Water flow in plant tissue

Business

Water Potential ? is the difference in intramolecular pressure exerted in a given specimen with reference to the intermolecular pressure exerted between molecules of pure free water at atmospheric pressure and the same temperature. The plant cell vacuole may be considered as a homogenous phase, separated by the tonoplast, cytoplasm and plasma membrane from the surrounding fluid. These may be considered as a single complex membrane, which is permeable only to water, that s for the purposes of this experiment. The cellulose wall which surrounds the cell is regarded as being completely permeable but of considerable strength and elasticity. Any pressure exerted by the cytoplasm on the vacuole is ignored in this experiment but is about 200 Kpa.

The main pressure is exerted by the wall. In solutions of high water potential or in pure water the vacuole takes in water and expands. As a result the cytoplasm is pressed against the cell wall until the wall prevents any further expansion. Plasmolysed cellA plant cell can therefore come into equilibrium with pure water. At this point the cell has the same waster potential, as pure water i.

e. 0Kpa. There is another component of the water potential. The organelles and colloids dissolved in the cytoplasm create their own potential known as the matric. We ignore this item also in this investigation.

Water in plants is subject to suction or tension, negative pressure and tensile stresses which reduce ? p below zero making ? p a suction, negative in sign. As a numerical value ? p of liquid water under vacuum is -1. 013 bar. Solute Potential. Foreign molecules dissolved in water attract some water

molecules, thus always increasing the attraction between the remaining water molecules. Water potentials so modified are always negative in sign ? s.

Insoluble molecules would repel water molecules hence ? s would be positive. The only exception to this rule is small hydrocarbons, which are hydrophobic. Their presence causes water to ‘ freeze’ at a temperature of 70 Celsius-forming clathrates. This effect can incidentally be used to purify water commercially and may explain why some crops such as maize are sensitive to frost damage at temperatures above zero Celsius. Thus ? s is practically always negative.

A gravitational component ? g is taken into account in advanced theory, here it will be incorporated into ? p . We may write:? = ? s + ? pCellular flow. Water flow through cells is inefficient when compared to vascular transport. i. e. through xylem and phloem in requiring much greater pressure gradients to drive a comparable flow.

Cellular pathways which transport water in quantity, for example leaves, are seldom longer than 5 cells. If ? of the pathway cells is measured, results usually indicate flow is osmotic from the higher to the lower ? values. ? p also plays a role, the gradient depends upon the ? s + ? p interaction. For example in the contrived situation shown below water continues to flow even from cell 2 to cell3 where ? rises and from cell 3 to cell 4 It is the overall value of ? turgor continually rising in a negative sense, hence falling in value.? = 0? s = -10? s = -6? s = -9? s = -10Pure water? p = 9? p = 4? p = 6? p = 6? = -1? = -2? = -3? = -4The aim of this experiment is to ascertain

the water potential inside potato cells in a variety of osmotica. This is simply provided by immersing samples of potato in graded solutions containing sucrose.

Measurement of a mass or a volume before and after immersion will give a measure of the water flow that has occurred and the direction in which this has taken place. Method and Plan. Apparatus. Boiling tubes, corks, beakers, glass rod balance. Graduated flask.

Materials. Samples of Fresh Potato, distilled water. 1. A standard solution of sucrose is prepared using the formulae weight of sucrose as C11H22O11. 2. Dilutions are obtained so as to obtain a range of concentrations shown in the table below.

3. Sample of potato are freshly cut into rectangular pieces and measured for length, breath and width . As a working guide the aim was to use a length of five centimetres and a cross section of 1. 4cm in other words a regular chip. A micrometer screw gauge was thought to be inappropriate here in view of the overall accuracy required in the experiment, a normal ruler was used measurements to the nearest 1mm.

While working on other aspects of the experiment freshly cut chips are stored in distilled water to prevent aerial oxidation. 4. Two sample chips are placed in a constant volume of sucrose solution (10ml). 5. Thus two replicates are used for each sucrose concentration. 6.

The samples are stored for 24 hours. The potato discs are removed dried between sheets of filter paper lightly and re-measured for their linear

dimension. 7. A table of results will be drawn up to m record volumes before and after the experiment. 8.

A graph will be plotted of percentage change in volume versus sucrose concentration. Results. A line graph (1) showed the general trend of the results. For low concentrated solutions of sucrose water through the process of osmosis enters the cells because there is a higher concentration of water outside the cell than inside. There comes a point where the concentration of solutes inside the cells exactly balances those of the bathing solution and no net flow occurs.

Presumably a dynamic equilibrium is set up here where movement on one direction is exactly counterbalanced by movement in the other. This is known as the point of incipient plasmolysis. A diagram showing this situation is presented. Where the line graph cuts the x-axis is the experimental determination of this point. From values of the solute potential of sucrose obtained from the literature, (graph 2), this value of the sucrose concentration can be used to read off the water potential of the cells at this point. By definition ? p is zero here and the water potential of the cells is thus recorded as the solute potential.

Evaluation. In procedures described elsewhere a cork borer is used to obtain standardised discs. Here an attempt was made to standardise by using accurate cutting but to compensate for the inevitable inaccuracies a volume method was chosen rather than a mass method. The volumes were sufficiently discriminated at each molarity to give a significant difference in the before and after measurements. Whatever the method of cutting some

disturbance to outer membrane and walls of surface cells is inevitable and these edge effects will affect the ability of the system as a whole to take up or release water as some membrane surfaces are inevitably damaged.

Also in procedures described elsewhere only one hour is allowed for equilibration time. Here one day was allowed for equilibration. Only two replications were performed per run which is non -ideal but dictated in terms of time and apparatus available. Whilst in a more detailed investigation attention would be paid to both standardisation and to the number of replicate experiments it is felt that the purpose of the experiment was more to demonstrate the effects of osmosis and less to furnish an accurate value for the solute potential of water in potato cells. If more accuracy were required then a more detailed search around the isotonic molarity would be the next logical step by performing more runs either side of the suggested isotonic point of 0. 15M sucrose.

There is also a systematic error in the investigation. The potato cells are in fact permeable to solutes. We actually measure ? apparent = ? x ? s ? is known as a reflection coefficient. If it has the value 1 then the membrane is said to reflect ions or molecules in other words they cannot pass through the membrane. If ? = 0 then the solute molecules can pass easilyThere is much biological significance in water potentials.

For example they govern the passage of water though the whole plant. Although the main driving force is often the transpiration rate driven by the sun. Seed germination may be slowed or prevented for example by a water

deficit.. The seed surface contact is a significant factor. The seed coat is likely to be permeable to most common osmotica.

Natural soil osmotica such as sodium chloride show some relationship with the nature of the habitat. Halophytes for example will germinate in relatively high sodium chloride concentrations that are inhibiting to glycophytes for example. Some desert plants are sensitive to rain. The Californian Filago californica will not germinate in moist cells, but any rainfall up to 20cm increases germination. Mass flow of solutes to the root surface may be controlled especially if elements not supplied by diffusion. For example Hoth and Norrish found the silicon content of Triticum vulgare (lemmas and glumes) to be strongly correlated with the total transported during growth.