DEPTH OF BIOLOGY

STUDY MATERIAL

YT-DEPTH OF BIOLOGY

INSTA- DEPTH OF BIOLOGY

TELE- DEPTH OF BIOLOGY

UNIT- 3RD DRYING

[DEPTH OF BIOLOGY]

•Drying is **the process of removing the presence of solvents (i.e. water or other liquids) in a formulation with the presence of heat**. The final product of this unit operation is a dry solid mass or powders. [DEPTH OF BIOLOGY]

•There are 2 ways to remove water by drying

1. Thermal process- by heating
2. Non-thermal- involves

a. Squeezing- by squezzing wet substance; eg : spongy material [DEPTH OF BIOLOGY]

b. By adsorption- water is absorbed by all dessicant particles.

c. By extraction- from wet solids

Machines which are used for drying are known as dryers

OBJECTIVES

In food technology, drying is carried out for one or morof the following reasons:

- 1. To avoid or eliminate moisture which may lead to corrosion and decrease the product stability.
- 2. To improve or keep the good properties of a material, e.g. flow ability, compressibility.
- 3. To reduce the cost of transportation of large volume materials (liquids)
- 4. To make the material easy or more suitable for handling.
- 5. Preservative.
- 6. The final step in: Evaporation, Filtration, Crystallization

MECHANISM OF DRYING

- Involves 2 process

1. Heat transfer
2. Mass transfer

1. HEAT TRANSFER- heat flows to exterior surface while generated within solid [DEPTH OF BIOLOGY]
2. MASS TRANSFER- involves movement of moisture to the surface & its subsequent evaporation from the surface.

- There are also some theories of drying

1. DIFFUSION THEORY
2. CAPILLARY THEORY

Diffusion theory- the movement is from higher to lower concentration. [DEPTH OF BIOLOGY]

- so when we apply heat to a substance the liquid particles at the bottom get heated & they transfer heat to next particle and so on it gets to the last particle and gets evaporated
- Finally all water is removed and dry solid is obtained

Capillary theory- there are some capillary like voids present in wet solid . So when heat is provided on solid, the water [liquid] get removed through voids and dry solid is obtained [DEPTH OF BIOLOGY]

MEASUREMENT & APPLICATION OF EMC

- When the moisture content of solid is in equilibrium with the given partial pressure of vapour in the gas phase is called EQUILIBRIUM MOISTURE CONTENT
- It also has 2 processes:

1. DESORPTION- solid contain more moisture than EMC, then it will contiuosly lose water until EMC is reached.
2. ABSORPTION- solid moisture< EMC moisture, then it will continuosly absorb water untill EMC is reached

- **BOUND WATER-** moisture content of a substance that exert equilibrium vapour pressure lower than that of liquid at same temperature.
- **UNBOUND WATER-** moisture content of a substance that exert equilibrium vapour pressure equal to that of liquid at same temperature.
- **FREE MOISTURE-** moisture content of solid in excess of the equilibrium moisture content
- **It can be measured by-** *ratio of weight of water in sample to weight of dry sample* [DEPTH OF BIOLOGY]

- **MOISTURE CONTENT=** $\frac{\textit{weight of water in sample} * 100}{\text{weight of dry sample}}$

MEASUREMENT OF EMC

Putting sample in dessicator which are maintained at known relative humidity.

Sample from each dessicator is collected and weighted at particular interval untill a constant weight is achieved. Final moisture content is EMC

APPLICATION OF EMC

- Analysis of drying operation & particularly in predicting final moisture content.
- Preventing over drying

RATE OF DRYING CURVE

-follow two drying zones

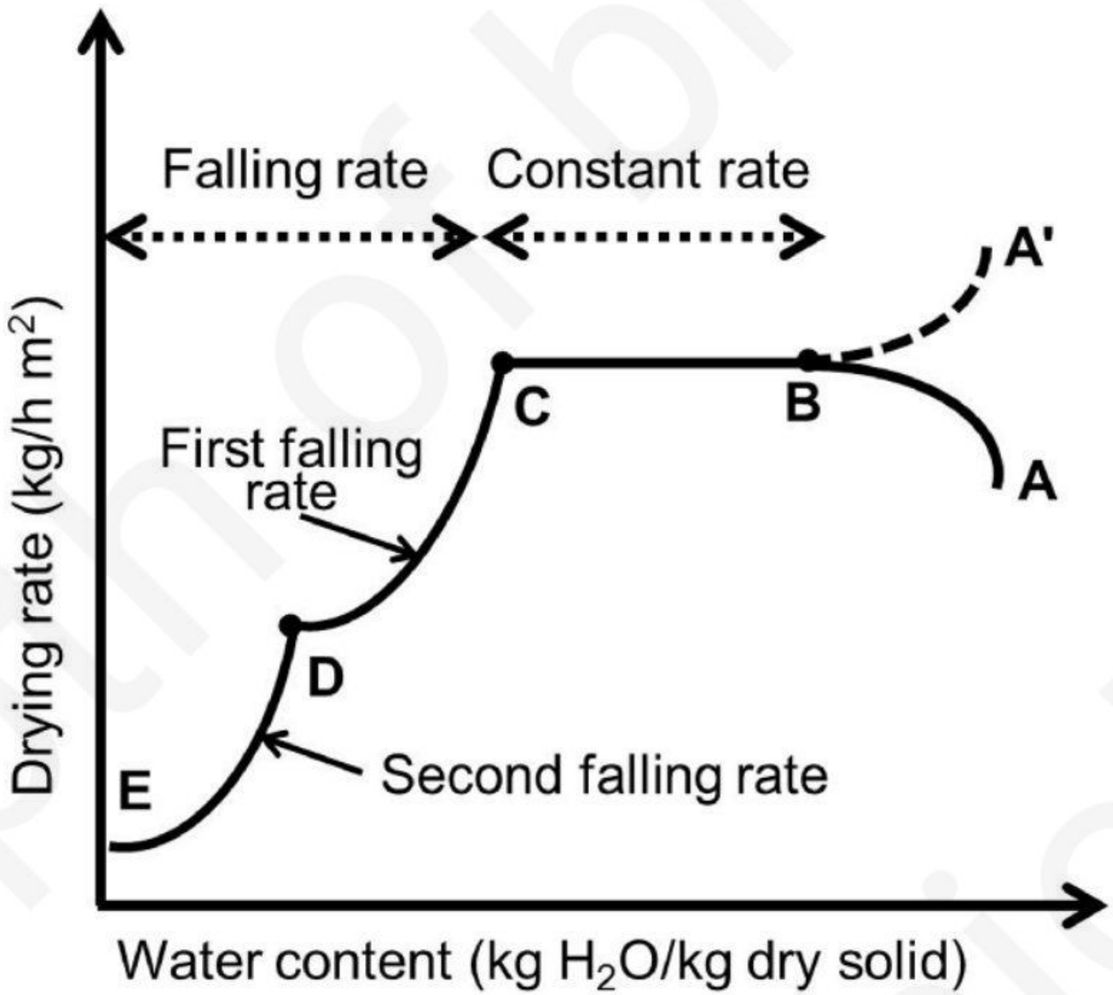
1. Constant rate period
2. Falling rate period

CONSTANT RP- moisture vaporised per unit time per unit area of drying surface remains constant

FALLING RP- moisture vaporised per unit time per unit area of drying surface decreases continuosly

CRITICAL MOISTURE CONTENT

- Break point of 2 zones where moisture content at which the constant rate drying period ends and the falling rate drying period starts



[DEPTH OF BIOLOGY]

- Point B represents temp condition of surface product
- Curve BC [constant rate]- removal of unbound water from product
- Curve CD [1st falling rate]- occurs when wetted spots in surface decline continuosly untill surface is dried
- Curve DE [2nd falling rate]- begins when surface is completely dry
- Point C –decrease in drying rate start is refrred to as CMC

- Rate of drying of a sample can be measured by following calculation

DRYING RATE= $\frac{\text{weight of water in sample}}{\text{time[h]*weight of dry solid}}$

LOSS ON DRYING- $\frac{\textit{mass of water *100}}{\textit{total mass of wet sample}}$

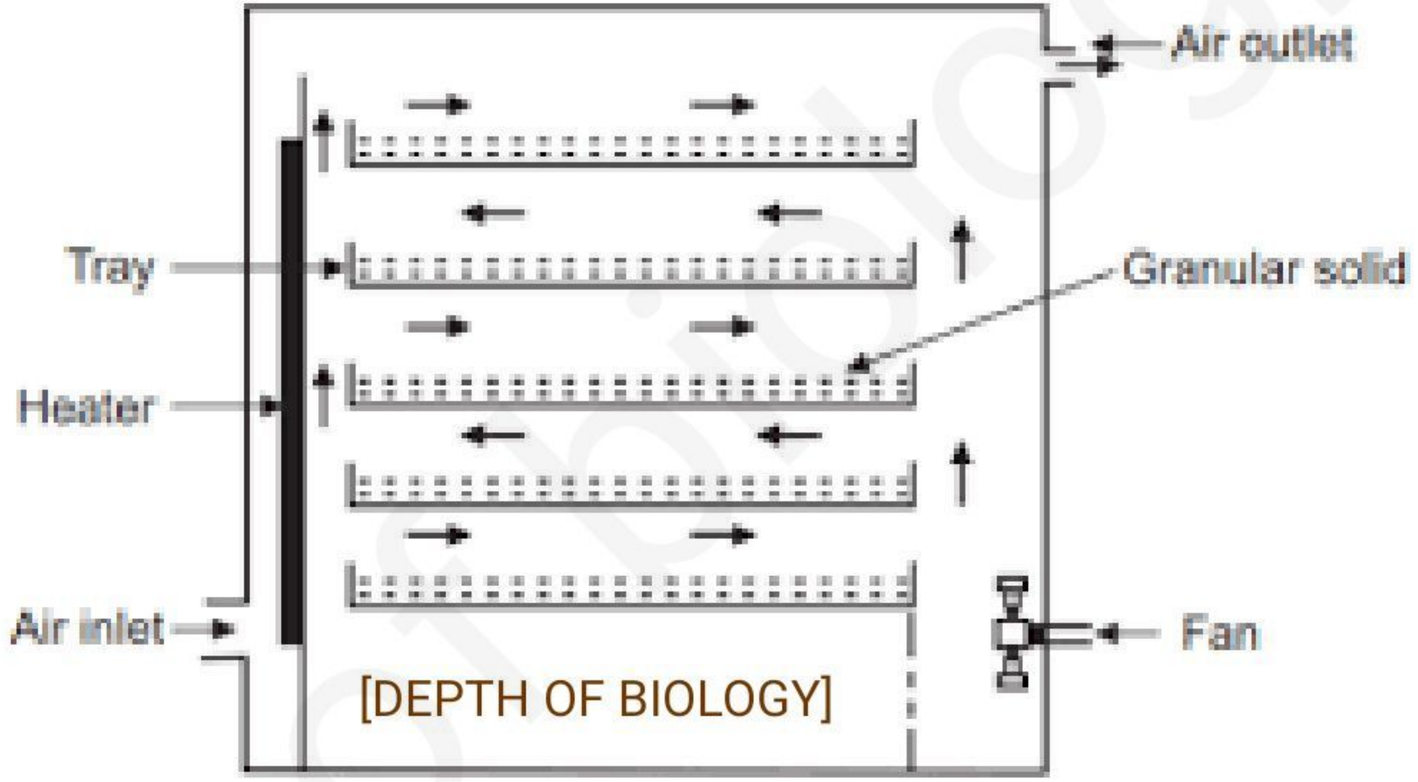
DRYER

- DEVICE OR TOOLS USED FOR DRYING
- Principles ,construction, working , use, merits & demerits of

1. Tray dryer
2. Drum dryer
3. Spray dryer
4. Fluidized bed dryer
5. Vacuum dryer
6. Freeze dryer

TRAY DRYER

- ***PRINCIPLE-*** continuous circulation of hot air, forced convection heating takes place to remove the moisture from wet solids placed in tray.
- ***CONSTRUCTION-***



- Consists of insulated rectangular chamber
- Trays placed inside heating chamber
- The number of trays varies according to size
- A fan is fitted in dryer to circulate air over trays
- Some direction valves are placed in corner of chambers to direct air in expected path

WORKING

- Wet material is spread into trays and placed into the chamber. The doors are closed.
- The air is introduced through an inlet and heater air heated up.
- Hot air is circulated by Tan over the tray. There should be uniform airflow otherwise proper drying will not be achieved.
- Even baffles are used to distribute the air uniformly over the trays.
- Some moist air is continuously vented through the outlet. The fresh air enters through the inlet.
- The water evaporates from the interior of the solid due to hot air. In the end, trays are removed from the chamber and dried material is collected.

USES

- Tray dryer is used in the drying of the sticky materials.
- Tray dryers are used in the drying of the granular mass or crystalline materials,
- Plastic substances can be dried by tray dryers.
- Wet mass preparations, precipitates, and pastes can be dried in a tray dryer.
- In the tray dryers the crude drugs, chemicals, powders, and tablet granules are also dried and show free flowing of the materials by picking up the water.
- Some types of equipment can also be dried in the tray dryers. [DEPTH OF BIOLOGY]

ADVANTAGES

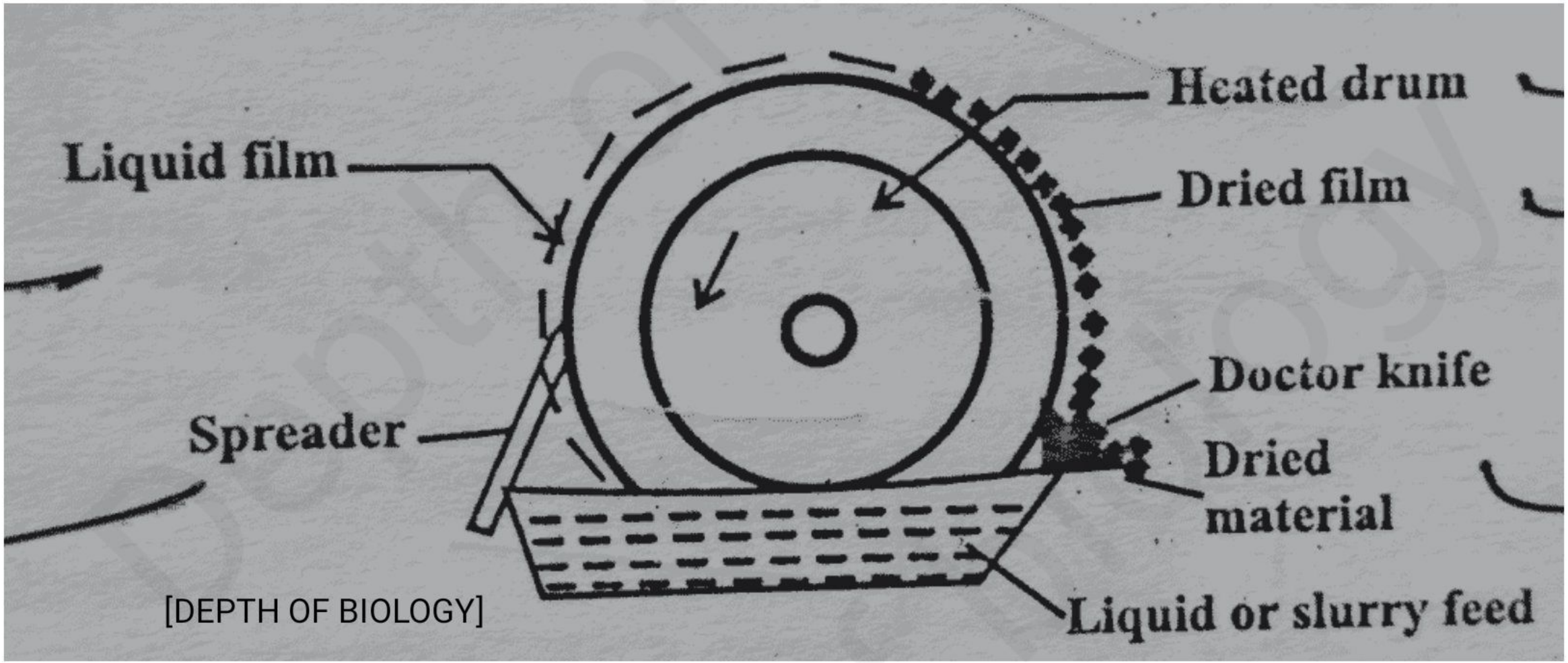
- It is a batch process and can also be used where the quantity of material is less.
- In the tray dryers, the handling of the materials can be done without losses.
- The batch sizes in the pharmaceutical industry are relatively small 250 kg or less per batch compared with the chemical industry 1000 kg or more per hour.

DISADVANTAGES

- Not suitable for oxidizable and thermolabile substances. [DEPTH OF BIOLOGY]
- The process takes a long time.
- The process is expensive to operate

DRUM DRYER

- Heated , hollow metal drum rotates on its longitudnal axis, which is partially dipped in a solution to be dryed
- The solution is carried as a film on surface of the dryer and dried to form a layer.
- A suitable knife scarps the dried material while drum rotates [DEPTH OF BIOLOGY]



CONSTRUCTION

- It consists of a hollow steel drum of about 0.75-1.5 m in diameter and 2-4 m in length.
- It is heated usually by steam and rotated on its longitudinal axis. The external surface of the drum is polished. [DEPTH OF BIOLOGY]
- Liquid or slurry is placed as feed in a pan. The drum is partially dipped in the pan.
- The spreader is used to spread liquid film evenly on the roller. The rotation of the drum is adjusted so that all of the liquid is fully vaporized.

- The drum is rotated continuously. The dried deposit or material can be scraped off with the help of a Doctors knife. [DEPTH OF BIOLOGY]
- The dried material is collected in a storage bin.

WORKING

- A drum rotates, the liquid material gets adhered to an external surface of a drum.
- The liquid is spread as a film onto the surface. The drying of the material is done by the process of steam when passed into the drum. [DEPTH OF BIOLOGY]
- By the mechanism of the conduction, the heat gets transferred into the drum, and the drying process takes place.
- The materials are completely dried during the whole process during its revolutions.
- The dried materials are scrapped by the knife and that falls into the bin.

USES

- Drum dryer is used for drying of solutions, slurries, and suspensions [DEPTH OF BIOLOGY]
- Milk products, starch products, ferrous salts, suspensions of zinc oxide, suspensions of the kaolin, yeast, pigments, malt extracts, antibiotics, glandular extracts, insecticides, DDT, calcium, and barium carbonates are dried by this method. [DEPTH OF BIOLOGY]

ADVANTAGES

- Drying takes place in less time.
- It is suitable for thermosensitive drugs.
- It occupies less space.

- To reduce the temperature of drying the drum can be enclosed in a vacuum chamber.
- Rapid drying takes place due to rapid heat and mass transfer.

DISADVANTAGES

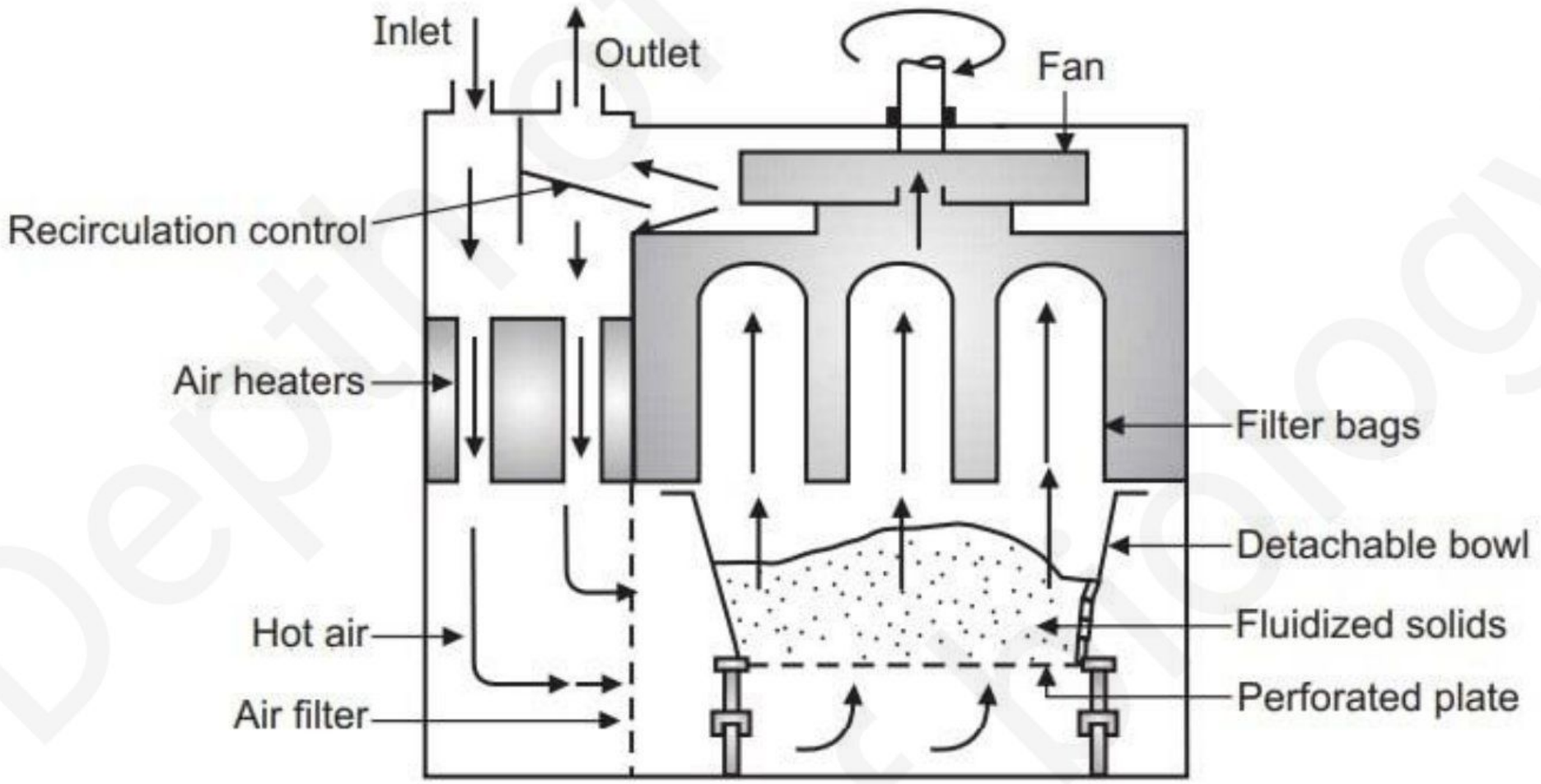
- The maintenance cost is high.
- Skilled operators are essential to control the thickness of the film. [DEPTH OF BIOLOGY]
- It is not suitable for fewer solubility products.
- The operating conditions are critical. Therefore it is necessary to introduce careful control on feed rate, film thickness, speed of drum rotation, and drum temperature [DEPTH OF BIOLOGY]

FLUIDIZED BED DRYER

- ***PRINCIPLE-*** In the fluidized-bed dryer, hot air is passed through a perforated bottom of the container containing granules to be dried. The granules are suspended in the air stream and rise from the bottom. This condition is called a fluidized state. Hot air surrounds each granule to dry it completely. Therefore, the materials or granules are dried uniformly.

CONSTRUCTION [DEPTH OF BIOLOGY]

- Made of stainless steel
- Detachable bowl is placed at the bottom of dryer [used for load material]
- Fan is mounted in upper part for circulating hot air
- Fresh air inlet, pre filter and heat exchanges are serially connected to heat air to required temperature [DEPTH OF BIOLOGY]
- Bag filters are placed above the drying bowl for recovery


Inlet
Outlet
Fan
Recirculation control
Air heaters
Filter bags
Detachable bowl
Hot air
Fluidized solids
Air filter
Perforated plate

WORKING

- The wet granules to be dried are placed in a detachable bowl. The bowl is inserted into the dryer.
- Fresh air can pass through a pre-filter, which is then heated when passing through a heat exchanger. Hot air flows through the bottom of the bowl.
- At the same time, the fan starts to rotate. The airspeed increases gradually.
- When the velocity of the air is greater than the sedimentation rate of the granules, the granules remain partially suspended in the gas stream.

- After a specific time, a pressure point is reached in which the friction drag on the particles is equal to the force of gravity. [DEPTH OF BIOLOGY]
- The granules rise in the container due to the high gas velocity of 1.5 to 7.5 m per minute and then fall back. This condition is said to be a fluidized state.
- The gas surrounds each granule to dry them completely. The air comes out of the dryer passing through the filters in the bag.
- The entrained particles remain adhered to the interior of the surface of the bags. [DEPTH OF BIOLOGY]
- Periodically, the bags are shaken to remove entrained particles.

- The residence time for drying is approximately 40 min. The materials are sometimes left in the dryer to reach room temperature.
- The bowl is removed for unloading. The final product is free-flowing. [DEPTH OF BIOLOGY]

USES

- It is used for the drying of granules in the production of tablets.
- It is used for the coating of granules.

ADVANTAGES

- It takes less time to complete drying as compared to other dryers.
- Drying is achieved at a constant rate.
- Handling time is also short
- It is available in different sizes with the different drying capacity
- The equipment is simple and fewer labor costs are required.

DISADVANTAGES

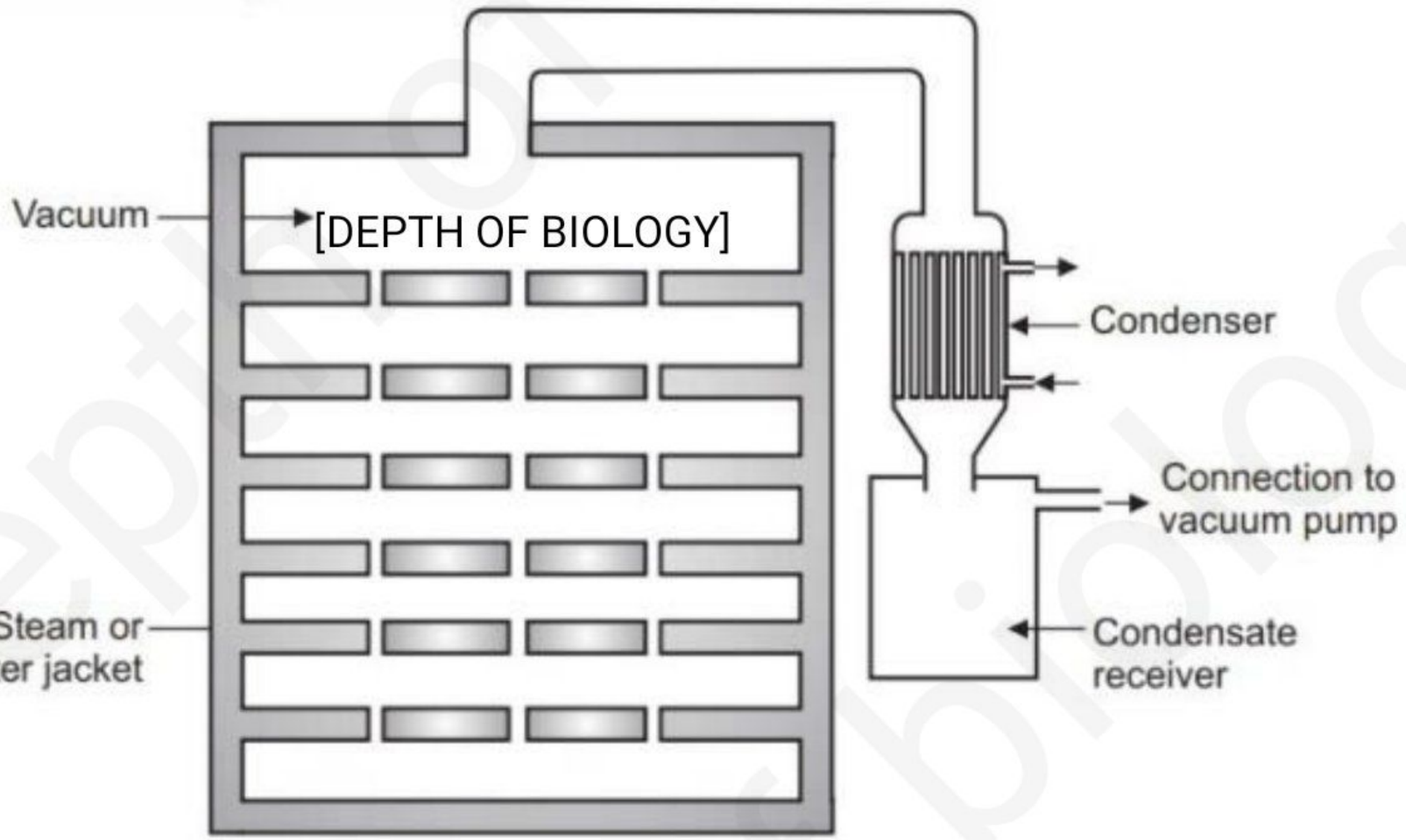
- Many organic powders develop electrostatic charges during drying. To avoid this efficient electrical grounding of the dryer is essential.
- Chances of attrition of some materials resulting in the production of fines. [DEPTH OF BIOLOGY]

VACUUM DRYER

- In a vacuum dryer, the materials are dried by vacuum. Due to vacuum, there is a decrease in pressure. Therefore water boils at a lower temperature and then the evaporation of water takes place faster.

CONSTRUCTION

- It consists of a heavy steam jacketed container made of cast iron.
- The closed chamber consists of shelves that are used to place metal trays consisting of material.
- The shelves provide a large area for heat conduction.
- The chamber is so strong to withstand under vacuum. The oven can be closed by a door.
- The oven is connected through a condenser and liquid receiver to a vacuum pump.



WORKING

- The trays that are present in the dryer are used to dry the materials that are placed on the shelves and the pressure is reduced to 30 to 60 kps by the vacuum pump. [DEPTH OF BIOLOGY]
- The door closes firmly and steam passes through the jacket space and the shelves.
- So the heat transfer is carried out by the conduction mechanism.
- When evaporating under a vacuum, the water is evaporated from the material at 25-30°C..

- The vapor goes to the condenser. After drying the vacuum line is disconnected.
- Then the materials are collected from the trays

USES

- A vacuum dryer can be used for the drying of heat-sensitive materials, dusty materials, hygroscopic materials, toxic materials, feed materials containing the solvents, drugs which are required as porous end products, and for friable dry extracts. [DEPTH OF BIOLOGY]

DISADVANTAGES

- A dryer is a batch-type process.
- It has low efficiency.
- It is more expensive.
- Labor cost is too high.
- Need high maintenance.
- There is a danger of overheating due to vacuum.

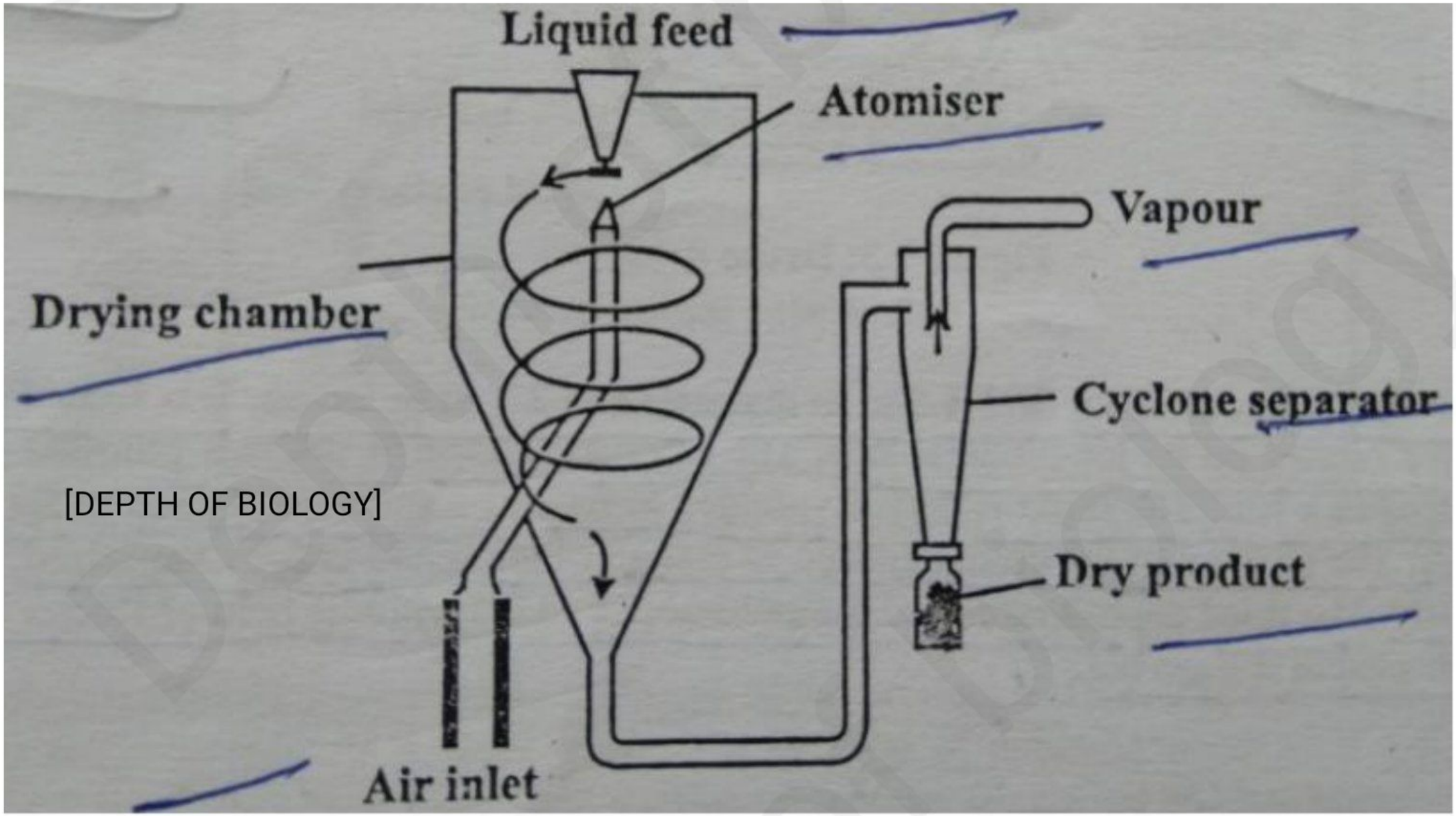
ADVANTAGES

- Material handling is easy.
- Hollow shelves which are electrically heated can be used. [DEPTH OF BIOLOGY]
- It provides a large surface area. So the heat can be easily transferred throughout the body of the dryer and fast-drying action takes place.
- Hot water can be supplied throughout the dryer, which helps in the drying process at the desired temperature [DEPTH OF BIOLOGY]

SPRAY DRYER

- The spray dryer provides a large surface for heat and mass transfer by atomizing the liquid into small droplets. These are sprayed in a stream of hot air so that each drop dries to get a solid particle.

CONSTRUCTION



- It consists of a drying chamber having a conical base. It is made of stainless steel.
- The inlet for hot air is also provided at the bottom and another inlet for spray disk atomizer at the top. [DEPTH OF BIOLOGY]
- Atomization may be achieved using single-fluid or two-fluid nozzles .
- The drying chamber is connected to a cyclone separator. The dry product is collected from the bottom of the cyclone separator

WORKING

1. ***ATOMIZATION OF THE FLUID:*** feed is introduced through the atomizer either by gravity or by using suitable pump to form the droplets [DEPTH OF BIOLOGY]
2. ***DRYING OF LIQUID DROPLETS-*** fine droplets are dried in drying chamber by supplying hot air through inlet
3. ***RECOVERY OF DRIED PRODUCT***- centrifugal force of atomizer drives the droplets to follow hellical path

- Particles are dried during their journey and finally fall at conical base which further move into cyclone separation [DEPTH OF BIOLOGY]
- All these process are completed in few seconds . Particle size obtained is ranging from 2-500 nm
- Max size of spray dryer has capacity of 2000kg per hour

USES

- A spray dryer can be used for drying both solutions or suspensions. [DEPTH OF BIOLOGY]
- Spray dryers are very useful for the drying of heat-sensitive substances.
- Citric acid, borax, sodium phosphate, hexamine, gelatine, and extracts are dried by this method.
- The suspensions of starch, barium sulfate, and calcium phosphate are also dried by the spray dryer.
- Milk, soap, and detergents are also dried by a spray dryer.

DISADVANTAGES

- The spray dryer is expensive.
- Difficult to operate. [DEPTH OF BIOLOGY]
- The thermal efficiency is low, as much heat is lost in the discharged gases

ADVANTAGES

- The process of drying completes within 3 to 30 seconds.
- Fewer labor costs are required as it is a continuous process.
- Uniform and controlled size products can be obtained.
- The product obtained has high bulk density and shows excellent solubility.
- The solutions or suspensions can be dried easily
- It is suitable for the drying of sterile products

FREEZE DRYER

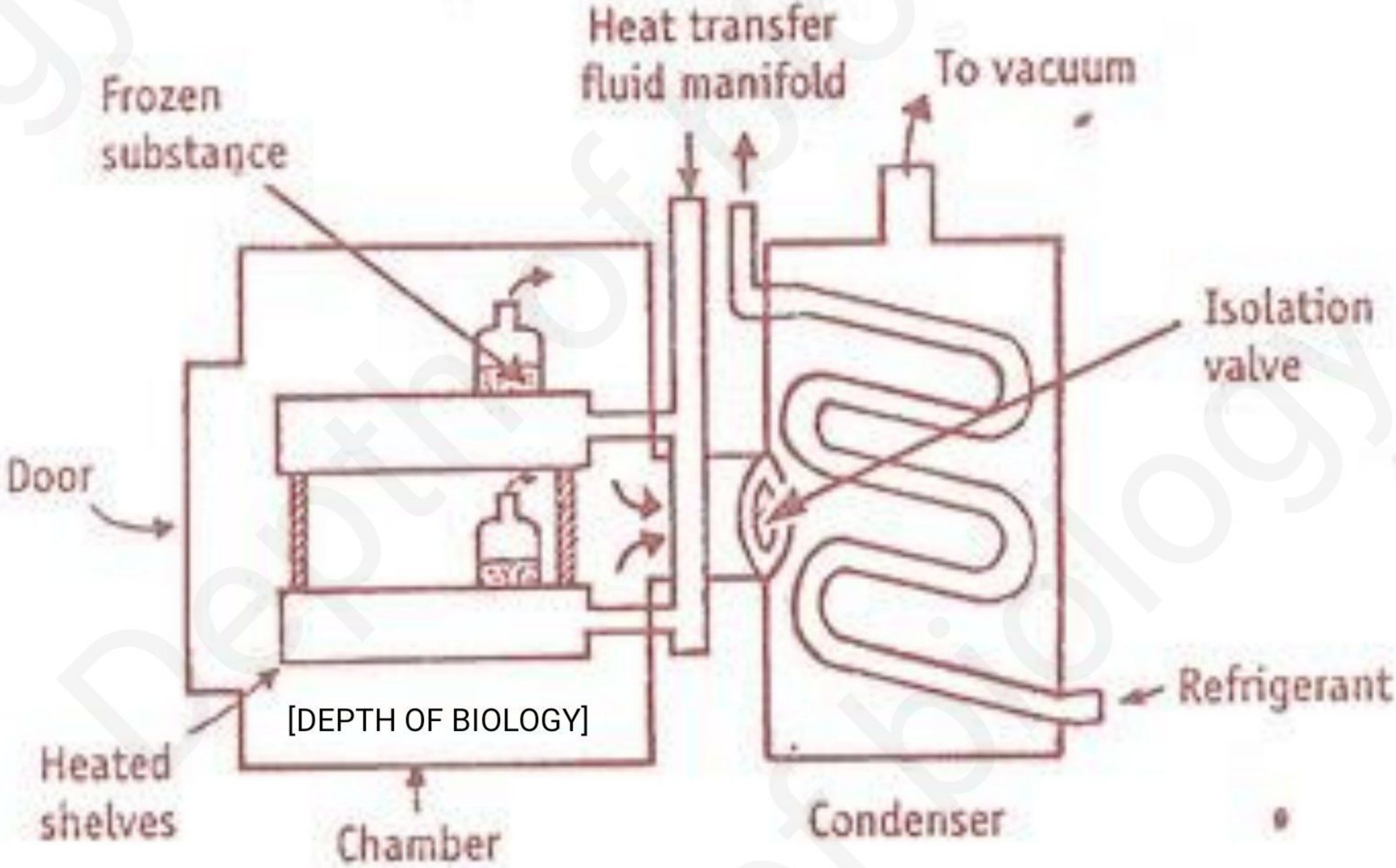
- ***Freeze Dryer:*** Freeze-drying or lyophilization is a drying process used to convert solutions of labile materials into solids of sufficient stability for distribution and storage.

[DEPTH OF BIOLOGY]

- The main principle involved in lyophilization is a phenomenon called sublimation. The water passes directly from the solid-state (ice) to the vapor state without passing through the liquid state. Water is removed from the frozen state material and then subjected to high vacuum to heat (by conduction or radiation or by both) so that the sublime frozen liquid leaves only solids or the dry components of the original liquid. Drying is achieved by subjecting the material to temperature and pressures below the triple point.

CONSTRUCTION

- It consists of drying chamber in which tray are loaded [DEPTH OF BIOLOGY]
- Heat supply in form of radiation
- Vapour condensing or adsorption system
- Vacuum pump or steam ejector


Heat transfer fluid manifold
To vacuum
Frozen substance
Isolation valve
Door
[DEPTH OF BIOLOGY]
Refrigerant
Heated shelves
Chamber
Condenser

WORKING

- Involves 5 stages

1. Preparation or pre treatment
2. Pre-freezing or solidify
3. Primary drying
4. Secondary drying
5. Packing

1. ***PREPRATION & PRE-TREATMENT-*** reduces actual drying by 8-10 times. Solution os pre-concentrated under normal tray drying, the final product becomes more porous [DEPTH OF BIOLOGY]
2. ***PRE-FREEZING TO SOLIDIFY WATER-*** vials. Ampoules or bottles in which the solution is packed are frozen in cold shelves. Cabinet is maintained at low temperature & atmospheric pressure [DEPTH OF BIOLOGY]

3.PRIMARY DRYING- the material which has to be dried is spread on large surface for sublimation.

Temperature and pressure should be below triple point of water i.e. 0.0098 and 0.533 kilopascal for sublimation [DEPTH OF BIOLOGY]

Vacuum is applied to the tune of about 3mmHg

The temperature is linearly increased to about 30 degree in span of 2 hours [DEPTH OF BIOLOGY]

To get highest possible water vapour at ice surface things have to be controlled in a such a manner that they give highest output

- Removes major moisture
- Still paces of moisture are present.

4. SECONDARY DRYING- the remaining paces are removed, rate of drying is very low and takes about 10-20 hours [DEPTH OF BIOLOGY]

5. PACKING-vacuum is replaced by inert gas and bottles are sealed

USES

- It is used in the production of injection, solution, and suspension. It is also used for the production of blood plasma and its fractionated products, bacterial and viral cultures, antibiotics and plant extracts, steroids, vitamins, and enzymes.
- Food items like mushrooms, prawns, meat products can be dried by this method 3. Coffee and tea concentrate and citrus fruit juices are also dried by this method [DEPTH OF BIOLOGY]

DISADVANTAGES

- The process is very slow
- Expensive process.
- It is not a general method of drying, but it is limited to certain types of valuable products that can not be dried by any other means. [DEPTH OF BIOLOGY]
- The period of drying is high
- The product is prone to oxidation, due to the high porosity and large surface area. Therefore, the product must be vacuum packed or with inert gas or in a container

ADVANTAGES

- This is suitable for drying heat sensitive products
- Freeze-dried product is porous and easy to be rehydrated and instantly dissolved.
- Drying takes place at very low temperatures, so that enzyme action is inhibited and chemical decomposition, particularly hydrolysis, is minimized.
- Denaturation of protein does not occur.
- Loss of volatile material is less. [DEPTH OF BIOLOGY]
- Sterility can be maintained.