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Transport in plants

lecture 03

Tarun sir

Topics

Meaning of transport

Short distance transport

Water potential Osmosis Plasmolysis

Imbibition

Bulk Flow and mass Flow . .

Transport of water

Transport of mineral

phloem-transport

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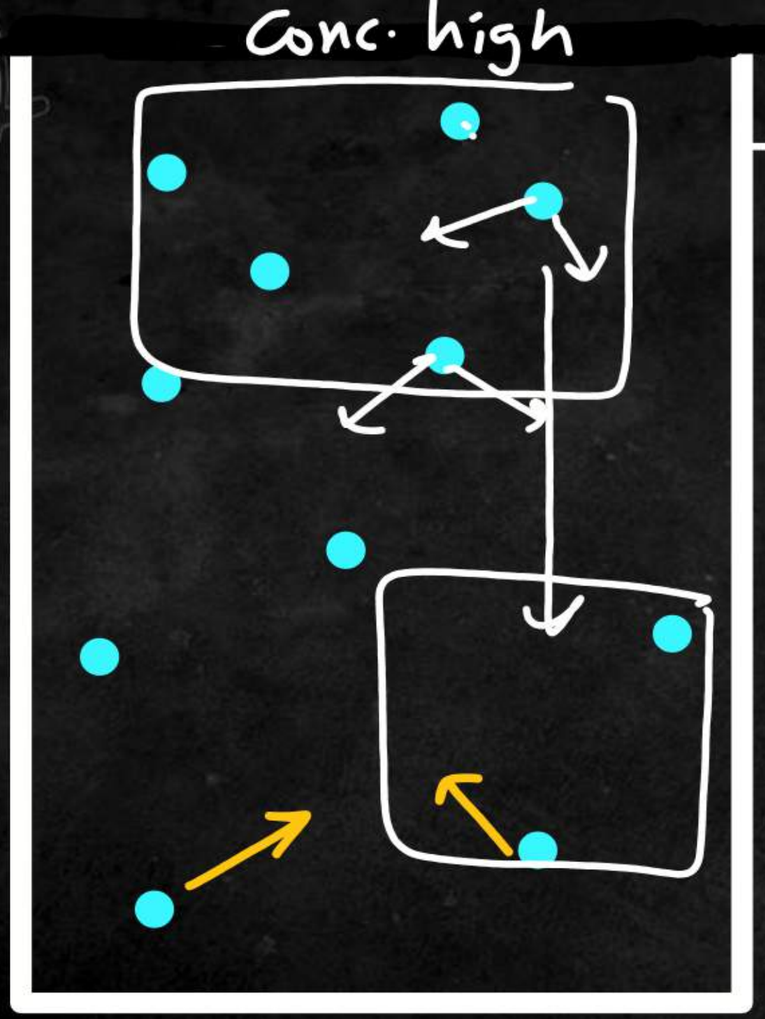
Revision of water potential



Beaker

Water molecule → Have K.E
(liquid + Gas)
↓
Random motion
↓
Direction → (no. of water molecule more Ψw) more

Psi Ψ
Unit pascal

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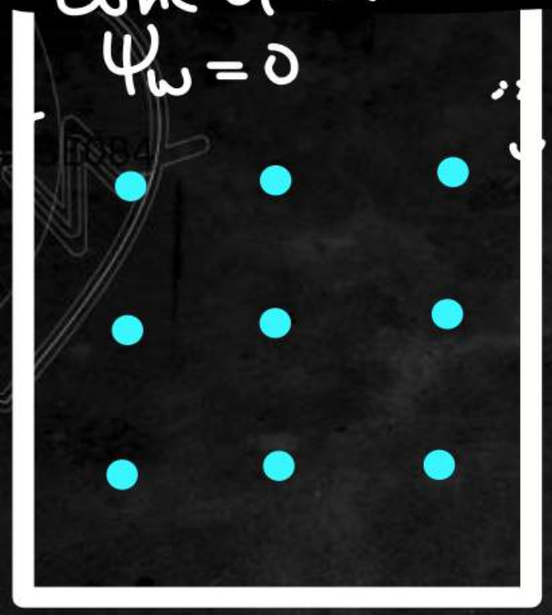
Pure water - maximum Conc. of water molecule

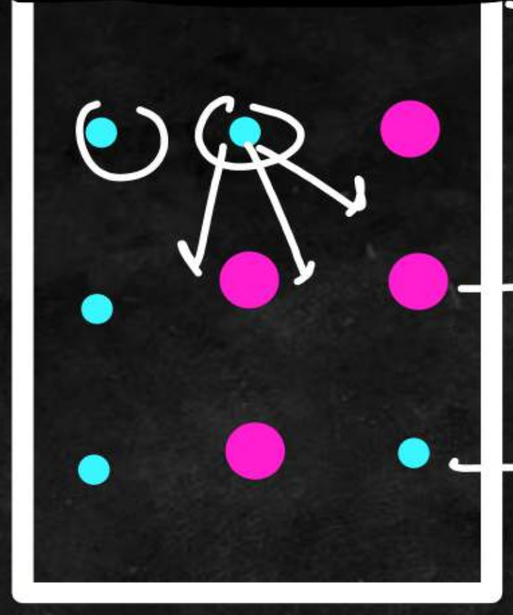
$\Psi_w = 0$



Pure water

$\Psi = 0$ (maximum number of water molecule)

- More is solute ✓
- lower is Ψ_w ✓



- Solute add / Conc. of water molecule dec. ↓ Random motion dec.
- Water molecule

solution

$\Psi_w = -5$

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$$\Psi_w = \Psi_s + \Psi_p$$

100 −40 +140

More is solute → more negative

→ lower is Ψ_s

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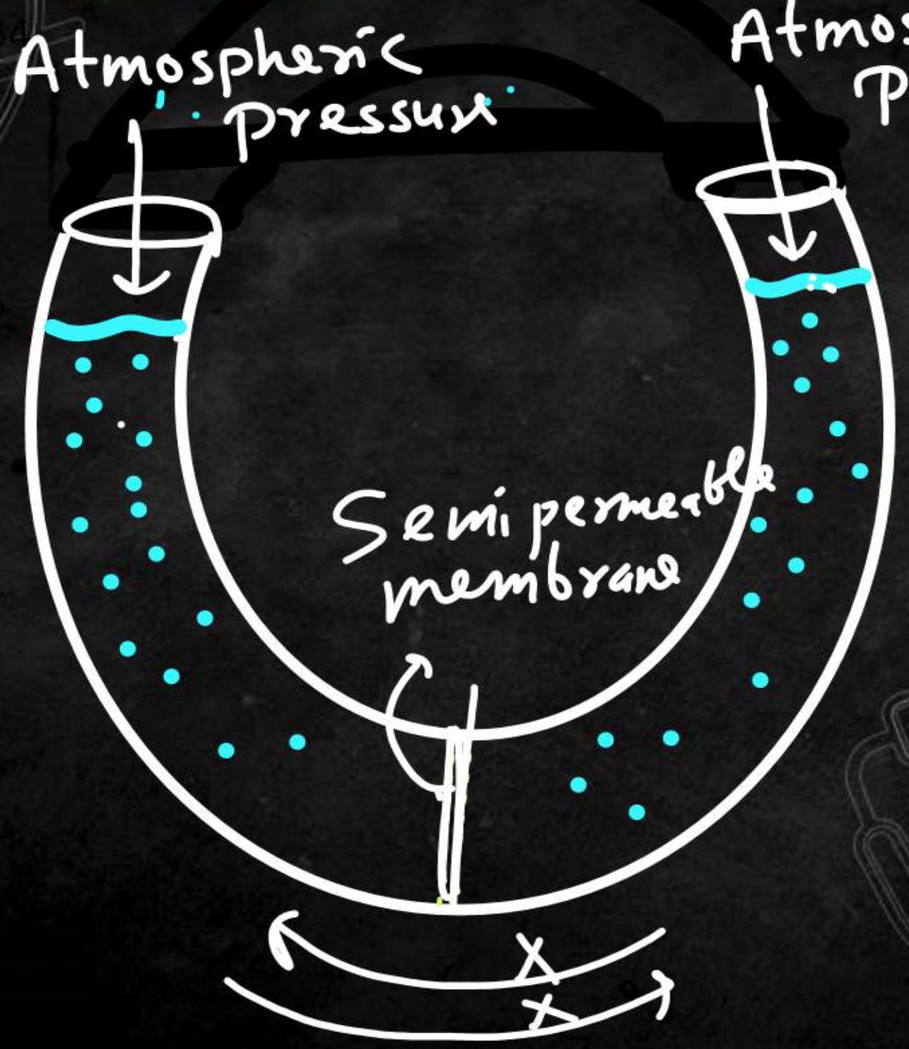
Pressure potential

When it is Zero

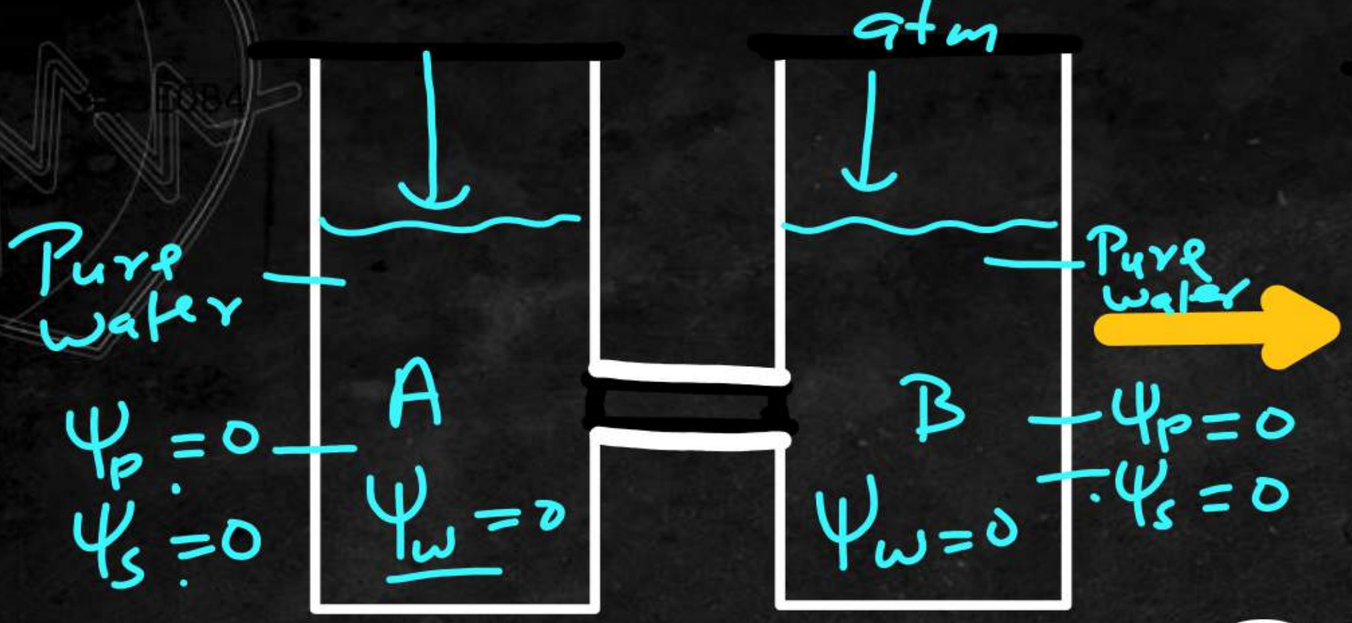


Since atmospheric pressure not play any role in movement of water

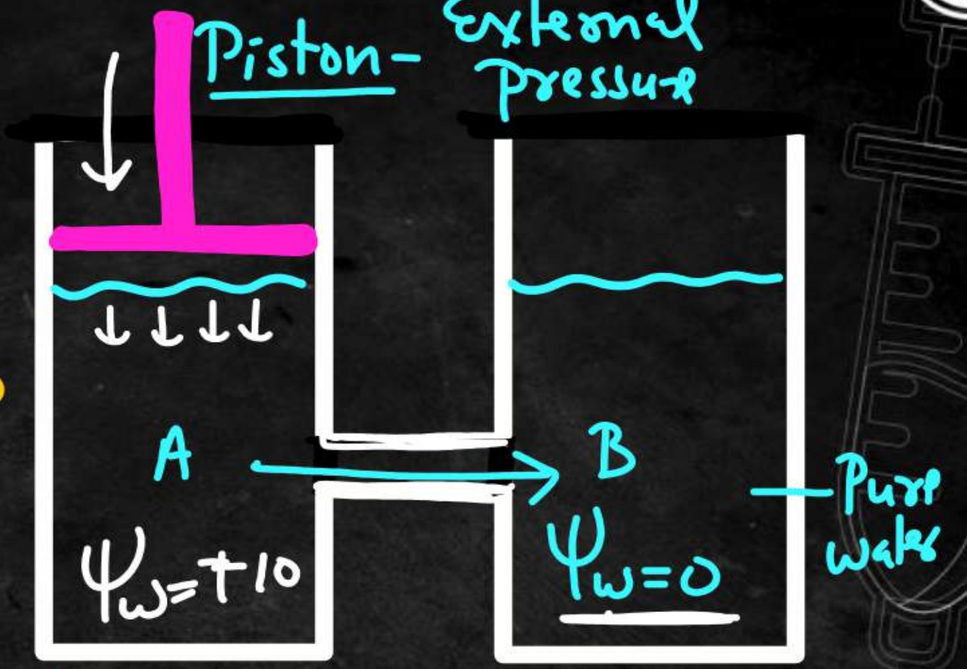
So, By convention

$\Psi_p = 0$ – atm

Pressure potential - when it is tue



In Both System atmospheric pressure work, no net movement $\Psi_p = 0$



Due to piston, External Pressure, tue pressure

Due to which Ψ_w in A is tue

So water move From A to B

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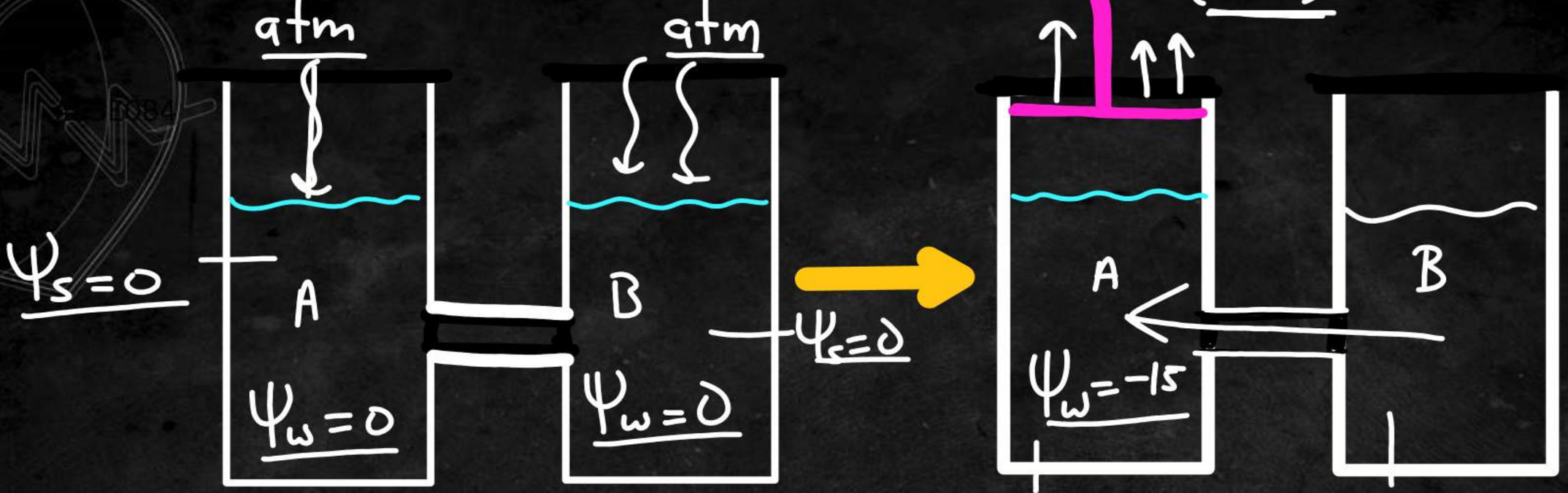
When Pressure is $-ve$ ($\psi_p = -ve$)



- atm = $\psi_p = 0$
- ψ_p = +ve (Push/Piston)
- ψ_p = -ve (Pull)

- $\psi_s = 0$
- $\psi_p = -15$

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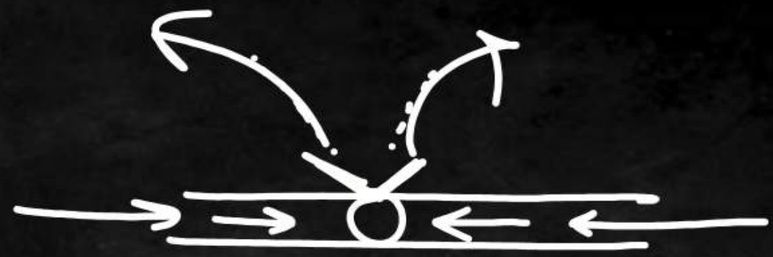
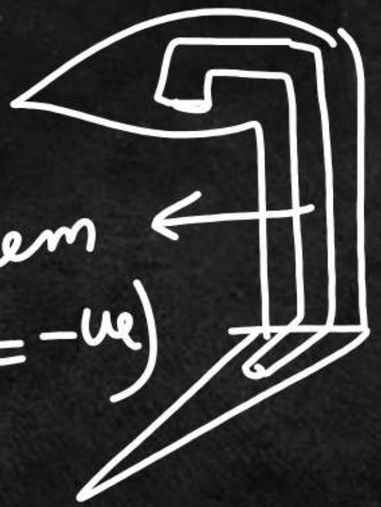
$$\Psi_w = \Psi_s + \Psi_p$$

Ψ_s (−ve)

Ψ_p (Usually +ve) But −ve pressure in Xylem



Garden hose (+ve) Ψ_p = +ve



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Summary of concepts

Ψ_w - symbol Psi - Greek word

Unit - Pascal

$\Psi_w \propto K \cdot \varepsilon \propto$ conc. of water molecule

$\Psi_s = -ve$

$[\Psi_w = \Psi_s]_{atm} \rightarrow \Psi_p = 0$

Direction → high Ψ_w to low Ψ_w
- high Ψ_s to low Ψ_s
  -5 -10

Direction of water movement

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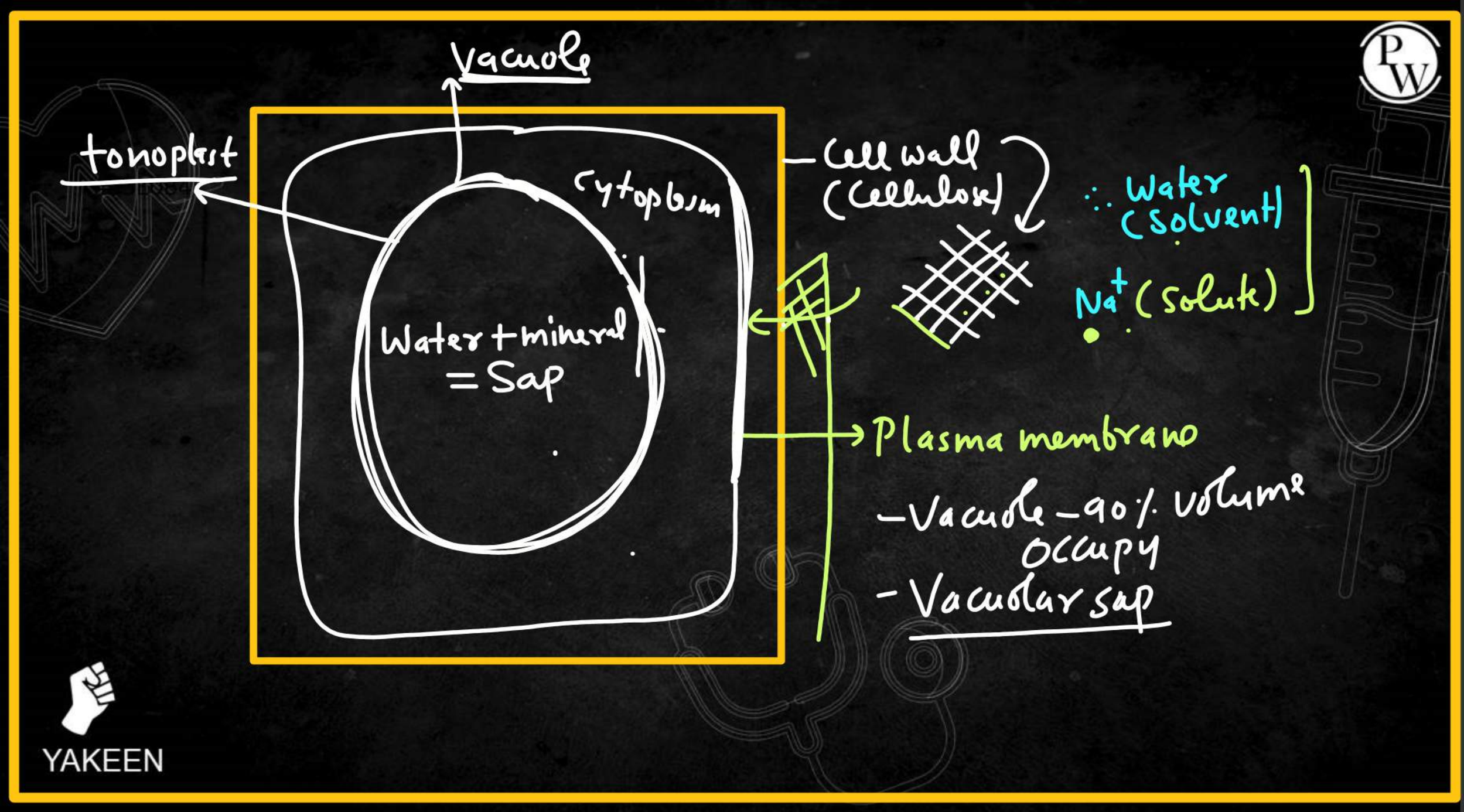
Vacuole
tonoplast
Cytoplasm
Water + mineral
= Sap
Cell wall
(Cellulose)
∴ Water
(Solvent)
Na+ (Solute)
Plasma membrane
- Vacuole - 90% volume
occupy
- Vacuolar sap
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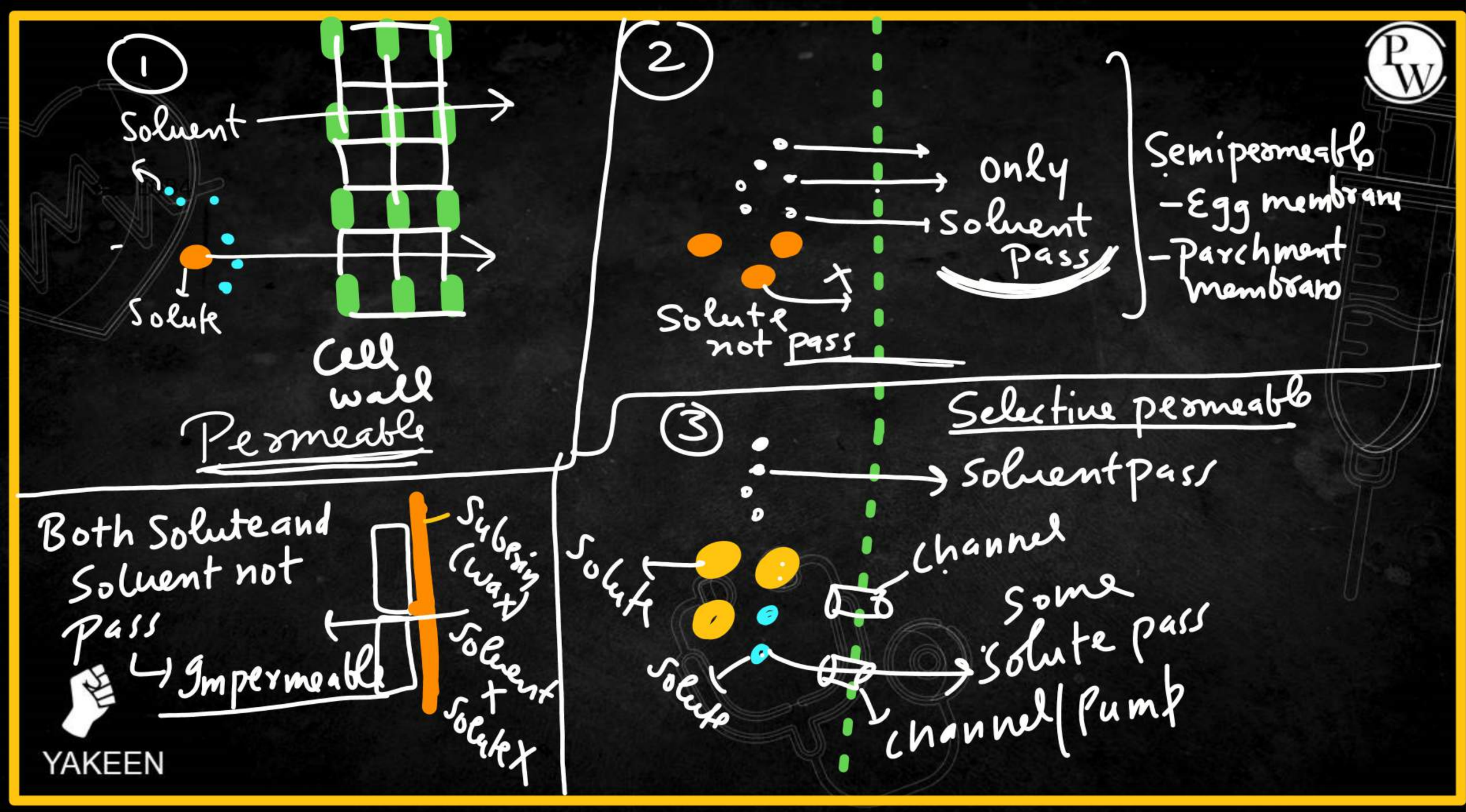
1
Solvent
Solute
Cell wall
Permeable
2
Only Solvent Pass
Solute not pass
Semipermeable
-Egg membrane
-Parchment membrane
3
Selective permeable
Solvent pass
Solute
Solute
Channel
Some Solute pass
Channel/Pump
Both Solute and Solvent not Pass
Impermeable
Solvent + Solute
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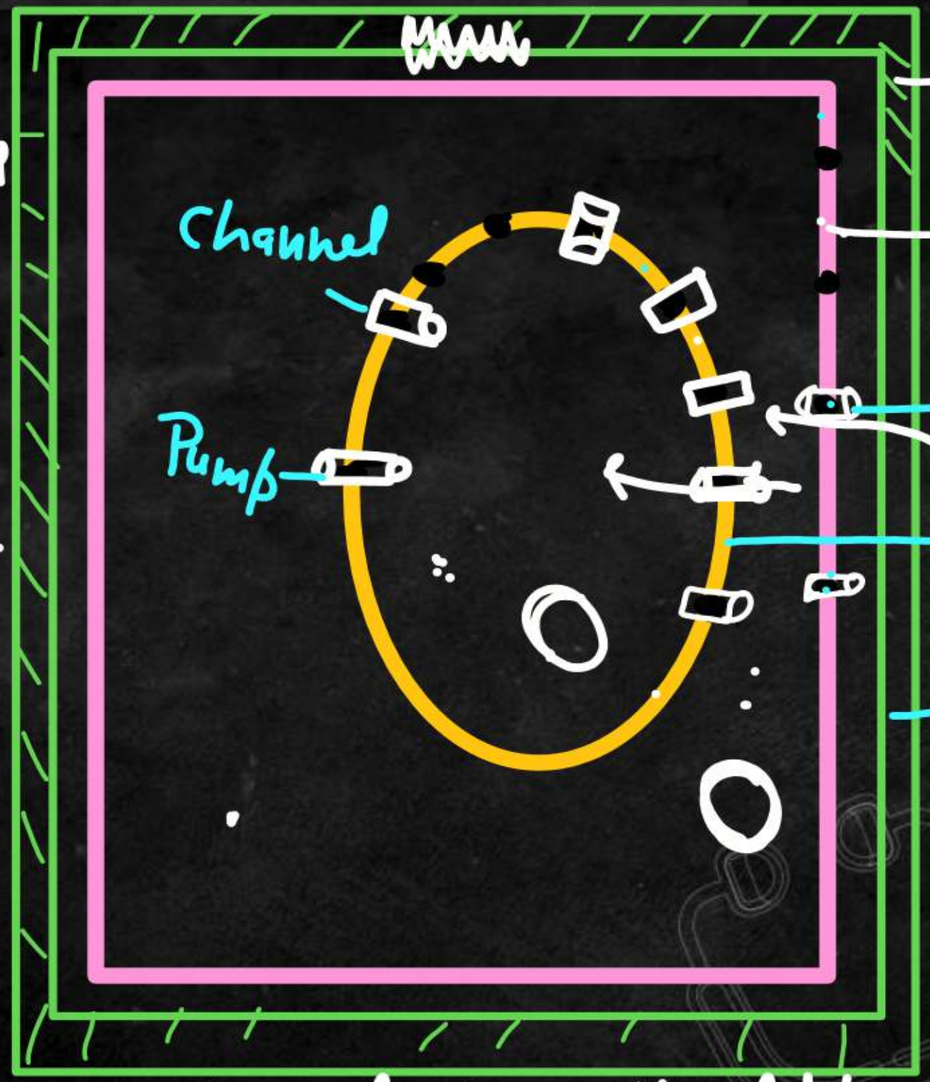
Type of membranes – 4 type



→ Cell membrane & tonoplast
- Control Amount of Solute inside

① Cell wall = Permeable For both solute + Solvent

② Plasma membrane] Selective permeable

Channel

tonoplast

cell wall

③ Semi permeable (only solvent pass)

④ Impermeable (Ex- Cork layer Endodermis)

Note- Vacuolar sap should be hypertonic to cytoplasm

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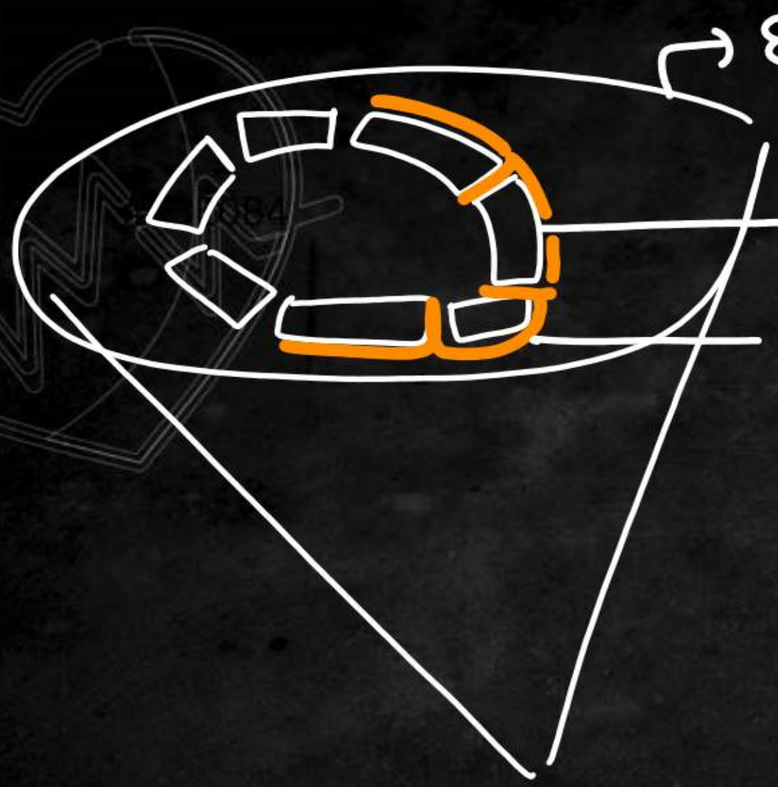

→ Epidermis

Endodermis

Wax layer – made up of Suberin] Impermeable

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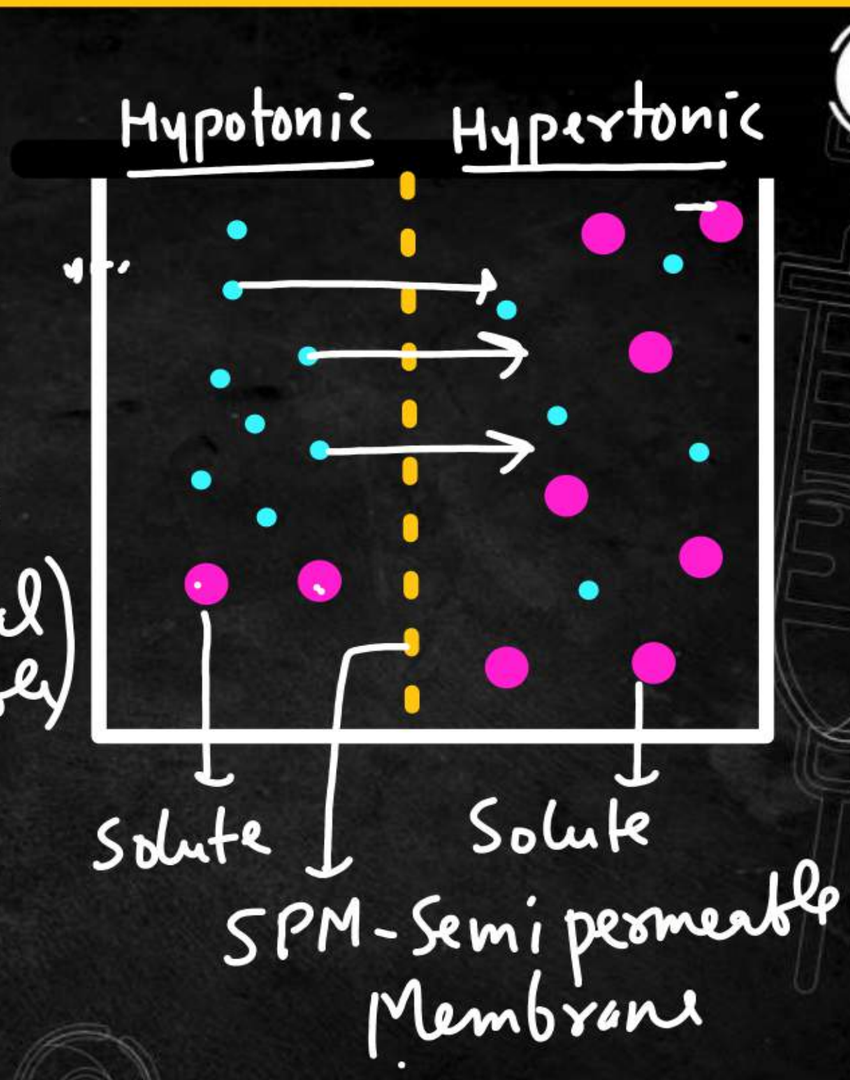
Osmosis

meaning - It is Diffusion of water molecule from high conc. of water to low conc. of water through Semi permeable (Selective or Differtial Permeable)

Role of P.M and tonoplast

Water move from Hypotonic to Hypertonic is Also by osmosis



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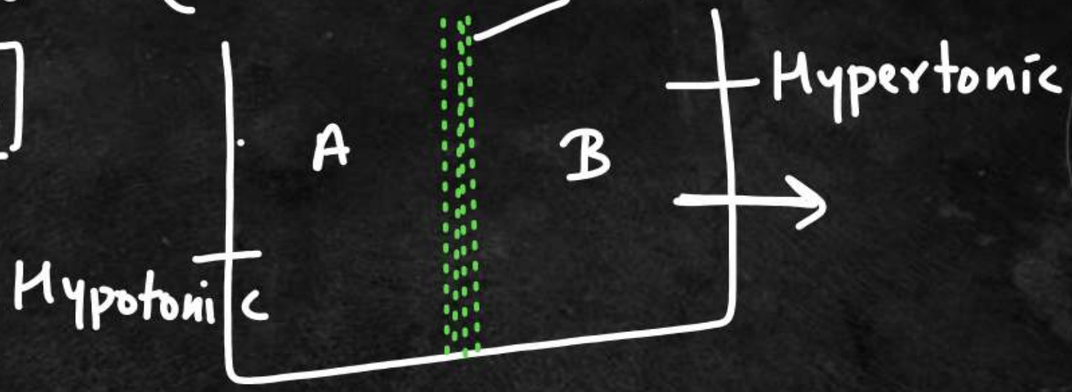
Osmosis – Diffusion of water molecule through Semi permeable membrane (SPM)

– Direction – Hypotonic (more water, less solute) to Hypertonic (more solute, less water)

Osmosis Require DRIVING FORCE

(a) Concentration of solute

(b) Pressure Gradient



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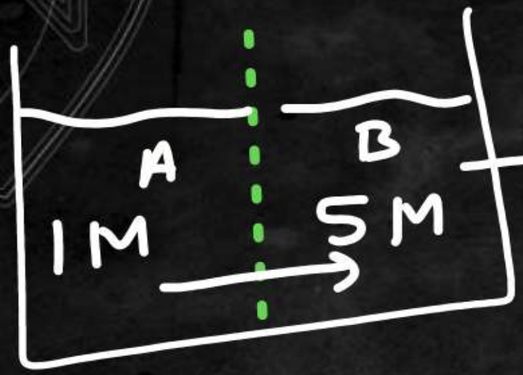
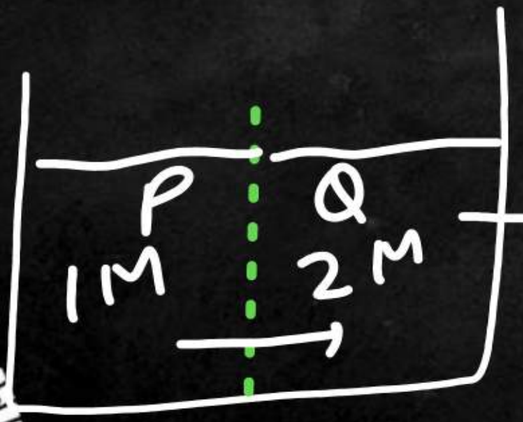
Direction of osmosis

- Direction And Rate of osmosis depend on — Concentration ✓
  — Pressure ✓



Hypertonic



Hypertonic

Direct in Beaker
A to B [Hypotonic to Hypertonic]
P to Q

⇒ Rate of A to B is Faster than P to Q

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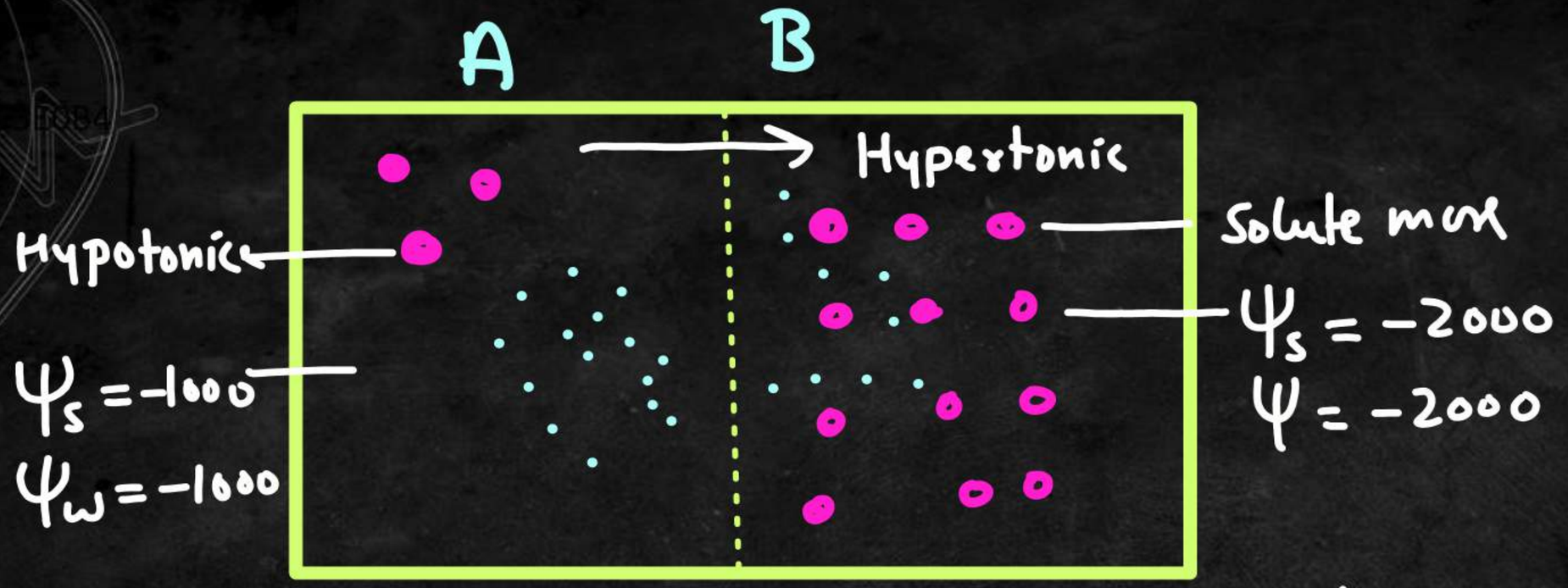

Direction Acc. to Osmosis = Hypotonic to Hypertonic

$\psi_w \rightarrow$ A to B

ψ_w high than ψ_B of B

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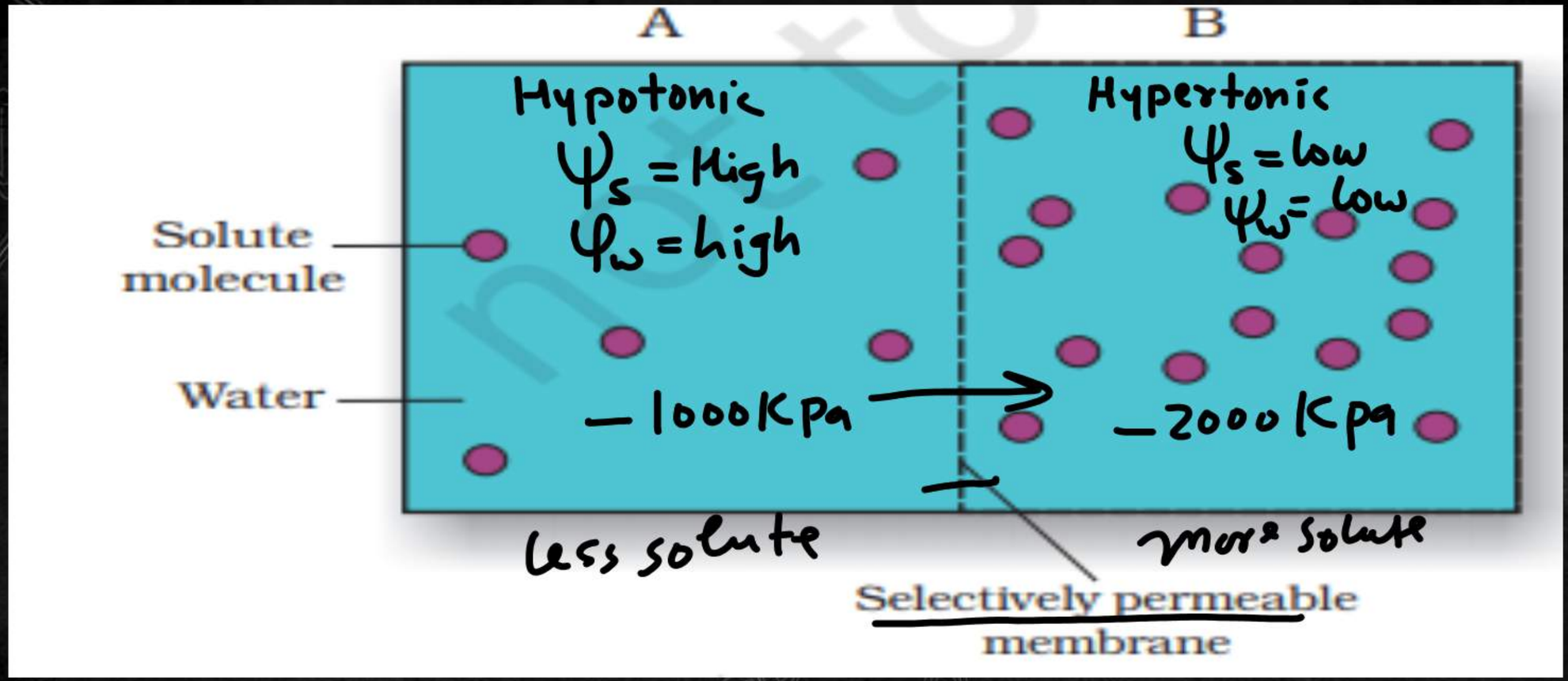
A
B
Hypotonic
ψ_s = High
ψ_w = high
Hypertonic
ψ_s = low
ψ_w = low
Solute molecule
Water
– 1000 KPa
– 2000 KPa
less solute
more solute
Selectively permeable membrane

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You may have made a potato osmometer in your earlier classes in school. If the potato tuber is placed in water, the water enters the cavity in the potato tuber containing a concentrated solution of sugar due to osmosis.

Study Figure 11.3 in which the two chambers, A and B, containing solutions are separated by a semi-permeable membrane.

(a) Solution of which chamber has a lower water potential? B

(b) Solution of which chamber has a lower solute potential? B

(c) In which direction will osmosis occur? A to B

(d) Which solution has a higher solute potential? A

(e) At equilibrium which chamber will have lower water potential? Both have same Ψ_w

(f) If one chamber has a Ψ of – 2000 kPa and the other – 1000 kPa, which is the chamber that has the higher Ψ?

$\Psi_w = 0.2 \rightarrow \Psi_w = 0.1$

(g) What will be the direction of the movement of water when two solutions with Ψ_w = 0.2 MPa and Ψ_w = 0.1 MPa are separated by a selectively permeable membrane?

Potato osmometer

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11.2.2 Osmosis

The plant cell is surrounded by a cell membrane and a cell wall. The cell wall is freely permeable to water and substances in solution hence is not a barrier to movement. In plants the cells usually contain a large central vacuole, whose contents, the vacuolar sap contribute to the solute potential of the cell. In plant cells, the cell membrane and the membrane of the vacuole, the tonoplast together are important determinants of movement of molecules in or out of the cell.

Osmosis is the term used to refer specifically to the diffusion of water across a differentially- or selectively permeable membrane. Osmosis occurs spontaneously in response to a driving force. The net direction and rate of osmosis depends on both the **pressure gradient** and **concentration gradient**. Water will move from its region of higher chemical potential (Ψ_w) (or concentration of water) to its region of lower chemical potential until equilibrium is reached. At equilibrium the two chambers should have nearly the same water potential.

Concept of Reverse osmosis (R.O)

Semipermeable membrane Source

- To study R.O we Require Semipermeable membrane
- Source is Egg → 

Hole Create in Egg

Albumin + yolk Remove

Put in HCl $CaCO_3$ (Dissolve)

Now we obtain Semipermeable membrane

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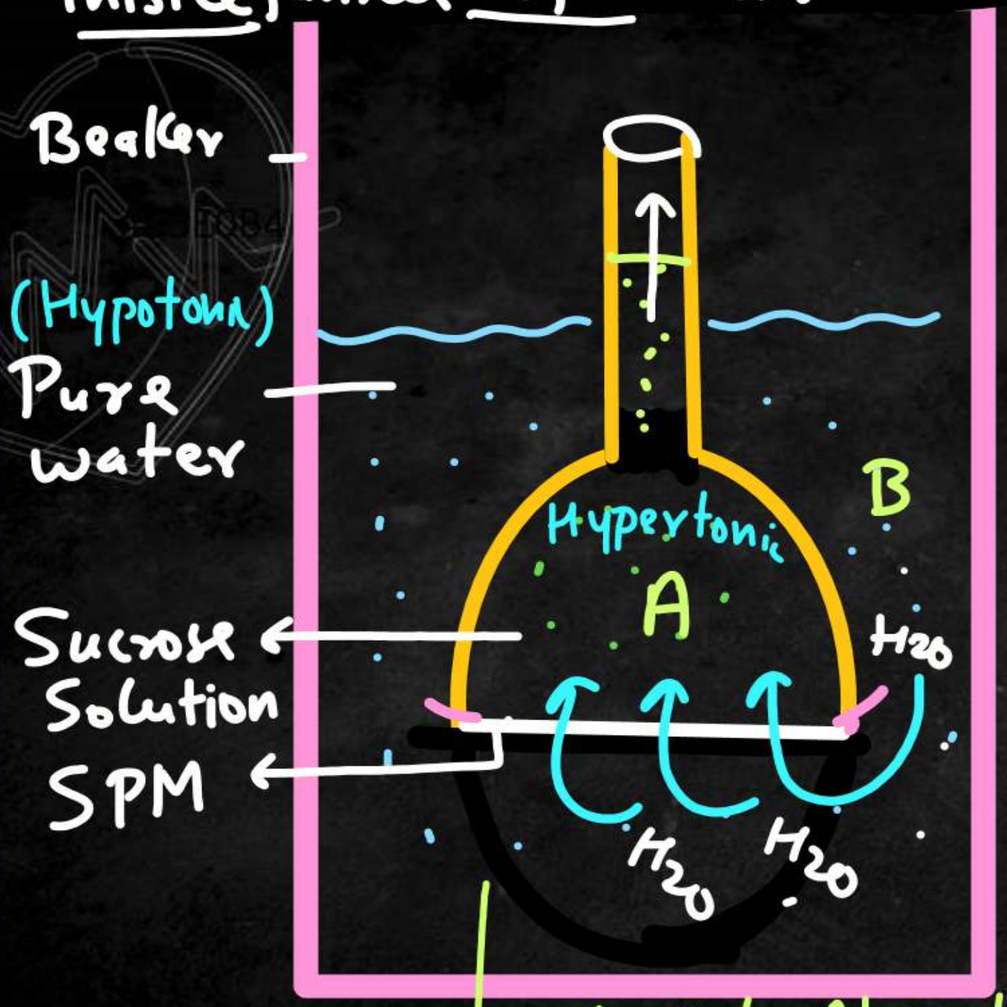
Thistle funnel Experiment



$\psi_w = 0$ (Solute Absent, pressure = atm)

In chamber B – Pure water $[\psi_w = 0]$
(Solute Absent)

In Funnel, due to Sucrose
$\psi_w = -ve$ [Assume $\psi_w = -5$]

Osmosis → (High ψ_w to low ψ_w]

Direction of water movement
high ψ_w to low ψ_w

B to A – Water move inside Funnel
Untill Equilibrium reached

If Sucrose move – Is Equilibrium Will achieve = no

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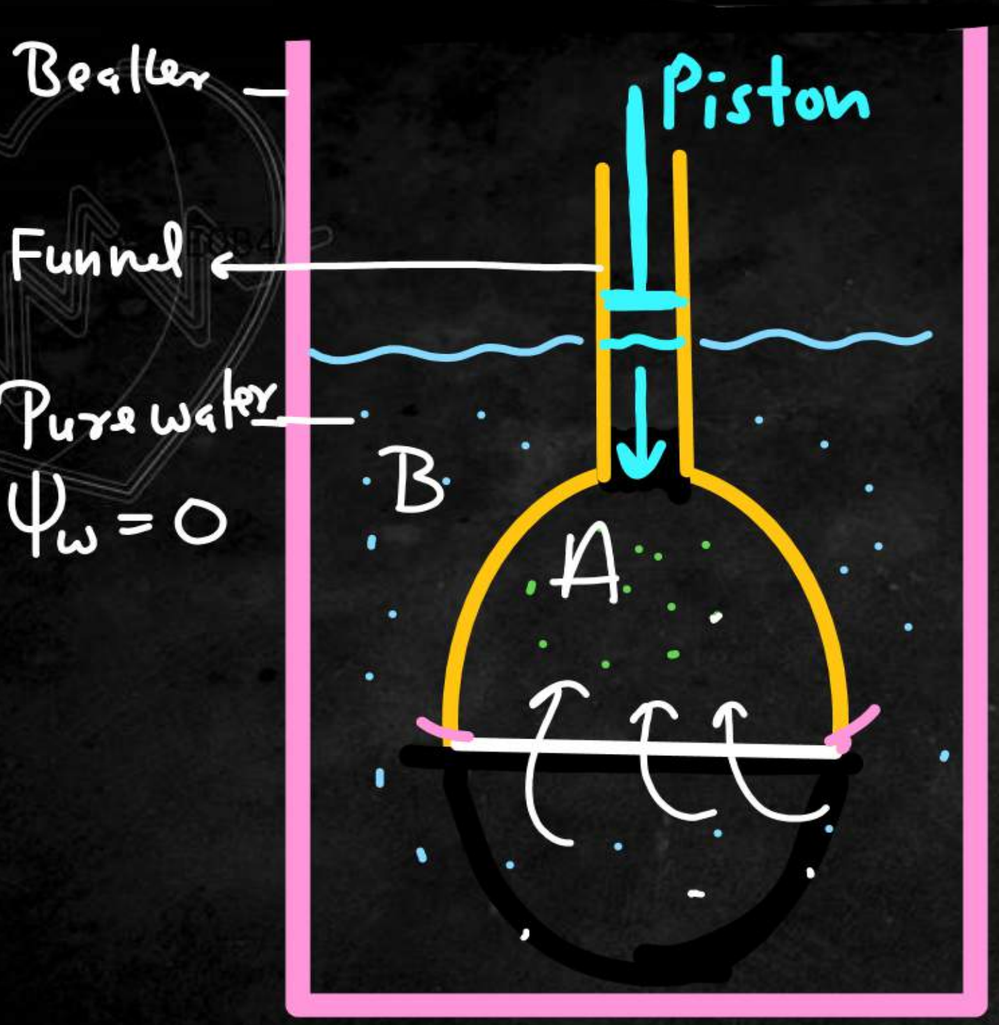

In chamber B $\rightarrow \psi_w = 0$ [water tend to move B to A]

How we can stop Entry of water :-

Piston Pressure Apply - Entry of water stop

Driving Force For Osmosis = Solute Conc.

If Entry of water stop it is possible Only when ψ_w Become Zero in Both **A & B**

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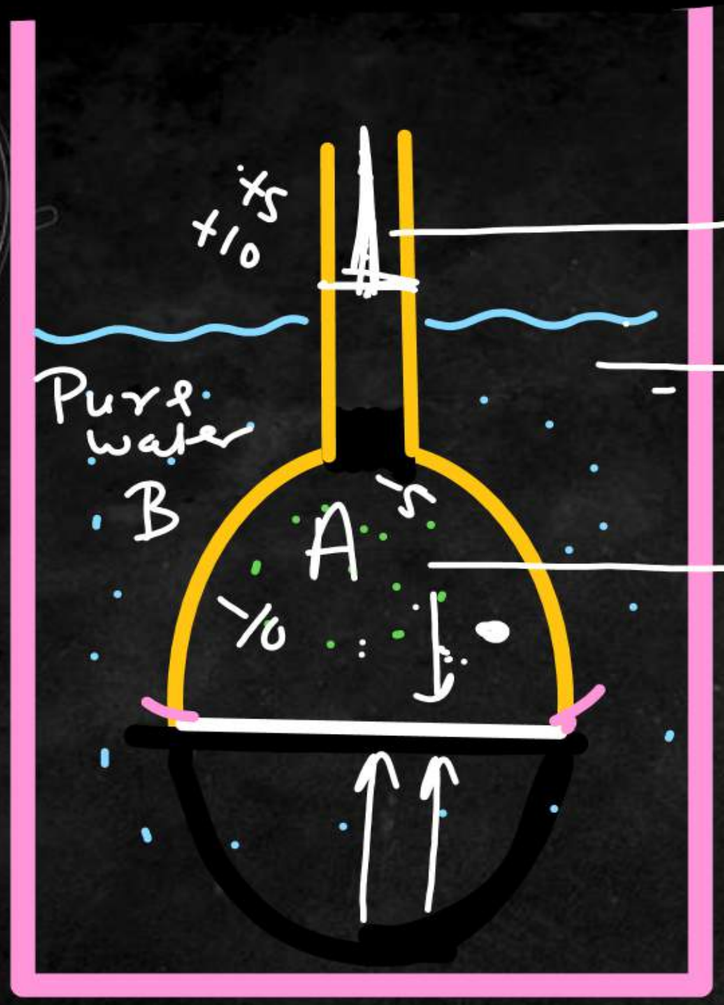

By Piston Pressure Apply More than Atmospheric Pressure

↓

It stop Entry of water in Funnel

$\rightarrow B = \psi_w = 0$ (magnitude of Pressure By piston Should be Equal to Solute Potential

$\psi_{w_A} = -5$ Initially, After Piston $\psi_{w_A} = 0$

$\psi_w = \psi_s + \psi_p$

$-5 \quad +5$

↓

By Piston

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Solute potential = ψ_s

Solute = osmotic potential

In chamber A, when Entry of water stop
It is due to the pressure By Piston

ψ_w in A = −5 → (Piston pressure apply) → ψ_w in A = 0

$\psi_w = \psi_s + \psi_p$

$\psi_w = 0$

$\psi_p + \psi_s = 0$

$\psi_p = -\psi_s$

Pressure Applied By Piston
depend on solute conc. in Funnel
Such prossure is **Osmotic pressure**

ψ_p → Osmotic pressure

ψ_s → Osmotic Potential

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$$-\Psi_S = \Psi_P$$

- Solute potential = Osmotic pressure
  or
  Osmotic potential
  (magnitude Same, Direction opposite)

- Piston – use to Apply pressure more than atmospheric pressure)

If a solution have $\Psi_S = -10$ than O.P = ?

O.P = +10

Solute $\propto$ O.P $\propto \frac{1}{\Psi_S}$

0 +10 -10

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Reverse Osmosis - Pressure more than Osmotic Pressure

$\psi_w = 0$

$\psi_w = -5 \left(\overset{-5}{\psi_s} + \overset{0}{\psi_p} \right)$ Initially

↓ Piston pressure apply

$\psi_w = 0$ (Entry of water stop)

$(\psi_p = +5)$

Pressure By Piston more than atm and it is Equal (Equal to O.P.)

$\psi_w = \underline{+10}$ (Piston Apply more pressure — more than Osmotic pressure

$\psi_s = -5$ $\psi_p = \underline{+15}$

Direction A to B

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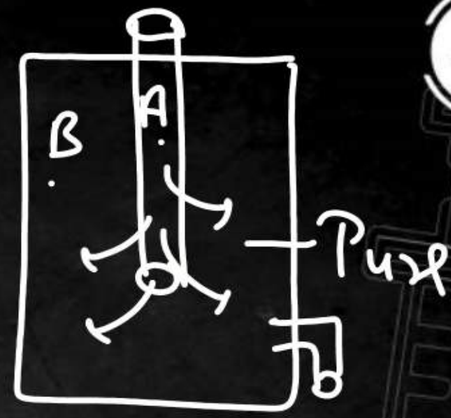

⊛ Osmosis ⇒ (Bealer Direction Funnel
Hypotonic to Hypertonic
high ψ_w to low ψ_w (Funnel)
0 $-ve$

⊛ R.O → Hypertonic to Hypotonic
(Funnel) (Bealer)
high ψ_w to low ψ_w
(+ve) (Bealer)
(Funnel)

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Give Direction of water

high Ψ_w $\longrightarrow$ low Ψ_w

$+20$ $\quad$ $+10$

Ψ_s $\longrightarrow$ Ψ_s

-10 (high) $\quad$ -20 (low)

O·P $\longrightarrow$ O·P

$+10$ low $\quad$ $+20$ high

Osmotic pressure

low O·P to high O·P

Ψ_s to low Ψ_s

High

$$-\Psi_s = O \cdot P$$

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why Roots of halophyte's have more solute in Root

Soil
O·P = 3

↓ High Salt conc.

Soil
O·P = 30

Halophytes

Root O·P should be Greater than Soil

Direction – low O·P to High O·D

To Absorb water Rooted halophytes Should Accumulate more salt

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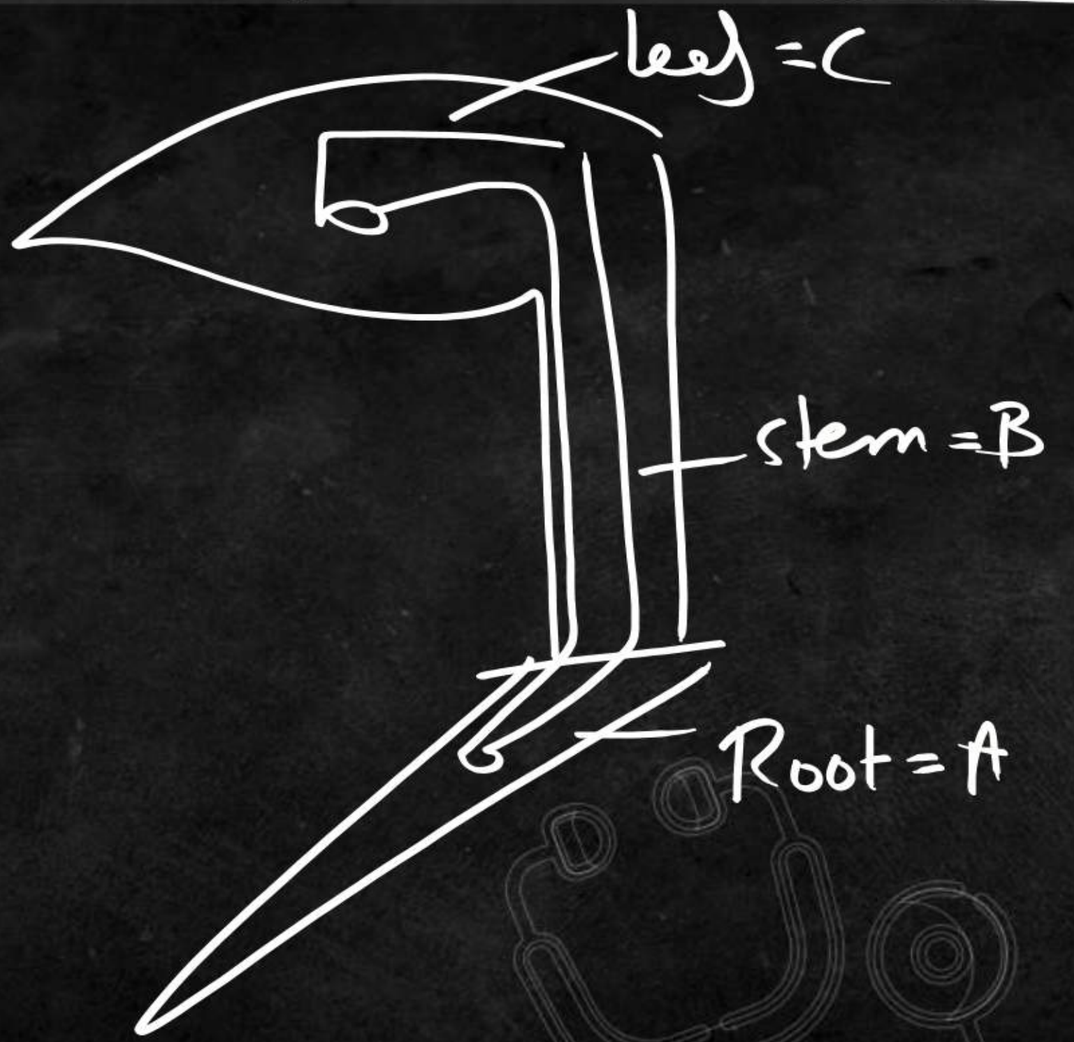
In which part of plant have highest op



A =
B =
C =

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Q1 In Reverse osmosis
Direction of Water

If value of $\Psi_s = -10$, than
Pressure which is O·P is =
and For R·O pressure is

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Let us discuss another experiment where a solution of sucrose in water taken in a funnel is separated from pure water in a beaker by a selectively (or Semi) permeable membrane (Figure 11.4). *You can get this kind of a membrane in an egg. Remove the yolk and albumin through a small hole at one end of the egg, and place the shell*

in dilute solution of hydrochloric acid for a few hours. The egg shell dissolves leaving the membrane intact. Water will move into the funnel, resulting in rise in the level of the solution in the funnel. This will continue till the equilibrium is reached. In case sucrose does diffuse out through the membrane, will this equilibrium be ever reached?

External pressure can be applied from the upper part of the funnel such that no water diffuses into the funnel through the membrane. This pressure required to prevent water from diffusing is in fact, the osmotic pressure and this is the function of the solute concentration; more

the solute concentration, greater will be the pressure required to prevent water from diffusing in. Numerically osmotic pressure is equivalent to the osmotic potential, but the sign is opposite. Osmotic pressure is the positive pressure applied, while osmotic potential is negative.

$-\psi_s = \psi_p$

O.P = +ve

ψ_s = −ve

7. The water potential of pure water is: (2017-Delhi)

a. Zero

b. Less than zero

c. More than zero but less than one

d. More than one

24. The movement of ions against the concentration gradient will be

(a) active transport ✓ (b) osmosis ✗

(c) diffusion (d) all of the above.

(2000)

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15. Which of the following criteria does not pertain to facilitated transport? (2013)

a. Uphill transport

b. Requirement of special membrane proteins

c. High selectivity

d. Transport saturation S SI

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THANK YOU !!