provides tools and databases to study DNA, RNA, and proteins.
- **Main Features**:
  - **BLAST Tool**: Compares sequences to find similarities.
  - **PubMed**: A database for research articles in biology and medicine.
- **Example**:
  If you discover a new DNA sequence, you can use the **BLAST tool** on NCBI to see if it matches known sequences.

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2. EBI (European Bioinformatics Institute)

- A Europe-based institute offering access to genomic and protein data.
- **Main Features**:
  - **Ensembl**: A database for exploring genomes of humans, animals, and plants.
  - **UniProt**: A protein database with detailed protein information.
- **Example**:
  Use **Ensembl** to study the gene responsible for eye color in humans and compare it with genes in animals.

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3. GenBank

- A database hosted by NCBI, storing DNA and RNA sequences from all types of organisms.
- **Main Features**:
  - Stores billions of sequences.
  - Includes both raw data and annotated sequences.
- **Example**:
  You can find the **DNA sequence of the COVID-19 virus** in GenBank to study its mutations.

In Simple Terms:

- **NCBI**: A one-stop shop for DNA, RNA, protein tools, and research papers.
- **EBI**: A hub for European resources, with specialized tools like **Ensembl** for studying genes.
- **GenBank**: A library of DNA and RNA sequences from organisms worldwide.

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Accessing Nucleic Acid and Protein Databases

Biological databases store information about DNA, RNA, and proteins. Scientists use these databases to study genes, proteins, and their functions.

1. Nucleic Acid Databases

These databases focus on storing and sharing **DNA** and **RNA** sequences.

Key Databases:

1. **GenBank (NCBI)**:
    - Stores DNA and RNA sequences from different organisms.
    - **Example**: A researcher can find the DNA sequence of the **insulin gene** in humans.
2. **Ensembl (EBI)**:
    - Provides detailed genomic data, including annotations.
    - **Example**: A scientist can study genes related to **eye color** in humans or animals.
3. **RefSeq (NCBI)**:
    - A curated database of reference sequences for genes and RNA.
    - **Example**: Finding the standard sequence for the **beta-globin gene**, linked to blood disorders.

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2. Protein Databases

These databases store information about proteins, such as their sequences, structures, and functions.

Key Databases:

1. **UniProt**:

    - Provides protein sequences and their functions.
    - **Example**: A researcher can study the **hemoglobin protein** to understand how it transports oxygen.
2. **PDB (Protein Data Bank)**:
    - Contains 3D structures of proteins and other molecules.
    - **Example**: Viewing the 3D structure of **enzymes** to understand how they work.
3. **SWISS-PROT (UniProt)**:
    - A manually reviewed protein sequence database.
    - **Example**: Searching for proteins involved in **immune responses** like antibodies.

How to Access These Databases

1. **Search Online**:
    - Visit websites like **NCBI**, **EBI**, or **UniProt**.
2. **Enter the Query**:
    - Example: Search for "COVID-19 spike protein" to find its sequence and structure.
3. **Analyze Data**:
    - Use tools like **BLAST** to compare sequences or download files for further study.

Example in Real Life

- **Nucleic Acid Database**: A scientist uses GenBank to find the DNA sequence of a virus to track its mutations.
- **Protein Database**: A researcher uses UniProt to study a cancer-related protein and design drugs to target it.

In simple terms, nucleic acid and protein databases are like online libraries for DNA and proteins, helping researchers explore and understand life at the molecular level.