AP® BIOLOGY
2006 SCORING GUIDELINES

Question 3

The movement of water through vascular plants is important to their survival.

(a) **Explain** the mechanism of water movement through vascular plants during transpiration. Include a discussion of how the anatomy of vascular plants and the properties of water contribute to this process. **(7 points maximum)**

***** Each dash = 1 point

Mechanism (in correct context)	**Anatomy** (related to how anatomy contributes to transpiration)	**Water Properties** (related to how property contributes to transpiration)
• Movement of water - water evaporates or leaves the plant - transpiration pull **OR** cohesion-adhesion tension theory - continuous column of water - capillarity - root pressure - ψ (water potential differences) - osmosis/diffusion/tonicity • Energy driving transpiration - environmentally powered (sun, wind, humidity) - passive on part of plant	- Stomata/guard cells - Spongy mesophyll - Xylem, tubes, tracheids, vessel elements - Any specific root structure (root hairs, Casparian strip)	- Polarity/hydrogen bonding - Cohesion - Adhesion/capillarity - High heat of vaporization (H_2O vapor exiting leaf)

* Each dash = 1 point

(b) **Explain** how gas exchange affects transpiration. **(2 points maximum)**

- Stomata
  - Open stomata → increased transpiration

    OR
  - Closed stomata → decreased transpiration
- Gas identification
  - CO_2 in and O_2 and/or H_2O out of the plant (gas exchange must be in correct direction)
- Consequence of gas exchange
  - tradeoff of more gas exchange (for more photosynthesis) resulting in more transpiration (and possible dehydration, wilting, flaccidity)
- Environmental factors such as:
  - humidity
  - air movement
  - evaporative cooling
  - wind stress
  - intense light/heat (factor must be tied to effect on transpiration)

Question 3 (continued)

* Each dash = 1 point

(c) **Describe** TWO adaptations that affect the rate of transpiration in desert plants.
(2 points maximum)

- Reduced surface area
  - small leaves
  - loss of leaves/other parts
- Leaf modifications
  - thick cuticle (not just "waxy")
  - thicker epidermis
  - reflective surfaces
  - epidermal hairs "trap" water vapor
  - leaf wilting/curling
  - leaf orientation
- Stem modifications
  - thick cuticle (not just "waxy")
  - thicker epidermis
  - have stomata
- Stomata
  - concentrated on lower/shady surface
  - in pits, furrows, depressions
  - fewer stomata
- Metabolism
  - stomata open at night (CAM plants)
  - stomata closed when arid/not open as long (C_4 plants) (no points for photorespiration)
  - hydraulic lift
- Water storage/uptake
  - in fleshy stems
  - roots (large, shallow system for maximum water capture; deep taproots, etc.)
- Dormancy

3A,

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3)A) Water moves through vascular plants by adhesion, cohesion, and tension. When water evaporates from the stomata of a leaf, there is a negative water potential ∴ where the H_2O was. This causes more water to come fill the space because of osmosis. The water moves in bulk flow. The hydrogen bonds of water cause cohesion. Cohesion is a molecules being attracted to the same kind of molecules. This causes water to stay together. Adhesion is when water sticks to the surface of other substances. Transpiration is when water is pulled up through the plant against gravity. It is caused by ~~cellular~~ solar energy, the sun. ~~Vas~~ Vascular plants use dead vessels and tracheias to move water. ∴ Water has strong ~~hydrog~~ hydrogen bonds.

3)B) ~~The~~ When ~~th~~ a plant is performing photosynthesis, the stomata need to be open to allow CO_2 to enter and O_2 to exit. Since the water potential of the air is lower than that of the inside of the leaf, water evaporates from the leaf, ~~cause~~ causing transpiration.

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3A2

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

3)C) Most desert plants are ~~CA~~ CAM plants. They open their ~~st~~ stomata at night to get CO_2. They then store ~~it~~ it as maltic acid in their vacuole. During the day their stomata ~~open~~ close. They ~~use~~ change maltic acid back into CO_2 and do the Calvin cycle. This prevents water loss from open stomata during the day. It ~~also~~ also prevents photorespiration which takes O_2 and makes CO_2, and ~~it~~ is costly for a plant. Desert plants also have spines instead of leaves. These have less surface area so less evaporation occurs. ~~Their~~ They don't waste as much water

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3B1

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(b) **Explain** how gas exchange affects transpiration.

(c) **Describe** TWO adaptations that affect the rate of transpiration in desert plants.

(a) The roots of a plant absorb water from the soil and the xylem carries the water up all the way to the leaves. Water is both cohesive and adhesive meaning it bonds to itself with hydrogen bonds between the molecules. And being adhesive, water molecules are attracted to other things, and vascular plants, like a straw, allows water to travel up the stem to the leaves.

(b) Vascular plants give off oxygen while taking in CO_2. Using hydrolysis - the split of compounds with water, the carbon and oxygen are split apart. The O_2 is given off as a waste product, and the carbon is used in the transpiration process.

(c) Desert plants don't see very much rain but a lot of hot scorching sun. Therefore they had to adapt to their environment in order to survive. The stomata of desert plants open up at night rather than the day. This allows them to be saved from being exposed to the harsh sun. They are light independent so they can photosynthesize under more favorable conditions. Also, the desert plants have a very thick cuticle - waxy, water proof layer on leaves. This keeps the moisture inside the plant rather than being

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3B2

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

evaporated out. This keeps plants hydrated even when going for months without water. These two adaptations slow the rate of transpiration so that the plant can survive longer.

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3C

3. The movement of water through vascular plants is important to their survival.

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(b) **Explain** how gas exchange affects transpiration.

(c) **Describe** TWO adaptations that affect the rate of transpiration in desert plants.

a) Water enters the plant through the roots then it is ~~taken~~ carried up through (tracheids + vessel elements) the plant through the xylem. Water is able to move up the plant due to the cohesive ability of H. The hydrogen bonding of water mlcs allows water to be transported through the plant. If there is too much water the guard cells fill and the stomata opens and H_2O is released.

b) Gas exchange through the stomata releases water. If the stomata are opened for too long too much water may be released.

c) Stomata allows the regulation of water loss through transpiration.
C_4 plants allow survival in very hot desert climate where water loss is an issue.
C_4 plants have specialized openning that allow CO_2 to be used without significant water loss.

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AP® BIOLOGY
2006 SCORING COMMENTARY

Question 3

Overview

The survival of plant species is dependent upon their ability to obtain and transport water. In part (a) students needed to describe the mechanism of water movement during transpiration in vascular plants. Some explanation of the anatomy of the structures involved and the properties of water that facilitate the movement of water was also expected. In part (b) students were asked to explain how gas exchange affects transpiration. Students earned points for their understanding of the specific gases exchanged at the stomata, if the direction of the exchanges were correct. Students earned points for understanding the effects of specific environmental conditions on the rate of transpiration, as well as the negative consequence of gas exchange with respect to water loss during transpiration. In part (c) students were expected to describe structural or functional adaptations that affect transpiration in a desert environment.

Sample: 3A
Score: 10

The response earned the maximum of 7 points in part (a): a point for an explanation of the mechanism of transpiration, and a point each for the discussion of stomata and tracheids and their role in the process. The student correctly discusses the cohesion and adhesion properties of water as they contribute to transpiration, earning a point for each. The response earned a point for the concept of transpirational pull, and a point for the energy mechanism of the process (solar). In part (b) a point was earned for correctly identifying the gases exchanged, in the proper direction, when stomata open during photosynthesis. It should be noted that the correct discussion of water potential was not awarded a point here because the response had already earned the maximum number of points allowed in part (a). In part (c) a point was earned for correctly describing stomata opening at night in CAM plants, and another point for the leaf modification of reduced surface area in desert plants.

Sample: 3B
Score: 6

In part (a) the response earned a point for correctly describing the role of the xylem, and a point each for giving the water properties of cohesion and adhesion as related to transpiration. In part (b) a point was awarded for correctly identifying the gases exchanged as related to transpiration. In part (c) the response earned a point each for describing two plant adaptations, stomates closed at night, and a thick cuticle.

Sample: 3C
Score: 4

In part (a) the response earned 2 points for correctly describing two anatomical structures involved in transpiration: xylem, and stomata. The response also earned a mechanism point for defining transpiration. In part (b) the student correctly explains how open stomata increase transpiration, earning a point. No points were earned in part (c).