



DEPTH OF BIOLOGY



# STUDY MATERIAL



YT-DEPTH OF BIOLOGY

INSTA- DEPTH OF BIOLOGY

TELE- DEPTH OF BIOLOGY





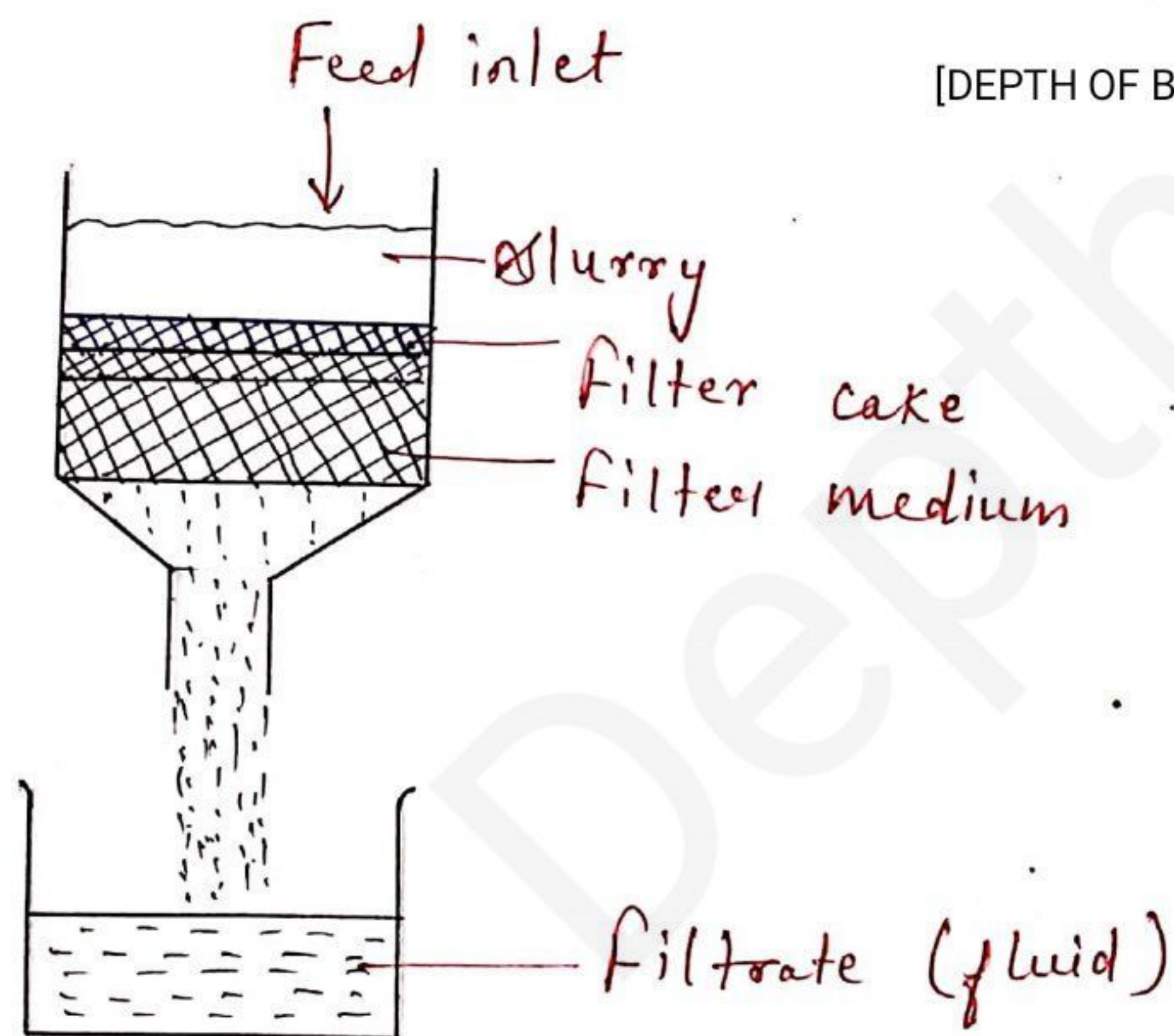
## Unit - 4

[DEPTH OF BIOLOGY]

### Filtration

- Filtration is the process, whereby solid particles are separated from the liquid or gas by passing it through a porous medium which retains the solid but allows the fluid to pass.

[DEPTH OF BIOLOGY]



[DEPTH OF BIOLOGY]

### Components :-

- Slurry is the mixture or suspension that is to be filtered.

[DEPTH OF BIOLOGY]



↳ Filter medium = A porous medium used to retain the solids.

↳ Filter cake = The accumulated solids on the filter.

[DEPTH OF BIOLOGY]

↳ Filtrate = The clear fluid passing through the filter.

Mechanism :-

↳ When the pores of filter medium are smaller as compared to size of particles to be separated, filtration takes place.

[DEPTH OF BIOLOGY]

↳ Fluid is allowed to pass as the filter medium resist solid particles.

↳ Filter cake resist some slurry and act as a secondary filter media.

[DEPTH OF BIOLOGY]

Objective and applications :-

Production of sterile products :-

- In sterilization process air is filtered through high efficiency particulate



air filters to obtain sterile air.

## Production of bulk drugs :- [DEPTH OF BIOLOGY]

- By filtration technique solids of intermediate and finished product are separated from the reaction mixture.

↳ Impurities can be removed by this method.

## Production of liquid and formulation :-

- In the production of liquid oral solution for obtaining clear solution 'filtration' is an essential process.

[DEPTH OF BIOLOGY]

↳ It can be used in -

↳ Dewaxing of oils.

↳ Removal of suspended oils from aq. solutions.

Such as eye drops, ear.

[DEPTH OF BIOLOGY]



## Waste water treatment :-

[DEPTH OF BIOLOGY]

- Waste solids must be separated from the waste liquid earlier to its disposal.

Clarification :- When the suspended solid particles are 1% or less than 1% in any fluid or slurry.

[DEPTH OF BIOLOGY]

## Theories of filtration :-

$$\text{Rate of filtration} = \frac{\text{Driving force}}{\text{Resistance}}$$

↳ Driving force = Pressure upstream - Pressure downstream

[DEPTH OF BIOLOGY]

↳ Resistance = Resist the filtration.



## Poiseuille's Equation

According to this, under pressure through capillaries filtration is indistinguishable to the streamline flow of a liquid. [DEPTH OF BIOLOGY]

$$V = \frac{\pi \Delta P r^4}{8 L \eta}$$

$V$  = rate of flow

$\Delta P$  = pressure difference across the filter

$r$  = radius of the capillary in the filter [DEPTH OF BIOLOGY]

$L$  = thickness of the filter cake

$\eta$  = viscosity of the filtrate

## Darcy's equation



$$V = \frac{KA\Delta P}{\eta L}$$

here,

[DEPTH OF BIOLOGY]

$K$  = Permeability coefficient of cake

$A$  = Surface area of filter medium

$\Delta P$  = Pressure difference

$\eta$  = Viscosity of the filtrate

$L$  = thickness of filter cake

Kozeny - Carman Equation

↳ Resultant equation of Poiseuille and

Darcy. [DEPTH OF BIOLOGY]

↳ widely used in filtration.



$$V = \frac{A}{\eta S^2} \cdot \frac{\Delta P}{KL} \cdot \frac{\varepsilon}{(1-\varepsilon)^2}$$

Here,

[DEPTH OF BIOLOGY]  $\varepsilon$  = Porosity of the cake  
 $S$  = Surface area of the particles comprising the cake  
 $K$  = Kozeny constant

▲ Other terms may be similar to Darcy's and Poiseuille's.

Factor affecting filtration :-

① Surface area of filter media :-

According to Darcy's - [DEPTH OF BIOLOGY]

Surface area  $\propto$  Filtration

i.e. Rate of filtration depends upon surface area of filter media.

[DEPTH OF BIOLOGY]

② Particle size of solids :-

Particle size  $\uparrow$  = Rate of filtration  $\uparrow$



③ Filter cake :-

$$\text{Filter cake} \propto \frac{1}{\text{Rate of filtration}}$$

[DEPTH OF BIOLOGY]

④ Viscosity :-

[DEPTH OF BIOLOGY]

$$\text{Viscosity} \propto \frac{1}{\text{Rate of filtration}}$$

⑤ Pressure difference :-

$$\text{Pressure difference} \propto \text{Rate of filtration}$$

Filter media and filter Aids :-

Filter media :- [DEPTH OF BIOLOGY]

- ↳ Substance helps in filtration process.
- ↳ Retain the solid residue that allow to pass liquid.
- ↳ Moreover, provide mechanical support for filter cake.



## Characteristics :-

- ↳ Must be insensitive.
- ↳ Should have enough mechanical strength. [DEPTH OF BIOLOGY]
- ↳ Allow the maximum passage of liquid.
- ↳ Opposition to corrosive.

## Materials used as a filter media :-

- Filter paper
- Woven material i.e. wool, cotton, silk etc
- Asbestos
- Membrane filter

## Filter Aids :- [DEPTH OF BIOLOGY]

- ↳ The substances which when added to the liquid to be filtered, reduce the resistance of the filter cake and increase the filtration.



## Characteristics :-

- Must be inert.
- Low specific gravity
- Ability to recover
- Porous other than dense

eg:- Tale, charcoal, Asbestos, Keiselguher etc.

Principle, Construction, working, Uses,  
merits and demerits of :-

[DEPTH OF BIOLOGY]

Plate and frame filter

## Principle :-

- ↳ The mechanism is surface filtration.
- ↳ By pressure the slurry enters the frame.
- ↳ And it flows through the filter media.
- ↳ The filtrate is collected on the plates and atlast sent to the outlet.

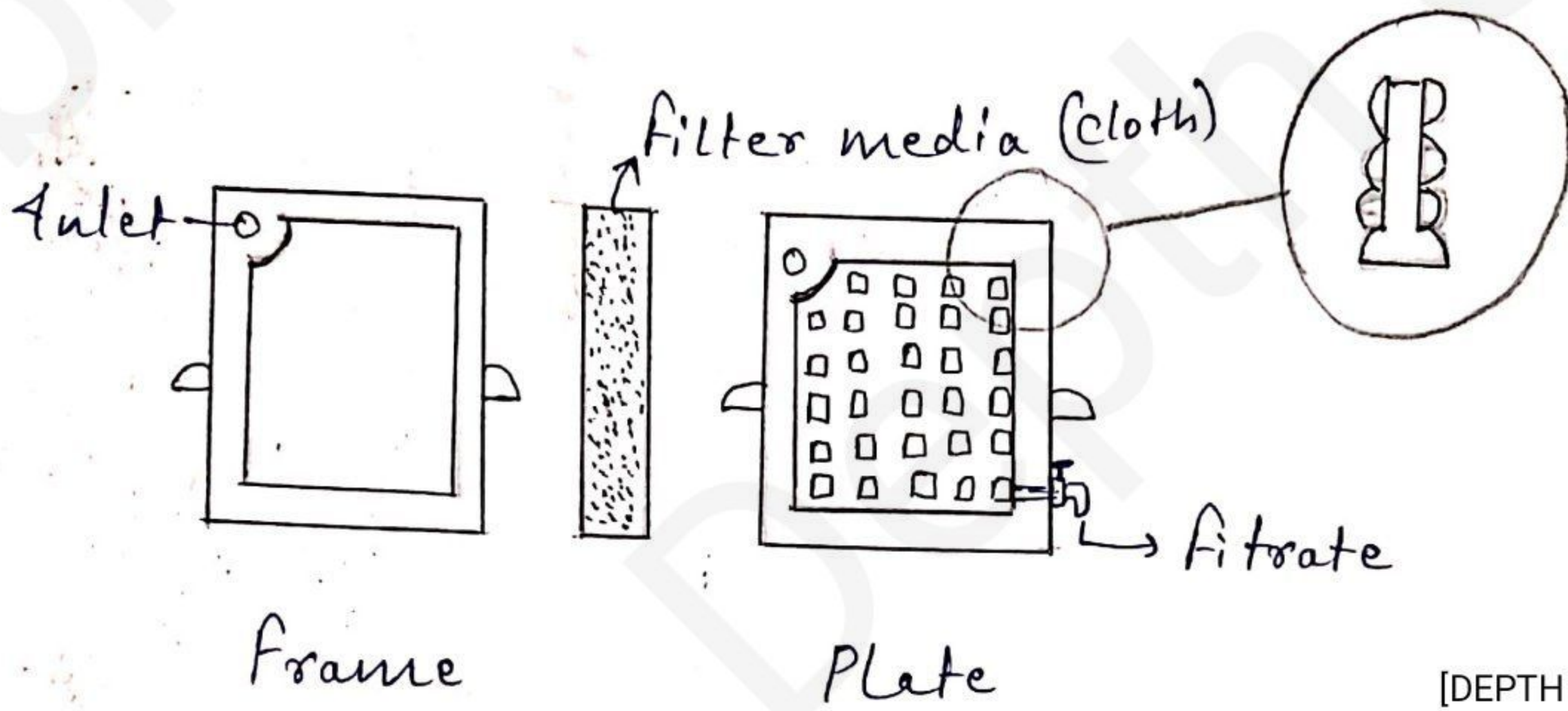
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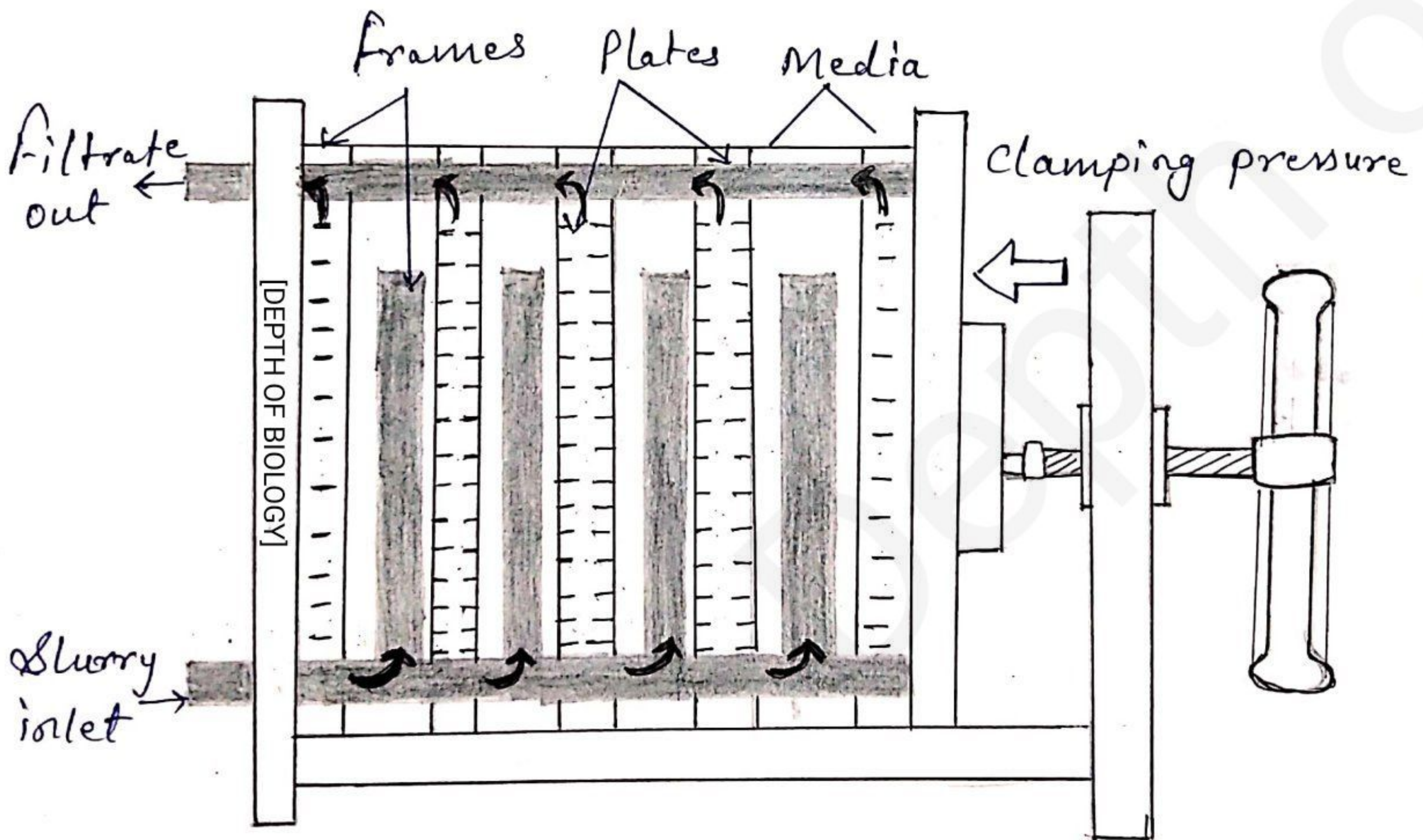
## Construction :-

- ↳ Consists of plates and frames.
- ↳ It is open and used as an inlet for the material to be filtered. Plate has a furrow support to the filter cloth.  
[DEPTH OF BIOLOGY]
- ↳ These plates and frames may be made of various metals that provides resistance or prevents corrosion or metallic contamination of the filtrate.
- ↳ On each side of the plate filter cloth is fitted.
- ↳ The plate and frames are placed in an alternate manner and gets fit in the outer frame of the press.  
[DEPTH OF BIOLOGY]
- ↳ Each plate acts as a single filtration unit.
- ↳ The outlet of each plate is connected to a common outlet pipe.  
[DEPTH OF BIOLOGY]





[DEPTH OF BIOLOGY]





Working :-

① Filtration :- The inlet of slurry through common inlet pipe of all filter frame that further pass through filter media and the filtrate i.e. liquid gets collected in the plates from where it gets collected through common outlet pipe. [DEPTH OF BIOLOGY]

↳ In the frames the cake is deposited.

The process of filtration is continued until the frame is filled with filter cake.

② Washing :- The frame is done vacant or washed with water when the process is stopped.

↳ It is mandatory as the filter cake create resistance for filtration. [DEPTH OF BIOLOGY]

↳ After washing, the cycle of filtration gets restarted.



### Uses:-

- ↳ It is capable of retaining bacteria if filter sheet of asbestos and cellulose is used.
- ↳ Precipitated protein from insulin liquors should be removed.

[DEPTH OF BIOLOGY]

### Advantages :-

- ↳ Provides large filtering area.
- ↳ Simple construction and variety of material can be used.
- ↳ Efficient washing of the cake is possible.

[DEPTH OF BIOLOGY]

### Disadvantage :-

- ↳ Expensive filter.
- ↳ Batch filter.



# Filter Leaf

[DEPTH OF BIOLOGY]

## Principle :-

↳ An apparatus consists of a drainage screen covered in filter cloth extending longitudinally.

↳ Due to surface filtration works as a sieve or strainer.

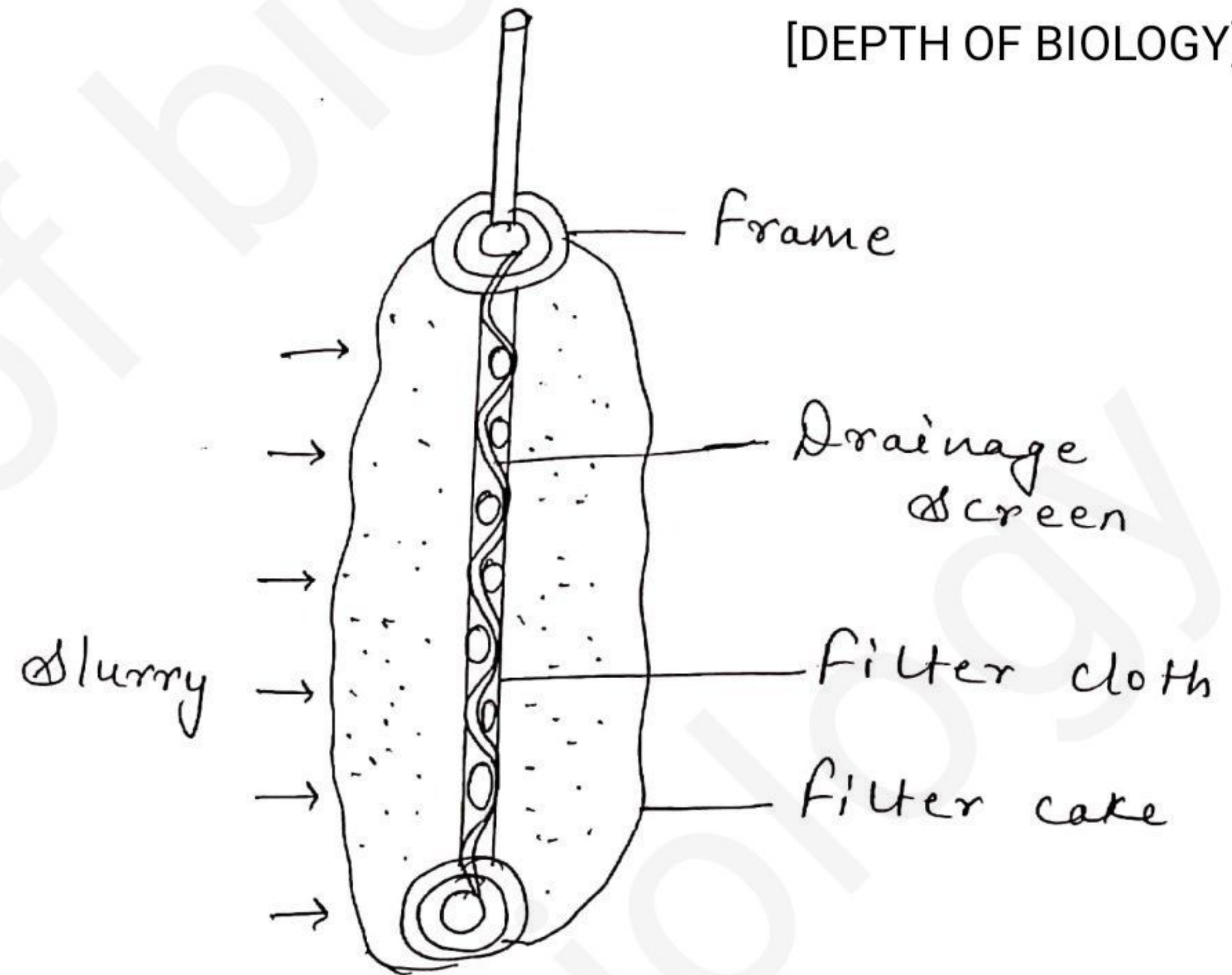
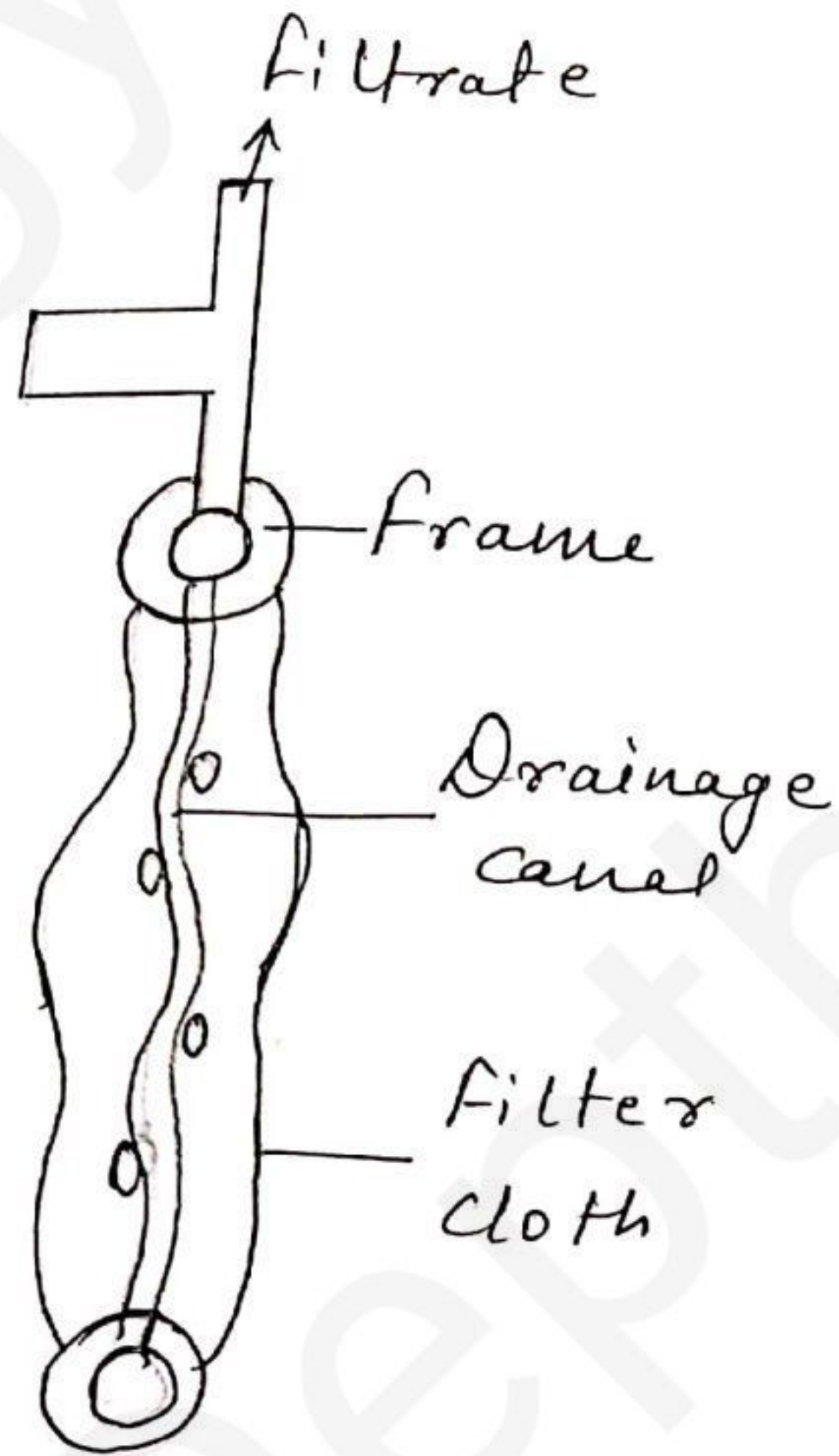
↳ By applying vacuum or pressure the rate of filtration can be increased.

## Construction :- [DEPTH OF BIOLOGY]

↳ Consists of an outer frame containing a drain screen.

↳ No restriction on the shape of the frame (circular, square or rectangular).





[DEPTH OF BIOLOGY]

[DEPTH OF BIOLOGY]

[DEPTH OF BIOLOGY]



↳ Filter cloth covering the entire unit.

↳ Filtrate exits through a suction connection on the inside of the frame.

[DEPTH OF BIOLOGY]

Working :-

↳ First of all filter leaf is immersed in the slurry.

↳ Connect the vacuum system to the filtrate outlet.

↳ Through the filter cloth the slurry passes.

↳ Filtrate enters the drainage canal.

↳ After that goes through the outlet into the receiver.

↳ Air is passed so that it flows in reverse direction to facilitate removal of cake.

[DEPTH OF BIOLOGY]



## Advantages :-

- Simplest form of batch filter.
- Highly efficient in washing.

[DEPTH OF BIOLOGY]

## Disadvantages :-

- Life of filter cloth is comparatively short.
- Unsuitable for high throughputs.

## Rotatory Drum Filter

Principle :- According to this -

[DEPTH OF BIOLOGY]

The Slurry is

filtered on a rotating drum surface  
by applying a vacuum.



↳ Also, Compression, drying and removing the filter cake is possible.

### Construction :-

↳ Consists of a horizontally mounted metal cylinder.

↳ Drum having a diameter of = 3 m  
length = 3.5 m

[DEPTH OF BIOLOGY]

Surface area =  $20 \text{ m}^2$

↳ Filter cloth = Used as filter media.

↳ The drum is radially separated dividing the annular space into separate compartments.

↳ Through a rotating valve each of it is connected by internal pipe to the centre of the drum.

### Working :-

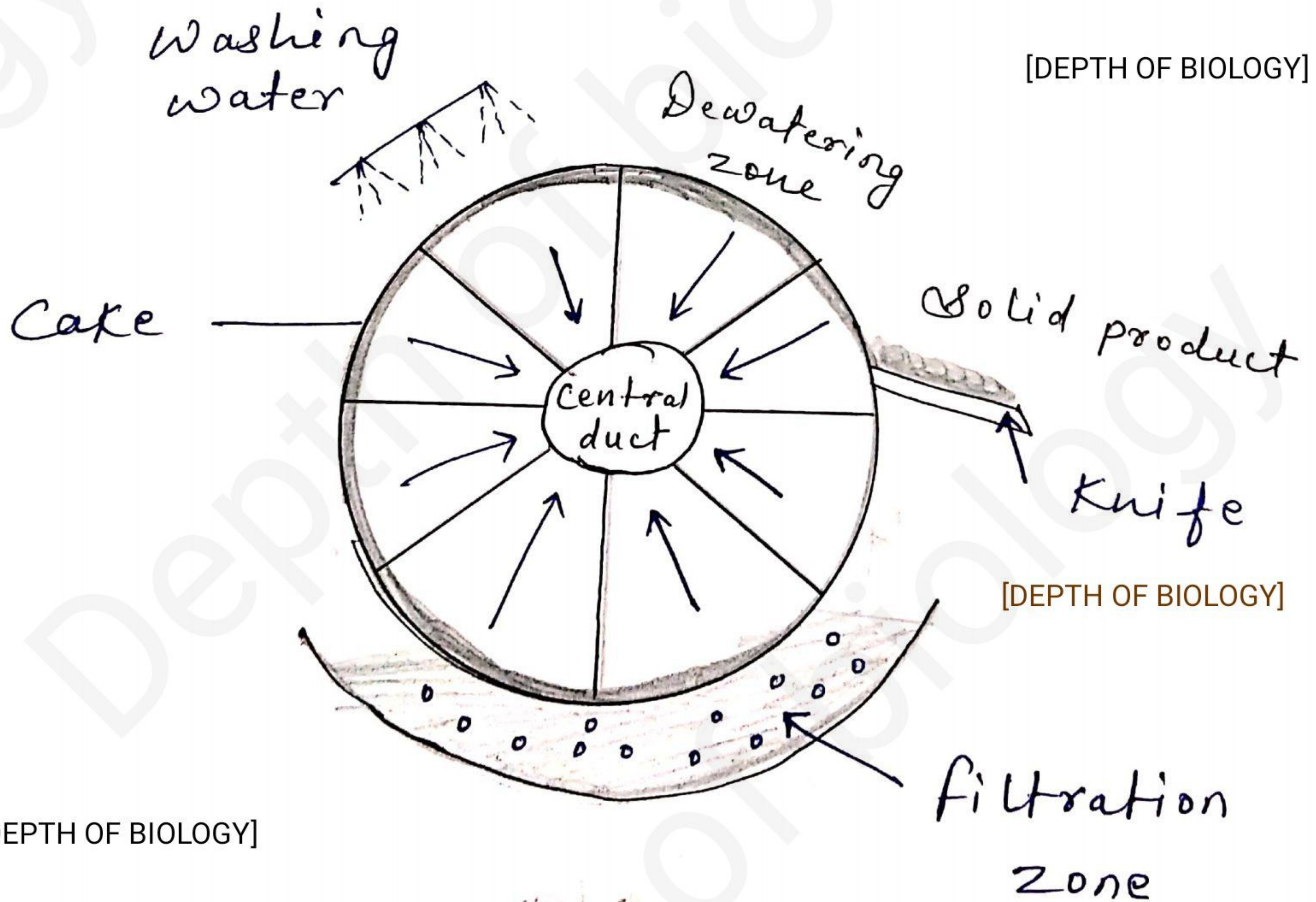
[DEPTH OF BIOLOGY]

- Pickup zone :-

The drum is dipped into the slurry and vacuum gets applied to the outlet that is connected to the filtrate



[DEPTH OF BIOLOGY]





↳ Filtration of calcium carbonate, starch etc.

### Advantage:-

↳ Automatic and continuous process, therefore, low labour cost.

↳ Large surface area.

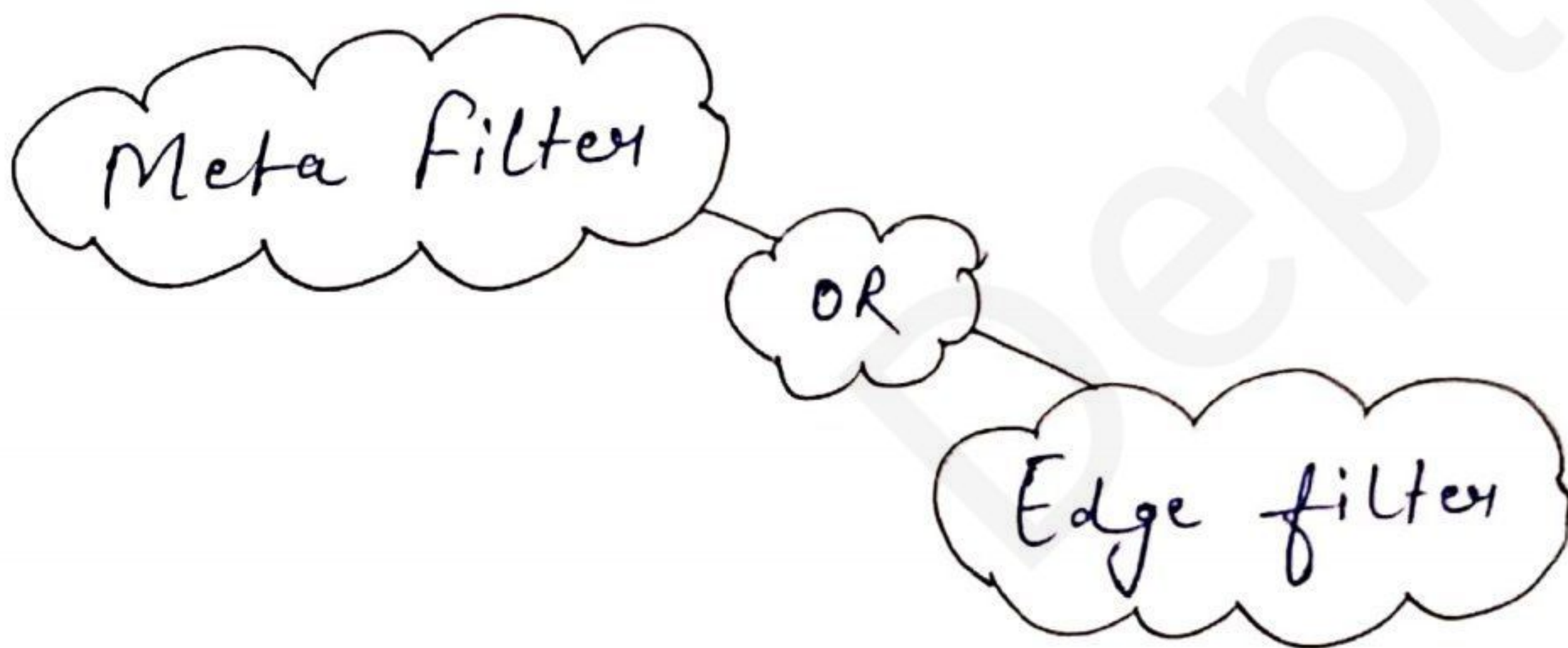
↳ Simultaneously removal of cake.

### Disadvantage:-

↳ Expensive

↳ Cake tends to crack.

[DEPTH OF BIOLOGY]



Principle:- This filter function as a surface filtration for the separation of particles.

[DEPTH OF BIOLOGY]



## Construction :-

↳ Consists of a grooved drainage column on which a series of metal rings are packed.

↳ These rings are made of stainless steel having -

[DEPTH OF BIOLOGY]

Thickness = 0.8 mm

Diameter :- Inside = 15 mm

Outside = 22 mm

↳ Rings have a number of semicircular projections on one surface. The opening between the rings is of about 0.2 mm when they are packed on the rod.

## Working :-

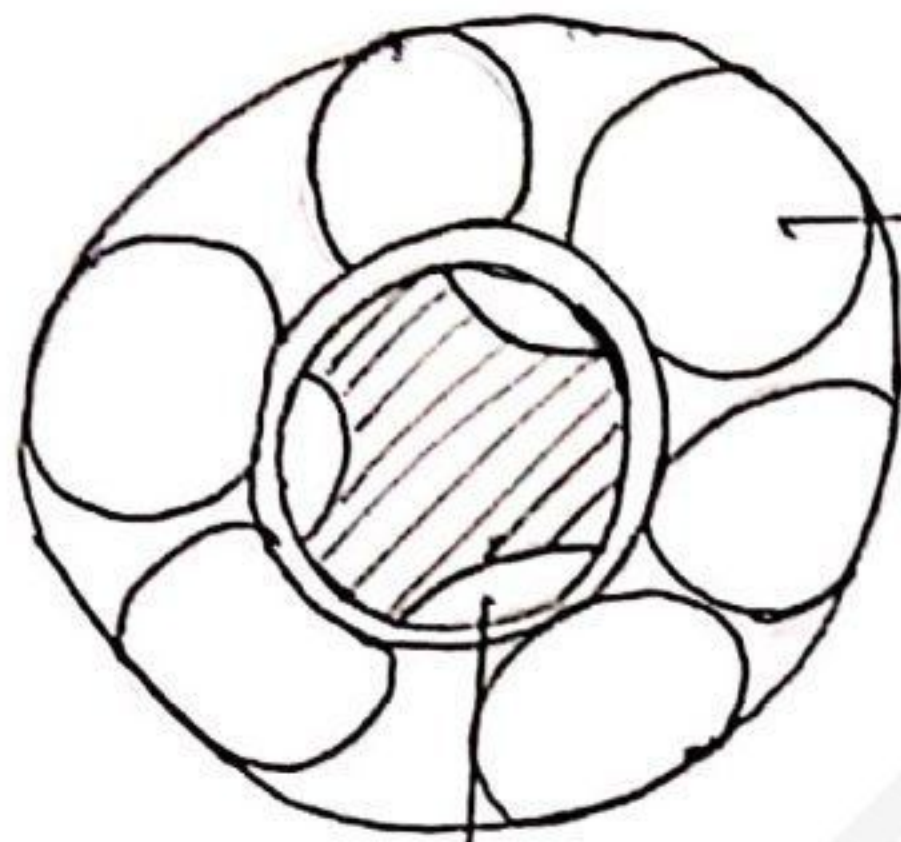
[DEPTH OF BIOLOGY]

↳ This filter is placed in a vessel and operated by pumping the slurry with vacuum at outlet.

↳ Between the rings the slurry passes through the channel formed on the edges.

[DEPTH OF BIOLOGY]

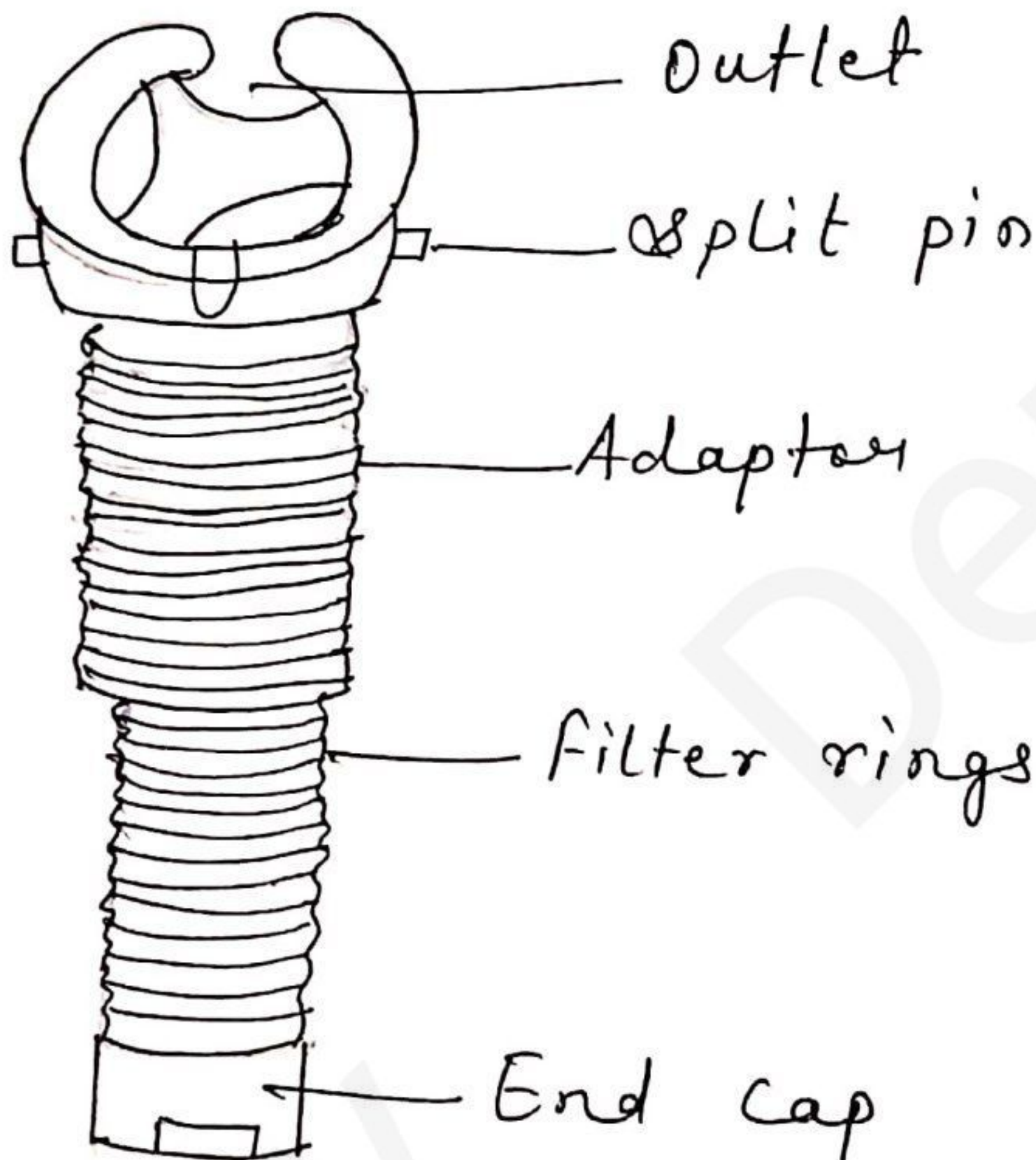




Projections on one surface of ring forming channels

[DEPTH OF BIOLOGY]

Drainage rod



[DEPTH OF BIOLOGY]

Outlet

Split pin

Adapter

Filter rings

End cap

[DEPTH OF BIOLOGY]



↳ Clear liquid rises up and gets collected into the receiver.

Uses:-

↳ Clarification of Syrup and insulin liquors.

↳ Filtration of injection solution.

Advantage:- [DEPTH OF BIOLOGY]

↳ An extreme versatile filter.

↳ Low at cost as separate filter media is not used.

↳ It is used under high pressure.

### Cartridge Filter

Principle:- A thin porous membrane having a combination of Pre-filter and membrane filter into a single unit. [DEPTH OF BIOLOGY]

↳ The act of filtration is mainly sieve like and the particles are retained on the surface.



## Construction :-

- ↳ Filter has cylindrical configuration with disposable / changeable filter media. [DEPTH OF BIOLOGY]
- ↳ Made up of plastic or metal.
- ↳ Made up of two membrane filter that is made of polypropylene, a pre-filter and an actual membrane filter with (0.2  $\mu\text{m}$ ) housed in a holder.

## Working :- [DEPTH OF BIOLOGY]

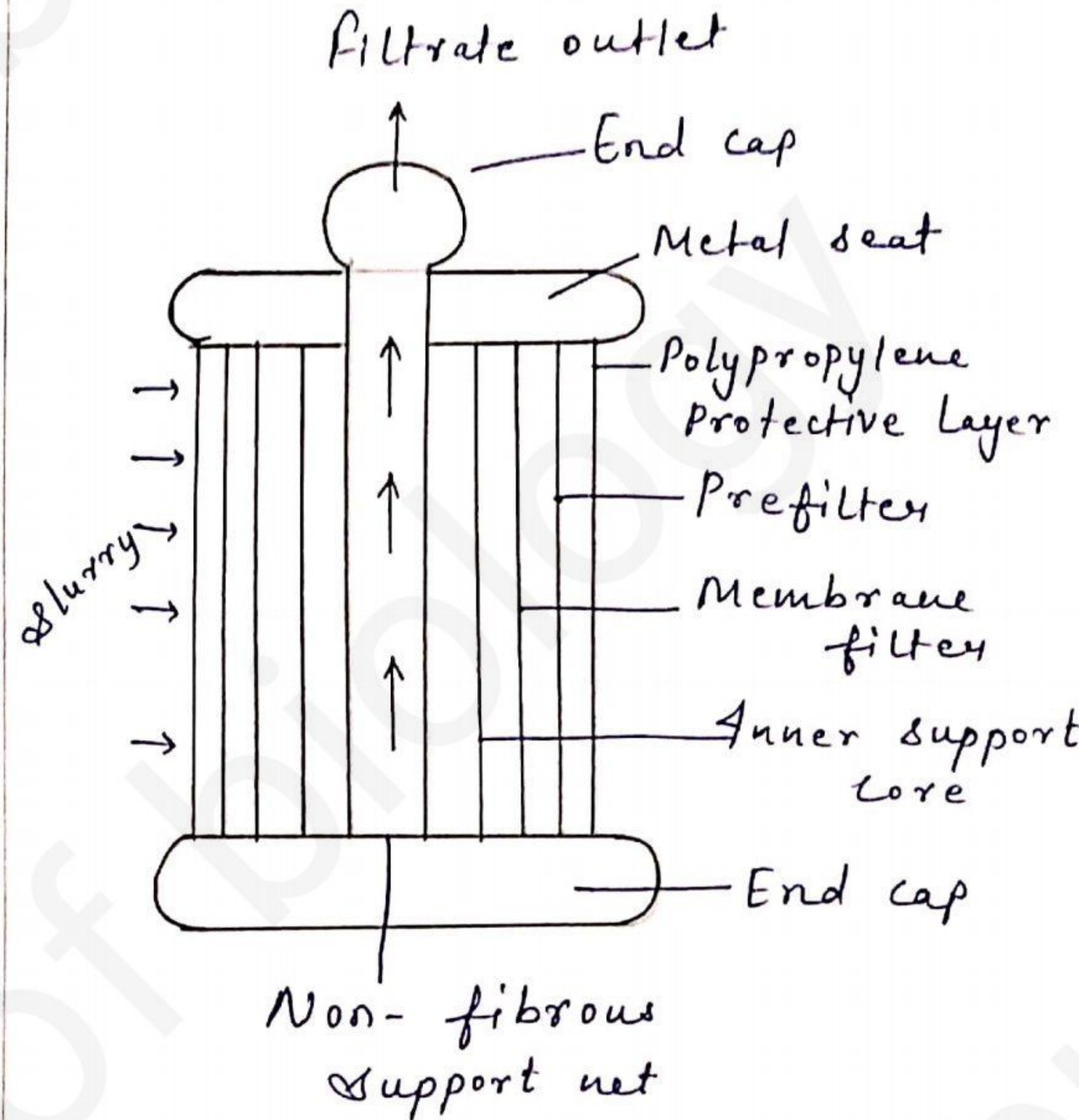
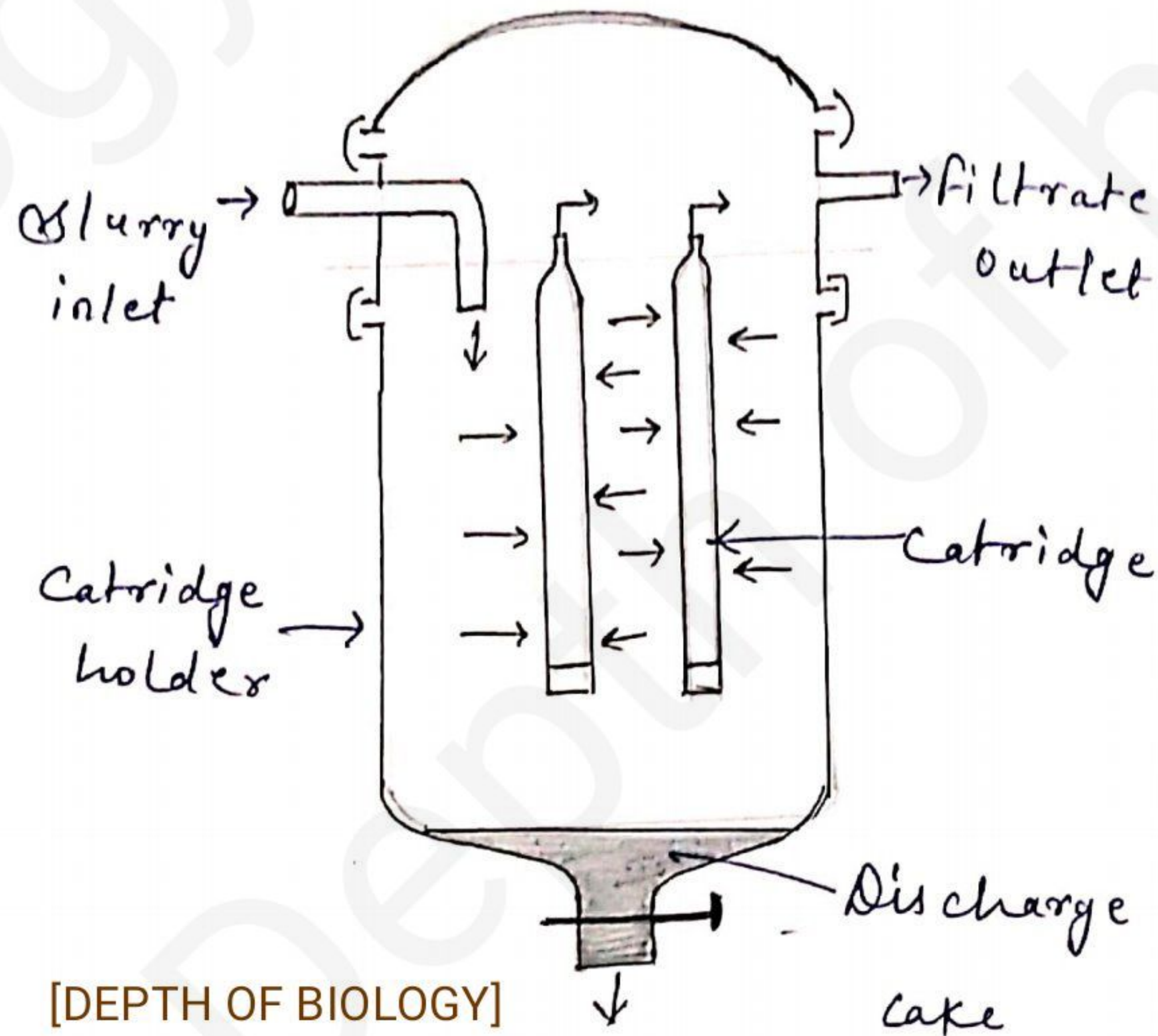
- ↳ Into the cartridge holder slurry is pumped.
- ↳ By the mechanism of straining it passes through cartridge filter unit.
- ↳ To the centre the clear liquid passes and moves up to collect through the outlet.

## Uses :- [DEPTH OF BIOLOGY]

- ↳ For preparation of particulate free solution for parenteral and ophthalmic uses.



[DEPTH OF BIOLOGY]





## Advantages :-

↳ Rapid disassembling and reusing of filter media is possible. [DEPTH OF BIOLOGY]

↳ construction of stainless steel permits autoclaving for sterile operations.

## Disadvantages :- [DEPTH OF BIOLOGY]

↳ It is expensive because of the cost of disposal elements.

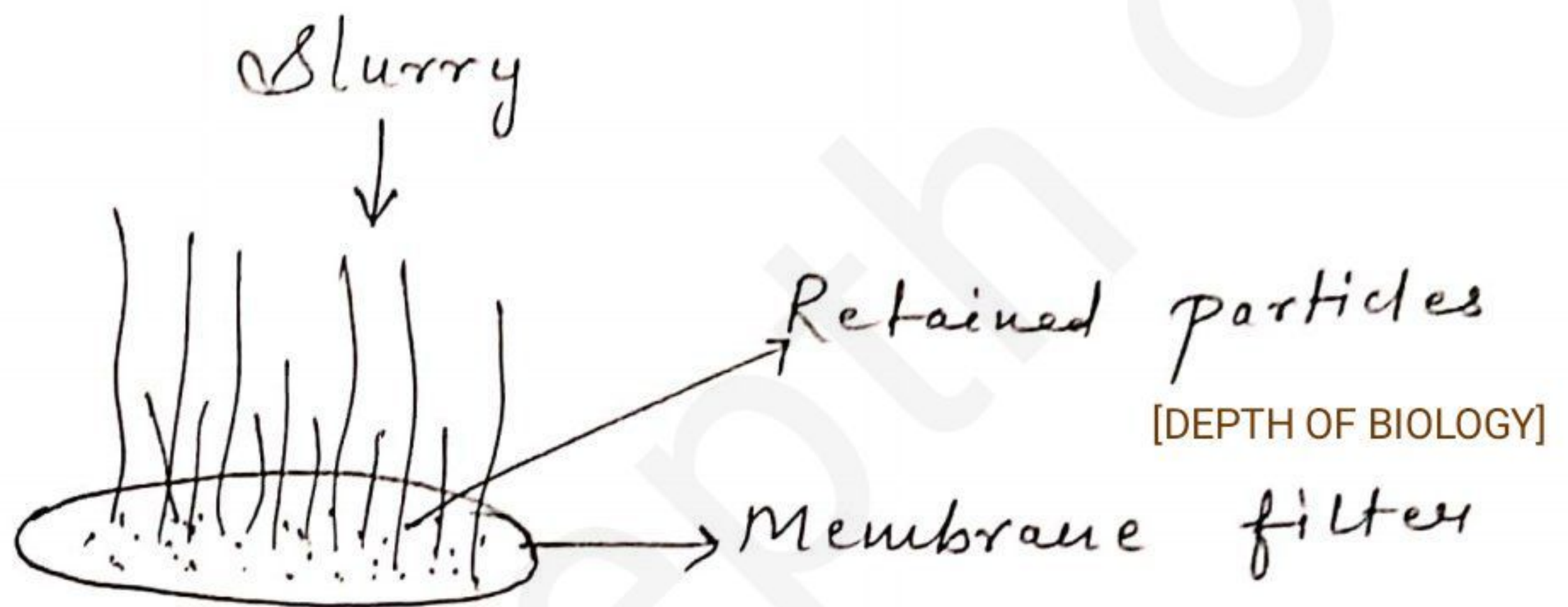
## Membrane filter

### Principle :-

- Acts like sieve. [DEPTH OF BIOLOGY]
- Particulate matter is retained on the surface of membrane.



Construction:-



→ These are made up of thin and flat membranes of cellulose derivatives like cellulose acetate & cellulose nitrate. [DEPTH OF BIOLOGY]

→ In dry state these are brittle and one can store it for an indefinite period.

→ Its thickness is between 50 and 150  $\mu$  and available in sizes upto 60  $\text{cm}^2$ . [DEPTH OF BIOLOGY]



### Working :-

↳ These filter has 400-500 million pores per  $\text{cm}^2$  of filter surface.

↳ Pores are entirely equal in size and occupy about 80% of filter volume. [DEPTH OF BIOLOGY]

↳ Pre-filter is often required to avoid rapid clogging of a membrane. [DEPTH OF BIOLOGY]

↳ For a particular application the selection of a membrane filter depends on the particles to be removed.

### Uses :-

↳ For sterilization of both aqueous and oily liquids.

### Advantages :-

↳ Rapid. [DEPTH OF BIOLOGY]

↳ Cross-contamination is prevented as these are available as disposable items.



Disadvantages :-

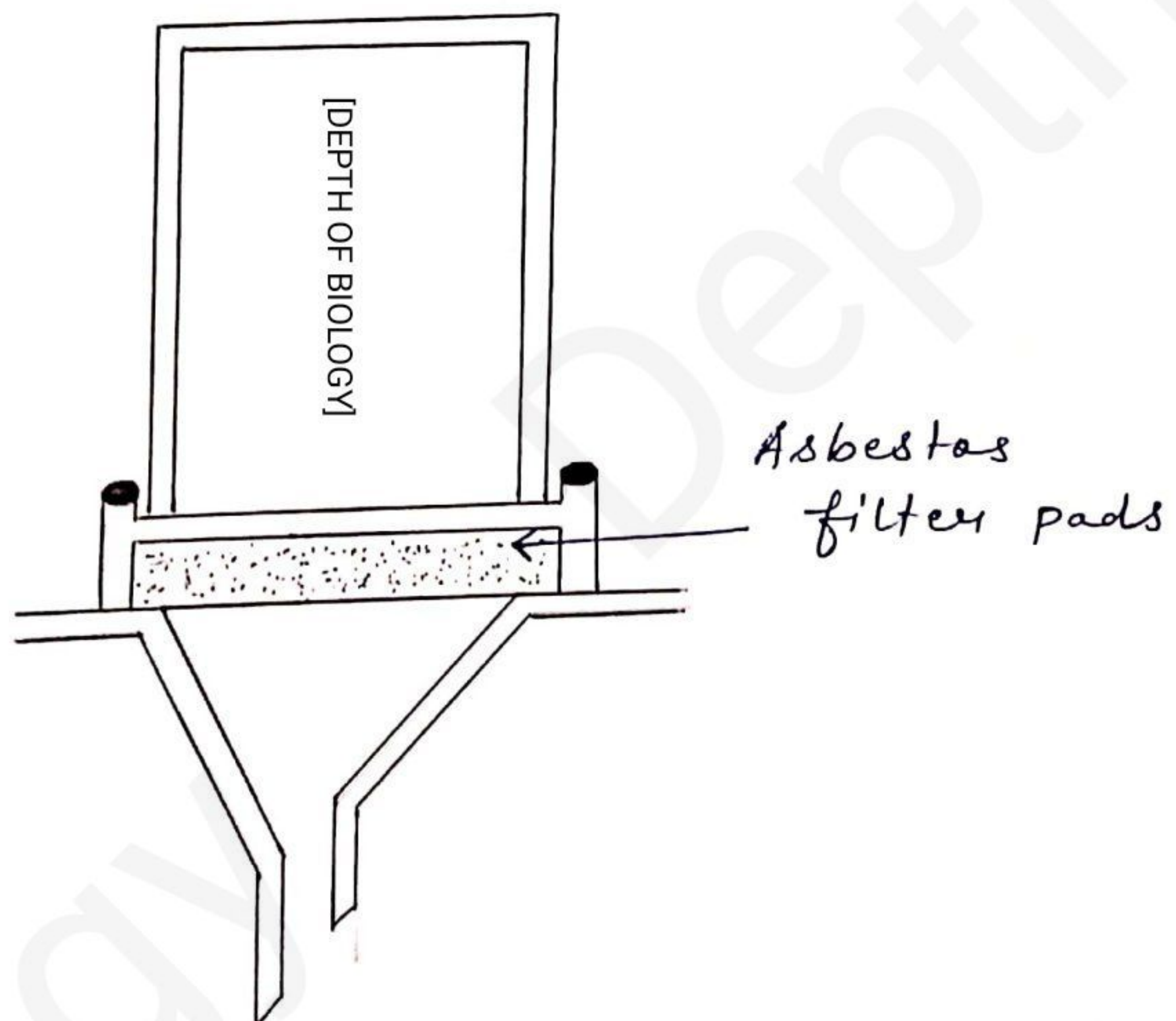
↳ Filtration of organic solvents cannot be done (like alcohols, ketones, esters and chloroform).

[DEPTH OF BIOLOGY]

## Seitz filter

Principle :- It is based on sieve-like mechanism through asbestos pad filter disc.

Construction :-





↳ Consist of compressed asbestos pads as a filtering medium.

↳ There is one upper part to fill the slurry.

↳ And one lower part to receive filtrate.

[DEPTH OF BIOLOGY]

↳ Pads are about 2mm thick.

Working :-

↳ Slurry is added upper part.

↳ Slurry gets deposited on asbestos pad and filtrate is passed through it. [DEPTH OF BIOLOGY]

↳ Almost perfect filtration is done with the help of finest pore size and small viruses are retained.

Uses :- [DEPTH OF BIOLOGY]

↳ For sterile filtration.

↳ For air filtration.



## Advantages :-

- ↳ Easy to use. [DEPTH OF BIOLOGY]
- ↳ Useful for viscous solution.

## Disadvantages :-

- ↳ Delicate / fragile.
- ↳ To avoid residue of previous filtration a new pad must be used for each filtration.

## Centrifugation

[DEPTH OF BIOLOGY]

- ↳ The process of separation of particles by use of centrifugal force.
- ↳ Separation of two immiscible liquids or a solids from a liquid can be done by using it.



↳ Used when filtration process is not applicable.

↳ The equipment / instrument used for separation is called centrifuge. [DEPTH OF BIOLOGY]

Principle :-

↳ Based on the principle of sedimentation.

↳ Centrifugal force is applied to get separation by a difference in density. [DEPTH OF BIOLOGY]

↳ Particles which have size more than  $5\text{ }\mu\text{m}$  are separated by simple filtration process.

↳ And the particles having size  $5\text{ }\mu\text{m}$  / less than  $5\text{ }\mu\text{m}$  do not sediment under gravity. Hence, centrifugal force is used.

↳ These force generated due to rotation i.e. acts radially outwards. [DEPTH OF BIOLOGY]



## Application :-

- ↳ Used for separation of blood cells from blood.
- ↳ For separation of drug present in blood, urine & tissue fluids.
- ↳ Mostly used in bulk drug industry to separate crystalline material from suspension. [DEPTH OF BIOLOGY]
- ↳ To extract cream from milk.
- ↳ Play a vital role in the fractionation of many subcellular organelles.
- ↳ To get pure form of insulin by selective precipitating other fraction of protein and separating them by ultracentrifugation.
- ↳ Ultracentrifugation = Used for separation of virus particles which are utilized in industrial applications. [DEPTH OF BIOLOGY]



# Equipment for Centrifugation :-

## ① Perforated Basket Centrifuge :-

### Principle :-

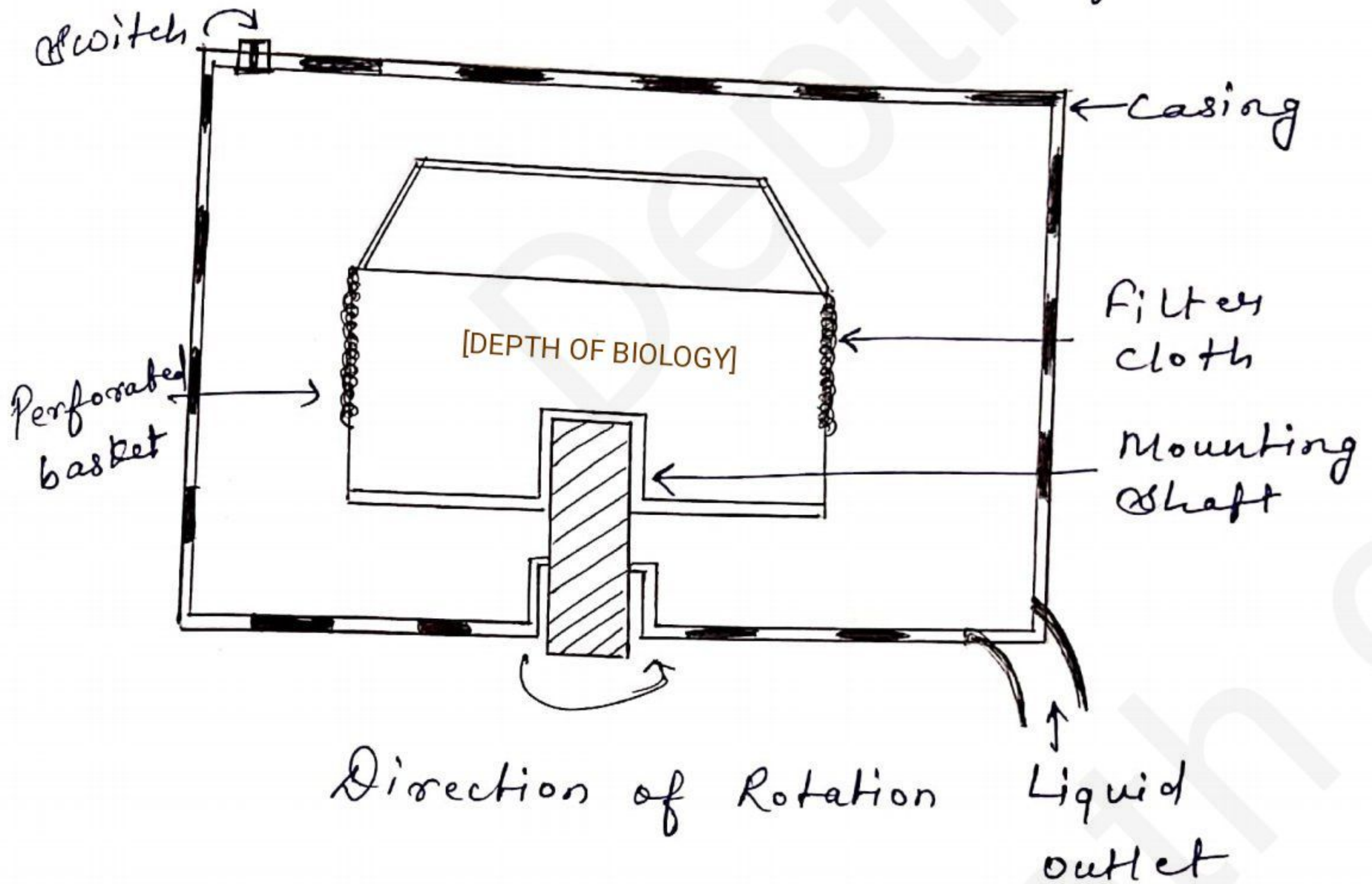
- Through perforated wall separation occurs. [DEPTH OF BIOLOGY]
- Depends on the difference in the densities of solids and liquid phases.

### Construction :-

- Consists of a steel or any other other suitable metal basket.
- Perforated with filter cloth.
- The basket is suspended on vertical shaft and driven by a motor. [DEPTH OF BIOLOGY]
- By casing the basket is surrounded that collect the filtrate and discharge through outlet.



- Diameter of basket = 0.9 m. [DEPTH OF BIOLOGY]
- Diameter of Perforation depends on crystal size.
- Basket operated at speed of 1000 rpm.



Working :- [DEPTH OF BIOLOGY]

↳ The material is loaded into the basket when it is stationary.

↳ Power applied to rotate 5 Kw and then reduced to 2 Kw.  
(Speed 1000 rpm)



↳ The liquid passes through perforated wall and solid retains in the basket.

↳ Liquid gets collected through casing.

[DEPTH OF BIOLOGY]

↳ Centrifuge stops by applying brake.

↳ Now solid can be unloaded.

Uses :- [DEPTH OF BIOLOGY]

↳ To separate crystalline drugs from mother liquor.

↳ For separation of precipitated protein from insulin.

Advantage :-

↳ Occupies less space.

↳ Rapid

↳ When solid concentration is high it can be used.

Disadvantage :- [DEPTH OF BIOLOGY]

↳ High labour cost.

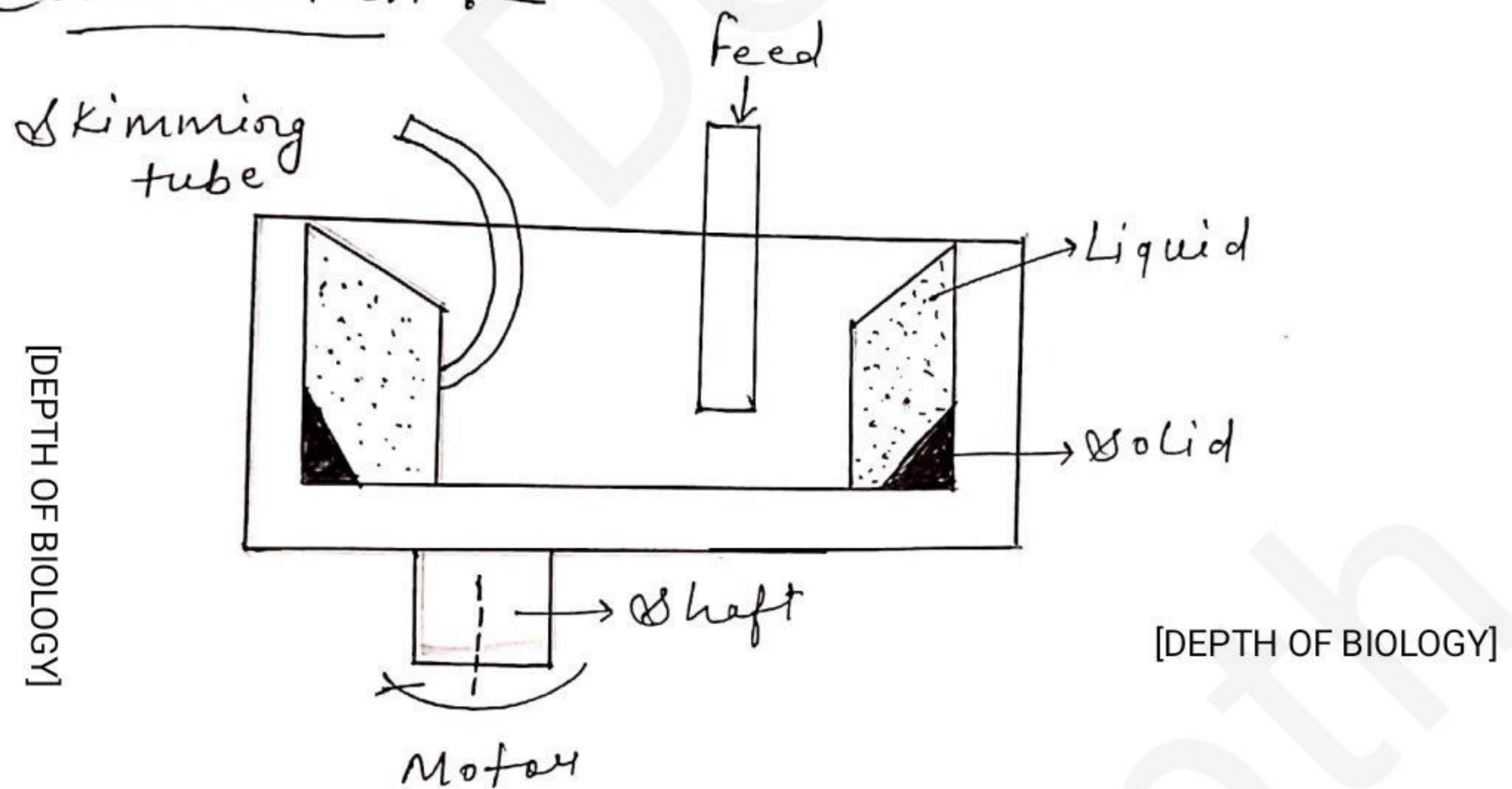
↳ Batch process.



## ② Noon - Perforated basket centrifuge :-

Principle :- The separation of solids and liquids phase is based on difference in densities of both the phases without porous barrier.

Construction :-



↳ Consists of steel made non-perforated basket.

↳ Through feed tube material is loaded into basket. [DEPTH OF BIOLOGY]

↳ The basket is mounted on vertical shaft that is rotated by motor.



↳ With the help of Skimming tube liquid is removed.

Working :- [DEPTH OF BIOLOGY]

↳ Through feed tube the suspension is fed into the basket continuously.

↳ During Centrifugation -  
Solid deposited at side of basket and the liquid remains at top that is removed by Skimming tube. [DEPTH OF BIOLOGY]

↳ As the sufficient quantity of solid get deposited at the site of basket, it is removed randomly by hand and continuously by scraper blade.

Uses :- [DEPTH OF BIOLOGY]

↳ Useful when the deposited solids offer high resistance to the flow of liquids.

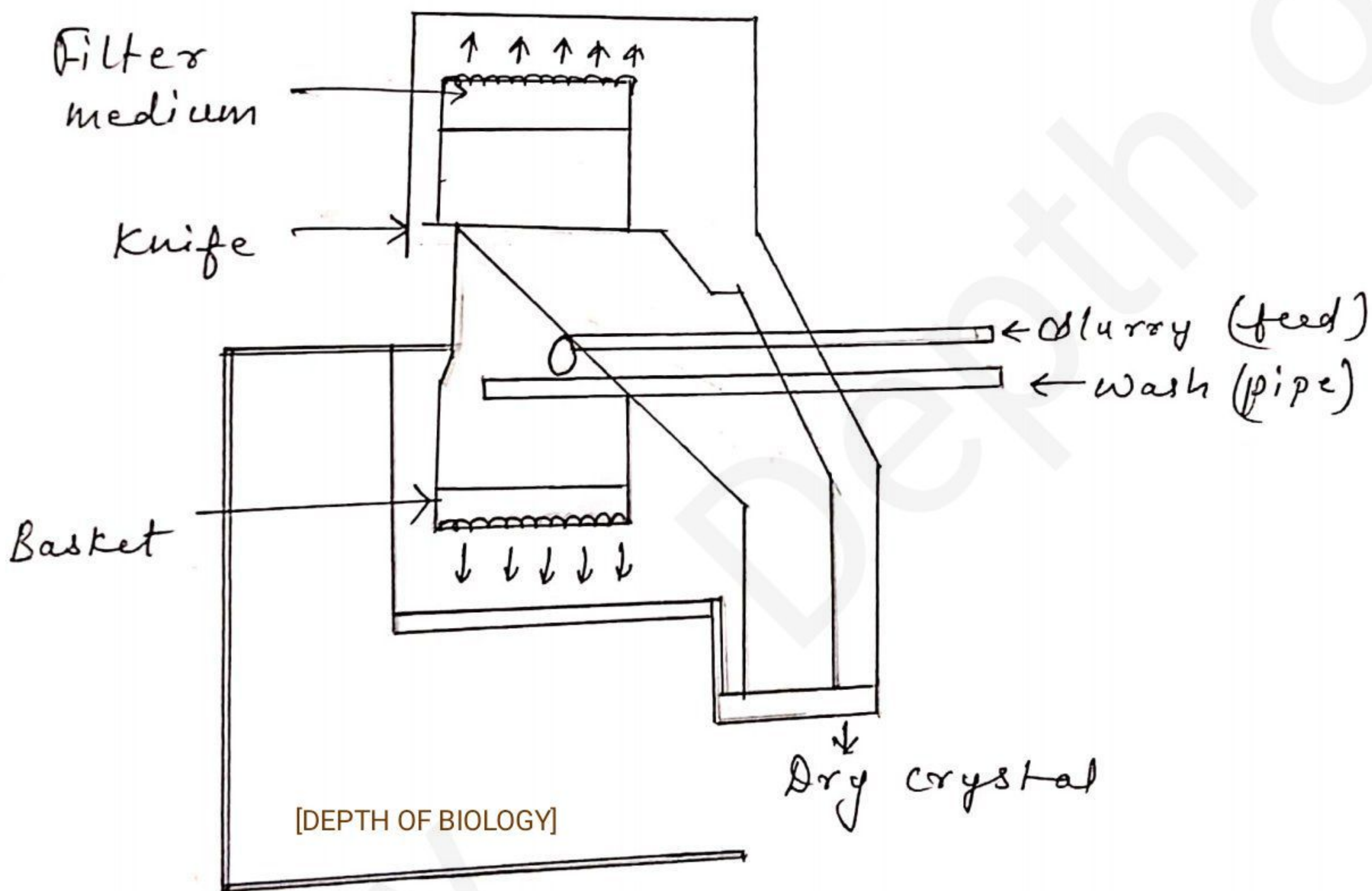


### ③ Semi continuous centrifuge :-

Principle :- Separation occurs through Perforated wall based on the difference in the density of Solids and liquid phases.

[DEPTH OF BIOLOGY]

Construction :-





↳ Consist of perforated basket mounted on horizontal shaft and run continuously by motor.

↳ Through feed pipe feed gets introduced and through wash pipe wash the crystal.

[DEPTH OF BIOLOGY]

↳ Through discharge assembly the layer of cake is removed by a knife.

Working :-

↳ Horizontally the basket is rotated with motor.

↳ Through feed pipe slurry is introduced.

[DEPTH OF BIOLOGY]

↳ Through perforated site of basket the liquid is eliminated and solid residue retain inside the basket.

[DEPTH OF BIOLOGY]



↳ The slurry inlet is stopped by feeder diaphragm valve assembly when the height of cake is approx 2-3 inch. [DEPTH OF BIOLOGY]

↳ The cake washed with water.

↳ At last the hydraulic apparatus raises the knife to cut the cake that collected through outlet. [DEPTH OF BIOLOGY]

### Uses & Advantages :-

↳ For separation of crystal from mother liquor.

↳ To clarify liquid removing unwanted solids dirt from oils.

### Disadvantages :-

↳ Complicated process.

[DEPTH OF BIOLOGY]

↳ Consuming high power.



#### ④ Super Centrifuge :-

Principle :- [DEPTH OF BIOLOGY]

- ↳ Based on the principle of sedimentation.
- ↳ Used to separate two immiscible liquid phases.

Construction :-

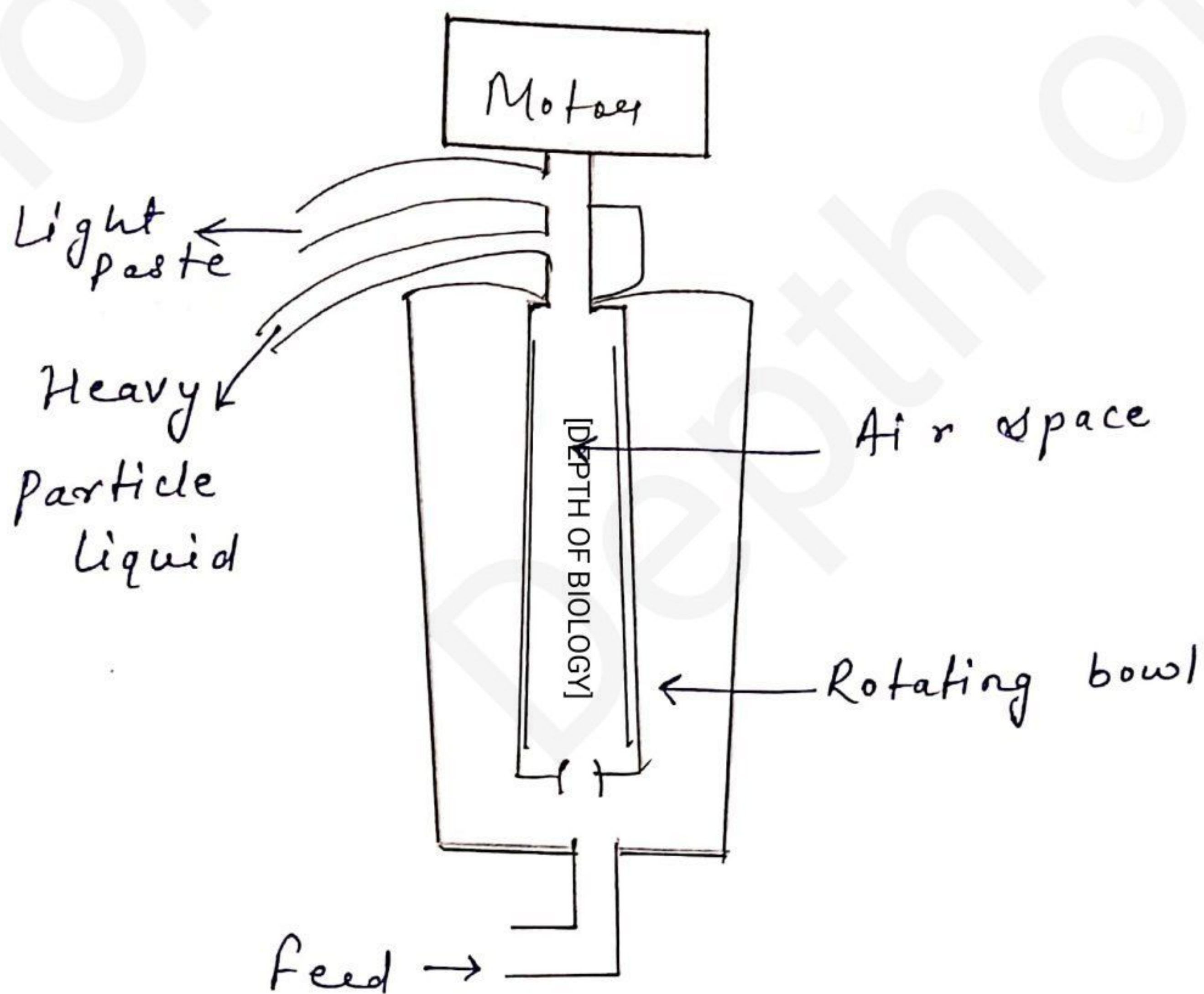
- ↳ Consists of a long, hollow, cylindrical bowl of small diameter and rotate on vertical axis.

[DEPTH OF BIOLOGY]

- ↳ From bottom through a nozzle with pressure feed is introduced.
- ↳ Two liquids outlets are provided at different height.
- ↳ Rotates approx 2000 rpm.

[DEPTH OF BIOLOGY]





Working :-

↳ Rotates at 2000 rpm on its axis and through bottom nozzle with pressure feed is introduced.

[DEPTH OF BIOLOGY]

↳ According to their density two liquid phases were separated. Towards the periphery heavier liquid moves and lighter liquid forms an inner layer.

[DEPTH OF BIOLOGY]



↳ Both liquids will ascend to the upper part of bowl.

↳ Through modified outlets these removed separately from different height.

↳ Uses : — [DEPTH OF BIOLOGY]

— To separate liquid phases of emulsion in food, biochemical and pharmaceutical industries.

[DEPTH OF BIOLOGY]