

AP[®] BIOLOGY
2006 SCORING GUIDELINES (Form B)

Question 3

While studying transpiration, a scientist used a dendrometer to record the small daily changes in the diameter of a tree trunk at two different heights (2 meters and 3 meters) above the ground at the same time. The diameter decreased in the daytime. This decrease happened first at the higher location. Discuss the following in relation to water movement in plants.

- (a) Identify how **two** different environmental factors could be involved in the daily fluctuations shown above. (**4 points maximum**; 2 points for each factor correctly associated with a mechanism)

Factor	How
Humidity	Humidity down → Transpiration up → Decreases diameter Humidity up → Transpiration down → Increases diameter
Sunlight	Sunlight up → Transpiration up (stoma open) → Decreases diameter Sunlight down → Transpiration down (stoma close) → Increases diameter
Temperature	Temperature up → Transpiration up → Decreases diameter Temperature down → Transpiration down → Increases diameter
Wind	Wind up → Transpiration up → Decreases diameter Wind down → Transpiration down → Increases diameter
Ground water	Transpiration removes water faster than roots pick it up → Decreases diameter

- (b) Discuss the mechanisms involved in the uptake and transport of water by vascular plants.
(4 points maximum)

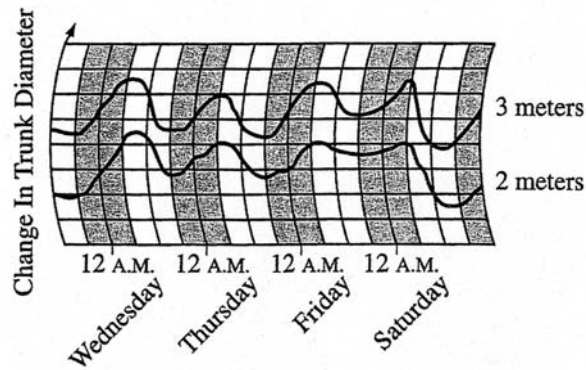
Uptake (2 points maximum) <ul style="list-style-type: none"> • Root hairs or mycorrhizae increase surface area • Osmotic adjustment in roots, water flows in due to gradient • Aquaporin moves water in • Water potential moves water in 	Transport (2 points maximum) <ul style="list-style-type: none"> • Transpiration pull when water exits leaves • Creates negative pressure (tension) • Cohesion of water in xylem/column of water • Adhesion of water in xylem/column of water
--	--

AP[®] BIOLOGY
2006 SCORING GUIDELINES (Form B)

Question 3 (continued)

(c) Discuss the role of water in the normal functioning of plants (**4 points maximum**; 2 points for each role correctly associated with a function, 1 point for function alone)

Role (2 points maximum)	Function (2 points maximum)
<ul style="list-style-type: none">• Photosynthesis (photolysis)• Transport• Structure• Solvent• Reproduction• Change in guard cells• Growth	<ul style="list-style-type: none">• e⁻ in electron transport, H⁺ in ATP synthesis• movement of nutrients and ions• Turgor (vacuole)/support• Media of chemical reactions• Mosses/ferns fertilization by sperm• Water intake increases turgor → guard cells open• Needed for cell elongation



3A,

3. While studying transpiration, a scientist used a dendrometer to record the small daily changes in the diameter of a tree trunk at two different heights (2 meters and 3 meters) above the ground at the same time. The diameter decreased in the daytime. This decrease happened first at the higher location. Discuss the following in relation to water movement in plants.

- Identify how two different environmental factors could be involved in the daily fluctuations shown above.
- Discuss the mechanisms involved in the uptake and transport of water by vascular plants.
- Discuss the role of water in the normal functioning of plants.

The daily fluctuations shown by the dendrometer show that the diameter of the tree trunk decreased during the day which means that there was water loss in the tree due to transpiration. During the day temperature changes and sunlight intensity are the major factors that cause the fluctuation.

i) Temperature rises during the day due to heat from the sun. Under ideal conditions, this means that volume of air and temperature are directly proportional. This means that since temperature rises, the volume of air around the tree increases and since the mass of air remains constant, its density decreases. When air is less dense, it has a capacity to take up vapourised water faster than when it is dense. This means that water vapour on the leaves of the tree are absorbed by the air increasing the transpiration pull thus pulling more water up the tree trunk and hence the decrease in diameter.

ii) Sunlight is another factor which affects ~~transpiration~~

↓
evaporation increases

GO ON TO THE NEXT PAGE.

explains the fluctuations. During the day, when light intensity increases, & the rate of photosynthesis of a tree increases, this means that the plant ~~takes~~ needs to take up more CO₂ from the air outside and needs to give out O₂ to the atmosphere. To do so, the stomata open & in the leaves. Water in the leaf cells and xylem vessels diffuse by osmosis into the leaf air spaces and finally into the atmosphere. Thus more water evaporates and ~~is~~ the transpiration pull of water increases thus dragging more water from the trunk, ~~and~~ hence the decrease in diameter. Also photosynthesising cells use H₂O as a substrate thus the amount of H₂O in the cells of a leaf decrease owing to the transpiration pull. This also accounts for the fact that the tree trunks at higher levels decrease in diameter first because leaves at higher areas receive more sunlight, photosynthesise more and ~~and~~ water transpire more.

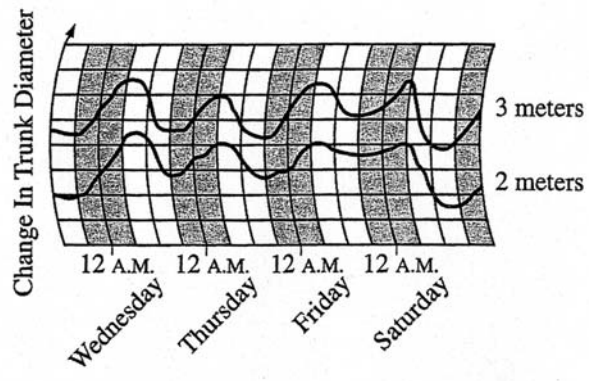
b) Vascular plants uptake water from the soil by osmosis. ~~This is done by~~ At first root hair cells in the soil take up ~~is~~ water from the soil by active transport thus lowering the water potential of their cytoplasm. This causes water from the soil to diffuse into these cells by osmosis since the soil is hypotonic to the root hair cell cytoplasm. Next water moves through root cells ~~and~~ by osmosis until it reaches the xylem vessels. Since water is always pulled up the xylem vessels, the water potential of the xylem vessels is low at the roots and water diffuses into the xylem by osmosis. Water travel up

GO ON TO THE NEXT PAGE.

xylem due to two forces, transpiration pull and root pressure. Thus water travels up the xylem from areas of higher water potential to lower water potential. Leaves high up in the xylem use a lot of water hence, have low water potential.

c) Water has a major role ~~to~~ during the functioning of a plant. This is because plants make carbon ~~and~~ compounds for food by photosynthesis and ~~also~~ water is a reactant in photosynthesis since it acts as an electron donor for photosystem II in the light reactions of photosynthesis. Also, water acts as a support for a plant. Water in cells and in the xylem maintain a high turgor pressure ~~to~~ in these areas, high turgor pressure means that the cells are more solid and the ~~plant~~ plant as a whole is more rigid. Water is also a reactant ^{or product} and in many polymerization reactions and hydrolysis reactions.

GO ON TO THE NEXT PAGE.



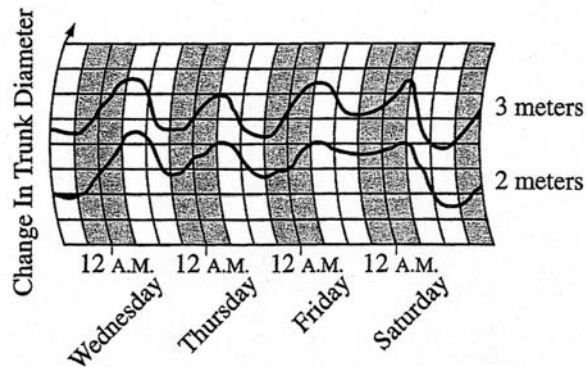
3. While studying transpiration, a scientist used a dendrometer to record the small daily changes in the diameter of a tree trunk at two different heights (2 meters and 3 meters) above the ground at the same time. The diameter decreased in the daytime. This decrease happened first at the higher location. Discuss the following in relation to water movement in plants.
- (a) Identify how **two** different environmental factors could be involved in the daily fluctuations shown above.
 - (b) Discuss the mechanisms involved in the uptake and transport of water by vascular plants.
 - (c) Discuss the role of water in the normal functioning of plants.

a) Temperature and relative humidity are factors which are involved in the fluctuation of tree trunk diameters. Transpiration is the evaporation of water from the leaves of the plant. As temperature increases, there is a better chance for transpiration to occur because a hotter temperature will make the water evaporate faster and thus cool down the plant. The relative humidity also affects the evaporating rate, because the more water molecules are in the air, the harder it is for a liquid drop of water to evaporate into water vapor. The high heat capacity of water is the reason why high temperatures are more useful in evaporating water.

GO ON TO THE NEXT PAGE.

b) First, the root hairs, of roots in the tree, increased surface area so that water can diffuse into roots by osmosis. As solutes/ions such as Mg^{2+} or N^{+} is transported into the root, this lowers the water potential of the root. Thus, water flows in from a place of high WP (soil) to low WP (roots). Then, vascular system transports the water up the stem and into leaves with the help of xylem (dead cells) and phloem cells (living). Water transport is a part of the TACT theory (adhesion, cohesion, tension). Water takes the apoplastic path (least resistance) around the xylem cells which have Casparian bands around them ~~to~~ & H_2O wouldn't flow back. Adhesion is the force which makes ~~the~~ water stick to other objects by H-bonds. The water from the root moves up by adhering to the cell walls of the plant cell. Then, cohesion, which is the force which makes water molecules stick to water molecules pull other water molecules along in the stem. Tension is the pressure of the water on the stem molecules which also moves water along. All of the transport of water is done by diffusion (thus, doesn't require energy).

GO ON TO THE NEXT PAGE.



3C,

3. While studying transpiration, a scientist used a dendrometer to record the small daily changes in the diameter of a tree trunk at two different heights (2 meters and 3 meters) above the ground at the same time. The diameter decreased in the daytime. This decrease happened first at the higher location. Discuss the following in relation to water movement in plants.
- Identify how **two** different environmental factors could be involved in the daily fluctuations shown above.
 - Discuss the mechanisms involved in the uptake and transport of water by vascular plants.
 - Discuss the role of water in the normal functioning of plants.

The temperature could cause the trunk to decrease or increase in diameter. The daytime usually ~~the~~ being when the sun is exposed and would decrease to keep moisture in. Most animals are active during the day and the decrease in size would make the tree more secure and compact from foreign outsiders such as insects, human and animals.

The ~~fab~~ roots of a plant or tree have little hairs at the outer part of them and at the end of the roots also. As the water is being absorbed, the water is circulated.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

throughout the plant. This making it a vascular plants. To get water regulated throughout the plant, a pump-like mechanism helps it do so.

Plants do need water, not only to ~~st~~ prevent wilting but to help transport nutrients. Water helps gather nutrients in the soil and helps assist in the transportation of nutrients throughout the plant. Then water also aids in the process of photosynthesis.

GO ON TO THE NEXT PAGE.

AP[®] BIOLOGY
2006 SCORING COMMENTARY (Form B)

Question 3

Sample: 3A

Score: 10

In part (a) the response earned the maximum of 4 points. It correctly identifies two environmental factors (temperature and sunlight) and describes how each affects the trunk diameter. In part (b) the response earned a point for the uptake of water being due to osmosis, a point for the active uptake of minerals lowering the water potential in the root, and a point for explaining the role of transpirational pull. In part (c) the response earned 1 point each for the role of water as a reactant in photosynthesis, its donation of electrons to the light reaction, and its role in maintaining turgor.

Sample: 3B

Score: 8

In part (a) the response earned the maximum of 4 points. It correctly identifies two environmental factors (temperature and humidity) and describes how each affects transpiration. In part (b) the response earned a point for root hairs increasing surface area, and a point for the uptake of water being due to osmosis. The response earned a point each for the roles of adhesion and cohesion in the transport of water. An additional point for tension would have been earned if the maximum for part (b) had not already been reached. Part (c) is not addressed.

Sample: 3C

Score: 4

In part (a) the response correctly identifies an environmental factor (temperature), which earned 1 point. The effect of temperature on transpiration, and hence stem diameter, is not discussed. No points were earned in part (b). Three role-of-water points were earned in part (c)—for photosynthesis, nutrient transport, and support or prevention of wilting.