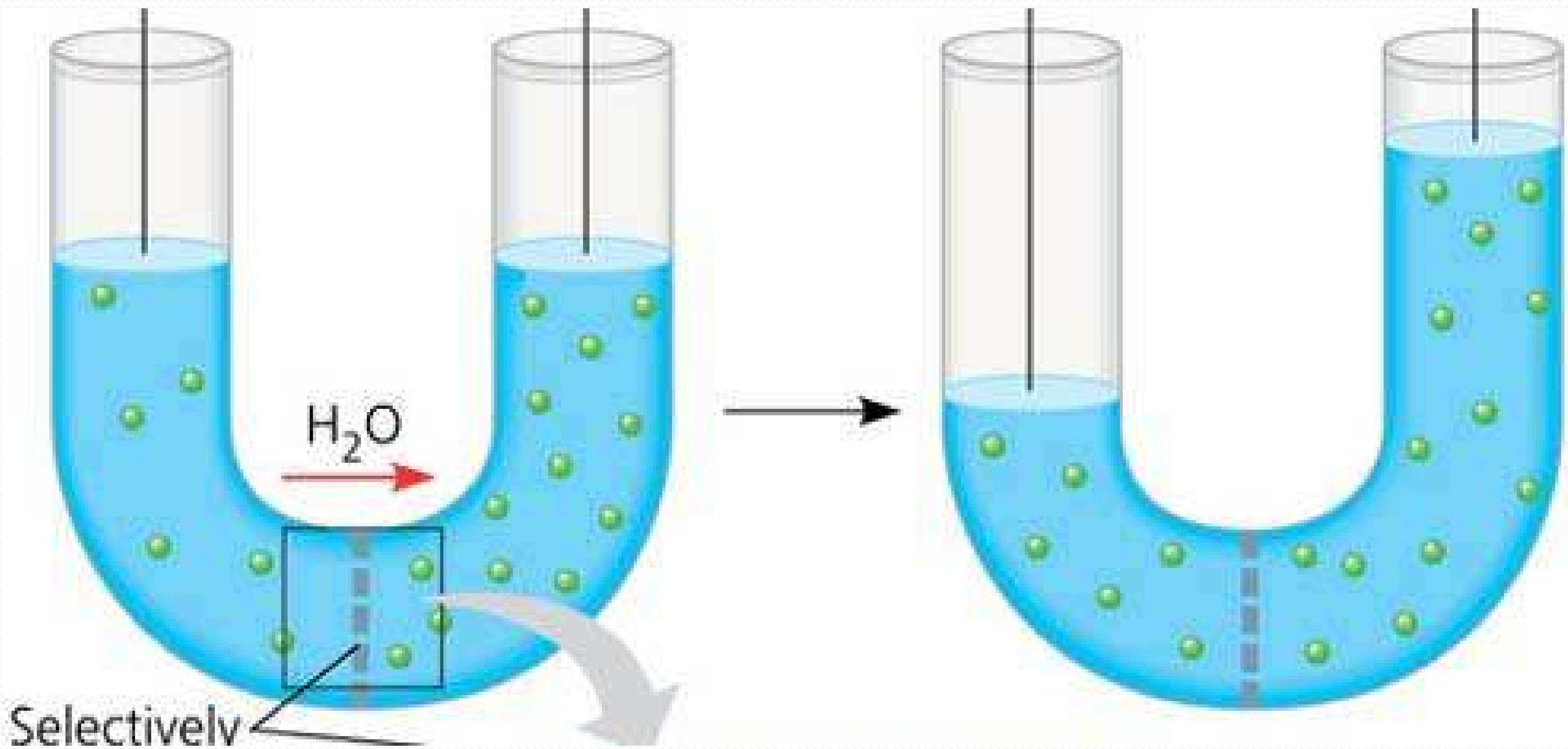
Water Potential

And some other osmosis related stuff

So far, what have we observed?

Osmosis

- Water diffuses from areas of high water concentration to areas of low water concentration
- How can we explain this?



Another way to think about it.

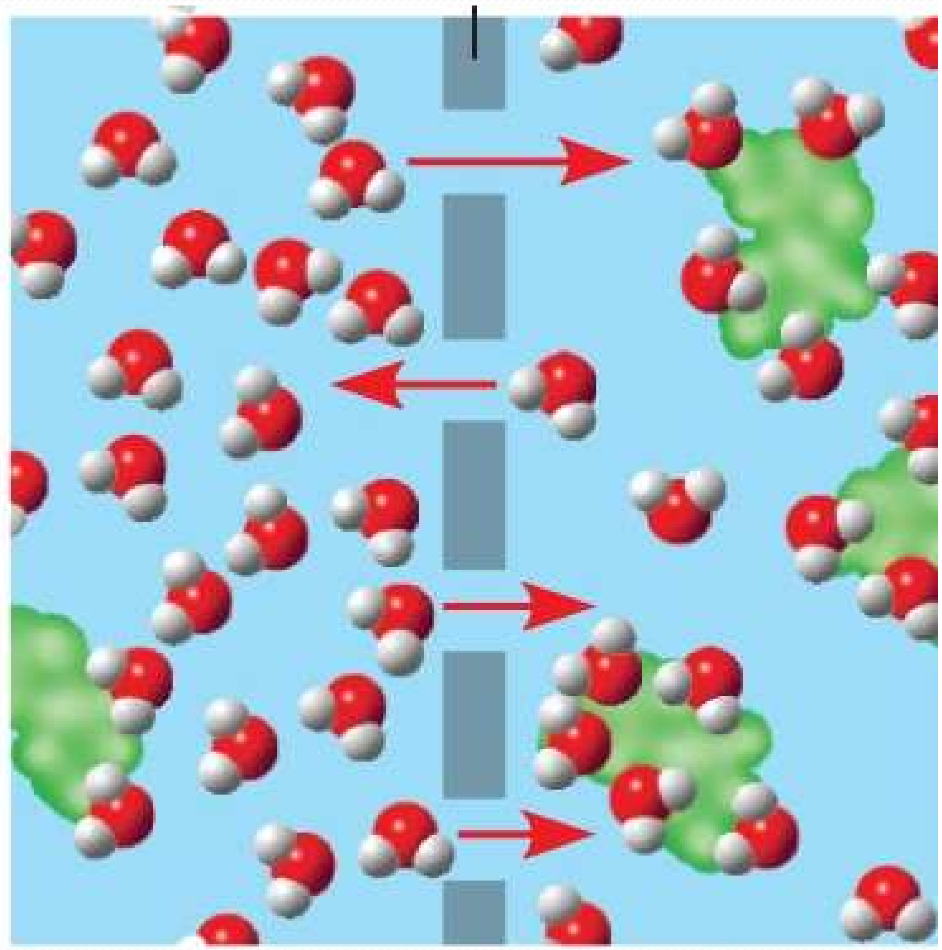
- Water moves from areas of low solute to high solute

- Logic says that having a higher concentration of solute, means also having a lower concentration of water and naturally water will flow into the area of lower water concentration.
- True, but what is the rest of the story?

Free water!

- Some water becomes unavailable to cross because it is attracted to a hydrophilic solute

- BUT, water will still move from the region of lower solute concentration to the region of higher solute concentration until the solute concentrations are equal



Dialysis tubing and tonicity

- What is able to move across the tubing?

How does osmosis affect cells?

- Animal cells?
- Plant cells?

What is water potential?

- Water potential predicts which way water diffuses through plant tissues.
- Abbreviated by the Greek letter psi (Ψ)

What is water potential?

- Potential energy of water
  - Free energy per mole of water
    - Mole: molecular weight of a substance
  - It takes pressure into account, along with solute concentration

- Where does the pressure come from?

The Equation

- $\Psi = \Psi_P + \Psi_S$

- Ψ_P is pressure potential
- Ψ_S is solute potential

- Water potential = Pressure potential + Solute Potential

The Equation

- $\Psi = \Psi_P + \Psi_S$

- Ψ_P: the physical pressure put on a solution.
  - Can be positive or negative.
- Ψ_S : proportional to the amount of dissolved solute in the solution. (Also called osmotic potential).
  - Always negative because it decreases the ability of water to move.

Water potential determines the direction of movement of water

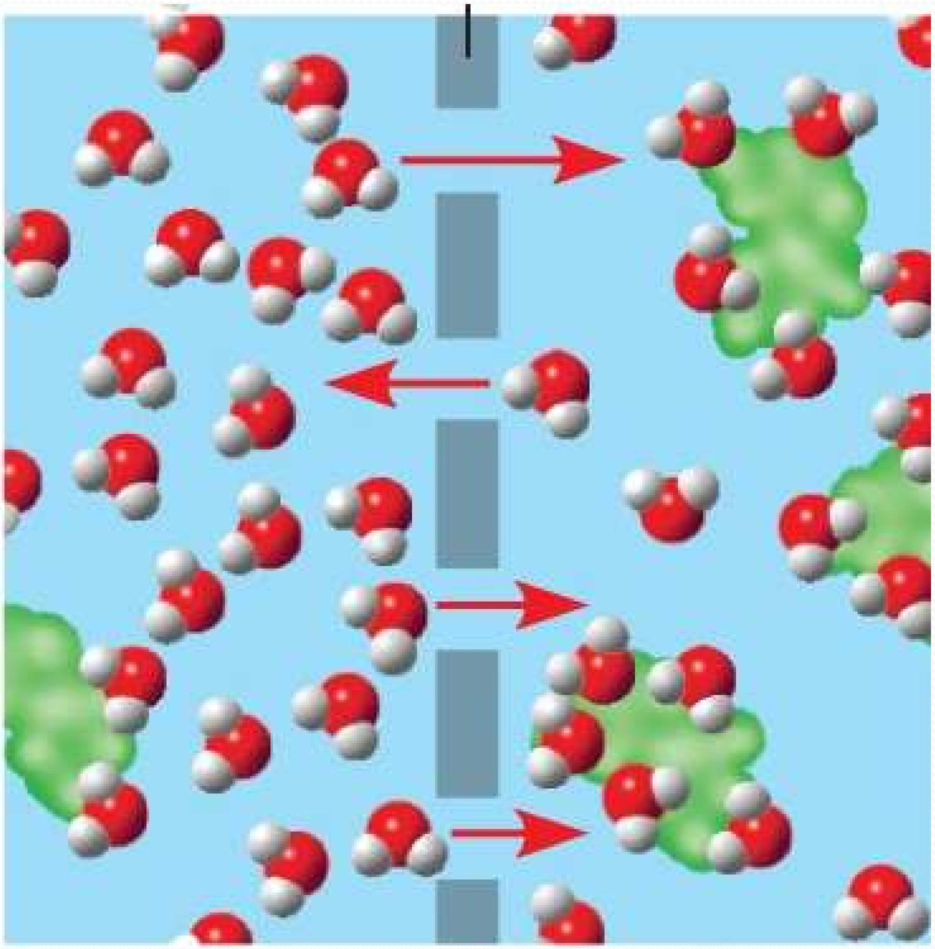
- $\Psi = \Psi_P + \Psi_S$

- This means that water will move from areas of high water potential to areas of low water potential.
- High water potential is more positive
- Measured in Mpa (Megapascals, a unit of pressure)

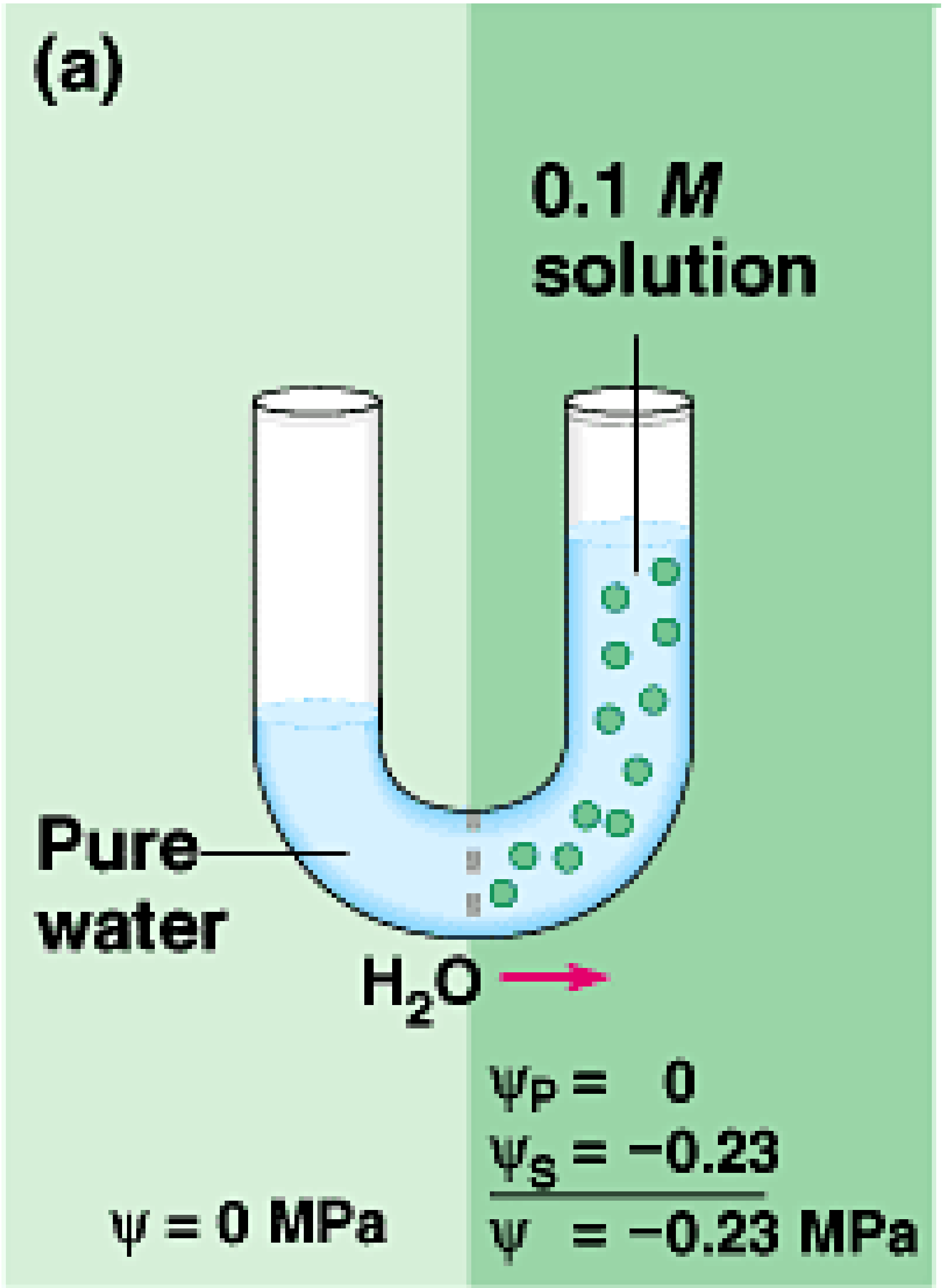
How do you get a negative pressure potential?

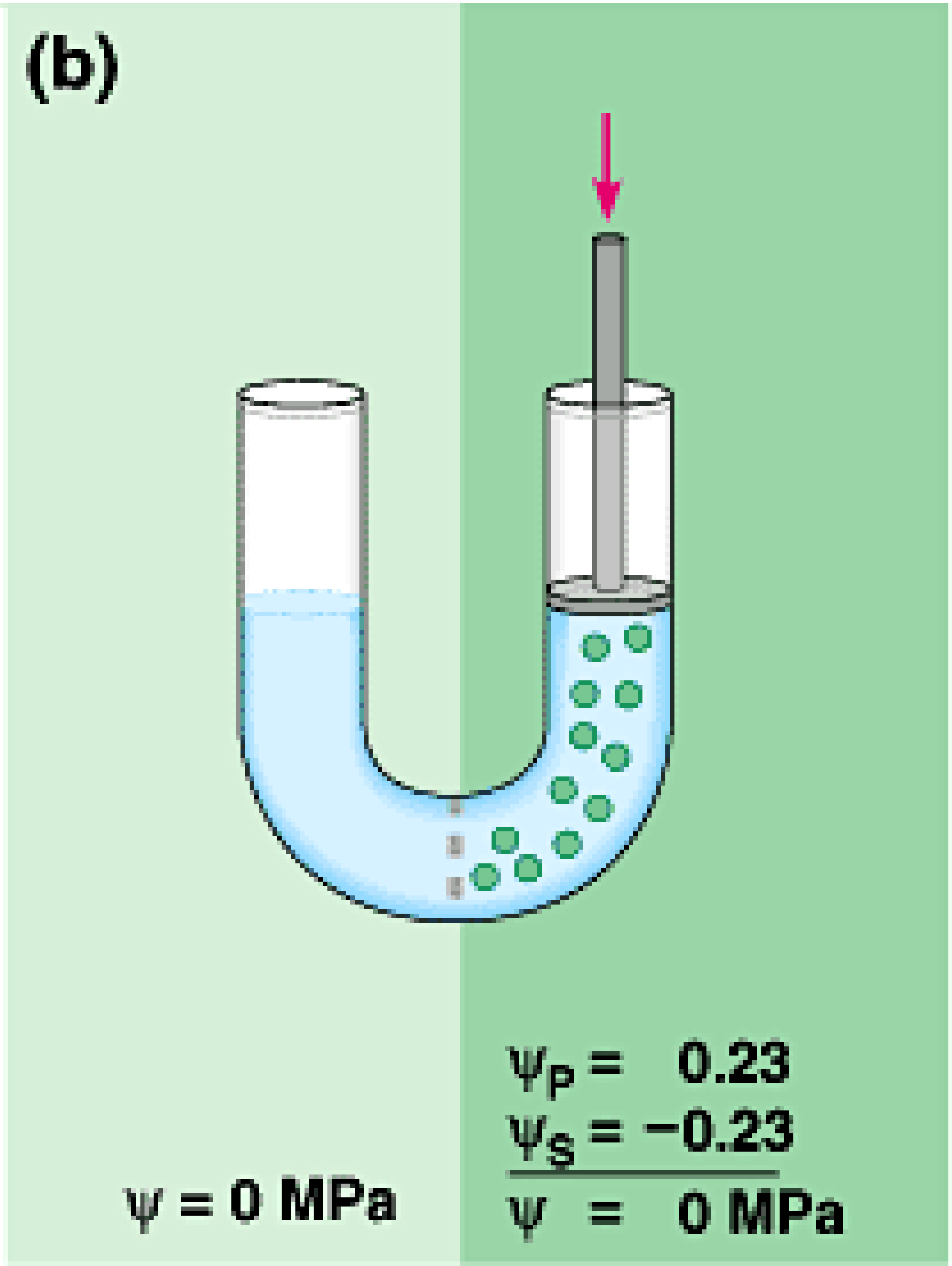
How do solutes decrease the ability of water to do work?

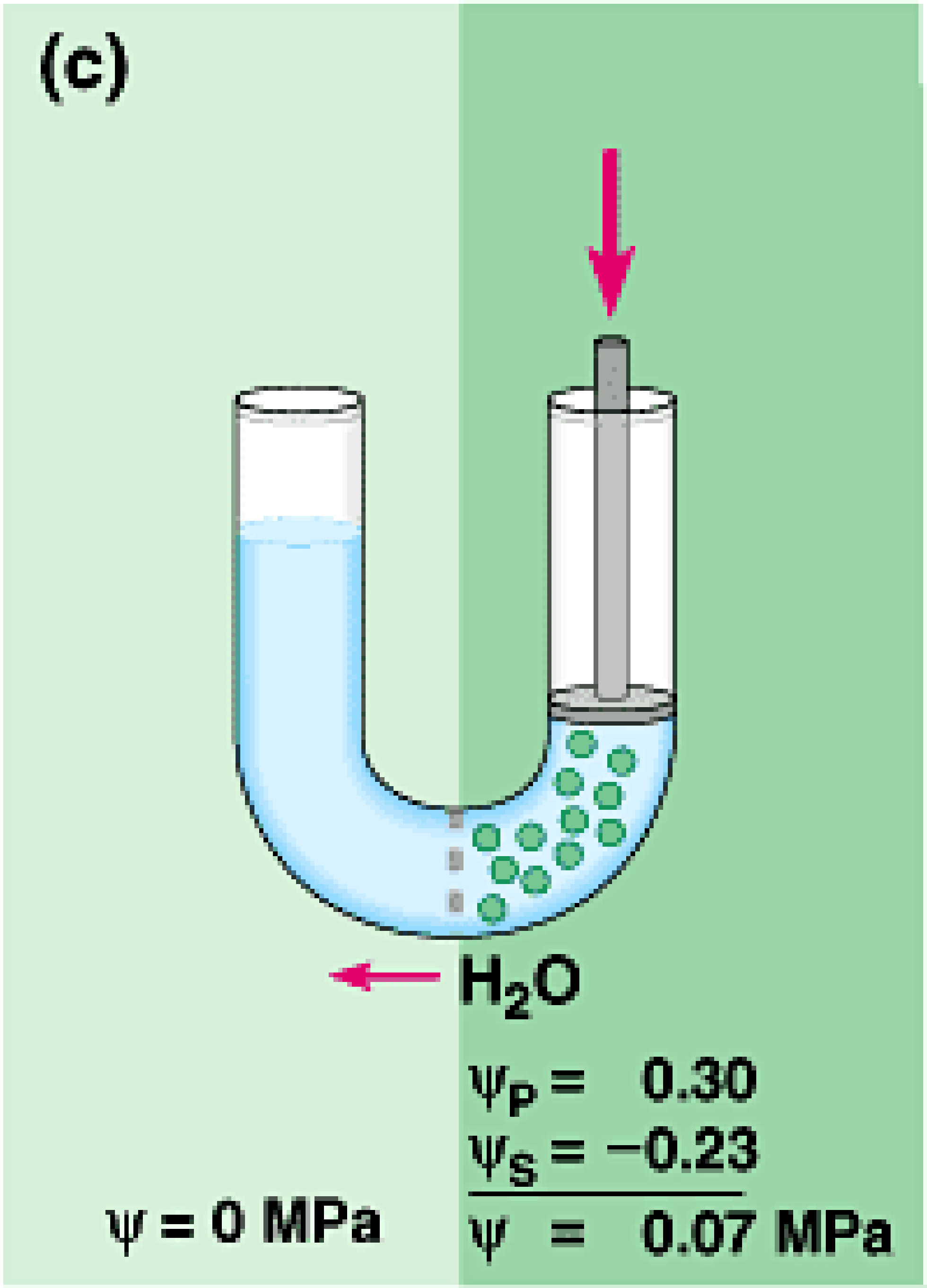
Free water!



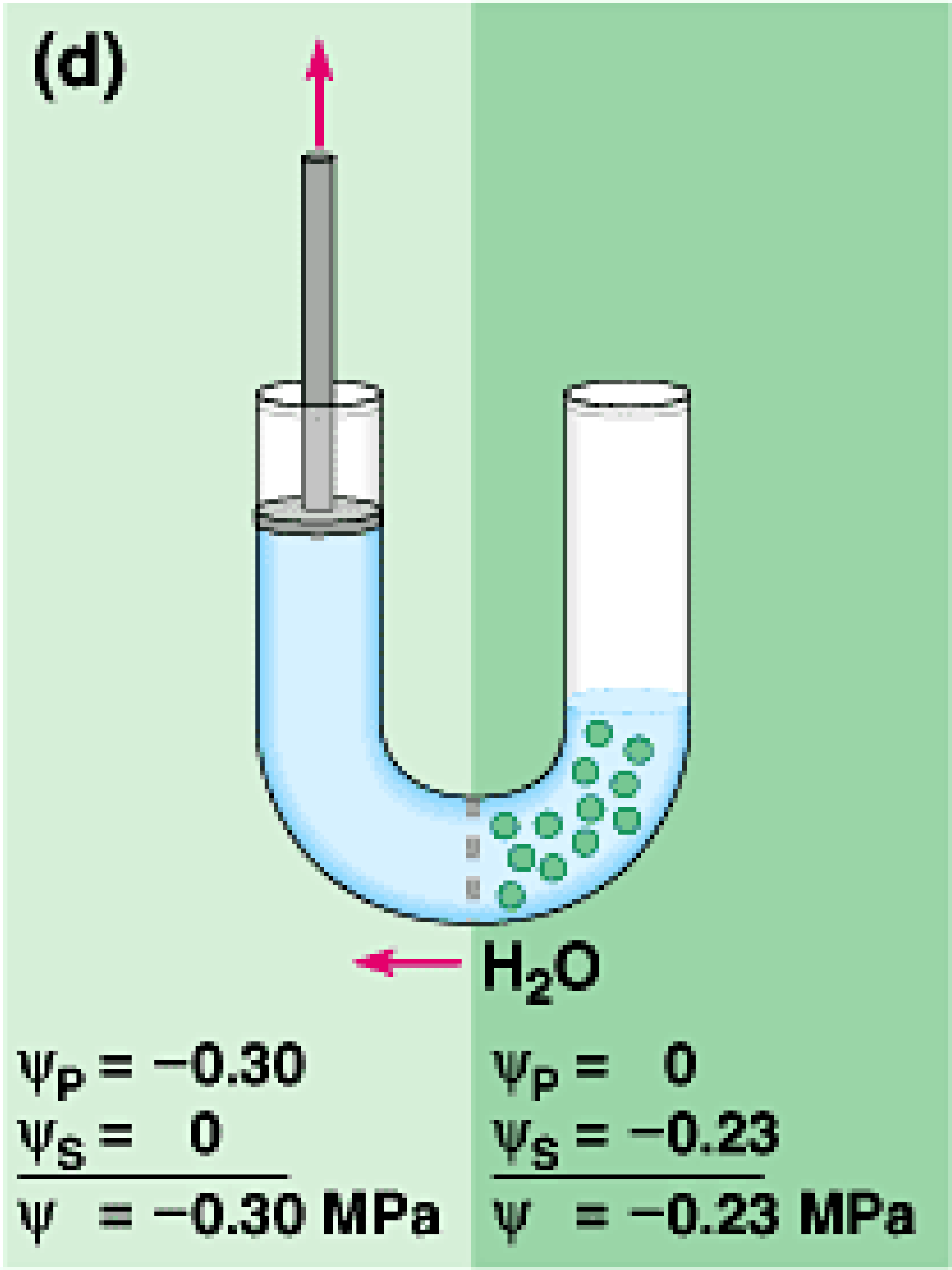
How can we explain water movement in an artificial system?


(a)
0.1 M solution
Pure water
H_2O
$\psi_P = 0$
$\psi_S = -0.23$
$\psi = -0.23$ MPa
$\psi = 0$ MPa

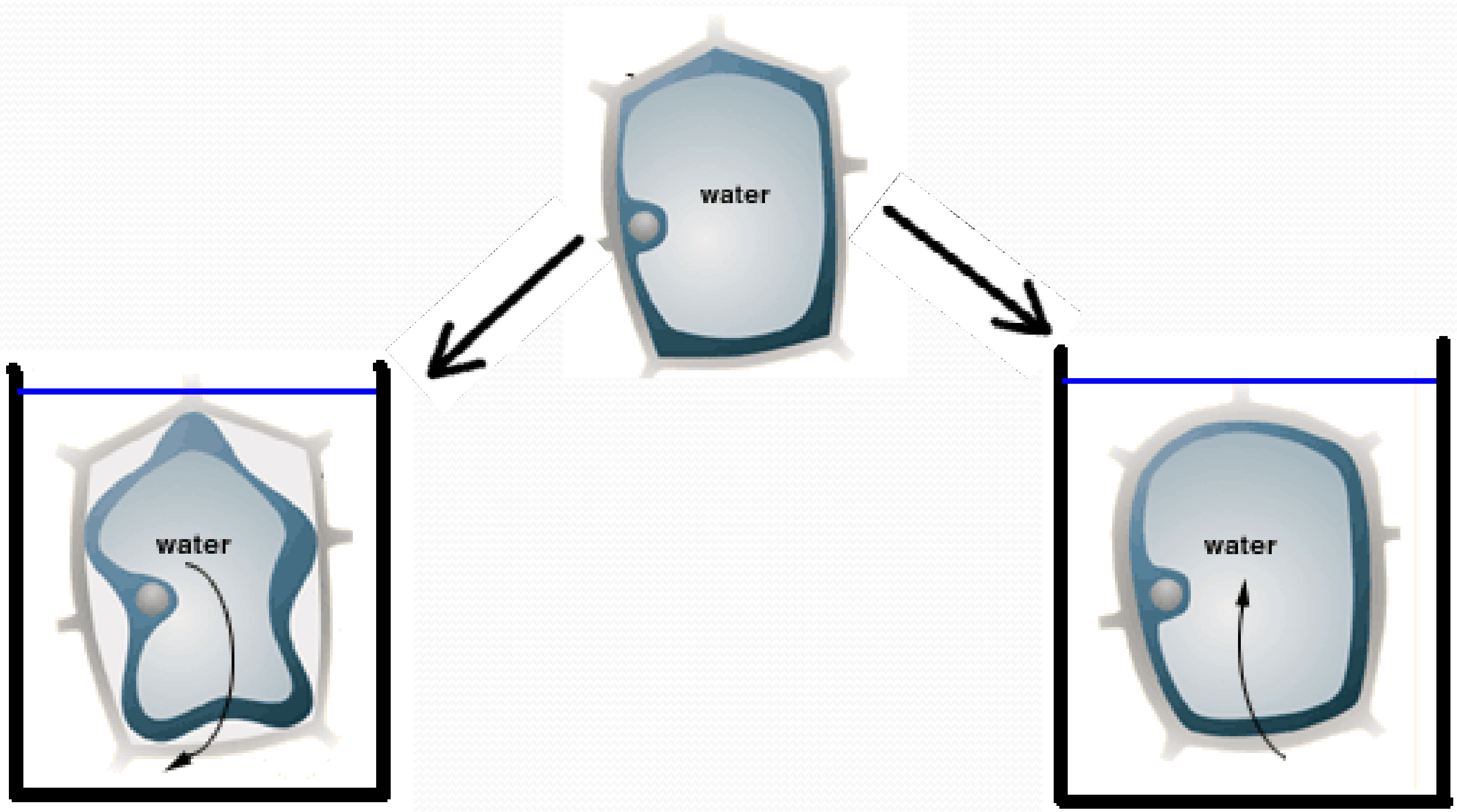

(b)
ψ = 0 MPa
ψP = 0.23
ψS = −0.23
ψ = 0 MPa



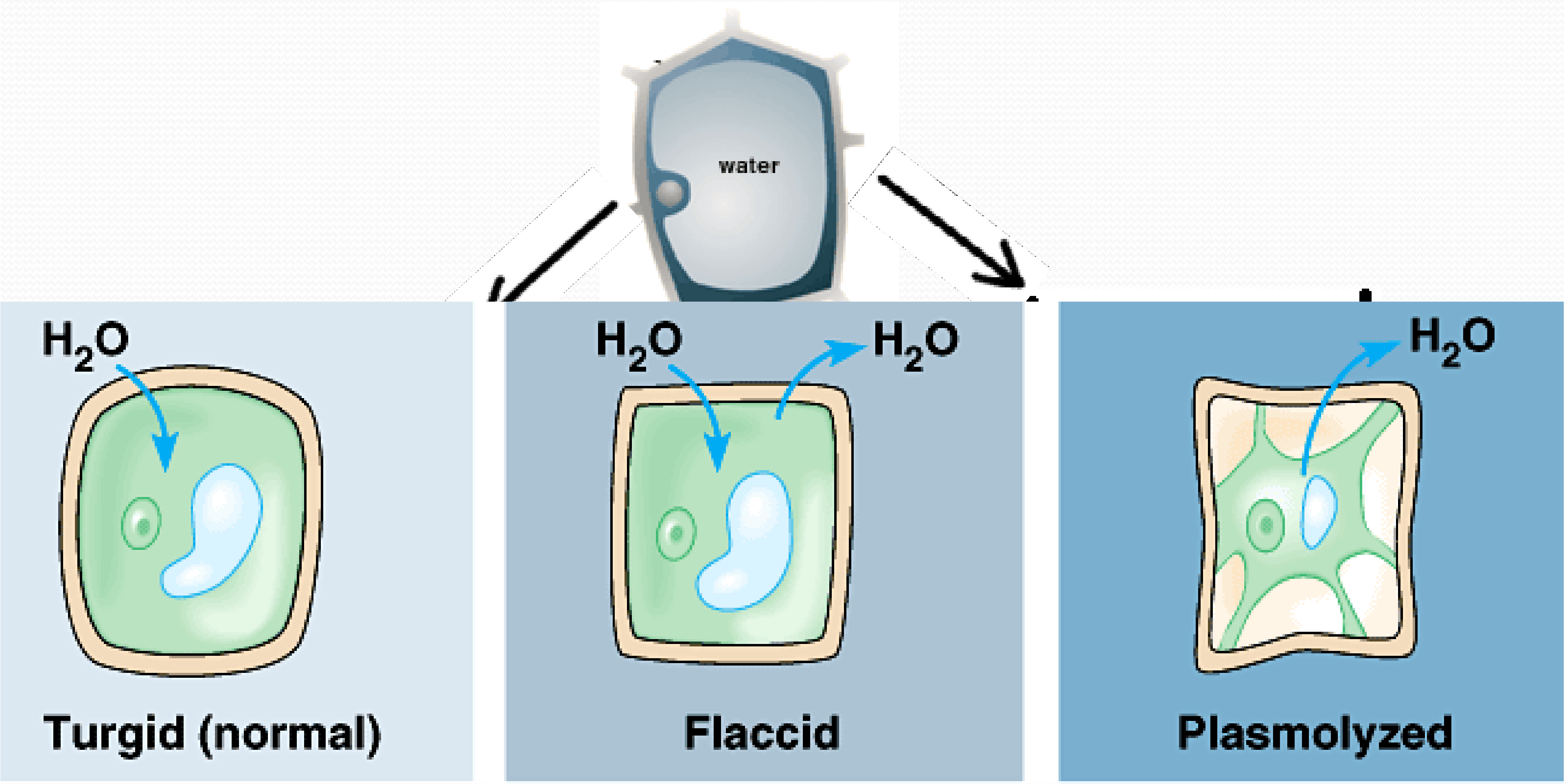
(c)
H_2O
$\psi_P = 0.30$
$\psi_S = -0.23$
$\psi = 0.07$ MPa
$\psi = 0$ MPa


(d)
H2O
ψP = −0.30
ψS = 0
ψ = −0.30 MPa
ψP = 0
ψS = −0.23
ψ = −0.23 MPa

How does water potential affect living plant cells?


water
water
water

What do we call the results on these cells?



How does turgor play a part in this?

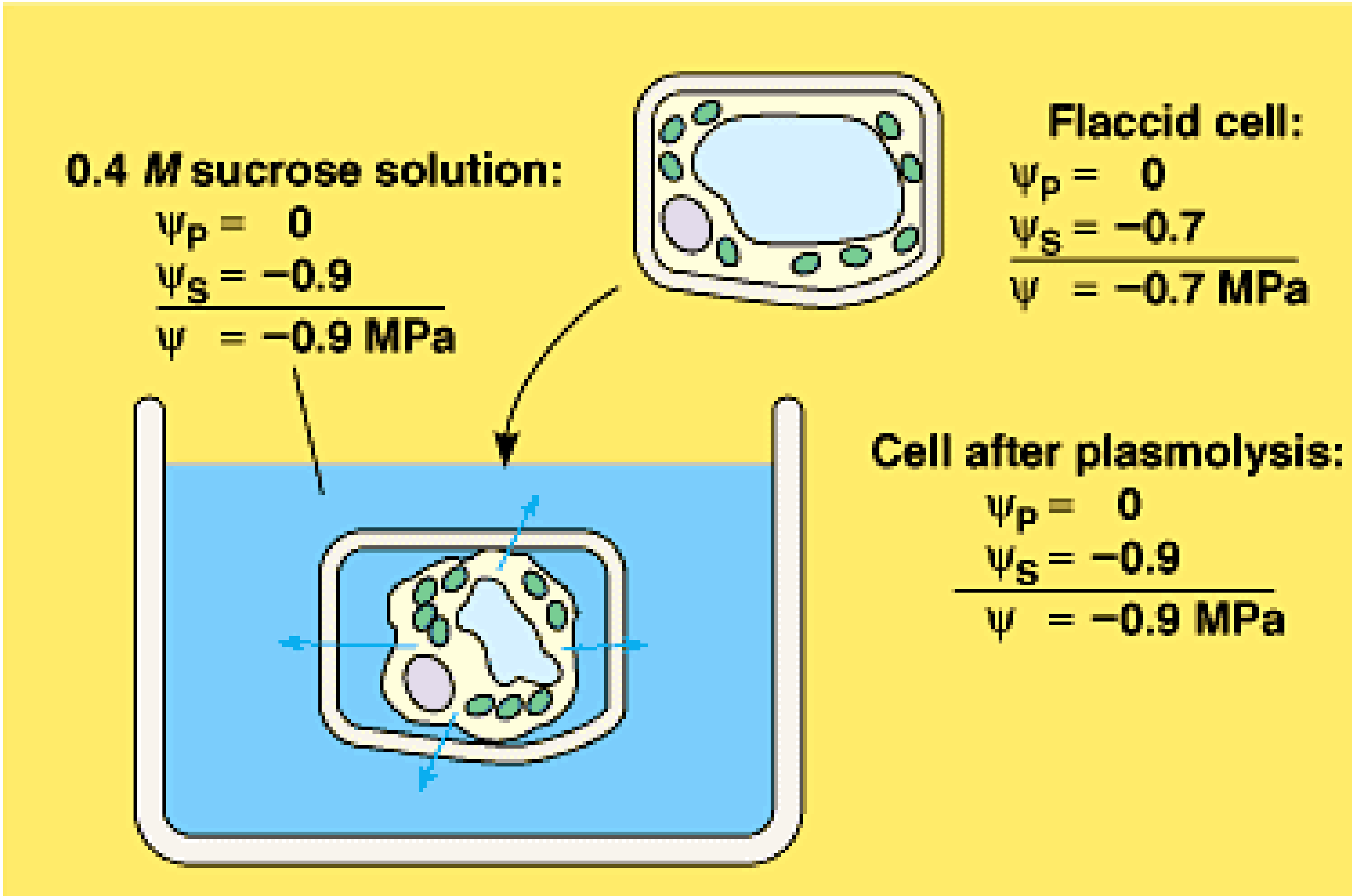
- As the cell swells, the plasma membrane pushes on the cell wall.
- The wall pushes back
- Eventually equilibrium is reached as Ψ_P is added

- What do you think happens to water movement at this point?
- Demonstrate how this can occur using the equation

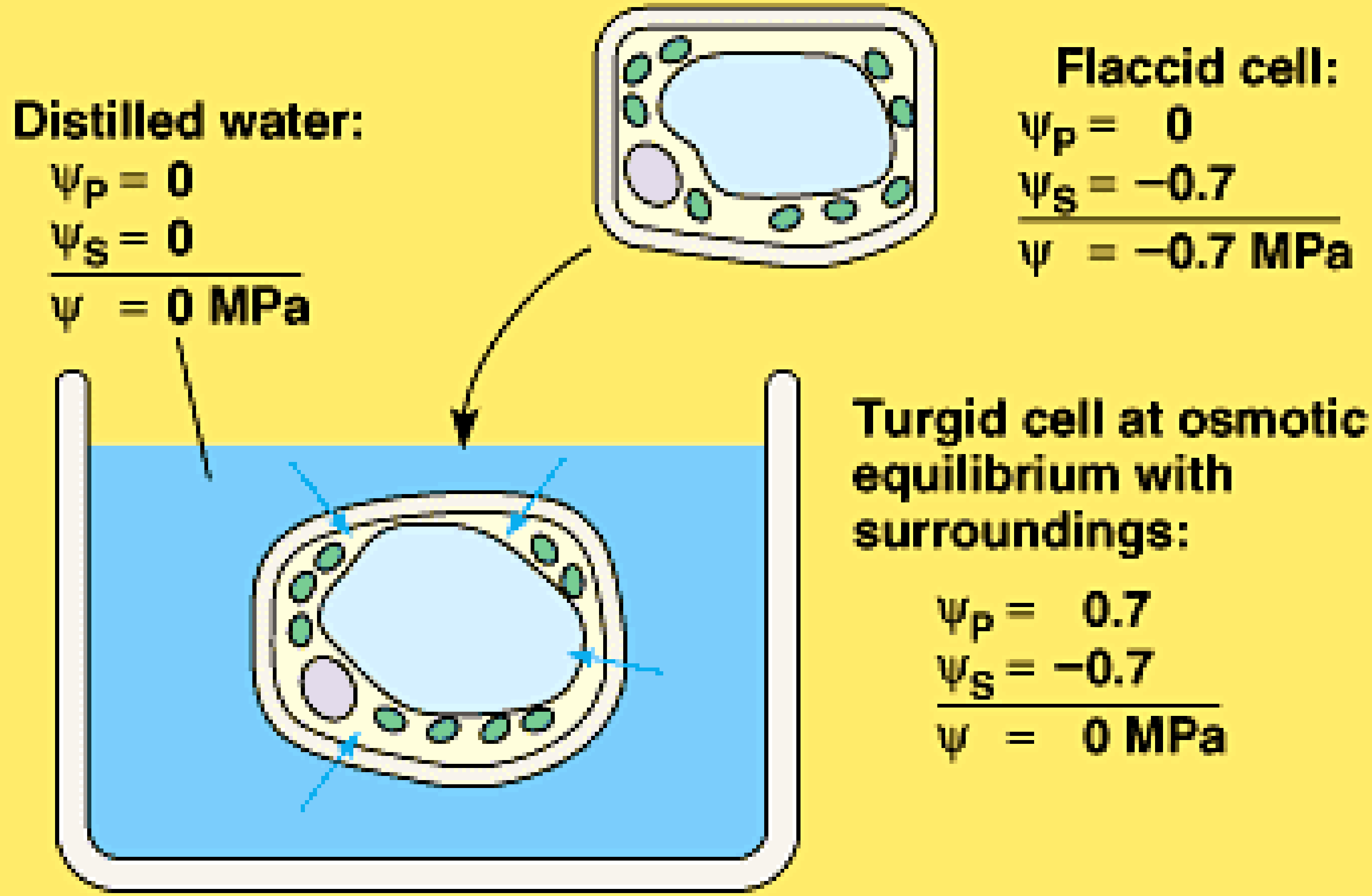
What's the point of all this?

- We can predict the direction that water will flow

- Remember, water will move from areas of high water potential to areas of low water potential



(a) Initial conditions: cellular ψ > environmental ψ



(b) Initial conditions: cellular ψ < environmental ψ


Benjamin
Cummings

Calculating the solute potential

- Page S 52
- Ψ_S =-iCRT
- i = Ionization constant (1.0 for sucrose)(What is ionization?)
- C= Molar concentration
- R= Pressure constant (0.0831 liter bars/mole K)
- T= Temperature in K (K = 273 + °C)

Practice

- Calculate the solute potential of a 0.1 M sucrose solution at 25 ^{o}C.

- If the concentration of sucrose inside of a plant cell is 0.15 M, which way will the water diffuse if the cell is placed into this solution?

- What must the turgor pressure equal if there is no net diffusion?

Practice

- Calculate the solute potential of a 0.1 M NaCl solution at 25 ^{o}C.

- If the concentration of NaCl inside of a plant cell is 0.15 M, which way will the water diffuse if the cell is placed into this solution?

- What must the turgor pressure equal if there is no net diffusion?

What do we do with $\boldsymbol{\Psi}_s$?

Ok, now let's answer the questions

- Page S59
- How can you measure the plant pieces to determine the rate of osmosis?
- How can you calculate the water potential of the cells?