Transport In Plants

Syllabus

Transport In Plants

Mineral Nutrition, Plant Water Relation, Absorpstion of water by Plants, Transpiration

Name : _____ Contact No. _____

ASCENT OF SAP

INTRODUCTION

- Upward conduction of water from roots to leaves through stem against force of gravity is called **ascent of sap.**
- The **inorganic substances** dissolved in xylem water are called **sap**.

PROBLEMS RELATED TO ASCENT OF SAP

(A) Path of Ascent of sap **(B) Mechanism of Ascent of Sap**

(A) Path of Ascent of Sap :

- The path of ascent of sap is **xylem** though exact mechanism is not clear.
- Important evidences -

  (i) Ringing or Girdling Experiment **(ii) Staining Experiment**

(i) Ringing or Girdling Experiment :

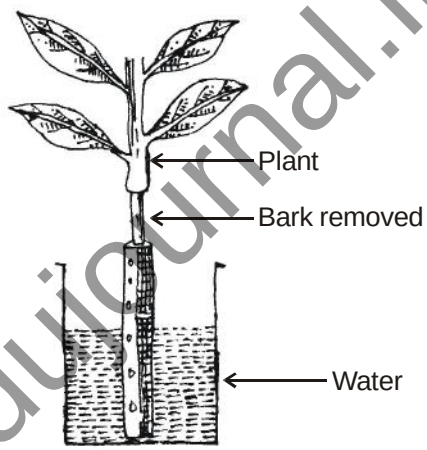


Fig.: Girdling Experiment : To show xylem as path of ascent of sap

- **Malpighi** (1671), **Stephen Hales** (1731) and **Hartig** (1837) proved by ringing experiment that ascent of sap not occurs through phloem or food conduction occurs by phloem.
- When ring or girdle upto 2-3cm of Bark (Secondry Phloem) is removed, the branches remain healthy.
- Ringing experiment cannot be performed in monocots due to presence of scattered vascular bundles in stem.
- Conclusion - Phloem is food conducting tissue or phloem is not water conducting tissue.

(ii) Staining Experiment–

- When a cut shoot of Balsam plant is dipped in solution of Eosine, **only xylem tissue is found stained**.
- **Blockage experiment -** By **Dixon,** xylem is blocked by wax.
- From above observations following conclusions can be drawn-

  Main path for ascent of sap is through **xylem cavities.**

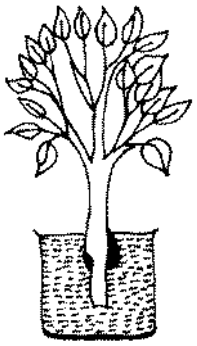


Fig.: Phloem blocked

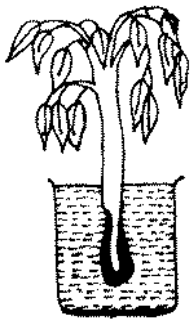


Fig.: Xylem blocked

MECHANISM OF ASCENT OF SAP

Two types of theories have been proposed for the mechanism of ascent of sap.

(i) Vital Force Theory **(ii) Physical Force Theory**

(i) Vital Force Theory :

According to this theory ascent of sap is due to **vital activities** of cells or **living cells** are responsible for ascent of sap. Main Supporters of this theory are -

- **Westermaier** (1884) was of the opinion that **xylem parenchyma** is responsible for ascent of sap. **Tracheids** and **vessels** only function as water **reservoir**.
- **Godlewski** (1884) gave **clambering force theory** or **relay pump theory** :

(i) According to this theory cells of **xylem parenchyma** and **medullary rays** shows rhythmic changes in osmotic pressure which causes upward movement of water.

(ii) When O.P. value of parenchyma rises, they absorb water from adjoining xylem vessel. Water rises up in parenchyma due to atmospheric pressure.

- **J.C. Bose - Pulsation theory :**

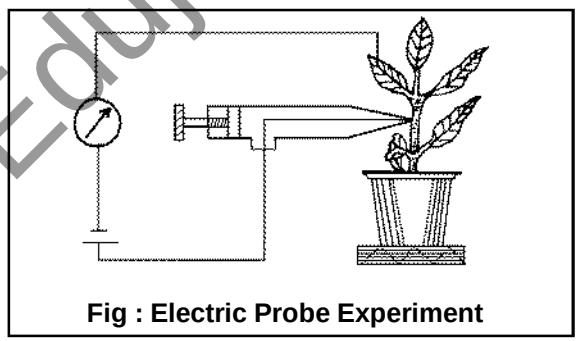


Fig : Electric Probe Experiment

(i) According to which **innermost layer of cortex** (=just outside the endodermis) is responsible for ascent of sap.

(ii) He concluded that these cells **pulsate like heart** and push water into the xylem cavity leading to ascent of sap.

(iii) He verified this with the help of **electric-probe experiment.** When electric probe reached in innermost layer of cortex, **vibrations** in galvanometer were **observed**.

(iv) Bose performed his experiment in **Desmodium gyrans** (a member of Papilionatae).

- **Strasburger** (1891) proved experimentally that **living cells are not essential** for ascent of sap. Ascent of sap can occur even after making the live cells dead by poisoning them (using Picric acid, $HgCl_2$ etc.)
- **Root Pressure Theory (By Priestlye) :**

Root pressure is respobsible for ascent of sap.

Objections -

- Root pressure is absent in woody plants, as secondry growth occurs in wood plant roots.
- When root pressure is high, during night, then ascent of sap is low.

(ii) Physical Force Theories :

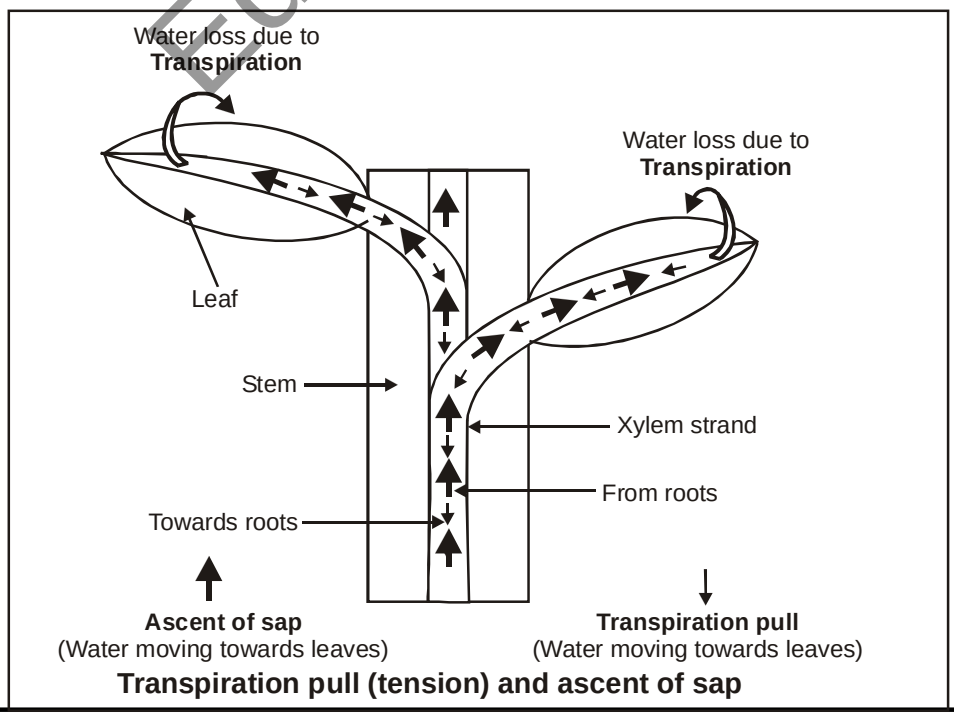
Supporters of this theory are of opinion that **forces responsible for upward conduction of water are physical in nature** and even dead cells can conduct water.

- **Capillary force theory : -** Proposed by **Boehm**. Xylem vessels acts as capillaries and water rises up due to **capillary action.**
- **Jamin's Theory : -** Also known as **chain theory**.
  - According to Jamin, there are **alternate regular layers of water** and **air in vessels.**
  - Ascent of sap occurs due to **expansion of air.**
- **Imbibition force theory :**
  - Proposed by **Unger** (1868) and supported by **Sachs** (1878).
  - According to this theory imbibition by thick walls of xylem vessels is responsible for **ascent of sap.**
  - **Sachs** considered **hydrophilic colloidal** substances present in cell wall of vessels to be responsible for this process.
- **Transpiration pull-cohesion force theory :**
  - This theory was proposed by **Dixon** and **Jolly** (1894).
  - **Most accepted** or universally accepted theory of ascent of sap. According to it three components are involved in ascent of sap.

(a) Cohesion : Mutual **attraction between the water molecule** is called **cohesion force,** which helps in forming water coloum in xylem elements.

(b) Adhesion : Attraction between xylem walls and water molecules is called **adhesion force,** which helps in maintainance of water coloumn of xylem.

(c) Transpiration Pull : A tension or negative pressure develops in xylem due to rapid transpiration in leaves (because of high DPD), this creates a transpiration pull, which is responsible for the pulling up of water column in xylem. So ascent of sap is constitutive effect of cohesion, adhesion and transpiration pull.



Transpiration pull (tension) and ascent of sap

FACTORS AFFECTING ASCENT OF SAP

- Amount of water in Soil
- Temperature
- Atmospheric humidity
- Atmospheric pressure
- Movement of wind
- Number of stomata in leaves
- Besides them, all other factors which affects root pressure and transpiration process, also affects ascent of sap directly or indirectly.

FOOD TRANSILOCATION IN PLANTS

- Food/organic material conduction in plants mainly occurs by phloem. (Proved by Girdling experiment).
- Food conduction occurs in between **source** and **sink**. Source is net exporter while sink is net importer.
- Generally green photosynthetic plant parts acts as **source** like leaves while non photosynthetic parts like root, shoot, fruits acts as **sink**.
- Food conduction may be in any required direction or **bidirectional** unlike the water conduction which is a unidirectional process.
- Translocation of food mainly occurs in the form of **sucrose** or it is non-reducing sugar and chemically inert in it's pathway of conduction.
- **Pressure flow/mass flow hypothesis of food/sucrose translocation - Given by E. Munch (1930).** This is the most accepted theory of food conduction in plants.

  According to it food translocation occur in between source and sink in order of turgor pressure gradient i.e., high T.P. to low T.P.
- **Phloem loading/sucrose loading at source** → It is an active process occurs with expenditure of ATP and helped by carrier molecules. At source due to phloem loading concentration of sieve cells increase, results in increase in osmotic pressure and water will moves from nearby xylem into sieve cells results in **increase in turgor pressure** (T.P.) and increase in water potential (Ψ_W). It establish a higher T.P at source end in sieve tubes. Sucrose moves from source in sieve tube towards sink from high T.P./ High $\psi\omega$ to towards the low T.P./low Ψ_W.
- **Phloem unloading/sucrose unloading at sink** → It is also active process occurs with expenditure of ATP and helped by carrier molecules. At sink sucrose is unloaded results in decrease in osmotic pressure (O.P.), it results in exit of water into near by xylem leads to decrease in Turgor pressure (T.P.) and water potential (Ψ_W) of phloem. In sink cells the unloaded sucrose is either changed into starch (as starch not change O.P.) or consumed, to maintain low O.P. and continuous unloading .
- The translocation of food between source and sink end is **passive process** as occurs in order of T.P. or Ψ_W gradient.
- So, the process of sucrose loading at source and unloading at sink continues. This turgor pressure difference will maintained and water will continue to move in at soure and out at sink.
- This mechanism was experimentally demonstrated by **Bimodel** exp. of **Munch.**

☛ According to evidences of modern research phloem conduction is an active process (only phloem loading and unloading) and it required metabolic energy of phloem cells.

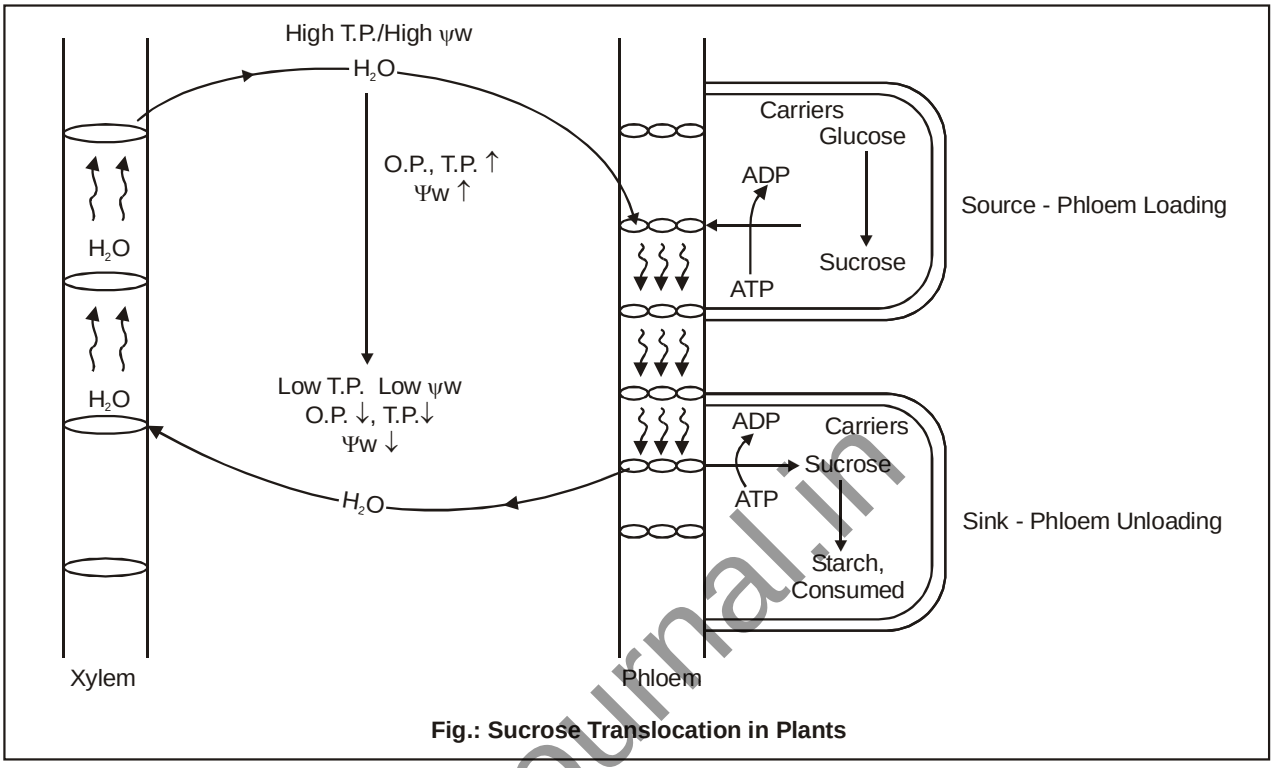


Fig.: Sucrose Translocation in Plants

EXERCISE - I

DIFFUSION, OSMOSIS & RELATED TERMS

Q.1 The physical process involved in the release of molecular oxygen from leaves is : -
(1) Diffusion (2) Transpiration
(3) Osmosis (4) Capillarity

Q.2 Who is called father of plant physiology ?
(1) K.V. Thimann (2) Stephan Hales
(3) M. Calvin (4) E. Rabinowitch

Q.3 Who is called father of Indain plant physiology?
(1) J.C. Bose (2) Calvin
(3) R. Mishra (4) K.K. Nanda

Q.4 One molar solution of which substance will have maximum O.P : -
(1) NaCl (2) Glucose
(3) Fructose (4) Starch

Q.5 Pieces of beet root do not lose their colour in cold water, but so in boiling water because :-
(1) The cell wall is killed in boiling water
(2) Hot water can enter cells readily
(3) The plasma membrane gets killed in boiling water and becomes permeable
(4) The pigment is not soluble in cold water

Q.6 The movement of molecules from their higher concentration to lower concentration is called-
(1) Osmosis (2) Diffusion
(3) DPD (4) DPG

Q.7 Osomosis is the diffusion of a solution of a weaker concentration when both are seperated by semi-permeable membrane. What is error in the statement ?
(1) The movement of solvent molecule is not specified
(2) There is no mention of DPD
(3) Behavior of semipermeable membrane is not specified
(4) The exact concentration of solutions are not indicated

Q.8 What statement can be cited for 10% sodium chloride solution and 10% sugar solution present ?
(1) Both have equal OP
(2) The concentration of sodium chloride solution will be less than concentration of sugar solution
(3) The OP of sugar solution will be higher than OP of sodium chloride solution
(4) DPD of sodium chloride solution will be higher than DPD of sugar solution

Q.9 If a plant cell is immersed in water, the water continues to enter the cell until the : -
(1) Concentration of the salts is the same inside the cells as outside
(2) Cell bursts
(3) Concentration of water is the same inside the cell as out side
(4) Diffusion pressure deficit is the same inside the cell as out side

Q.10 If a cell swells, after being placed in solution, the solution is : -
(1) Neutral (2) Hypotonic
(3) Hypertonic (4) Isotonic

Q.11 Osmosis means : -
(1) Solute from low concentration to higher
(2) Solute from higher concentration to low
(3) Solvent from low concentration of solution to higher conc. of solution
(4) Solvent from higher concentration solution to low concentration solution

Q.12 If cell is reduced in size (shirnks) of placing in a solution of sugar, the solution is : -
(1) Hypertonic
(2) Hypotonic
(3) Isotonic
(4) None of the above

Q.13 The process of osomosis involves : -
(1) Movement of solute through a semipermeable membrane
(2) Movement of solvent through a semipermeable membrane
(3) Movement of solution through semipermeable membrane
(4) None of the above

Q.14 A cell increases in volume if the external medium is
(1) Hypotonic
(2) Slightly hypertonic
(3) Isotonic
(4) Much more concentrated than the protoplasm of the cell

Q.15 Osmosis involves diffusion of : -
(1) Suspended particles from higher to lower concentration
(2) Suspended particles from lower to higher concentration
(3) Water from more to less conentration solution
(4) Water from less to more concentrated solution

Q.16 A cell placed in a strong salt solution will shrink because : -
(1) They cytoplasm will be decomposed
(2) Mineral salts will break the cell wall
(3) Salt will enter the cell
(4) Water will move out the cell by exosomosis

Q.17 Grapes placed in salt solution shrink due to :
(1) Imbibition (2) Endosmosis
(3) Exosmosis (4) Osmosis

Q.18 Process of selective transmission of a liquid through semi permeable membrane is called :-
(1) Diffusion (2) Osmosis
(3) Plasmolysis (4) Transmission

Q.19 Water enters into the root hair from the soil in its normal condition because the osmotic pressure of the soil solution :-
(1) Remains lesser than that of root hair sap
(2) Remains equal to that of root hair sap
(3) Remains higher than that of root hair sap
(4) And that of root hair sap remains zero

Q.20 Potato slices are immersed in a series of solution of diffferent osmotic concentrations. No change in volume or weight is observed with slices in a 0.3 M solutions. The osmotic concentration of vacuolar sap, therefore : -
(1) 0.3 M
(2) Greater than 0.3M
(3) Less than 0.3 M
(4) Not related at all to the out side solution

Q.21 Which helps in maintaining form and structure of cells & soft parts of plants ?
(1) Osmotic pressure (2) Turgor pressure
(3) Atmospheric (4) DPD

Q.22 Who propounded the concept of osmosis ?
(1) Abbe Nollet (2) Mayer
(3) Dixon and jolly (4) Renner

Q.23 In terms of permeability, the cell wall and plasmalemma are : -
(1) Permeable and differentially permeable respectively
(2) Both semipermeable
(3) Semipermeable and permeable
(4) Both differentially permeable

Q.24 Plasma membrane controls : -
(1) Passage of water only
(2) Passage of water and solutes in and out of the cell
(3) Passage of water and solutes into the cell
(4) Movement of cell contents out the cell

Q.25 Which process occurs against a concentration gradient of solute ?
(1) Diffusion (2) Osmosis
(3) Transpiration (4) Translocation

Q.26 When a plant cell is placed in a hypotonic solution, which of the following will not apply?
(1) Wall pressure is decreased
(2) The cell become turgid
(3) Suction pressure of the cell sap will decrease
(4) Water potential of the cell sap will increase

Q.27 When beet root slices are washed and then placed in cold water, anthocyanin does not come out, because plasma membrane is ?
(1) Differentially permeable to anthocyanin
(2) Dead structure
(3) Impermeable to anthocyanin
(4) Permeable to anthocyanin

Q.28 Osmotic pressure is highest in : -
(1) Xerophytes (2) Lithophytes
(3) Halophytes (4) Mesophytes

Q.29 If osmotic potential of a cell is – 10 bars and its pressure potential is 5 bars, its water potential would be :-
(1) – 5 bars (2) 5 bars
(3) – 10 bars (4) 10 bars

Q.30 Osmosis means : -
(1) Movement of molecules from higher concentration to lower concentration
(2) Uptake of water by roots
(3) Passage of solvent from a weaker solution to stronger solution across a semipermeable membrane
(4) Passage of solvent from a weaker to a stronger solution separated by a membrane

Q.31 The osmotic pressure of distilled water will be : -
(1) Zero
(2) Maximum
(3) Higher than any solution
(4) Variable

Q.32 Tonoplast is : -
(1) Permeable membrane
(2) Semi permeable membrane
(3) Impermeable membrane
(4) Selectively permeable membrane

Q.33 If in a cell suction pressure value is 30 atm. While osmotic pressure 42 atm. then calculate the turgidity developed in form of TP in the cell : -
(1) 12 atm. (2) 72 atm.
(3) – 12 atm. (4) 1.4 atm.

Q.34 If the molar concentration of the given sugar solution is 0.3 M, find out the osmotic pressure of this solution : -
(1) 6.72 atm (2) 67.2 atm
(3) 2.24 atm (4) 5.60 atm

Q.35 Osmosis is the phenomenon expressed by :-
(1) Solutes present in the solution
(2) Solution
(3) Semi-permeable membrane
(4) O_2

Q.36 The osmotic pressure of the cell is measured by : -
(1) Plasmolysis method
(2) Osmometer
(3) Molar concentration of the cell sap
(4) Deplasmolysis

Q.37 When grapes are placed in water, then which process occurs ?
(1) Plasmolysis
(2) Exomosis
(3) Endosomosis
(4) None of the above

Q.38 Maximum osmotic pressure is found in : -
(1) Root hair
(2) Cortex cell of the root
(3) Passage cell of the root
(4) Mesophyll cell

Q.39 The osmotic pressure is due to : -
(1) Solute
(2) Semi permeable membrane
(3) Hypertonic solution
(4) Water

DPD (SP)

Q.40 When a cell is fully turgid which of the following will be zero ?
(1) Turgor pressure (2) Wall pressure
(3) Suction pressure (4) Osmotic pressure

Q.41 Water from the soil enters in to the root hairs on account of : -
(1) Turgor pressure
(2) Suction pressure DPD
(3) Barometric pressure
(4) Osmotic pressure

Q.42 In a fully turgid cell the values of DPD, OP and TP should be : -
(1) DPD = 10 atm., OP = 15 atm., TP = 5atm
(2) DPD = 5 atm., OP = 12 atm., TP = 7atm
(3) DPD = 10 atm., OP = 15 atm., TP = 5atm
(4) DPD = 0 atm., OP = 15 atm., TP = 15atm

Q.43 When the cell is placed in water, it takes water this is due to ?
(1) Osmotic pressure
(2) Suction pressure
(3) Diffusion
(4) Water potential and TP

Q.44 What is the direction of the movement of water if two cells have the same OP but differ in TP ?
(1) No net flow
(2) From lower T.P to higher TP
(3) From higher TP to lower TP
(4) Data insufficient

Q.45 The hydrostatic pressure developed in the cell is called : -
(1) Turgor pressure (2) Wall pressure
(3) Osmotic pressure (4) Suction pressure

Q.46 In fully turgid cell : -
(1) DPD = WP (2) DPD = OP
(3) DPD = OP - TP (4) DPD = 0

Q.47 In flaccid cell : -
(1) DPD = WP (2) DPD = OP
(3) DPD = 0 (4) DPD = OP - TP

Q.48 Turgor pressure of a plasmolysed cell is : -
(1) Positive (2) Zero
(3) Negative (4) None of these

Q.49 When water enters into a cell what happens to its OP, TP and DPD ?
(1) OP & TP increase & its DPD increase
(2) OP & DPD increase & TP decrease
(3) TP & DPD decrease & OP increase
(4) OP & DPD decrease & TP increase

Q.50 What is the value of DPD of a cell ?
(1) DPD = OP × TP (2) DPD = OP + TP
(3) DPD = OP – TP (4) DPD = OP ÷ TP

Q.51 Under natural conditions the osmotic pressure is : -
(1) More than turgor pressure
(2) Less than turgor pressure
(3) Equal to turgor pressure
(4) Zero

Q.52 What maintains the shape of a cell ?
(1) Osmotic pressure (2) Turgor pressure
(3) Suction-pressure (4) Wall-pressure

Q.53 Osmotic potential is numerically equal to :-
(1) Turgor pressure (2) Wall pressure
(3) Osmotic pressure (4) D.P.D

Q.54 You are given three cells, a root hair, a cell of the inner cortical layer and a cell of the mesophyll arrange them in ascending order of DPD : -
(1) Root hair < Cortical cell < Mesophyll
(2) Cortical cell < Mesophyll < Root hair
(3) Mesophyll < Root hair < Cortical cell
(4) Root hair < Mesophyll < Cortical cell

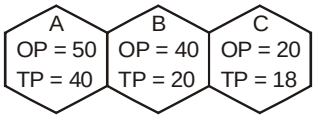
Q.55 Osmotic pressure is highest in : -
(1) Atriplex confertifolia
(2) Salsola foetida
(3) Rhizophora
(4) Chenopodium

Q.56 The direction of the movement of water : -
(1) From low OP to high OP
(2) From low DPD to high DPD
(3) From high DP to low DP
(4) All of the above

Q.57 The term "DPD" was coined by : -
(1) Renner (2) Kamer
(3) B.S. mayer (4) Stephen hales

Q.58 The entry of water from the soil up to xylem elements of root is due to : -
(1) Gradient of suction pressure
(2) Turgor pressure
(3) Degree of imbibition
(4) Concentration of ions in water

Q.59 The three cells A, B & C are joined in a linear manner. Demostrate the movement of water & direction in these ?
(1) A → B → C
(2) A ← B ← C
(3) A → B ← C
(4) A ← B → C



Q.60 When the solute has been added in the solution, then following observation can be made ?
(1) The DPD of the solution decreases
(2) The Ψ_w of the solution increases
(3) DPD of the solution decreases while its Ψ_w increases
(4) DPD of the solution increases while its Ψ_w decreases

Q.61 If the given solution is of 25% concentration; then what cannot be presented for this :-
(1) OP (2) DPD
(3) Solute potential (4) TP

Q.62 In a flaccid cell which condition does not occur -
(1) TP = 0 (2) SP = 0
(3) WP = 0 (4) SP = OP

Q.63 Osmotic pressure of a cell is zero when :-
(1) T.P. is maximum
(2) DPD is maximum
(3) T.P. is zero
(4) Not possible

Q.64 The accurate relationship between SP, OP, TP can be expressed as -
(1) SP = OP + TP (2) OP = SP – TP
(3) TP = SP – OP (4) SP = OP – TP

Q.65 In which condition the Turgor pressure of the cell becomes equal to the osmotic pressure : -
(1) In flaccid cell
(2) In plasmolysed cell
(3) In fully turgid cell
(4) It never happens

Q.66 Select the correct statement -
(1) Pure water has minimum Ψ_w
(2) Pure water has maximum Ψ_w
(3) Pure water has maximum D.P.D
(4) Pure water has variable Ψ_w & D.P.D.

Q.67 The best condition by which fully turgid cell can be identified is : -
(1) TP is minimum (2) SP is maximum
(3) OP less than SP (4) TP = OP

PLASMOLYSIS & PERMEABILITY

Q.68 Plasmolysis can be used for : -
(1) Good growth of plants
(2) Good growth of weeds
(3) Killing the weeds
(4) None of the above

Q.69 Along with plasmolysis which decreases in the cell -
(1) Osmotic pressure
(2) Diffusion pressure
(3) Imbibition pressure
(4) Turgor pressure

Q.70 If a plasmolysed cell is placed in distilled water then it returns to its original state & become turgid, this is called as : -
(1) Plasmolysis (2) Exosmosis
(3) Endomosis (4) Deplasmolysis

Q.71 If there is high amount of fertilizer present in soil & it is deficient in water then what will be the effect
(1) Over growth (2) Under growth
(3) No effect (4) Wilting of plants

Q.72 Plant cells do not burst in distilled water because : -
(1) Cell wall is permeable
(2) Cell wall is living
(3) Cell wall is elastic, rigid and get stretched
(4) Cell wall is dead and impermeable

Q.73 When a plant cell is placed in a hypertonic solution it becomes plasmolysed what shall be present between cell wall and plasmalemma at this stage ?
(1) Water and air (2) Cell sap
(3) Hypertonic solution (4) Solutes

Q.74 Bacteria can not survive in a highly salted pickle. Because
(1) Salt inhibits reproduction of bacteria
(2) Enough light is unavailable for photosynthesis
(3) They become plasmolysed and death occurs
(4) Nutrients in the pickle medium can not support life

WATER POTENTIAL

Q.75 Value of water potential for pure water is : -
(1) 1 (2) 2 (3) 3 (4) Zero

Q.76 Water potential is affected by : -
(1) Osmotic potential (2) Matric potential
(3) Pressure potential (4) All of the above

Q.77 When the solute has been added to the solution; it water potential will ?
(1) Increases
(2) Decreases
(3) Remains unchanged
(4) First increases then decreases

Q.78 Water potential of a cell when its placed in hypertonic solution : -
(1) Decreases
(2) Increases
(3) First increases then decreases
(4) No change

Q.79 Osmotic potential (ΨS) of a solution is always : -
(1) Positive (2) Negative
(3) Zero (4) Variable

Q.80 Water potential (Ψ) of a solution is always :-
(1) + Ve (2) – Ve
(3) Zero (4) Variable

Q.81 When the water potential of a cell become zero, it is said to be in ?
(1) Fully turgid state
(2) Flaccid state
(3) Incipiently plasmolysed state
(4) Completely plasmolysed state

Q.82 A root hair cell under ordinary coditions have a water potential in the range of : -
(1) – 1 to – 4 atm. (2) – 1 to + 4 atm.
(3) 1 to 2 atm. (4) – 1 to 2 atm.

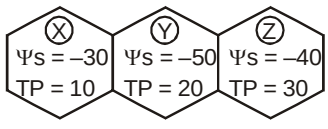
Q.83 Why hygroscopic water is not available to plants ?
(1) Because its Ψ_ω is greatly increased
(2) Because its DPD is greatly decreased
(3) Because its Ψ_ω becomes strongly negative
(4) Because its Ψ_ω is increased and DPD is decreased

Q.84 The concept of water potential was propounded by : -
(1) Robert mayer (2) Abbe Nollet
(3) Slatyer & Taylor (4) Levitt

Q.85 The solute potential can be determined in a simple manner by : -
(1) Water potential (2) DPD
(3) Osmotic pressure (4) Suction pressure

Q.86 The accurate equation for presenting water potential is : -
(1) $\Psi\omega = \Psi_s + \Psi_p + \Psi_m$
(2) $\Psi_s = \Psi\omega + \Psi_p + \Psi_m$
(3) $\Psi\omega = \Psi_s - \Psi_p - \Psi_m$
(4) $\Psi\omega = -\Psi_s - \Psi_p - \Psi_m$

Q.87 The direction of the water flow in given cells X,Y & Z can be presented as : -
(1) X → Y ← Z
(2) X → Y → Z
(3) X ← Y ← Z
(4) X ← Y → Z



Q.88 The water potential & osmotic potential of pure water is : -

(1) 100 & zero (2) Zero & zero

(3) 100 & 200 (4) Zero & 100

Q.89 The relationship between DPD & Ψw can be expressed as : -

(1) DPD = Ψ_w (2) Ψ_w – DPD = 0

(3) $\frac{DPD}{\psi_w} = 0$ (4) Ψ_w = – DPD

Q.90 Solute potential can be presented as : -

(1) Ψs = – OP (2) Ψw = OP

(3) OP – Ψs = 0 (4) $\frac{\psi s}{OP} = 0$

Q.91 In plant water relations, Ψ indicates -

(1) DPD (2) Solute potential

(3) Water potential (4) Suction pressure

Q.92 If the solute is added in the given solution than what osbervation can be made -

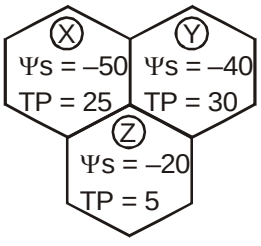
(1) Its DPD decreases

(2) It's water potential decreases

(3) DPD & water potential remains unchanged

(4) Its water pontential increases

Q.93 If three cells X, Y and Z are joined to each other & their solute potential & Turgor pressure values are given in the figure; then demonstrate the direction of flow of water in this system : -



(1) 

(2) 

(3) 

(4) 

Q.94 In 0.1M solution of a none electolyte,Ψw value will be : -

(1) zero bar (2) +2.3 bar

(3) – 2.3 bar (4) –22.4 bar

Q.95 If a cell is placed in a hypertonic solution then Ψ_w of the cell will be : -

(1) Increased

(2) Decreased

(3) Unchanged

(4) First increases then decreases

Q.96 The Ψ_w of pure water is : -

(1) Minimum (2) Less than DPD

(3) Maximum (4) Variable

Q.97 If the OP of any osmotic system is 35 atm and its turgor pressure 9 units. Find out water pontential present in the osmotic system : -

(1) – 44 unit (2) – 26 unit

(3) 26 unit (4) – 3.88 unit

IMBIBITION

Q.98 Seeds swell when placed in water due to : -

(1) Osmosis (2) Imbibition

(3) Hydrolysis (4) All of these

Q.99 During rainy season wooden doors generally swell up due to : -

(1) Osmosis (2) Imbibition

(3) Bad wormanship (4) Wood quality

Q.100 Imbibition process involves : -

(1) Both diffusion and capillary action

(2) Only diffusion

(3) Only capillary action

(4) None of the above

Q.101 The most powerful imbibant is : -

(1) Agar - agar (2) Proteins

(3) Cellulose (4) Lignin

Q.102 Swelling of wooden planks and door-penals during the rainly season is due to : -
(1) Imbibition (2) Endosmosis
(3) Deplasmolysis (4) Diffusion

Q.103 First step of influx of water into a plant (or) a root hair cell (or)a seed is : -
(1) Osmosis (2) Imbibition
(3) Absorption (4) Suction

Q.104 Which of the following is imbibiant ?
(1) Proteins(2) Pectin
(3) Starch (4) All of the above

Q.105 Which of the following seeds develope a greater imbibition pressure ?
(1) Wheat seed (2) Gram seed
(3) Rice seed (4) Mustard oil seed

Q.106 Swelling in wooden block placed in water is due to
(1) Endosmosis (2) Capillarity
(3) Absorption (4) Imbibition

Q.107 The right sequence for imbibition is : -
(1) Agar agar > cellulose > protein
(2) Protein > cellulose > agar agar
(3) Agar agar > protein > cellulose
(4) Agar agar < protein < cellulose

Q.108 To initiate cell plasmolysis, the salt concentration must be : - **[MPPMT-2002]**
(1) Isotonic (2) Hypotonic
(3) Hypertonic (4) Atonic

Q.109 When a plasmolysed cell is placed in a hypotnonic solution then water will move inside the cell this will happen due to which force **[RPMT-2002]**
(1) DPD (2) OP
(3) W.P (4) None of them

Q.110 Which of the following statement is not correct ?
(1) Plants absorb excess quantity of water
(2) Plants take small quantity of mineral salts through soil water
(3) Water and inorganic salts may also simultaneously by root hair
(4) Plant absorb only one thing at a time water or inorganic salts

Q.111 Which of the following is a rapid type of absorption ?
(1) Passive absorption (2) Active absorption
(3) Salt absorption (4) Root absorption

Q.112 The form of water absorbed by plant's root system, from the soil is : -
(1) Hygroscopic water
(2) Gravitational water
(3) Capillary water
(4) All of these

Q.113 The pathway of water from soil upto the secondary xylem : -
(1) Soil → root hair → cortex → endodermis → pericycle → protoxylem → Meta xylem
(2) Metaxylem → protoxylem → pericyle → cortex → endodermis → soil → root hair
(3) Cortex → root hair endodermis → pericycle → protoxylem → metaxylem
(4) Pericycle → soil → root hair → cortex → endodermis → protoxylem → metaxylem

Q.114 Humus in soil is necessary for plant growth because it : -
(1) Increase aeration and water absorption capacity of soil
(2) Makes soil compact
(3) Makes soil sterile
(4) Decreases rate of percolation

Q.115 Water will be absorbed by root hairs when : -
(1) Concentration of salts in the soil is high
(2) Concentration of solutes in the cell sap is high
(3) The plant is rapidly respiring
(4) They are separated from the soil by a semipermeable membrane

Q.116 Water in plants is transported by ascent of sap takes place through : -
(1) Cambium (2) Phloem
(3) Xylem (4) Epidermis

Q.117 In poorly aerated soil, the rate of water absorption will : -
(1) Increase (2) Decrease
(3) Remains the same (4) None of these

Q.118 Which of the following water comes under echards ?
(1) Available to the plant
(2) Whole of the soil water
(3) Amount of water not available to the plant
(4) None of the above

Q.119 Which plant hormone help in active absorption of water ?
(1) Auxin (2) GA
(3) Cytokinin (4) ABA

Q.120 What is true for the water available in the soil ?
(1) Holard = Chresard + Echard
(2) Holard = Chresard – Echard
(3) Chresard = Holard + Echard
(4) Echard = Holard + Chresard

Q.121 Passive absorption of water takes place by : -
(1) Osmosis
(2) The presence of energy
(3) Root pressure
(4) Transpiration pull

Q.122 Root hairs occurs in : -
(1) Meristematic zone
(2) Cell elongation zone
(3) Cell maturation zone
(4) Old root

Q.123 All the following involves osmosis except :-
(1) Movement of water from soil to root
(2) Movement of water from root hair to endodermis and pericycle
(3) Movement of water between xylem elements
(4) Movement of water from xylem to mesophyll cells of the leaves

Q.124 Suitable temperature for active absorption of water by root is : -
(1) 40-45ºC (2) 10-15ºC
(3) 20-35ºC
(4) Can take at any temperature

Q.125 "Osmotic theory" for an active absorption of water was given by : -
(1) Thiman (2) O. Hertwig
(3) Atkin & Priestley (4) J.C. Bose

Q.126 Root cap plays no role in the absorption of water in a plant because : -
(1) Its cells are loosly arranged
(2) It has no root hairs
(3) It has no connection with xylem tissue
(4) it's cells are dead

Q.127 Energy dependent absorption of water against osmotic phenomenon is : -
(1) Active absorption
(2) Passive absorption
(3) Imbibition
(4) Bulk absorption

Q.128 In a yound root the most active absorption of water takes place through : -
(1) Root cap region
(2) Root hair region
(3) Zone of elongation
(4) Mature region with a corkly layer

Q.129 Water is actively absorbed by root when : -
(1) Soil solution is hypotonic
(2) Soil solution is hypertonic
(3) Transpiration rates are high
(4) Shoot pressure is high

Q.130 Maximum absorption of water by a root occur in the region of : -
(1) Cell division
(2) Cell elongation
(3) Cell maturation
(4) Cell division and root cap togther

Q.131 Absorption of water is increased when : -
(1) Transpiration is increased
(2) Photosynthesis is increased
(3) Respiration is increased
(4) Root pressure is increased

Q.132 Passive absorption of water from the soil by the root is mainly effected by : -
(1) Typical tissue organisation
(2) Respiratory activity of root
(3) Tension on cell sap due to transpiration
(4) None of the above

Q.133 Active absorption of water from the soil by the root is mainly effected by : -
(1) Typical tissue organisation
(2) Resipiratory activity of root
(3) Tension on cell sap due to transpiration
(4) None of the above

Q.134 The water held tightly by the soil particles around them is known as : -
(1) Field capacity (2) Run away water
(3) Hygroscopic water (4) Capillary water

Q.135 Percentage of water left in the soil when a plant begins to wilt is known as : -
(1) Wilting coefficient
(2) pH value of soil
(3) Field capacity
(4) Water holding capacity

Q.136 Which of the following factors inhibit the absorption of water by roots ?
(1) Low soil temperature
(2) High concentration of soil solution
(3) Low soil aeration
(4) All of the above

Q.137 Which of the plants can absorb water in the form of vapour from its atmosphere ?
(1) All xerophytes
(2) Low transpiring cacti
(3) Succulents plants
(4) Epiphytes & Lichen

Q.138 "Non-osmotic" theory for an active absorption of water was given by : -
(1) Thimann & Bennet clark
(2) Atkin & Priestley
(3) J.C. Bose
(4) O. Hertig

Q.139 When the temerature of soil becomes 1ºC then ?
(1) Absorption of water increases
(2) Absorption of water decreases
(3) Absorption of water remains unaffected
(4) Both (2) and (3) are correct

Q.140 When the concentration of the soil solutes is low, the absorption of water is ?
(1) Retarted (2) Increase
(3) Remains normal (4) Stopped

Q.141 Which type of plant are physiologically dry ?
(1) Hydrophytes (2) Epiphytes
(3) Lithophytes (4) Halophytes

Q.142 Which method is responsible for most of the absorption in higher plants?
(1) Active absorption
(2) Passive absorption
(3) Osmotic absorption
(4) Non osmotic absorption

Q.143 The absorption of water due to expenditure of energy is called : -
(1) Non osmotic active absorption
(2) Osmotic active absorption
(3) Passive absorption
(4) All

Q.144 Halophytes can grow on physiologically dry soil due to -
(1) Dry soil
(2) Excessive humidity outside
(3) Excessive salts in plants
(4) Excessive salts in water

ASCENT OF SAP

Q.145 Water rises in the stem due to : -
(1) Cohesion and transpiration pull
(2) Turgor pressure
(3) Osmotic pressure
(4) None

Q.146 Sap ascends in woody stem because of : -
(1) Transpiration pull (2) Capillarity
(3) Molecular adhesion (4) Photosynthesis

Q.147 Pulsation theory to explain ascent of sap in Desmodium was proposed by : -
(1) Dixon and Jolly (2) Curtis
(3) J.C. Bose (4) None of these

Q.148 Dixon and Jolly are associated with : -
(1) Light reaction photosynthesis
(2) An aerobic respiration
(3) Cohesion and transpiration pull theory of ascent of sap
(4) Apical dominance

Q.149 The continuity of water column in xylem is maintained due to : -
(1) Presence of air bubbles
(2) Cohesive property of water
(3) Evaporation power of water
(4) None of the above

Q.150 Relay pump theory of ascent of sap was proposed by : -
(1) Boase (2) Godlewsky
(3) Westermaier (4) Von sachs

Q.151 The first vital theory to explain ascent of sap was proposed
(1) J.C. Bose (2) Godlewski
(3) Westermaier (4) Dixon and Jolly

Q.152 Capillary force theory to explain ascent of sap was proposed by :-
(1) Boehm (2) Sachs
(3) Jamin (4) Priestley

Q.153 Ringing experiment to explain ascent of sap path was firstly done by : -
(1) Hartig, Malpighi
(2) Dixon & Jolly
(3) Godlewski & J.C. Bose
(4) Stephen hales and Boehm

Q.154 Passage of ascent of sap is shown by :-
(1) Osmometer (2) Porometer
(3) Manometer
(4) Blockage experiment

Q.155 Transpiration - cohesion - tension theory operates in : -
(1) Active absorption
(2) Passive absorption
(3) Active & passive absorption
(4) None of the above

Q.156 Attractive forces of cell for water molecules is termed as : -
(1) Adhesion (2) Cohesion
(3) Osmosis (4) Plasmolysis

Q.157 The imbibition theory for the ascent of sap was suggested by : -
(1) Sir J.C. Bose (2) Strassburger
(3) Sachs (4) Dixon and Jolly

Q.158 If all the tissue of a plant to certain points are removed except the xylem which is left intact : -
(1) The leaves will wilt
(2) The stem will die first
(3) The root will die first
(4) The whole plant will die at the same time

Q.159 Which of the following is incorrect match ?
(1) Pulsation theory - J.C. Bose
(2) Relay pump theory - Godlewsky
(3) Imbibition theory - Von sachs
(4) Capillary theory - Priestley

Q.160 Which tissue are removed when a plant is girdled ?
(1) Xylem & pith
(2) Xylem & Phloem
(3) Phloem to epidermis
(4) Phoem to pith

Q.161 Removal of a ring of bark from the trunk of a tree eventually kills it because : -
(1) Water can not go up
(2) Fungi & insects attack exposed parts
(3) Food does not travel down & root becomes starved
(4) Air blocks the xylem

Q.162 Which would do maximum harm to a tree ?
(1) The loss of half of its leaves
(2) The loss of all its leaves
(3) The loss of half of its branches
(4) The loss of its bark

Q.163 Ringing experiment can not be done on a sugar cane plant because : -
(1) Its xylem is scanty
(2) Its phloem is with out phloem parenchyma
(3) Its vascular bundles are sacttered
(4) Its phloem is present inside the xylem

Q.164 In plants the translocation of organic solutes take place through : -
(1) Epidermis (2) Xylem
(3) Phloem (4) Pith

Q.165 Most accepted theory for Ascent of sap given by : -
(1) Godlewski & Sacks
(2) J.C. Bose
(3) Stephan Hales
(4) Dixon and Jolly

Q.166 Ringing experiment is to show : -
(1) Path of ascent of sap
(2) Comparision of transpiration
(3) Passive absorption
(4) Stomatal opening & closing

Q.167 The conduction of water from root hair to root xylem is :-
(1) Symplastic
(2) Apoplastic
(3) Osmotically
(4) Symplastic + Apoplastic

Q.168 Dixons blockage experiment is concerned with : -
(1) Transpiration
(2) Passive absorption
(3) Path of ascent of sap
(4) Vital theory for ascent of sap

Q.169 The pulsation theory is related with : -
(1) Guttation
(2) Bleeding
(3) Vital theory for ascent of sap
(4) Physical theory for ascent of sap

Q.170 Root pressure theory was proposed by : -
(1) Priestley (2) Stephen Hales
(3) Levitt (4) Sachs

Q.171 By which process absorbed water reaches upto the leaves ?
(1) Transpiration (2) Guttation
(3) Root pressure (4) Ascent of sap

Q.172 Ringing experiment was performed in : -
(1) Balsom plant
(2) Mirabilis plant
(3) Indian telegraph plant
(4) Avena plant

TRANSPIRATION

Q.173 Opening of stomata is due to : -
(1) Turgidity of guard cells
(2) Size of guard cells
(3) Number of gurad cells
(4) Amout of CO_2 in the atmosphere

Q.174 Transpiration in plants will be lowest when :-
(1) There is high humidity in the atmosphere
(2) High wind velocity
(3) There is excess of water in the soil
(4) Environmental conditions are very dry

Q.175 The metal ion involved in the stomatal regulation is
(1) Iron (2) Magnesium
(3) Zinc (4) Potassium

Q.176 The following percentage of water absorbed by herbaceous plants is lost in transpiration :-
(1) 80% (2) 60% (3) 40% (4) 99%

Q.177 Transpiration from plants would be most rapid when
(1) There is lot of humidity in atmosphere
(2) The air is more humid
(3) There is excess rain fall
(4) Environmetal conditions are dry

Q.178 Processes occur in leaves, which may lower their temperature is : -
(1) Respiration (2) Photosytnhesis
(3) Hydrolysis (4) Transpiration

Q.179 When Oak leaf stomata opens, process is :-
(1) Water molecules enter adjacent guard cells
(2) Atmosphere outside stomata become less humid
(3) Auxins are accumulated in guard cells
(4) Salt molecules are excreted by adjacent gurad cells

Q.180 Wilting of a plant result from excessive : -
(1) Respiration (2) Photosynthesis
(3) Absorption (4) Transpiration

Q.181 The rate of transpiration is high when : -
(1) The atmosphere is saturated with water vapour
(2) Light is very dim
(3) The temperature is low
(4) The atmosphere is dry and the temperature is high

Q.182 Excessive loss of water causes wilting of leaves, it can be prevented by : -
(1) Keeping the plant in bright light
(2) Spraying the plant with alcohol
(3) Applying vaseline on the leaf surface
(4) Adding high amounts of fetilizers to the soil

Q.183 Leaves which appear wilted in the day time recover at night because :-
(1) Light is esstential for photo synthesis
(2) The stomata close down, temperature decrease, transpiration is reduced and the plant is able to absorb more water from the soil
(3) Respiration and translocation of organic substance both increases
(4) The plant is ***sleeping*** because of dark conditions

Q.184 Conversion of starch to organic acid is essential for
(1) Stomatal closure (2) Stomatal opening
(3) Stomatal initiation (4) Stomatal growth

Q.185 Increase in CO_2 concentration around leaf results in : -
(1) Rapid opening of stomata
(2) Partial closure of stomata
(3) Complete closure of stomata
(4) No effect on stomatal opening

Q.186 Which of the following wall of guard cells is thick ?
(1) Outer (2) Inner
(3) Sidewall (4) All the three

Q.187 Potometer and Clinostat are used to study :-
(1) Photosynthesis and respiration
(2) Transpiration and growth
(3) Phototropism and Geotropism
(4) Transpiration and Geotropism

Q.188 The rate of transpiration will be high when there is ?
(1) Rainy season (2) Winter season
(3) Summer season (4) None of these

Q.189 Which type of transpiration is more commen -
(1) Cuticular
(2) Stomatal
(3) Lenticular
(4) Bark transpiration

Q.190 Maximum transpiration is taking place through the
(1) Stomata (2) Lenticel
(3) Hydathode (4) Cuticle

Q.191 The inter conversion of sugar & starch is dependent on pH changes in the guard cells; was demonstrated by : -
(1) Levitt (2) Lloyd
(3) Sayre (4) Steward

Q.192 The spray of PMA causes :-
(1) Decrease in transpiration
(2) Increase in transpiration
(3) Increase in absorption
(4) Increase in guttation

Q.193 When the stomata are opening; we observe following changes in the gurad cells ?
(1) OP increase, TP decreases
(2) OP & TP increases
(3) OP decreases, TP increases
(4) OP & TP decreases

Q.194 The pH in the guard cells was observed when stomata were open it ranges : -
(1) 9 - 10 (2) 4 - 5
(3) 7.5 (4) 2 - 4

Q.195 What will be the effects on stomata, if relative humidity is 100% in atmosphere ?
(1) Completely open (2) Partially open
(3) No effects (4) Closed

Q.196 Which of the following is produced during water stress condition ?
(1) Cytokinin (2) ABA
(3) Phytochrome (4) ATPase

Q.197 Which chemical is used to detect transpiration comparatively ?
(1) Calcium carbonate (2) Cobalt carbonate
(3) Cobalt chloride (4) Mercuric acetate

Q.198 Active K^+ ion exchange mechanism of opening and closing of stomata was given by :-
(1) Khorana (2) Scrath
(3) Levitt (4) Kohli

Q.199 Cuticular transpiration is observed mainly in :-
(1) Xeropytes
(2) Herbaceous plants
(3) Trees
(4) Shrubs

Q.200 What is action spectrum of transpiration ?
(1) Green and U.V (2) Blue and Yellow
(3) Blue and far red (4) Blue and red

Q.201 In which of the following plants, the metabolism will be hindered if upper surface of leaves are coated with wax ?
(1) Hydrilla (2) Nelumbium
(3) Vallisneria (4) Utricularia

Q.202 Which of the following substance serve as an anti-transpirant in plant ?
(1) Phenyl mercuric acetate
(2) Asprin
(3) Silicon oil
(4) All of these

Q.203 Which of the factor acts as anti-transpirant?
(1) SO_2 (2) CO
(3) CO_2
(4) All pollutant gasses

Q.204 Transpiration is a non-enzymatic process its Q_{10} value is : -
(1) 1 (2) 2 (3) 3.5 (4) Zero

Q.205 The most important factor affecting transpiration is
(1) Light
(2) Temperature
(3) Wind
(4) Atmospheric humidity

Q.206 Presence of thick cuticle, hairs, scales & fewer sunken stomata are found in the leaves of xerophyte it is to : -
(1) Stop transpiration
(2) Facilitate transpiration
(3) Store water
(4) Chck excessive transpiration

Q.207 Which factor regulates the loss of water through transpiration : -
(1) Nitrogen (2) Humidity
(3) Level of O_2 in air (4) Xylem

Q.208 With increase in temperature the rate of transpiration becomes : -
(1) Low
(2) High
(3) Low in herbs and high in tress
(4) Immediately stopped

Q.209 Which of the following plant do not transpire ?
(1) Alage
(2) Fungi
(3) Submerged hydrophytes
(4) All the above

Q.210 Wilting of plant results from an excessive :-
(1) Absorption
(2) Photosynthesis & poor osmosis
(3) Respiration
(4) Transpiration

Q.211 Transpiration is completely absent in : -
(1) Xerophytes
(2) Mesophytes
(3) Sumerged hydrophtes
(4) Succulents at night

Q.212 Who states "Transpiration to be an unavoidable evil' ?
(1) Blackman (2) Steward
(3) Priestley (4) Curtis

Q.213 Which pigment regulates opening and closing of stomata ?
(1) Chlorophylls (2) Carotenoids
(3) Phytochrome (4) Flavines

Q.214 Which photoreceptor controls the opening & closing of stomata ?
(1) Chlorophyll-a (2) Chlorophyll-b
(3) Phytochrome (4) Carotene

Q.215 For plants transpiration is : -
(1) Not very important
(2) Important to same
(3) A neccessary evil
(4) An important burden

Q.216 Significance of transpiration lies in : -
(1) Circulation of water
(2) Absorption and distribution of water
(3) Regulating the temperature of the plant body
(4) All of the above

Q.217 In apple type of stomata : -
(1) Stomata are present only on the upper surface of leaf
(2) Stomata are present only on the lower surface of leaf
(3) Stomata are present on both surfaces of leaf
(4) Stomata are vestigeal

Q.218 Which of the following plant product act as an internal anti-transpirant ?
(1) Phenyl mercuric acetate
(2) CO_2 and malic acid
(3) Abscisic acid
(4) Ferulic acid

Q.219 In the mechanism of the opening to stomata, the important factor is : -
(1) Turgidity of the guard cells
(2) Chlorophyll content of the guard cells
(3) Hormone content of the subsidary cells
(4) Protein content of the epidermal cells

Q.220 Stomata open at day because in day the guard cells have :-
(1) To help gas exchange
(2) A low pH
(3) A high level of sugar, organic acid ATP & K^+ ion
(4) Unequally thickened walls

Q.221 Basic of stomatal opening is : -
(1) Exosmosis
(2) Endosmosis
(3) Decrease in cell sap concentration
(4) Plasmolysis of guard cells

Q.222 Guard cells are found in : -
(1) Stomata
(2) Hydathodes
(3) Both
(4) None of the above

Q.223 Shape of guard cells in gramineae family :-
(1) Kidney shaped (2) Oval
(3) Round (4) Dumbel shaped

Q.224 Scotoactive stomata are occurs in : -
(1) Sacculent xerophytes
(2) Hydrophytes
(3) Mesophytes
(4) None of the above

Q.225 With decrease in atmospheric pressure the rate of transpiration will : -
(1) Remain unaffected
(2) Increased
(3) Decrease slowly
(4) Decrease rapidly

Q.226 Which of the following statement is not true ?
(1) Transpiration is increased when root shoot ratio is increased
(2) Transpiration is increased when latex & mucilage is increased in tissue
(3) Transpiration is decreased when stomata are sunken
(4) Transpiration is decreased when leaves becomes leathery of hairy

Q.227 Which one of the following will reduce the rate of transpiration ?
(1) Increase in wind velocity
(2) Rise in temperature
(3) Increase in water uptake by plants
(4) Decrease in light intensity

Q.228 The most important fuction of transpiration in plants is to cause : -
(1) Loss of surplus water
(2) Cooling of the plant
(3) Rapid ascent of sap
(4) Rapid rise of minerals

Q.229 Which of the following plants economises transpiration loss of water ?
(1) C_3-plants (2) C_4-plants
(3) Both equally (4) C_2-plants

Q.230 The change in turgor pressure which causes the opening and closing of Stomata is caused by-
(1) Reversible starch-sugar conversions
(2) Reversible absorption and loss of K-ions
(3) Loss of chloride ions
(4) None of these

Q.231 The "proton transport concept" for the opening of photoactive stomata was given by :-
(1) Yin tung (2) Levitt
(3) Sachs (4) Sayre

Q.232 According to Scarth the opening & closing of stomata is governed by :-
(1) pH (2) Phosphorylation
(3) $NaDPH_2$ (4) Enzymes

Q.233 Before opening of stomata accumulation of the following ion is seen in : -
(1) PO_4 (2) K^+ (3) Mg^{++} (4) Na^+

Q.234 In sacculent plants the stomata opens at night and closes by day. Which of following would be best hypothesis to explain the mechanism of stomata opening at night only?
(1) CO_2 used up, increased pH results in accumulation of sugars
(2) CO_2 accumulates, reduces pH stimulates enzymes resulting in accumulation of carbohydrate
(3) Increase in CO_2 concentration, conversion of organic acids in to starch resulting in the increased uptake of potassium ions and water
(4) High CO_2 concentration causes accuumulation of organic acids in guard cells resulting in to the increased concentration of cell sap

Q.235 Guard cells differ from other epidermal cells in having :-
(1) Large vacuoles
(2) Secondary walls
(3) Chloroplast with PEP-carboxylase enzyme
(4) Absence of mitochondria

Q.236 The trunk of a tree shrinks in day due to : -
(1) Rapid translocation of food
(2) Transpiration induced tension
(3) Rapid growth in day hours
(4) Light induced elongation of plant

Q.237 Apparatus used for measuring the transpiration : **[RPMT-2002]**
(1) Evapometer (2) Potometer
(3) Osmometer (4) Tensiometer

Q.238 Transpiration occures from : -
(1) Leaves (2) Stems
(3) All parts (4) All aerial parts

Q.239 Leaves of submerged hydrophytes are : -
(1) Epistomatic (2) Hypostomatic
(3) Astomatic (4) Above 1 & 2

Q.240 The diffusion of water vapours through areial parts of the plants is called : -
(1) Osmosis (2) DPD
(3) Transpiration (4) All

Q.241 If the absorption is more, but transpiration is less; then process affected will be : -
(1) Root pressure (2) Guttation
(3) Bleeding (4) All

Q.242 Active $K^+ \rightleftharpoons H^+$ exchange theory explained -
(1) Ascent of sap
(2) Phloem conduction
(3) Ion absorption
(4) Stomatal movement

Q.243 Transpiration is a necessary evil, given by -
(1) Levitt (2) Curtis
(3) Steward (4) Sachs

Q.244 Which of the following theory gives the latest explanation for closure of stomata ? **[BHU 2002]**
(1) ABA theory
(2) Munch theory
(3) Starch-glucose theory
(4) Active K^+ transport theory

Q.245 Potassium ions concentration is more in guard cells when stomata are open but less when stomata are closed. This was reported by :-
(1) Hsio, Fisher (2) Fujino
(3) Levitt (4) Lloyd

Q.246 The loss of water in the form of water drops is taking place through the : -
(1) Hydathodes (2) Lentical
(3) Stomata (4) All

Q.247 The potometer is based on the principle that : -
(1) Transpiration is based on stomatal opening
(2) Stomata open during day time
(3) Absorption = Transpiration
(4) Transpiration tension present in leaves

Q.248 Gutaation is dependent on : -
(1) Root pressure
(2) Active absorption
(3) Flaccidity of root cortical cells
(4) High rate of transpiration

Q.249 Due to increasing temperature, transpiration:-
(1) Increases
(2) Decreases
(3) First increases then decreases
(4) Unaffected

Q.250 If temperature remains constant then with increasing alttitude, the transpiration will : -
(1) Increases
(2) Decreases
(3) First decreases then increases
(4) Unaffected

Q.251 The conversion of starch to organic acid is essential for stomatal : -
(1) Closure (2) Growth
(3) Initiation (4) Opening

Q.252 Transpiration increases when atmospheric temperature rises, due to : -
(1) Wider opening of stomata
(2) Stomatal opening becomes narrow
(3) Water holding capacity of the air increases
(4) More photosynthesis in guard cells

Q.253 The names of Yin & Tung are assoicated with findings of : -
(1) Phosphorylase enzyme
(2) Sugar-starch conversion
(3) Localization of phosphorylase enzyme in guard cells
(4) Exchange of K^+ & H^+

Q.254 Due to more wind velocity, the transpiration rate will be : -
(1) Less
(2) More
(3) Unaffected
(4) First increases then decreases

Q.255 Foliar transpiration : -
(1) Includes stomatal and cuticular transpiration
(2) Does not occur
(3) Includes all type of transpiration
(4) Shows stomatal transpiration

Q.256 Radial micellation of cellulose occurs at :-
(1) Outer wall of guard cells
(2) Inner wall of guard cells
(3) Inner wall subsidiary cells
(4) None of the above

Q.257 The Sugarcane plant has : - **[AIIMS-2004]**
(1) Dumb-bell shaped guard cells
(2) Pentamerous flowers
(3) Reticulate venation
(4) Capsular fruits

GUTTATION, BLEEDING, ROOT PRESSURE, WILTING

Q.258 Root presence is maximum, when : -
(1) Transpiration is high and absorption is very low
(2) Transpiration is very low and absorption is high
(3) Absorpton is very high and transpiration is also very high
(4) Absorption is low and transpiration is alwo very low

Q.259 Wilting in plant occurs when : -
(1) Xylem is blocked
(2) Epidermis is pealed off
(3) Pith is removed
(4) Phloem is blocked

Q.260 Pressure exerted on the fluid contents of the cortical cells of root by turgidity. Which forces the water in to xylem vessels and upward in the stem for a certain height is : -
(1) Imbibition (2) Root pressure
(3) Capillarity (4) Turgor pressure

Q.261 The process of the escape of liquid from the tip of uninjured leaf is called : -
(1) Evaporation
(2) Transpiration
(3) Guttation
(4) Evapo-transpiration

Q.262 Guttation take place during night when : -
(1) Root pressure is positive
(2) Root pressure is negative
(3) Always take place
(4) It does not takes place at all

Q.263 The hydathodes are related with : -
(1) Transpiration (2) Guttation
(3) Bleeding (4) All

Q.264 Who discovered the root pressure :-
(1) Stephen hales (2) Priestley
(3) Dixon (4) Renner

Q.265 Root pressure can be measured by the instrument
(1) Potometer (2) Auxenometer
(3) Manometer (4) Barometer

Q.266 In summer afternoon, rate of transpiration is greater than the rate of absorption then what happens to plants : -
(1) Temporary wilting
(2) No effect
(3) Leaves becomes yellow
(4) Plant will die

Q.267 Which conditions favours "Guttation" ?
(1) High water absorption
(2) High transpiration
(3) Low transpiration
(4) (1) and (3) both

Q.268 When stem of a herbaceous plant is cut, water or sap oozes out, this is due to ?
(1) Guttation (2) Transpiration pull
(3) Root pressure (4) Imbibition

Q.269 Maximum bleeding occurs in : -
(1) Agave (2) Vitis
(3) Betula (4) Caryota urens

Q.270 Guttation usually occurs in a well watered herbaceous plant and well drained soil only in : -
(1) Morining hours (2) Evening hours
(3) Noon hours (4) Day hours

Q.271 Hydathodes open during : -
(1) Hight hours (2) Day hours
(3) Noon hours (4) Always open

Q.272 The "Guttation" word was given by : -
(1) Bergerstein (2) Sayre
(3) Scarth (4) Stephen hales

Q.273 Which of the following is not a rhythmic phenomenon ?
(1) Stomatal opening & closing
(2) Guttation
(3) Nyctinasty
(4) Photonastic movments

Q.274 Water of guttation is : -
(1) Pure water
(2) Water with dissolved salts
(3) Solution of organic food
(4) Condensed water vapour

Q.275 Cells present on hydathodes is -
(1) Complementary cells
(2) Epithem cells
(3) Guard cells
(4) Kranz cells

Q.276 The process involved in the formation of Toddy is : -
(1) Guttation (2) Transpiration
(3) Bleeding (4) All

Q.277 The whitish powder around hydathode is due to : -
(1) Guttation
(2) Salt depositon from air
(3) Salt formation over surface
(4) Bleeding

MINERAL ABSORPTION & NUTRITION

Q.278 Which of the group of elements is not essential for a normal plant ?
(1) K, Ca, Mg (2) Fe, Zn, Mn, B
(3) Pb, I, Na (4) Mg, Fe, Mo

Q.279 Hydroponics is a technique in which plants are grown in ?
(1) Green house
(2) Water saturated sand
(3) Balanced nutrient solution
(4) Purified distilled water

Q.280 For cholrophyll formation a plant needs :-
(1) Fe, Ca & light (2) Fe, Mg & Light
(3) Ca, K & light (4) Mn & Cu

Q.281 Brown heart rot of beets is due to deficiency of-
(1) B (2) P (3) Mg (4) Mo

Q.282 Die back disease in citrus is due to deficiency of : -
(1) Mo (2) B (3) Cu (4) Zn

Q.283 The disease related with deficiency of molybdenum is : -
(1) Whiptail disease of cauliflower
(2) Little leaf disease
(3) Reclamation disease of cereals
(4) Brown heart disease

Q.284 Protoplasmic elements are : -
(1) C, H, O, P, N, S (2) C, H, O, Fe, N
(3) N, S, Fe, P, K (4) Fe, Mg, Ca, N, P

Q.285 Which element is not considered as macronutrient ?
(1) Mg (2) Ca (3) Mn (4) P

Q.286 The element which can not be placed along with micronutrients : -
(1) Mn (2) Mo (3) Cu (4) Ca

Q.287 The amino acid having S in its composition is -
(1) Cystine (2) Cysteine
(3) Methionine (4) All

Q.288 Which elements are considered as balancing elements ?
(1) Ca & K (2) C & H
(3) N & S (4) Mg and Fe

Q.289 The group of mineral nutrients known as frame work elements : -
(1) N, S, P (2) C, H, O
(3) Mg, Fe, Zn (4) Zn, Mn, Cu

Q.290 Which element essential for stability of chromosome structure ?
(1) Zn (2) Ca (3) Mo (4) Fe

Q.291 "Reclamation" and "Little leaf" disease, caused by deficiency of -
(1) Zn and Mo (2) Cu and Zn
(3) Cu and B (4) Mn and Cu

Q.292 Which element is required in comparatively least quantity for the growth of plant ?
(1) Zn (2) N (3) P (4) Ca

Q.293 Which of the following essential element is not properly placed in the given category ?
(1) Cu (2) Zn (3) Mg (4) Mn

Q.294 Criteria for essentiality in mineral nutrition were shown firstly by : -
(1) Arnon (2) Liebig
(3) Steward (4) Levitt

Q.295 Which mineral nutrients are called critical element for crops ?
(1) N, P, K (2) C, H, O
(3) N, S, Mg (4) K, Ca, Fe

Q.296 The mineral nutrient mainly concerning with apical meristematic activity is : -
(1) K (2) Ca (3) N (4) S

Q.297 Little leaf disease is caused by -
(1) Zn - deficiency (2) Cu - deficiency
(3) Mo - deficiency (4) Mn - deficiency

Q.298 Which of the following does NPK denote ?
(1) Nitrogen, Potassium, Kinetin
(2) Nitrogen, Protein, Kinetin
(3) Nitrogen, Protein, Potassium
(4) Nitrogen,Phosphours, Potassium

Q.299 Plants absorb mineral salts from the soil solution through : -
(1) A semipermeable membrane into the cytoplasm
(2) Perforations at the apex of root hair cells
(3) The cell wall which is semipermeable
(4) None of these

Q.300 Mineral salts which are absorbed by the roots from the soil are in the form of : -
(1) Very dilute solution
(2) Dilute solution
(3) Concentrated solution
(4) Very concentrated solution

Q.301 By which method ions are absorbed by the plants ?
(1) Diffusion (2) DPD gradient
(3) Carrers proteins (4) Water pontential

Q.302 Hydrophytes absorb salt and water by : -
(1) Root and root hairs (2) Leaves and root
(3) Roots and stem (4) General epidermis

Q.303 Active and passive absorption terms were coined by : -
(1) Kramer (2) Deutrochet
(3) Priestley (4) Renner

Q.304 Which is free ion present in a cell ?
(1) P (2) K (3) Fe (4) B

Q.305 Who give the Cytochrome pump theory ?
(1) Sachs (2) Lundegradh
(3) Bose & Renner (4) Bennet - Clark

Q.306 Who proposed the protein lecithin theory ?
(1) Sachs (2) Lundegradh
(3) Bose & Renner (4) Bennet & Clark

Q.307 Carrier protein helped in : -
(1) Active absorption of ions
(2) Passive ions absorption
(3) Water absorption
(4) Vaporization

Q.308 Active uptake of minerals depends upon :-
(1) Active water absorption
(2) Transpiration
(3) Photorespiration
(4) Dephosphorylation

Q.309 When chlorophyll is burnt, which one obtained ?
(1) Fe (2) Mg (3) Ca (4) Mn

Q.310 Which element related with Khaira disease, of Paddy & auxin synthesis : -
(1) Fe (2) Zn (3) B (4) Cu

Q.311 Generally plants absorbed N_2 in the form of :-
(1) NO_2^- (2) NO_3^-
(3) $N \equiv N$ (4) HNO_2

Q.312 Cobalt present in : -
(1) Vit. – A (2) Vit. – B_2
(3) Vit. – B_{12} (4) PC

Q.313 Which is essential for N_2 metabolism ?
(1) B (2) Mo (3) Cu (4) Mg

Q.314 The major portion of the **dry weight** of plants comprises of : - **[AIPMT-2003]**
(1) Nitrogen, phosphorus and potassium
(2) Calcium, magnesium and sulphur
(3) Carbon, nitrogen and hydrogen
(4) Carbon, hydrogen and oxygen

Q.315 Which one of the following mineral elements plays an important role in biological nitrogen fixation ? **[AIPMT-2003]**
(1) Copper (2) Manganese
(3) Zinc (4) Molybdenum

Q.316 Stomata of CAM plants : - **[AIPMT-2003]**
(1) Are always open
(2) Open during the day & close at night
(3) Open during the night & close during the day
(4) Never open

Q.317 Stomata of a plant open due to : - **[AIPMT-2003]**
(1) Influx of potassium ions
(2) Efflux of potassium ions
(3) Influx of hydrogen ions
(4) Influx of calcium ions

Q.318 Plants deficient of element zinc, show its effect on the biosynthesis of plant growth hormone **[AIPMT-2003]**
(1) Auxin (2) Cytokinin
(3) Ethylene (4) Abscisic acid

Q.319 In which one of the following is nitrogen not a constituent ? **[AIPMT-2003]**
(1) Idioblast (2) Bacteriochlorophyll
(3) Invertase (4) Pepsin

Q.320 Gray spots of Oat are caused by deficiency of- **[AIPMT-2003]**
(1) Cu (2) Zn (3) Mn (4) Fe

Q.321 The most abundant element present in the plants is - **[AIPMT-2004]**
(1) Iron (2) Carbon
(3) Nitrogen (4) Maganese

Q.322 The ability of the Venus Flytrap to capture insects is due to - **[AIPMT-2005]**
(1) Chemical stimulation by the prey
(2) A passive process requiring no special ability on the part of the plant
(3) Specialized "muscle-like" cells
(4) Rapid turgor pressure changes

Q.323 The deficiencies of micronutrients, not only affects growth of plants but also vital functions such as photosynthetic and mitochondrial electron flow. Among the list given below, which group of three elements shall affect most,both photosynthetic and mitrochondrial electron transport : **[AIPMT-2005]**
(1) Cu, Mn, Fe (2) Co, Ni, Mo
(3) Mn, Co, Ca (4) Ca, K, Na

Q.324 Potometer works on the principle of : **[AIPMT-2005]**
(1) Amount of water absorbed equals the amount transpired
(2) Osmotic pressure
(3) Root pressure
(4) Potential difference between the tip of the tube and that of the plant

Q.325 Farmers in a particular region were concerned that pre-mature yellowing of leaves of a pulse crop might cause decrease in the yield. Which treatment could be most beneficial to obtain maximum seed yield **[AIPMT-2006]**
(1) Removal of all yellow leaves and spraying the remaining green leaves with 2,4,5-trichlorophenoxy acetic acid
(2) Application of iron and magnesium to promote synthesis of clorophyll
(3) Frequent irrigation of the crop
(4) Treatment of the plants with cytokinins alongwith a small dose of nitrogenous fertilizer

Q.326 Sulphur is an important nutrient for optimum growth and productivity in **[AIPMT-2006]**
(1) Fibre crops (2) Oil seed crops
(3) Pulse crops (4) Cereals

Q.327 A plant requires magnesium for : **[AIPMT-2007]**
(1) Cell wall development
(2) Holding cells together
(3) Protein synthesis
(4) Chlorophyll synthesis

Q.328 Which of the following is a flowering plant with nodules containing filamentous nitrogen-fixing microoganism ? **[AIPMT-2007]**
(1) Cicer arietinum
(2) Casuarina equisetifolia
(3) Crotalaria juncea
(4) Cycas revoluta

Q.329 About 98 percent of the mass of every living organism is composed of just six elements including carbon, hydrogen, nitrogen oxygen and : **[AIPMT-2007]**
(1) Calcium and phosphorus
(2) Phosphorus and sulphur
(3) Sulphur and magnesium
(4) Magnesium and sodium

Q.330 Which one of the following elements is not an essential micronutrient for plant growth ? **[AIPMT-2007]**
(1) Ca (2) Mn (3) Zn (4) Cu

Q.331 Carbohydrates are commonly found as starch in plant storage organs. Which of the following five properties of starch (a–e) make it useful as a storage material ? **[AIPMT-2008]**

(I) Easily translocated
(II) Chemically non-reactive
(III) Easily digested by animals
(IV) Osmotically inactive
(V) Synthesized during photosynthesis
The useful properties are-

(1) (I), (III) and (V) (2) (I) and (V)
(3) (II) and (III) (4) (II) and (IV)

Q.332 Nitrogen flxation is root nodules of Anlus is brought about by : - **[AIPMT-2008]**

(1) Frankia (2) Azorhizobium
(3) Bradyrhizobium (4) Clostridium

Q.333 Guard cells help in : - **[AIPMT-2009]**

(1) Fighting against infection
(2) Protection against grazing
(3) Transpiration
(4) Guttation

Q.334 Manganese is required in : - **[AIPMT-2009]**

(1) Chlorophyll synthesis
(2) Nucleic acid synthesis
(3) Plant cell wall formation
(4) Photolysis of water during photosynthesis

Q.335 An element playing important role in nitrogen fixation is- **[AIPMT-2010 (Pre)]**

(1) Manganese (2) Zinc
(3) Molybdenum (4) Copper

Q.336 Which one of the following is not a micronutrient? **[AIPMT-2010 (Pre)]**

(1) Zinc (2) Boron
(3) Molybdenum (4) Magnesium

Q.337 The chief water conducting elements of xylem in gymnosperms are- **[AIPMT-2010 (Pre)]**

(1) Transfusion tissue (2) Tracheids
(3) Vessels (4) Fibres

Q.338 Which one of the following structures between two adjacent cells is an effective transport pathway? **[AIPMT-2010 (Pre)]**

(1) Endoplasmic reticulum
(2) Plasmalemma
(3) Plasmodesmata
(4) Plastoquinones

Q.339 One of the free-living, anaerobic nitrogen-fixer is- **[AIPMT-2010 (Pre)]**

(1) *Rhizobium* (2) *Azotobacter*
(3) *Beijernickia* (4) *Rhodospirillum*

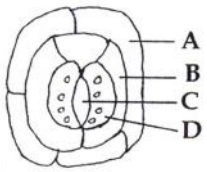
Q.340 The common nitrogen-fixer in paddy field is- **[AIPMT-2010 (Pre)]**

(1) *Oscillatoria* (2) *Frankia*
(3) *Rhizobium* (4) *Azospirillum*

Q.341 Transport of food material in higher plants takes place thrugh : **[AIPMT-2010 (Mains)]**

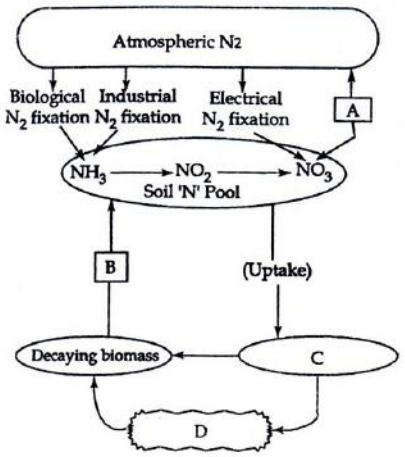
(1) Transfusion tissue
(2) Tracheids
(3) Sieve elements
(4) Companion cells

Q.342 Given below is the diagram of a stomatal apparatus. In which of the following all the four parts labelled as A, B, C and D are correctly identified? **[AIPMT-2010 (Mains)]**



	A	B	C	D
(1)	Guard cell	Stomatal aperture	Subsidiary cell	Epidermal cell
(2)	Epidermal cell	Guard cell	Stomatal aperture	Subsidiary cell
(3)	Epidermal cell	Subsidiary cell	Stomatal aperture	Guard cell
(4)	Subsidiary cell	Epidermal cell	Guard cell	Stomatal aperture

Q.343 Study the cycle shown below and select the option which gives correct words for all the four blanks A, B, C and D.
[AIPMT-2010 (Mains)]



Option :

	A	B	C	D
(1)	Dentrification	Ammonification	Plants	Animals
(2)	Nitrification	Dentrification	Animals	plants
(3)	Dentrification	Nitrification	Plants	Animals
(4)	Nitrification	Ammonification	Animals	plants

Q.344 Leguminous plants are able to fix atmospheric nitrogen through the process of symbiotic nitrogen fixation. Which one of the following statements is not correct during this process of nitrogen fixation? **[AIPMT-2010 (Mains)]**
(1) Nodules act as sites for nitrogen fixation
(2) The enzyme nitrogenase catalyses the conversion atmospheric N_2 to NH_3
(3) Nitrogenase is insensitive to oxygen
(4) Leghaemoglobin scavenges oxygen ans is pinkish in colour.

Q.345 The function of leghaemoglobin in the root nodules of legumes is : **[AIPMT-2011 (Pre)]**
(1) expression of nif gene
(2) inhibition of nitrogenase activity
(3) oxygen removal
(4) nodule differentiation

Q.346 Which one of the following elements is plants is not remobillised ? **[AIPMT-2011 (Pre)]**
(1) Sulphur (2) Phosphorus
(3) Calcium (4) Potassium

Q.347 In land plants, the guard cells differ from other epidermal cells in having : **[AIPMT-2011 (Pre)]**
(1) Chloroplasts
(2) Cytoskeleton
(3) Mitochondria
(4) Endoplasmic reticulum

Q.348 A prokaryotic autotrophic nitrogen fixing symbiont is found in **[AIPMT-2011 (Pre)]**
(1) Pisum (2) Alnus
(3) Cycas (4) Cicer

Q.349 Which one of the following is not a biofertilizer ? **[AIPMT-2011 (Pre)]**
(1) Mycorrhiza (2) Agrobacterium
(3) Rhizobium (4) Nostoc

Q.350 Guttation is the result of : **[AIPMT-2011 (Mains)]**
(1) Root pressure (2) Diffusion
(3) Transpiration (4) Osmosis

Q.351 Function of companion cells is : **[AIPMT-2011 (Mains)]**
(1) Loading of sucrose into sieve elements
(2) Providing energy to sieve elements for active transport
(3) Providing water to phloem
(4) Loading of sucrose into sieve elements by passive transport

Q.352 Which one of the following is not an essential mineral element for plants while the remaining three are ? **[AIPMT-2011 (Mains)]**
(1) Phosphorus (2) Iron
(3) Manganese (4) Cadmium

Q.353 Leghaemoglobin in root nodules of legumes **[RPMT-2011]**
(1) protects nitrogenase
(2) converts N_2 to NH_3
(3) oxidises NO_2 to NO_3
(4) helps in development of infection threads

Q.354 The chief sinks for the mineral elements are - **[RPMT-2011]**
(1) Senescent leaves (2) Ripe fruits
(3) Lateral meristems (4) Bark

ANSWER KEYS

EXERCISE - I

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	2	1	1	3	2	1	4	4	2	3	1	2	1	4	4	3	2	1	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	1	1	2	2	1	3	3	1	3	1	4	1	1	3	1	3	4	1	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	2	4	2	3	1	4	2	3	4	3	1	2	3	1	1	4	3	1	3	4
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	4	2	4	4	3	2	4	3	4	4	4	3	3	3	4	4	2	1	2	2
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	1	3	3	3	1	1	2	4	1	3	2	3	3	2	3	2	2	2	1
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	1	1	2	4	2	4	3	3	1	4	1	3	1	1	2	3	2	3	1	1
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	4	3	3	3	3	2	1	2	2	3	1	3	2	3	1	4	4	1	2	2
Ques.	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Ans.	4	2	1	3	1	1	3	3	2	2	3	1	1	4	2	1	3	3	4	3
Ques.	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Ans.	3	4	3	3	4	1	4	3	3	1	4	3	1	1	4	4	4	4	1	4
Ques.	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
Ans.	4	3	2	2	2	2	4	3	2	1	3	1	3	3	1	2	3	3	2	4
Ques.	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
Ans.	2	4	3	2	4	4	2	2	4	4	3	2	3	3	3	4	2	3	1	3
Ques.	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
Ans.	2	1	4	1	2	2	4	2	2	2	2	1	2	4	3	2	2	4	3	3
Ques.	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
Ans.	4	4	2	1	2	1	3	1	3	1	4	3	3	4	1	2	1	2	1	2
Ques.	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
Ans.	3	1	2	1	3	1	4	3	4	1	4	1	2	2	2	3	1	3	3	2
Ques.	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
Ans.	1	3	1	1	3	4	4	1	2	2	2	1	3	1	1	2	1	4	1	1
Ques.	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
Ans.	3	4	4	2	2	4	1	4	2	2	2	3	2	4	4	3	1	1	1	3
Ques.	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
Ans.	2	4	1	1	2	2	4	2	2	1	4	1	3	4	3	4	2	3	4	1
Ques.	341	342	343	344	345	346	347	348	349	350	351	352	353	354						
Ans.	3	3	1	3	3	3	1	3	2	1	2	4	1	3						

EXERCISE - II

Q.1 When stomata open, the pH of guard cells : - **[Uttaranchal PMT 2004]**
(1) Increases (2) Decreases
(3) Remains same (4) Both 'A' and 'B'

Q.2 Water lost in guttation is : - **[Uttaranchal PMT 2004]**
(1) Pure water (2) Impure water
(3) In vapour form (4) Either 'A' and 'B'

Q.3 Which of the following elements are essential of the photolysis of water : - **[Uttaranchal PMT 2004]**
(1) Ca and Cl (2) Mn and Cl
(3) Zn and I (4) Cu and Fe

Q.4 What will happen if plant cells are placed in hypertonic solution : **[Uttaranchal PMT 2004]**
(1) Turgid (2) Plasmolysed
(3) Deplasmolysed (4) Lysed

Q.5 Loss of water from tips of leaves is called : **[Uttaranchal PMT 2005]**
(1) Bleeding (2) Guttation
(3) Respiration (4) Transpiration

Q.6 Root pressure is measured by : **[Uttaranchal PMT 2005]**
(1) Manometer (2) Potometer
(3) Auxanometer (4) Osmometer

Q.7 Which of the following is releated with transfer of food material : **[Uttaranchal PMT 2005]**
(1) Xylem (2) Collenchyma
(3) Phloem (4) Parenchyma

Q.8 Which of the following apparatus is commonly used to measure the rate of transpiration is : **[Uttaranchal PMT 2006]**
(1) Porometer (2) Altimeter
(3) Potometer (4) Luxmeter

Q.9 Which of the following element is most mobile in plant metabolism : **[Uttaranchal PMT 2006]**
(1) Calcium (2) Phosphorus
(3) Carbon (4) Magnesium

Q.10 The process of converting ammonia to nitrate by bacteria is known as : **[Uttaranchal PMT 2006]**
(1) Ammonification (2) Nitrification
(3) Nitrogen fixation (4) Denitrification

Q.11 Root nodules which are present in plants are meant for fertilizers and are found in/on : **[Uttaranchal PMT 2006]**
(1) Certain leguminous plants
(2) Casurina
(3) Alanus
(4) All of the above

Q.12 Agriculturists have reported about 40-50% higher yieds of rice by applying : **[Uttaranchal PMT 2006]**
(1) Azolla
(2) Cyanophycean members
(3) Mycorrhizae
(4) Thorn forest

Q.13 A nutrient element essential for the formation of micro-tubules of the mitotic spindle apparatus during cell division is : **[Uttaranchal PMT 2006]**
(1) Phosphorus (2) Sulphur
(3) Clacium (4) Zinc

Q.14 Non-symbiotic N_2 fixer is : **[West Bengal JEE 2007]**
(1) Anabaena (2) Rhizobium
(3) Azotobactor (4) Azolla

Q.15 Leaves of Nelumbo plant are : **[West Bengal JEE 2007]**
(1) Epistomatic (2) Hypostomatic
(3) Amphistomatic (4) None of these

Q.16 The N_2 fixing bacterium associated with root nodules of legumes is known as : **[C.G. PMT 2004]**
(1) Azotobacter (2) Nitrobacter
(3) Lactobacillus (4) Rhizobium

Q.17 The bacteria which convert nitrate in to molecular nitrogen is called : **[C.G. PMT 2004]**

(1) Nitrifying bacteria
(2) Methanobacteria
(3) Diazotrophic bacteria
(4) Denitrifying bacteria

Q.18 The bacterium capable of anaerobic N_2 Fixation is known as : **[C.G. PMT 2004]**

(1) Clostridium (2) Bacillus
(3) Azotobacter (4) Rhizobium

Q.19 0.1 M solution has water potential of : **[C.G. PMT 2004]**

(1) –2.3 bars (2) 0 bar
(3) 22.4 bars (4) +2.3 bars

Q.20 A small mesophytic twig with green leaves is dipped into water in a big beaker under sunlight. It demonstrates : **[C.G. PMT 2004]**

(1) Photosyntesis (2) Respiration
(3) Transpiration (4) None of the above

Q.21 Which one is not related to transpiration : **[C.G. PMT 2004]**

(1) Regulation of plant body temperature
(2) Absorption and distribution of mineral salt
(3) Circulation of water
(4) Bleeding

Q.22 Which element is essential for photolysis of water **[C.G. PMT 2004]**

(1) Nitrogen(2) Manganese
(3) Carbon (4) Oxygen

Q.23 Which of the following can utilize molecular nitrogen (N_2) as nutrient for growth **[C.G. PMT 2004]**

(1) Rhizobium (2) Spirogyra
(3) Mucor (4) Methancoccus

Q.24 Sinks are related to : **[C.G. PMT 2005]**

(1) Transport of organic solutes
(2) Stomata
(3) Enzymes
(4) phytochrome

Q.25 Supply ends in transport of solute are : **[C.G. PMT 2005]**

(1) Green leaves and storage organs
(2) Root and stem
(3) Xylem and Pholem
(4) Hormones and enzymes

Q.26 Sotmata can open at night also in **[C.G. PMT 2005]**

(1) Xerophyte (2) Gametophyte
(3) Hydrophyte (4) None of these

Q.27 Who had said that "transpiration is necessary evil" : **[C.G. PMT 2005]**

(1) Curtis (2) Steward
(3) Andersen (4) J.C. Bose

Q.28 Which of the following is a biofertilizer : **[C.G. PMT 2006]**

(1) Funaria (2) Fern
(3) Anabaena (4) Fungus

Q.29 Stomata opens during day because the guard cells have : **[C.G. PMT 2006]**

(1) Outer walls thin (2) Kidney shape
(3) Chlorophyll (4) Large nuclei

Q.30 Mo is related with : **[C.G. PMT 2006]**

(1) N_2 fixation
(2) Flower induction
(3) Chromosome contraction
(4) Carbon collection

Q.31 Which one of the following elements is present in chlorophylls : **[C.G. PMT 2006]**

(1) Manganese (2) Magnesium
(3) Copper (4) Iron

Q.32 Which one of the following bacteria has potential for nitrogen fixation : **[C.G. PMT 2006]**

(1) Nitrosomonas (2) Nitrobacter
(3) Nitrosococcus (4) Rhizobium

Q.33 Stomata open and close due to : **[Jharkhand 2006]**
(1) Turgor pressure change
(2) Hormone change
(3) Temperature change
(4) All of the above

Q.34 For nitrogen fixation, pigment useful is : **[Jharkhand 2006]**
(1) Nitrogenase (2) Haemoglobin
(3) Myoglobin (4) Leghaemoglobin

Q.35 In plasmolysed cell, the space between cell wall and Protoplasm is occupied by : **[Jharkhand 2006]**
(1) Hypotonic solution
(2) Hypertonic solution
(3) Isotonic solution
(4) Distil water

Q.36 In CAM plants stomata are : **[Jharkhand 2005]**
(1) Closed at night and open during the day
(2) Closed at the day and open at night
(3) Never closes
(4) Never opens

Q.37 The real force resposible for the movement of water from cell to cell is : **[Jharkhand 2005]**
(1) OP (2) TP (3) DPD (4) WP

Q.38 Which of the following is symbiotic bacteria : **[Jharkhand 2005]**
(1) Rhizobium (2) Azotobactor
(3) Clotrisdium (4) Streptomyces

Q.39 Which of the following have sunken stomata : **[Jharkhand 2003]**
(1) Nerium (2) Mangifera
(3) Hydrilla (4) Zera mays

Q.40 When a plasmolysed cell is placed in a hyotonic solution then water will move inside the cell. Which force causes this : **[Jharkhand 2003]**
(1) DPD (2) OP
(3) WP (4) None of these

Q.41 Rate of transpiration is measured by : **[Jharkhand 2003]**
(1) Manometer (2) Auxanometer
(3) Potometer (4) Barometer

Q.42 If a cell shrinks when placed in a solution, this solution is : **[Jharkhand 2003]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) Pure solvent

Q.43 If a cell A with DPD 4 bars is connected to cell B, C, D whose osomotic pressure and turger pressure are respectively 4 and 4, 10 and 5, 7 and 3 bar, the flow of water will be : **[Jharkhand 2002]**
(1) B to A, C and D (2) A to D, B and C
(3) C to A, B and D (4) A to B, C and D

Q.44 Guard cell controls : **[Bihar 2004]**
(1) Intensity of light entering
(2) Photosynthesis
(3) Closing and opening of stomata
(4) Change in green colour

Q.45 Active transport : **[Bihar 2003]**
(1) Releases energy
(2) Requires energy
(3) Produces ATP
(4) Produces a toxic substance

Q.46 The metal ion involved in stomatal regulation is **[Bihar 2002]**
(1) Fe (2) Mg (3) Zn (4) K

Q.47 Valamen tissues are associated with **[Bihar 2002]**
(1) Hautorial function
(2) Assimilation
(3) Aborption of moisture
(4) Nutrition

Q.48 Cohesion-tension theory regarding ascent of sap was given by : **[Bihar 2001]**
(1) Dixon and Jolly (2) J.C. Bose
(3) Cristian Wolf (4) Godlewski

Q.49 Velamen tissue is found in : **[Bihar 2004]**
(1) Mesophytes (2) Epiphytes
(3) Hydrophytes (4) Xerophytes

Q.50 In a fully turgid plant cell which one is zero : **[Bihar 2001]**
(1) Trugor pressure (2) Wall pressure
(3) Suction pressure (4) None of these

Q.51 Who proposed the 'Chohesion Theory of ascent of sap: **[Bihar 2006]**
(1) Strasburger (2) Godlewski
(3) Western (4) Dixon and Jolly

Q.52 The most accepted theroy for ascent of sap is : **[UP CPMT 2001]**
(1) Relay pump theory
(2) Pulsation theory
(3) Root pressure theory
(4) Transpiration pull cohesion theory theory

Q.53 Legume plants are important for crop production because they : **[UP CPMT 2002]**
(1) Help in NO_2 Fixation
(2) Do not help in NO_2 Fixation
(3) Increase soil fertility
(4) All of these

Q.54 Transport of water and salt is mediated by : **[MP PMT 2006]**
(1) Xylem (2) Sieve tubes
(3) Sclerenchyma (4) Phloem

Q.55 Removal of ring wood of tissue outside the vascular cambium from the tree trunk kills it because : **[UP CPMT 2002]**
(1) Water cannot move up
(2) Food does not travel down and root become starved
(3) Shoot become starved
(4) Annual ring are not produced

Q.56 Wilting of plant is present in : **[UP CPMT 2002]**
(1) Moss (2) Fern
(3) Algae (4) Angiosperm

Q.57 Root hair absorb water from the soil on account of :
(1) Turgor pressure (2) Osmotic pressure
(3) Suction pressure (4) Root pressure

Q.58 Increased humidy in atmosphere decreases rate of : **[UP CPMT 2003]**
(1) Transpiration (2) Photosynthesis
(3) Glycolysis (4) Growth

Q.59 In osmosis there is movement of : **[UP CPMT 2003]**
(1) Solute only
(2) Solvent only
(3) Both (1) and (2)
(4) Neither solute nor solvent

Q.60 Which of the following is a nitrogen fixing organism **[UP CPMT 2003]**
(1) Some BGA (2) Rhizobium
(3) Both (1) and (2) (4) Aspergillus

Q.61 Which of the following of bacteria is involved in two step conversion of NH_3 into nitrate : **[UP CPMT 2004]**
(1) Azotobacter and nitrosomonas
(2) Nitrosomoans and Nitrobacter
(3) Azotobacter and Achromobacter
(4) Pseudomonas and Nitrobacter

Q.62 A metal ion involved in stomatal regulation is : **[UP CPMT 2004]**
(1) Iron (2) Potassium
(3) Zinc (4) Magnesium

Q.63 The plant ash is an indication of : **[UP CPMT 2005]**
(1) Organic matter of plant
(2) Waste product
(3) Mineral salts absorbed by plants
(4) None of these

Q.64 Guttation takes place through : **[UP CPMT 2005]**
(1) Lenticels (2) Phenumatophores
(3) Stomata (4) Hydrathodes

Q.65 Plant ash has maximum content of : **[UP CPMT 2006]**
(1) Mg (2) Fe (3) K (4) B

Q.66 Which of the following is part of cytochrome: **[UP CPMT 2006]**
(1) Mg (2) Zn (3) Fe (4) Ca

Q.67 Food in plants is translocated in the form of : **[UP CPMT 2006]**
(1) Glucose (2) Starch
(3) Sucrose (4) Fructose

Q.68 Which of the following statements is correct ? **[UP CPMT 2003]**
(1) Cell membrance is involved only in exosmosis
(2) Cell membrance is involved only in endosmosis
(3) Cell membrance is involved both in exosmosis and endosomosis
(4) None of the above

Q.69 Which of the following is not related to N_2 fixation **[UP CPMT 2006]**
(1) Rhizobium (2) Anabaena
(3) Pseudomonas (4) Azotobacter

Q.70 The root hairs absorb which of the following type of water : **[UP CPMT 2006]**
(1) Capillary water
(2) Hygroscopic water
(3) Gravitational water
(4) All of the water

Q.71 If flowers are cut and dipped in dilute NaCl solution, then : **[UP CPMT 2007]**
(1) Transpiration is low
(2) Endo-osmosis occurs
(3) No bacterial growth takes place
(4) Absorption of solute inside flower cell takes place

Q.72 Which of the following is not caused by deficiency of mineral : **[MP PMT 2007]**
(1) Chlorosis
(2) Etiolation
(3) Shortening of internodes
(4) Necrosis

Q.73 The mineral present in cell walls is : **[MP PMT 2007]**
(1) Na (2) Ca
(3) K (4) Mg

Q.74 What happened when we inoculated Rhizobium in wheat field : **[MP PMT 2007]**
(1) No increase in production (nitrogen content of soil remains same)
(2) A lot of increase in production (nitrogen content of soil increase)
(3) Fertility of soil decreases
(4) Fertilite of soil increases

Q.75 Nitrifying bacteria are able to : **[MP PMT 2007]**
(1) Convert atomospheric nitrogen into soluble form
(2) Convert ammonia to nitrate
(3) Ammonia to nitrogen
(4) Nitrate to nitrogen

Q.76 Plant cell plasmolysed in a solution which is : **[MP PMT 2006]**
(1) Hypotonic
(2) Hypertonic
(3) Isotonic
(4) Concentration no means

Q.77 Nitrogenase enzyme is found in Nostoc in the cell of : **[MP PMT 2001]**
(1) Vegetative
(2) Heterocyst
(3) Both vegetative and heterocyst
(4) None of these

Q.78 Turgidity in guard cells is controlled by:
(1) Chloride
(2) Malic acid
(3) Potassium
(4) Potassium, chloride and malic acid

Q.79 Magnesium is found in : **[MP PMT 2001]**
(1) Chlorophyll (2) Carotenoid
(3) Phycobilin (4) Cytochrome

Q.80 Stomata are not found in : **[MP PMT 2001]**
(1) Algae (2) Mosses
(3) Ferns (4) Liverworts

Q.81 In which of the following the rate of transpiration is high : **[MP PMT 2001]**
(1) CAM plant (2) C_3 plants
(3) C_2 and C_4 plants (4) C_4 plants

Q.82 Which of the following is a trace element : **[MP PMT 2001]**
(1) S (2) Mg (3) Cu (4) P

Q.83 Cell sap is found in which cell organelle : **[MP PMT 2001]**
(1) Nucleous (2) Chloroplast
(3) Vacuole (4) Golgi Apparatus

Q.84 Which one of the following fixes nitrogen **[MP PMT 2002]**
(1) TMV
(2) Yeast
(3) Nostoc
(4) Denitrifying bacteria

Q.85 Active transport of ions by the cell requires : **[MP PMT 2002]**
(1) High temperature (2) ATP
(3) Alkaline pH (4) Salts

Q.86 To initiate cell plasmolysis, the salt concentration must be : **[MP PMT 2002]**
(1) Isotonic (2) Hypotonic
(3) Hypertonic (4) Atonic

Q.87 Which one of the following organisms may respire in the absence of oxygen : **[MP PMT 2002]**
(1) Azotobacter (2) Clostridium
(3) Rhizobium (4) Lactobacillus

Q.88 Which of the following is not a trace element : **[MP PMT 2003]**
(1) Zn (2) Mn (3) Mg (4) Cu

Q.89 Symbiotic microorganism is : **[MP PMT 2003]**
(1) Clostridium (2) Azotobacter
(3) Rhizobium (4) Chromatium

Q.90 The basis of stomatal opening is : **[MP PMT 2004]**
(1) Endosmosis
(2) Plasmolysis of guard cells
(3) Decrease in cell sap concentration
(4) Exosmosis

Q.91 Essential mineral nutrients are the element **[MP PMT 2005]**
(1) In the absence of which plants cannot complete their life cycle
(2) Which cannot be replaced by other element in its function
(3) The element which is directly associated with metabolism of the plant
(4) All of the above

Q.92 Plants absorb carbon dioxide from : **[MP PMT 2005]**
(1) Millets
(2) Cereals
(3) Carbohydrates present in the soil
(4) Aotmosphere

Q.93 Stomatal movement is controlled by : **[MP PMT 2005]**
(1) Na (2) Mg (3) K (4) P

Q.94 Which of the following enzyme fixes nitrogen **[MP PMT 2005]**
(1) Nitrate reductase (2) Nitrogenase
(3) PEP caboxylase (4) Rubisco

Q.95 Transpiration will increase with the increase of : **[MP PMT 2005]**
(1) Humidity (2) Temperature
(3) Carbon dioxide (4) Sulphur dioxide

Q.96 If is possible to drop a small particle through the stomata of leaf, what will you conclude : **[MP PMT 2005]**
(1) It will fall on the earth surface
(2) It will stop on lower epidermis
(3) It will stop on mesophyll cells
(4) It will stop on vascular tissue

Q.97 The bacterium capable of anaerobic nitrogen-fixation is : **[MP PMT 2006]**
(1) Azatobacter (2) Rhizobium
(3) Bacillus (4) Clostridium

Q.98 In plant metabolism phosphorus play a major role to : **[MP PMT 2006]**
(1) Evolve oxygen during photosynthesis
(2) Create aerobic condition
(3) Generate metabolic energy
(4) Evolve carbon dioixde during respiration

Q.99 Photosynthetic food material is transported in the form of : **[MP PMT 2006]**

(1) Glusose (2) Sucrose

(3) Starch (4) Fructose

Q.100 During transpiration turgidity in guard cells is controlled by : **[MP PMT 2006]**

(1) Potassium (2) Bromine

(3) Sodium (4) Oxalic acid

Q.101 Chlorosis is caued due to deiciency of **[MP PMT 2006]**

(1) Mg (2) Ca

(3) B (4) Mn

Q.102 What will happen if plant cells are placed in hypertonic solution : **[Uttaranchal PMT 2004]**

(1) Turgid (2) Plasmolysed

(3) Deplasmolysed (4) Lyse

ANSWER KEYS

EXERCISE - II

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	2	2	2	2	1	3	3	2	2	4	1	3	3	1	4	4	1	1	3
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	2	1	1	1	1	1	3	1	1	2	4	1	4	2	2	3	1	1	1
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	2	1	3	2	4	3	1	2	3	4	4	3	1	2	4	3	1	2	3
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	2	3	4	1	3	3	3	3	1	1	2	2	1	2	2	2	4	1	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	2	3	3	3	2	3	2	3	3	1	4	4	3	2	2	3	4	3	2	1
Ques.	101	102																		
Ans.	1	2																		

EXERCISE - III

These questions consist of two statements each, printed as "ASSERTION" and "REASON". While answering these Questions you are required to choose any one of the following responses.

(1) If both Assertion and Reason are True and the Reason is a correct explanation of the Assertion.

(2) If both Assertion and Reason are True but Reason is not correct explanation of the Assertion

(3) If Assertion is True but the Reason is False.

(4) If both Assertion and Reason are false.

Q.1 **Assertion :** Rate of water absorption decreases by decrease in temp. of soil.
Reason : Permeability of cell membrane decreases at low temperature.

Q.2 **Assertion :** Most available form of water in plants is capillary water.
Reason : Ψ_ω of capillary water is highly negative.

Q.3 **Assertion :** Ascent of sap takes place by vessels & trachieds.
Reason : These are non living elements of phloem.

Q.4 **Assertion :** Endosmosis causes flaccidity in Guard cells.
Reason : Stomata opens due to flaccidity in Guard cells.

Q.5 **Assertion :** Plant ash contains many inorganic substances or mineral elements.
Reason : All the elements presents in plant ash are essential.

Q.6 **Assertion :** Chlorine, Calcium & Manganese are important for light reaction.
Reason : Photolysis of water is helped by these elements.

Q.7 **Assertion :** Osmotic pressure of solution is always higher than pure solvent.
Reason : O.P. is property of solvent molecules.

Q.8 **Assertion :** In transpiration water, vapour diffuses from leaves in atomosphere.
Reason : Diffusion takes place from higher conc. to lower conc.

Q.9 **Assertion :** Ascent of sap continues, after the living cells of xylem are killed by poison.
Reason : Path of ascent of sap is symplastic.

Q.10 **Assertion :** In a plasmolysed cell the space between cell wall and plasma membrane is occupied by hypertonic solution.
Reason : Cell wall is permeable.

Q.11 **Assertion :** Root pressure is maximum during noontime.
Reason : Temperature & light intensity is higher during noontime.

Q.12 **Assertion :** T.P. of Guard cells determines the mechanism of opening and closing of stomata.
Reason : Inner wall of Guard cell is thin.

Q.13 **Assertion :** Plant leaves become wilted after girdling or ringing.
Reason : Ascent of sap is taking place by phloem.

Q.14 **Assertion :** DPD in plasmolysed cell is higher than O.P.
Reason : T.P. is negative in plasmolysed cell.

Q.15 **Assertion :** The movement of ions from epidermis to xylem elements is an active process.
Reason : It requires the metabolic energy.

Q.16 **Assertion :** Ringing Experiment is impossible in sugarcane plants.
Reason : Vascular bundles in sugarcane are scattered.

Q.17 **Assertion :** Ascent of sap is function of Xylem parenchyma.
Reason : Xylem parenchyma is non living element.

Q.18 **Assertion :** Active absorption of water takes place in Halophytes.
Reason : Halophytes can absorbe water non-osmotically.

Q.19 **Assertion :** O.P. of pure water is higher.
Reason : O.P. is property of solvent.

Q.20 **Assertion :** Root cells have lower Ψ_ω than leaf cells.
Reason : Root cells have greater solute concentration as compared to leaf cells.

Q.21 **Assertion :** Rate of transpiration is higher in dry & hot atmosphere.
Reason : Diffusion of water vapour is rapid in dry atmosphere.

Q.22 **Assertion :** Guttation occurs during night & morning.
Reason : Hydathodes remain open during all time.

Q.23 **Assertion :** Minerals mainly absorbed by Meristematic zone of roots.
Reason : Metabolic energy is produced by photosynthesis in meristematic part of roots.

Q.24 **Assertion :** The movement of ions from soil to endodermis & Xylem elements is an active process.
Reason : It requires metabolic energy.

Q.25 **Assertion :** Wooden doors and windows are hard to open or close in moist season.
Reason : They imbibe water in humid rainy season and increase in volume.

Q.26 **Assertion :** Guttataion is loss of water in liquid form from the hydathodes.
Reason : Hydathodes open during day time.

Q.27 **Assertion :** Halophytes can grow on salty soil.
Reason : Osmotic pressure in halophyte is higher as comapred to normal plants.

Q.28 **Assertion :** Transpiration is higher in humid climate.
Reason : Rate of water absorption is higher in heliophytes.

Q.29 **Assertion :** Water is mainly absorbed by passive process in plants.
Reason : Passive absorption occurs by expenditure of metabolic energy.

Q.30 **Assertion :** Cold soil is physiologically dry.
Reason : Viscosity of water is higher in cold soil.

Q.31 **Assertion :** Ascent of sap occurs by xylem tissue.
Reason : Xylem is presents only in dicot plants.

Q.32 **Assertion :** Root hair cells absorb water from soil.
Reason : O.P. of soil is lower than root cells.

Q.33 **Assertion :** Ascent of sap is stopped by killing the xylem parenchyma.
Reason : Ascent of sap occurs by parenchyma.

Q.34 **Assertion :** Passive absorption of H_2O increases by increase in transpiration.
Reason : Passive absorption of water requires ATP.

Q.35 **Assertion :** O.P. of leaf cells is lower than root cells.
Reason : Root cells has more solute.

Q.36 **Assertion :** Ascent of sap occurs by living part of xylem.
Reason : Ascent of sap requires metabolic energy.

Q.37 **Assertion :** Maximum transpiration takes place through the stomata.
Reason : Stomatal transpiration occurs through the leaves.

Q.38 **Assertion :** Rate of transpiration decreases with increase in conc. of CO_2.
Reason : CO_2 reacts with ABA in subsidiary cells.

Q.39 **Assertion : Potamogeton** possesses non-functional stomata.
Reason : Potamogeton is submerged hydrophyte.

Q.40 **Assertion :** Transplanted plant can not grow easily.
Reason : Uptake of CO_2 is not possible at new places.

Q.41 **Assertion :** Rate of water absorption decreases at low temp.
Reason : Viscocity of water is increased at low temp.

Q.42 **Assertion :** Ascent of sap occurs by xylem vesseles ad tracheids.
Reason : These are living elements of xylem.

Q.43 **Assertion :** Orchids or epiphytes can absorb atm. humidity.
Reason : Orchids are photosynthetic plants.

Q.44 **Assertion :** Rate of transpiration decreases with increase in atm. humidity.
Reason : At high atm. humidity sotmata close.

ANSWER KEYS

EXERCISE - III

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	3	3	4	3	1	3	1	3	1	4	3	4	1	1	1	4	1	4	4
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	3	1	1	3	1	4	3	1	3	1	4	3	4	4	2	3	1	3
Ques.	41	42	43	44																
Ans.	1	3	2	3																

MINERAL NUTRITION

INTRODUCTION

- Soil the main source of mineral nutrients. These mineral nutrients are mainely absorbed by the **meristemetic region of roots**.
- Mineral nutrients are present with soil particles in colloidal form and in water as soil solution. Conduction of mineral nutrients is done through the xylem.
- Absorption of meneral in plant is an active process.

ESSENTIAL ELEMENTS

About 50-60 elements are present in plant body but **16** elements are considered as essential elements

According to **Arnon-Criteria of essentiality of minerals:**

- The element must be **neccessary for normal growth and reproduction** of all plants.
- The requirement of element **must be specific for plant life**. That is indespensible element to plant.
- The Element must be **directly involved in metabolism** of plant.

C, H, O, N, K, S, Ca, Fe, Mg, P, Cu, Mn, B, Cl, Zn, Mo, Ni

CLASSIFICATION OF ESSENTIAL ELEMENTS

Arnon divides these necessary elements in two group on the basis of requirement of plant

- **Major element/Macro nutrients:** Concentration must be **1-10 mg L^{-1} more than 10 m mole $kg^{-1}$of dry matter. (mmole-Milimolar)**

  C, H, O, N, P, Mg, S, K, Ca
- **Minor element/Micro nutrients:** (Concentration **present 1.0-0.1 mg L^{-1} less than 10 m mole kg^{-1} per gram of dry matter)**

  Cu, Zn, N, Mo, Mn, B, Cl, Fe

General functions of essential elements-

1. **Protoplasmic elements - C, H, O, N, P, S**
2. **Elements of Redox Reaction - Fe, Cu, Mn, Cl**
3. **Balancing / Antagonetic - K, Ca**
4. **Membrane Permeability - K, Ca**
5. **Co-factor of enzymes - All micronutrients except B**
6. **Osmotic pressure of cell.**

Benificial nutrients: Mineral elements other than essential elements, which satisfy specific additional nutrient requirement of some specific plants.

Ex. **Na** - Halophytes (eg. Atriplex - helps in C_4 pathway)
Si - Grasses (Provides mechanical strength)
Se - Astragalus
Co - Leguminous plants (root nodule formation)

- **Toxic elements/Toxicity:-** Any mineral ion concentration in plant tissue, that reduces the dry weight of tissue by about 10 percent is considerd as toxic or toxic element and this effect is called toxicity.

- Most of the micronutrients become toxic as their required amount for plants is very low. This excess concentration inhibits activity of other essential elements.

  Ex : Toxicity of Mn (Manganese) may induce deficiency of iron, magnesium and calcium cause appearance of brown spots surrounded by chlorotic veins. Mn competes with iron (Fe) and magnesium (Mg) for uptake and for binding to enzymes. Mn also inhibits, calcium translocation into the shoot apex and causes disease **'Crickle leaf '**.

  So the dominant symptoms of Mn toxicity may actually be the symptoms of Fe, Mg and Ca deficiency.

Deficiency symptoms and mobility of minerals.

- The deficiency symptoms of highly **mobile elements** in plants like **N, P, K, Cl** and **Mg** first appear in **older plant parts.** These minerals are present as structural constituent of biomolecules of mature plant parts and when plant parts become older, these biomolecules broken down making these elements available for younger plant parts.
- The deficiency symptoms of **immobile elements** like **Ca, S, B, Fe** first appear in **young plant parts,** as they are not transported from older plant parts.

MINERAL SALT ABSORPTION/M ECHANISM OF MINERAL ABSORPTION

(A) Passive absorption of minerals : (Without expenditure of ATP)

(1) By simple diffusion : According to this method mineral ions may diffuse in root cells from the soil solution. Facilitated diffusion of minerals also occurs with help of carrier proteins.

(2) By mass flow : Proposed by Hymo (Supported by Kramer) According to this method mineral ions absorption occurs with flow of water under the influence of transpiration.

(3) By ion exchange : By Jenny and Over street. This is exchange of mineral ions with the ions of same charge.

(i) By contact exchange : When the mineral ion exchange occurs with the H^+ and OH^- ions.

(ii) Carbonic acid exchange : When the mineral ion exchange takes place with the ions of carbonic acid.

(4) By Donnan equilibrium : This theory explains the passive accumulation of ions against the concentration gradient or electrochemical potential (ECP) without ATP. At the inner side of cell membrane, which separates from outside (external medium), there are some anions, which are fixed or non diffusible and membrane is impermeable to these anions, while cations are diffusible.

- In such condition, for maintenance of equilibrium additonal cations are needed to balance negative charges of anions (at inner side of membrane). Thus some cations moves, inside the cell from soil solution.
- So according to this theory Donnan equilibrium is attained, if the anions and cations in the internal solution become equal to the anions and cations in external solutions.

Objections for passive mineral absorption / evidences in favour of active mineral absorption :

(1) Absorption of K^+ions in **Nitella** algae is observed against the concentration gradient.

(2) Rate of respiration of a plant is increases, when plant transferred to mineral solution. (Salt respiration)

(3) Factors like deficiency of oxygen, CO, CN, which inhibits rate of respiration, these factors also inhibit the absorption of mineral ions in plants.

Thus ion absorption in plants is considered mainly as an active process.

(B) Active ion absorption : (By expenditure of ATPs)

(1) Cytochrome pump theory : By **Lundegardh and Burstrom (1933)** according to this theory, **only anions** are absorbed by active mechanism through cytochrome pumping and absorption of cation is passive process.

According to cytochrome pump theory **salt respiration** is called as **anion respiration.**

(2) Carrier concept : By **Vanden Honert.** According to this theory some specific carrier molecules made up of **proteins** are present in cell membrane of root cell, which absorb both the ions and form **ion-carrier complex.** This complex is broken inside the cell membrane with the use of energy.

(3) Protein - Lecithin theory : By **Bennet Clark**

According to this theory a **phospholipid lecithin** in root cell membrane works as carrier for both type of ions.

Lecithin has two type of groups:

Lecithin → **Phosphate** group (⊕ **ions** absorption)
Lecithin → **Choline** group (Θ **ions** absorption)

☛ **Goldacre** - A contractile protein is associated, with absorption of minerals.

Mineral absorbed by the roots of plants are carried by xylem by two pathways, apoplastic and symplastic pathway.

☛ **P.R. Stout** and **Hoagland** (1939) proved that **mineral salts are translocated through xylem** along with transpiration pull (exp. with help of radioisotopes).

SPECIFIC ROLES OF DIFFERENT ELEMENTS

Mineral Element	Principl Functions	Deficiency symptoms
1. Nitrogen NO_3^- /Nitrate form	(a) All living matter (b) Amino acids, proteins (c) Purines, pyrimidines (d) Early defoliation (e) NAD, NADP, FMN, FAD (f) Chlorophyll, cytochromes	**Chlorosis** first in older leaves, premature leaf fall reduced yield. Development of anthocyanin pigment **(Mottled chlorosis)**
2. Phosphorus $H_2PO_4^-$ & HPO_4^- orthophosphate anion form	(a) Nucleic acids (b) Nucleoproteins (c) Phspholipids (d) AMP, ADP, ATP, (e) NAD, NADP (f) Indispensible role in energy metabolism	Chlorosis with necrosis, **premature abscission of leaf,** poor vasculature.
3. Potassium K^+ in free form	(a) Permeability (b) Osmotic regulation and hydration (c) Commonest free ion in cell (d) Stomatal movements (e) Translocation of sugars (f) Enzymes concerned with photosynthesis, nitrate reduction, protein bio -synthesis, respirations, etc	**Mottled chlorosis,** premature death, **loss of apical dominance** lodging in cereals. Bushy habit. Cotton rust

4. Calcium Ca^{++} form	(a) Cell wall Structure (b) Membrane structure (c) Influence nitrate reductase (d) In ion transport (e) In cell elongation and spindle formation (f) Activators of amylases, adenyl kinase, ATPase, etc.	Stunted growth, **degeneration of meristems,** chlorosis, curling first in young leaves. Black heart of *Celery*.
5. Magnesium Mg^{++} form	(a) Component of chlorophyll (b) Activators of a number of photosynthetic and respiratory enzymes (c) Combiness the subunits of ribosomes (d) Synthesis and hydrolysis of ATP	Marginal curling, interveinal chlorosis with anthocyanin accumulation first appearing in older leaves. 'Sand drown' of Tobacco.
6. Sulphur SO_4^{2-} form (Sulphate)	(a) Part of CoA, Ferredoxin, Vit. H, Thiamine, Lipoic acid. (b) Amino acids e.g. Cysterine, Cystine, methionine	Chlorosis first in young leaves, reduced nodulation in legume. **Tea yellow,** extensive root system.
7. Iron Fe^{++}/Fe^{+++} Form	(a) Structural component of porphyrin molecules, cytoch -romes, catalase, peroxidase leghaemoglobin	**Interveinal chlorosis** first in young leaves. Green Netting of Citrus.
8. Molybdenum MoO_4^{2-} form	(a) Component of nitrate reductase (b) Important in N_2 fixation	Mottled chlorosis, **whiptail of cauliflower,** loosening of inflorescence of cauliflower. Scald of beans.
9. Boron H_3BO_3 / BO_3^{-3} (Borate) form	(a) Translocation of sugars (b) For seed, pollen and spore germination (c) Enzymes of phosphorylation (d) RNA metabolism (e) Phenol metabolism and cell differentiation (f) Regulates pentose phosphate pathway (g) Flowering and fruiting	**Brown heart of turnip**, **internal cork** of apple, **heart rot** of sugarbeet, decreased nodulation in legumes. Hollow stem of caulifilower, stem crack of *Celery*.
10. Copper CU^{++} form	(a) Oxidase enzyme: tyrosinass plastocyanin, cytochrome oxidase.	**Dieback, exantheme, reclamation disease,** blackening of potato, tubers, chlorosis

11. Manganese Mn^{++} form	(a) In chlorophyll synthesis (b) In photolysis of H_2O in phtosynthesis (c) Maintenance of chloroplast membrane structure (d) Enzyme systems; RNA polymerase, NAD-malic enzyme in C_4 plants	Interveinal chlorosis, **grey speck** of oat, **marsh spot disease of pea**.
12. Zinc Zn^{++} form	(a) Tryptophan synthesis (precursor of auxin) (b) Dehydrogenase enzymes, pyriding nucleotide, alcohol, glucose-6-p and triose phosphate (c) Carbonic anhydrase (d) Promotes synthesis of cytochromes (e) Stabilizes ribosomal fractions.	**Little leaf,** leaf rosettes leaf malformations. White bud, whip tip of maize, sickle leaf of cocao, **khaira disease of rice.**
13. Chlorine	(a) In the transfer of electron from water to PS II (Photolysis) (b) Maintain cation-anion balance	Bronze colour in leaves, chlorosis, necrosis, swollen root flower abscission.
14. Nickel	(a) Urease and hygrogenase activity	It helps in germination and early seeding growth of Jack Bean seeds. It causes necrotic spots.

N_2 METABOLISM

Role of Nitrogen in Plants:- Constituent of proteins, nucleic acids ATP, GTP, Vitamins, chlorophyll, alkaloids, cytochromes, hormones. Nitrogen is necessary to plants for heridity, reproduction, growth metabolism and development.

Sources of Nitrogen to plants :

(1) Atmospheric nitrogen:
N ≡ N (Molecular, inert or elemental form) used by Rhizobium (Legumes), BGA, Lichens.

☛ These **converts atm. N_2 into metabolically usefull ammonia(NH_3).** This process is called as biological nitrogen fixation.

(2) NO_3^-,NO_2^-,NH_4^+ in soil:

These are major source of nitrogen to plants.

☛ **Nitrate ions (NO_3^-)** are **cheif form of nitrogen used by majority of plants.**

Plants grow in acidic soil & found in forest use ammonium ions (NH_4^+) as major N_2 source.
Nitrate ions are cheif source of N_2 for plants but they can not be used directly in metabolic pathway in plant cells, as it is highly oxidised form. so NO_3^- (Nitrate) first converted into NO_4^+ **(ammonium ions)** called **nitrate reduction**. So NH_4^+ ions enters in plant metabolism.

(3) Organic nitrogen in soil: as amino acids, protein body.
Due to death & decay of organisms. This is not a major source of N_2.

(4) Insect bodies: for some plants (insectivorous plants)

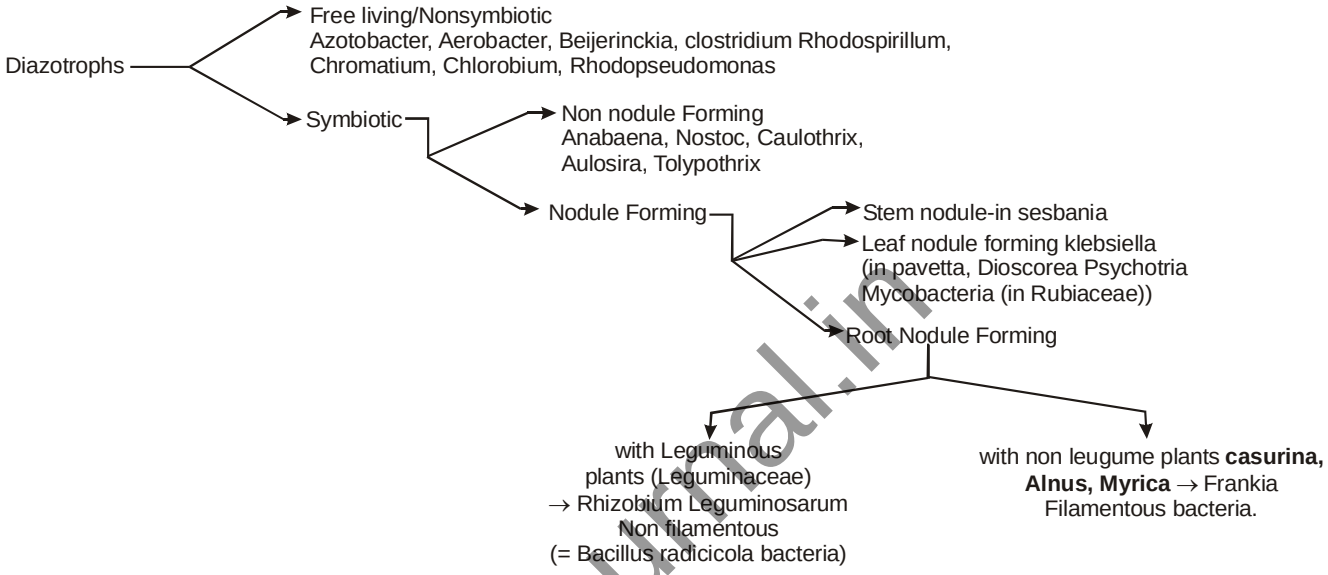
(5) Urea as chemical/artificial fertilizers

Nitrogen (N_2) Cycle:

(1) Biological Nitrogen Fixation/Diazotrophy ($N_2 \rightarrow NH_3$):- Conversion of molecular or elemental nitrogen ($N \equiv N$) into inorganic nitrogenous compounds (NH_3) through agency of living organisms is called as **biological nitrogen fixation** or **Diazotrophy**

Nitrogen Fixing organisms (Diazotrophs):

☛ Free living diazotrophs carry out diazotropy only in free living condition while symbiotic diazotrophs only in symbiotic condition.



(2) Ammonification: Conversion of dead organic nitrogenous compounds into ammonia. **Bacillus mycoides**, **B. ramosus.**

(3) Nitrification: Oxidation of ammonia, produced by ammonification **into nitrates** by **nitrifying bacteria** is called as nitrification.

(i) $2NH_3 + 2O_2 \xrightarrow{\text{Nitrosomonas}} 2NO_2^- + 2H_2O + 2H^+$

Ammonia — Nitrite ion

(ii) $2NO_2^- + O_2 \xrightarrow{\text{Nitrobacter}} 2NO_3^-$

Nitrate ions

Some fungi like **Aspergillus**, **Penicillium** can also carry out this process.

(4) Denitrification: Nitrates or nitrites converts back into molecular or atm. nitrogen by **denitrifying bacteria** is denitrification. Ex. **Pseudomonas** denitrifications.

(5) Nitrate reduction:

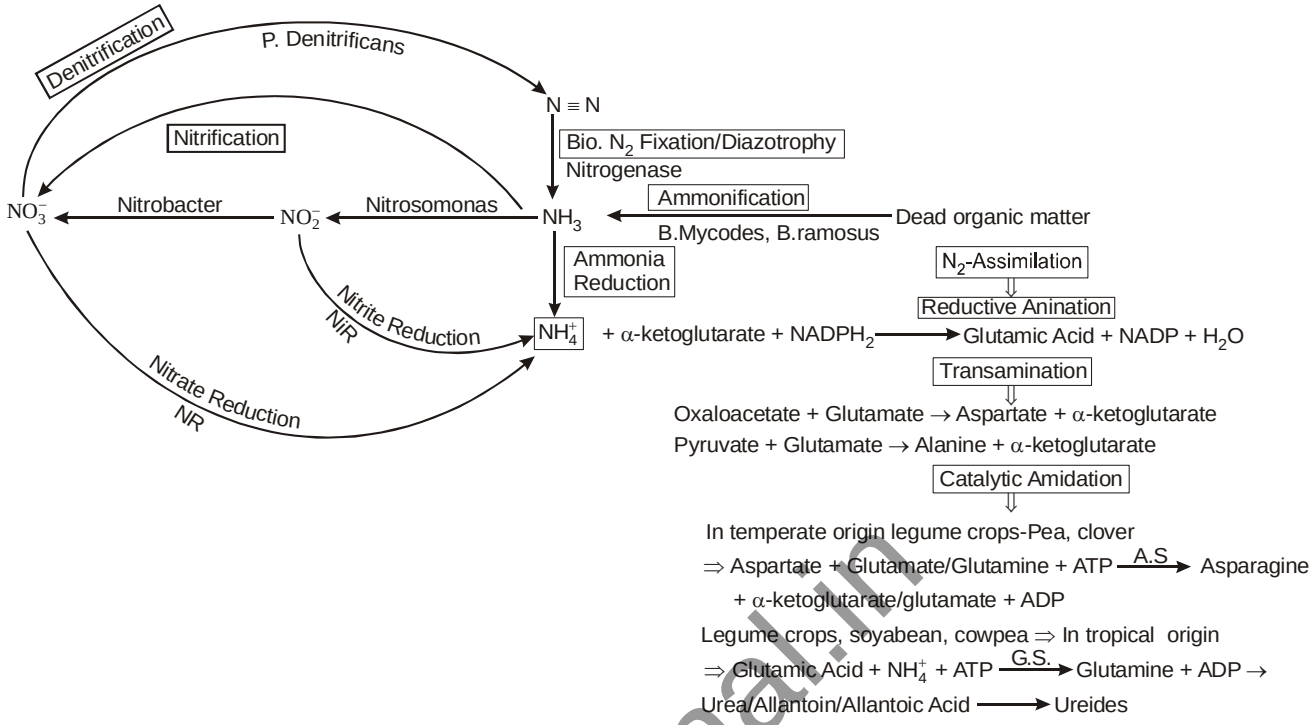
☛ Plants take nitrogen from soil, chiefly in nitrate forms which is highly oxidised form.
so **NO_3 converts in ammonia by following method**

(a) $NO_3^- + NADH_2 + H^+ \xrightarrow{\text{Nitrate reductase}} NO_2 + NAD + H_2O$

(b) $NO_2^- \xrightarrow{2e^-, 2H^+} NOH \xrightarrow{2e^-, 2H^+} NH_2OH \xrightarrow{2e^-, 2H^+} NH_4^+$

or $2NO_2^- + 6H_2O + 4H^+ \xrightarrow{\text{Nitrate reductase}} 2NH_4^+ + 3O_2 + 4H_2O$

☛ Nitrate reductase is Molybdo flavoprotein isolated by Evans and Nason 1953 from Neurospora and Glycin max.



Symbiotic N_2 fixatiion (Diazotrophy): It is done by symbiotic bacteria & free living bacteria. In **leguminous plants (Fabaceae)** by symbiotic bacterium **Rhizobium**, which form nodules in their roots.

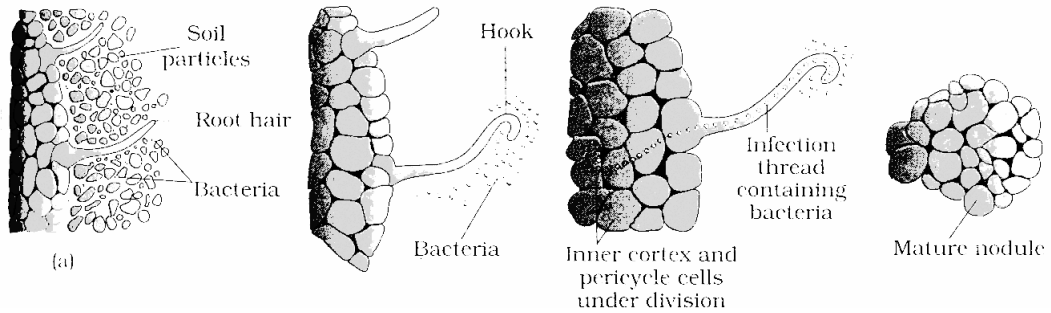
- **N_2 convert into NH_3 ion**, which is used in plant metabolism.
- Root nodules act as site for N_2 fixation. It contains all necessary biochemical components like enzyme Nitrogenase, Leghaemoglobin, required in N_2 fixation.

NODULE FORMATION

It is due to interactions between bacteria and host root. It occurs in following steps:

- **Multiplication & colonization of Rhizobia** at Rhizosphere and attachment to epidermal root hair cells. Initial attraction of Rhizobia to host root is **chemotactic** (Rhicadhesin protein of bacterial cell identify host root) as **root exude amino acids, sugars, organic acids** and **flavonoids**.
- **Characterstic curling of root hairs and invasion of the bacteria** to form an **infection thread,** by the invegination of plasma membrane of root hair cells and it reaches up to the cortex of roots.

  Curling of root hairs is stimulated by **specific complex polysaccharides found on the surface of rhizobia,** recognised by **Lectins (small proteins of host plant roots).**
- **Nodule initiation & development in root cortex. Mitogenic agents secreted (Kinetin) by bacteria & auxin produced by plant cell promotes cell division & extension** leading to nodule formation. Nodule establishes direct vascular connection with host for exchange of nutrients. Root nudule cells have chromosome in double to other somatic cells. Thus nodule cells are polyploid specially **Tetraploid**.



Development of root nodules in soyabean : (a) *Rhizobium* bacteria contact a susceptible root hair, divide near it, (b) Upon successful infectionof the root hair cause it to curl, (c) Infected thread carries the bacteria to the inner cortex. The bacteria get modified into rod-shaped bacteroids and cause inner cortical and pericycle cells to divide. Division and growth of cortical and pericycle cells lead to nodule formation, (d) A mature nodule is complete with vascular tissues continuous with those of the root

Release of bacteria from infection thread and they differentiable as specilized nitrogen fixing cell.

- Bacteria continue to multiply during it's path in root thair cells & bacteria distribute in most of cells.
- The membrane of infection thread bud off to form small vesicles with containing one or more bacteria. Then bacteria stop dividing & enlarge & differentiate in **nitrogen fixing cells called bacteroid** & it's membrane called **peribacteroid membrane.**

MECHANISM OF BIOLOGICAL N_2 FIXATION

By Burris. The atm. N_2 is reduce by the addition of hydrogen atoms.

- The three bonds between two nitrogen atoms N ≡ N or dinitrogen are broken & ammonia **(NH_3) is formed by reduction of N ≡ N.**

$$N \equiv N + 8H^+ + 8e^- + 16ATP \xrightarrow[\text{Nitrogenase}]{} 2NH_3 + H_2 + 16ADP$$

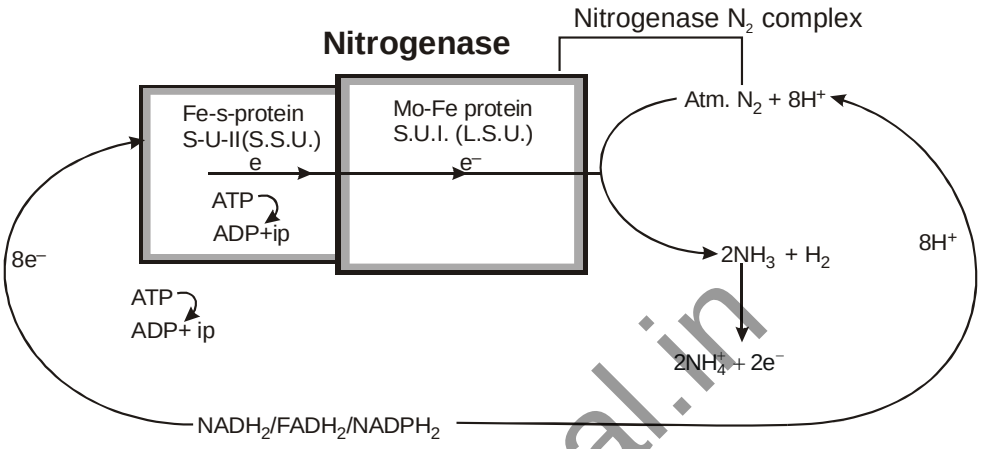
(1) **Nitrogenase:** ⇒ Exclusively present in prokaryotes
⇒ Inducible enzyme
⇒ Larger sub unit/SU-I **Mo-Fe-protein**
smaller Subunit / SU-II-**Fe-S-protein/ ferredoxin**
⇒ Both Subunits bind togather at the time of N_2 fixation.
⇒ Oxygen sensitive enzyene

(2) **O_2 Regulation:** ⇒ Most of diazotrophs are obligate anaerobes
⇒ Some diazotrophs are facultative like Rhizobium, perform anaerobic respiration at the time of diazotrophy
⇒ In root nodule of leguminous plants - O_2 Scavenger Leghaemoglobin (lhb) (similar to haemoglobin of animals) is present, bind with O_2 to become oxyleghaemoglobin (olhb) and regulates minimum O_2 concentration.
⇒ Leghaemoglobin is synthesized by combined activity of host (gives protein part globin) and bacteria (gives haem' part).
⇒ In the Heterocyst- Non photosynthetic and thick walled.

(3) **Source of H^+ and e^-**
⇒ Reducing agents $NADH_2/FADH_2/NADPH_2$ obtained from Photosynthesis and respiration

(4) **Source of ATP** ⇒ From Photosynthesis and respiration

(5) **Genes** — Host-NOD(Nodulin protein forming gene)
Bacteria-nod (Nodule forming gene)
Fix nif (nitrogenase inducing factor)
Fix (Nitrogen fixation gene)



Biological N_2 fixation

Mechanism of nitrogen fixation

(a) The 2nd unit (ferredoxin) of nitrogenase, receive electrons from e^- donar ($FADH_2/NADH_2/NADPH_2$) and become reduced.

(b) This reduced 2nd unit is now activate by ATP and form a complex called **ferredoxin ATP complex.**

(c) On other side unit 1st (Fe-Mo protein) of nitrogenase, reacts with molecular nitrogen to form **nitrogenase-nitrogen complex.**

(d) Ferredoxin ATP complex then transfer electron to nitrogenase-nitrogen complex, so that the later gets reduced. This reaction utilize of ATP.

(e) The reduced nitrogenase-nitrogen complex now receives proton (H^+) resulting in formation of ammonia (NH_3).

SYNTHESIS OF AMINO ACIDS & NITROGEN ASSIMILATION

Nitrogen assimilation:- Inorganic NH_3 (Produced by nitrate reduction or biological fixation or obtained from soil as NH_4^+) reacts with a TCA cycle intermediate-α-ketoglutaric acid to form an amino acid **glutamic acid**.This process known as **Reductive amination or Amino acid Biosynthesis.**

α-Ketoglutaric acid + NH_4^+ + $NADPH_2$ $\underset{\text{dehydrogenase}}{\overset{\text{Glutamate}}{\rightleftharpoons}}$ Glutamic acid + H_2O + NADP

Transamination:- Transfer of Amino group from glutamic acid to other keto acid is known as transamination. This is a process of formation of other amino acids in plats. **(transaminase enzyme)** Ex.
Glutamic acid + Pyruvic acid a ⇌ **Alanine** + α-ketoglutarate
Glutamic acid + OAA ⇌ **Aspartic acid** + α-ketoglutaric acid.

☛ **Glutamic acid is first formed amino acid in plants** & can synthesize different amino acids by transamination.

Catalytic Amidation:

Transportation of fixed N_2/Assimilated N_2 in plats occurs mainly in form of amides especially in leguminous plants as amides are more stable than amino acids and posses high Nitrogen to Carbon ratio (2N to 4C - in Asparagine, 2N to 5C in glutamine (as glutamate posses 1N to 5C)

Formation of amides from amino acids catalysed by enzymes called as catalytic amidation.

In legumes of temperate origine like pea and clover-Asparagine is translocated in non nodulated plant parts.

In legumes of tropical origin like soyabean and cowpea-ureides are translocated in non nodulated plant parts.

Glutamine synthesis:

Glutamic acid/Glutamate + $NH_4^+ + ATP \xrightarrow{\text{Glutamine (G.S.) Synthase}}$ Glutamine + ADP + iP

Asparagine syntnesis:

Glutamine/Glutamate + Aspartate + ATP $\xrightarrow{\text{Asparagine (A.S.) Synthase}}$ Asparagine + ADP + iP + Glutamate/α-Ketoglutaric acid

SPECIAL POINTS

- C, H, O, N and P are main constituents of protoplasm (organic materials). So they are called **protoplasmic elements.** C, N & O from atmosphere and H_2O from soil for H & O.
- **C, H and O** are the main components of **nucleic acid, proteins, enzymes, carbohydrates, fats. (frame work elements)**
- Mostly soil is deficient of **NPK** and these elements are known as **critical elements,** NPK-fetilizer is good for crop yield.
- Silica (SiO_2) is present in cell wall of diatoms grasses and paddy straw.
- **Aℓ** present in pteridophytes i.e. - Lycopodium.
- Mo, required in minimum quantity.
- **Hydroponics/solution culture/**soil less growth/tank farming and **ash analysis** is a technique which determines the role of nutrients in plants. (By Geriack)
- Gold (Au) present in Equisetum, mustard plants.
- Na^+ found in **halophytes** for their grawth (marine plants).
- **Trace - elements are micro-nutrients,** while while **tracer-elements** are **radio-isotopes**.
- Mg present in chlorophyll, as non-ionic form.
- Mg remains after chlorophyll burning.
- One abundant and stable from of Fe in leaves is stored in chloroplasts as an iron protein complex called **phytoferritin** (Seckback 1983).
- C, H, O are provided by H_2O, O_2 and CO_2, but 13 elements essential to all plants are absorbed as ions from the soil solution, is called a **solution mining.** (N_2 from soil & atm.)
- **Putrification/proteolysis:-** Bacillus, Pseudomonas, Clostridium.
- Proteins $\xrightarrow{\text{Proteases}}$ peptides $\xrightarrow{\text{Peptidase}}$ amino acids (conversion of proteins in to amino acids) smell of dead bodies.
- **Deamination:-** Removal of amino group as NH_3 from an amino acid.
- Root pressure is measured by **manometer**

PLANT WATER RELATIONS

INTRODUCTION

- The study of various vital activities and metabolism of plants is know as **Plant physiology.**
- **Stephan Hales** is known as father of plant physiology.
- **J.C. Bose** is known as **Father of Indian Plant physiology.**
- Plants grow in soil and absorb water and minerals, which are available in soil. So that water has great importance for plant. Water forms 80-90% of fresh weight of plant body. The method or technique, plant cells obtain water, comes under the heading of **Water relation**.
- To understand the plant water relations, we should know the following process-

DIFFUSION

"The movement of molecules or atoms or ions of a materials from an area of higher concentration to an area of their lower concentration is called diffusion.

- The diffusion is continue till the dynamic equilibrium is established. At this stage the net movement of molecule is equal in both direction.
- The kinetic energy, which is present in the molecules of material is distributed equally in their available space by their nature.

Diffusion rate $\rightarrow$ **Gas > Liquid > Solid**

Diffusion pressure :

"The diffused molecules or ions exert a pressure on the substance or medium in which diffusion take place, known as Diffusion pressure."

- This is developed due to difference in the concentration of molecules of the material. **Diffusion pressure of a pure solvent (1236 atm) is always higher than its solution.**
- Water molecules moves from their higher concentration to the their lower concentration in plants.
- The rate of diffusion decrease with increasing size of molecules.
- The speed and direction of movement of molecules of substances depends upon the concentration of the molecules.
- Due to the difference in the concentration of molecules, diffusion pressure results.
- The potential ability of a substance to diffuse from an area of its greater concentration to an area of less concentration, is called **diffusion pressure**.
- D.P. $\propto$ concentration of substance.

Significance of diffusion :

- Exchange of gases like CO_2, O_2 take place through the diffusion.
- The distribution of hormones in the plants takes place through the diffusion.
- The process of transpiration is a diffusion process. The evaporation of water from the intecellular spaces is linked with diffusion during the transpiration.
- The ions of the minerals may diffused into the plant body.
- The process of **osmosis is a special type of diffusion** of solvent molecules through semi-permeable membrane.

OSMOSIS

"Osmosis is defined as the special diffusion of solvent (water in this context) from the solution of lower concentration to the solution of higher concentration when both the solutions are separated by a semipermeable membrane."

- Osmosis was discovered by **Abbe Nollet.**
- The detailed explanation of osmosis was given by **Traube** and **Duterochat.**
- Passing of **solvent** through the semipermeable membrane is the example of osmosis.
- The water moves into the cell during the osmosis is called **endosmosis.**

  Ex.: Grapes placed in water.
- When the water starts moving out of the cell then it is called **exosmosis.**

  Ex.: Grapes kept in salt solution.

Types of membrane :

The exchange of materials in and out through the membrane is called permeability.

- The membranes are divided in the following types on the basis of permeability :-

(i) Permeable membrane :

Such membranes are **permeable for both - solutes and solvent.** e.g. **cell wall, filter paper.**

(ii) Semipermeable membrane :

Such membranes **allow diffusion of solvent molecules, but do not allow the solutes.** e.g., artificial membrane like **Cellophane** and **Copper ferrocyanide membranes, parchment paper, goat bladder.**

(iii) Selective permeable membrane OR differentially permeable membrane :

Such membranes allow some selective solutes to pass through them along with the solvent molecules.

e.g., **Cell membrane, Tonoplast, Organelles membrane.**

- These membranes are permeable for CO_2, N_2 O_2 gases, alcohol, ether and water, but impermeable for polysaccharides and proteins.

(iv) Impermeable membrane : Rubber membrane, Al-foil, Suberised cell wall, cork wall.

Types of Solution :

(i) Isotonic solution :

If solution in which a cell is placed, has equal osmotic concentration to that of cell sap, the outer solution is called **isotonic solution.**

(ii) Hypotonic solution :

If the osmotic concentration of outer solution is lesser than that of the cell sap, the outer solution is called **hypotonic solution.** If a cell is placed in such solution **endosmosis** takes place, results, cell swells up.

(iii) Hypertonic solution :

If the osmotic concentration of a solution is higher than that of the other (cell sap), solution is known as **hypertonic solution.**

- If a cell placed in this type of solution, **exosmosis** takes place. It means water of the cell sap diffused out into the outer solution, resulting cell become flaccid.

  e.g., Grapes placed in higher concentration of sugar solution becomes flaccid (contracts).

Osmotic pressure or O.P. :

- **Osmotic pressure is the pressure developed in a solution when solution, and water are separated by semipermeable membrane (given by Pfeffer)**

  or "O.P. of solution is equal to pressure, which required to be applied on a solution in order to prevent an increase in it's volume due to tendency of solvent to enter in when the two are separated by a semipermeable membrane."
- The osmotic pressure of **pure water is zero. O.P. is due to presence of solute** into the solution.
- The osmotic pressure of solution is directly proportional to the **concentration of solute in** it.
- The osmotic pressure shows maximum variation in the plants cells.
- According to **Hariss** the osmotic pressure is **highest in leaves** and **lowest in roots.**
- The **highest osmotic pressure** is found in the **halophyte** group. **Atriplex confortifolia (202 atm).**
- The **lowest osmotic pressure** is found in aquatic plants or **hydrophytes.**
- **Hydrophytes < Mesophytes < Xerophytes < Halophytes.**
- Generally osmotic pressure is lesser during the night and higher at noon.
- Osmotic pressure of a solution is measured by **osmometer.** O.P. of cell is measured by **incipient plasmolysis.** First osmometer was made by Pfeffer.
- The osmotic pressure can be measured by various methods.

  The formula of Vont Hoff for measuring O.P. :

  OP = mRT

  Here m = Molar concentration

  R = Gas constant [0.082 mole/molecules]

  T = Absolute temperature

  the osmotic pressure of 1 mole. glucose solution at 0ºC-

  OP $\Rightarrow$ 1 × 0.085 × 273 $\Rightarrow$ 22.4 atm., for non electrolytes.

  The **O.P. of electrolytes** is find out by the following formula-

  OP = MRT I

  Where I is the constant of ionisation of electrolytes.
- The **osmotic pressure of electrolytes is h**igher than that of non electrolytes.
- For example - solution of 1 M NaCl and 1 M glucose. The molar concentration of both solutions are equal but **O.P. of 1 M NaCl is higher than solution of 1 M glucose.**
- **Water moves from lower O.P. towards the higher O.P.**

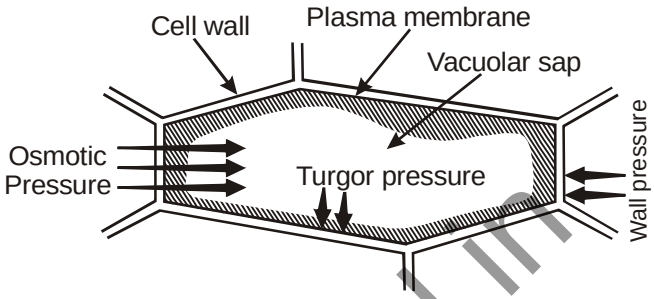
Significance of Osmosis / Osmotic Pressure :

- Water absorption from the soil by the plants.
- Transport of water from cell to cell in plants.
- To maintain turgor pressure.
- Origin of root pressure.
- Opening & Closing of stomata is affected by Osmosis.

TURGOR PRESSURE OR T.P.

"When a cell is immersed in water, then water enter into the cell because osmotic pressure of the cell sap is higher. The cell content press upon the wall or develop a pressure against the cell wall, which is called turgor pressure."

- Turgor pressure is **not applicable for free solution.** This is only applicable for osmotic system of a plant cell. Turgor pressure is also known **hydrostatic pressure.**
- The turgor pressure in encounter balanced by an equal but opposite pressure of the thick cell wall on the enclosed solution or protoplasm is known as **wall pressure.** It means whatever the amount of pressure exerted inner side on the cytoplasm.



TURGOR PRESSURE

- Therfore, **wall pressure and turgor pressure are equal** to each other but W.P. is inward in direction.

$$TP = WP$$

- Plant cell does not burst, when placed in pure water due to wall pressure, but an animal cell burst when placed in pure water because wall pressure is absent due to absence of cell wall.

  For example the consequence of endosmosis in animal cell can be demonstrated by placing RBCs of human blood in distilled water.
- A **flaccid cell has zero turgor pressure.**
- The **highest value of turgor pressure is found in fully turgid cell** and it is equal to the osmotic pressure. **Fully turgid cell has TP = OP**
- The value of **turgor pressure is normally from zero to in between the osmotic pressure** in plant cell.
- The value of **turgor pressure is assumed as negative (–ve) during the plasmolysis** of the cell.

Significance of T.P. :

- Protoplasm of the cell attached with the cell wall due to turgidity of the cell and cell is in stretched condition. It **maintains the normal shaped of the cell** in which physiological processes are going on.
- The **3-D structure of mitochondria, chloroplast and microbodies** is maintained due to turgor pressure, which is essential for their physiological activities.
- Turgor pressure is essential for **maintaining definite shape of delicate organs.**
- Turgor pressure helps in **cell elongation or growth of cell.**
- Plant movement like, **movement of guard cells of stomata, wilting movements and seismonastic movements** etc. depend upon turgor pressure.
- Turgor pressure provides essential power to the plumule to coming out from the soli and help in penetration of radicle into the soil.

DIFFUSION PRESSURE DEFICIT (DPD) OR SUCTION PRESSURE

DPD : The difference between the diffusion pressure of the solution and it's pure solvent at particular temperature and pressure is called DPD.

or The DPD of any solution is the difference between the diffusion pressure of the water, which is present in the solution and diffusion pressure of pure water.

- The term **Diffusion Pressure deficit (DPD)** is used by **B.S. Mayer. Renner** named as **Suction Pressure (S.P.)** in cell.
- **DPD determines the direction of osmosis and it is the power of absorption of water for the cell (Suction Pressure)**
- This is also known as **demand of water in cell. DPD ∝ concentration of solute.**
- The **diffusion of water** takes place from the **region of lower DPD to the region of higher DPD** in the process of osmosis.

$$\text{Lower DPD} \xrightarrow[H_2O]{SPM} \text{Higher DPD}$$

- Normally, **osmotic pressure is greater than the turgor pressure** in a cell. The difference between osmotic pressure and turgor pressure is called **suction pressure** or DPD.

DPD = OP – TP

- The DPD of any **free solution** is equal to the osmotic pressure of that solution.

DPD = OP

(i) DPD in partialy turgid or normal cell :

DPD = OP – TP

(ii) DPD for fully turgid cell :

- When a cell is placed in pure water or hypotonic solution then water enter into the cell, results turgor pressure develop in the cell. The cell starts swelling due to the turgor pressure. Simultaneously, concentration of cell sap decreases due to continuous inflow of water. Therefore **OP is goes on decreasing** and **T.P. increase due** to this, when value of TP will be equal to the OP then DPD will be zero.

At this stage cell becomes **fully turgid.** Therefore in a fully turgid cell.

DPD = OP – TP

When, OP = TP or OP – TP = O

So that **DPD = O**

(iii) DPD in flaccid cell :

- If, the cell is in flaccid state then its T.P. or WP would be zero and value of DPD would be equal to O.P.

TP or WP = O

Therefore, **DPD or S.P. = OP**

- If a flaccid cell placed in water then waters enter into cell because DPD of the cell sap is higher.

(iv) DPD for plasmolysed cell :

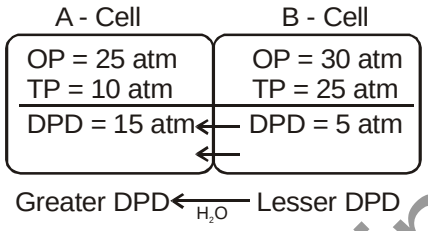
- Sometimes the value of turgor pressure is negative as in plasmolysed cell. In this state

DPD = OP – TP

∴ [TP = – Ve]

DPD = OP – [– TP] = OP + TP

- So that the **DPD of the plasmolysed cell is greater than osmotic pressure.**
  It means - **DPD = OP + TP**
  Demand of water = **Plasmolysed cell > Flaccid cell > Partially turgid cell > Fully turgid cell**
- The **demand of water in plasmolysed cell is highest.**
- It means, when the osmotic pressure and turgor pressure will be equal, then the DPD will be zero. Water will not enter in this type of cell and **cell become fully turgid.**
- But, when turgor pressure is lesser than the osmotic pressure, in normal cell then some DPD will be definitely present in the cell and water would enters into the cell.
  For Ex.



WATER POTENTIAL OR Ψ_w

"The difference between the free energy of molecules of pure water and free energy of the solution is called water potential of the system."

- Now a day according to concept of free energy and thermodynamics DPD of a solution is also represented by **water potential.** (Given by **Taylor** and **Slatyer**)
- The **water potential of pure water is maximum** the pure water has greater free energy. The **free energy, lower down by addition of solute.**
- **Water always flows from higher water potential to lower water potential.**
- Water potential is represented by Greek word ψ (Psi)/ ψ_W and it is measured in **bars** or **Pascal (Pa).** Water potential is equal to **DPD,** but opposite in sign. Its value is **negative.**

$\psi_W = \psi_S + \psi_P + \psi_g$ and DPD = O.P. – T.P.

So, $\boxed{\psi_W = -DPD}$

ψ_S = Solute potential = – O.P.

ψ_P = Pressure potential = T.P.

ψ_g, ψ_m is neglesible

- Water potential has following components :

1. Osmostic potential (ψ_s) :

- Osmotic potential or solute potential represents the concentration of the solutes. Water potential (ψ_W) is negative in the presence of solutes. So that osmotic potential is also negative.
- According to thermodynamics, **osmotic pressure** is called **solute potential** or **osmotic potential.** It is represented by ψ_S and shown by negative sing (–ve) or it is better to say **osmotic potential** on the basis of free energy.
- Osmotic potential or solute potential measured in bars. (1 Bar = 0.987 atmospheric pressure)
- OP = 22.4 atm => osmotic potential = –22.4 atm. (1 M glucose solution)

2. Pressure potential (ψ_P)

- Turgor pressure is known as **pressure potential.** It is shown by **positive sign (+ve).**
- 1 Bar = 10^6 dynes/sq. cm. or 0.987 atm. (1 megapascal = 10 bars)
- According to this concept their relation is as follows.
  Water potential = Osmotic potential + pressure potential + matric potential
  $\Delta\psi$ or $\psi_W = \psi_S + \psi_P + \psi_m$

$\psi_W = \psi_S + \psi_P$ As ψ_m and ψ_g (Matric potential and gratitational potential) are negligible

$$\psi_W = -ve$$
$$\psi_S = -ve$$
$$\psi_P = +ve$$

- According to the above concept the relation of the three phases of the cell by the water potential will be as follows :-

[A] In case of fully turgid cell -

- There is **no flow of water in a fully turgid cell,** because the cell is in equilibrium condition with water which is present out side the cell. So that water potential will be zero at this state. Because osmotic potential and pressure potential are equal in the cell.
- For example - If the value of osmotic potential of a cell is – 10 and pressure potential (ψ_P) is + 10, then water potential will be zero as-

$$\psi_W = \psi_S + \psi_P$$
$$\psi_W = -10 + 10$$
$$\psi_W = 0$$

[B] In case of flaccid cell -

- Turgor pressure is zero at this stage. It means pressure potential is zero. If osmotic potential of the cell is – 10 bar then, $\psi_W = \psi_S$

$$\psi_W = \psi_S + \psi_P$$
$$\psi_W = -10 + 10 \text{ bar}$$
$$\psi_W = -10 \text{ bar}$$

$\because \psi_P = 0 = TP$

[C] In Plasmolysed cell-

- The pressure potential (ψ_P) means turgor pressure is negative in this stage. Therefore water potential (ψ_W) of this cell will be more negative [more – ve].
- If the value of osmotic potential is –10 bar of a plasmolysed cell and value of pressure potential is –2 bars then its water potential (ψ_W) will be –12 bars.

$$\psi_W = \psi_S + \psi_P$$
$$\psi_W = -10 + (-2) \text{ bar}$$
$$\psi_W = -12 \text{ bar}$$

- So, this is the conclusion that **water always move from higher water potential towards the lower water potential.**
- For example if the water potential of 'A' cell is –10 bars and water potential of 'B' cell is –12 in two cells, then water will be flow from 'A' cell to the 'B' cell.

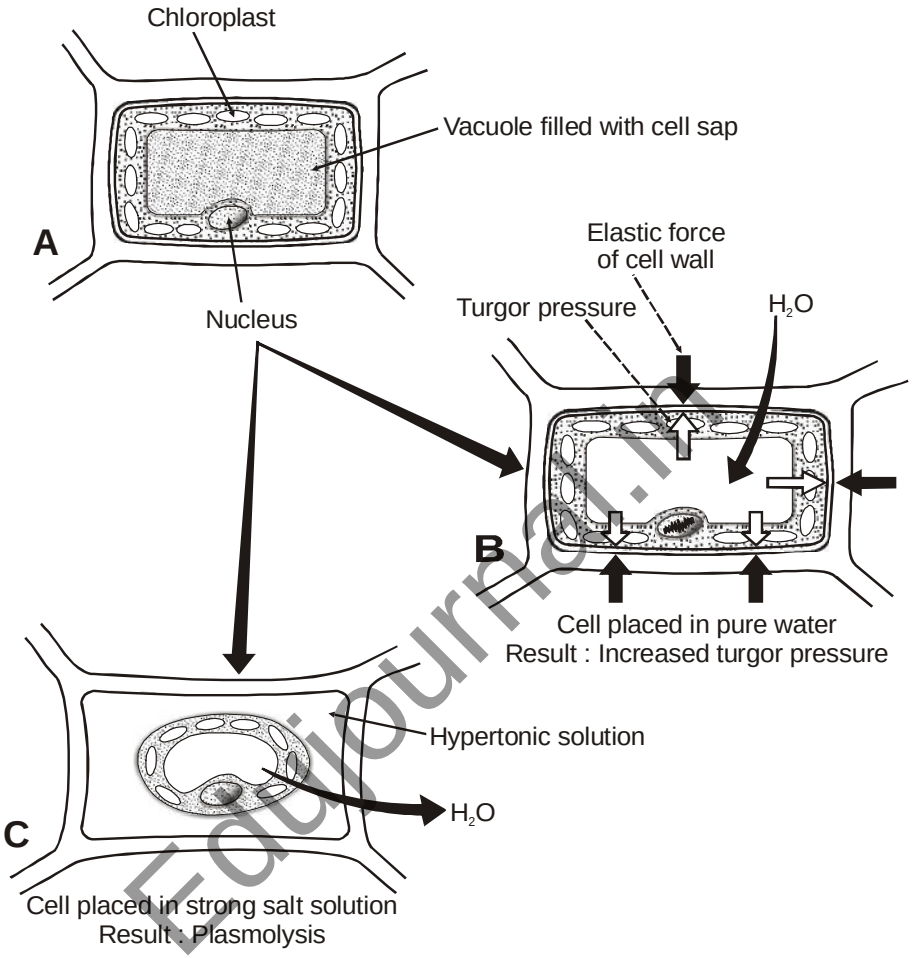
PLASMOLYSIS

"If a plant cell placed in a hypertonic solution, water molecules diffused out from the cell. As a result of exosmosis, the protoplasm of the cell detached from the cell and starts shrinking. This is called plasmolysis.

- The various sequences of plasmolysis are as follows -

(i) In a turgid cell, the cell sap pushed away the protoplasm, so that it is in close contact with cell wall.

(ii) When it placed in a hypertonic solution, the volume of the cell reduces due to shrinking of cell because some amount of water of cell sap diffuses out by **exosmosis.** Turgor pressure decreases by which cell wall is not pushed by the protoplasm, so that shrinking cell membrane reduces in total volume of the cell. This situation is called the **first stage of plasmolysis** or **limiting plasmolysis.**



Plasmolysis :

A - A cell in normal stage, B - A cell placed in pure water and resulting in increased turgor pressure and C - A cell placed in strong salt solution leading to plasmolysis

(iii) If the diffusion of water to the outside is continue by the exosmosis then central vacuole contracts and with this protoplasm also shrinks but cell wall is not contracting. So that protoplasm is **seems to detach from the corners of cell wall.** This condition is known as second phase of the plasmolysis or **incipient plasmolysis.**

(iv) The shrinking of protoplasm is continuous due to continuous exosmosis, it detaches from the cell wall and assumed a spherical shape. This phase is known as **evident plasmolysis / full plasmolysis.**

☛ **Hypertonic solution is present in between the cell wall and protoplasm.**

Significance of plasmolysis

[i] A living cell is distinguished from the non living [dead] cell through the plasmolysis. Because plasmolysis does not occur in dead cell.

[ii] The osmotic pressure of any cell can be measured by **incipient plasmolysis.**

[iii] If the plasmolysis remains for long duration in a cell then it dies. To destroy the weeds, salts puts in their roots.

[iv] Fishes and meat are prevented from spoilage by salting, which inhibits the growth of bacteria and fungus.

[v] Higher concentration of sugar in jams and jellies stops the growth of bacteria and fungus.

[vi] High amount of chemical fertilizers near the root causes death or browning of the plant due to plasmolysis.

[vii] The fresh water growing plants are either wilted or die when they are kept in marine water.

IMBIBITION

Adsorption of undissolved liquid by any solid material is called imbibition or adsorption of water by hydrophilic colloids is known as imbibition.

- This is a physical process by which a dry solid colloid material swells up by adsorption of water.
- The cell wall is made up of colloidal substance as cellulose, pectin, hemicellulose etc. All they are hydrophilic in nature. Therefore they imbibe water.
- Proteins, Agar - agar, starch etc, these are all imbibant **materials**.
  Agar - agar can adsorbs 99 times more water than that of its weight. Some of the proteins adsorb 15 times more water.

  Imbibition power = Agar – Agar > Pectin > Protein > Starch > Cellulose

  Affinity must be between imbibant and liquid material and movement of water occurs in order of water potential gradient.
- The heat released during the **imbibition** is called **heat of wetting.**
- A huge pressure is developed in material due to imbibition. This pressure is called **Imbibition pressure (IP).**
- IP is also called as **matric potential** with respect to water potential. $\Psi_w = \Psi_m$
- The imbibition is less in compact arranged material like wood, and more in lighter or soft material like gelatin.
- Imbibition decreases with increasing pressure on imbibant material.

Significance of Imbibition :

- **Absorption of water** during due the seed germination is only initiate through the imbibition.
- **Breaking of seed coat** during the seed germination is due to imbibition process. Proteins, fats and starch is present in the kernel. This kernel swells up more as compared to the seed coat which breaks the seed coat.
- Initial process of water absorption in roots by root hairs is imbibitions.
- Resurrection in many plants like Selaginella, Lichen take place due to the process of imbibition.
- The water enter into the aerial roots and dry fruits is due to imbibition.
- Newly **formed wood swells up in rainy season.**
- Dry wood is filled in the natural grooves of rocks and watered them. The rocks are broken due to their swelling.

Movement of water molecules :

Higher D.P. $\longrightarrow$ Lower D.P.
Lower O.P. $\longrightarrow$ Higher O.P.
Lower DPD $\longrightarrow$ Higher DPD
Higher (less –ve) Ψ_w $\longrightarrow$ Lower (more –ve) Ψ_w
Higher T.P. $\longrightarrow$ Lower T.P.
Hypotonic $\longrightarrow$ Hypertonic
Lower conc. of solution $\longrightarrow$ Higher conc. of solution.

ABSORPTION OF WATER BY PLANTS

SIGNIFICATION OF WATER IN PLANTS

- 75-80% part of cells is water. In aquatic plant cells, upto 95% water may be present.
- Water is a **universal solvent.**
  (a) Gases, solids, minerals and organic compounds are found dissolved in it. Their transfer in plants occurs through aquetic medium.
  (b) Water is essential for **metabolic reactions** occuring in plants.
- Water is used in many reactions (hydrolysis, photosynthesis etc.)
- The cells remain turgid due to water, so that shape of cells/organs is maintained. Many types of movements, opening and closing of stomata, metabolic reactions, growth etc. are affected by turgidity.
- Water protects the plants from harmful effects due to high and low temperatures.
- Water is essential for **seed germination**.

FORM OF WATER

- Water is mainly obtained through rain. Some of the water goes into the reservoirs. This is called **run off water.** Rest of the water enter into the land. Water present in soil is following type-

(a) Gravitational water :-

Form of water, which reaches at the soil water table due to the gravitational force after the rainfall. This form is not available to plants but available by mechanical methods or by tubewell irrigation. Some plants can absorbe this water - **Calotropis, Prosopis, Capparis, etc.**

(b) Hygroscopic water :-

Thin film of water is tightly held by the soil particles is called hygroscopic water. This water is also **not available** to the plants.

ψ_w of hygroscopic water is highly negative or very low.

(c) Chemically combined water :-

The amount of water present in the chemical compounds, which are present in the particles of soil. This is **not available** to the plants ..... 24 H_2O, ... 7 H_2O

(d) Capillary water :-

Water exists between soil particles in small capillary pores is called **Capillary water**. It is **the most common available form to the plants. Plants only obsorb this form of water.**

(e) Atmospheric humidity :-

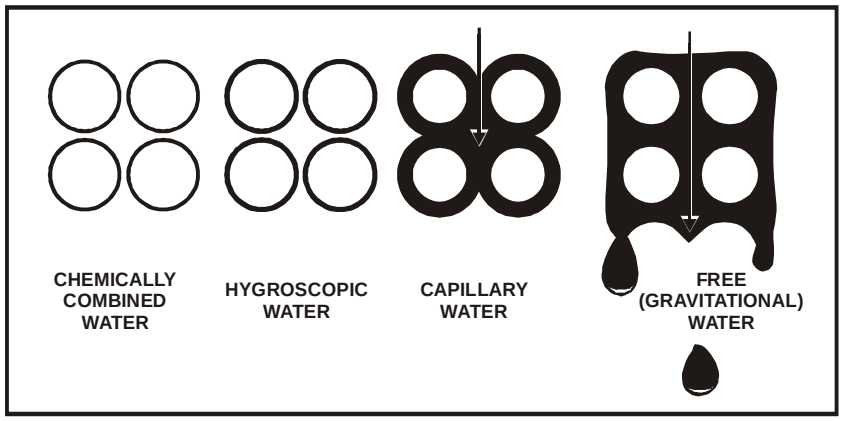
This is water vapour present in air, which can be absorbed by hanging roots of the epiphytes due to presence of velamen tissue and hygroscopic hairs.

Holard : It is the **total amount of water presents in the soil.**

$$\boxed{\text{Holard} = \text{Chresard} + \text{Echard}}$$

Chresard : This is the **water available** to the plants.

Echard : This **water is not available** to the plants.



WATER ABSORBING SYSTEM

- In thalophytes (fungi and algae) water absorption takes place through the whole surface of all cells.
- In Bryophyta it occurs by **Rhizoids**.
- In Pteridophyta & spermatophyta it occurs **by roots**.
- Root System consists of following parts -

(a) **Root cap region** or **calyptra**- Present at the apex of the root as a protective tissue ; it is **impermeable** to water & solute absorption.

- It percept the **stimuli of gravity.**

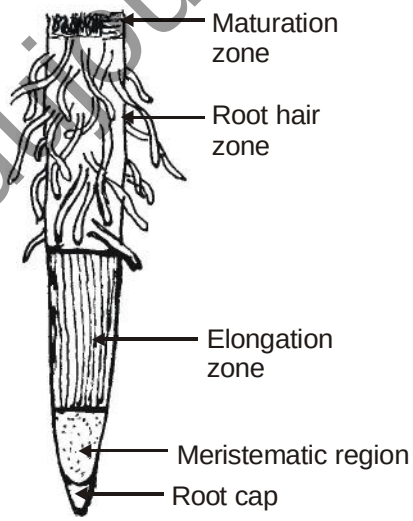


Fig.: Water absorbing system

(b) **Meristematic region**-Region of active cell division situated above root cap.

- **Mineral absorption** mainly occurs from this region.

(c) **Region of cell elongation -** Next to meristematic region, here growth in length of the root takes place.

(d) **Maturation region** - The cells at this region are highly differentiated to carry out different function. It includes root hair region.

- Root hairs are the **water absorbing** organs of plants.

PATH OF MOVEMENT OF WATER

- Water present in soil must reach the xylem of roots. Root hair is in contact with soil water. Their cell wall is thin & water easily diffuses in.
- From root hairs water reaches epidermis & from their to cortex made of parenchymatous cells.
- From innermost layer of cortex water enters in endodermis consisting of thin walled **passage cells** found against each protoxylem.
- In last, water reaches to xylem passing through **thin** walled **pericycle**.

In Short : -Soil water → Root hair → Epiblema → Cortex → endodermis (passage cells) → Pericycle → Xylem

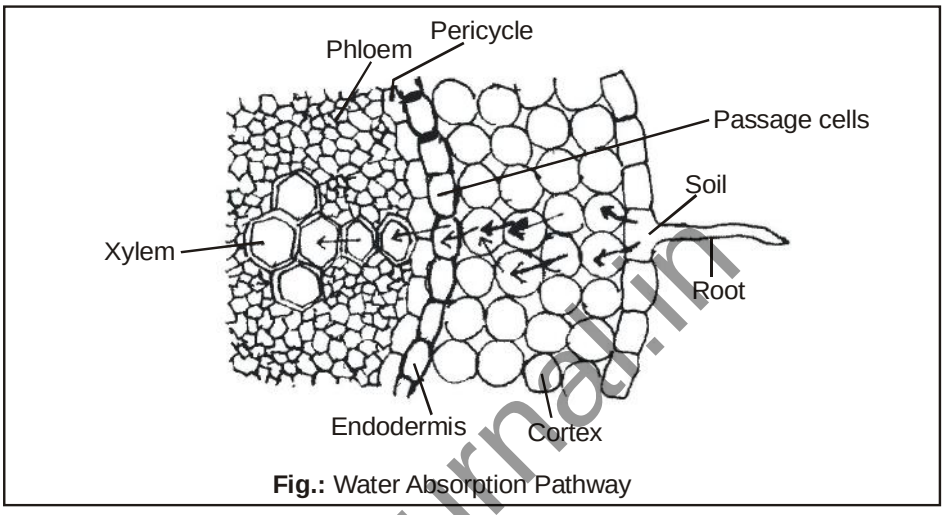


Fig.: Water Absorption Pathway

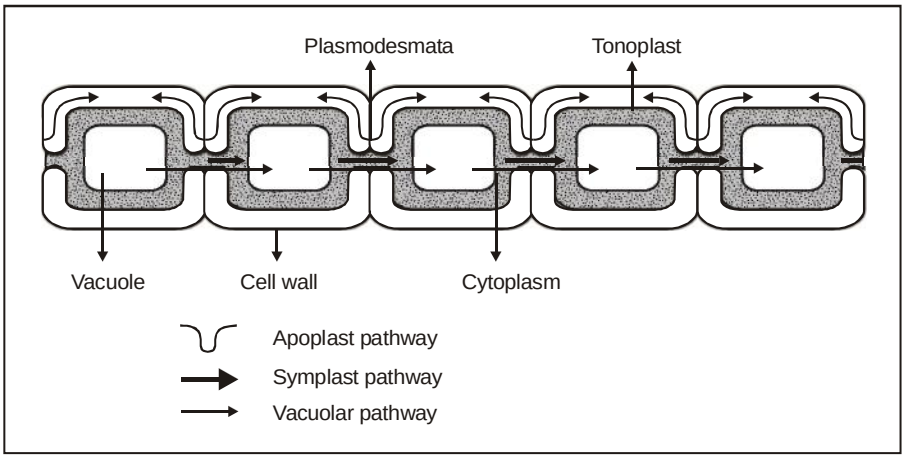
Pathway of Apoplast and Symplast :

(A) Symplast -

A substainable **living path** is known as symplast. This is the living passage. The movement of water from cell to cell through plasmodesmata is called **symplastic path** in plant. This movement of water through cell membrane is also called as **transmembrane pathway.**

(B) Apoplast -

This is the **non living path** in plants. Watered cell wall, intercellular space and xylem cavity associate together to form apoplast.



- Term **"apoplast"** & **"symplast"** given by **Munch**
- The path of water from root hair to cortex, may be apoplastic or symplastic. In **endodermis** subarised **casparian strips** blocks the apoplast, thus water must passes through passage cell via symplast.

MECHANISM OF WATER ABSORPTION

- Term active & passive absorption was proposed by **Ranner.**
- Water is absorbed by two different ways-

(1) Active water absorption **(2) Passive water absorption**

(1) Active absorption of water → According to this method water is absorbed due to the osmotic acitivity of roots or by expenditure of ATPs.

(I) Osmotic active water absorption → This is given by **Atkins** & **Priestley.** According to this method water is absorbed due to the osmotic activity of roots in order to O.P. & D.P.D. **No direct ATP are consumed** in this method. It is effective during night in herbaceous plant and developes root pressure.

(A) Root Pressure :

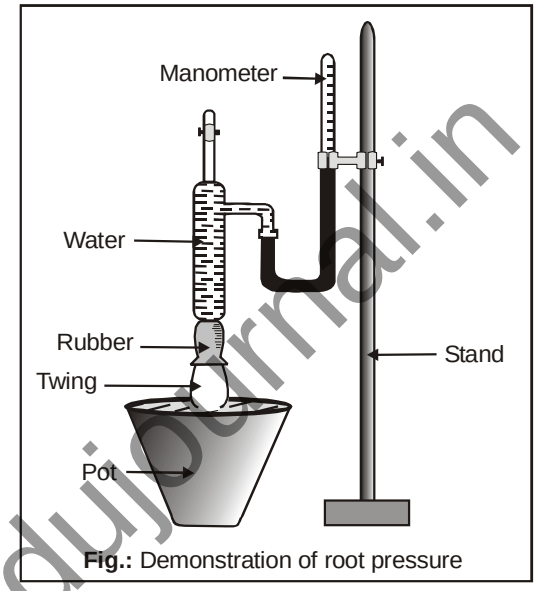


Fig.: Demonstration of root pressure

- Root pressure is the **positive hydrostatic pressure** which develops due to turgidity of cortical cells of root which excert pressure on the xylem sap of roots due to accumulation of water absorbed by roots, during night.
- Term **root pressure** was coined by **Stephan Hales**.
- Root pressure is developed when **rate of osmotic active water absorption is more than the rate of transpiration** and due to which water is pushed up in tracheary elements of roots.
- When a plant is cut near the base, the oozing of the liquid from the cut end is called **bleeding or exudation**. It is indicative of root pressure.
- The **maximum value** of root pressure can be upto **2 atm.**
- Its maximum value is found in plants growing in well aerated, well watered soil under and moist environment.
- **Root pressure** is **absent** in most of the **conifers, woody plants** and **in rapidly transpiring plants** (negative pressure is effective).
- Guttation is also the **result of root pressure**.
- Root pressure is high under favourable conditions (rains and spring). At this time **transpiration** rate is comparatively **low**. **In summers**, when there is greatest need for water, **root pressure is lacking**.
- Thus root pressure is not important in most plants. It may be effective in herbaceous plants which transpire slowly, during night.

(B) Guttation :

Loss of water from the margin of leaves of the herbaceous plant in the form of water droplets is called as guttation.

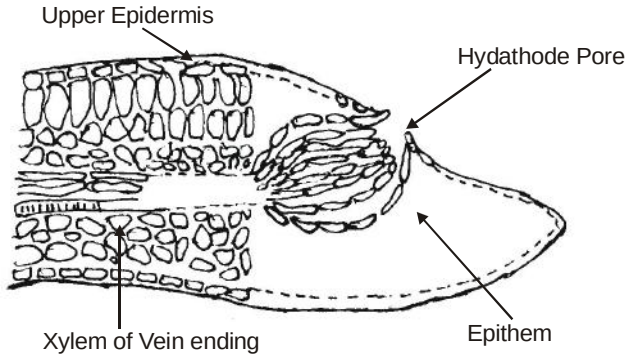


Fig.: Hydrathode

- The term **"Guttation"** was coined by **Burgerstein.**
- Exuded liquid of guttation along with water contains some **organic and inorganic (dissolved)** substances. It means it is not pure water.
- Normally, guttation process is found in herbaceous plants like **Grasses, Tomatos, Balsum, Nausterium, Colocasia, Sexifraga** and in some of the plants of **Cucurbitaceae** family.
- Guttation occurs from the margins of the leaves through the special pore (always open) like structure are called **hydathodes** or **water stomata.**
- Generally guttation occurs during mid night or early morning.
- Parenchymatous and loose tissue are lie beneath the hydathode, which are known as **epithem** or **transfer tissues.**
- The process of guttation take place due to **root pressure,** develope in cortex cells of root.

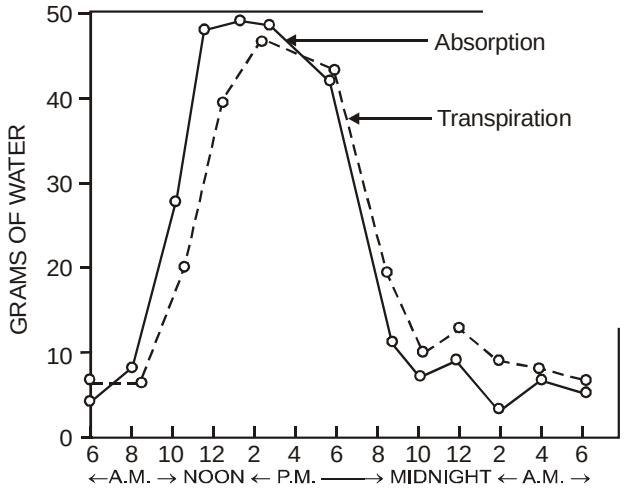
(C) Bleeding :

Fast flowing of liquid from the injured or cut parts of the plants is called bleeding or exudation.

- This process takes place due to high **root pressure.**
- Sugar is obtained from the sugar mapple by this process.
- The highest bleeding is found in **Caryota urens** (Toddy palm) (about 50 liter per day)
- Bleeding is important in economic biology, because **Opium, latex of rubber** is obtained by this.

(II) Non osmotic active water absorption → Proposed by **Thieman, Bennet-Clark.** According to this method absorption of water occur **against the osmotic concentration** by direct investment / **expenditure of metabolic energy** in the form of ATPs. Generally this process present in **Halophytes.** Only 4% of total absorbed water is taken by this process.

(2) Passive absorption of water → Given by **Kramer**. According to this method forces for the absorption of water originates in **aerial parts** by rapid transpiration & roots remain as passive organ. According to **Kramer** water absorption in plants is followed by transpiration. **About 96% of water is absorbed by passive method.** Due to rapid transpiration, D.P.D. of leaf cells ↑ result in suction force, which suck the water from roots.



Wilting :

- Drooping of soft parts of the plants due to loss of turgidity in their cells is called wilting. Wilting is caused due to high rate of transpiration during mid-day or deficiency of water in soil and also in prolonged drought condition.
- Wilting may be temporary or permanent.
- **Incipient wilting :** This is starting of wilting without any external symptom is called incipient wilting.

FACTORS AFFECTING WATER ABSORPTION

[1] Available soil water :-

- **Plant absorbs capillary water,** which is present in soil. Absorption of water depends on the amount of capillary water present in the soil. Absorption increases by increasing amount of capillary water.
- If, water is present in higher amount in the soil then such type of soil is called **"Water logged soil".** This soil is **Physiologically dry** and lack oxygen. Because of this an aerobic respiration takes place in roots, and alcohol is formed. Roots can be degenerate due to form alcohol. (**Dry soil** is physically dry.)

[2] Soil temperature :-

- Soil temperature affects the following mechanisms-
  [i] Low temperature decreases the permeability of cell membrane.
  [ii] It is essential for the activity of enzymes for the formation of root hairs.
  [iii] At low temperature viscosity of capillary water is increased.
- Generally, normal absorption of water take place at temperature of soil between 20 - 35ºC.
- Increasing or decreasing soil temperature of soil between 20 - 35ºC.
  Cold soil is as **physiologically dry.**

[3] Soil Air :-

- Absorption of water proceeds more rapidly in well aerated soil. Deficiency of oxygen in soil causes improper respiration in roots.
- **Poorly aerated soil is physiologically dry.**

[4] Soil Concentration :

- The rate of the absorption is inversely proportional to the concentration of minerals present in soil.

$$\text{Water Absorption} \propto \frac{1}{\text{concentration of soil minerals}}$$

- Water absorption is only take place in appropriate soil solution. If the concentration of soil minerals is high, it decreases the rate of absorption. Therefore **saline soil** is **physiologically dry.** Halophytes can grow only in this soil.

[5] Transpiration :-

- According to **Kramer** the rate of water absorption is directly proportional to the rate of transpiration. The rate of absorption increases due to increase in the transpiration. Because passive water absorption increases due to transpiration.

TRANSPIRATION

INTRODUCTION

- Though large quantities of water is absorbed by the roots from soil, but only 2-5% of it is utilized by plant and rest 95-98% is lost in form of **transpiration**.
- Definition :- The loss of water from the aerial parts of plant in the form of vapours is **called transpiration**.
- The instrument used for measuring transpiration is **potometer**.
- **"Transpiration is an essential evil" - by Crutis.**

  "Transpiration is an unavoidable evil" - by Steward.
- The minimum transpiration is found in succulent xerophytes and no transpiration in submerged hydrophytes.
- **Maximum transpiration is found in mesophytes.**

Significance of transpiration :

[1] In regulation of temperature :

- **Cooling effect** on the surface of leaves is produced by the process of transpiration, due to which temperature remains constant in plants.
- The plant are protected from the burning of heat due to transpiration. Evaporation of water produces cooling effect.

[2] In mineral absorption :

- Mass flow of water is found during the passive absorption of water. Hence it is assumed that minerals enter the roots through the water.

[3] In ascent of sap

[4] In water absorption

[5] Distribution of absorbed salts

[6] Gaseous exchange

[7] Control of hydrological cycle

TYPES OF TRANSPIRATION

(A) Lenticular transpiration :

- Loss of water through **lenticles** (pores found in epidermis of mature stems, some roots & some fruits)
- It results in **0.1%** of water loss out of total transpiration.

(B) Cuticular transpiration :

- **10%** of total transpiration occurs from **surface**, outer wall of epidermis of aerial parts.
- The outer wall has cuticle which affects diffusion of water. It is inversely proportional to thickness of cuticle & amount of water.
- Cuticle minimize stomatal transpiration.

(C) Stomatal transpiration :

- Loss of water through **stomata** (small opening on the epidermis of leaves).
- **90%** of total transpiration occurs through **stomata**.
- The water lost from leaves is called **foliar transpiration.**

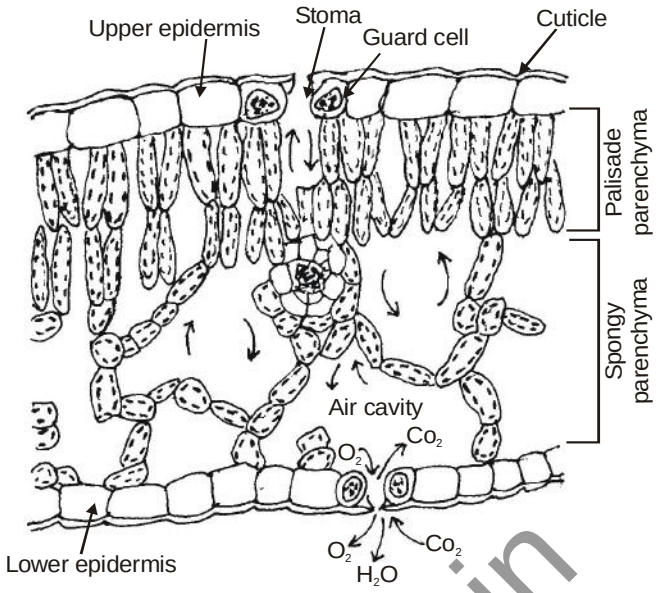


Fig.: T.S. of a leaf showing the stomatal transpiration.

STOMATA

- The name '**stomata**' was given by **Malpighie.**
- Stomata was discovered by **Pfeffer**.
- Stomata cover 1-2% of leaf area.
- Algae, fungi and submerged plants do **not possess stomata**.

Structure of stomata :

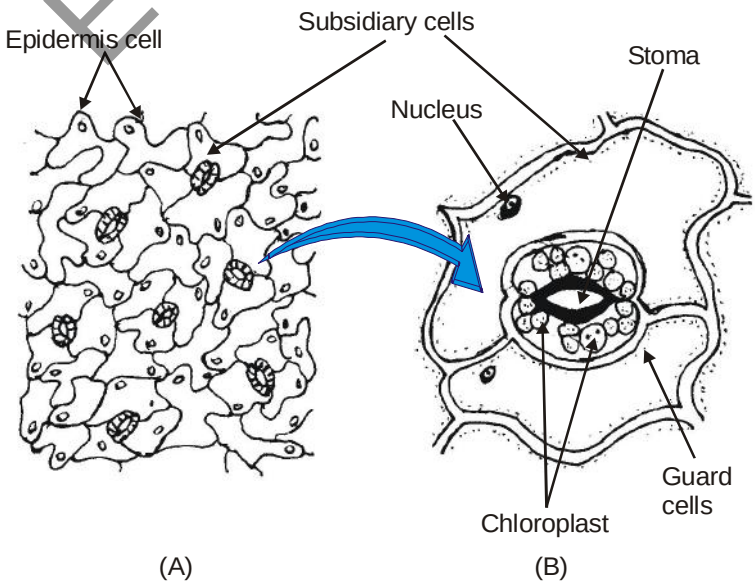


Fig.: (A) Lower epidermis of a leaf to show stomata
(B) Structure of one stomata

- Stomata are small **elliptical pores** found on the epidermis of plant leaves.
- The size of the pore varies from plant to plant for e.g. - In maize the size of pore is **4µ wide to 26µ long**.
- This pore is surrounded by **kidney shaped** or bean shaped epidermal cells called **guard cells**.
- Guard cells are living & have nucleus, chloroplast, vacuole and cytoplasm.
- Chloroplast is functionally active only in dicots. In monocots it is either rudimentry or absent or functionally inactive.
- Inner wall is thick & less elastic and outer wall is thin & more elastic in guard cells.
- Guard cells are surrounded by specialized epidermal cells called **subsidiary** or **accessory cells**.
- The pore opens or closes by the movement of guard cells.
- In the inner tangential walls of guard cells micro filaments of cellulose are present in circular form called as **radial micellation**.
- The air cavities to which the stomata opens are called as **substomatal cavity.**

Distribution of stomata :

- In monocots, stomata are **uniformly distributed** and are present on the upper and lower surface of the leaf.
- In dicots, stomata are **unevenly distributed** and are present more on the lower surface.
- In dicots guard cells are **kidney shaped**, reniform or bean like.
- In monocots, guard cells are **elliptical** or **dumbell shaped** which are called as **Graminaceous stomata.**
- In xerophytes stomata are situated in a **groove** and are thus called as **sunken stomata.**

Types of Stomata :

- **On the basis of distribution : 5 types**

Apple or Mulberry or **Hypostomatous**	**Potato type** or **Amphistomatous**	**Oat type** or **Amphistomatous**	**Water lily type** or **Epistomatous**	**Potomogeton** or **Astomatous**
Stomata present onlyon lower surface of leaf. e.g. Apple, Oxalis, Mulberry.	Stomata present on both surface of leaf but more on lower surface e.g. : Potato, Pea, Tomato, Cauliflower & other dicots.	The no. of stomata are equal on both sides. e.g. :- Oat & other monocots like grasses, cereals, Maize.	Stomata on upper surface only. e.g. :- Water lily, Lotus, Victoria.	Stomata absent or vestigeal. e.g.:- Potamogeton, Hydrilla, Vallisneria.

- **On the basis of subsidiary cells :- 4 types**

Anomocytic	**Anisocytic**	**Paracytic**	**Diacytic**
Subsidiary cells are similar in structure & 5 or 6 in no. e.g.-Ranunculaceae family	Subsidiary cells are 3 in no. & one is bigger than other two. e.g.- Crucifereae family	Subsidiary cells two in no. & are situated parallely with guard cells e.g. - Rubiaceae family	Subsidiary cells are two in no. & are longitudinal with guard cells. e.g.- Caryophyllaeae family

☛ **On the basis of daily stomatal movement :- 4 types (loftfield, 1912)**

Alfa-Alfa type	Potato type	Barley Type	Equisetum type
Stomata open in day. e.g.: Sunflower, Pea, Apple, Grapes, Mustard, Raddish.	Stomata open in day & night but get closed in the evening for few hours. e.g.: Potato, Banana, Onion, Cabbage, Cucurbita, Pumpkin.	Stomata open for some-time in day & then remain closed. e.g.: In Cereals, like - Wheat, Maize, Barley	Stomata always remains open. e.g.: Amphibious plants.

☛ **On the basis of Light :- 3 types**

Photoactive	Scotoactive	Hydroactive
Stomata opens in presence of light e.g. In all normal plants	Stomata opens only at night. e.g.- Opuntia	Stomata opens only in presence of moisture. e.g.- Some epiphytes plants

☛ **On the basis of development (Pant , 1965) : 3 types**

Mesogynous type	Perigynous type	Mesoperigynous type
In this type of stomata guard cells as well as subsidiary or Accessory cells both are developed from one mother cell. e.g. : Rubiaceace & Brassicaceae family.	In this type guard cells are formed from mother cell while subsidiary cells from nearby mother cells. eg.: Cucurbitaceae family.	In this type guard cells & one subsidiary cell is formed from mother cell while other subsidiary cells deve-lop Independently. e.g.: Ranunculaceae, Caryophyllaceae family.

Stomata in Gymnosperms :
(i) **Syndetochielic -** When subsidiary cells & guard cells originate from single cell.
(ii) **Haplochielic -** Both cells arises from separate cells.

MECHANISM OF TRANSPIRATION ::

This involves 3 steps :

Osmotic diffusion of water in the leaf :

☛ Inside the leaf mesophyll cells are in contact with xylem & also with inter cellular spaces above the stomata.

☛ Mesophyll cells draw water from the xylem which makes the cells turgid. Their diffusion pressure deficit and osmotic pressure decreases and in turn they release water in the form of vapours in intercellular spaces close to stomata by diffusion.

☛ After releasing water the O.P. & D.P.D. of mesophyll cells increases & hence they draw water from xylem again.

Opening & closing of stomata :

☛ When guard cells becomes **turgid** stomatal pore **opens**, while when they becomes **flaccid** stomatal pore **closes**.

☛ Stomata generally open during the day and closed during the night except in CAM plants. The important theories of stomatal movements are as follows-

(1) Photosynthesis in guard cell hypothesis :

This theory was proposed by **Schwendener and Von mohl.** According to this theory guard cell chloroplast perform photosynthesis during the day time. This produce sugars in guard cell which increases the O.P. of GC, compared to adjacent epidermal cells (subsidiary cells). Water enters in guard cells form subsidiary cells by endosmosis, due to this guard cells become turgid and stomata will open.

Objections -

(i) In CAM plants stomata open during dark/night.

(ii) Chloroplast of monocot guard cells are non-functional (inactive) photosynthetically.

(2) Starch $\rightleftharpoons$ Sugar interconversion theory :

- This theory was proposed by **Sayre** (1926). First of all Lloyd stated that amount of sugar in GC is increases during the day time and starch in night.
- Detail study of this change was done by **Sayre** & given **starch hydrolysis theory.** According to **Sayre,** starch converts into sugar during day time when pH of guard cell is high. Sugar changes into starch during night at low pH in guard cells (Supported by **Scarth**). **Sayre** clarified that CO_2 reacts with water during night. Due to accumulation of H_2CO_3, pH in guard cell is decreases.
- **Hanes -** Stated that this change takes place by phosphorylase enzyme.
- **Yin & Tung** reported the presence of phosphorylase enzyme in guard cells.

$$\text{Starch + ip} \underset{\text{Night pH- 4.5-5}}{\overset{\text{Day ph 7.5}}{\rightleftharpoons}} \text{Glucose-1, P} \Rightarrow \text{conc. of GC increased} \rightarrow \text{Entry of } H_2O \text{ in GC} \downarrow \text{GC - Turgid} \rightarrow \text{Stomata open.}$$

- **Stewards modification -** According to Steward (1964) appreciable change in O.P. of GC is possible after the conversion of glucose - 1 P into Glucose & ip (inorganic phosphate)

(i) Glucose-1, P $\xrightarrow{\text{Mutase}}$ Glucose-6P

(ii) Glucose-6, P $\xrightarrow{\text{Phosphatase}}$ Glucose + iP

$\Downarrow$

Conc. of GC increased

$\downarrow$

osmotic entry of **H_2O → GC-Turgid → open.**

(iii) Glucose + ATP $\xrightarrow{\text{Hexokinase}}$ Glucose-1, P → Starch → Stomata closed

Objections -

(i) Starch is absent in GC of some monocots like onion.

(ii) Formation of organic acid is observed during stomatal opening.

(3) Active K^+ $\rightleftharpoons$ H^+ exchange theory or active proton pump mechanism-

- Given by **Levitt (1973-74)**. This is modern and most accepted theory for stomatal opening and closing.
- First of all **Fujino** observed that influx of K^+ions in guard cells during stomatal opening. (Supported by Fisher and Hsiao). Detail study of this phenomenon was done by **Levitt**, who proposed this theory. According to him stomata opens by following mechanism.

(i) Cabohydrates $\xrightarrow{\text{Enzymes}}$ PEP + CO_2 $\xrightarrow[\text{Carboxylase}]{\text{PEP}}$ OAA

(ii) O.A.A. ⟶ Malic Acid $\rightarrow$ $H^+ \underset{\text{ATP}}{\rightleftharpoons} K^+$; Malate$^-$

(iii) Malate + K^+ ⟶ K-malate ⟶ Conc. of GC increased

$\downarrow$

Entry of H_2O in GC → **GC turgid → Stomata open**

☛ **Closing of stomata :-** Plant hormone ABA-acts on guard cells, which interfere the exchange of $K^+ \rightleftharpoons H^+$ ions in gurad cells, results in reverse of rxn. of opening of stomata, hence stomata closed. pH of guard cells is decrease during night, which favours stomatal closing.

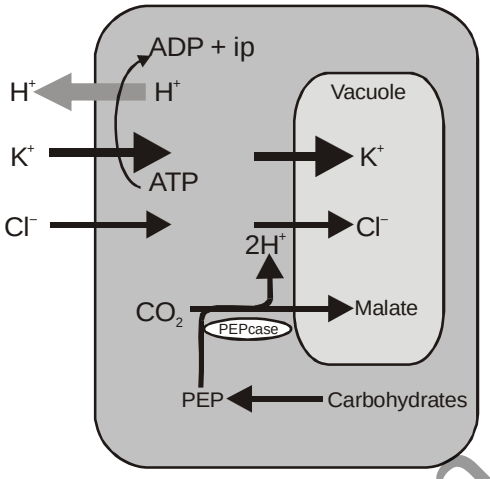


Fig.: Role of potassium, chloride and malate ions in stomatal opening. The ions accumulate in the vacuole of guard cells, lowering the water potential and thereby increasing water uptake and subsequently opening the stomata (PEPcase = Phosphoenol pyruvate carboxylase)

☛ High concentration of K^+ ions in guard cells is electrically balanced by uptake of Cl^- and malate ions in guard cells.

(4) Ca-ABA second messenger model - Given by **Desilva** & **Cowan** (1985) this is modern explanation of stomatal closing only.

☛ **Ramdas & Raghvandra** suggested that ATPs for stomatal movement comes from cyclic ETC.

☛ **Bowlings :** Malate switch hypothesis.

Raschke : K^+ ions in guard cells comes from subsidiary cells.

☛ Stomata opens during the night in succulent plants and closed during the day. This nature of stomata in opuntia is called **Scotoactive stomata.**

☛ In CAM plants organic acid is formed during night which broken down during day and CO_2 is liberated which is used in photosynthesis.

FACTORS AFFECTING RATE OF TRANSPIRATION

Factors affecting stomatal opening and closing :

[1] Light :

In most of the plants stomata open during the day except succulent xerophytic plants and close during the dark. Opening of stomata completes in the presence of blue and red light. **Blue light is most effective** and causing stomatal opening.

[2] Temperature :

Loft Field show temperature quotient of opening of stomata is **$[Q_{10}] = 2$**

[3] CO_2 concentration :

☛ Stomata opens at low concentration of CO_2 while closed at high concentration of CO_2.

[4] Growth Hormones :

☛ **Cytokinin hormone induce opening of stomata.** It increase the influx of K^+ ions and stimulate the stomata for opening.

- While **ABA** stimulate the stomata for closing. This hormone **oppose the induction effect of cytokinin.**
- ABA effects the permeability of the guard cells. It prevent the out flux of H^+ ions and increase the out flux of K^+ ions. Because of this pH of the guard cells decreased.

  Cl^- ions also plays important role in stomatal movement. Above mentioned effects also found in high amount of CO_2
- ABA is formed due to high water stress in chloroplast of leaves.

[5] Atmospheric humidity :

- Stomata opens for long duration and more widen in the presence of humid atmosphere, while stomata remains closed in dry atmosphere or partial opening at higher atm. humidity transpiration will be stop but stomata remains completly open.

Factors affecting the rate of transpiration :

Factors affecting the rate of transpiration are divided into two types :

[A] External Factors (Environmental factor)

[B] Internal Factors

[A] EXTERNAL FACTORS (Environmental factor)

[1] Atmospheric humidity : $T_r \propto \frac{1}{\text{Relative humidity}}$

- This is the most important factor. The rate of transpiration is higher in low atmospheric humidity while at higher atmospheric humidity, the atmosphere is moistened, resulting decreasing of rate of transpiration.
- Therefore, the rate of transpiration is high during the summer and low in rainy season.

[2] Temperature : $T_r \propto \text{Temperature}$

- The value of Q_{10} for transpiration is 2. It means by increasing 10ºC temperature, the rate of transpiration is approximately double. (By Loftfield)
- Water vapour holding capacity of air increased at high temperature, resulting the rate of transpiration increased.
- On contrary vapour holding capacity of air decreased at low temperature so that the rate of transpiration is decreased.

[3] Light :

- Light stimulates, transpiration by heating effect on leaf.
- **Action spectrum** of transpiration is **blue** and **red.**
- Rate of transpiration is **faster in blue light** than that of red light. Because stomata are completely opened as their full capacity in the blue light.

[4] Wind velocity : $T_r \propto \text{Wind velocity}$

- Transpiration is less in constant air but if wind velocity is high the rate of transpiration is also high, because wind removes humid air (saturated air) around the stomata.
- Transpiration increases in the beginning at high wind velocity [30-50 km./hour] But latter on it cause closure of stomata due to mechanical effect and transpiration decrease.

[5] Atmospheric pressure :

- The speed of the air increase at low atmospheric pressure, due to this rate of the diffusion increase which increase the rate of transpiration.
- The rate of transpiration is found maximum in the high intensity of light at high range of hills.

Traspiration ratio (TR) : Moles of H_2O transpired/moles of CO_2 assimilated.

- Ratio of the loss of water to the photosynthetic CO_2 fixation is called TR.
- TR is low for C_4 plants (200-350) while high of C_3 plants (500-1000). It means C_4 conserve water with efficient photosynthesis.
- CAM plants passes minimum TR(50-100)

[6] Anti transpirants :

- Chemical substances which reduce the rate of transpiration are known as **antitranspirants.** Anti transpirants are as follows-
- **Phenyl Mercuric Acetate (PMA), Aspirin, (Salicylic acid), Abscisic acid (ABA), Oxi-ethylene, Silicon oil, CO_2 and low viscous was.**
- PMA closed the stomata for more than two weeks partially.
- Antitranspirants are used in dry farming.

[B] INTERNAL FACTORS :

- These factors are concerned with structure of plants. These are following types :

[1] Transpiration area :

Pruning increase the rate of transpiration per leaf but overall reduce the transpiration.

[2] Anatomical characteristics of leaf and leaf orientation :

Several structures of leaf effect the transpiration as follows :-

Stomatal characteristics :

Transpiration is effected by the structure of stomata, position of stomata, distance between the stomata, number of stomata per unit area and activity of the stomata.

By Salisbury - Stomatal Index (SI) = $\frac{S}{E+S}$

SI = Stomatal index S = Number of stomata/unit area

E = Number of epidermal cells in same unit area.

[3] Water status of leaves

[4] Root - Shoot Ratio :

- The rate of transpiration decreases with decrease in root-shoot ratio.
- The rate of transpiration increases with increase in root-shoot ratio.

The following characteristics are found in leaf to reduce the transpiration.

(i) Leaves modify in spines.

(ii) Leaves transformed into needle e.g. **Pinus**

(iii) Folding and unfolding of leaves by bulliform cells. eg., **Amophilla, Pea etc.**

(iv) Small size of the leaves.

(v) Presence of thick waxy layer on leaves. eg., **Banyan tree.**

:: SPECIAL POINTS ::

- Transpiration in old stems and fruits occurs through **lenticels**.
- The loss of water through transpiration in increasing unit dry weight of the plant is called **transpiration ratio**.
- The quantity of water transpired by unit area of leaf surface in unit time is called **transpiration flux**.
- The **diurnal periodicity** was diagrammatically represented by **Von mohl**.
- Fresh weight of a plant would be maximum in the morning and minimum in the afternoon.
- The main reason of osmotic pressure for stomata is **potassium chloride or potassium malate.**
- **Porometer** is used to find out the area of stomata on the leaf.
- Transpiration measuring instrument is called **Potometer**. The rate of absorptioon of water is measured through this instrument. In potometer **rate of water absorption is proportional to the rate of transpiration.**
- **Cobalt-chloride test :** This method is used for the comparision of transpiration at both the surface of the leaves. It is first of all shown by **Stall.**
- Stomata covers 1-2% of total leaf area. Size of stomata is 10-40μ (Length) × 3 – 12μ (width)
- The photophosphorylation process in the guard cells is a energy metabolic process, not CO_2-metaboic process.
- The rate of transpiration of C_4 plants is less as compared to C_3 plants. In CAM plants minimum transpiration occurs.
- **Distribution of stomata on leaf surface :**

Plant Type	**Stomata No./mm^2**	
Dicots	**Upper epidermis**	**Lower Epidermis**
Sunflower	120	175
Alfa-Alfa	169	188
Geranium	29	179
Monocots		
Wheat	50	40
Barley	70	85
Onion	175	175

- **Auxins** which increases metabolic activities of the cells **stimulate absorption of water**.
- **Wilting Coefficient :** The amount of water expressed as percentage of dry weight of soil, which is left in soil at the time of permanent wilting is called **wilting co-efficient.**
- Value of **Tensile strength** of xylem sap is upto **300 atm.**
- The maximum value of transpiration pull has been found to be **20 atm. 1 atm** force can raise water upto **10 m** height. Thus ascent of sap can occur upto **200 meters** height by transpiration pull.
- Besides the translocation of water upwards, water is also translocated radially and downwards. **Radial translocation** is more common.
- **Cytokinin enhances opening** of stomata while **ABA induce closing** of stomata.
- In moist environment, stomata open more widely and for longer time & opposite is the case in dry environment.
- The OP of guard cells when stomata open is 30-40 atm.
- During wilting rate of photosynthesis also decreases.
- The no. of stomata per unit area of leaf is called **stomatal frequency**. It depends on position of leaf, external envirommment ect. In a leaf, it increases from base to tip and from midrib to lateral sides.