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Transport in plants

lecture 02

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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Can you Answer?

Lowest conc. of CO_2 in Our Body

Cell
↓
Blood
↓
$\boxed{\text{Lungs}}$

Plant — Lowest conc. of CO_2? ?? — Stroma of chloroplast

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simple diffusion

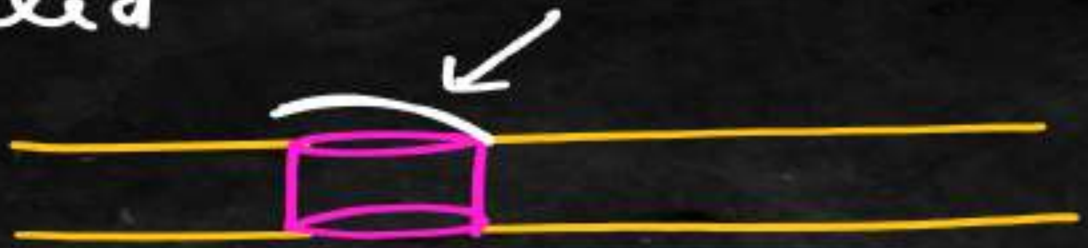
- Passive
- Random
- High conc. to low
- Along conc. gradient
- Affect By temp. pressure and peomeability
- Gas liquid not of solid
- Plant - Gas movement

Facilitated Diffusion

→ Gradient already present ⟶ movement
Facilitate By channel
↓
So it is – Downhill
– Passive
– Along conc. gradient

Can channel be controlled

Some channels are Uncontrolled



Channels can be controlled By Signal
— Signals can be → Chemical signals (Hormones)
— Electrical signals

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What are porins

→ Large size channel (protein) – Present on Outer Surface of Chloroplast (Plastid) mitochondria & Some bacteria (Gram –ve)

→ Some proteins can pass through porins

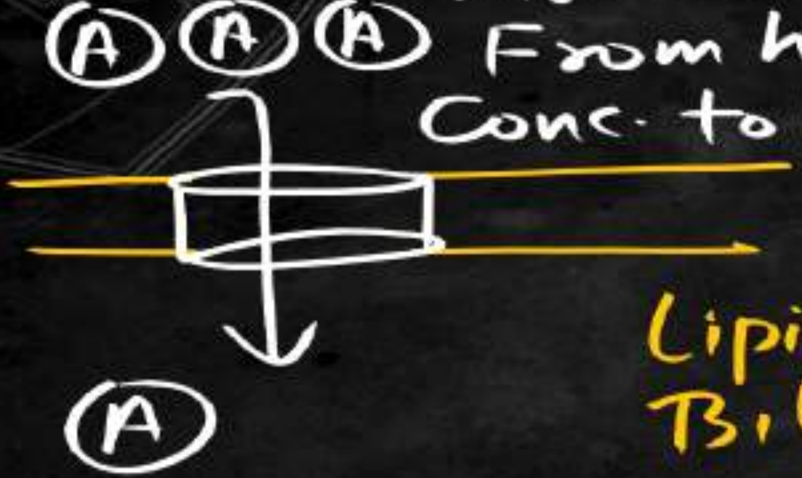
Water channels

- normally water move by – Osmosis (Diffusion)
- But in some special cases – water move By channel
  (water channels)

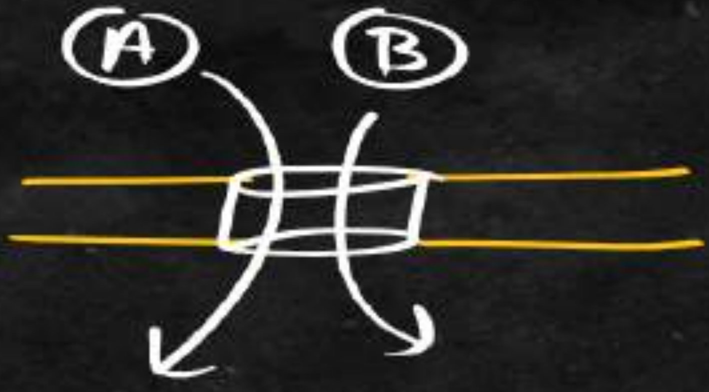
Co-transport (two molecule move)

Uniport

Single type of molecule
From high Conc. to low



Symport



Two molecule move
Direction same
Na^+ – Glu – Symport

Antiport

Ex – Chloride shift

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11.1.2 Facilitated Diffusion

As pointed out earlier, a gradient must already be present for diffusion to occur. The diffusion rate depends on the size of the substances; obviously smaller substances diffuse faster. The diffusion of any substance across a membrane also depends on its solubility in lipids, the major constituent of the membrane. Substances soluble in lipids diffuse through the membrane

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faster. Substances that have a hydrophilic moiety, find it difficult to pass through the membrane; their movement has to be facilitated. Membrane proteins provide sites at which such molecules cross the membrane. They do not set up a concentration gradient: a concentration gradient must already be present for molecules to diffuse even if facilitated by the proteins. This process is called **facilitated diffusion**.

In facilitated diffusion special proteins help move substances across membranes without expenditure of $\boxed{\text{ATP energy}}$. Facilitated diffusion cannot cause net transport of molecules from a $\boxed{\text{low to a high concentration}}$

high to low

– this would require input of energy. Transport rate reaches a maximum when all of the protein $\boxed{\text{transporters}}$ are being used $\boxed{\text{(saturation)}}$. Facilitated

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diffusion is very specific: it allows cell to select substances for uptake. It is sensitive to inhibitors which react with protein side chains.

The proteins form channels in the membrane for molecules to pass through. Some channels are always open; others

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can be controlled. Some are large, allowing a variety of molecules to cross. The **porins** are proteins that form large pores in the outer membranes of the plastids, mitochondria and some bacteria allowing molecules up to the size of small proteins to pass through.

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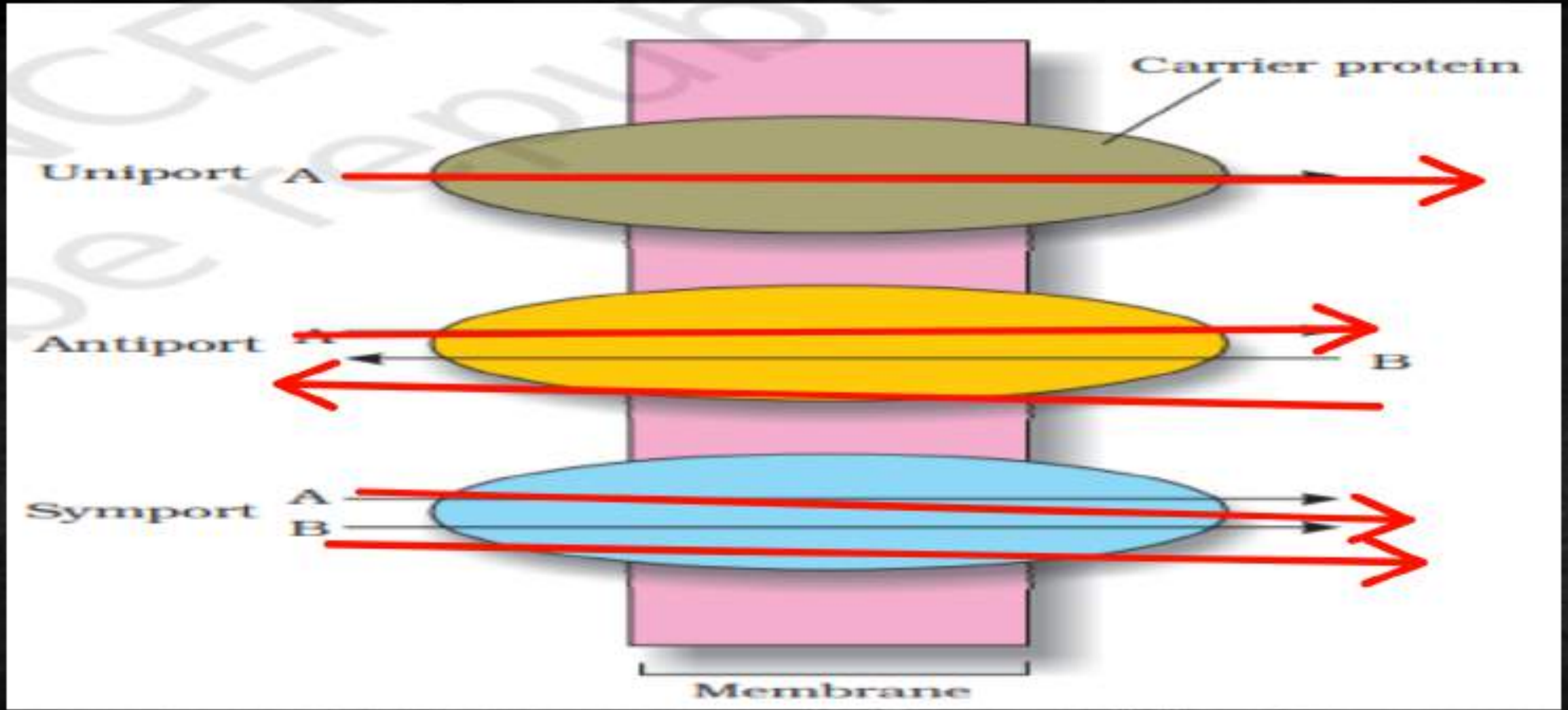
Carrier protein
Uniport
A
Antiport
A
B
Symport
A
B
Membrane

plastids, mitochondria and some bacteria allowing molecules up to the size of small proteins to pass through.

Figure 11.1 shows an extracellular molecule bound to the transport protein; the transport protein then rotates and releases the molecule inside the cell, e.g., water channels – made up of eight different types of **aquaporins**.

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11.1.2.1 Passive symports and antiports

Some carrier or transport proteins allow diffusion only if two types of molecules move together. In a **symport**, both molecules cross the membrane in the same direction; in an **antiport**, they move in opposite directions (Figure 11.2). When a

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Active transport

- Some molecules (Hydrophilic) need to move low conc. to high conc.
- → It Require Pumping of molecule [Energy spend]
  - ↓ ATP Form
  - (Active process)
- → Movement – low conc to high (Uphill)
- → Pump further increase gradient
- – Pump is also membrane $\boxed{\text{protein}}$ – Some similarity with channel

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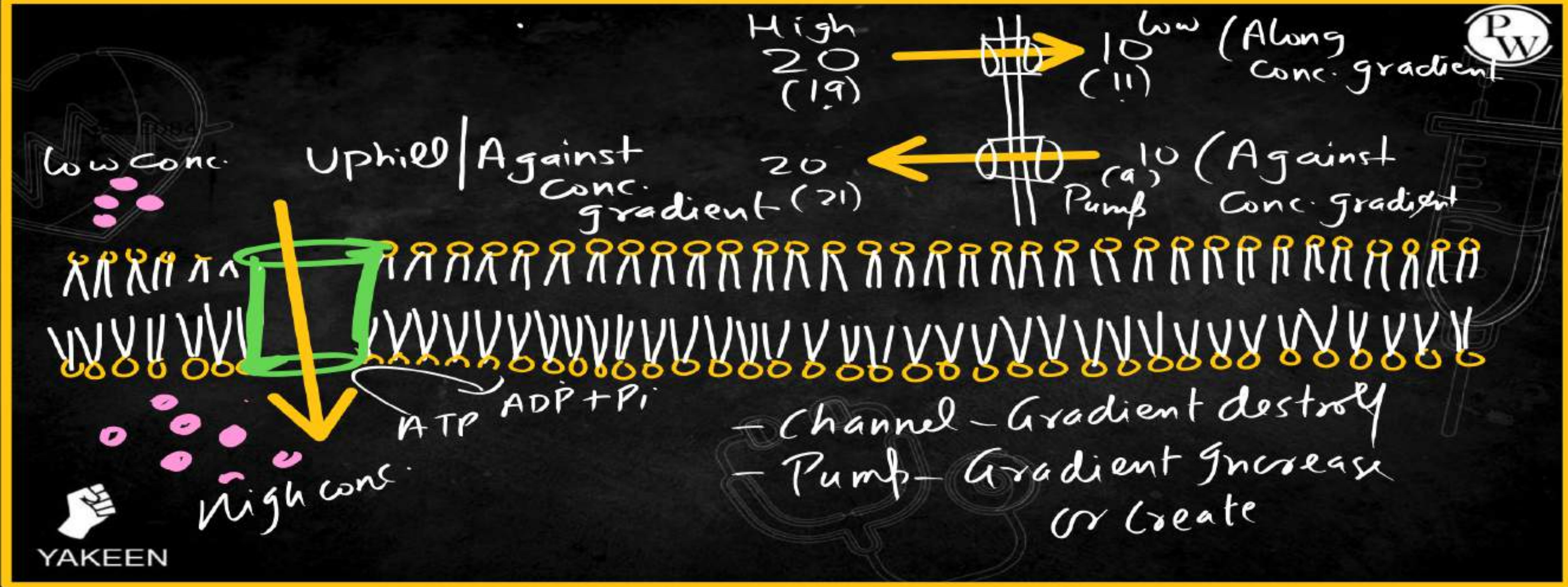
High
20
(19)
Low 10
(11)
(Along Conc. gradient)
20
(21)
10
(9)
Pump
(Against Conc. gradient)
Low Conc.
Uphill | Against Conc. gradient
ATP
ADP + Pi
High conc.
– Channel – Gradient destroy
– Pump – Gradient Increase or Create
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Feature of Active transport

- Uphill – low conc. to high / Against conc. gradient
- Active – Energy spend – in form of ATP
- Create Gradient
- made up of protein → Pump also show

S – Selective
S – Saturation
I – Inhibition

Hormones & Electrical Signal can control opening of Pump.

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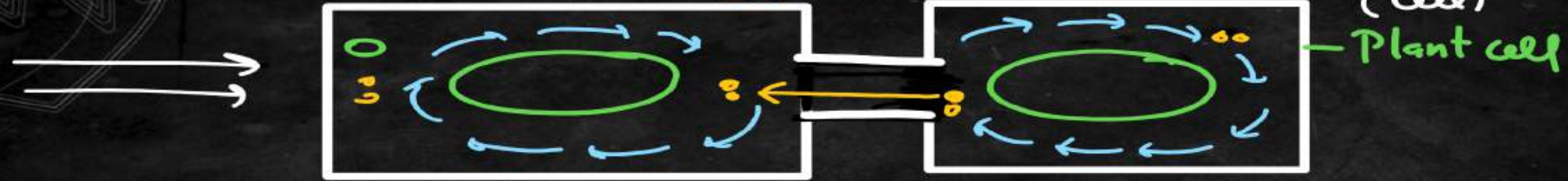
Cytoplasmic streaming — observe in Ex- Hydrilla (cell)

↳ It is an Active process, Cytoplasm is moved | Rotate in a Particular direction



Purpose – It can help within cell transport
– Distribution of organelles
(In Afternoon, chloroplast orientation Change to Avoid Direct Light)

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comparison

Feature	Diffusion	Facilitated diffusion	Active transport
① Along conc. gradient	✓	✓	✗
② Against conc. gradient	✗	✗	✓
③ Downhill	✓	✓	✗
④ Uphill	✗	✗	✓
⑤ Energy	✗	✗	✓

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comparison

Feature	Diffusion	Facilitated diffusion	Active transport
Selectivity	✗	✓	✓
Saturation	✗	✓	✓
Inhibition	✗	✓	✓

Both have Protein

Table 11.1 Comparison of Different Transport Mechanisms

Property	Simple Diffusion	Facilitated Transport	Active Transport
Requires special membrane proteins	No	Yes	Yes
Highly selective	No	Yes	Yes
Transport saturates	No	Yes	Yes
Uphill transport	No	No	Yes
Requires ATP energy	No	No	Yes

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11.1.3 Active Transport

Active transport uses energy to transport and pump molecules against a concentration gradient. Active transport is carried out by specific membrane-proteins. Hence different proteins in the membrane play a major role in both active as well as passive transport. Pumps are proteins that use energy to carry substances across the cell membrane. These pumps can transport substances from a low concentration to a high concentration ('uphill' transport). Transport rate reaches a maximum when all the protein transporters are being used or are saturated. Like enzymes the carrier protein is very specific in what it carries across the membrane. These proteins are sensitive to inhibitors that react with protein side chains.

11.1.4 Comparison of Different Transport Processes

Table 11.1 gives a comparison of the different transport mechanisms. Proteins in the membrane are responsible for facilitated diffusion and active transport and hence show common characterstics of being highly selective; they are liable to saturate, respond to inhibitors and are under hormonal regulation. But diffusion whether facilitated or not – take place only along a gradient and do not use energy.

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Plant water relation

- All metabolic Rxn occur in Aquatic medium

WATER = Medium

- In plants - water content of some tissue - leaf, Fruit - high

Water tend to maintain shape these tissue

- Plant - water movement - Play Important role

↓

Traspiration → Give pull For Xylem

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11.2 Plant-Water Relations

Water is essential for all physiological activities of the plant and plays a very important role in all living organisms. It provides the medium in which most substances are dissolved. The protoplasm of the cells is nothing but water in which different molecules are dissolved and (several

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nothing but water in which different molecules are dissolved and (several particles) suspended. A watermelon has over 92 per cent water; most

100 gm → 10–15 → 80–85%

herbaceous plants have only about 10 to 15 per cent of its fresh weight as dry matter. Of course, distribution of water within a plant varies – woody parts have relatively very little water, while soft parts mostly contain

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water. A seed may appear dry but it still has water – otherwise it would not be alive and respiring!

Terrestrial plants take up huge amount water daily but most of it is lost to the air through evaporation from the leaves, i.e., **transpiration**. A

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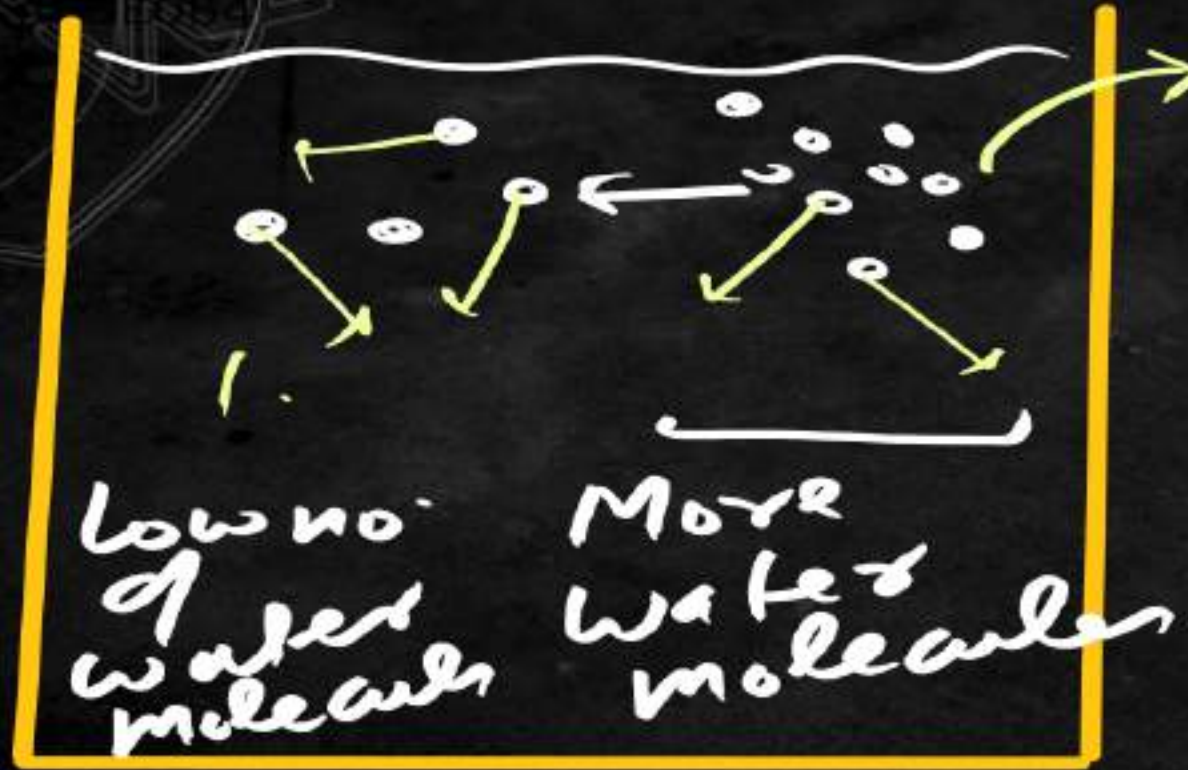
mature corn plant absorbs almost three litres of water in a day, while a mustard plant absorbs water equal to its own weight in about 5 hours. Because of this high demand for water, it is not surprising that water is often the limiting factor for plant growth and productivity in both agricultural and natural environments.

WATER potential



Water molecule – In liquid & Gas phase

They have K.E (Kinetic Energy)

Due to this K.E they are in Random Motion → Energy of water molecule Due to which they are in Random motion – known as Water potential (more is number of water molecule) → (More is Random motion) → (High water potential)

DIRECTION of water movement

High Ψ_w to low Ψ_w

Symbol use → Ψ (Psi) Ψ_w = water potential

— Unit – measured in terms of pressure = Pascal

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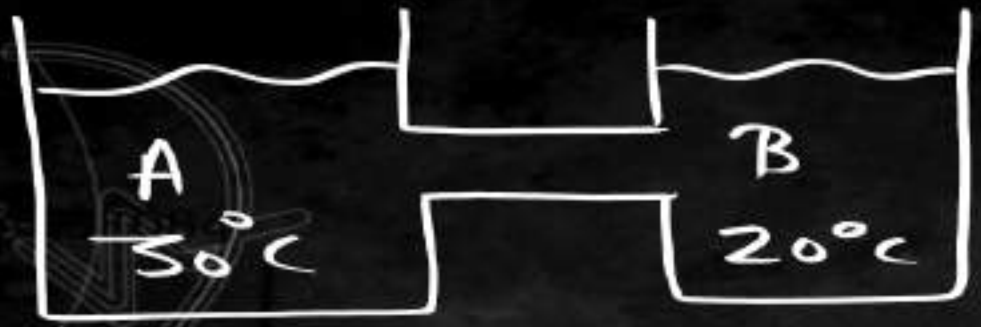

Amount of water same
A have more Ψ_w than B
Increase in temp → Random motion (K.E Inc.)

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Water potential

(Important points)

- Symbol – Ψ_w
- Unit – Pascal (Pressure unit)
- Applicable to – gas & liquid
  $H_2O(g)$
- Directly proportional to K.E
- Random motion
- no. of water molecule
- Direction — high Ψ_w to low Ψ_w

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component of water potential

(there are many component which contribute in Ψ_w)

Ψ_w →

- Ψ_s = Solute potential] NCERT
- Ψ_p = pressure potential] NCERT
- Ψ_g - gravity potential
  - → When water move Upward Ψ_g = -ve
  - → Downward movement Ψ_g = +ve

  (For height upto 5 m no effect of gravity potential
- Ψ_m = matric potential

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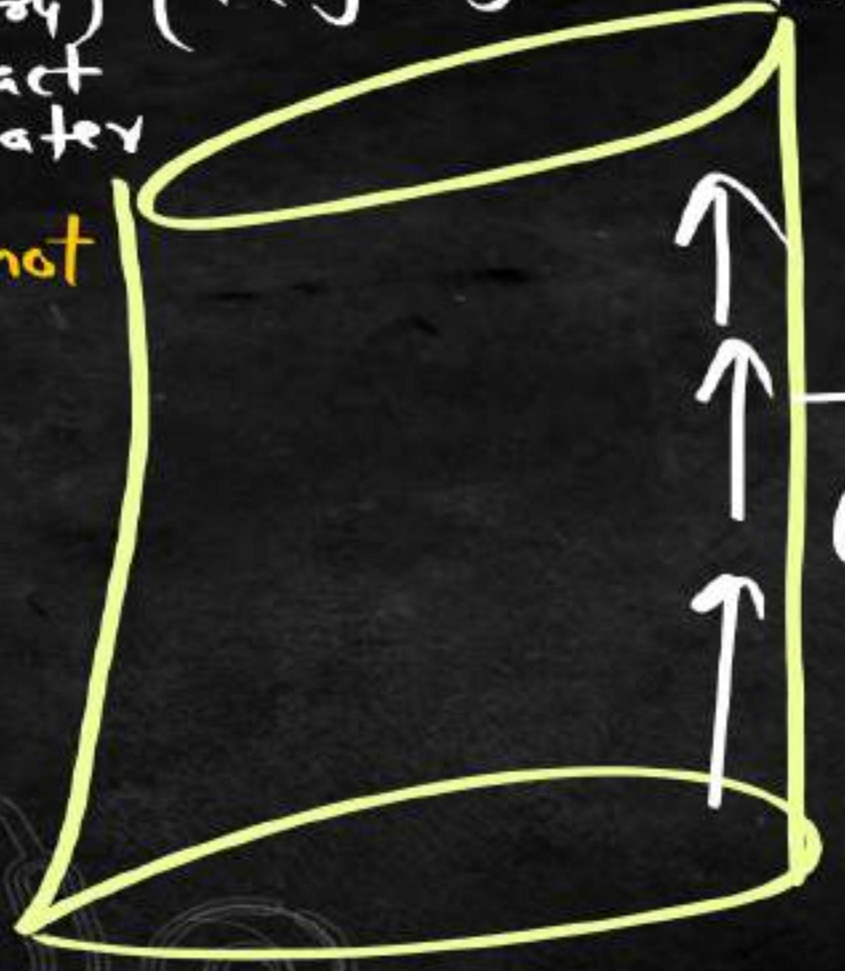
Ψ_m = matric potential

Some rules to decide whether Ψ_w is +ve or not

Anything which decrease Random motion of water

It contribute = −ve value

Anything which increase Random motion it contribute +ve value in Ψ_w



11.2.1 Water Potential

To comprehend plant-water relations, an understanding of certain standard terms is necessary. **Water potential** (**Ψ_w**) is a concept fundamental to understanding water movement. **Solute potential** (**Ψ_s**) and **pressure potential** (**Ψ_p**) are the two main components that determine water potential.

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Water molecules possess kinetic energy. In liquid and gaseous form they are in random motion that is both rapid and constant. The greater the concentration of water in a system, the greater is its kinetic energy or 'water potential'. Hence, it is obvious that pure water will have the greatest water potential. If two systems containing water are in contact, random movement of water molecules will result in net movement of water molecules from the system with higher energy to the one with lower energy.

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Thus water will move from the system containing water at higher water potential to the one having low water potential This process of movement of substances down a gradient of free energy is called diffusion. Water potential is denoted by the Greek symbol Psi or Ψ and is expressed in pressure units such as pascals (Pa). By convention, the water potential of pure water at standard temperatures, which is not under any pressure, is taken to be zero.

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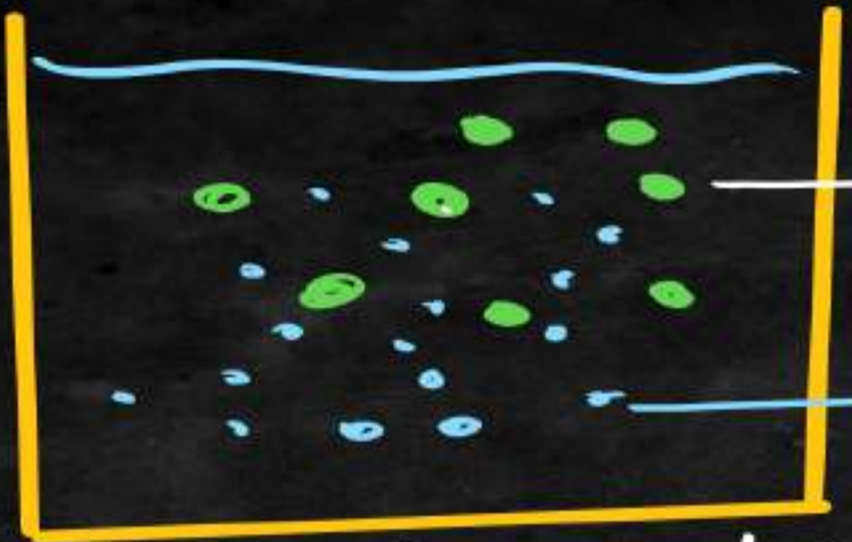
Solute potential

- Solute contribute $-ve$
- Addition of solute (NaCl, Glucose) will decrease Random motion of water
  → this means when you $\boxed{\text{Add}}$ solute it decrease Ψ_w



→ Solute

→ water molecule

— Addition of solute decrease Ψ_s

- Ψ_s is that Ψ_w which is control of solute

more is solute → less random motion → Ψ_w dec.

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$$\xrightarrow{\text{Solute add}}$$

More is solute lower is Ψ_s

$\Psi_w = -10$

$\Psi_s = -10$

$\Psi_w = -15$

$\Psi_s = -15$

more is solute

$\downarrow$

lower is Ψ_s

$\downarrow$

And hence lower is Ψ_w

$$\boxed{\Psi_s \propto \Psi_w \propto \frac{1}{\text{Amount of solute}}}$$

Ψ_s

→ Always negative

→ More is solute, lower is solute potential

→ $\Psi_s \propto \frac{1}{\text{Amount of solute}}$

→ More is solute — lower is Ψ_w

$\Psi_w \propto \frac{1}{\text{Amount of solute}}$

→ Solution $= \Psi_s \Rightarrow$ -ve

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Q1 Two Beaker with Solute (NaCl) is 2M and 5M
(which have high solute potential)
— If Both Beaker Connected, Give Direction of water
(External pressure = 0)

Ψ_w		Ψ_w
-20	$\longrightarrow$	-40
high		low

low solute

$-20 = \Psi_w$ high

Ψ_s high

high solute

Ψ_w low $= -40$

$\Psi_s =$ low

If some solute is dissolved in pure water, the solution has fewer free water molecules and the concentration (free energy) of water decreases, reducing its water potential. Hence, all solutions (−ve) have a lower water potential than pure (0) water; the magnitude of this lowering due to dissolution of a solute is called **solute potential** or $\boldsymbol{\Psi_s}$. $\boldsymbol{\Psi_s}$ is always negative. The more the solute molecules, the lower (more negative) is the Ψ_s. For a solution at atmospheric pressure ($\Psi_p = 0$) (water potential) Ψ_w = (solute potential) Ψ_s.

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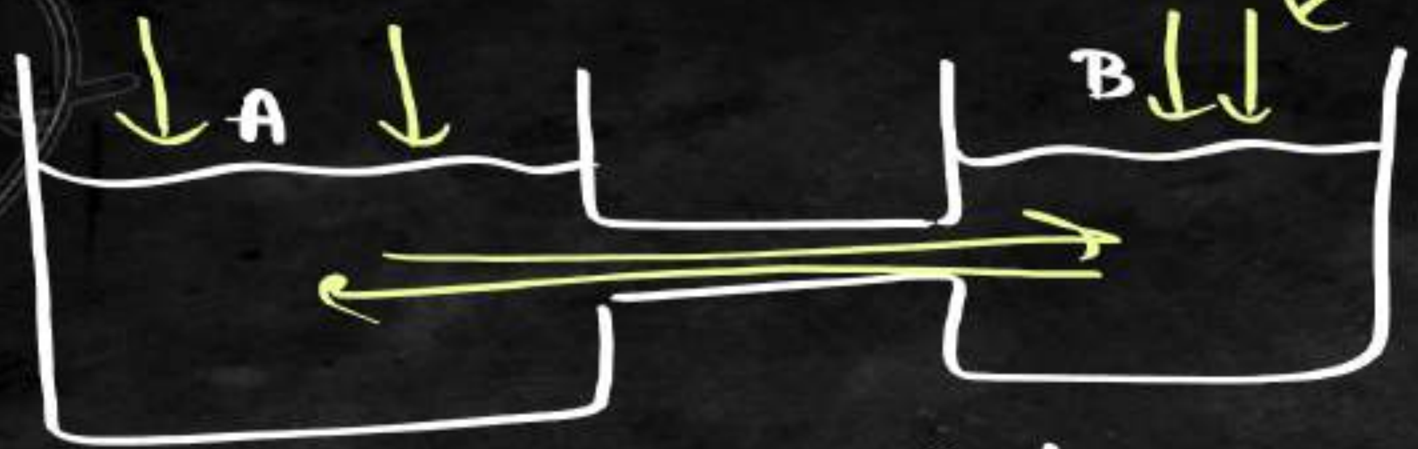
Pressure potential

Atmospheric pressure is considered as zero



$\Psi_w = A$ is Equal to $\Psi_w = B$

- Both have same level of pure water
- Both Beaker pressure which work is Atmospheric pressure
- net movement is zero

Reason it it is not Contributing in net movement of water

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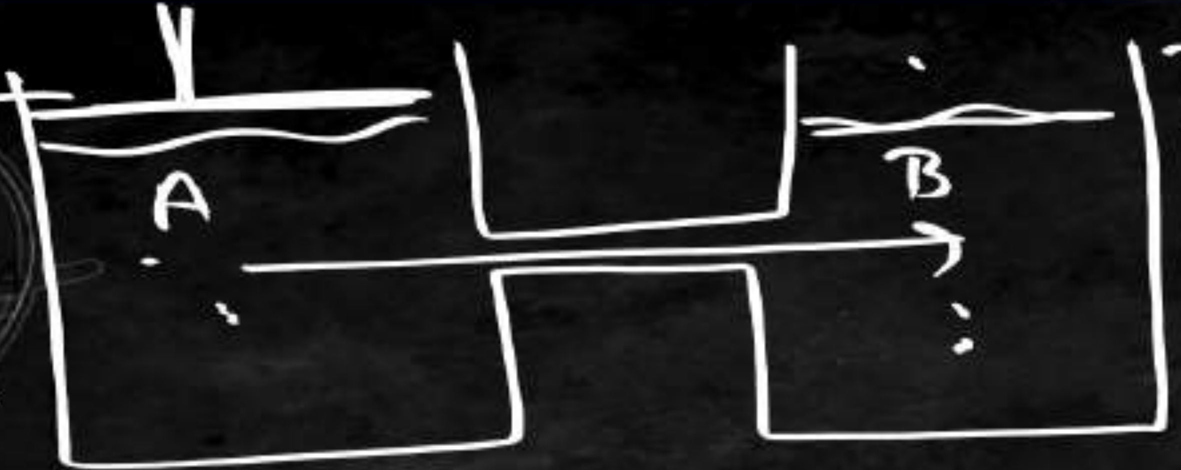
Piston
↓
Push
↓
Pressure more than atmospheric Pressure
↓
$\underline{\Psi_P}$ = +ve pressure (Push)



Pure water, same level

$\boxed{\Psi_P = 0 = atm}$

— If pressure more than atmospheric pressure Apply = +ve pressure

— If pull → Ψ_P = −ve (less than atmospheric pressure)

$\underline{\Psi_P}$
- 0 – atm
- +ve – Push → Garden hose
- −ve – Pull [straw use to pull liquid)

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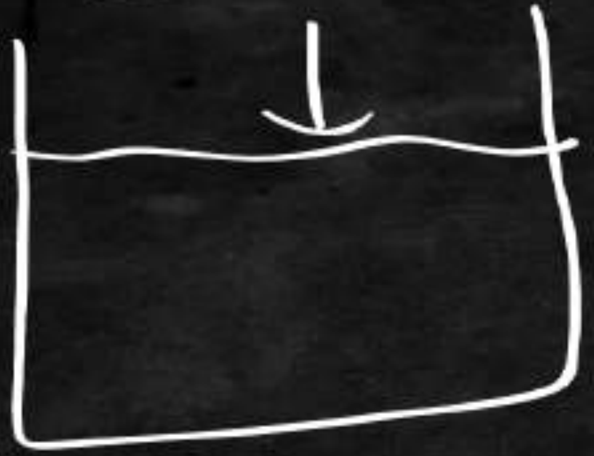
Open Beaker - Pure water

$\underline{\Psi_w = 0}$ - (Reason)



Open Beaker Pure water

$\Psi_P = atm = 0$

$\Psi_s = 0$ (Solute Absent)

$$\underline{\Psi_w} = \underset{0}{\Psi_s} + \underset{0}{\Psi_P}$$

Open Beaker Solute present (Solution)

$\Psi_w = \Psi_s$

$\to \Psi_s = -5$

$\to \Psi_s = 0$ (atm)

$$\Psi_w = \Psi_s + \underset{\Rightarrow 0}{\Psi_P}$$

$$\boxed{\Psi_w = \Psi_s}$$

Ψ_w → $\Psi_s = -ve$ (Always)

Ψ_w → $\Psi_p = +ve,\ 0,\ -ve$

Ψ_w: $+ve, 0, -ve$

→ natural system like cell $-\Psi_p = 0$

Example $= \Psi_p = 0$

$\boxed{\Psi_w = \Psi_s}$

Q why in most cell Ψ_w is $-ve$

So, in most cell value of $\Psi_w = -ve$

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If a pressure greater than atmospheric pressure is applied to pure water or a solution, +ve its water potential increases. It is equivalent to pumping water from one place to another. Can you think of any system in our body where pressure is built up? Pressure can build up in a plant system when water enters a plant cell due to diffusion causing a pressure built up against the cell wall, it makes the cell **turgid** (see section 11.2.2);

this increases the **pressure potential**. Pressure potential is usually positive, though in plants negative potential or tension in the water column in the xylem plays a major role in water transport up a stem. Pressure potential is denoted as Ψ_p.

Water potential of a cell is affected by both solute and pressure potential. The relationship between them is as follows:

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

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