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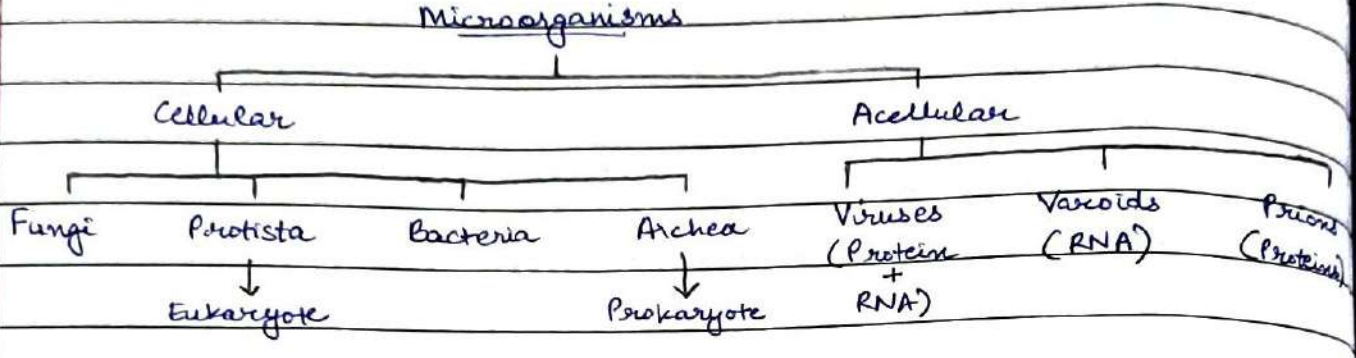
Unit 4 - Basics of Microbiology and Immunology

▷ Basics of Microbiology

→ Branch of science which includes the study of microorganisms is called microbiology.



[Prions are deadlier than viruses]

* History

→ Leeuwenhock first observed living organisms.

→ Spontaneous generation theory

According to this theory, living organisms all develop from non-living matter. [It was later disproved.]

→ Germ theory

According to this theory, infectious diseases were thought to be caused by supernatural powers [later disproved]

→ Koch's Postulates

1) Suspected pathogens (disease-causing microorganisms) must be present in all cases of infected organism and absent in healthy organism.
2) Pathogens must be grown in pure culture (artificially)
3) Cells from pure culture must cause disease in healthy organism.
4) Suspected pathogen must be reinsulated and shown to be same as the original.

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* Microbiological Tools

1) Light Microscope
→ Light microscope can allow to see microorganisms but not smaller ones like viruses.

2) Culturing Media
→ Made of agar-agar and liquid mediums.

3) DNA Sequence
→ Sequencing genes, genome (set of DNA in an organism).

Note :- Species vs variants.
Change in DNA Sequence makes variants and can be achieved in labs. Different Species take several hundred years to form.

* Microbial Diversity

→ 3 types of microbial diversity :
1) Physical / Structural eg. Cell shape
2) Biochemical / Metabolic eg. energy sources.
3) Genomic eg. DNA sequence.

1) → Physical / Structural Diversity

Prokaryotes

Cocci	Bacillus
- Spherical shaped	- Rod-shaped
- 1 μm diameter	- 1 μm × 3 μm
- eg.	- eg.
Chains - Streptococci	Coccobacillus (very short rods) :-:
Clusters - Staphylococci	Filamentous (long rods) {{{
	Vibrio (curved rods) ~~

I guess nothing comes here ....

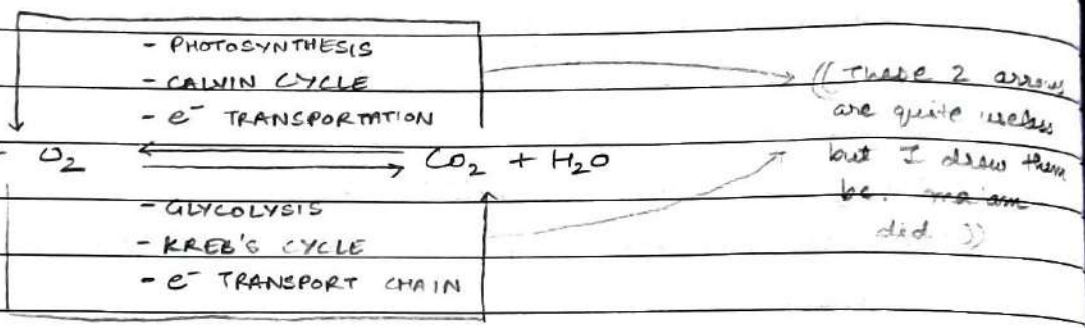
2) → Metabolic Diversity

Metabolism refers to all the chemical reactions in a cell

SCP

Microorganisms show enormous metabolic diversity. Due to highly variable environments, microbes have evolved diverse ways of obtaining energy & matter for growth.

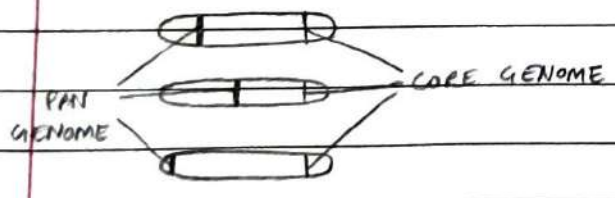
→ Diverse energy sources of microorganisms
  ↳ Organic chemical
  ↳ Light
  ↳ Inorganic chemical.



→ Diverse e^- donors → H_2O, H_2S
→ Diverse terminal e^- acceptors → O_2, NO_3, SO_4
→ Organic compounds eg. fermentation.

3) Genomic Diversity

→ 'Genome' means complete set of DNA in an organism.
→ Genome → Core Genome (Common to all strains of microbes)
  ↳ Pan Genome (variable to all)
→ Strain is a sub-type of subspecies



* Microbial Nutrition

↳ As plants and animals require materials for nutrition, microorganisms also require the same.

→ Types

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1) Essential Micronutrients

→ Required in large amount.

↳ More than 95% of dry of microbes comprises of micronutrients.

eg. Lipids (lipids, oils, fats), nitrogen (required for synthesis of amino acids), phosphorus (required for synthesis of nucleic acids or nucleotides & in formation of ATP [Adenosine triphosphate] i.e. 'energy currency of body'), sulphur (required for synthesis of different amino acids eg. methionine, cystine)

2) Cofactors

eg Potassium, sodium, calcium, magnesium

↳ Cofactors are metal ions or organic part which are required by the enzymes for their proper functioning. For eg. Structure & function of ribosome is stabilised by calcium & magnesium (3) Trace elements i.e. required in very small amounts but are essential for proper functioning of microbes eg. Fe, Mg, Mn, Zn, Cu, Ni, Mo, I)

[3) was trace elements only... I'm sorry]

4) Growth Factors

↳ Some microbes are unable to synthesize certain molecules & obtain them from the environment or provided in growth medium.

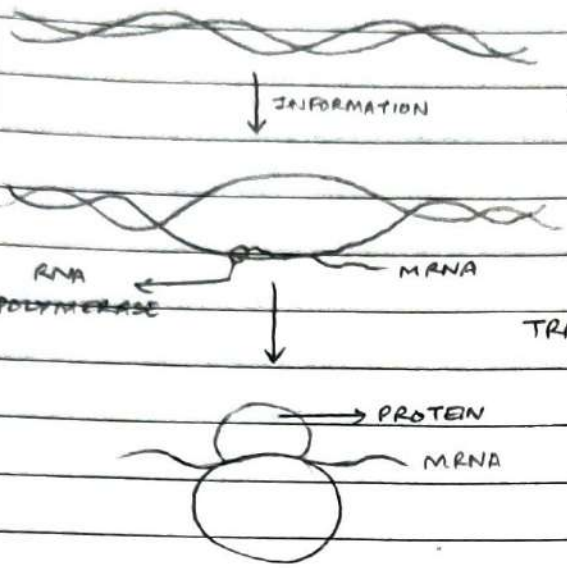
eg. Lactobacillus lose ability to make its own amino acids i.e., to grow, we have to add these amino acids ourselves. These include amino acids, purines, pyrimidines & vitamins

* Central Dogma of Molecular Biology

→ DNA strand unwinds [made of series of nitrogenous bases containing info.]

→ RNA polymerase reads & decodes information present in DNA and synthesises mRNA

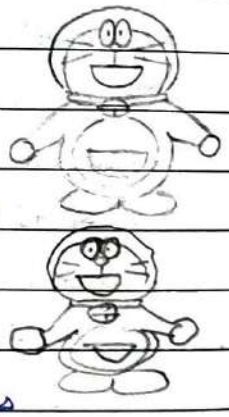
→ mRNA → messenger ribonucleic acid.



→ mRNA is transported from nucleus to RER to ribosome
→ Ribosome produces proteins which are used by organisms. [Non-essential proteins]

* Nutrition Type in Microorganism

↳ All microbes need energy and carbohydrates for nutrition.
↳ Chemotrophic – energy from chemicals
eg1. bloom of cyano bacteria → energy from light
↳ carbon from CO_2
↳ splits H_2O as a source of e^- with photosynthesis.
eg2. Purple sulphur bacteria → energy from light
↳ carbon from CO_2
↳ splits H_2S as source of e^-



* Microbial Culture

↳ Growing environment / growth medium for microbes
↳ Must contain all nutrients needed for growth of microbes.
↳ Classified based on

- Chemical Constituents
  - Defined → conc. of all components are known
  - Complex → conc of some components are unknown
- Physical Nature
  - Liquid, semi-solid, solid
- Function
  - Supportive
  - Selective
  - Enriched.

→ Defined culture media – eg. chemically defined medium for growing a chemoheterotroph such as E. Coli

→ Complex culture media – eg. complex of nutrient agar ; peptones (protein hydrolysation prepared by partial digestion of protein source).

→ Supportive culture – Supports growth of many organisms (microbes)

→ Selective culture – Supports growth of a particular microbe

→ Enriched culture – A general-purpose media with blood or other nutrients required for growth of microbe

* Introduction to Immunology

* Immune System

↳ It includes all parts of the body that help in the recognition and destruction of foreign materials.
eg. WBC, phagocytes, bone marrow, lymph nodes, spleen, thymus.

* Immunity

↳ Protection against diseases is called immunity.

* Immune Response

↳ A coordinated reaction of the immune system against infection is called immune response.

* Cells of Immune System

↳ Lymphocytes → B-cells (produce antibodies against antigens)
↳ T-cells (kills body's own cells eg. cancerous cells, cells taken over by viruses).

↳ T-Cells → Helper T-cells (Sends signals (to killer T-cells) that direct immune system to fight infections)
↳ Killer T-Cells (destroy the infected cell).

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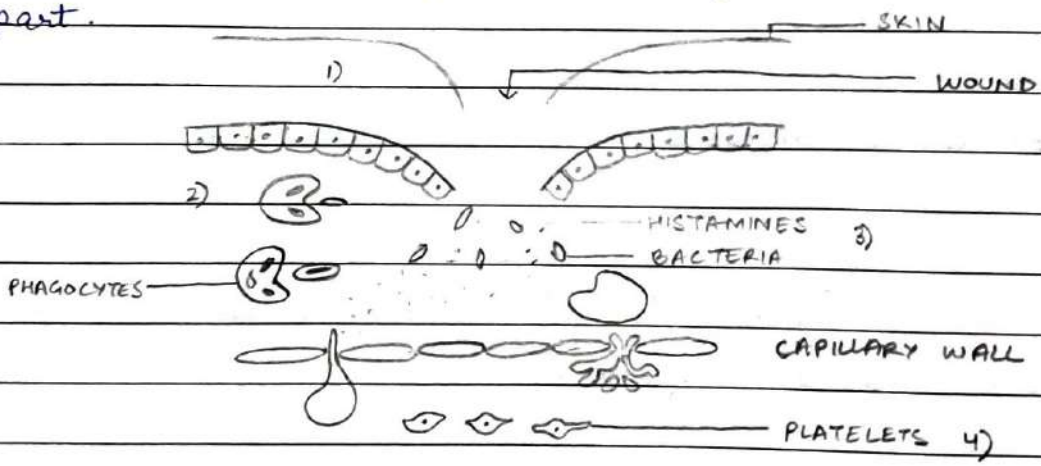
* Host Defence

- **Innate (non-specific)** → common to all pathogens
  - **First Line**: Physical Barrier — eg. skin, tears, sweat, mucus, stomach acid
  - **Second Line**: Chemical Barrier (Inflammatory response) — eg. redness, itching, heat, fever
- **Acquired (specific)** → for specific pathogen
  - **Third Line**: eg. antibodies, T cells, cytokines.

* Steps in Inflammatory Response

1) Damaged tissues release histamines to increase blood flow to the area.
2) Histamines cause capillaries to leak, releasing phagocytes & clotting factors into the wound.
3) Phagocytes engulf bacteria & dead cells.
4) Platelets move out of the capillary to seal the wounded part.



* Active & Passive Immunity

i) Active Immunity

↳ Resistance developed by an individual as a result of antigen stimulus.

↳ lead to antibody synthesis.

ii) Passive Immunity

↳ Resistance transferred to the individual in a ready-made form is called passive immunity. Here, individual immune system plays no active role.

↳ The formed antibodies are administered to the body.

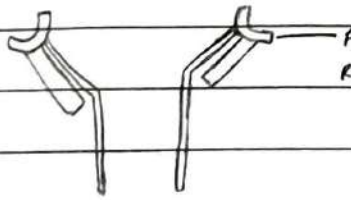
* Antigen

↳ ~~Resistance~~ Any foreign material that binds specifically to an antibody.

↳ Antibody → Proteins → Immunoglobulins (Ig)

↳ Antibody recognises a particular antigen & binds specifically to it.

↳ β cells produce antibodies.



IgM
IgA
IgD
IgE
IgG

* Humoral & Cellular Immunity

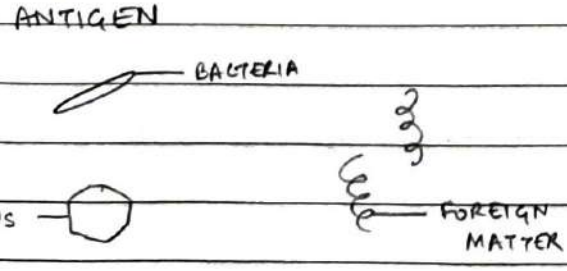
i) Humoral Immunity Response

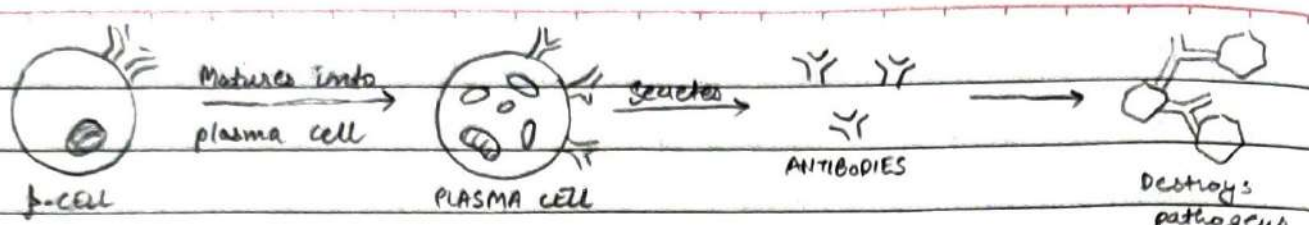
↳ Soluble proteins called antibodies function as recognition & bind specifically to antigen

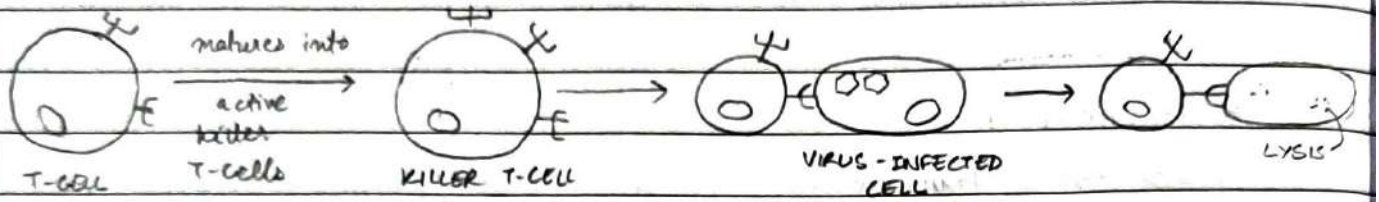
↳ Antibodies are separated by plasma cells that are derived from β cells

ii) Cellular Immunity Response

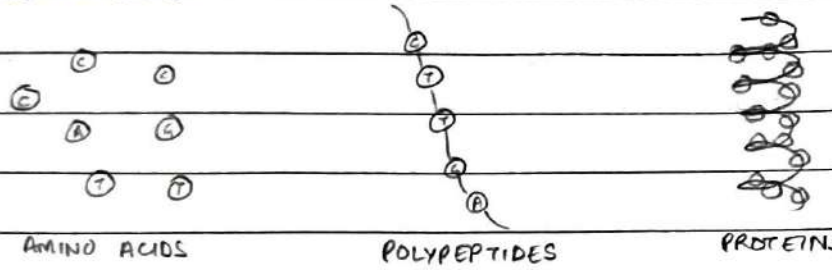
↳ Here, T-cells kill cells that display foreign motifs on their surfaces.



i) 

ii) 

Note :- Immunology → classical example of permutation & combination.



Case Study

↳ Immunoglobulin heavy diversity 1.1 (Ig HD 1.1) — GTTGT

→ G → 2 times, T → 3 times.

[Glycine (G) Thiamine (T)]

$X = [2, 3]$, $n = 5$, $n_1 = 2$, $n_2 = 3$

According to law of permutations & combinations,

$$\frac{n!}{n_1! \, n_2!} = \frac{5!}{2! \cdot 3!} = 10$$

i.e. GGTTT TTGTG

GTGTT TTTGG

GTTGT TGGTT

GTTTG TGTGT

TTGGT TGTTG

Ig HD 1.1 - Only GTTGT is occuring in nature & none of the remaining 9 amino acids occur in nature.

This shows that the nature picked or selected 1 out of 10 amino acid combinations to form a functional peptide.

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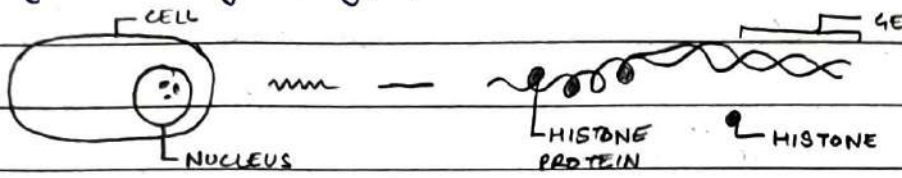
* Concept of Gene

↳ Gene is smallest part of DNA.

↳ Gene is a unit of genetic [information/] material that specifies the synthesis of polypeptide.



↳ Gene is specific for a particular polypeptide.

* Gene Theory

↳ Proposed by T. M. Morgan

i) Chromosomes are bearers of hereditary units. Each chromosome carries hundreds or thousands of genes.

2) Genes are arranged on the chromosomes in linear order and on special regions known as locus.

* Terms Related to Genes

i) Recon - Smallest unit of DNA (Part of Gene) capable of undergoing crossing over or recombination.

ii) Muton - Gene that can undergo mutations.

iii) Cistron - Gene that is capable of synthesizing polypeptide.

* Gene Types

i) Basic Gene - Fundamental genes that bring expression of particular phenotypic trait.

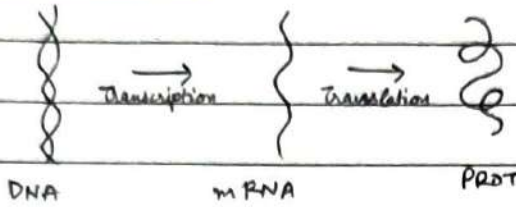
Note:- Phenotype - Physical appearance / character
Genotype - Genetic character.

2) Multiple Genes - Two or more genes that independently work & produce a single phenotypic trait.

3) Cumulative Genes - Genes that have additive effects on the action

of other genes.

* Gene Action



* Gene Regulation - Process of turning genes on and off.

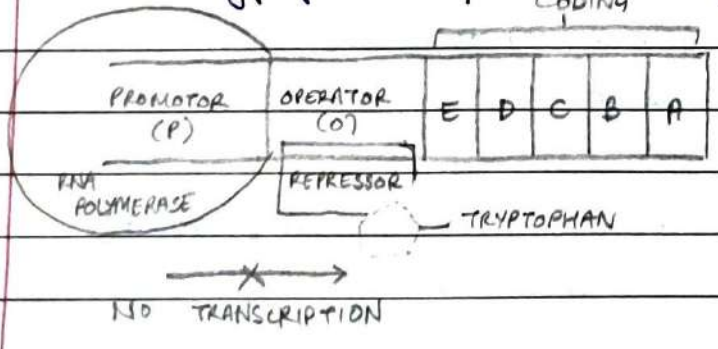
→ Some terms related to gene regulation -

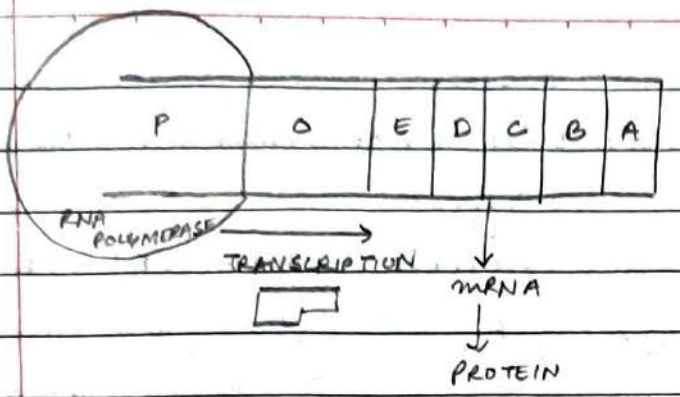
1) Operon - set of genes which perform a specific function. (Genetic regulatory system)
2) Repressor - Molecule of protein that inhibits transcription/expression of genes.
3) Promotor - Part of gene where RNA polymerase bind for transcription.
4) Inducer - Protein that regulates (reduces or enhances) transcription depending on need of cell.

→ In prokaryotes [eg. E. Coli], transcription and translation occur at the same time. continuously until need of cell is fulfilled.

1) Tryptophan Operon (Tryp-operon)

↳ Tryptophan is an amino acid needed for survival of E.Coli. When E. Coli cannot obtain it from surroundings, it synthesizes more Tryptophan from existing Tryptophan within it.





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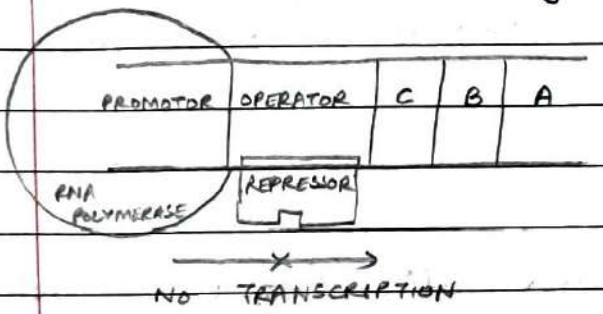
2) Lactose Operon (lac-operon)

↳ Lactose → Galactose + ~~Glucose~~ Glucose

↳ lac-operon → Low Glucose level

↳ High Glucose level



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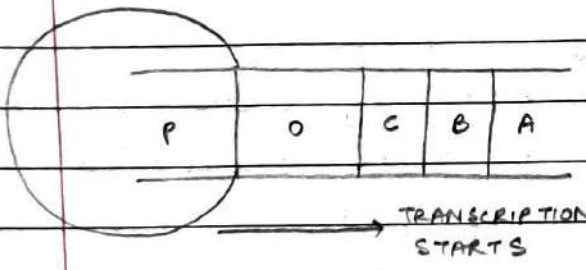

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* Drug Antagonism & Synergism

↳ Drug antagonism → when two drugs, taken together, nullify each other's effect.

↳ Drug synergism → when two drugs, taken together, enhance each other's effect

Drug Antagonism	Drug Synergism
1) One drug decreases or inhibits the effect of other	2) One drug facilitates the effect of other drug when given

drug.
Effect of A+B < Effect of A + Effect of B

2) Types :

i) Physical (eg. Charcoal adsorbs alkaloid in alkaloid poisoning)

ii) Chemical (eg. CaNaEDTA form insoluble complexes with As / Pb)

iii) Functional - Two drugs act on two different types of receptors and antagonise action of each other. (eg. Glucagon and insulin)

together.
Effect of (A+B) ≥ Effect of (A) + Effect of (B)

2) Types :

i) Additive - (A+B) = (A) + (B)

eg1. Aspirin - (-) Prostoglandin analgesia (+)
Codeine - (-) Prostoglandin analgesia (+)
(+)(+)

eg2. Ibuprofen - (-) PG - analgesia (+)
Paracetamol - (-) PG - analgesia (+)
(+)(+)

ii) Supra Additive - (A+B) > (A) + (B)

eg. Sulphamethoxazole + Trimethoprim
↓
Block two step synthesis of folic acid in microorganism.

* Cancer Biology

↳ Control & regulation

↳ In our body, cell growth and differentiation is highly controlled and regulated. In cancer cells, there is a breakdown of these regulatory mechanisms.

↳ Normal cells show contact inhibition by virtue of which contact with other cells inhibits their uncontrolled growth. Cancer cells lose this property.

↳ As a result of this, cancerous cells just continue to divide, giving rise to a mass of cells called tumor.

↳ Types of Tumor

1) Benign Tumor

The tumors are confined to their original location and don't spread to other parts.

2) Malignant Tumor

These cells grow rapidly, invading and damaging the surrounding normal cells

* Causes of Cancer

↳ Cancerous cells may be induced by physical, chemical or biological agents known as carcinogens.

1) Ionizing radiations like X-Rays, γ-Rays, UV light
2) Chemical carcinogens present in tobacco smoke.
3) Cancer-causing viruses called oncogenic viruses
4) Several genes called cellular oncogenes present in normal cells which, on activating under certain conditions, lead to cancer.

* Cancer Detection and Diagnosis

↳ Early detection of cancer is essential as it allows the disease to be treated successfully in many cases.

↳ Cancer detection is based on biopsy i.e. procedure to remove a piece of tissue or a sample of cells so that it can be tested in a laboratory.

↳ Histopathological studies → Study of pathogens that cause cancer.

↳ Techniques of Diagnosis

1) Radiography (use of X-Rays)
2) CT (Computed Tomography)
3) MRI (Magnetic Resonance Imaging)

↳ Antibodies against cancer-specific antigens are also used for detection of some cancers. (not all)

* Treatment (of Cancer)

1) Surgery
2) Radiation therapy
3) Immuno therapy
4) Chemicals called α-interferons which activate immune system and help in destroying tumor