


POLLUTION
FIRST STAGE

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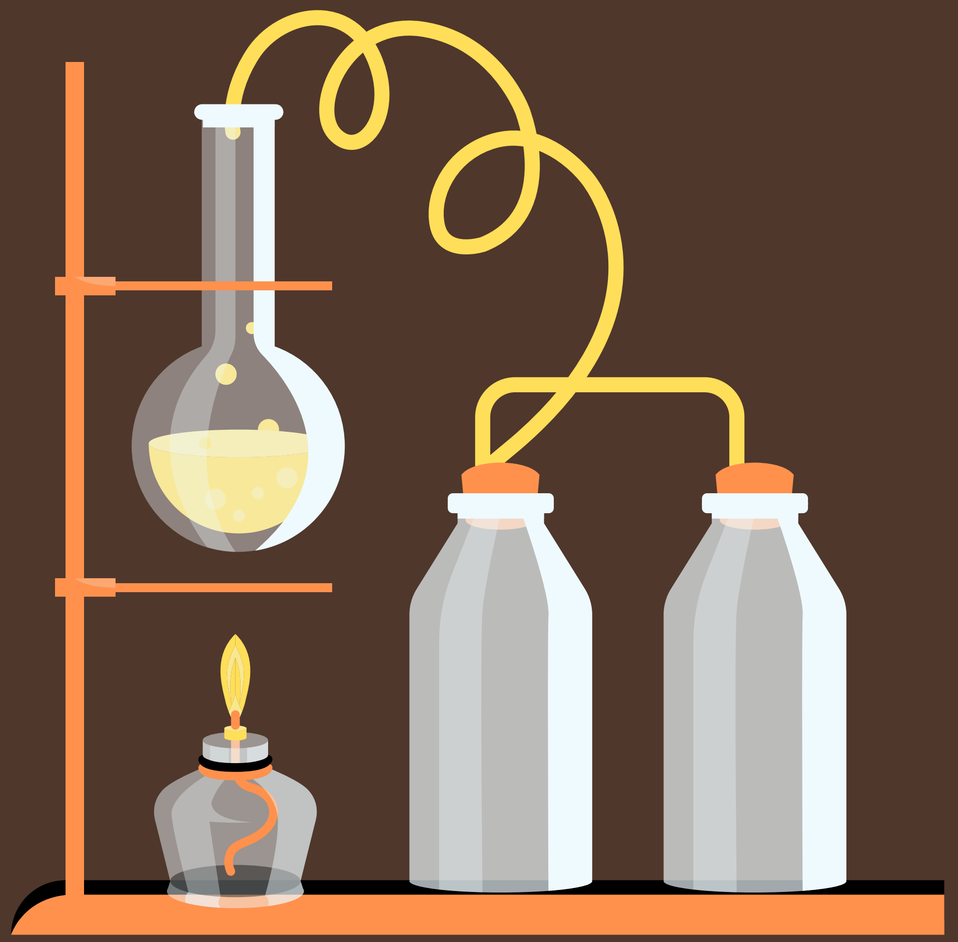
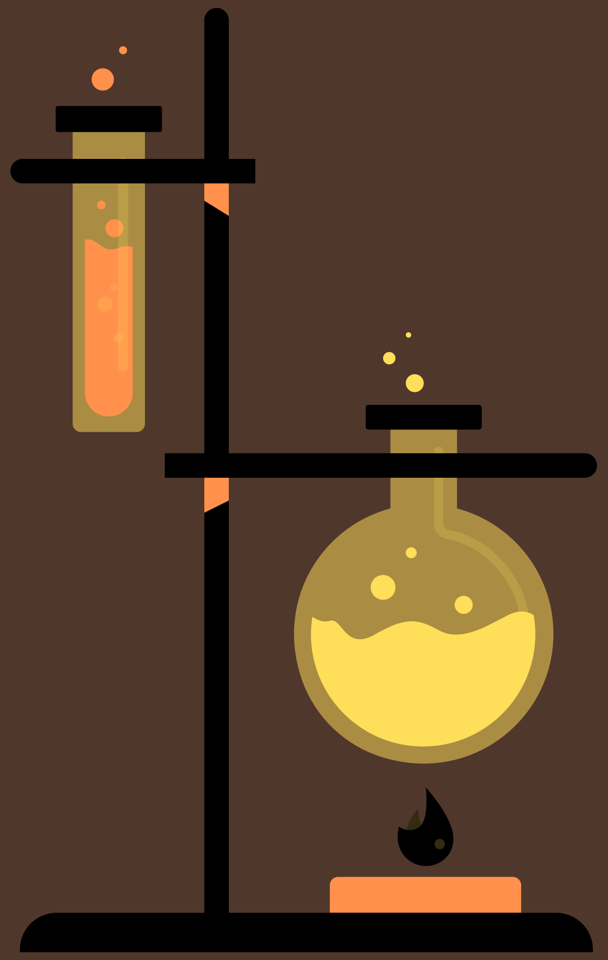
MEDICAL BIOCHEMISTRY

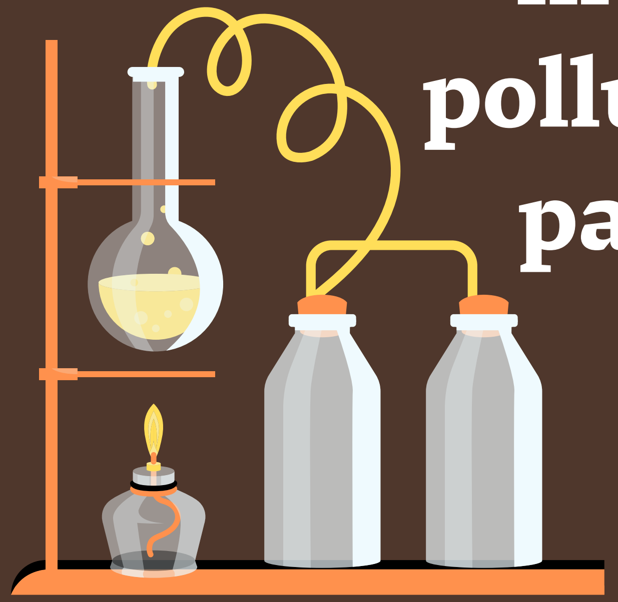



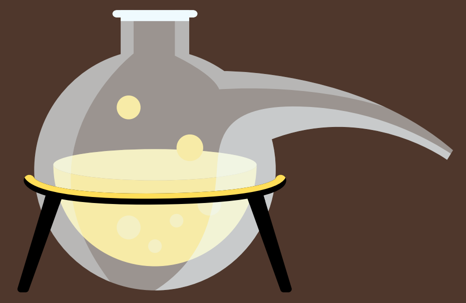
chemical stress and pollution :

human overuse of natural resources disrupts ecological balance, leading to resource depletion and waste accumulation, which results in air, water, and food pollution. Pollution is defined as

the excessive concentration of harmful foreign matter in outdoor air. normal air composition includes approximately 78.1% Nitrogen, 20.93% Oxygen, and trace amounts of other gases.

industrial growth and urbanization have led to primary pollutants, such as Carbon Monoxide, Nitrogen Oxides, and particulates, contributing over 90% of global pollution.





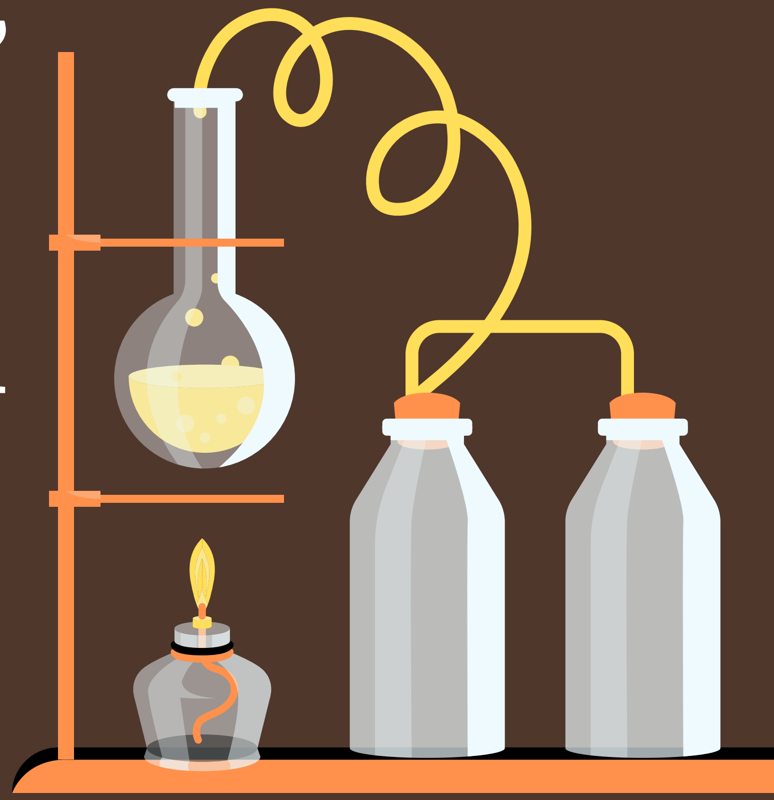
sources of air pollution :

(1) Industrial processes: Chemical, Metallurgical, oil refineries, fertilizer factories, etc.

(2) Combustion: industrial and domestic combustion of coal, oil and other fuel is another sources of smoke, dust and sulphur dioxide

(3) Motor vehicles: motor vehicles are significant contributors to urban air pollution, emitting hydrocarbons, carbon monoxide, lead, nitrogen oxides, and particulates. in strong sunlight, some

hydrocarbons and nitrogen oxides can convert into photochemical pollutants that are oxidizing in nature.



(4) Miscellaneous.

pollutants

over 100 contaminants have been identified, with key ones including CO_2, Carbon Monoxide, Sulfur

Dioxide, Hydrogen Sulfide, Nitrogen Oxides, Ammonia, and various carcinogenic agents.

Meteorological condition: the primary indicators of overall air pollution levels are sulfur dioxide, smoke, and suspended particles.

(1) Sulphur dioxide: this gas, a major contaminant in urban and industrial areas, is produced by

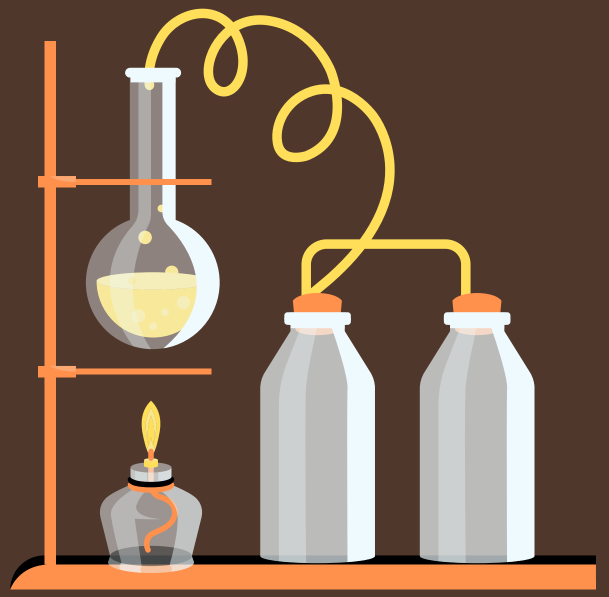
burning coal and fuel oil. key air pollutants include carbon monoxide, nitrogen oxides, hydrocarbons, sulfur oxides, and particulates.

(2) Smoke index or soiling index.

(3) Suspended particles.

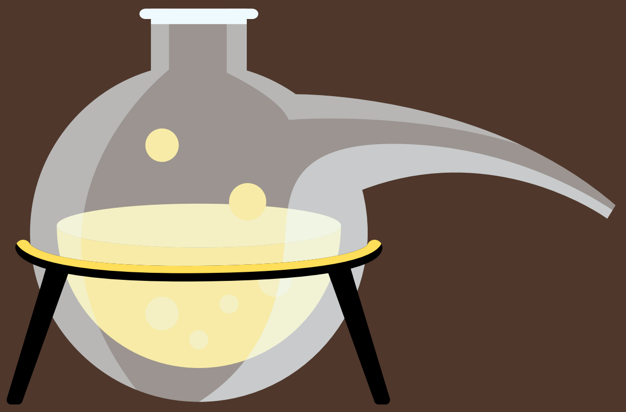
health effects of air pollution :

Oxides of sulphur: sulphur dioxide and other corrosive gases, primarily from burning sulfur-containing oil and



coal, harm the respiratory system and can lead to bronchitis and lung cancer at concentrations above 0.1 ppm. these gases also damage plants, causing leaf spotting, burning, and stunted growth.

Oxides of Carbon: cells can tolerate CO_2 increases up to 7.5% for short periods, with adaptation to 3% involving changes in acid-base balance and ion levels in red blood cells. rising CO levels from



incomplete fuel combustion displace oxygen in the blood, leading to hypoxia and decreased mental performance, especially in individuals with heart, lung, or anemia conditions.

Photochemical oxidants: sunlight causes nitrogen oxides and hydrocarbons from fuel combustion to form harmful

secondary products, including ozone, which can irritate eyes and lungs, trigger asthma attacks, and damage vegetation.

Particulates: dust, consisting of various solid and liquid particulates from industrial processes and fuel burning, poses serious health risks, particularly pneumoconiosis

and related conditions like silicosis and asbestosis. additionally, indoor particulate levels correlate with cigarette

smoking, increasing respiratory illnesses and lung cancer risk in nonsmokers exposed to secondhand smoke.

other effect of air pollution :

Acid Rain: acid rain, resulting from sulfur dioxide and nitrogen dioxide emissions that form sulfuric and nitric

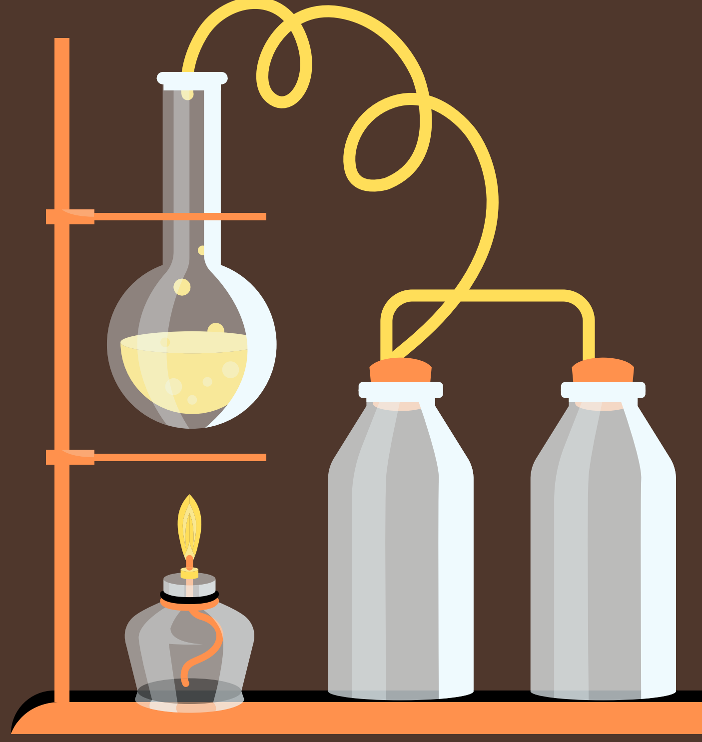
acids, pollutes water bodies and soil,
reducing soil fertility. these pollutants can travel long distances, impacting neighboring towns and countries.

Increased CO_2 concentration: green house effect the burning of coal and oil, along with deforestation, increases atmospheric CO_2 levels, disrupting ecological balance and

trapping heat near the earth's surface, leading to global warming—a phenomenon known as the "greenhouse effect."

Future Consequences: even a slight increase in CO_2-induced global warming could cause polar ice to melt,

raising sea levels and threatening to flood coastlines and low-lying towns and cities worldwide.

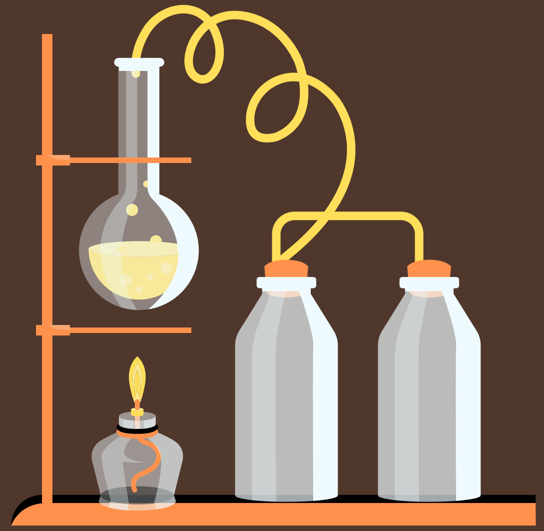


Water Pollution: water, essential for life and constituting much of living cell weight, is

increasingly scarce due to pollution from municipal industrial, and agricultural waste, complicating its usability for modern needs.

A large number of water pollutants may be broadly classified as:

Organic pollutants: (a) Water pollutants include oxygen-demanding wastes, disease agents, nutrients, sewage, and synthetic compounds, with decreased dissolved oxygen (4-6 ppm) indicating pollution primarily from organic matter like sewage and industrial runoff. (b) Production of synthetic organic chemicals: the presence of various synthetic compounds, including fuels, plastics and pharmaceuticals, in water has increased tenfold since 1950, leading to undesirable tastes, odors, and colors. (c) Pesticides: while pesticides such as insecticides and herbicides have effectively eradicated diseases like malaria and typhus, their residues pose a threat to ecosystems and the food chain.



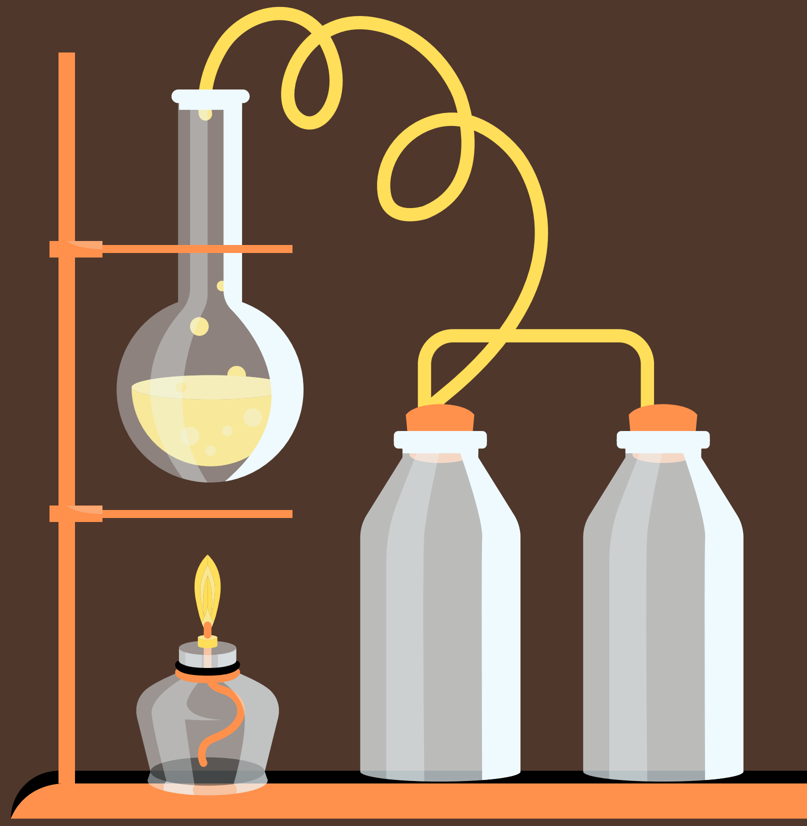
- Inorganic pollutants: water can carry pathogenic microorganisms, causing diseases like typhoid and cholera, highlighting the need for sewage management and treatment, as well as addressing eutrophication, which leads to excessive plant growth and depletion of dissolved oxygen in water bodies.

- Sediments pollutants.

- Radioactive materials.

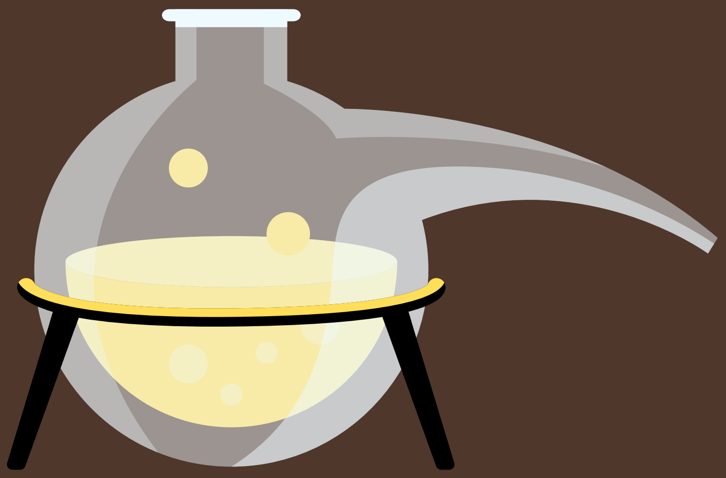
- Thermal pollutants.

classification (pesticides) :



a. Chlorinated hydrocarbons, e.g. DDT, aldrin, dieldrin, etc. persistent stay in environment for 20 years.

b. Chlorophenoxy acids, e.g. Atrazine, 2,4-D. non persistent, last only for few days.



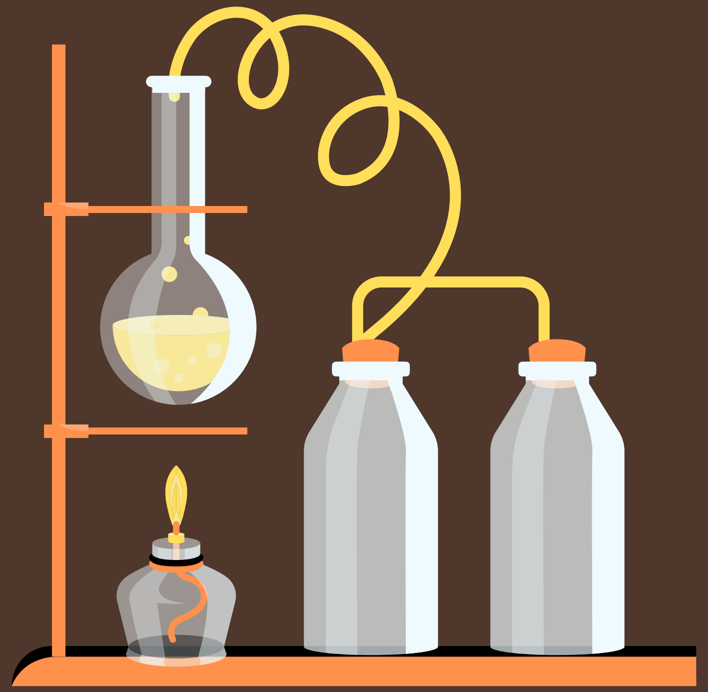
c. Organophosphorus (ORP) e.g. Malathion, diazinon.

d. Organocarbamates (ORC) Baygon, sevin.

Nature and mode of action of the insecticides :

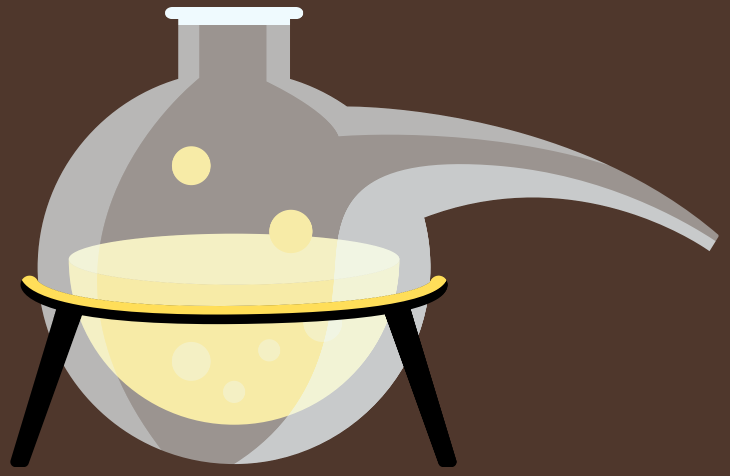
DDT, a fat-soluble pesticide banned in many countries, accumulates in body tissues and contributes to environmental pollution.

Aldrin and Dieldrin: this cyclic halogenated hydrocarbon is a highly toxic, fat-soluble



insecticide that accumulates in adipose tissue and is metabolized into toxic epoxides.

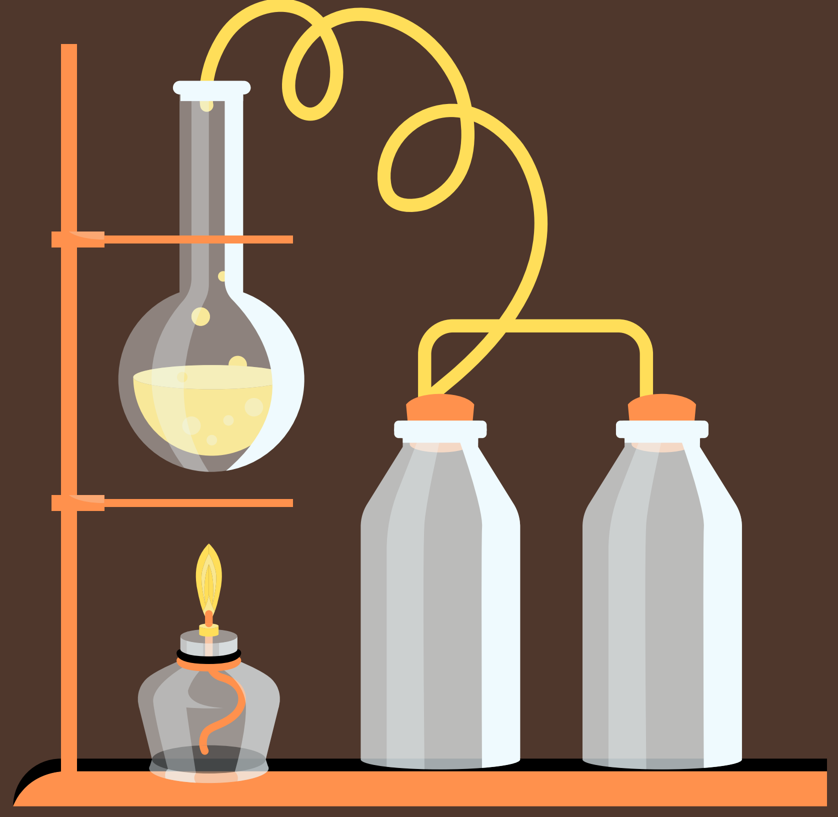
Organophosphorus (ORP) and organo-carbamates (ORC): powerful neurotoxic agents inhibit cholinesterase, causing acetylcholine accumulation



and nerve impulse disruption, while petroleum oil pollution leads to lethal toxicity and habitat disruption in marine organisms.

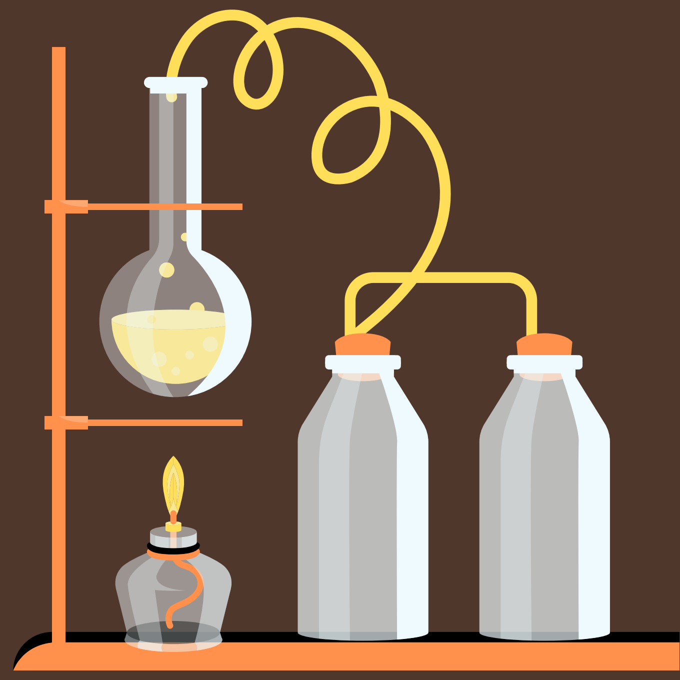
Inorganic pollutants: a. Heavy metal pollutants

A. Lead B. Arsenic heavy metals and metalloids in polluted water pose a growing health threat by entering the food chain, even at trace levels.



heavy metal pollutants mechanism of action :

the heavy metals have a great affinity for sulphur and attack sulphur bonds in enzymes, thus immobilising the latter. other vulnerable sites are protein carboxylic acid and amino groups. heavy metals bind to cell



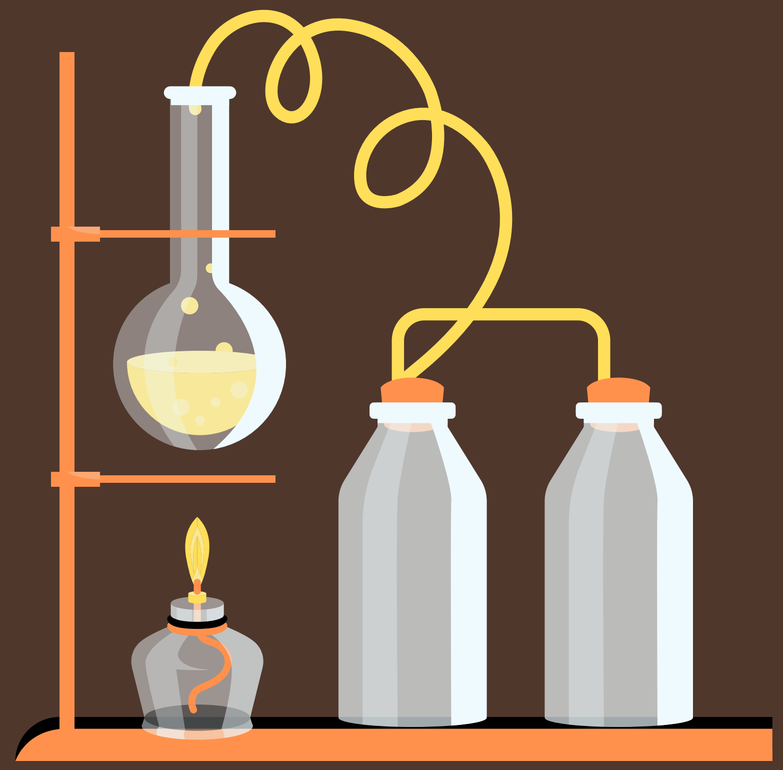
membrane, affecting transport processes through the cell wall. they also tend to precipitate phosphate biocompounds or catalyse their decomposition.

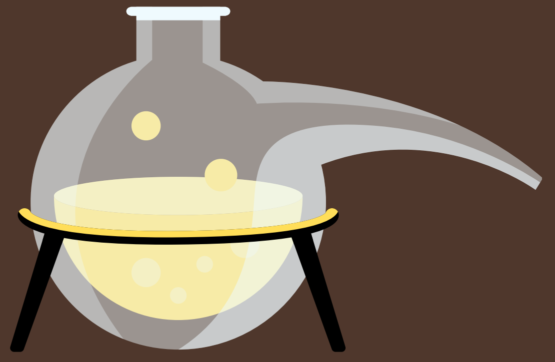
organic mercurials used as bactericides or fungicides can cause neurological disorders and death. Lead (Lead tetraethyl) used in gasoline causes blocking of spindle

fiber mechanism in cell division, uncoupling oxidative phosphorylation and altered rapid eye movement phase of sleep, leading to insomnia.

the most disheartening feature of metal toxicity is the early effect on behaviour and intelligence. before appearance of any outward sign of disability or diseased condition, areas of the brain are damaged

out of which arise many neurological and behavioural abnormalities. pathetically, children suffer most from this malady as the neuronal functions are more readily affected during the early phase of development.

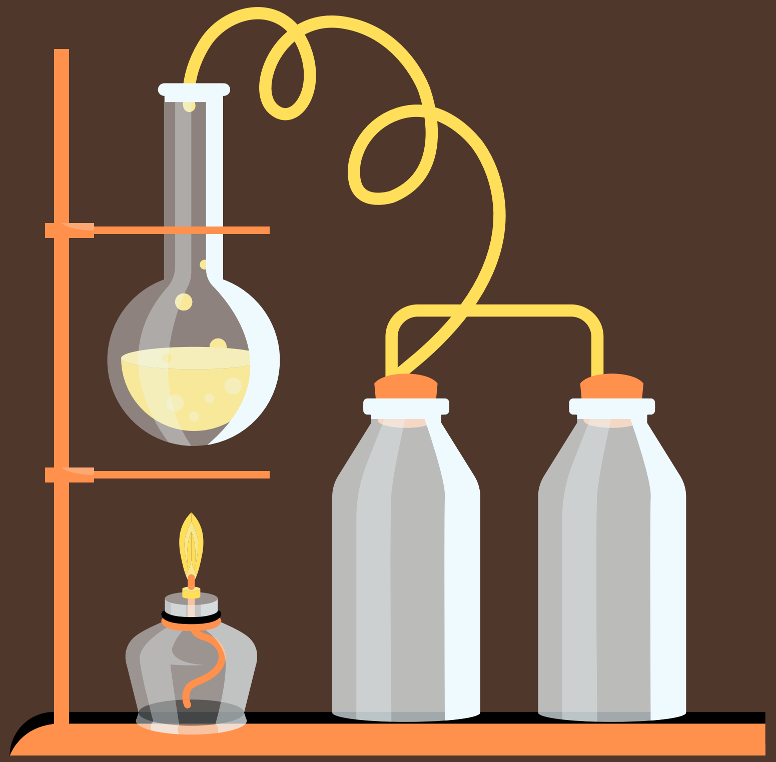




lead

A. Lead amongst the heavy metal pollutants lead deserves special mention

B. Sources: young children are particularly susceptible to lead poisoning. the "hand to mouth" activity of the toddler greatly increases



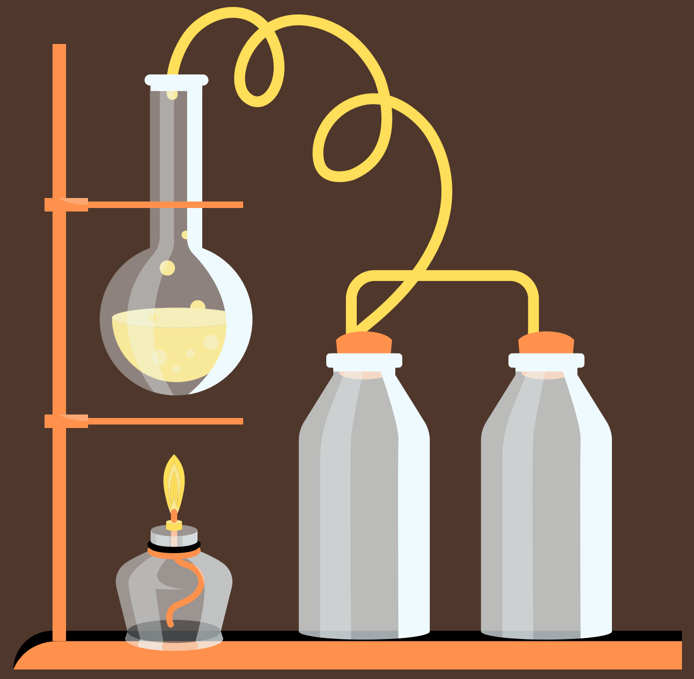
the likelihood of ingesting lead contaminated dust and dirt's. paint is the major source of exposure in the children as they bite

painted toys and suck lead pencils.
Clinical features in children: mental retardation, poor concentration skills, behavioral changes, learning disabilities are seen.

The new guidelines recommend universal lead testing for all children under six years of age, and expand the definition of

lead poisoning to include any child with a blood lead level of 10 g/dL or more.

discolouration and blue line along the gums are characteristic features of acute lead poisoning.

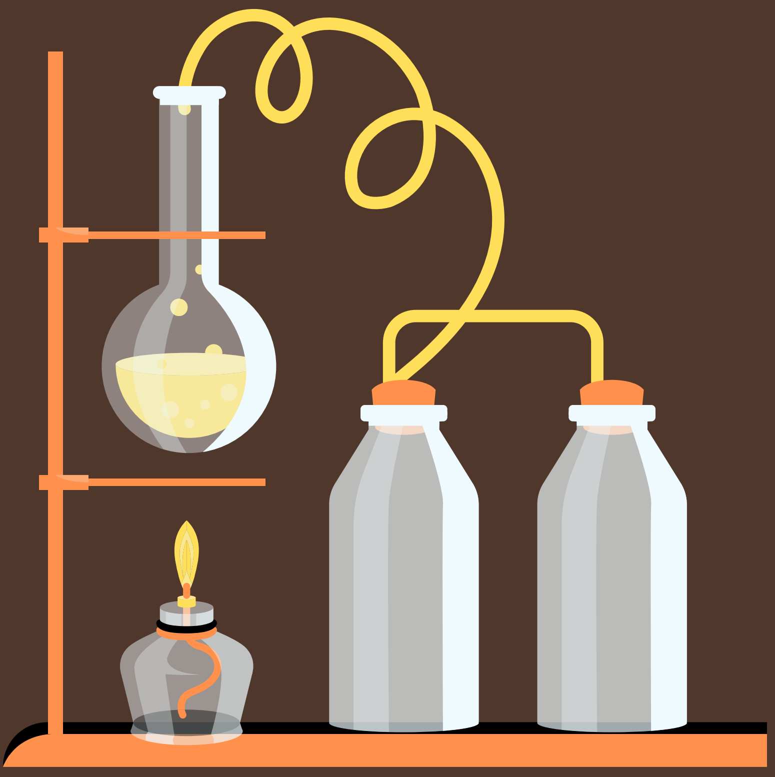


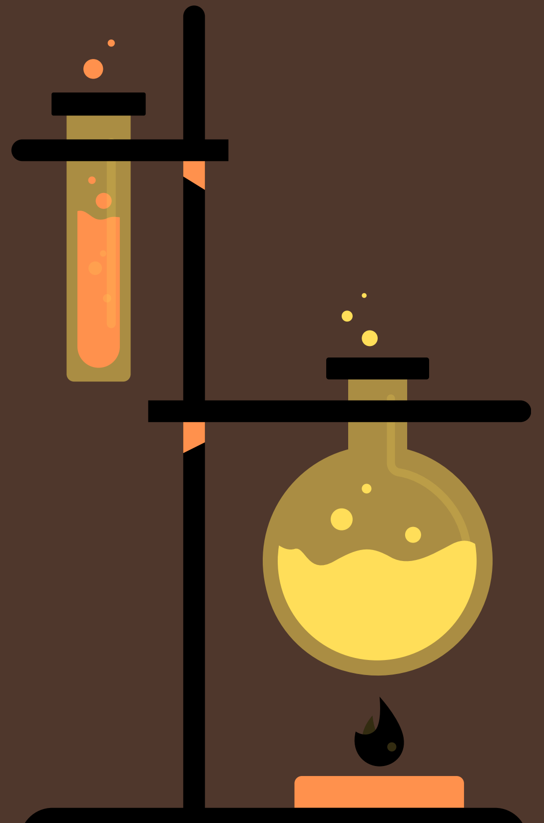
Arsenic :

Arsenic: toxic effects: produces dizziness, chills, cramps and paralysis leading to death.

Arsenic inhibits the sulfhydryl enzymes and interferes with cellular metabolism.

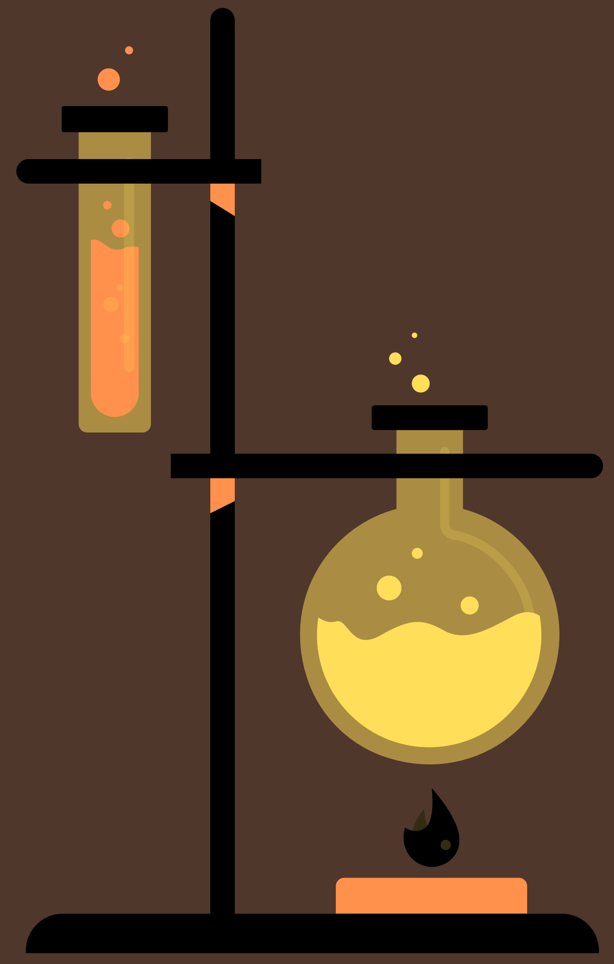
it may also cause intravascular haemolysis leading to hemoglobinemia and hemoglobinuria.





food pollution :

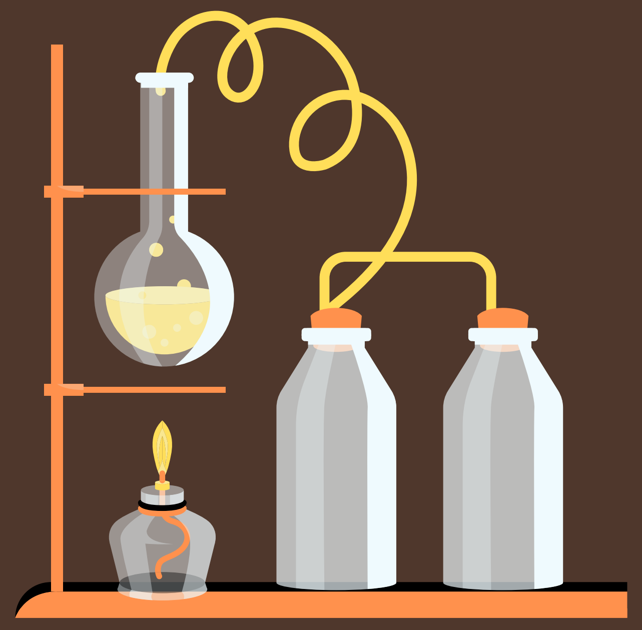
it may occur due to various factors like: (a) Processing of food. (b) Natural toxins present in plants. (c) Changes occurring during storage. (d) Adulteration of food.



processing of food this includes:

(i) defective operation in freezing, e.g. milk maybe contaminated by Salmonella and Staphylococcus aureus.

(ii) defective packing techniques: this can lead to Botulism especially with marine products andcooked soups.

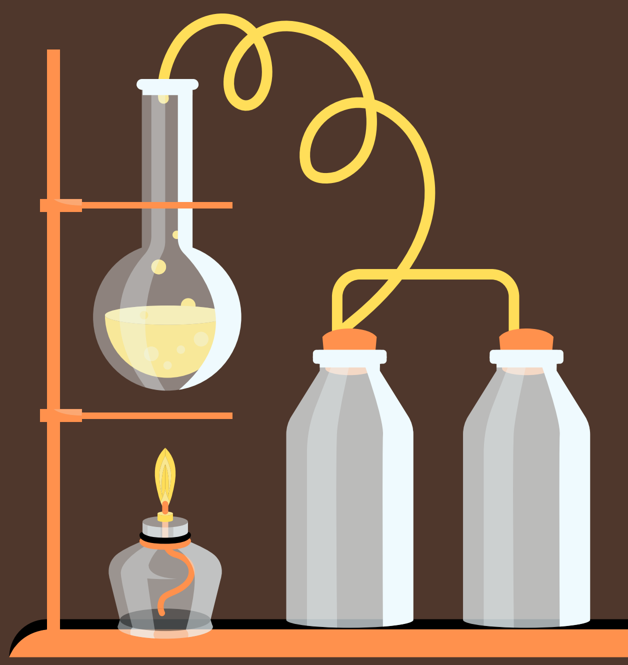


(iii) food additives Cyclamate used as sweetening agent may cause carcinoma of bladder.

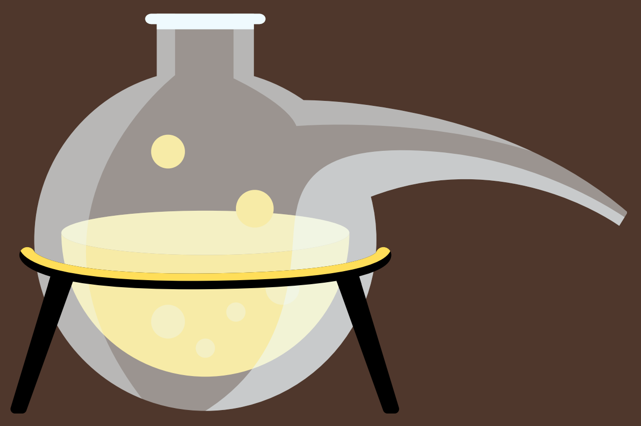
Natural toxins :

(i) Natural toxins review: this is a condition seen in individuals having glucose-6-phosphate dehydrogenase

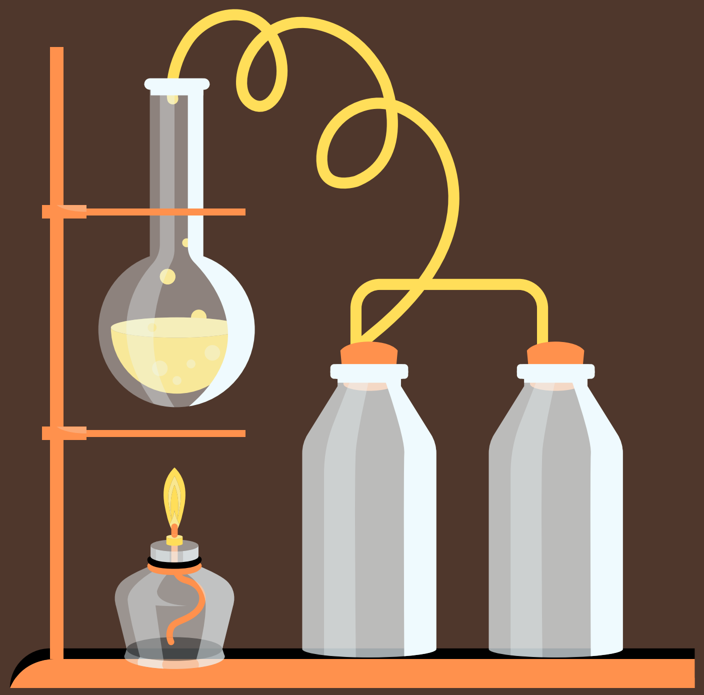
deficiency on ingestion of uncooked broad bean (Vicia faba). manifested in form of hemolytic anaemia. cooking and decanting minimizes the toxicity.



Alkaloids: alkaloids like muscarine found in toxic variety of mushroom may produce nausea, vomiting, diarrhoea and in large quantity can cause acute necrosis of liver and death.



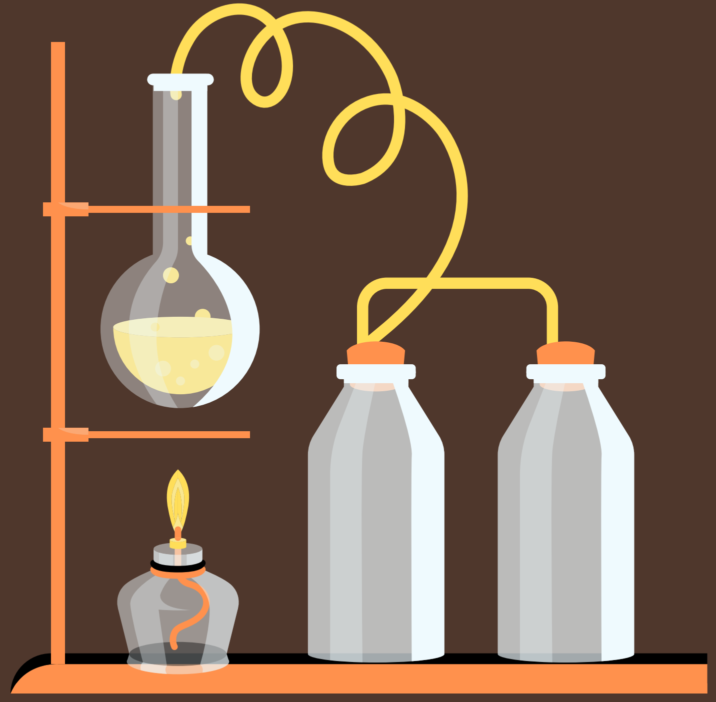
Pressor amines: bananas, cheese, etc. normally on consumption they are catabolized by MAO. but they may lead to hypertension in patients on MAO inhibitors.



Goitrogens: the goitrogens present in foods may be broadly grouped under the following heads: 1. Thioglycoside derivatives "Progoitrin" in vegetarians and in food field oils "cabbage goitres" may occur.

Protease Inhibitors: many cereals (corn), tubers (potato and sweet potato), peanut, legumes (soybeans) contain trypsin inhibitors. usually they are heat labile

and are destroyed in cooking, hence not harmful. but partially cooked foods or raw foods may have these and may inhibit the digestion and absorption of amino acids.



Cyanogenic glycosides: cyanogenic glycosides are present in certain cereals like sorghum, legumes like lima bean and in tubers like tapioca.

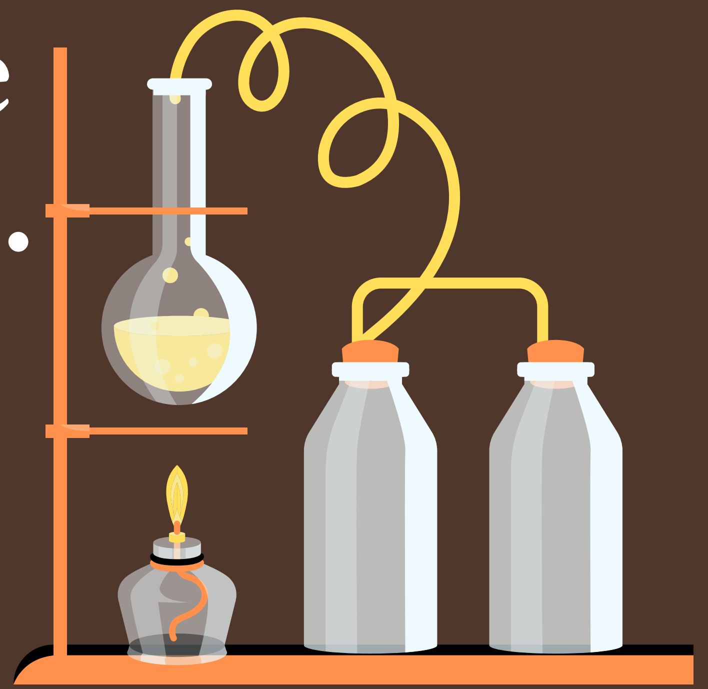
these compounds
on hydrolysis produce hydrocyanic acid. hence they are highly toxic when taken raw.

storage contamination:

Aflatoxins Aspergillus flavus on groundnut, coconut, etc. are hepatotoxic and carcinogenic.

Ergotamine, ergotoxin and ergometrine ergotism found in ergot that grows on moist food grains like rye, millet, wheat, bajra.

contamination of rice "Penicillium islandicum" the fungus has got toxic effects on liver and kidney, i.e. it is hepatotoxic and nephrotoxic.

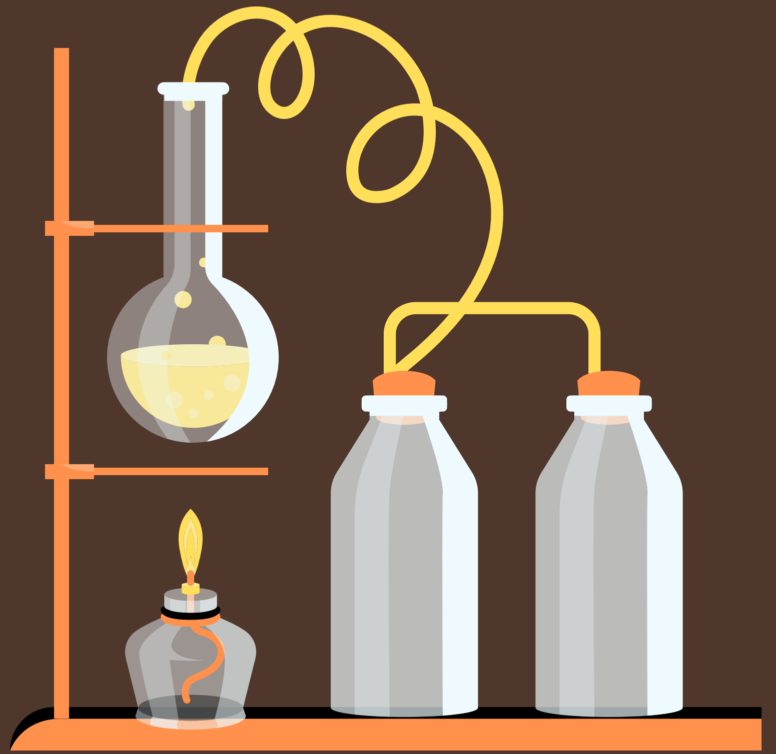


Adulteration of food:

Epidemic dropsy: mustard oil adulterated with argemone oil, containing the toxic alkaloid sanguinarine, can cause epidemic

dropsy, leading to severe health issues, with notable outbreaks reported in india.

Endemic ascites: in areas where millet is adulterated with crotalaria seeds, the resulting pyrrolizidine alkaloids can cause hepatotoxicity, leading to ascites and jaundice.



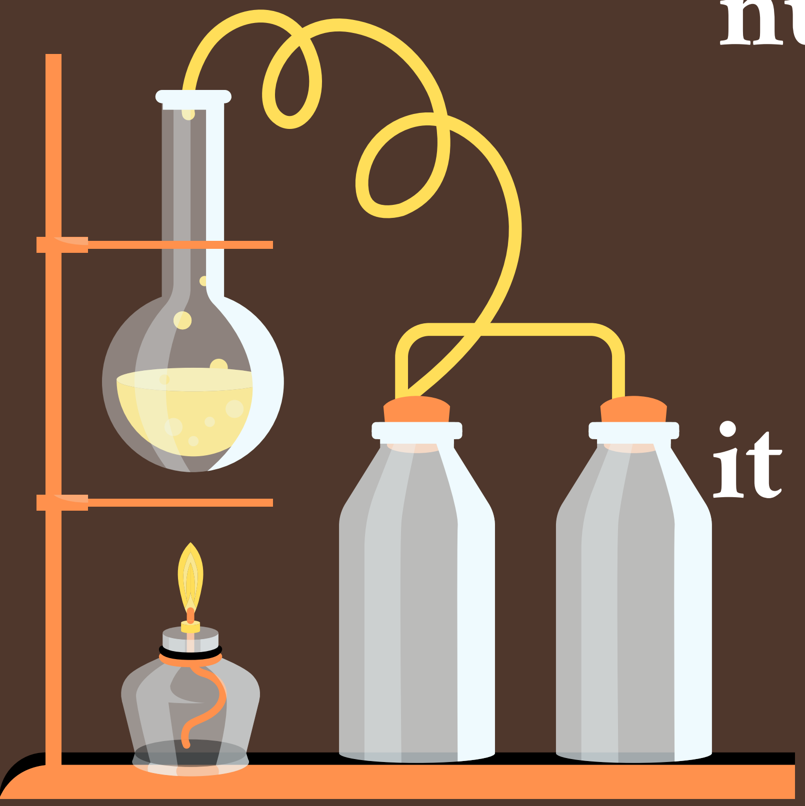
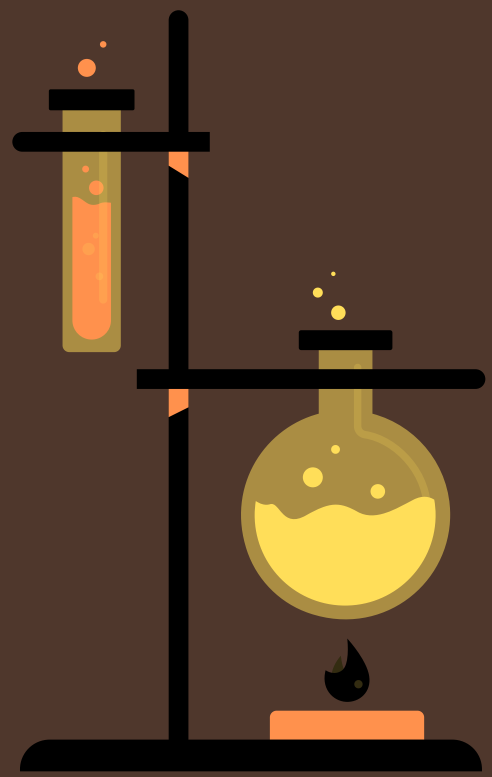

human cells and compartments :

human cells are highly organized and contain various compartments, or organelles, each serving specific functions crucial for the cell's

survival and operation. here's an overview of the main compartments of human cells, their components, and their functions:

Nucleus: components: nuclear envelope, nucleoplasm, chromatin, nucleolus. function: the nucleus is the control center of the cell, containing the cell's genetic material (DNA)

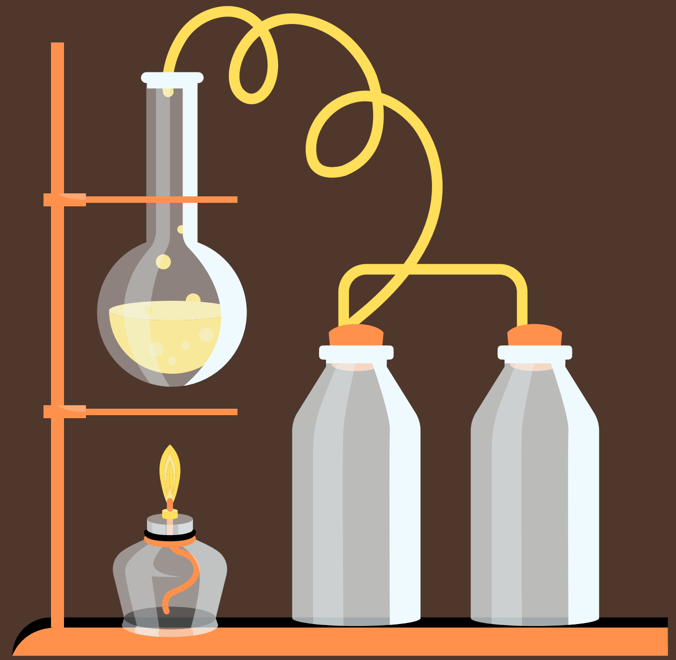
it regulates gene expression and cell division. the nucleolus, located within the nucleus, is responsible for ribosome synthesis.

Cytoplasm: components: cytosol, organelles, and cytoskeleton. function: the cytoplasm is the gel-like substance that fills the cell, providing a medium for

biochemical reactions. it hosts the organelles and is involved in cellular processes like glycolysis and signaling.

Plasma Membrane: components: phospholipid bilayer, proteins, carbohydrates, cholesterol. function: the plasma membrane separates the cell from its environment, controlling the

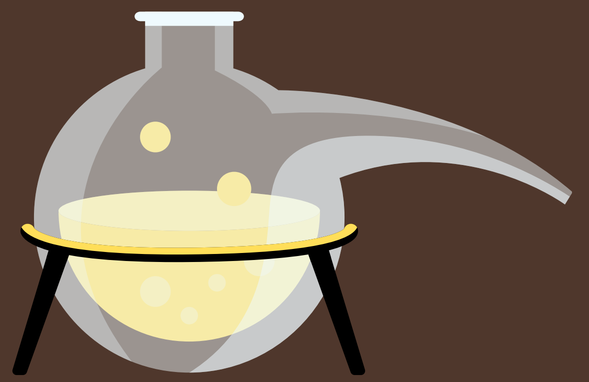


entry and exit of substances. it plays a role in communication and signaling through membrane proteins.

Mitochondria: components: outer membrane, inner membrane, intermembrane space, mitochondrial matrix.

function: often referred to as the powerhouse of the cell, mitochondria produce ATP via cellular respiration. they are also involved in regulating apoptosis (programmed cell death).

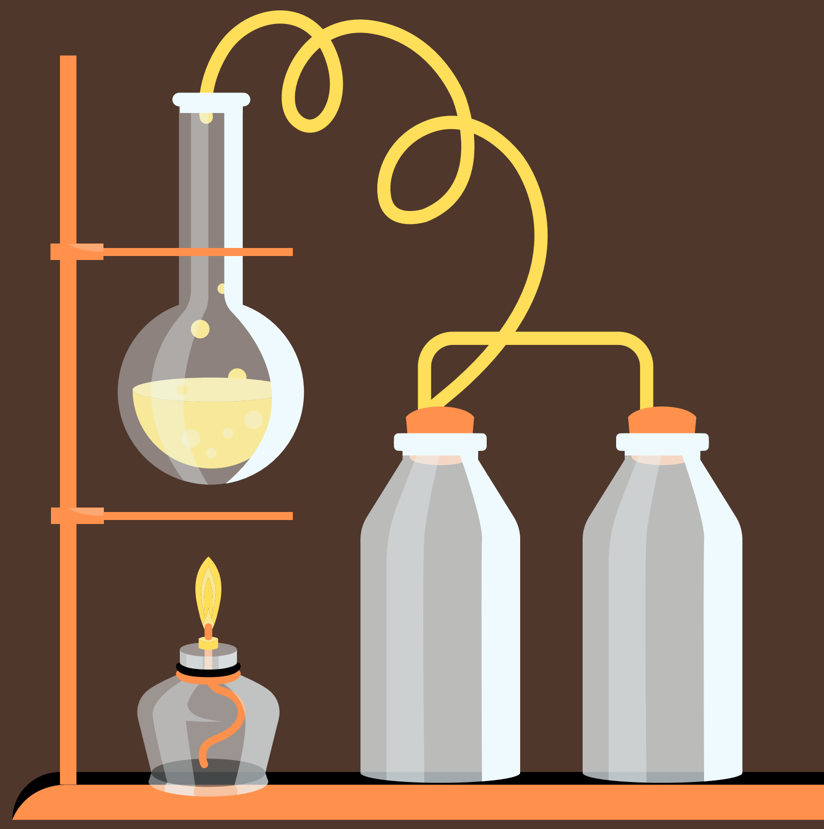
Endoplasmic Reticulum (ER): components: rough ER (with ribosomes), smooth ER (without ribosomes).



Human cell cycle :

the human cell cycle is a series of stages that a cell passes through to grow and replicate its DNA to produce daughter cells. the cell cycle is divided into two main stages: interphase and the mitotic phase (M phase).

Interphase: (i) G1 Phase (Gap 1): the cell grows in size and performs its normal functions. it prepares for DNA replication by synthesizing



necessary proteins and enzymes. (ii) S Phase (Synthesis): the cell replicates its DNA, ensuring that each daughter cell will have a complete set of genetic information.

(iii) G2 Phase (Gap 2): the cell continues to grow and prepares for mitosis by synthesizing proteins and organelles needed for cell division.

Mitotic Phase (M Phase): the mitotic phase includes mitosis and cytokinesis.

Mitosis: the phase is further divided into several stages: Prophase: chromatin condenses into visible chromosomes. the nuclear envelope starts to break down.

Metaphase: chromosomes align along the metaphase plate (the cell's equator) and attach to spindle fibers. Anaphase: sister chromatids are pulled apart toward opposite poles of the cell.

Telophase: chromosomes decondense, and nuclear envelopes reform around each set of chromosomes, creating two nuclei.

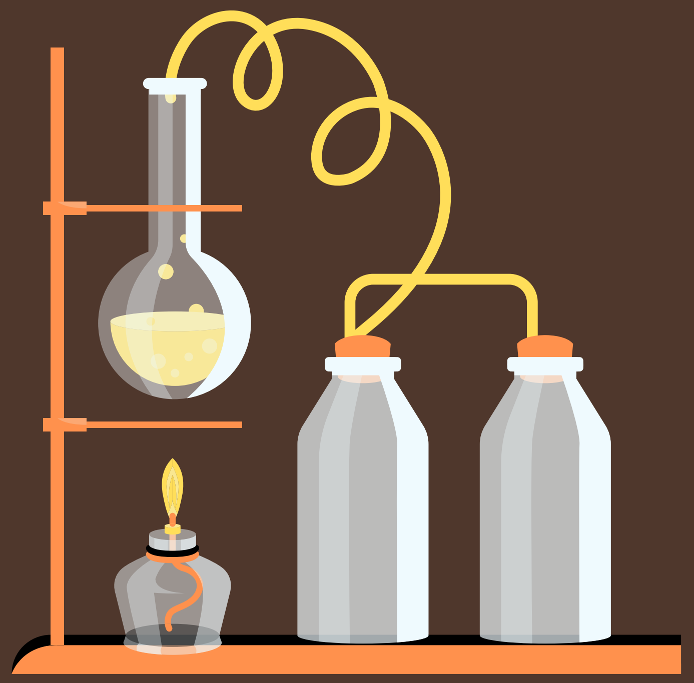
Cytokinesis: this is the final step where the cell's cytoplasm divides, resulting in two daughter cells, each with a nucleus. in animal cells, a contractile ring forms to separate the two cells.

Cell cycle regulation

the cell cycle is tightly regulated by various checkpoints and proteins :

Checkpoints: G1 Checkpoint: checks for DNA damage and the cell’s size; decides to proceed to DNA synthesis. G2 Checkpoint: ensures all DNA is replicated and undamaged before entering mitosis. M Checkpoint: ensures that all chromosomes are properly attached to the spindle before anaphase begins.

Cyclins and Cyclin-dependent Kinases (CDKs): these proteins work together to regulate the progression through the cell cycle. cyclin levels fluctuate throughout the cell cycle, activating CDKs, which then phosphorylate target proteins to advance the cycle’s phases.

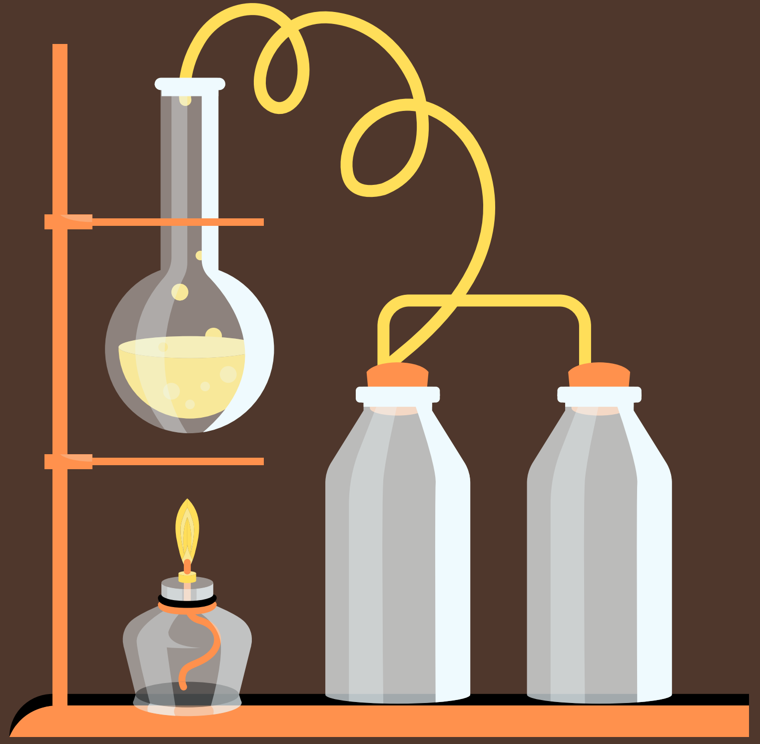


Significance of the cell cycle :

the cell cycle is essential for: growth and development of organisms, tissue repair and regeneration, maintaining tissue homeostasis, proper functioning of the immune system.

disruptions in the cell cycle can lead to uncontrolled cell division, which is a hallmark of cancer.

understanding the cell cycle is crucial for developing treatments that target cancerous cells and improve regenerative medicine.



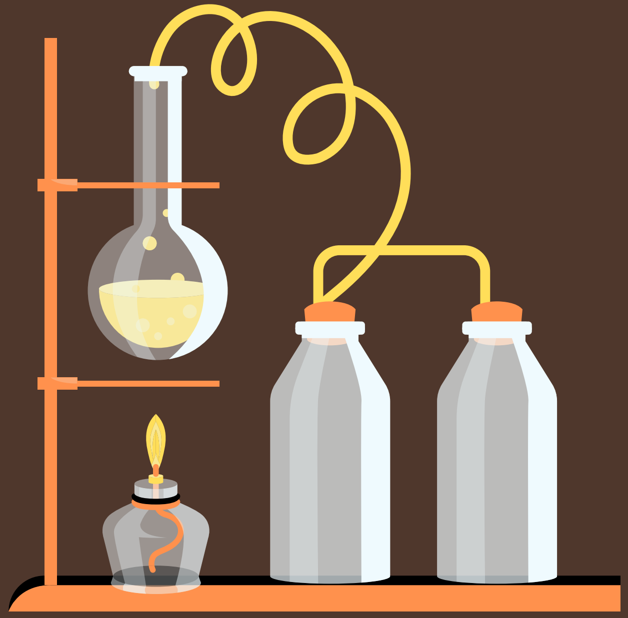
DNA replication :

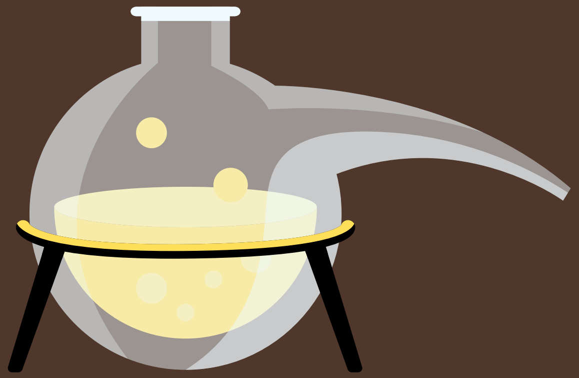
DNA replication is a fundamental biological process that occurs in all living organisms. it involves copying the entire DNA molecule to

produce two identical DNA molecules. here’s a breakdown of the key steps involved in DNA replication:

Initiation: origin of replication: the process begins at specific locations on the DNA molecule called origins of replication.

unwinding: the enzyme helicase unwinds and separates the double-stranded DNA, creating a replication fork.

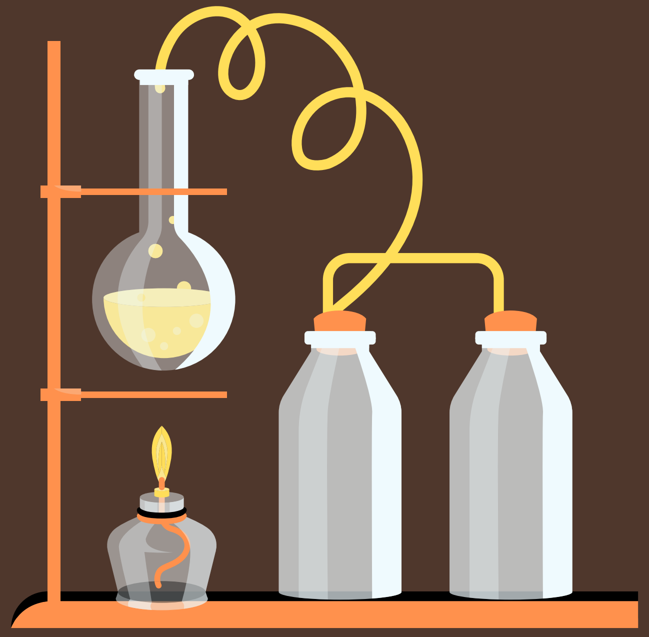




Elongation: primer binding: RNA primers synthesized by primase bind to the single-stranded DNA to provide a starting point for DNA synthesis.

leading strand synthesis: DNA polymerase adds nucleotides in the 5' to 3' direction continuously on the leading strand. lagging strand synthesis: DNA on the lagging strand is synthesized

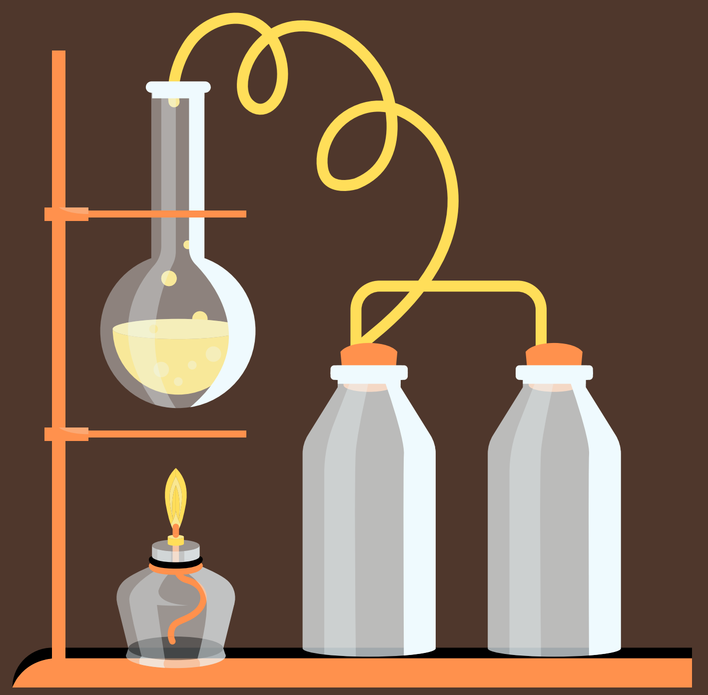
discontinuously in short segments called Okazaki fragments. each fragment is initiated by a new RNA primer.



Termination: fragment joining: the enzyme DNA ligase seals gaps between Okazaki fragments, forming a continuous strand.
completion: when replication is complete, two identical double-stranded

DNA molecules are formed, each with one original and one new strand (semiconservative replication).

Proofreading and Repair: DNA polymerase also has proofreading capabilities to correct any errors in nucleotide insertion.



Key enzymes involved :

Helicase: unwinds the DNA double helix.

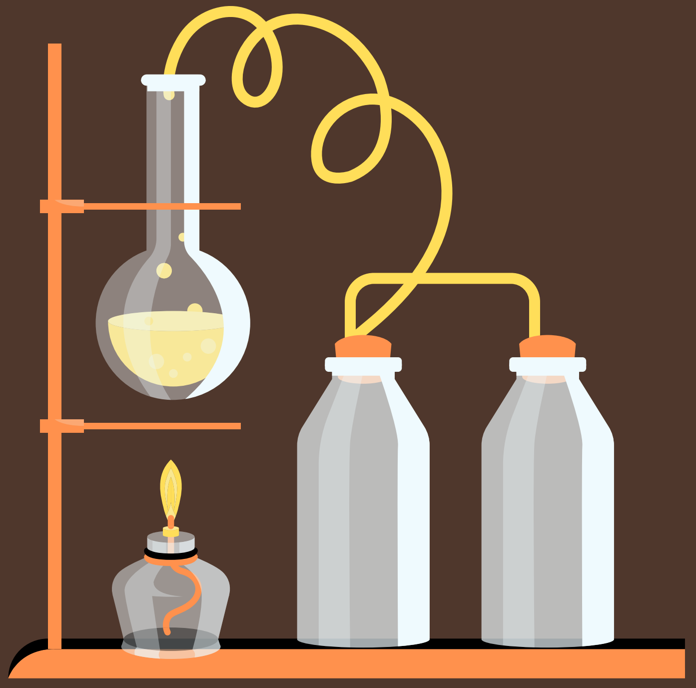
Primase: synthesizes RNA primers.

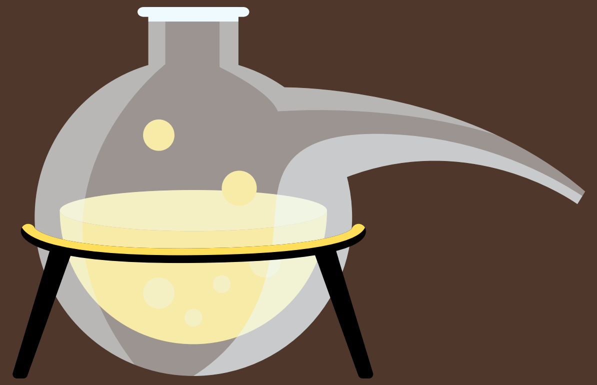
DNA Polymerase: adds nucleotides to the growing DNA strand.

Ligase: joins Okazaki fragments.

Importance of DNA Replication: DNA replication is essential for cell division, growth, and repair. it ensures that each daughter cell receives an exact copy

of the genetic information. this process is crucial for genetic continuity and plays a vital role in heredity, evolution, and cellular function.





DNA damage and mutation :

DNA damage occurs naturally within cells due to various environmental factors, metabolic processes, and replication errors.

on average, it is estimated that each cell experiences about 10,000 to 1,000,000 DNA lesions per day.

this can include single-strand breaks, double-strand breaks, and various forms of base damage.

the body has mechanisms to repair this damage, such as:

Base Excision Repair (BER): fixes small, non-helix-distorting base lesions.

Nucleotide Excision Repair (NER): handles bulky DNA adducts and UV-induced damage.

Homologous Recombination: repairs double-strand breaks accurately.

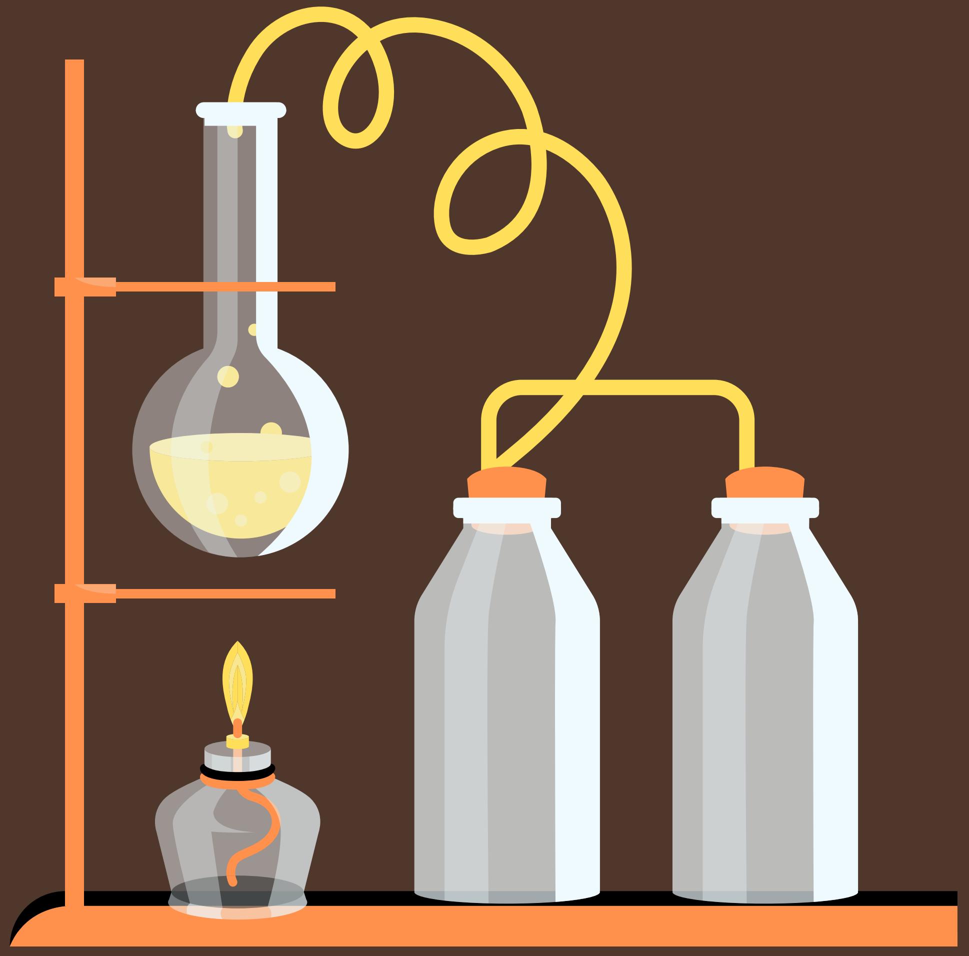
Non-Homologous End Joining (NHEJ): offers a quicker repair for double-strand breaks.

DNA mutation :

a mutation is a change in the DNA sequence that can lead to variations in genes. mutations are crucial for evolution, but they can also cause diseases, including cancer. they can occur spontaneously or due to environmental factors.

Types of Mutations:

Point Mutations: description: a single nucleotide change in the DNA sequence. types:



Silent Mutation: no change in the amino acid sequence. for example, a change from CAA to CAG still codes for glutamine.

Missense Mutation: changes one amino acid in the protein, potentially altering its function. for example, a change from GAA to GUA changes glutamic acid to valine.

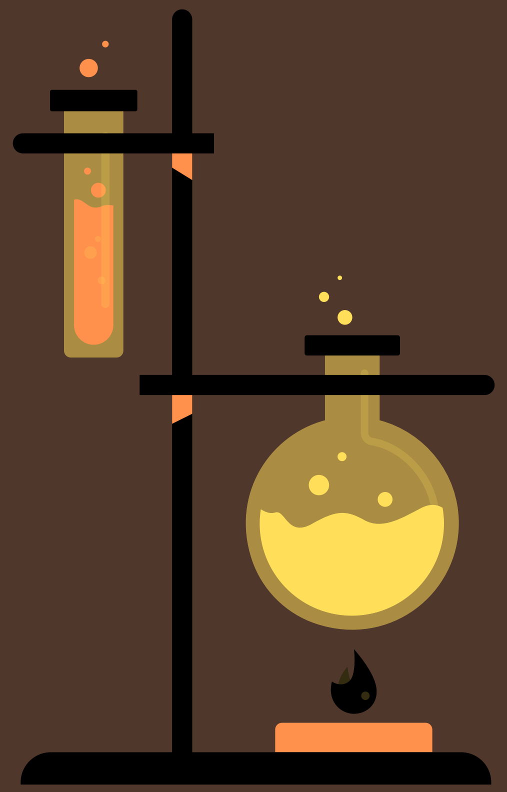
Nonsense Mutation: introduces a premature stop codon, leading to a truncated protein. for example, a change from UAC to UAA results in a stop codon.

Insertions and Deletions (Indels):

description: addition or loss of one or more nucleotides in the DNA sequence.
effects:

Frameshift Mutation: changes the reading frame of the sequence, potentially altering all subsequent amino acids. for instance, if a base is inserted or deleted in a sequence, it shifts codons
downstream, leading to different proteins being produced.

In-frame Mutation: if the insertion or deletion is in multiples of three, it can add or remove amino acids without changing the reading frame.



Duplication: description: a segment of DNA is duplicated, leading to repeated sequences in the genome.


Thank You for your attention !