GPAT & NIPER 2025 CRASH COURSE

Pharmaceutical Engineering

Lecture- 01

Flow of Fluids & Size Reduction

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4 Lecture

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4-5(6)

Pharmaceutical Engineering

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4-5 6

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4 Lecture

6-7

4-5 6

30-35

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GrowUp Pharma

Pharmaceutical Engineering

Lecture- 01

4 Lecture 6-7 30-35

Flow of Fluids & Size Reduction

4-5 6

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Flow of Fluids

- Flow of fluids is the flow of substance (liquids and gases) that does not permanently resist distortion.
- This is the study of how liquids and gases move within a system

- Fluid mechanics is divided into two classes

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ii. Fluid dynamics.

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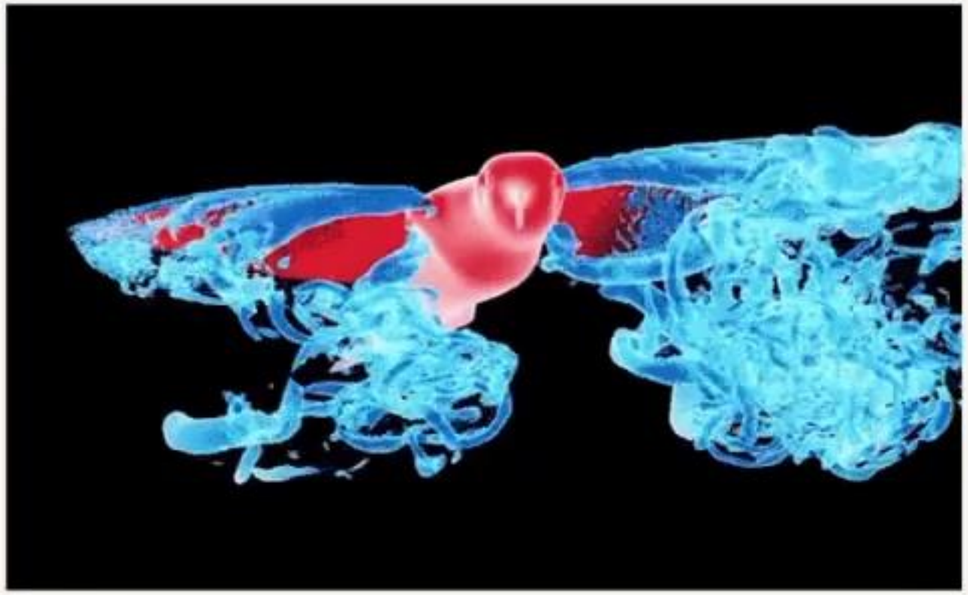
  Eg: Reynold's experiment apparatus



MANOMETER

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SIMPLE MANOMETER

It is a device which measures pressure at a point in a fluid contained in a pipe or vessel.

Also known as U tube fluid manometer

Eg: Orifice meter & Venturi meter

USES

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- Used in conjunction with flow meters for measurement of flow of fluids

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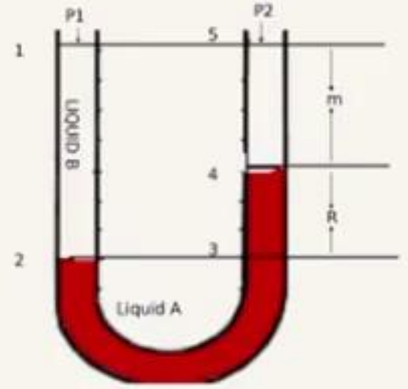

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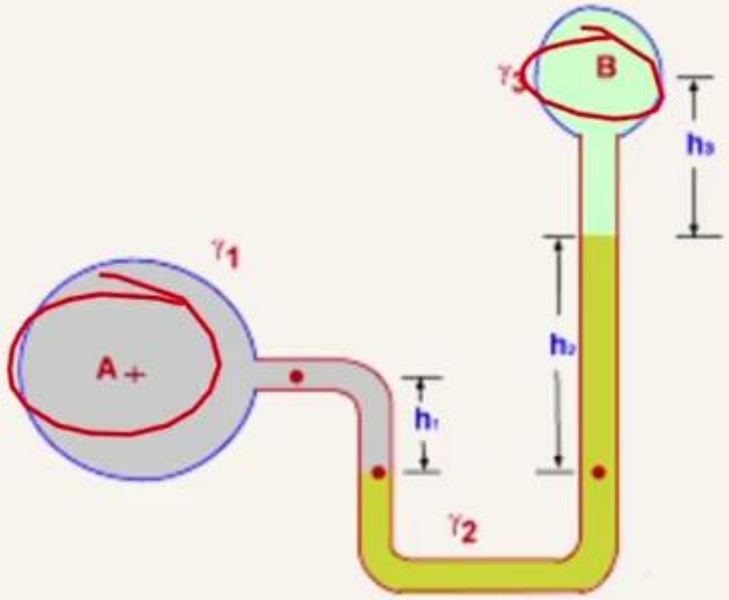
USES

Useful for measuring even small gas pressures

Used in measurement of small pressure differences.

Most accurate and precise

Error free



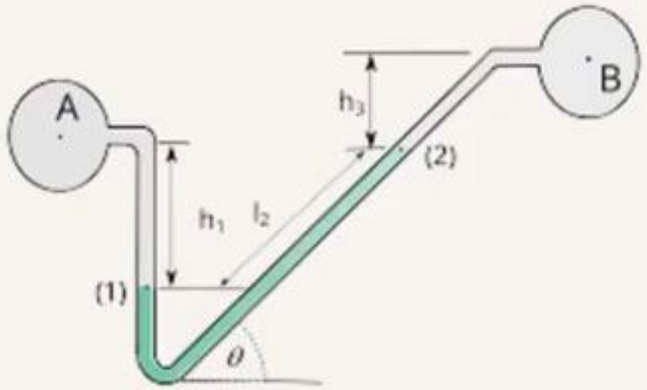
MANOMETER

INCLINED MANOMETER

- It is a device which **measures the minute pressure** differences between any two points in a fluid contained in a pipe or vessel.

USES

This type of manometer increases the accuracy of the pressure determination of particularly for small head.



Ink Blank Screen

Simple → Pressure cut a point

Differentia

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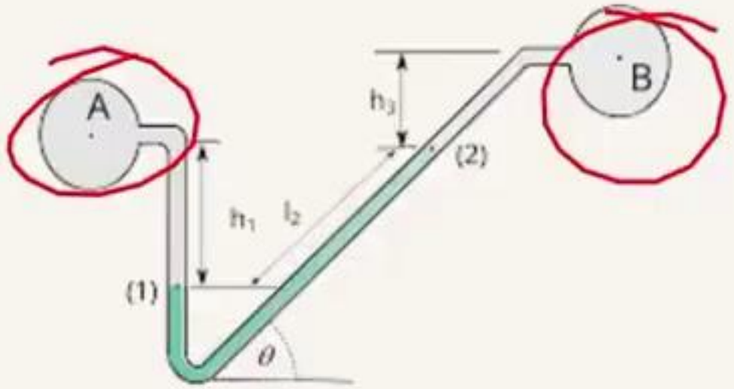

REYNOLDS NUMBER

- It is used for measurement and type of flow determination.
- It is widely used to classify flow behavior of fluids is the ratio viscous forces.

Reynold's number, $R = \frac{Dup}{n}$

R = Reynold's Number

D= Diameter of pipe

u = Average velocity

η = Viscosity of fluid

ρ = Density of liquid

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$R \Rightarrow \frac{\text{Inertial force}}{\text{Viscous}}$

TYPES OF FLUID FLOW

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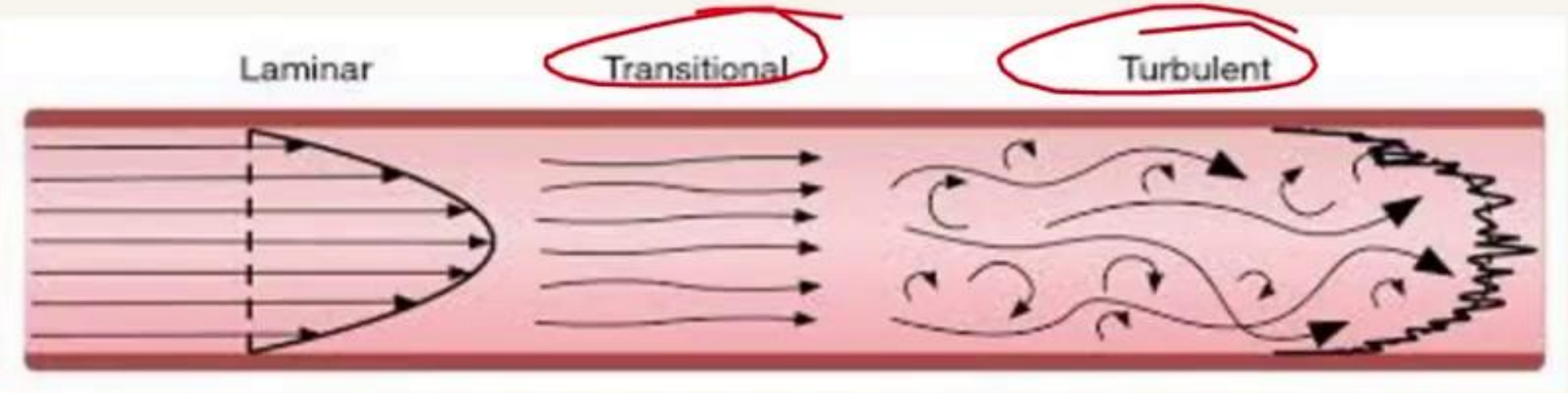

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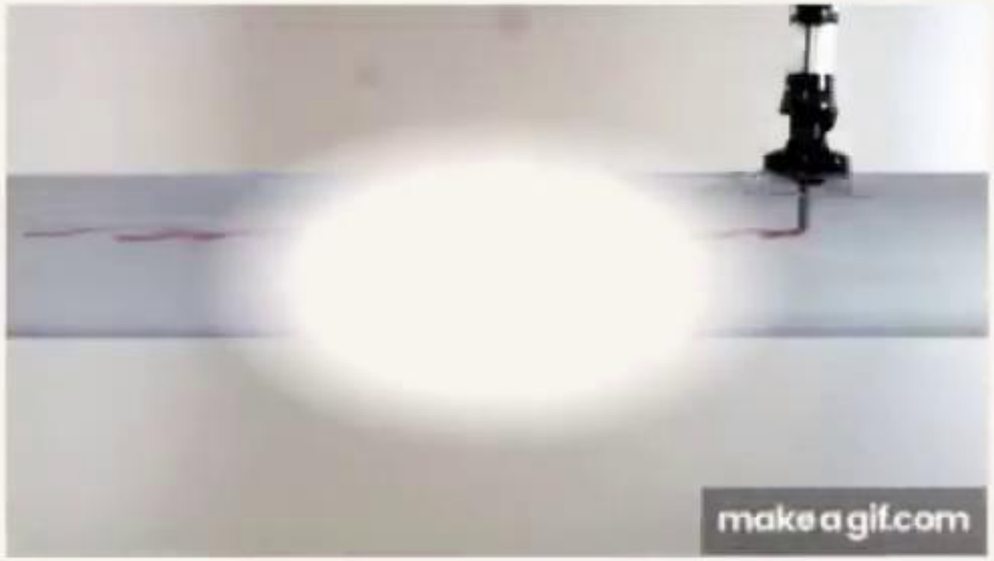

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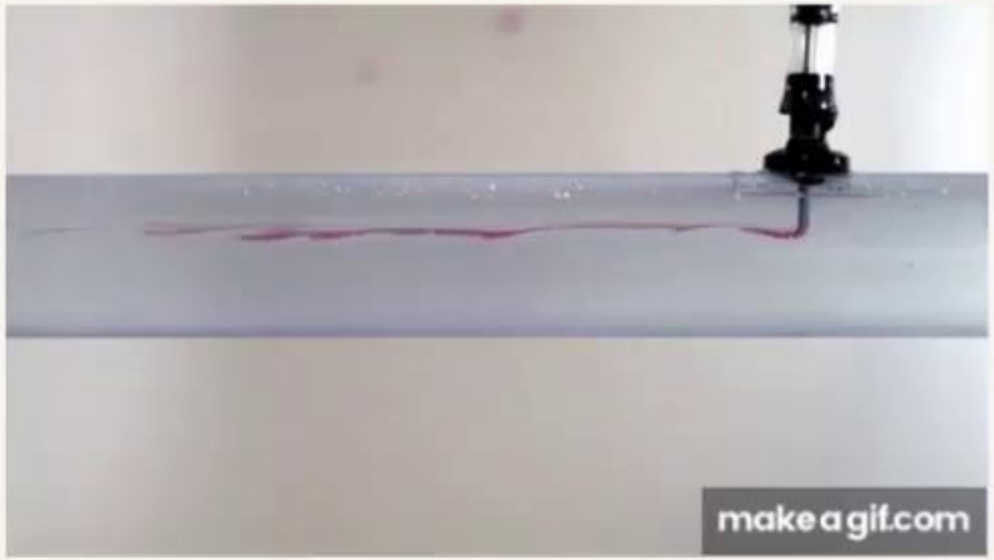

REYNOLDS NUMBER

- When Re < 2000 then flow is laminar or viscous or streamline.
- Re > 4000 then flow is turbulent.
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- Re > 4000 then flow is turbulent.
- Re is 2000 - 4000 then flow is laminar or turbulent.
- A large Reynold number is indication of highly turbulent flow.

CRITICAL VELOCITY :- It is defined as average velocity of any fluid at which viscous flow changes into turbulent flow

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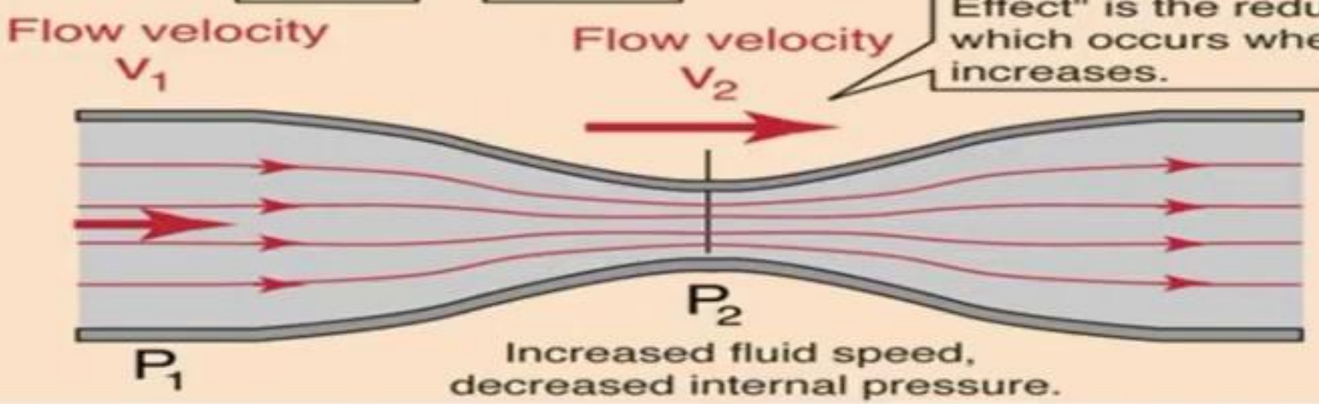
Energy per unit volume before = Energy per unit volume after

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

- P_1: Pressure Energy
- $\frac{1}{2}\rho v_1^2$: Kinetic Energy per unit volume
- $\rho g h_1$: Potential Energy per unit volume

The often cited example of the Bernoulli Equation or "Bernoulli Effect" is the reduction in pressure which occurs when the fluid speed increases.



$A_2 < A_1$

$v_2 > v_1$

$P_2 < P_1$!

MEASUREMENT OF RATE OF FLOW OF FLUIDS

- Direct weighing or measuring
- Hydrodynamic methods
  - Orifice meter
  - Venturi meter

Hydrodymamic method

Orifice Meter / Variable Head Meter

Measures the variation in the pressure across a fixed constriction placed in the path of flow consisting of a constant area

Used for testing purpose like for steam lines

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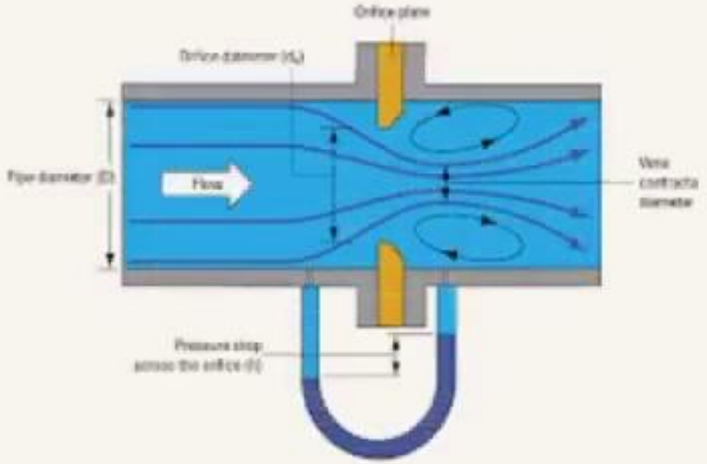

Venturi Meter/ Variable Head Meter

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Used for liquids mainly water

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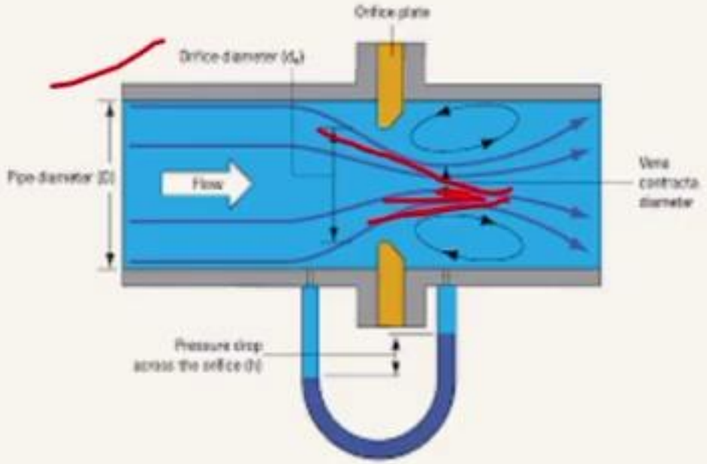

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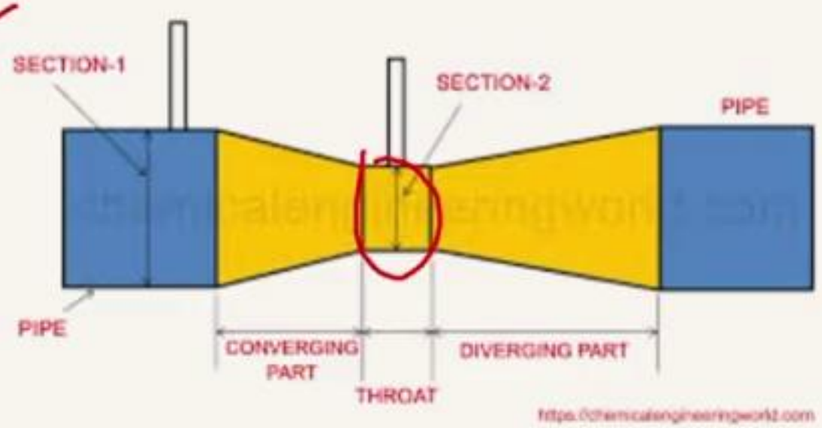
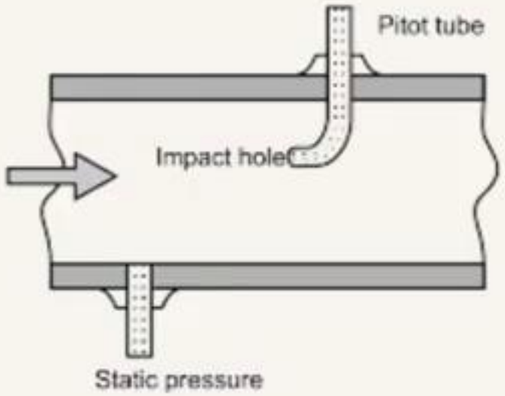


Hydrodymamic method

Pitot tube/ Insertion Meter

Used to measure the velocity head of the flow

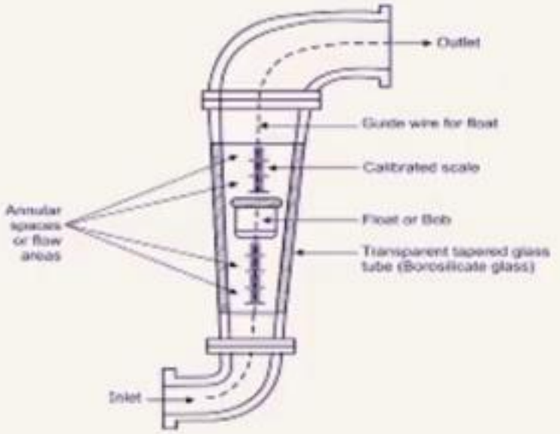
Measures velocity at one point only.



Rotameter / Area Meter

Measures the area of flow

Used in fermenters and bulk drug chemical industries



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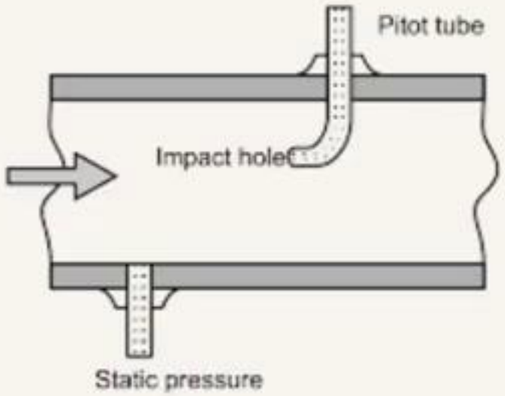

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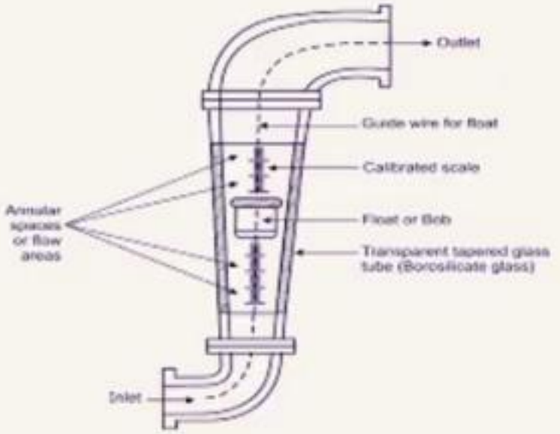

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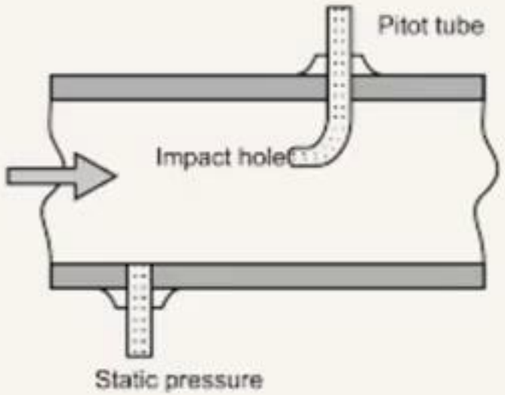

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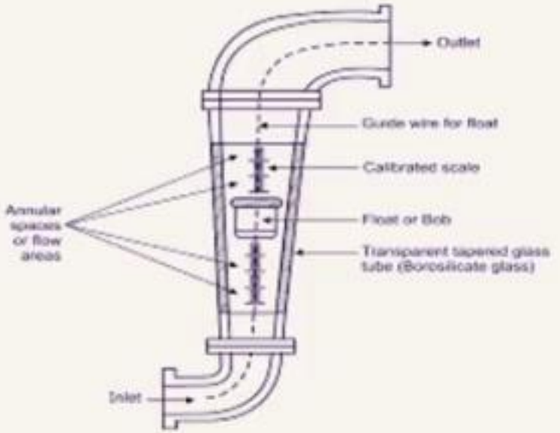

VALVES

- Valves are used to control the rate of flow of fluids in a pipeline
- Devices that control fluid flow within a pipeline by opening, closing, or partially obstructing the flow. They're critical for managing pressure and directing fluids where needed.

Types of VALVES

NAME OF VALVE	USES
Plug cocks valve	Used for complete stopping or starting the flow of fluid. Also used for handling compressed air
Globe valve	Used for regulating flow or pressures as well as complete shutoff flow. Used in pipes size NMT 50mm
Gate valve	Used to completely shut off fluid flow or, in the fully open position, provide full flow in a pipeline Minimises the differential pressure during opening and stopping the flow
Diaphragm valve	Used to control fluid flow by regulating the area with which media can enter and exit the valve, effectively changing its speed and velocity. More suitable for fluids containing suspended solids
Needle valve	It is Precise control of flow.

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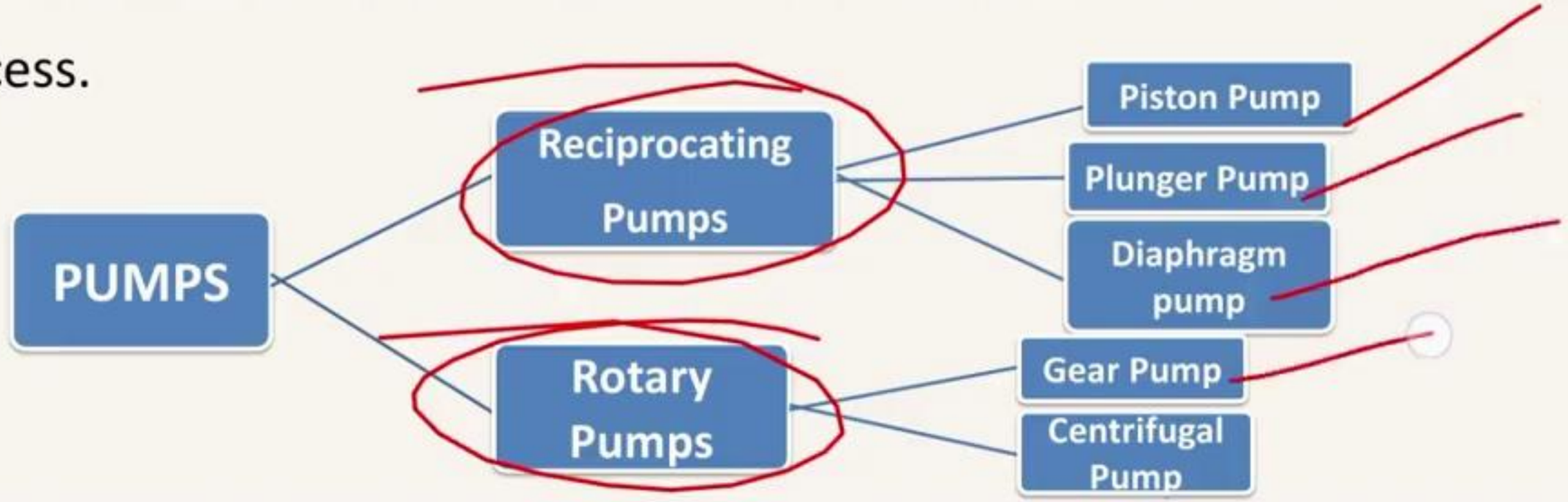

Types of Rotary pumps

NAME	CHARACTERISTICS AND USES
Gear pumps	Used for handling viscous or heavy liquid like vegetable oil, waxes. Used for aqueous film coating.
Centrifugal pumps **(a) Volute pumps** **(b) Turbine pump**	Used for viscous liquids Used for non-viscous and non-corrosive liquids. Used for handling organic solvents

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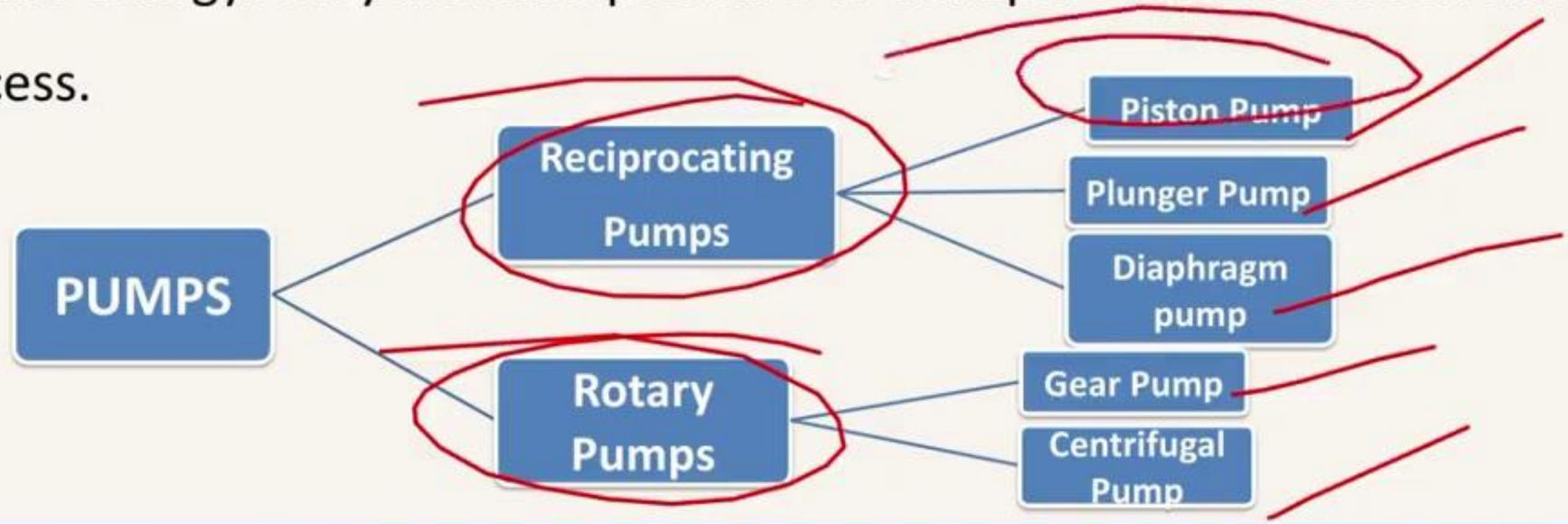


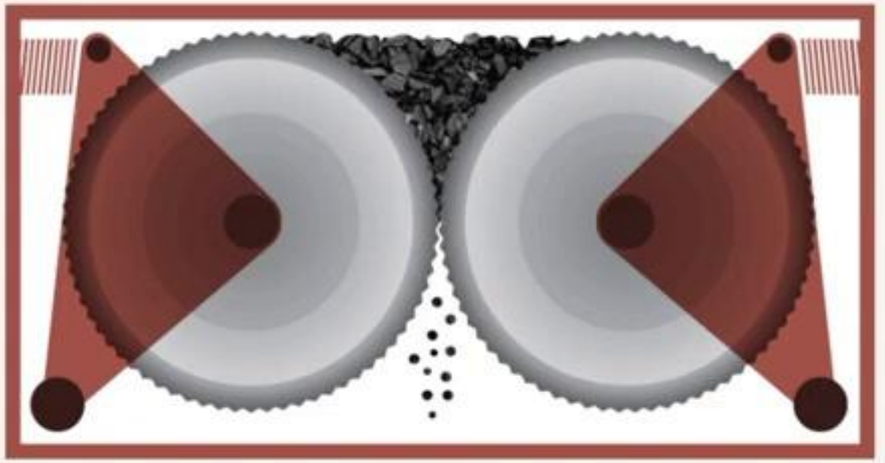
Types of Reciprocating pumps

NAME	CHARACTERISTICS
Piston pump	Used in peristaltic and HPLC pumps and for spray system in sugar coating and film coating operations. These types of pumps are used to move liquids or compressed gases.
Plunger pump	Used for handling liquids at high pressure. Used for transport viscous liquid and liquid contain suspended solids
Diaphragm pump	A diaphragm pump is an optimistic displacement pump that uses a rubber, thermoplastic or teflon diaphragm with appropriate valve interactions on both sides of the diaphragm to pump a fluid. Used in transporting liquid containing solids. Hazardous, toxic and corrosive liquids can also handle.

Size Reduction

- Size reduction is a process of reducing large solid unit masses into small unit masses, i.e., coarse particles or fine particles.
- Size reduction process is also termed as

Comminution, or Diminution or Pulverisation



OBJECTIVES OF SIZE REDUCTION

- It increases surface area of the particle, hence increases rate of dissolution and absorption and bioavailability, and therefore increases therapeutic efficacy.
- It facilitates mixing and drying by milling by increase surface area.
- In ophthalmic, aerosol, inhalation and parenteral preparation where controlled particle size is required which facilitate by size reduction.

Advantages/ Applications of Size Reduction

- ✓ Content Uniformity
- ✓ Uniform Flow
- ✓ Effective Extraction of Drugs
- ✓ Effective Drying
- ✓ Improved Physical Stability
- ✓ Improved Dissolution Rate
- ✓ Improved Rate of Absorption

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Disadvantages of Size Reduction

- ✓ Drug Degradation
- ✓ Contamination
- ✓ If size reduced for hydrophobic materials, then it increase the effective surface area.
- ✓ Aggregation of particles is possible, as very fine particle possess strong cohesive force

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- ✓ Finer drug particle are more susceptible to atmospheric degradation.(specially when they have volatile ingredients)

Mechanisms of Size Reduction

Modes	Characteristics
Cutting	The material is cut by means of a sharp blade. It is useful for comminution of fibrous or waxy solids Example: cutter mill..
Compression	The material is Crushed between rollers by the application of pressure. Example: Roller mill.
Impact	This involves the operation of hammers or bars at high speeds. When a lump of material strikes the rotating hammers, the material splitsapart. Example: Hammer mill.
Attrition	This process involves breaking down of the material by rubbing action between two surfaces. Example: Fluid energy mill.

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Factors affecting the Size Reduction

FACTORS	CHARACTERISTICS
Hardness	Harder the material, more difficult to reduce its size.
Moisture content	<5% moisture suitable for dry grinding and >50% for wet grinding.
Elastic materials	Synthetic gums, waxes and resins become soft and plastic during milling.
Solvated materials	Sodium sulphate and other hydrates liberate water during milling and cause clogging of the mill.
Stickiness	Adhesion & cohesion leads in choking of meshes of machine

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THEORY OF SIZE REDUCTION

A number of theories have been proposed to establish a relationship between energy input and the degree of size reduction produced.

- Rittinger's theory
- Bonds' s theory
- Kick's theory
- Walker's theory

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Rittinger's theory

Energy, E required for size reduction of unit mass is directly proportional to the new surface area produced.

Worked use for particulate size reduction is directly proportional to the new surface produced

THEORY OF SIZE REDUCTION

Bonds' s theory

The energy used in crack propagation is proportional to the new crack length produced.

It states that the energy used for deforming or fracturing a set of particles of equivalent shape is proportional to the change in particles dimensions.

$$E = 2K_B \left(\frac{1}{\sqrt{Dn}} - \frac{1}{\sqrt{Di}} \right)$$

Where

K_B = Bond's work index.

Di = initial diameter

Dn = new diameter.

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THEORY OF SIZE REDUCTION

SUMMARY

- ✓ **Rittinger's theory:**

Energy α new surface area formed.

- ✓ **Bond's theory:**

Energy used in crack propagation α crack length produced.

- ✓ **Kick's theory:**

Energy α ratio of change in size.

SIZE REDUCTION EQUIPMENT

MILL	PRINCIPLE	PRODUCT SIZE	CHARACTERISTICSAND USES	NOT USED FOR
Cutter mill	Cutting	20-100 mesh	Rotate at speeds from 200 - 900 revolutions. Fibrous, animal tissue & vegetable drugs, adhesive material.	Friable material
Hammer mill	Impact	4-325 mesh (10-400 mm)	8000 to 15000 revolutions per minute. It is used to dry materials, wet filter press cakes, ointments, slurries.	Abrasive material
Roller mill	Pressure / Compression	20 -200 mesh	Soft material	Abrasive material
Fluid energy mill (Jet mill, Micronizers, Ultrafine grinders)	Impact & attrition	1-30 mm	Compressed air of 600 kilopascals to 1.0 megapascal is used. It is used for antibiotics and vitamins. Moderately hard, friable material and thermolabile material.	Soft & sticky material

SIZE REDUCTION EQUIPMENT

MILL	PRINCIPLE	PRODUCT SIZE	CHARACTERISTICSAND USES	NOT USED FOR
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SIZE REDUCTION EQUIPMENT

MILL	PRINCIPLE	PRODUCT SIZE	CHARACTERISTICSAND USES	NOT USED FOR
Colloidal mill	Shearing	3-75 pm	3000 to 20000 revolutions per minute. It is used for colloids dispersion,suspensions,emulsions and ointments. It can be used for sterile products.	Dry milling
Edge runner mill and End runner mill	Crushing & Shearing	20 - 80 mesh	Used for plant based products. It is also used for chemicals and drugs.	Sticky material
Ball mill (Pebble mill and tumbling mill)	Impact & Attrition	20 -200 mesh (100 to 5mm)	Balls occupy about 30 to 50 % of the volume of cylinder It is used for the production of ophthalmic and parenteral products. Ball mill at low speeds is used for milling dyes, pigments and insecticides. Brittle materials. Operated at 60 - 85% of the critical speed. Harding mill is a variant of ball mill.	Soft material
Disintegrator	Impact		All type of drugs	-

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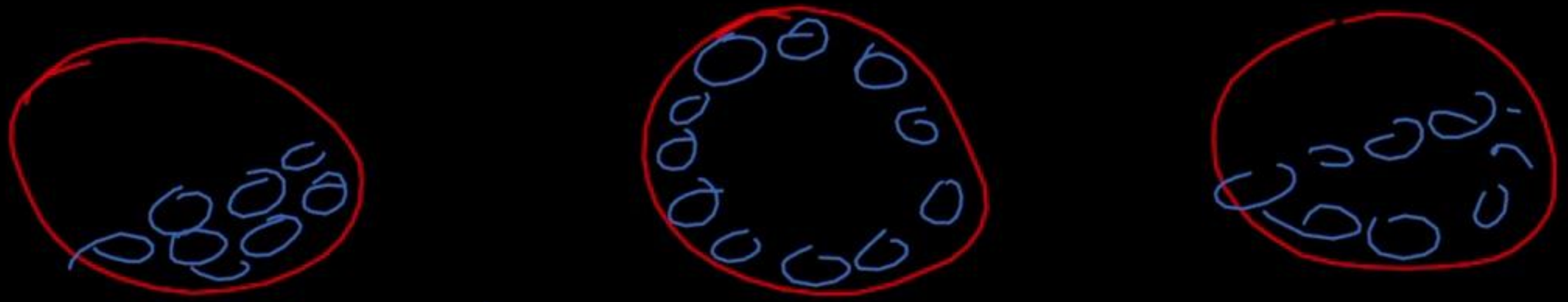
Ink
Blank Screen



Ballmill
↳ Hardinge mill
→ Continous ball mill

GPAT & NIPER 2025 CRASH COURSE

Grow Up Pharma

Pharmaceutical Engineering

Lecture- 01

Size Separation & Heat Transfer

Size Separation

- Size separation is a unit operation that involves the separation of a mixture of various sizes of particles into two or more portions by means of screening surfaces.
- Size separation is also known as Sieving, Sifting, Classifying or Screening
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GRADES OF POWDER

Grade of powder	Sieve through which all particles must pass	Sieve through which not more than 40 per cent of particles pass
Coarse	10	44
Moderately coarse	22	60
Moderately fine	44	85
Fine	85	Not specified
Very fine	120	Not specified

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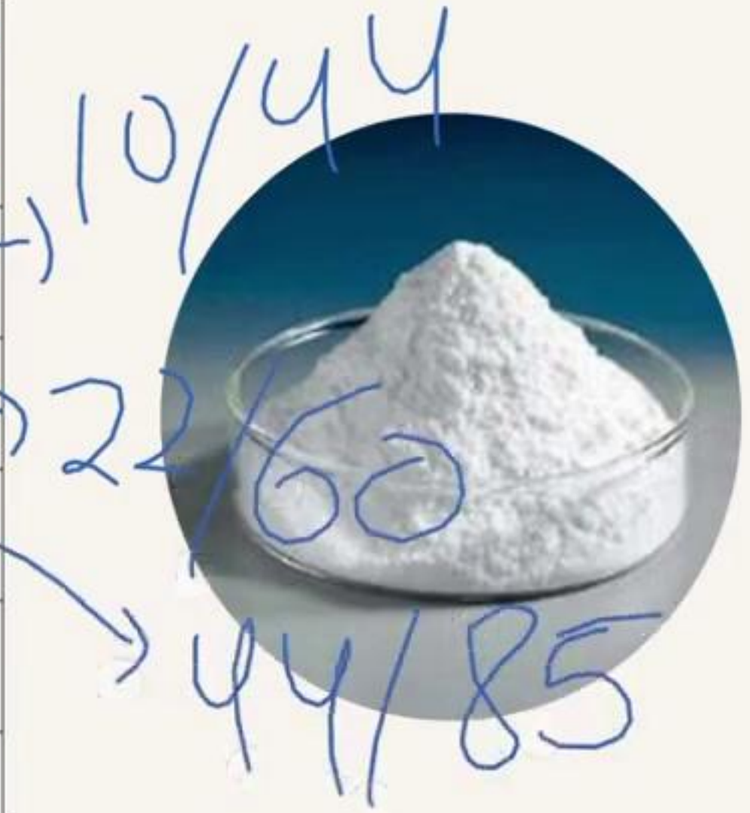

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Coarse	10 → 1.7 mm	44
Moderately coarse	22 → 710 µm	60
Moderately fine	44 → 355	85
Fine	85 → 180 µm	Not specified
Very fine	120 → 125 µm	Not specified

STOKE'S LAW

- When a solid particle is suspended in a liquid the particle settles downward at a velocity, V
- This velocity is called sedimentation rate
- It is found that this rate of sedimention depend on the diameter of the particle density of the lquid and particle, visousity of the liquid and the acceleration due to gravity

$$v_p = \frac{(\rho_p - \rho_w)d^2 g}{18\mu}$$

v_p = particle settling velocity (m/s or ft/s)
ρ_p = particle density (kg/m^3 or lb$_m$/ft^3)
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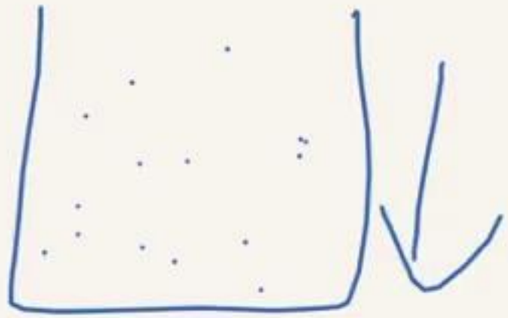

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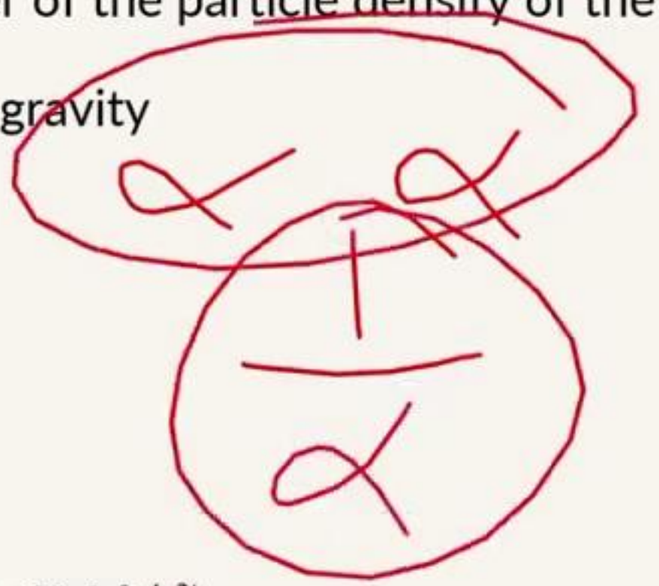

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The working of mechanical sieving devices are based on any of the following methods:

- Agitation
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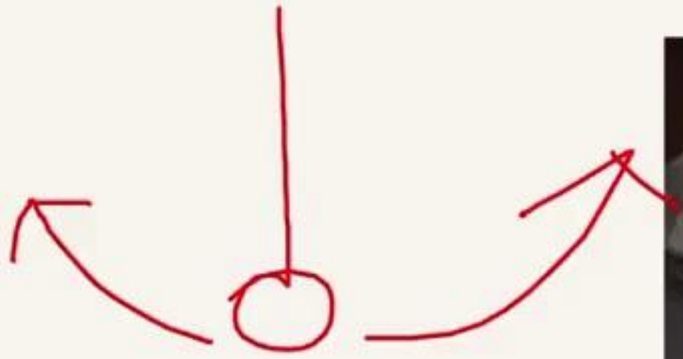

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SEPARATING EQUIPMENTS

EQUIPMENT	PRINCIPLE	PARTICLE DIAMETER
Mechanical Siever	Agitation	5 - 10,000 gm
Agitator	Sieving	5 - 5000 gm
Cyclone separation	Centrifugal force	2-50 gm
Sedimention tank	Sedimentation	Gravitational (5 - 1000 gm) Centrifugal (0.1 - 5 gm)
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EQUIPMENT FOR SOLID-LIQUID SEPARATION

EQUIPMENT FOR SIZE SEPARATION

METHODS	PRINCIPLE	DETAIL
Shaking screen	Oscillation	The screen is allowed to shake in a reciprocating motion.
Rotex screen	Oscillating Agitation and Vibration	Granular matrices and powdered foods are also size separated by rotex screen.
Cyclone separator	Centrifugal force	It is used to separate the solids from gases. It is also used for size separation of solids in liquids. It is used for separating the heavy or coarse fraction from fine dust.
Air separator	Centrifugal force	Air separators are often attached to the Ball mill or Hammer mill to separate and return over sized particles for further size reduction.
Bag filter	Suction and Pressure	Bag filter is connected to the discharge end of the Fluidized energy mill
Scrubbers	Inertial Impact and Absorption	This equipment combines the action of cyclone for separation of entrained droplets of water.

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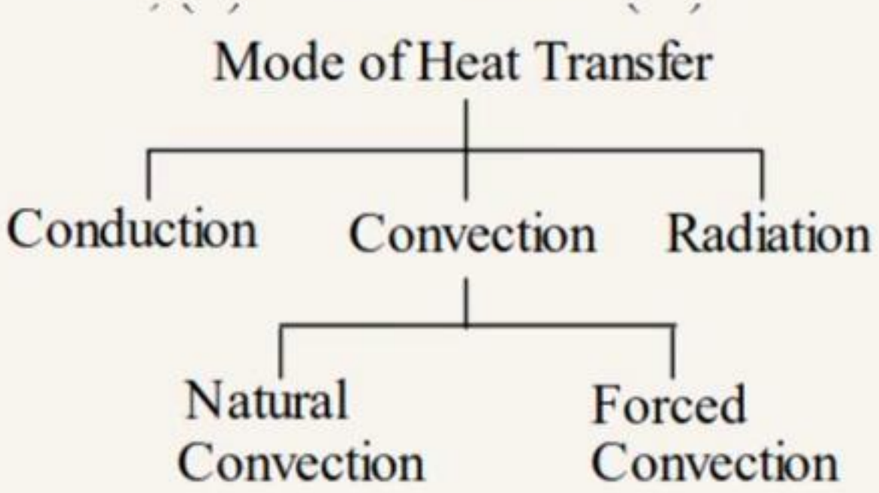

Modes Heat Transfer

CONDUCTION

- Heat is transferred from one particle of matter to another in an object without the movement of the object
- Energy transfer occurs without the mixing action of molecules

FOURIERS LAW

Rate of heat flow through uniform material is proportional to area and temperature drop and inversely proportional to the length of the path flow

$$q = -\frac{KAdt}{dL}$$

Where,
A = Area perpendicular to the heat flow
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RADIATION

- Radiation is the transfer of energy by electromagnetic waves.
- Radiation does NOT require matter to transfer thermal energy.

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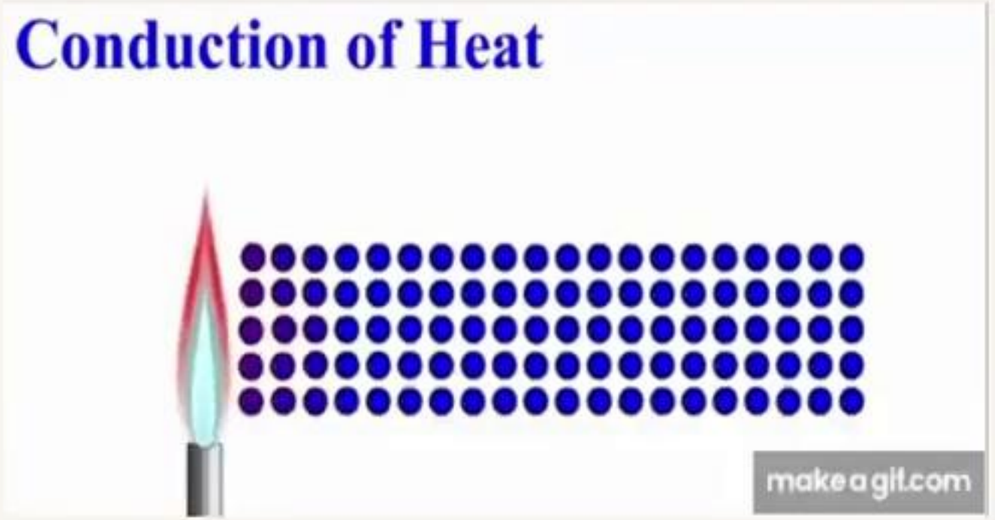

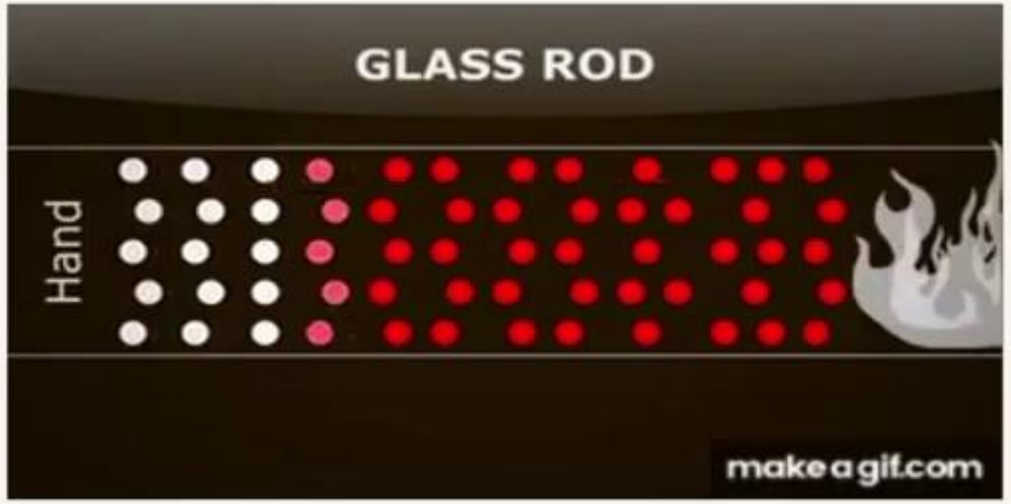

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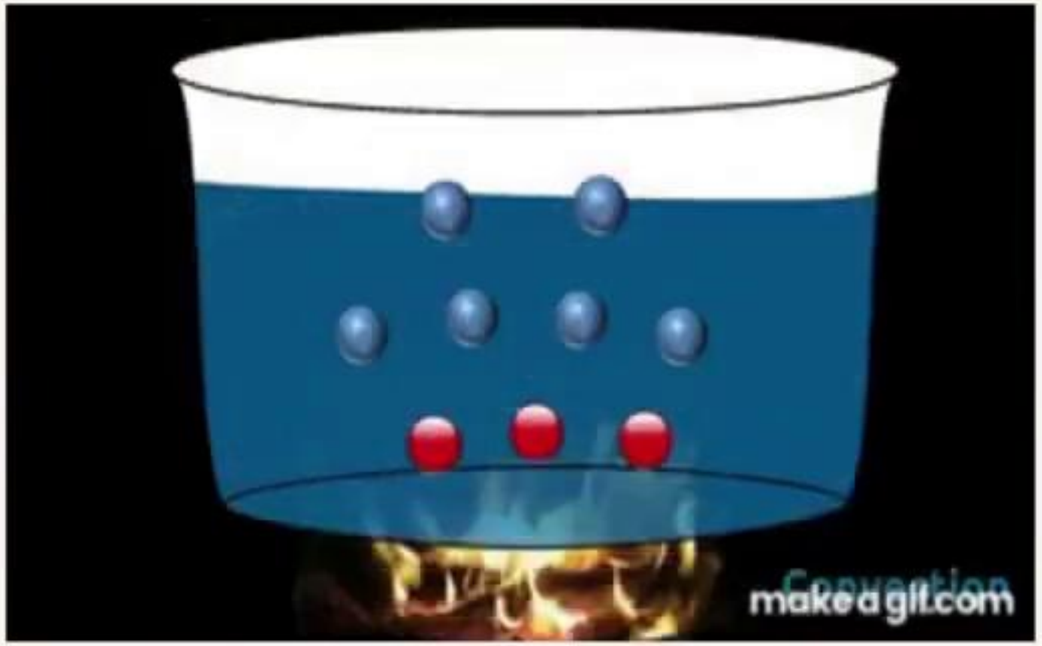

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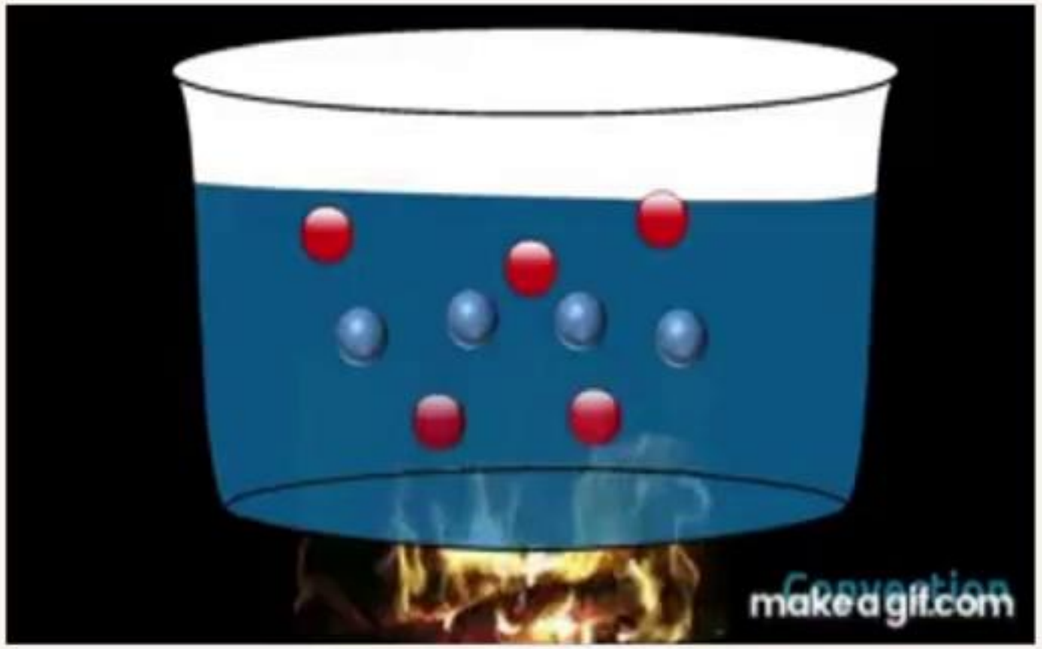
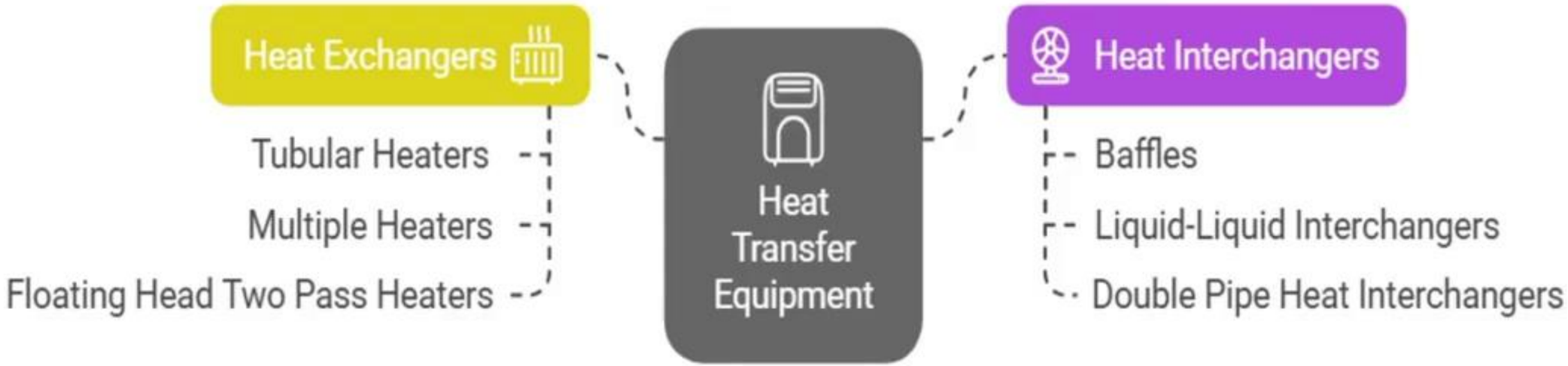


Heat Transfer Equipments



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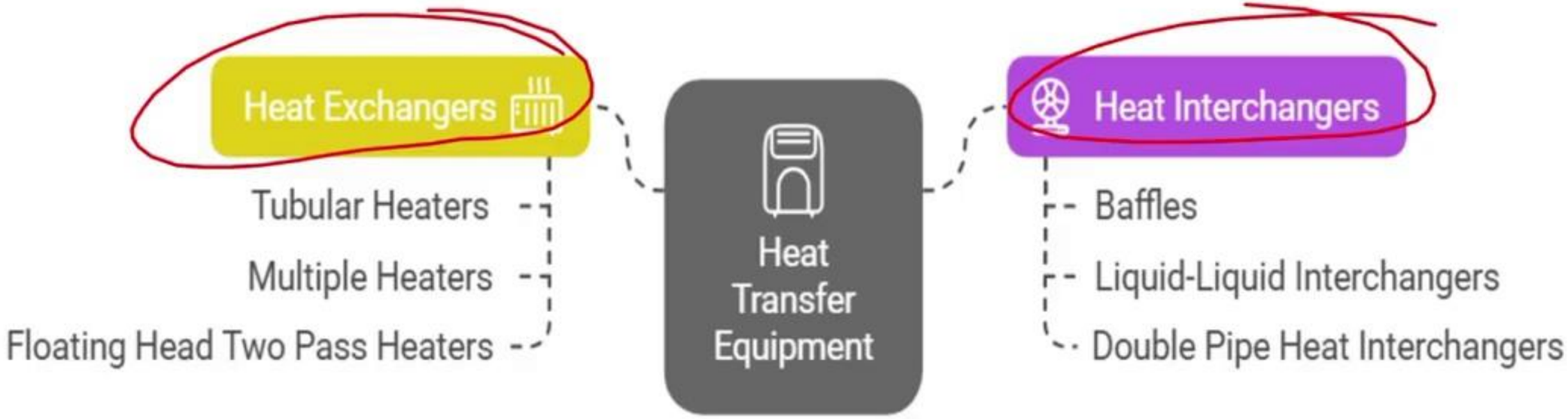

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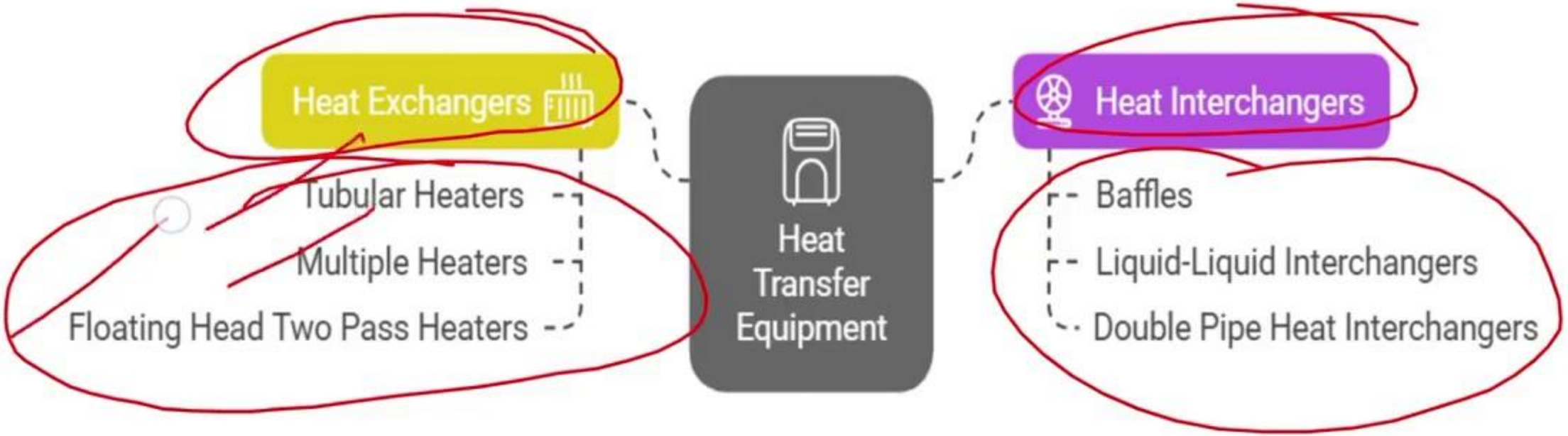

Black Body

It is defined as a body that radiates maximum possible amount of energy at given temperature. Normally, hot bodies emit radiation, Stefan- Boltzmann law gives the total amount of radiation emitted by black body.

$$q = bAT^4$$

q= Energy radiated per second

A = Area of radiating surface

T = Absolute temperature of radiating surface

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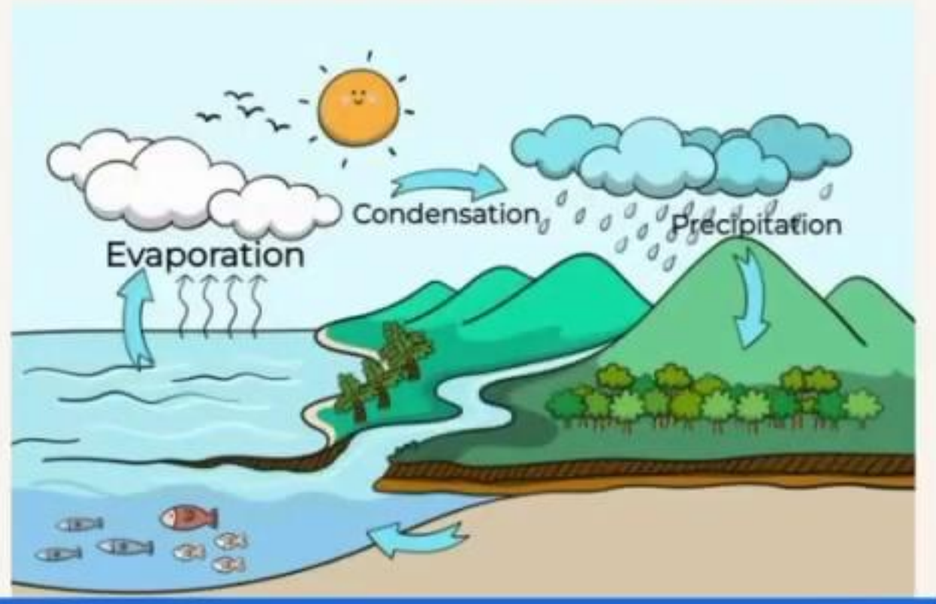
- Evaporation is a process of vaporizing large quantities of volatile liquid to get a concentrated product.
- Evaporation means simply vaporization from the surface of the liquid

Objective of evaporation:

- To make a solution more concentrated.
- Generally extracts are concentrated in this way.



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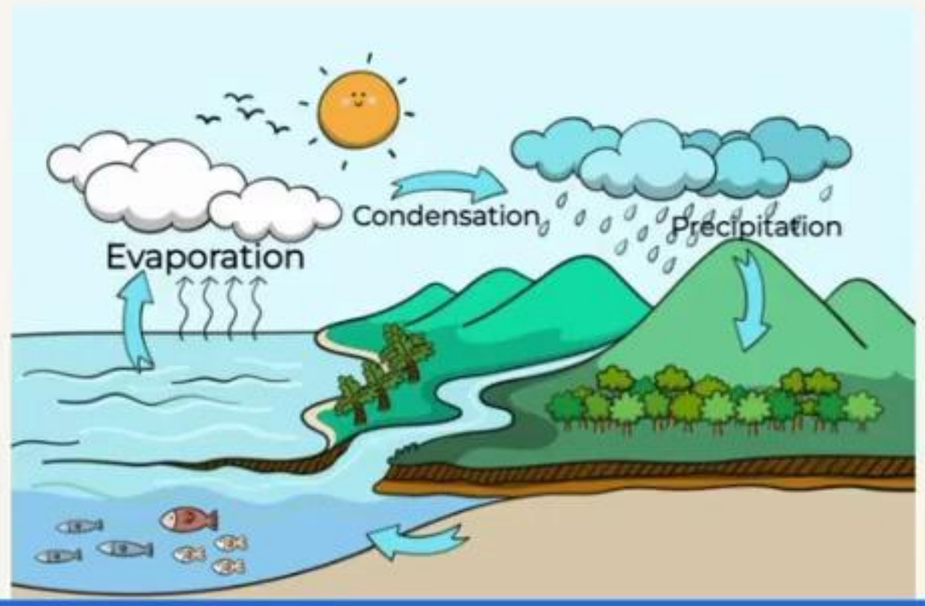

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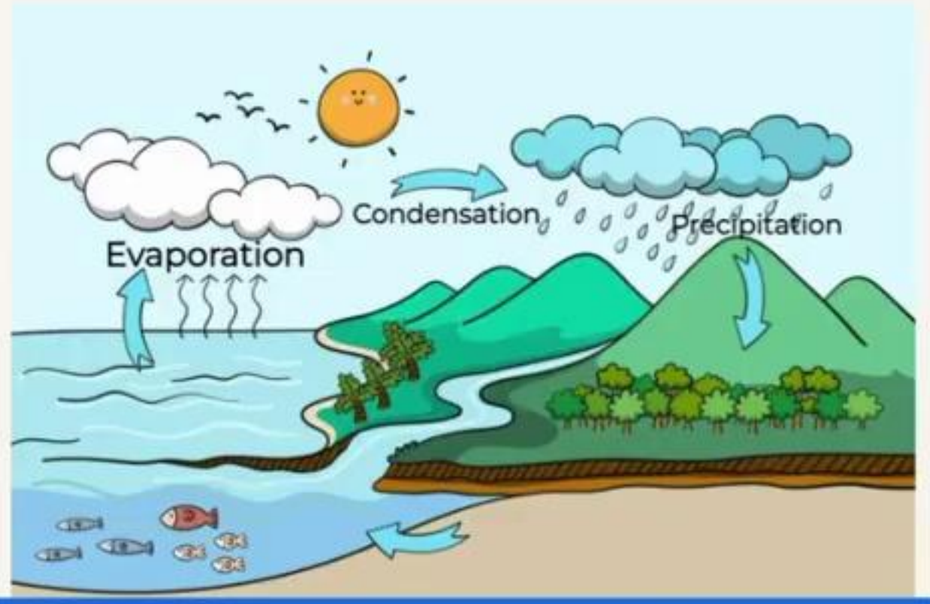
- Generally extracts are concentrated in this way.



FACTOR INFLUENCING EVAPORATION

Factors	Effect in Evaporation
Temperature	Higher the temperature, higher will be evaporation.
Vapour Pressure	Rate of evaporation is directly proportional to the vapour pressure of the liquid.
Surface area	The greater the surface area of the liquid, the greater will be the evaporation.
Agitation	It breaks scum or layer and increase rate of evaporation.

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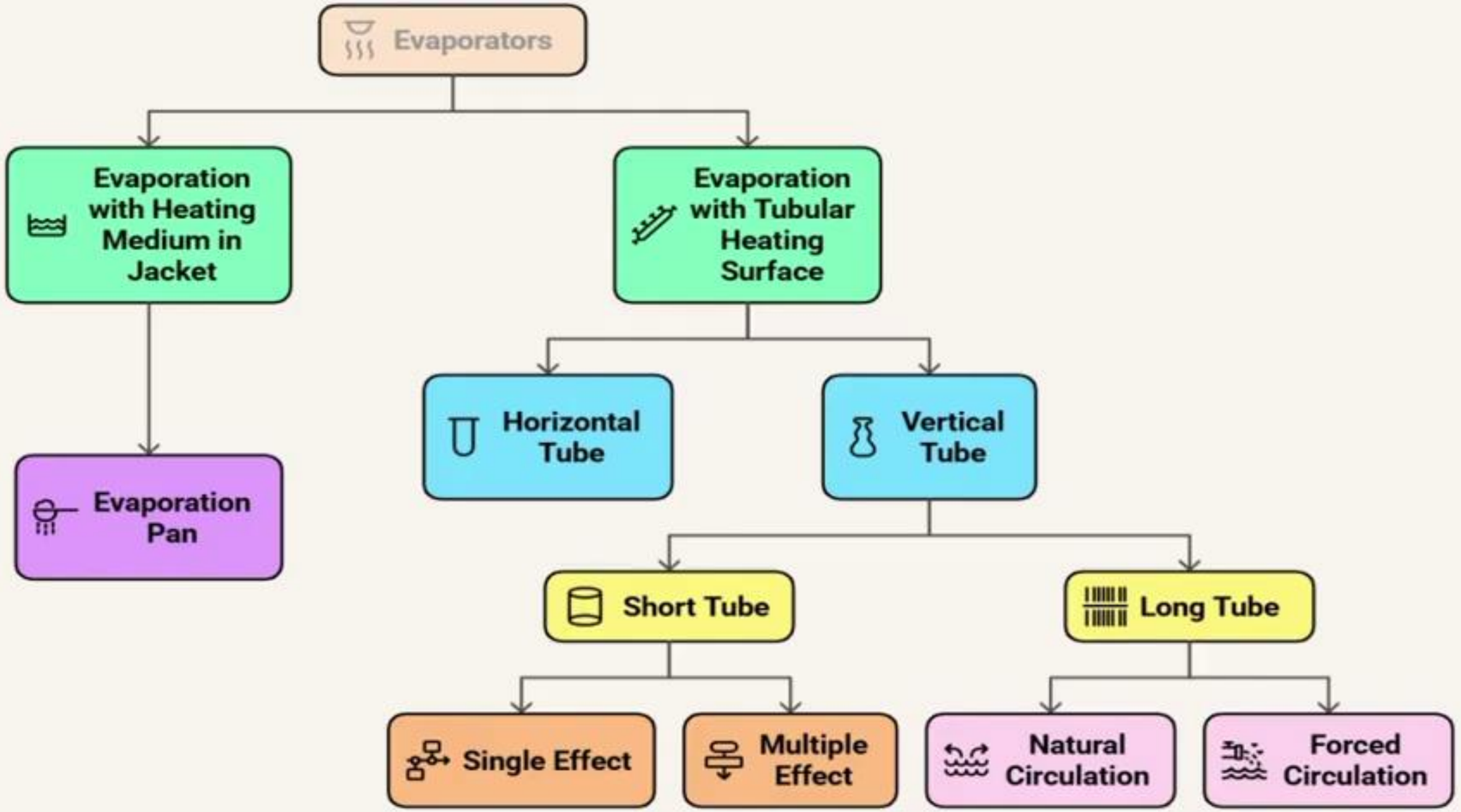
Ink Blank Screen

Temp → ↑ Temp ↑ Evap.

VP → ↑ VP ↑ Evap

SA → ↑ SA

Classification of Evaporators



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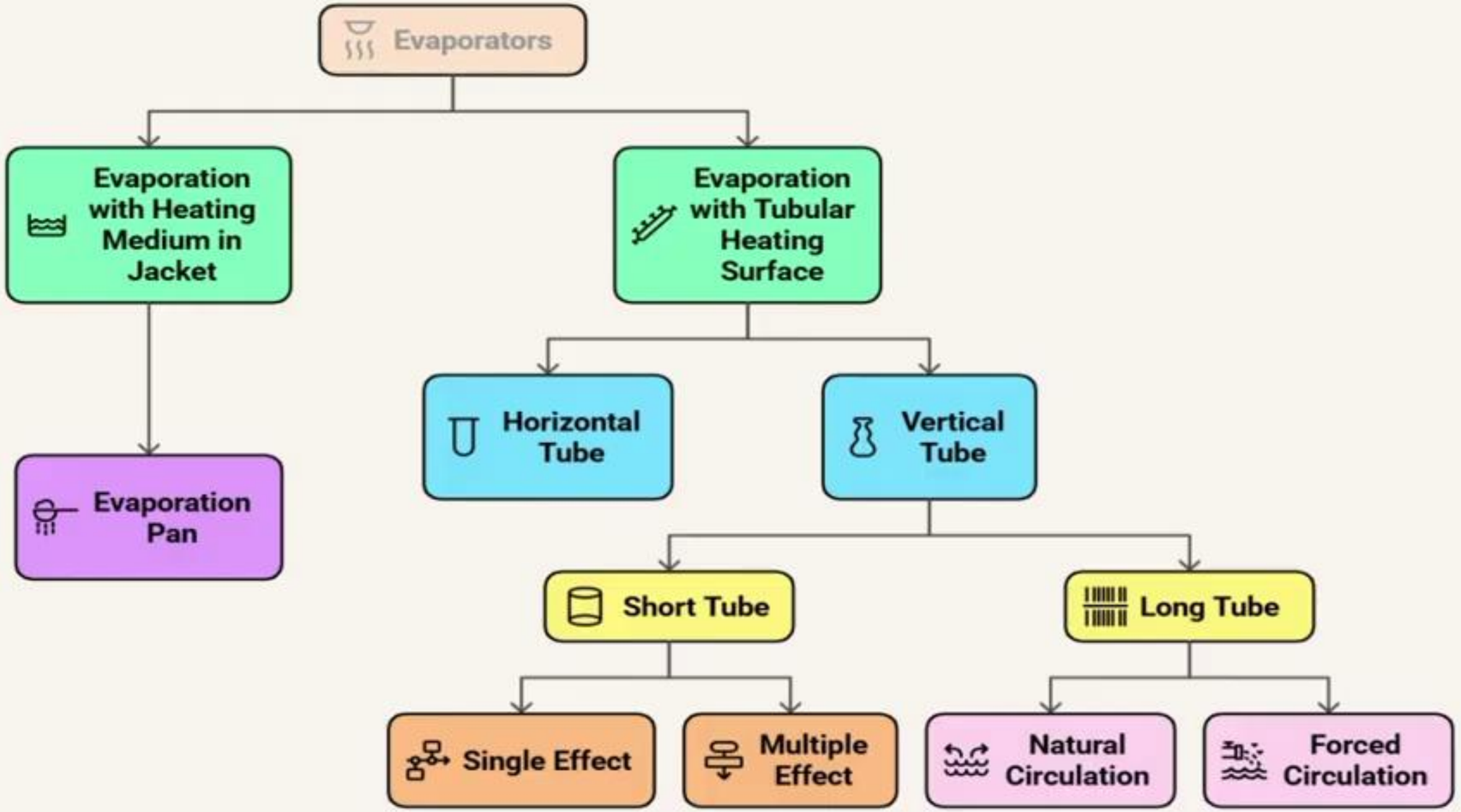

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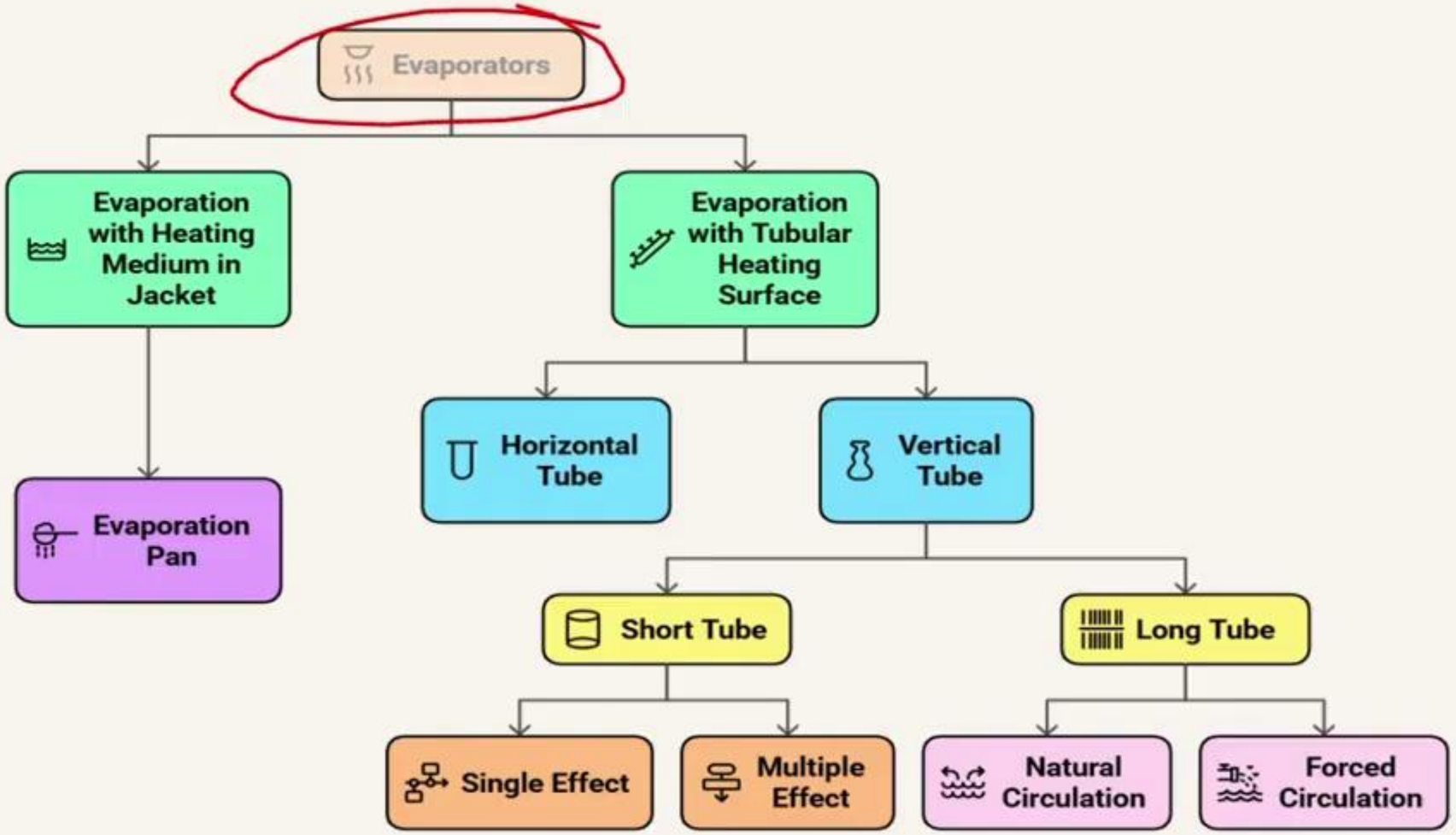

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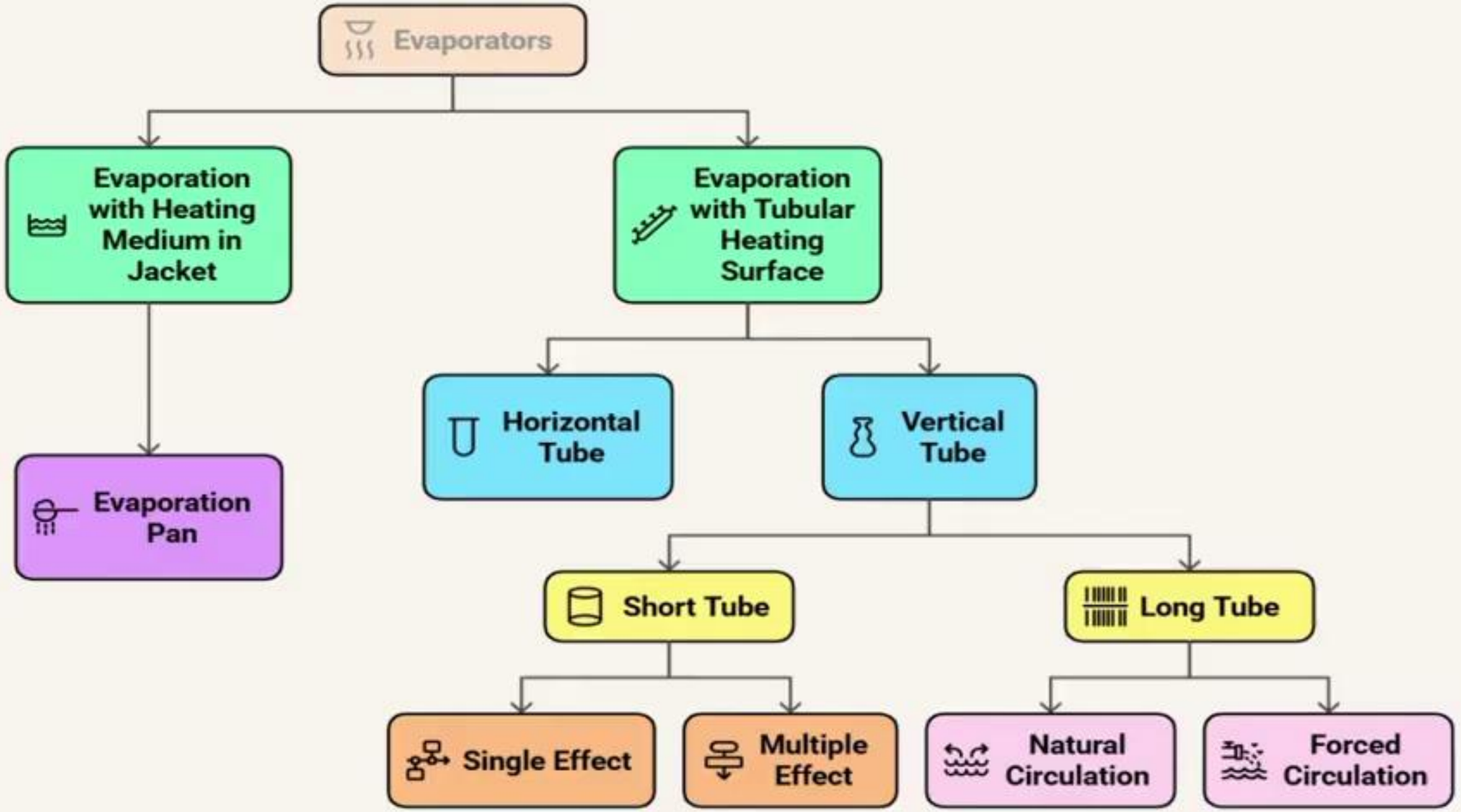

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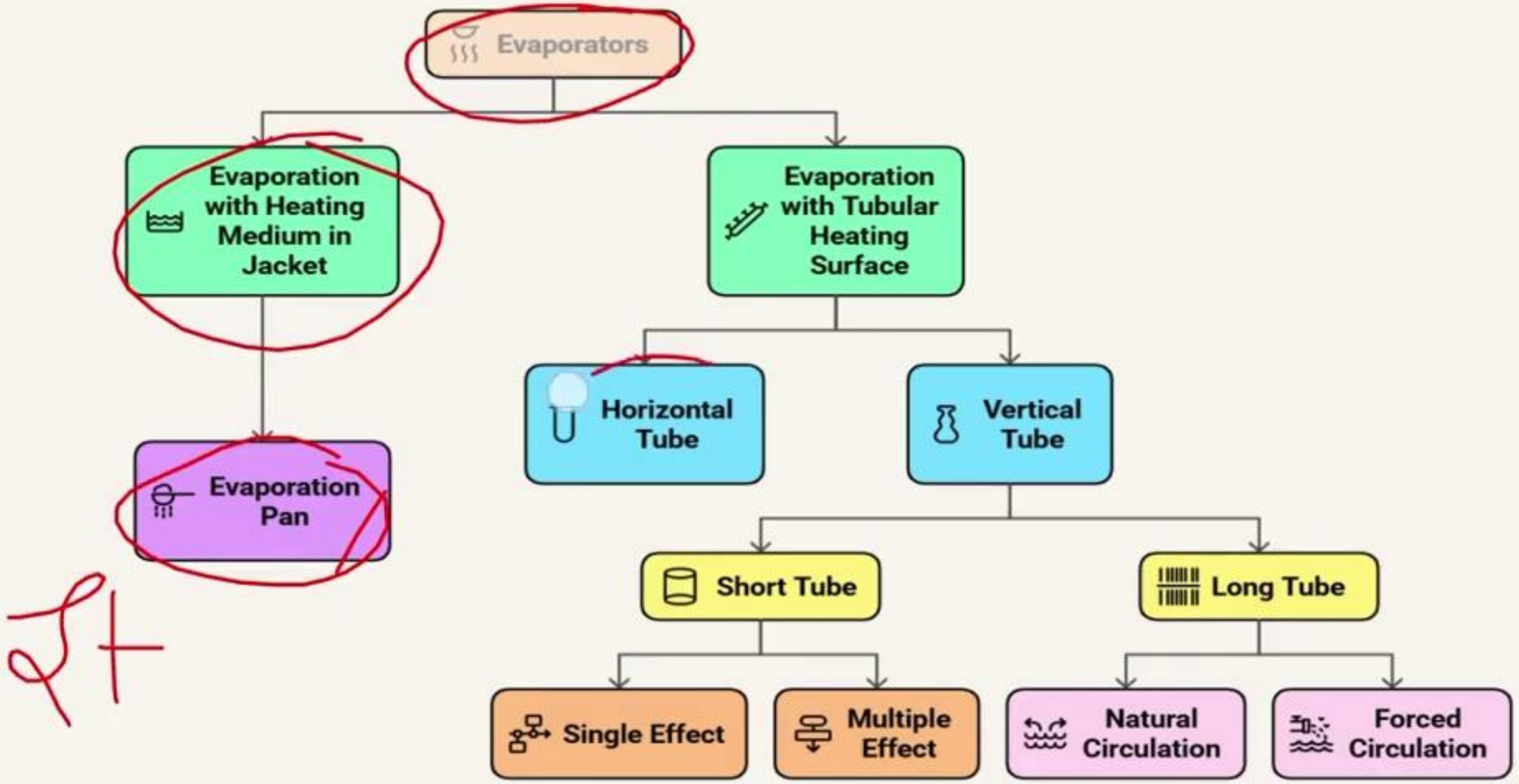

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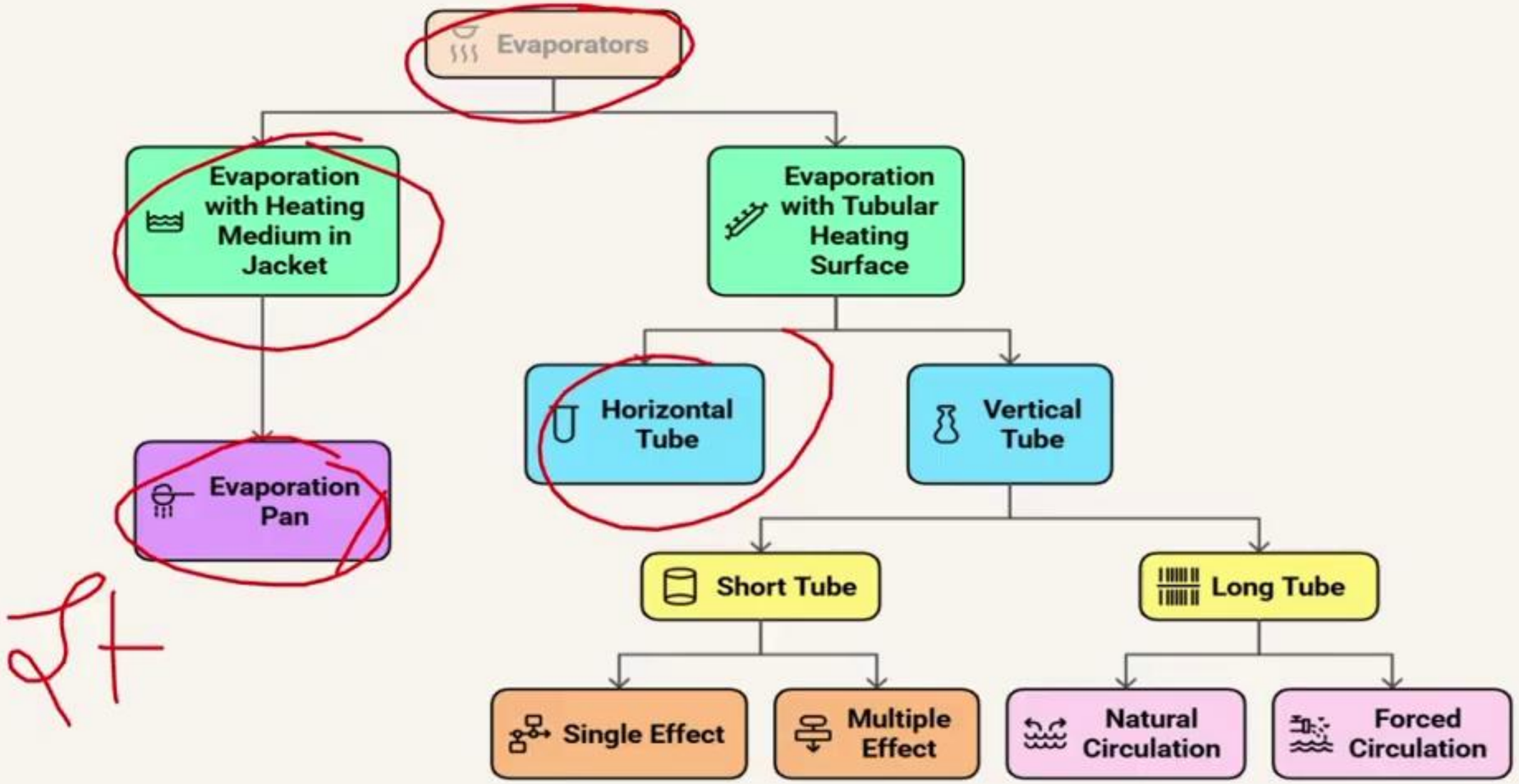

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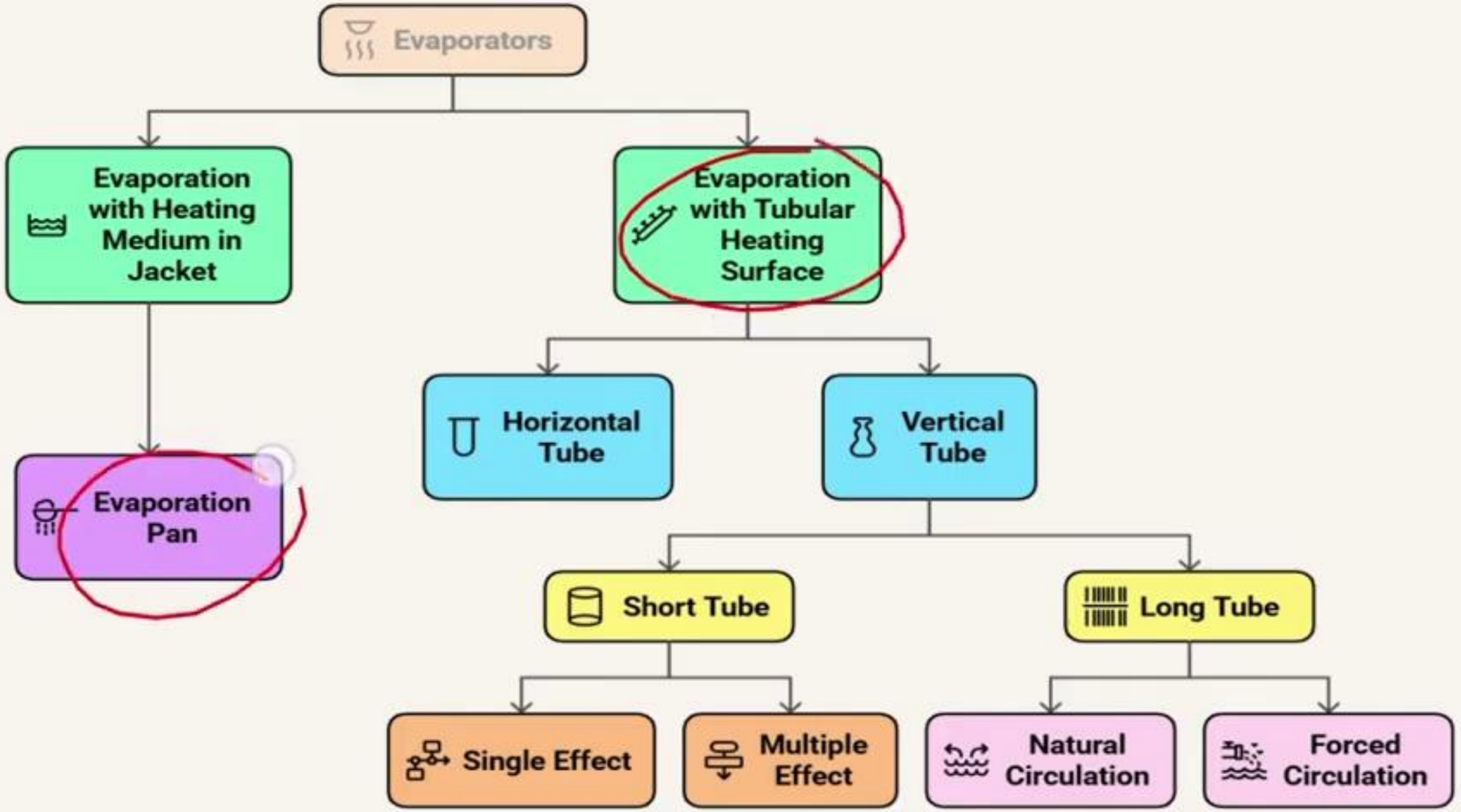

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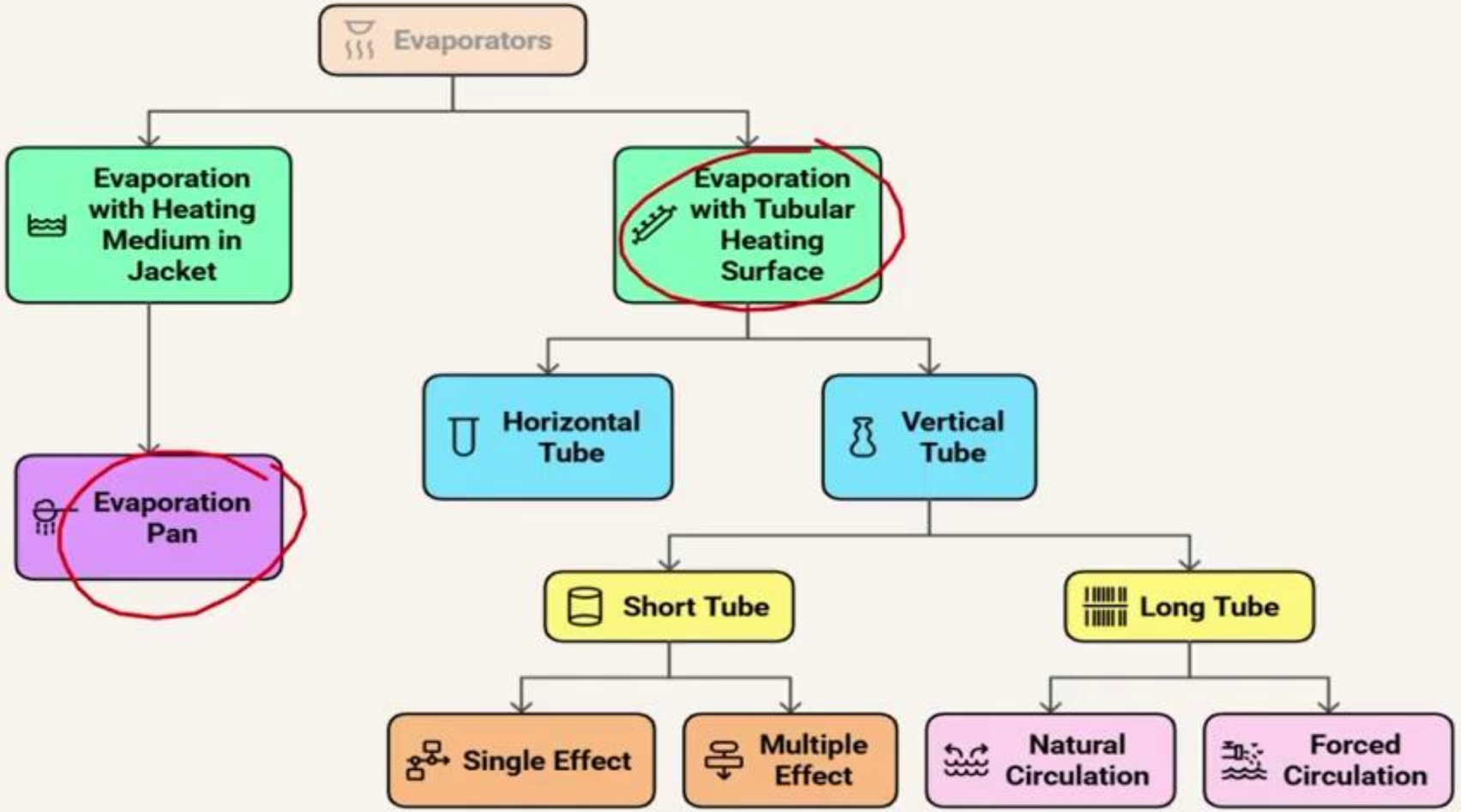

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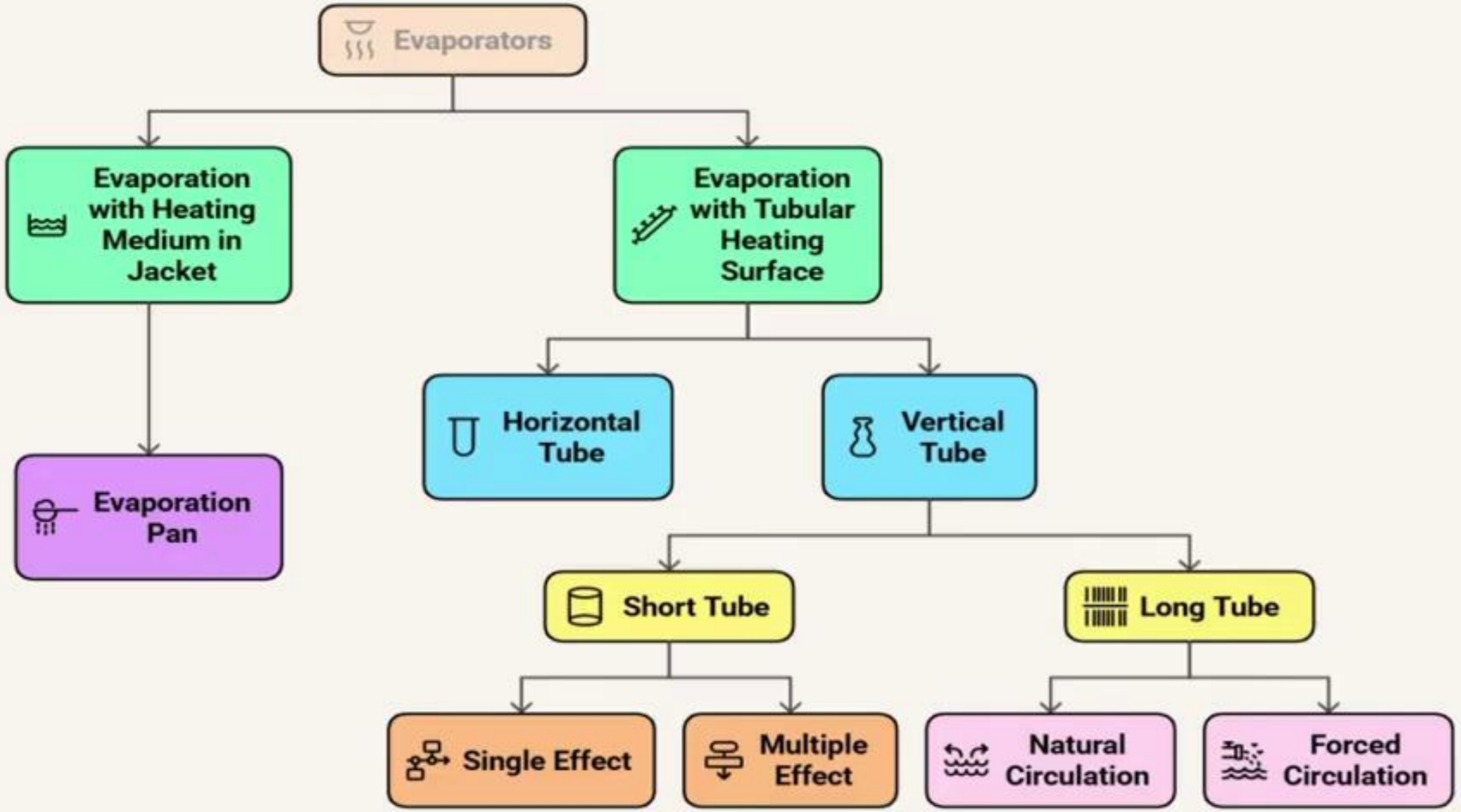

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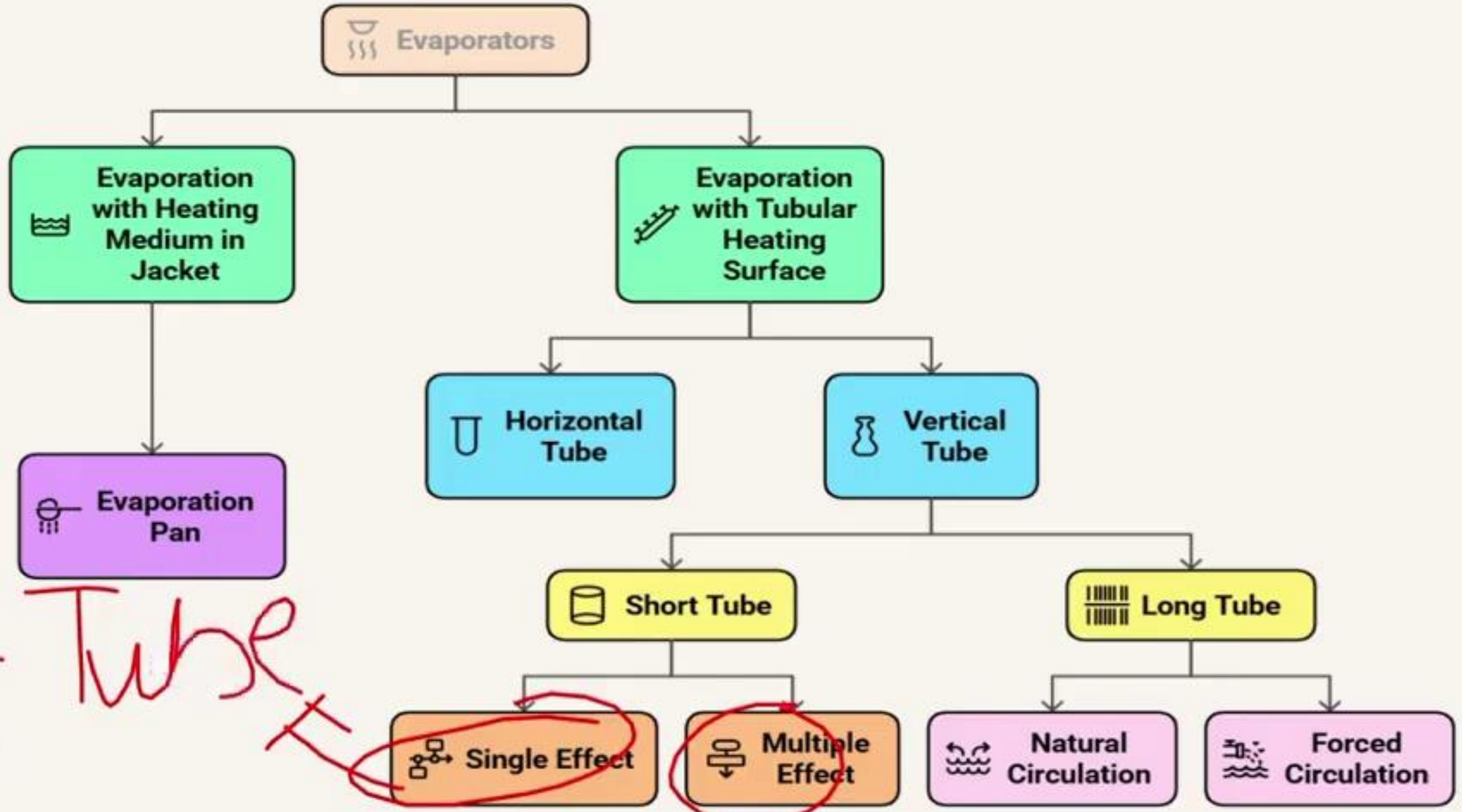
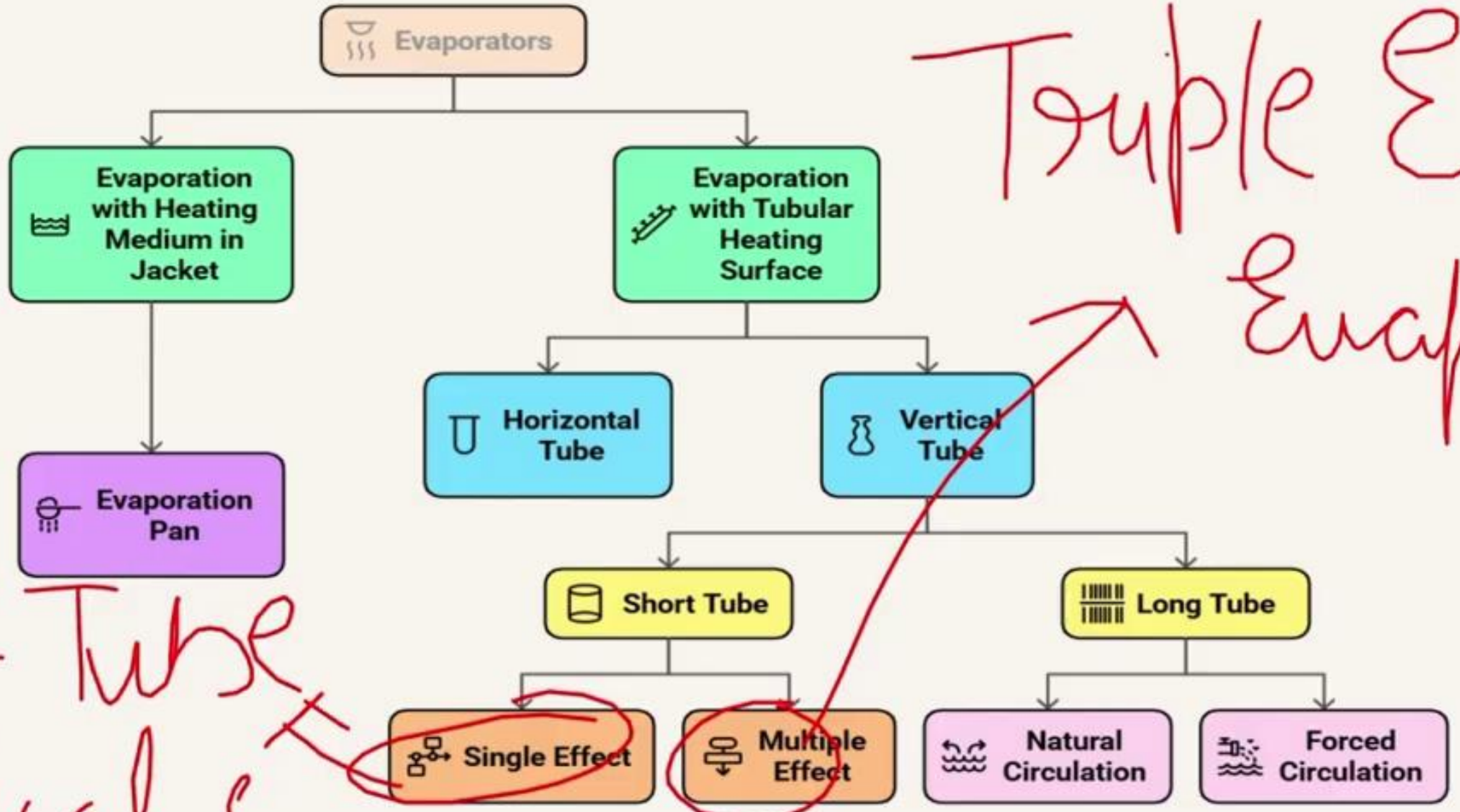


Short Tube
Vert

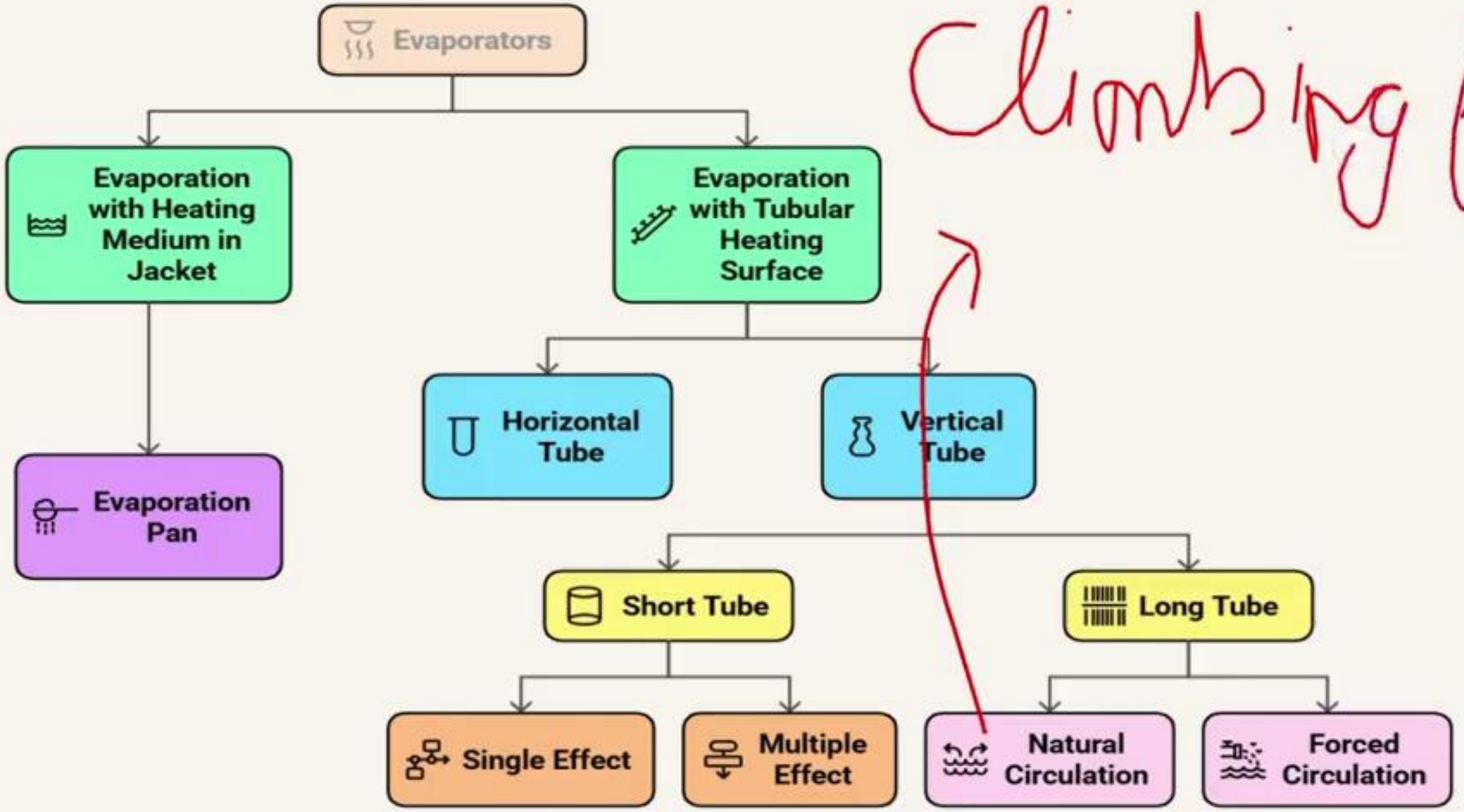
Classification of Evaporators



Triple Effect Evap.

Short Tube Vertical Ev.

Classification of Evaporators



Climbing f

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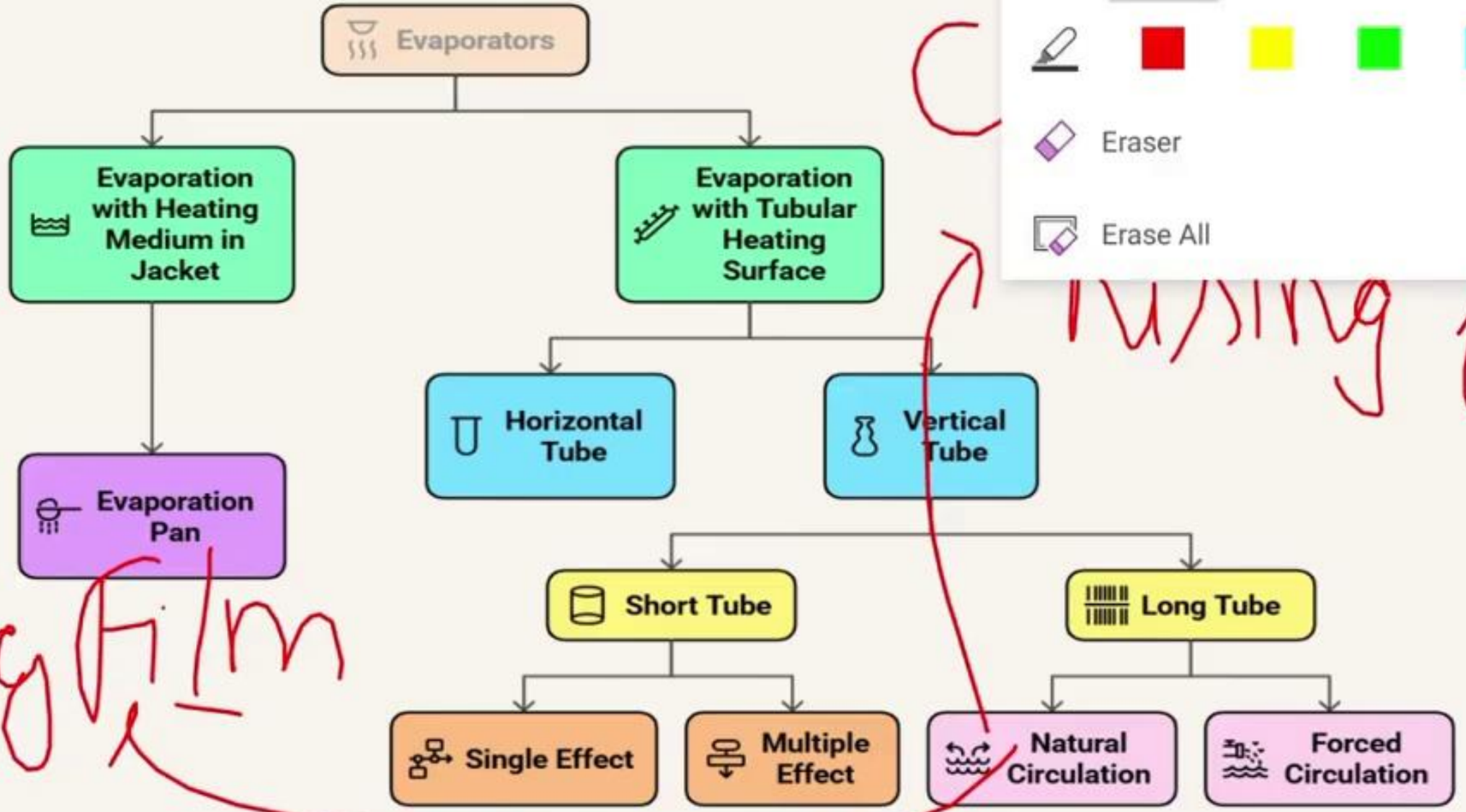

Falling Film

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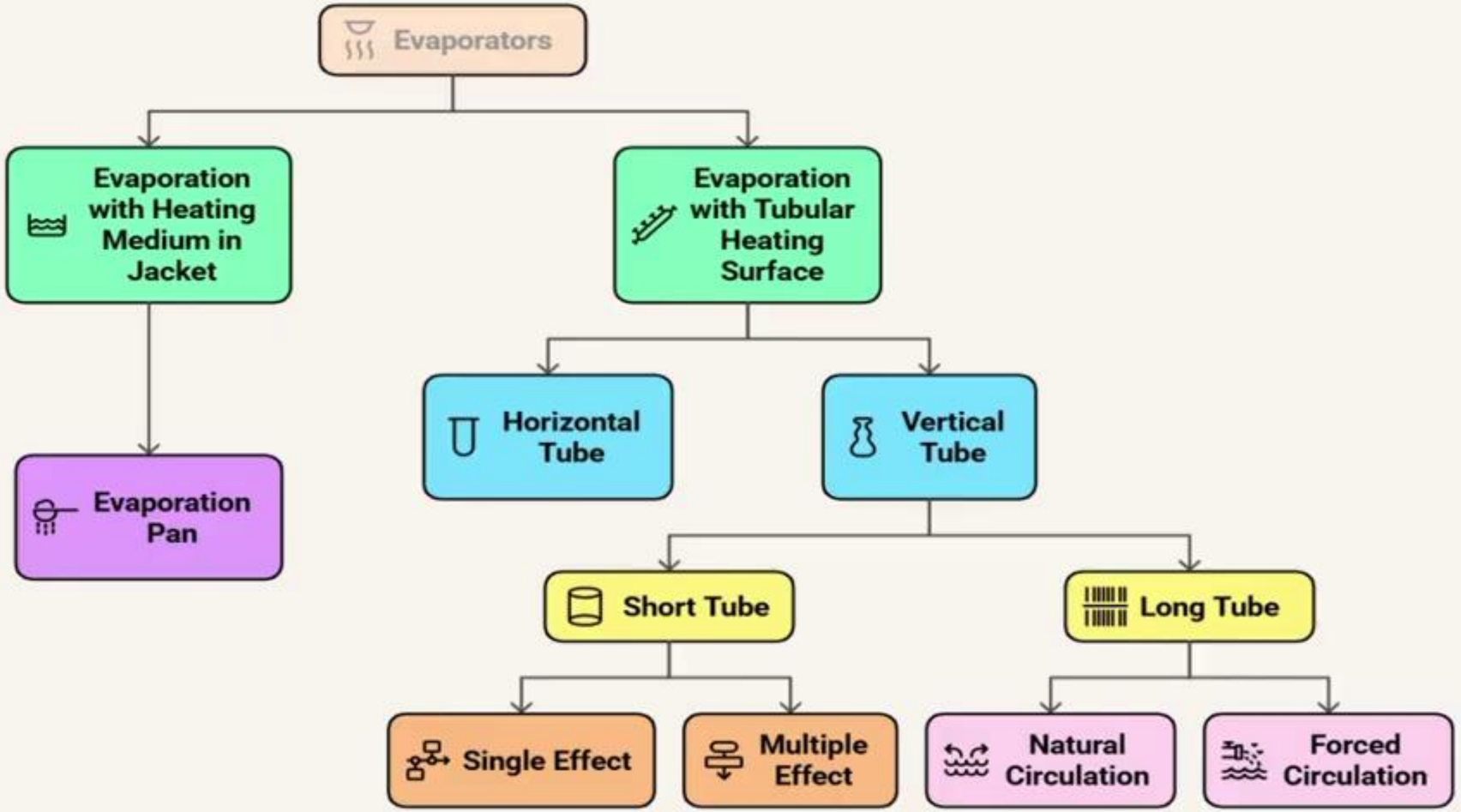

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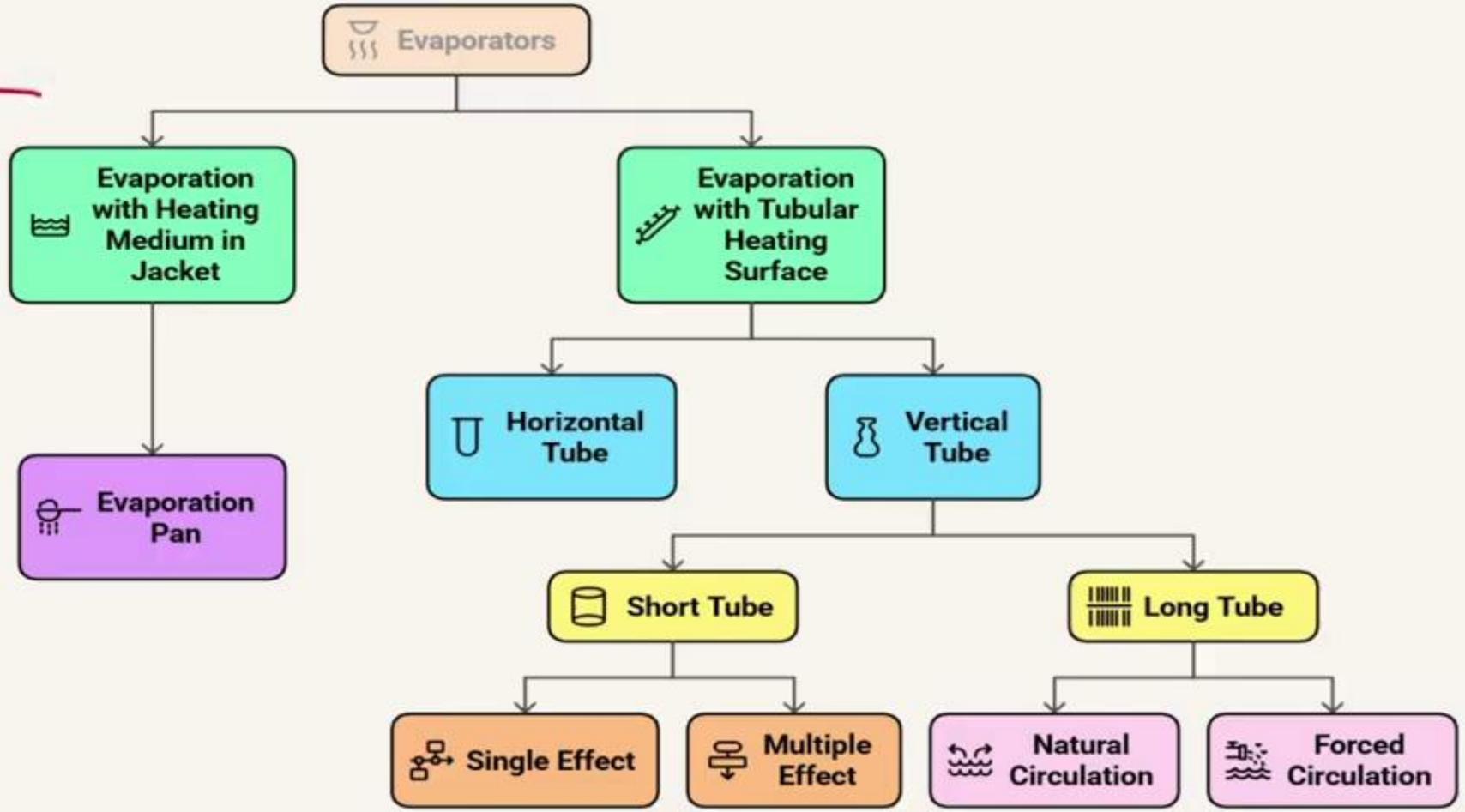

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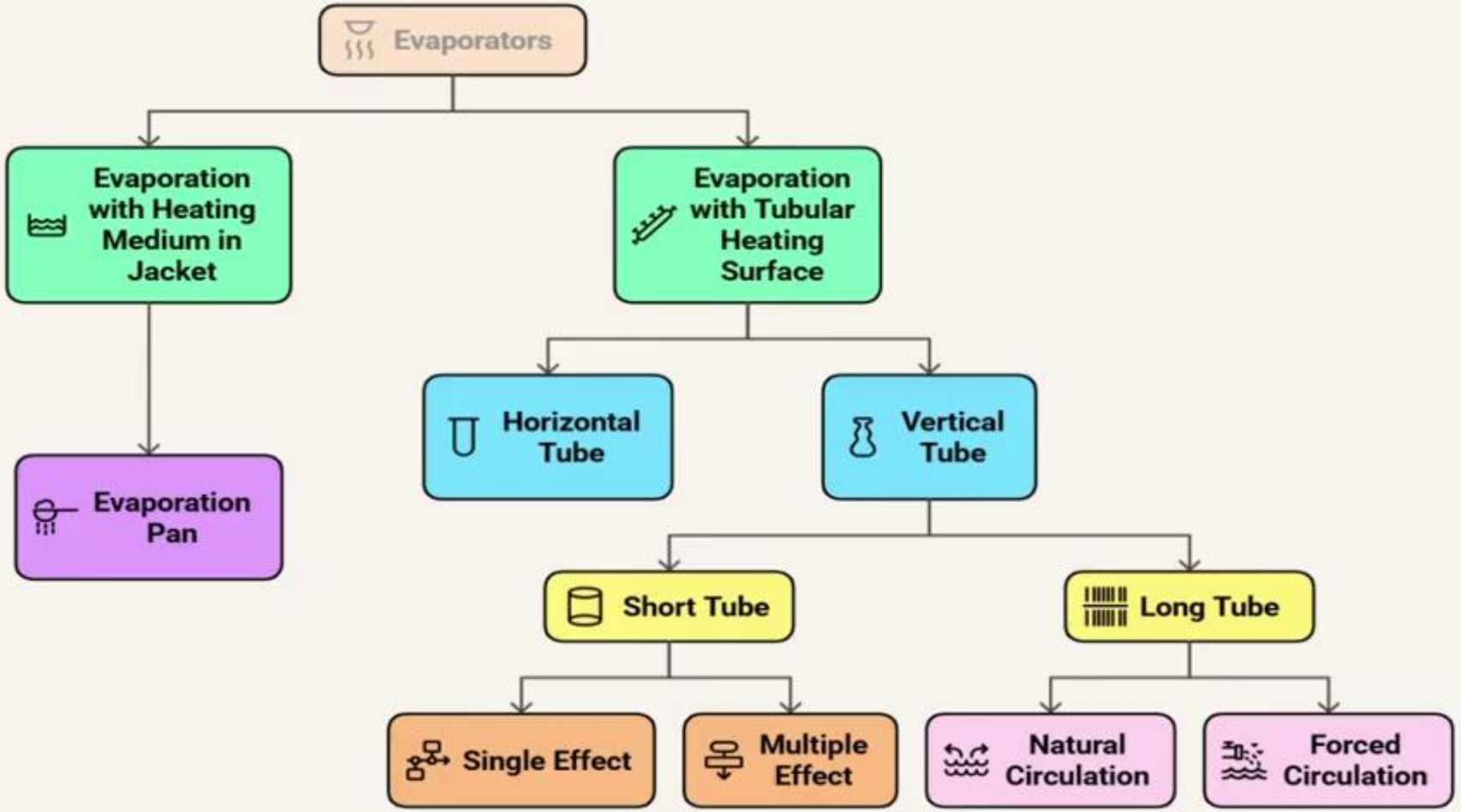

EVAPORATION EQUIPMENTS

EVAPORATOR	CHARACTERISTICS
Evaporating pan (Steam jacketed kettle)	It contain liner as pan and use for aqueous and thermostat liquor.
Vacuum pan	Use for thermolabile materials.
Evaporating stills	Use for thermolabile materials.
Horizontal Tube Evaporator	Use for liquor that do not crystallize and not form scale and non-viscous.
Vertical tube Evaporator	Use in sugar industry, concentrate cascara extract and not for foamy liquid.
Vertical tube (Basket type) evaporator	Use for sugar, salts and heavy chemical.
Climbing film (Kestner Tube) Evaporator	Use for Insulin, Vitamin Blood plasma, Liver extract like thermolabile material and for foamy corrosive liquid. Not for viscous liquids.

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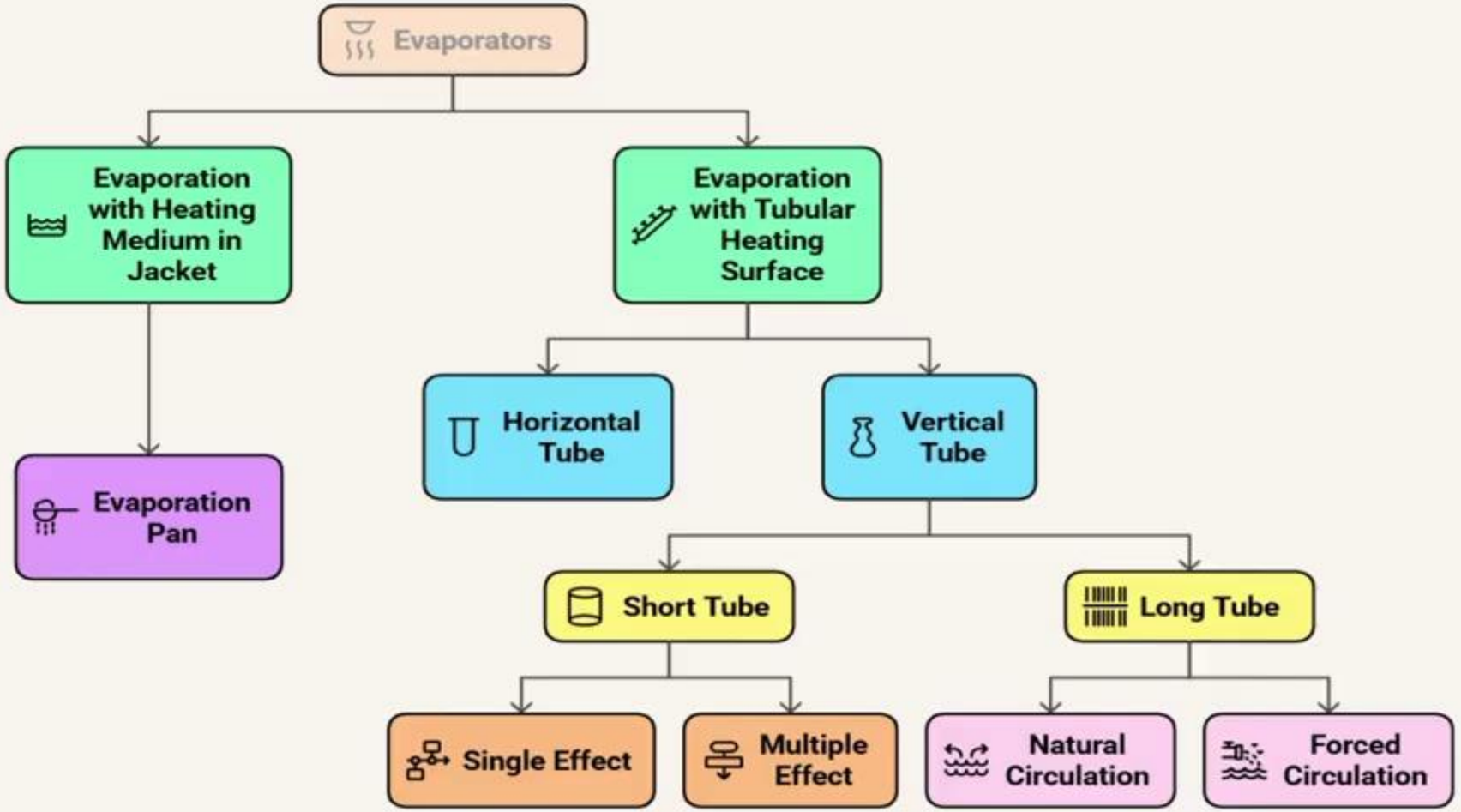


Distillation

- Jabir ibn Hayyan is discovered distillation.
- Distillation may be defined as the separation of the constituents of a mixture including a liquid by partial vaporization of the mixture and separate and collect the vapor.

Such separation may include:

(i) one liquid from non-volatile impurities.

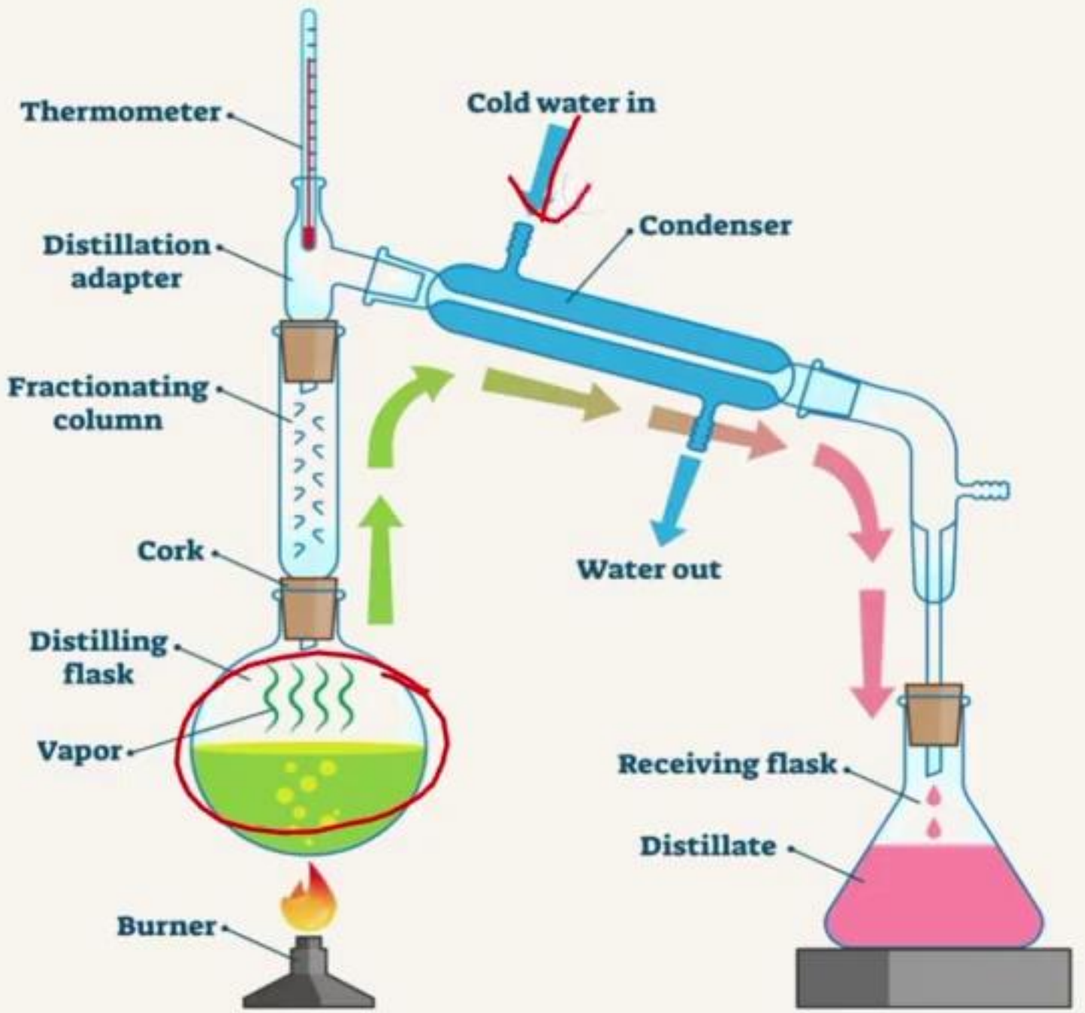
(ii) one liquid from one or more other liquids, with which it may be miscible, partially-miscible or immiscible

Ink

Blank Screen

100°C

Distillation



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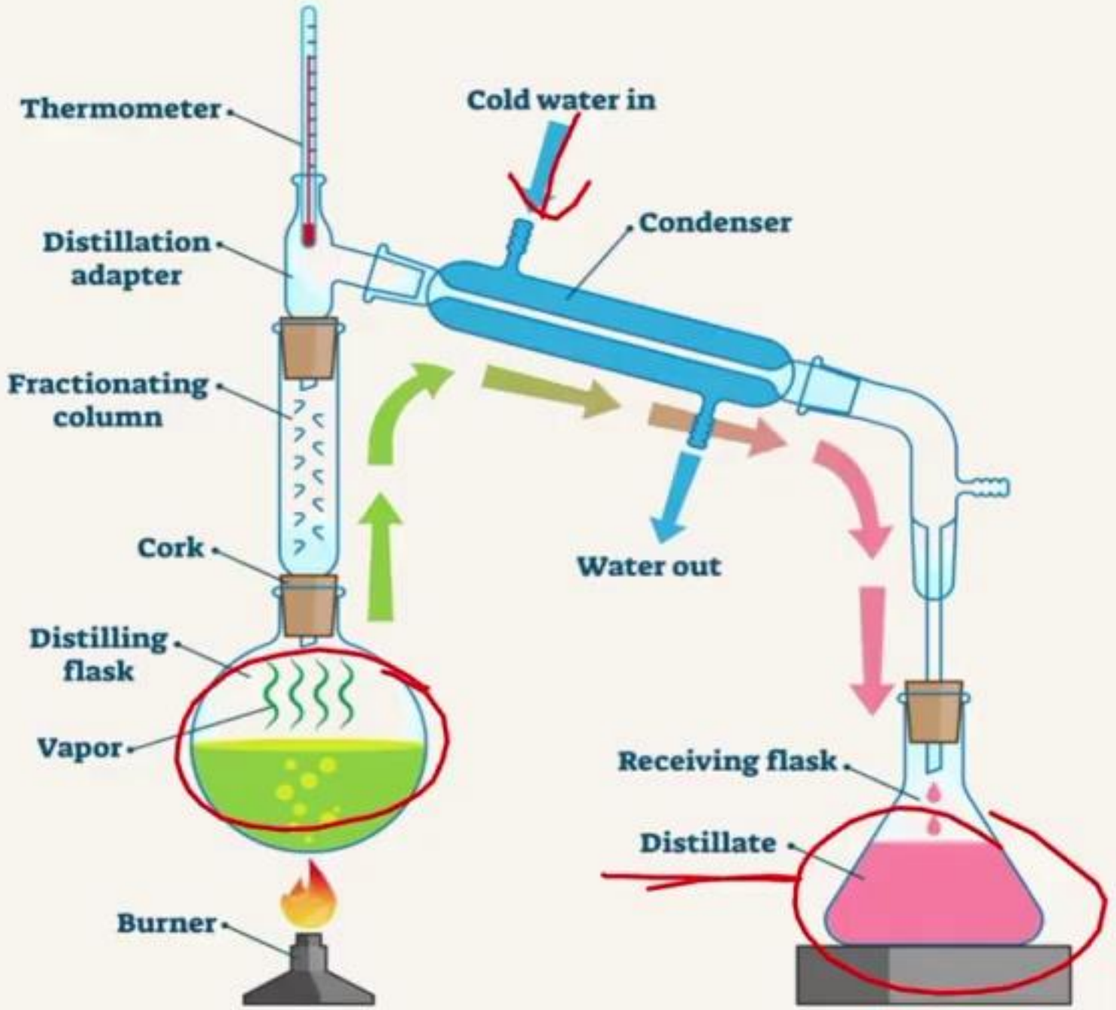

Types of Distillation

I. Simple Distillation (Differential distillation)
II. Flash Distillation (Equilibrium distillation)
III. Vacuum distillation (distillation under reduced pressure)
IV. Molecular Distillation (Evaporation distillation or short path distillation.)
V. Fractional Distillation (Rectification)
VI. Aezotropic (extractive) Distillation
VII. Steam Distillation
VIII. Destructive Distillation
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Fractional distillation (Rectification)	This method is used for the separation of miscible liquids such as acetone and water, chloroform and benzene.
Azeotropic (Extractive distillation)	Preparation of absolute alcohol Also used for determination of water content by using Toluene
Compression distillation	Use for obtaining fresh water from sea- water which is pyrogen free.
Steam distillation	It is used for the separation of immiscible liquids Purification of liquid with high boiling point Used for extracting most of the volatile oils such as clove, anise and eucalyptus. Also used for preparation of **Aromatic waters**

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2017

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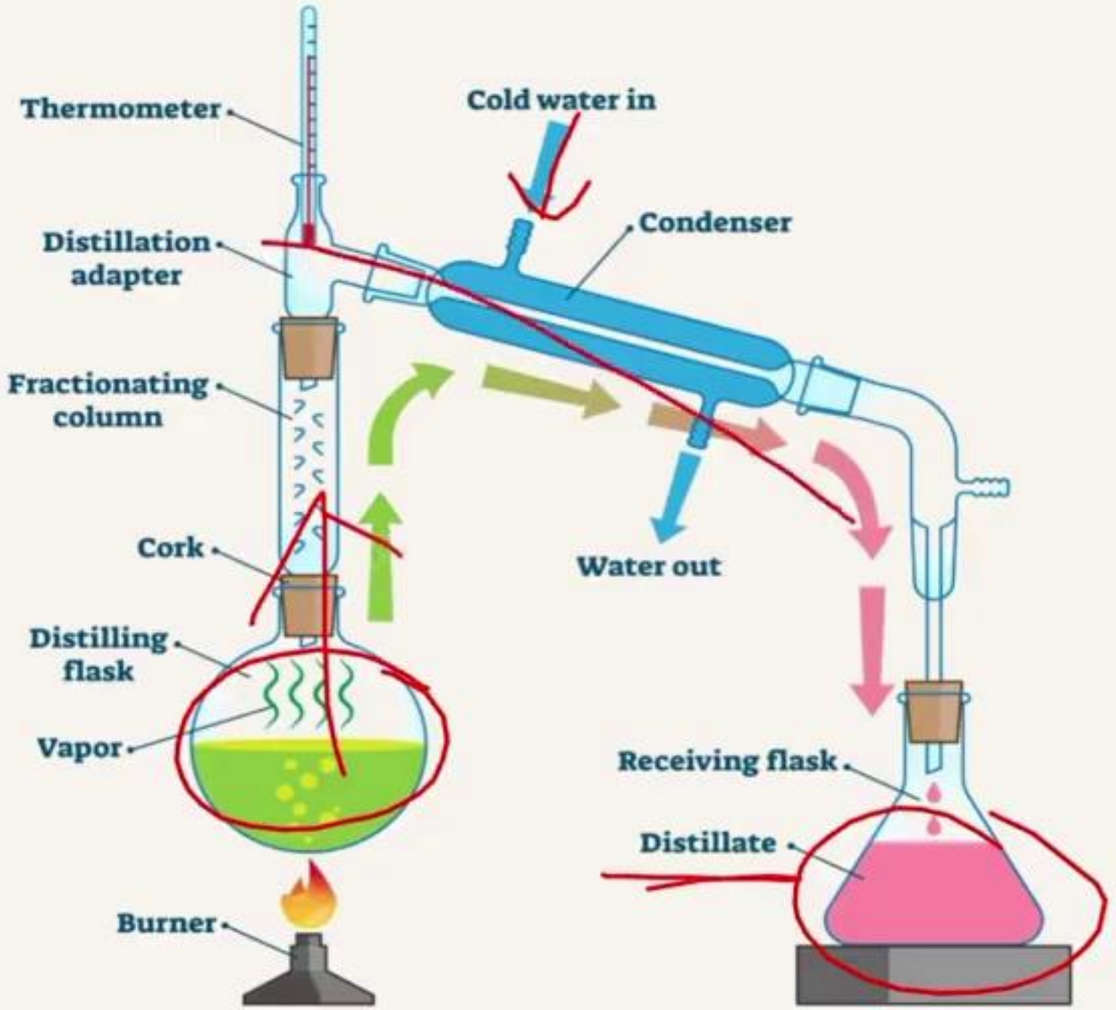
Difference between Distillation, Drying & Evaporation

In practice it is difficult to distinguish between evaporation, distillation and drying.
Based on the intention:
(i) when condensation vapor is required the operation is called distillation
(ii) when the concentrated liquid residue is required the operation is called evaporation.
(iii)when the dried solid residue is required as product the process is called drying

Distillation



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THEORY OF DRYING

Bound water

It is the minimum water (moisture) held by the material that exerts an equilibrium vapour pressure less than the pure water at the same temperature.

Unbound water

It is the amount of water (moisture) held by the material that exerts an equilibrium vapour pressure equal to that *of* pure water at the same temperature.

Free moisture content

- Free moisture content is the amount of water that is free to evaporate from the solid surface.
- During drying, only free moisture can be evaporated.

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$$\%\ Moisture\ content = \frac{Weight\ of\ water\ in\ sample}{Weight\ of\ dry\ sample} \times 100$$

Rate of Drying:

$$Drying\ Rate = \frac{Weight\ of\ water\ in\ sample\ (kg)}{Time\ (h) \times Weight\ of\ dry\ solid\ (kg)}$$

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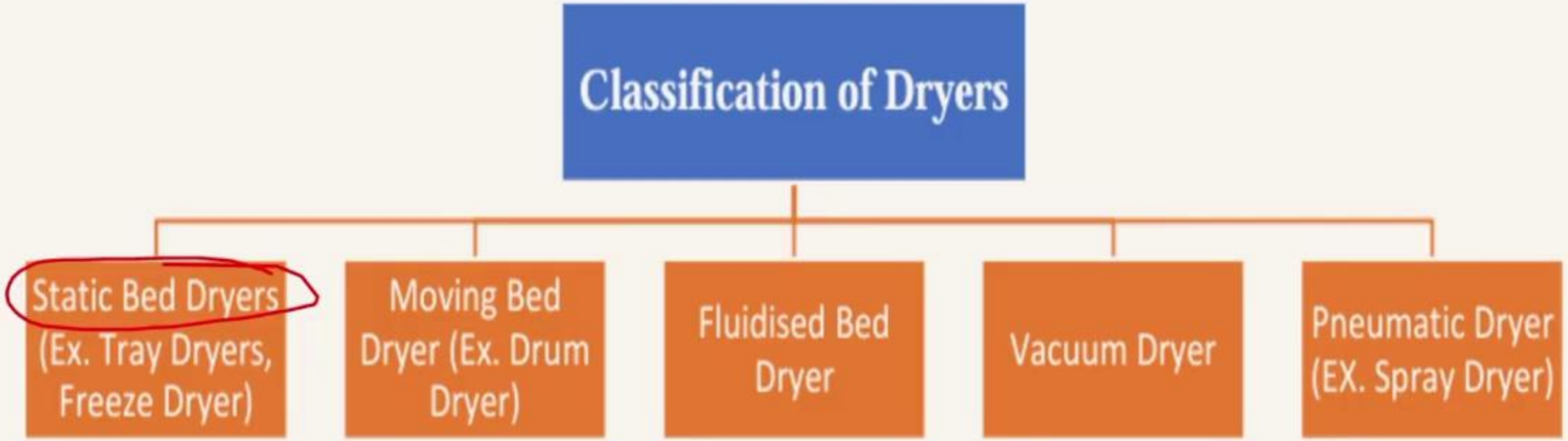

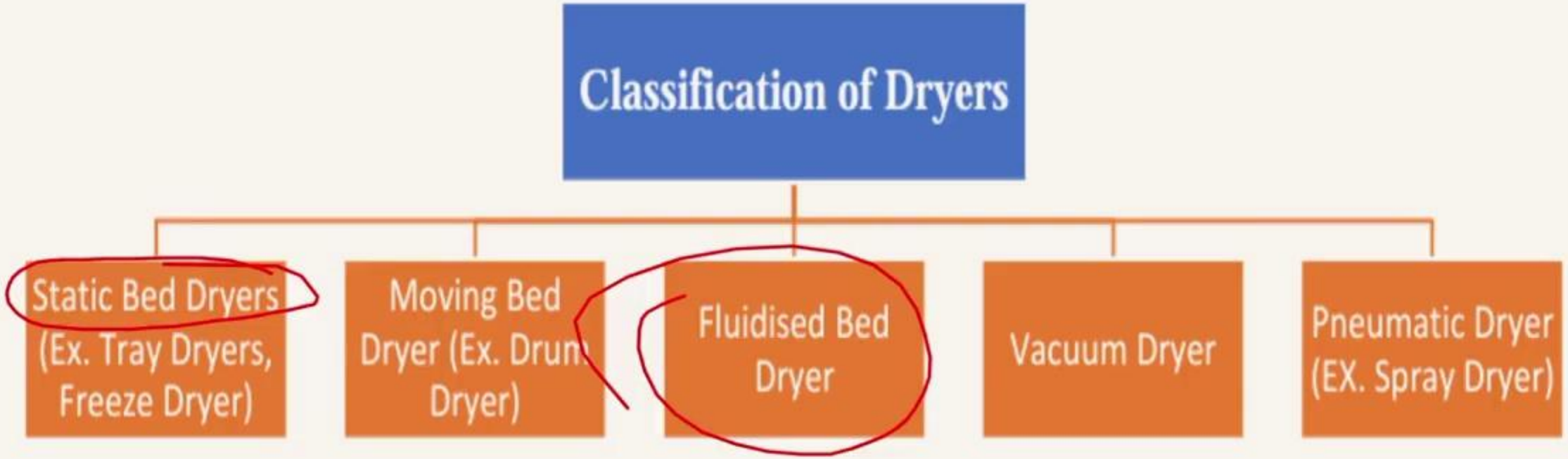

90%

Dryers

Method	Characteristics and uses
Tray dryer	Sticky materials, plastic substances, crystalline materials, precipitates and pastes can be dried in a tray dryer. Crude drugs, chemicals, powders, tablet granules or parts of equipment are dried.
Drum dryer (Roller dryer or Film drum dryer)	Drying capacity is directly proportional to the surface area of the drum. It is used for drying solutions, slurries, suspensions etc The products dried are milk products, starch products, ferrous salts, antibiotics, suspensions of zinc oxide and suspension of kaolin
Spray dryer	Spray dryer involves 3 stages – ✓ Atomization of the liquid, ✓ Drying of the liquid droplets, ✓ Recovery of the dried product The product is thermolabile, hygroscopic or undergoes chemical decomposition. It is used for gelatin, small pox vaccine, blood, milk, hormones, fruit juices, plasma etc.

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Tray dryer	Sticky materials, plastic substances, crystalline materials, precipitates and pastes can be dried in a tray dryer. Crude drugs, chemicals, powders, tablet granules or parts of equipment are dried.
Drum dryer (Roller dryer or Film drum dryer)	Drying capacity is directly proportional to the surface area of the drum. It is used for drying solutions, slurries, suspensions etc The products dried are milk products, starch products, ferrous salts, antibiotics, suspensions of zinc oxide and suspension of kaolin
Spray dryer	Spray dryer involves 3 stages – ✓ Atomization of the liquid, ✓ Drying of the liquid droplets, ✓ Recovery of the dried product The product is thermolabile, hygroscopic or undergoes chemical decomposition. It is used for gelatin, small pox vaccine, blood, milk, hormones, fruit juices, plasma etc.

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Method	Characteristics and uses
Fluidized bed dryer	It is used for drying of granules in the production of tablets. It is used for three operations such as mixing, granulation and drying.
Vacuum dryer	Heat sensitive materials, dusty and hygroscopic materials. Drugs containing toxic solvents. Materials are dried by the application of vaccum
Freeze dryer (Lyophilization)	In freeze drying, water is removed from the frozen state by sublimation. The drying is achieved by subjecting the material to temperature and pressures below the triple point. Drying the thermolabile products. It is used for blood plasma and its fractional products. Antibiotics, plant extracts, Steroid, vitamin and enzymes.

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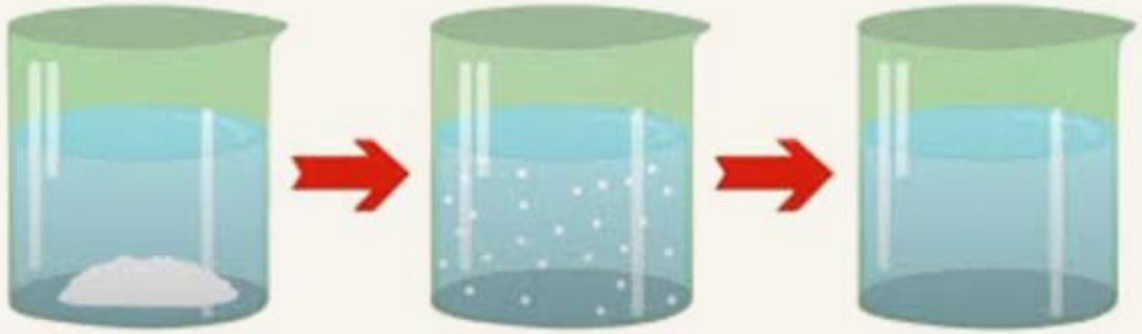
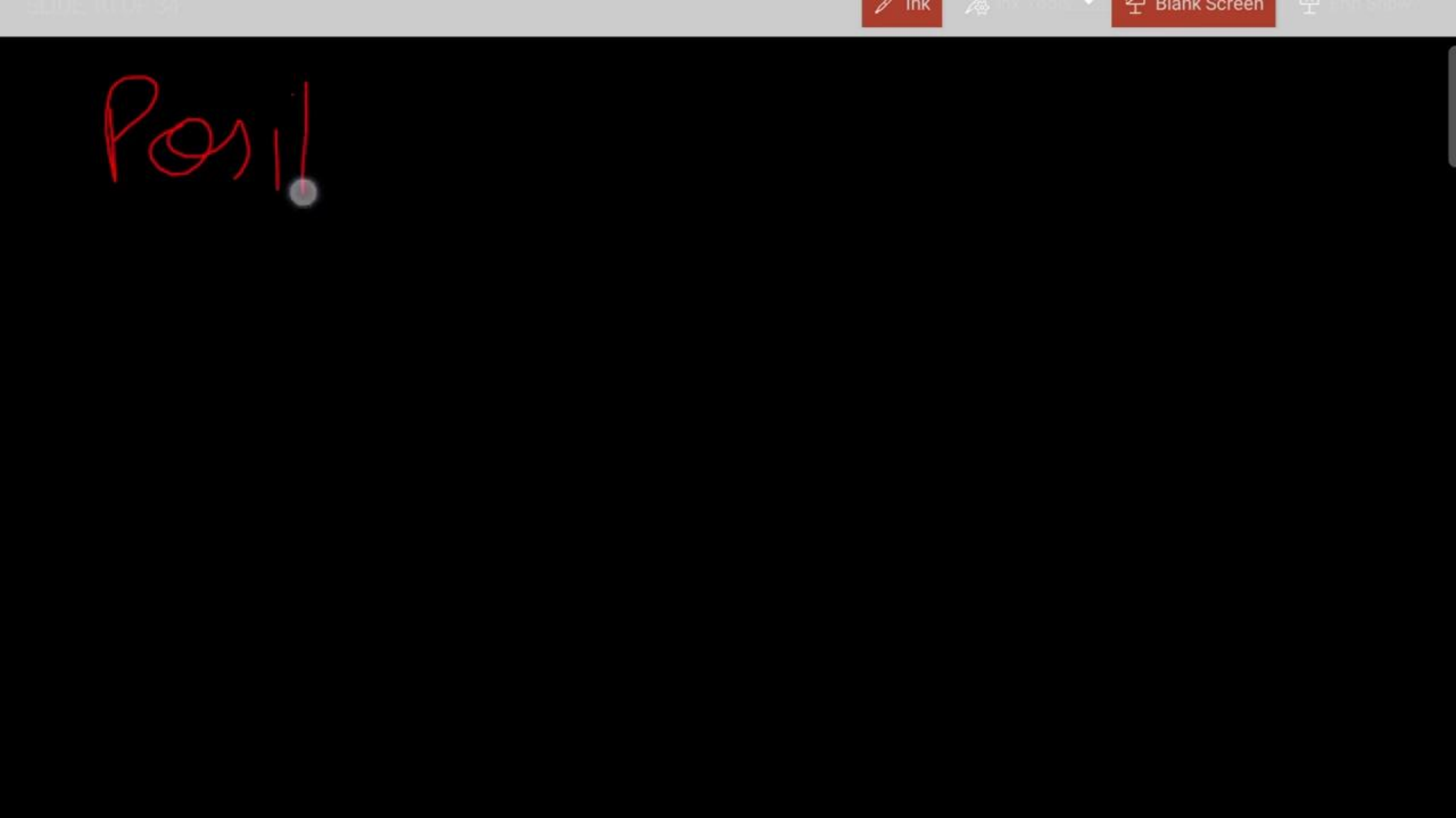
Mixing

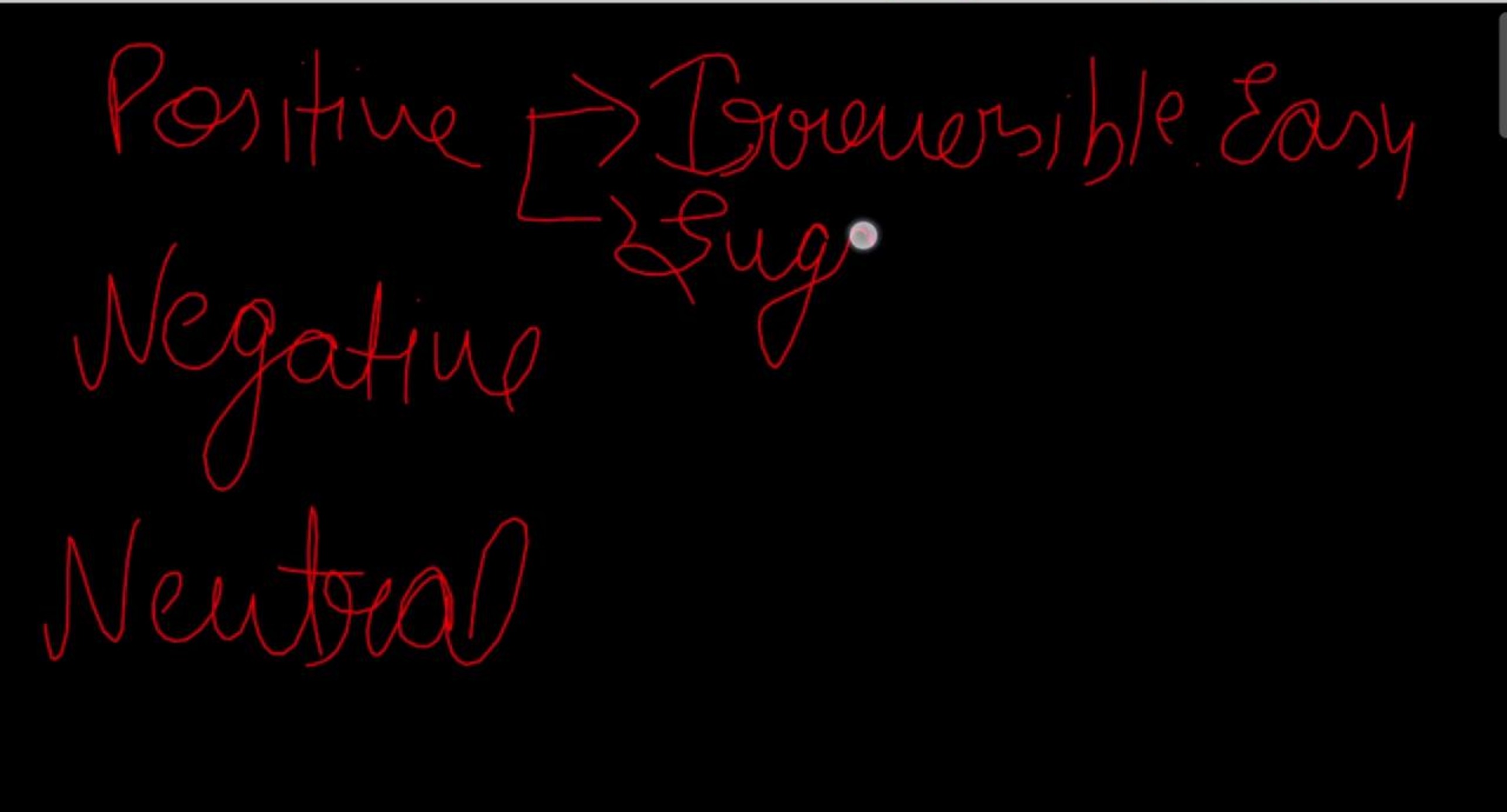
- Mixing (or blending) is a unit operation in which a uniform mixture is obtained from two or more components, by dispersing one within the other
- Mixing is a defined as a process that tends to result in a randomization of dissimilar particles within system.



Factor influencing Mixing

1. Nature of surface.
2. Density of the particles.
3. Particle size and shape.
4. Particle charge.
5. Proportion of materials


Ink
Blank Screen
Pos!


Positive ⇒ Reversible Easy
Negative
Neutral

Positive → Reversible Easy
↳ Sugar in water

Negative → Oil Reversible
↳ Emulsion Suspen.

Neutral

Positive → Dissolves Easily
↳ Sugar in water

Negative → Diff. Reversible
↳ Emulsion, Suspn.

Neutral → Do not mix
↳ Ointment, Paste

Difference between Solid & Liquid Mixing

Solid Mixing	Liquids Mixing
In solid mixing two or more substances are intermingled by continuous movement of particles	This is achieved by mixing elements of suitable shape to act as impeller to produce appropriate flow pattern in mixing vessel.
This is used for mixing of dry powders.	This is used in preparation of emulsion, suspension and mixtures.
Large sample size is required.	Small sample size is sufficient.
High power required for mixing.	Less power required for mixing.

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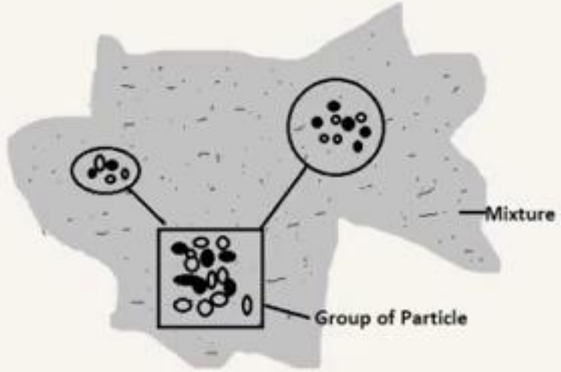
MECHANISMS OF MIXING IN SOLIDS

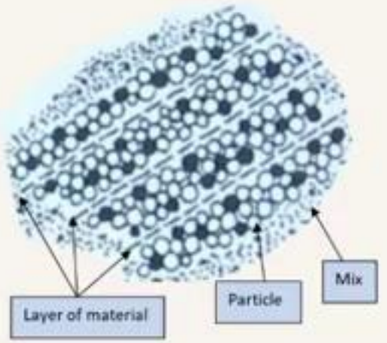
Convective mixing

Groups of particles move from one position to another by using blades or paddles, also known as macro mixing



Shear mixing

This type of mixing occurs when a layer of material flows over another layer resulting in the layers moving at different speeds and therefore mixing at the layer interface.



Diffusive mixing

Diffusive mechanism occurs by random movement of the particle within the powder bed and causing them to change their relative position relation to one another, known as micro mixing.

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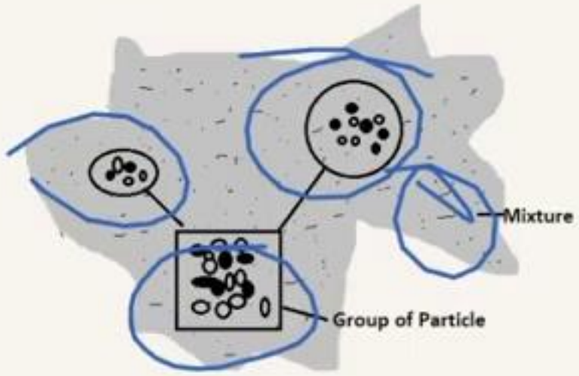

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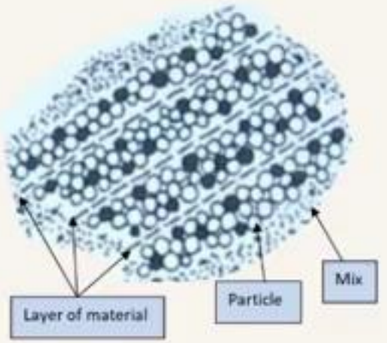

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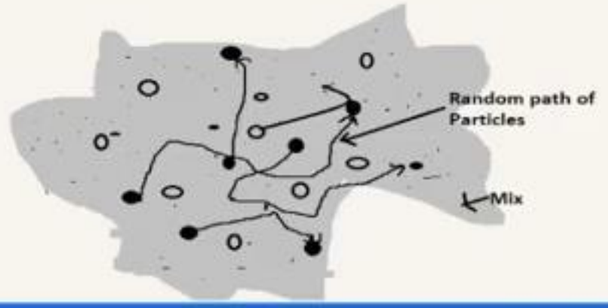

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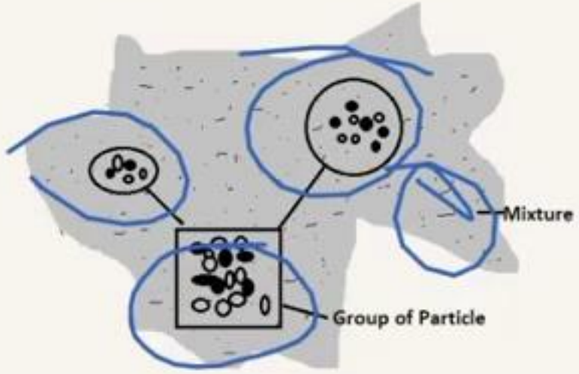

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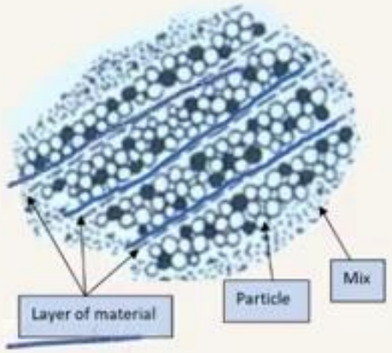

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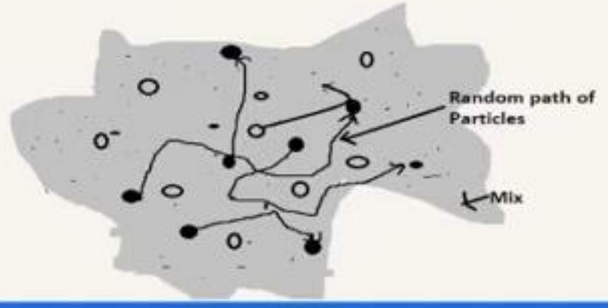

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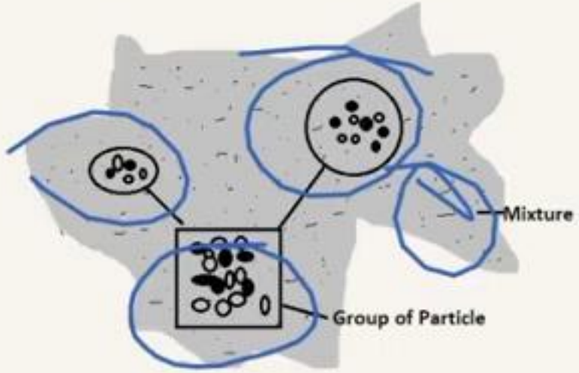

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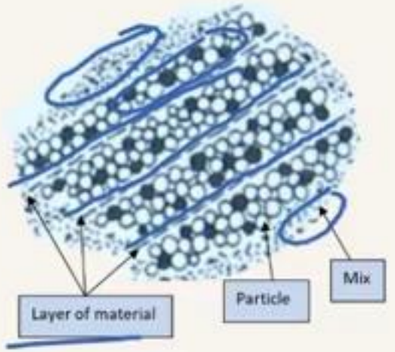

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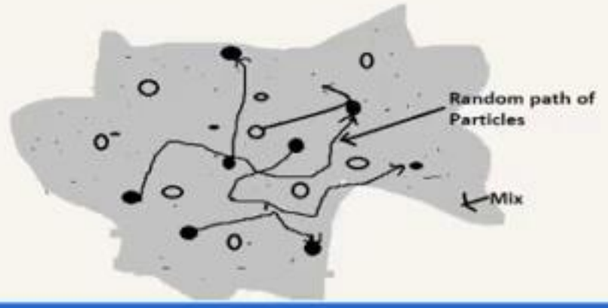

MIXING EQUIPMENT FOR SOLID MIXER

NATURE OF MIXER	EXAMPLES	MECAHNSIM OF ACTION
Small scale	Mortar and pestle	Trituration
Tumbling mixers or Cylindrical mixers without mixing blade	Double cone blender, V cone mixers without baffles cube blender	Tumbling action
Tumbling mixer with a mixing blade	V cone blender with a mixing blade Double cone blender with a mixing blade	Tumbling action as well as shearing with blade
Static mixers	Ribbon blender, Sigma blender Planetary paddle	Stationary shell and rotating blade
Air mixers or Fluidized mixers	Fluidized mixer	Air supported blending
Large scale	Barrel type, Zigzag type	Rotating shell with rotating blade

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EQUIPMENT FOR SOLID MIXING

EQUIPMENT	CHARACTERISTICS AND USES
Ribbon blender	. Mechanism of mixing is shear, which is transferred by moving blades (ribbon shaped) in a fixed (non-movable) shell. . It is fitted with two helical blades. . It is used to mix finely divided solids, wet solid mass, sticky and plastic solids.
Sigma blade mixer	. Mechanism of mixing is shearing and kneading actions. . It is used for mixing of dough ingredients in the baking industry. . It is used in wet granulation process in the manufacture of tablets, pill masses and ointments. . This is used for high viscosity material.

EQUIPMENT FOR SOLID MIXING

EQUIPMENT	CHARACTERISTICS AND USES
Planetary mixer	. Mechanism of mixing is shearing and tumbling motion. . It consists of vertical cylindrical shell. . Low speeds are used for dry blending. . Faster speeds are used for wet granulation. . It is also known as change can mixer
Air mixer or Fluidized mixer	. Mechanism of mixing is tumbling action. . This method is used for coating.
Barrel type/Continuous mixer	Mechanism of mixing is tumbling action.
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LIQUID MIXER

MIXER	CHARACTERISTICS AND USES
Propeller mixer	. The propeller mixer mainly works on the principle of shearing force. . Use for low viscous liquid and rotate at<8000 RPM, . Used for mixing of low viscosity emulsions and also used in mixing suspensions with particle size up to 0.1 to 0.5 mm.
Turbine mixer	• The turbine mixer works mainly on the principle of shearing action. • It contains impeller and use for viscous liquid like liquid glucose and due to high shear force use in emulsification. And not for suspension.
Paddle mixer	• Agitator used for mixing and rotate at 100 RPM • Paddles are used in the manufacture of antacid suspensions (aluminium hydroxide gel and magnesium hydroxide), agar and pectin related purgative, antidiarroheal mixtures such as bismuth-kaolin

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EQUIPMENT FOR IMMISCIBLE LIQUIDS

Equipments	CHARACTERISTICS
Silverson mixer (Emulsifier)	. Mechanism of mixing is shearing force and turbulence . Used in preparation of creams, ointments, pharmaceutical suspension and emulsion of fine particle size.
Colloid mill	. Mechanism *of* mixing is shearing force. . Colloid mill is a mixer as well as milling equipment.
Ultrasonic emulsifiers (Rapisonic homogenizer)	. Mechanism of mixing is compression and rarefaction. . It has the capacity to produce dispersed globules of one micron size. . It is suitable for thermolabile substances.

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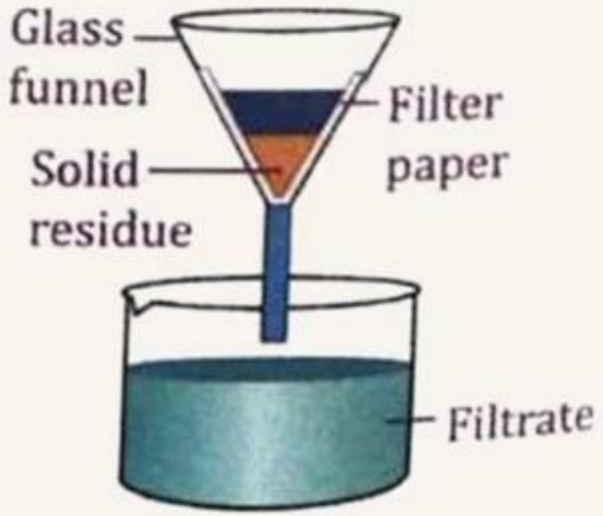
Filtration

- Filtration may be defined as a process of separation of solids from a fluid by passing the same through a porous medium that retains the solids, but allows the fluid to pass through
- When solid are present in very low concentration, i.e., not exceeding 1.0% w/v, the process of its separation from liquid is called clarification.



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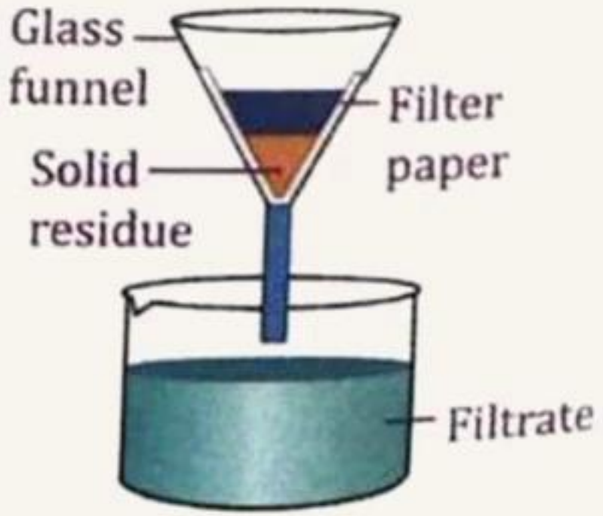

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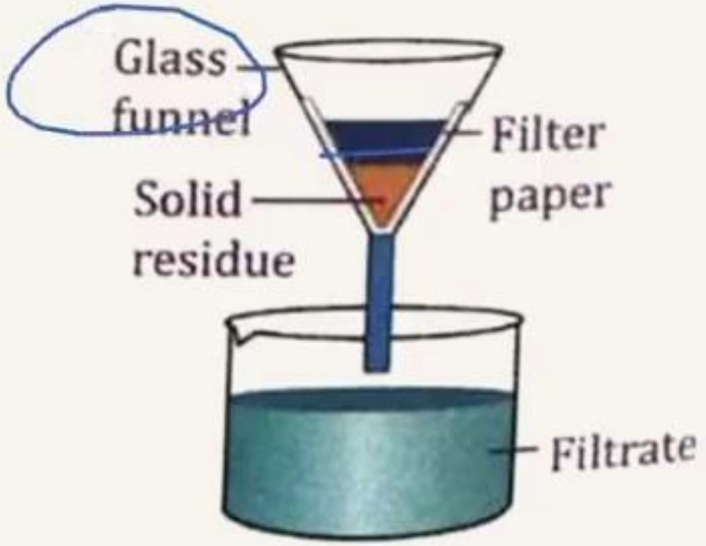
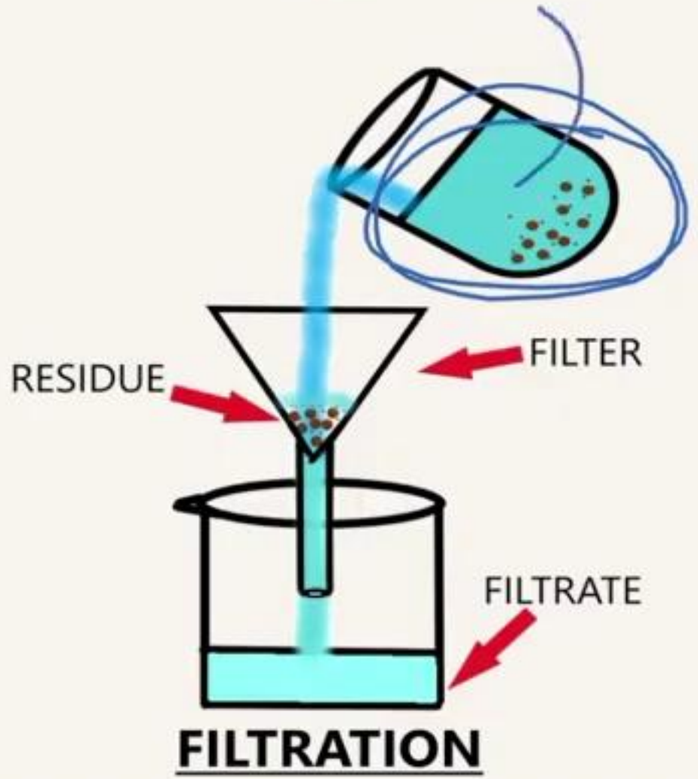


Terms used in Filtration

- **Slurry** - Suspension to be filtered
- **Filter medium** - Porous medium used to retain solid
- **Filter cake** - Accumulated solids on the filter
- **Filtrate** - Clear liquid passing through the filter



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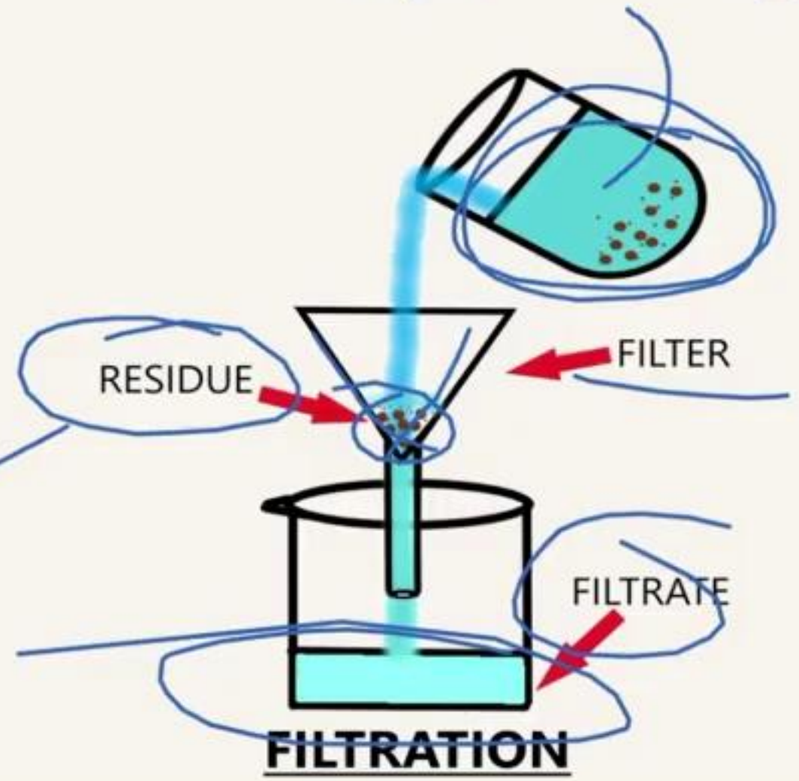

Types of Filtration

Surface filtration (screen filtration)

It is a screening action by which pores or holes of the medium prevent the passage of solids.

Mechanisms- Straining and Impingement

Depth filtration

In this process, slurry penetrates to a point where the diameter of solid particles is greater than that of the tortuous void or channel.

Mechanism - Entanglement

Examples - ceramic filters, sintered fillers

Types of Filtration

Surface filtration (screen filtration)

It is a screening action by which pores or holes of the medium prevent the passage of solids.

Mechanisms- Straining and Impingement

Depth filtration

In this process, slurry penetrates to a point where the diameter of solid particles is greater than that of the tortuous void or channel.

Mechanism - Entanglement

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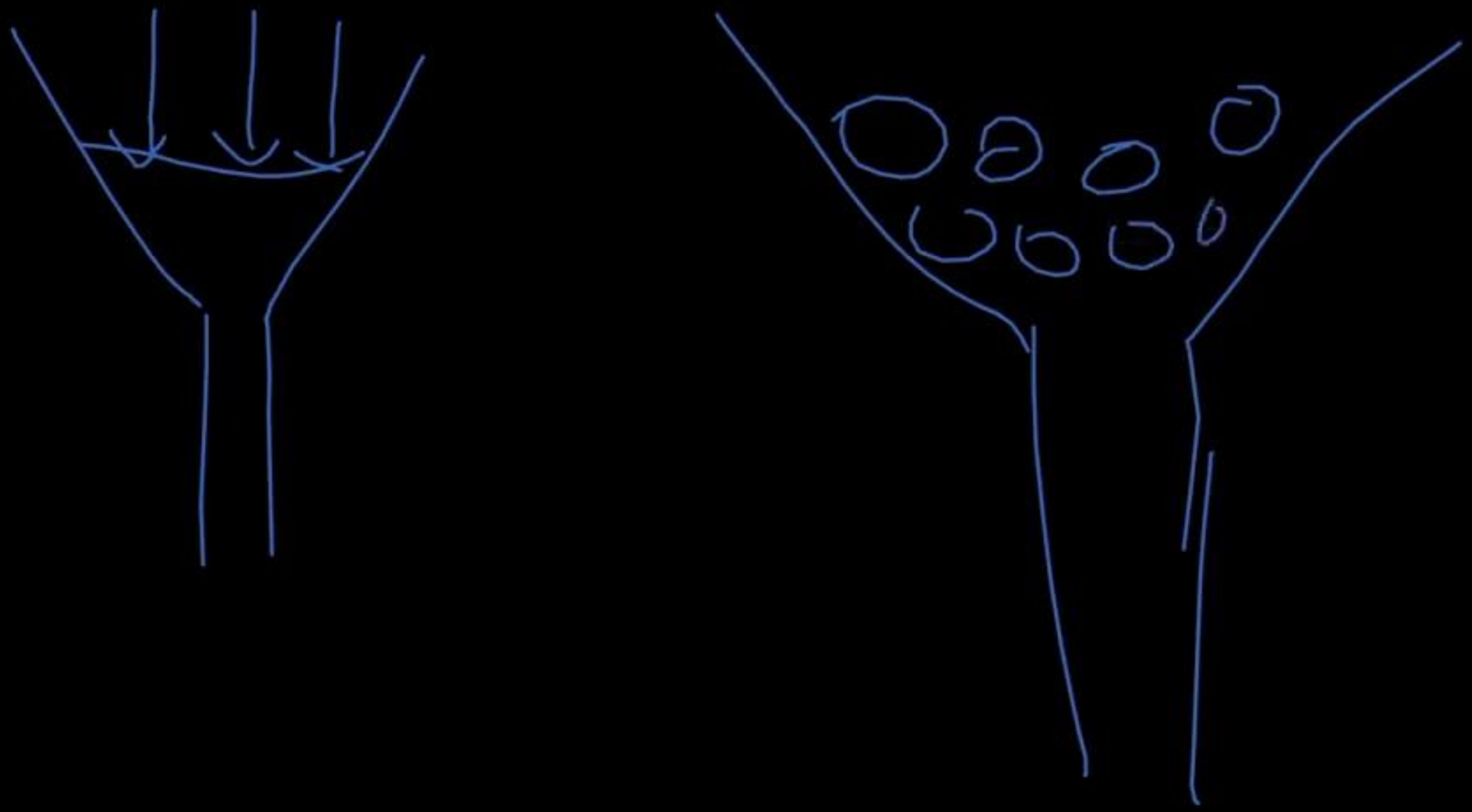
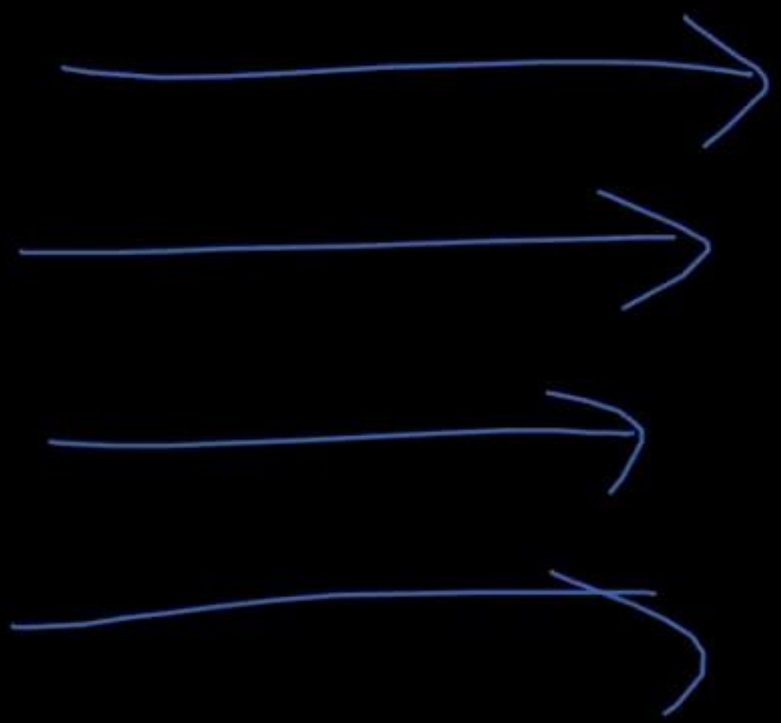


MECHANISMS OF FILTRATION

Straining	• The particles of larger size cannot pass through the smaller pore size of the filter medium.
Impingement	. Solids having the momentum move along the path of streamline flow and strike (impinge) the filter medium. . Thus, the solids are retained on the filter medium.
Entanglement	. Particles become entwined (entangled) in the mass of fibres due to smaller size of particles than the pore size, . Thus the solids are retained within the filter medium.
Attractive forces	• Solids are retained on the filter medium as a result of attractive forces between particles and filter medium, as in case of electrostatic precipitation.



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THEORY OF FILTRATION

Poiseuille's Equation—

Poiceuille considered that considered that filtration is similar to the streamline flow of a liquid under pressure through Capillaries.

$$V = \pi \Delta P r^4 / 8 L \eta.$$

Where → V = rate of flow, that is volume of liquid flowing in unit time m^3/s.

ΔP = Pressure difference across the filter. Pascal.

r = radius of the capillary in the filter bed. Meter

L = Thickness of the filter cake (capillary length). Meter

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THEORY OF FILTRATION

Darcy Equation

Darcy's law describes the relationship between the instantaneous rate of discharge through a porous medium and pressure drop at a distance.

$$V = KA\Delta P/\eta L.$$

K = permeability coefficient of cake m^2.

A = Surface area of the porous bed (filter medium) m^2.

The term k depends on the characteristics of the cake, such as porosity, specific surface area and compressibility.

THEORY OF FILTRATION

Kozeny-Carman Equation

The Kozeny-Carman equation is a formula that calculates the pressure drop of a fluid flowing through a packed bed of solids

$$V = A/\eta s2 \times \Delta P/KL \times \varepsilon^3/(1-\varepsilon)^2$$

Where → ε = porosity of the cake (bed)

S = Specific surface area of the particles comprising the cake m^2/m^3.

K = Kozeny constant (usually taken 5).

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EQUIPMENT FOR FILTRATION

EQUIPMENT	CHARACTERISTICS AND USES
Plate and frame filter press	The mechanism is surface filtration. Capable for retaining bacteria. Collection of precipitated antitoxin, removal of precipitate proteins from insulin liquors and removal of cell broth from fermentation medium.
Chamber press	Chamber filter is used for clarification of syrups an tracing of injection and solutions
Filter leaf	The mechanism is surface nitration and acts as sieve or strainer Vacuum or pressure can be applied to increase the rate of filtration.

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Meta filter **(Edge filters)**	. Clarification of syrups and insulin liquors. . Filtration of injection solutions and viscous liquids can be achieved by applying pressure.
Cartridge filter	• It is useful for the preparation of particulate free solutions for parenteral and ophthalmic uses
Drum filter **(Rotary drum filter)**	. It is used for the production of penicillins, the extract is separated from mycelium by drum filters. . It is used for collecting calcium carbonate, starch and magnesium carbonate.
Pressure sand filter	. The mechanism is impingement and entanglement. . It is used for the separation of precipitates that can be removed from the sand.

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- Centrifugation invented by GG Stokes
- Centrifugation is a process which involves the use of the centrifugal force for the sedimentation of heterogeneous mixtures with a centrifuge, used in industry and in laboratory settings.
- This process is used to separate two immiscible liquids.
- More-dense components of the mixture migrate away from the axis of the centrifuge,while less dense components of the mixture migrate towards the axis.
- Centrifuge is a device for separating particles from a solution according to there size,shape, density, viscosity of the medium

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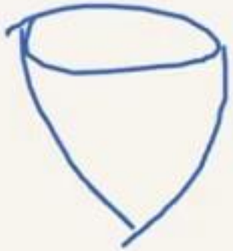

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CLASSIFICATION BASED ON SCALE OF USAGE

LABORATORY SCALE	Horizontal spinning arm type
	Angle centnfuge (45 to 50 angle)
	High speed centrifuge (10,000 revolotions per minute)
	Ultracentrifuge (85,000 revolutions per minute)
COMMERCIAL SCALE	
Batch type	Perforated basket centrifuge
Semi-continuous scale	Short-cycle batch centrifuge
Continuous centrifuge	Supercentrifuge

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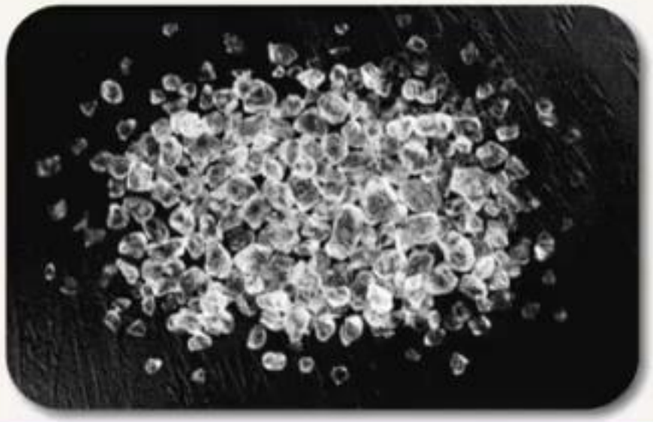
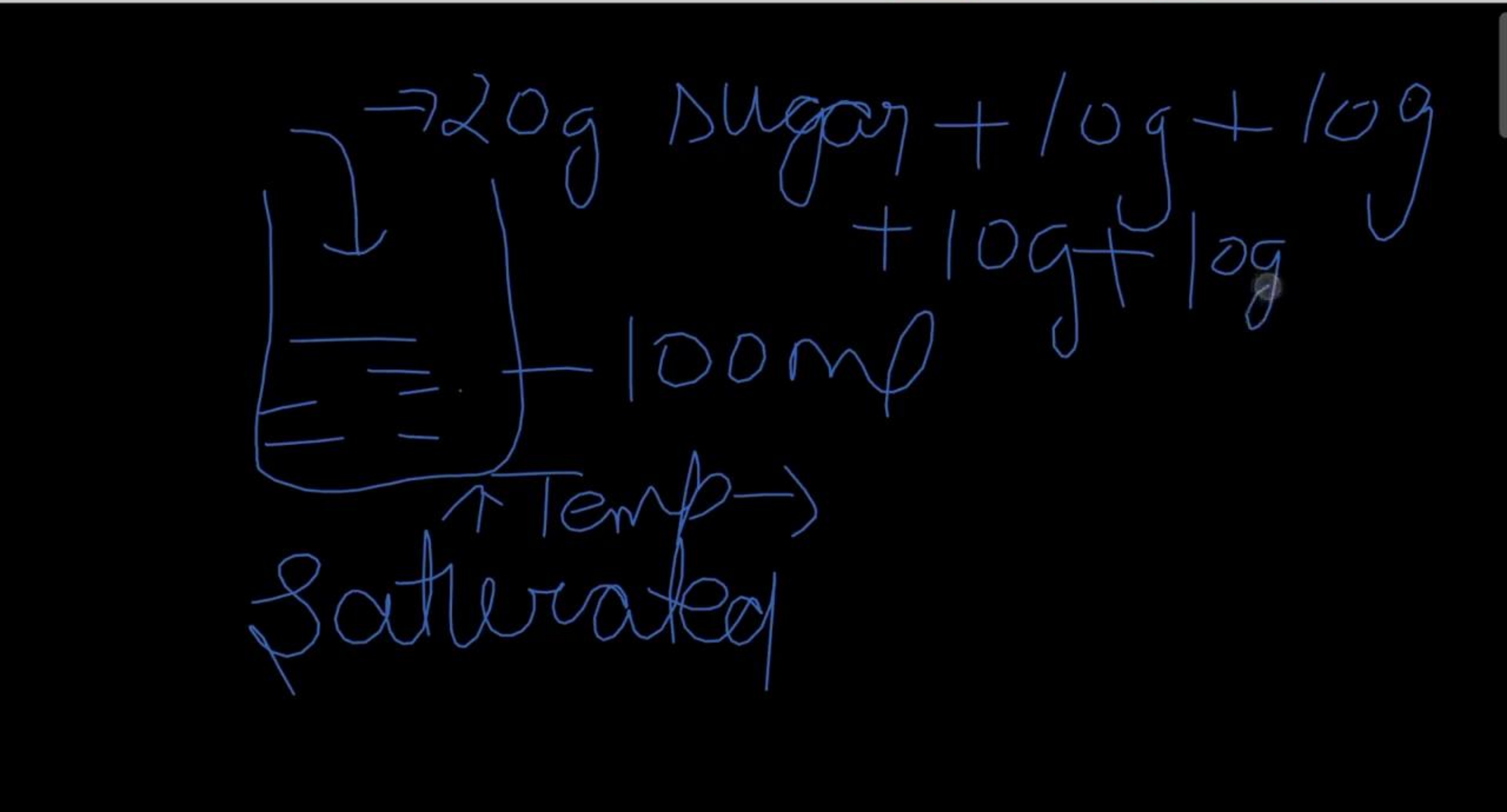
Crystallization

- Crystallization is a technique used for the purification of substances. A separation technique to separate solids from a solution.
- Crystallization can be defined as the process through which the atoms/molecules of a substance arrange themselves in a well-defined three-dimensional lattice and consequently, minimize the overall energy of the system



→ 20g sugar + 10g + 10g

+ 100ml


→20g sugar + 10g + 10g
+ 10g + 10g
100ml
↑ Temp →
Saturated

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100ml

↑ Temp → Supersat.

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↑ Temp → Supersat

Saturated

↓ Crystals

MECHANISM OF CRYSTALLIZATION

Supersaturation	. By evaporation of solvent. . By cooling of solution. . By formation of a new solute. . By addition of more soluble substance in solvent
Nucleation	. Nucleation refers to the birth of very small bodies of a new phase within a homogenous saturated liquid phase . Low nucleation rate condition favor formation of large crystal
Crystal growth	• Crystal growth is a diffusion process and surface phenomenon.

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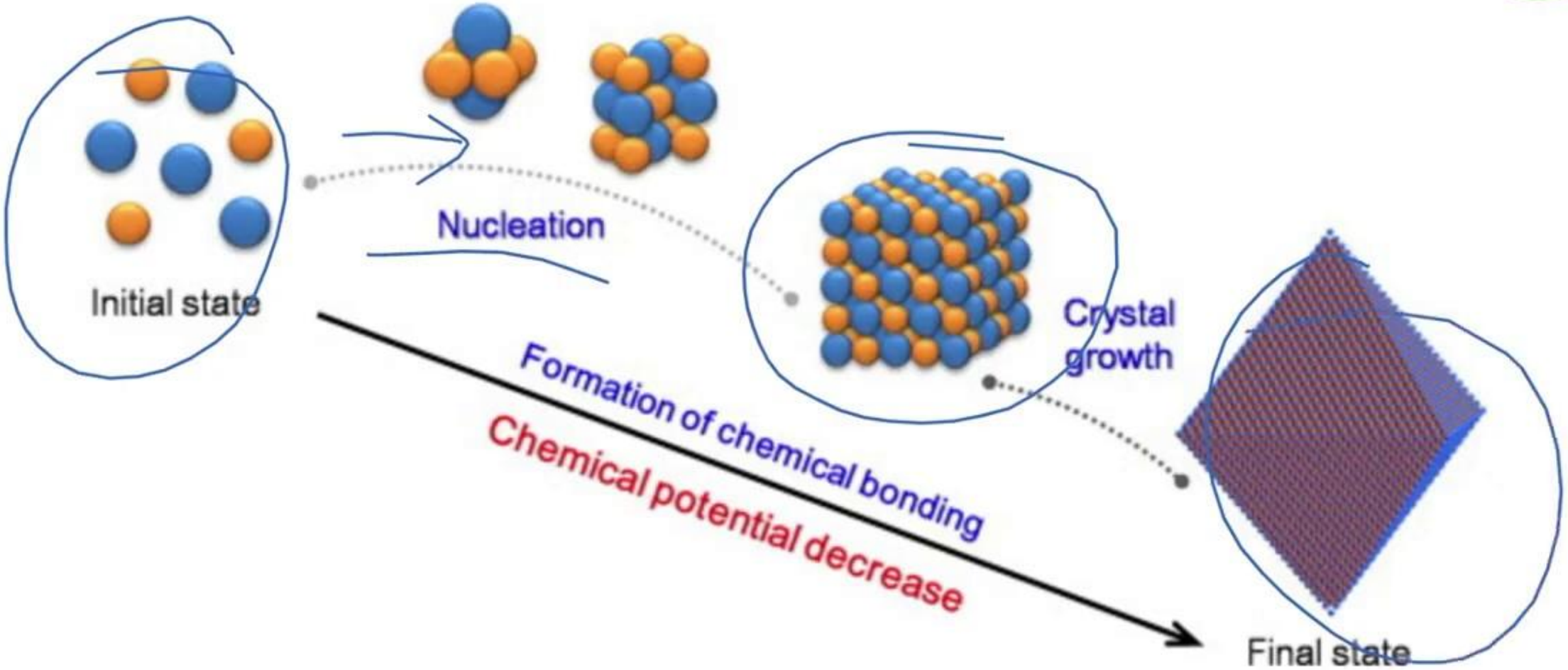

EQUIPMENTS USED FOR CRYSTALLIZATION

CRYSTALLIZER	METHOD	CHARACTERISTICS
Agitated batch crystallizer	Temperature reduction	. Batch process . Uniform crystals are formed
Swenson walker crystallizer	Cooling	. Continuous process . Uniform crystals are formed
Krystal crystallizer	Evaporation	• It is used for crystallization of Sodium Chloride and Magnesium sulphate
Vacuum crystallizer	Adiabatic evaporative cooling	• It is used for thermolabile substances.

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