DO NOW

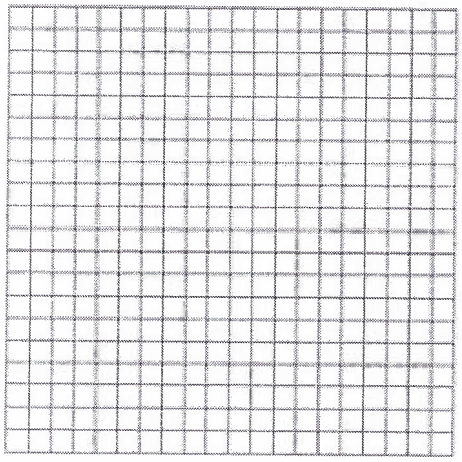
Question 1a and 1b

Plants lose water from their aboveground surfaces in the process of transpiration. Most of this water is lost from stomata, microscopic openings in the leaves. Excess water loss can have a negative effect on the growth, development, and reproduction of a plant. Severe water loss can be fatal. Environmental factors have a major impact on the rate of plant transpiration.

Transpiration Rate Versus Temperature

Temperature (°C)	20	23	27	28
Transpiration Rate (mmol/m².sec)	1.5	3	5	4.5

(a) Using the data above and the axes provided, **draw** a graph showing the effect of temperature change on the rate of transpiration. **Explain** the shape of the curve from 23 degrees to 28 degrees.



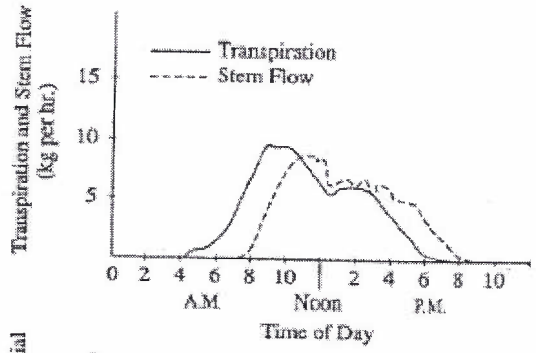
Explanation of Curve Shape of Temperature Change

(b) Using your knowledge of scientific concepts, justify why temperature affects the rate of transpiration as shown on the graph.

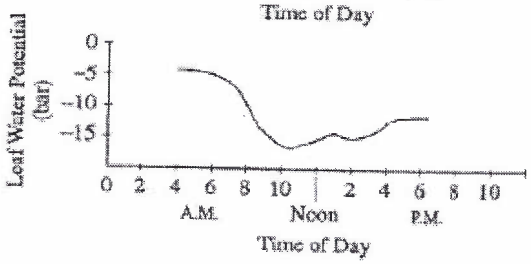
Question 2a and 2b

The rate of transpiration, the flow of water through the stem, and leaf water potential are measured in a tree during a 24-hour period under normal environmental conditions. The results from these measurements are shown in the graphs below.

Graph I



Graph II



2a. Based on Graphs I and II above, which of the following is the best conclusion that can be reached?

a. Decreases in leaf water potential are caused by increased transpiration.
b. The increased rate of transpiration increased leaf water potential.
c. The flow of water through the stem has no effect on leaf water potential.
d. Leaf stomata are closed at 10 AM.
e. Water is most likely to flow into the leaf at 4 AM.

2b. Which of the following can be deduced from Graph I?

a. The rate of transpiration is constant throughout this 24-hour period.
b. There is no correlation between the rate of transpiration and the flow of water through the stem.
c. The maximal flow of water through the stem lags behind the maximal rate of transpiration.
d. The rate of transpiration never reaches zero
e. At noon, the rate of transpiration exceeds the rate of water flow through a stem.

Name _____ Period _____ Date _____

BUOI 1: Plants and Biogeochemical Unit Unpacked

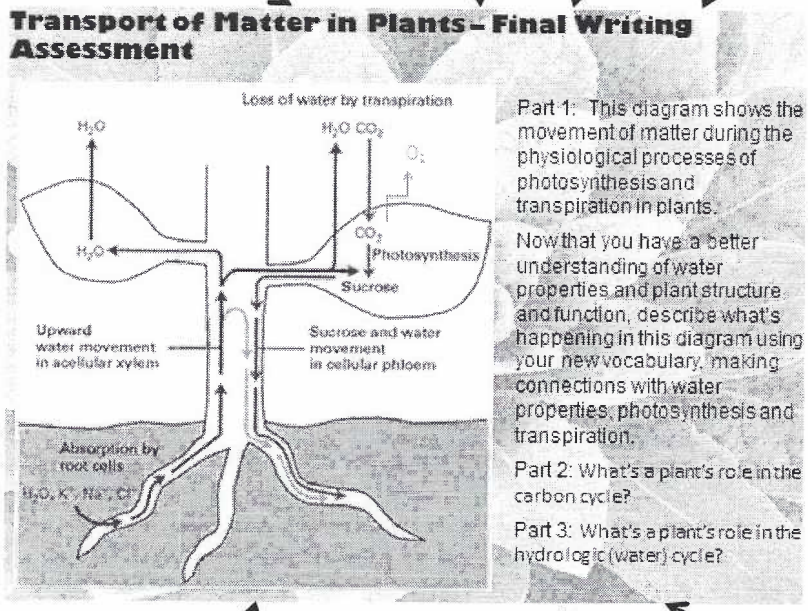
On a scale of 1-5 rate your level of understanding for each statement.

Plants undergo the chemical reaction photosynthesis to produce their own food.

Transpiration is an important player in the hydrologic (water) cycle, which returns water from the soil to the atmosphere.

Photosynthesis relies on carbon dioxide and water as reactants, therefore photosynthesis is a player in both the carbon and water cycle.

Transpiration is impacted by both environmental factors and the plant's anatomical features.



Students should understand the structure and function of plant organs, including: roots, stems, and leaves.

Students should understand the structure and function of plant tissues including: dermal, ground, and vascular. Students should be able to cite examples of each tissue type in the roots, stems, and leaves.

Students should relate plant structure and function to transpiration and photosynthesis, and hence the hydrologic and carbon cycles.

Water processes (osmosis, transpiration) and properties (solvent, surface, tension, cohesion, adhesion) contribute to movement of water through a plant.

Just in Time Teaching

Factors That Affect The Rate of Photosynthesis

The three main factors affecting the rate of photosynthesis are:

1. **Light**
2. **Temperature**
3. **Carbon dioxide**

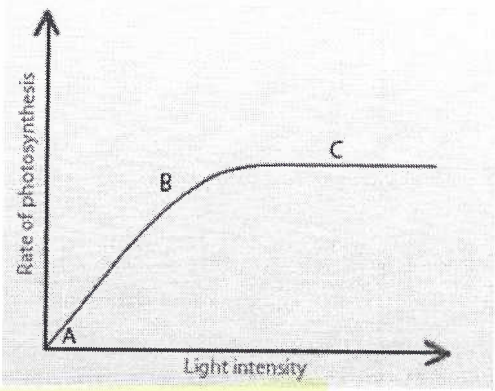
These three factors are called **LIMITING FACTORS**.

In a process like photosynthesis, which is affected by more than one factor, its rate is limited by the factor that is closest to its minimum value. So at any point in time if one of the three factors are in low supply, this factor will be the **limiting factor**. Only a change to the limiting factor will increase or decrease the rate of photosynthesis. Changing the other two will have no effect.

1. Light

The rate of photosynthesis increases when light gets brighter.

The rate of photosynthesis increases linearly with increasing light intensity (from point A to B on the graph).



Gradually the rate falls of and at a certain light intensity the rate of photosynthesis stay constant (from point B to C on the graph). Here a rise in light intensity has no effect on the rate of photosynthesis as the other factors such as temperature and carbon dioxide become limiting. Many plants spread out their leaves in such a way that each leaf maximizes the amount of light falling on them and the lower leaves are not shaded by the ones above. Too much light at a high intensity can damage chloroplasts. Some woodland plants photosynthesize more efficiently in dim light and are so called shade plants.

This text is adapted from
http://www.passmyexams.co.uk/GCSE/biology/factors-affecting-rate-of-photosynthesis.html

2. Temperature

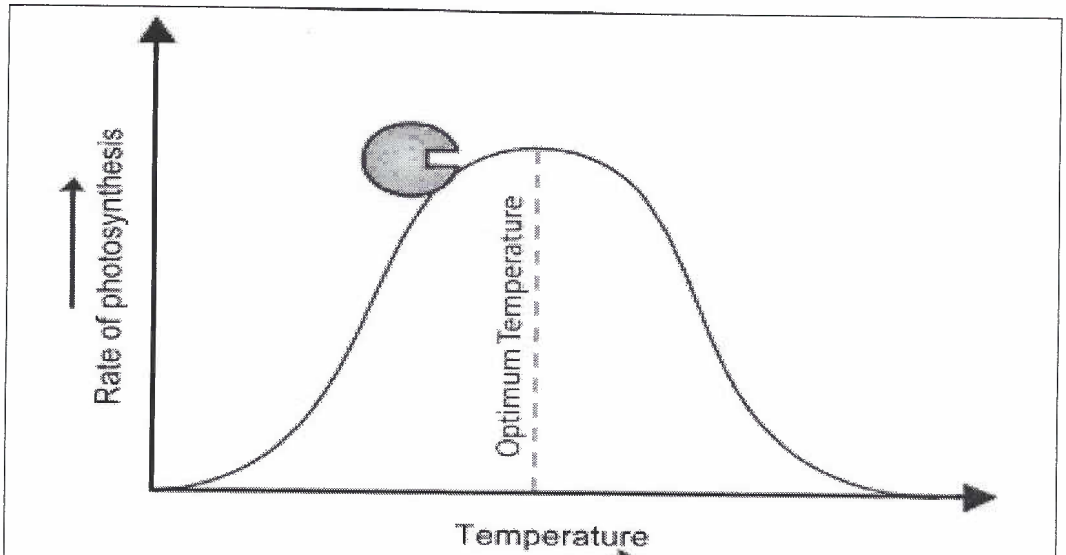
The higher the temperature, then typically the greater the rate of photosynthesis. Photosynthesis is a chemical reaction and the rate of most chemical reactions increases with temperature. However, for photosynthesis at temperatures above 40°C, the rate slows down. This is because the enzymes involved in the chemical reactions of photosynthesis are temperature-sensitive and destroyed at higher temperatures. Recall, enzymes are proteins produced by living things that act to catalyze (lower the activation energy, and hence speed up) chemical reactions, which includes photosynthesis.

To better understand the effects of temperature on photosynthesis, it is important to know the effect of temperature on the enzymes involved in photosynthesis. Enzymes are affected a great deal by temperature. If the temperature is too cold the enzymes move around too slowly to meet the substrate and for a reaction to occur. As the temperature increases though, so does the rate of reaction. This is because heat energy causes more collisions between the enzyme and the substrate. However, all enzymes are proteins and at too high temperatures the proteins break down. The active site of the enzyme becomes distorted and so the substrate no longer fits and hence the reaction does not occur. We say that the enzyme has been **denatured**.

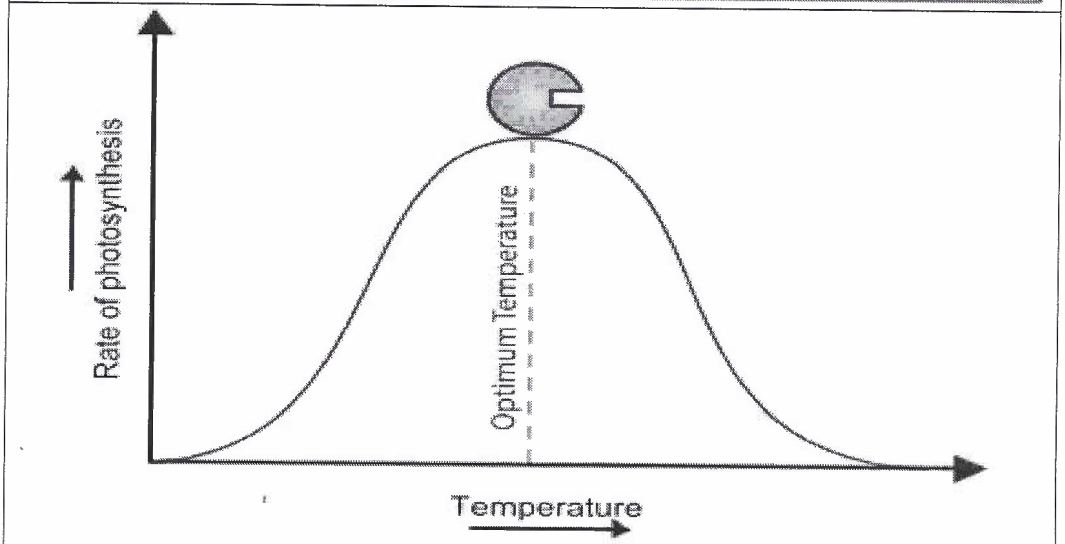
* Add video *

- watch video

This text is adapted from
http://www.passmyexams.co.uk/GCSE/biology/factors-affecting-rate-of-photosynthesis.html

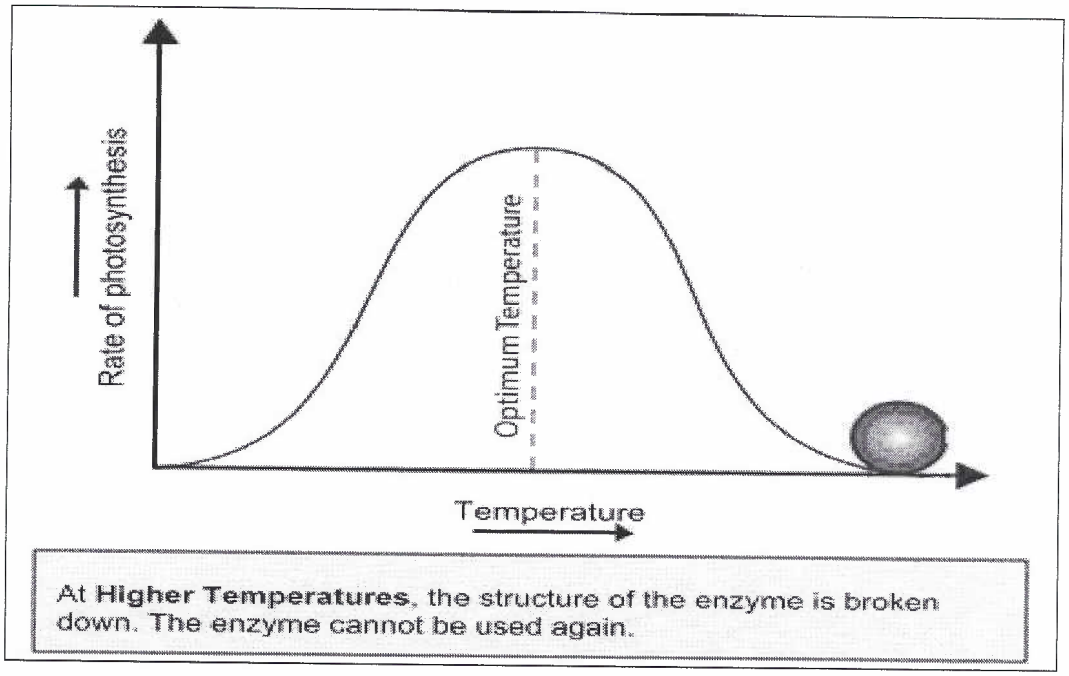


At **Low Temperatures**, the enzymes does not have enough energy to meet many substrate molecules, so the reaction is slowed.



At the **Optimum Temperature**, the enzyme is most efficient.

This text is adapted from
http://www.passmyexams.co.uk/GCSE/biology/factors-affecting-rate-of-photosynthesis.html

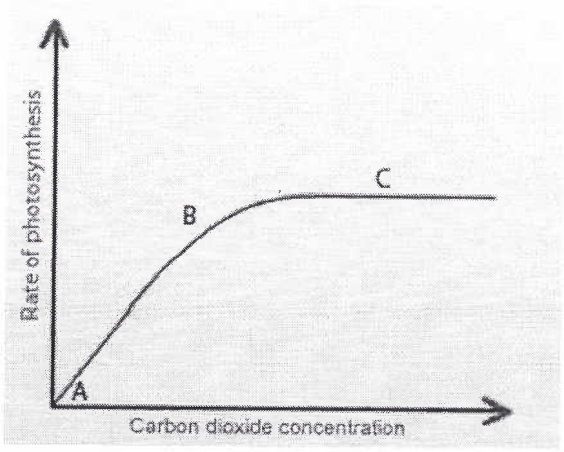


3. Carbon Dioxide

Carbon dioxide is used to make sugar in the photosynthesis reaction. The concentration of carbon dioxide in the Earth's atmosphere varies between 0.03% and 0.04%. An increase in the concentration of carbon dioxide gives an increase in the rate of photosynthesis. It is difficult to do this out in the open air but is possible in a greenhouse.

The rate of photosynthesis increases linearly with increasing carbon dioxide concentration (from point A to B on the graph).

Gradually the rate falls of and at a certain carbon dioxide concentration the rate of photosynthesis stays constant (from point B to C on the graph). Here a rise in carbon dioxide levels has no affect on the rate of photosynthesis as the other factors such as light intensity become limiting.



This text is adapted from
http://www.passmyexams.co.uk/GCSE/biology/factors-affecting-rate-of-photosynthesis.html

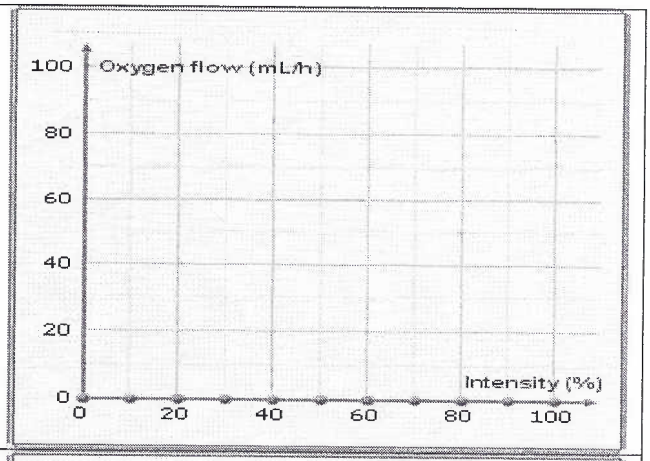
The Research Question: How and why do light intensity and temperature affect the rate of photosynthesis in plants?

My Claim:

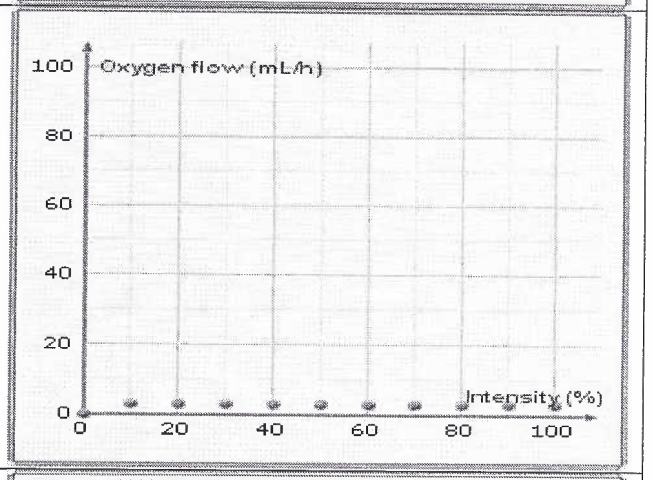
Our Evidence:

Our Justification of the Evidence:

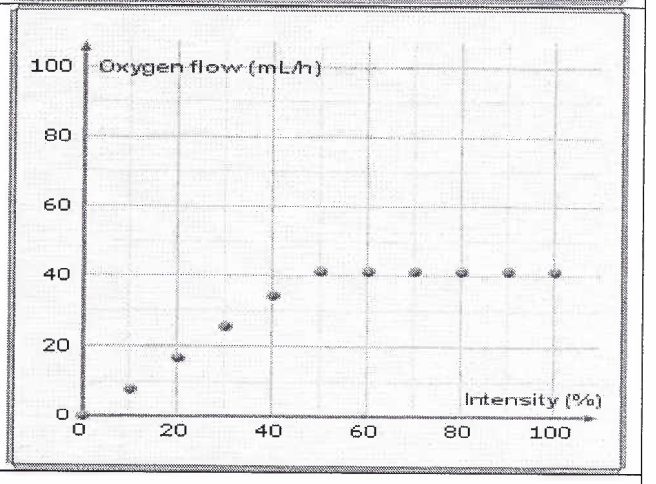
I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
0	0	500	W	0
10	0	500	W	0
20	0	500	W	0
30	0	500	W	0
40	0	500	W	0
50	0	500	W	0
60	0	500	W	0
70	0	500	W	0
80	0	500	W	0
90	0	500	W	0
100	0	500	W	0



I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
0	10	500	W	0
10	10	500	W	3.1
20	10	500	W	3.1
30	10	500	W	3.1
40	10	500	W	3.1
50	10	500	W	3.1
60	10	500	W	3.1
70	10	500	W	3.1
80	10	500	W	3.1
90	10	500	W	3.1
100	10	500	W	3.1

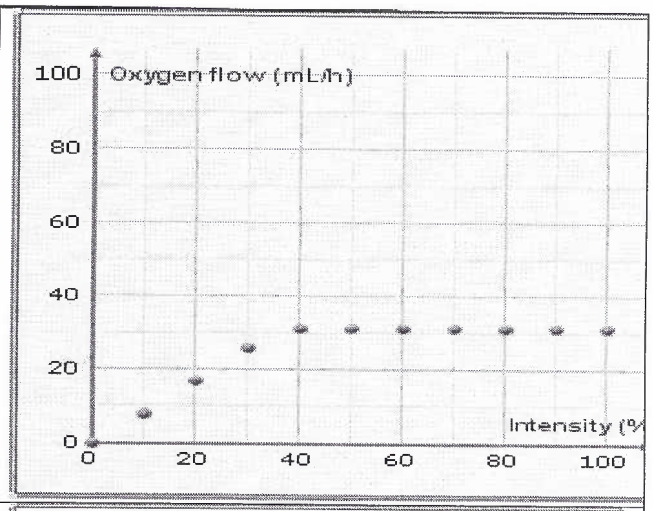


I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
0	20	500	W	0
10	20	500	W	8.2
20	20	500	W	17.1
30	20	500	W	26.1
40	20	500	W	34.7
50	20	500	W	41.7
60	20	500	W	41.7
70	20	500	W	41.7
80	20	500	W	41.7
90	20	500	W	41.7
100	20	500	W	41.7

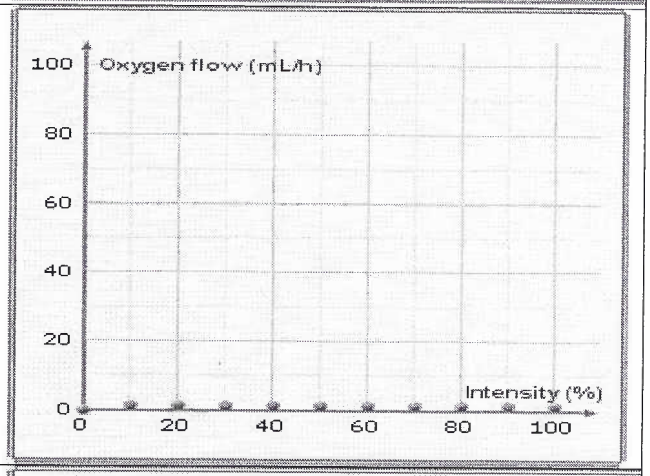


Oxygen Flow (mL/h) versus Light Intensity (%)

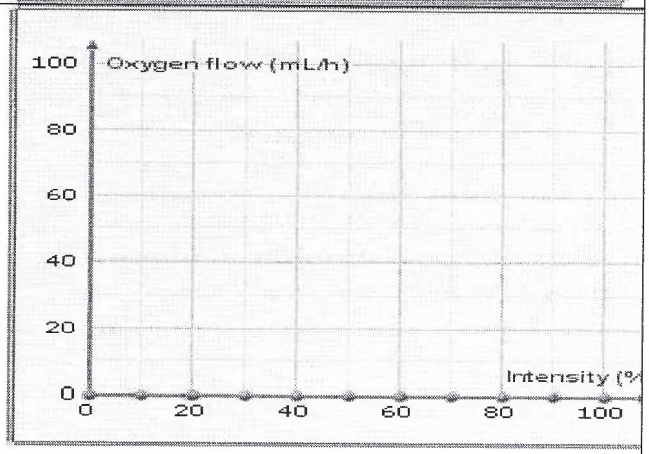
I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
0	30	500	W	0
10	30	500	W	8.2
20	30	500	W	17.1
30	30	500	W	26.1
40	30	500	W	31.3
50	30	500	W	31.3
60	30	500	W	31.3
70	30	500	W	31.3
80	30	500	W	31.3
90	30	500	W	31.3
100	30	500	W	31.3



I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
0	40	500	W	0
10	40	500	W	1.3
20	40	500	W	1.3
30	40	500	W	1.3
40	40	500	W	1.3
50	40	500	W	1.3
60	40	500	W	1.3
70	40	500	W	1.3
80	40	500	W	1.3
90	40	500	W	1.3
100	40	500	W	1.3

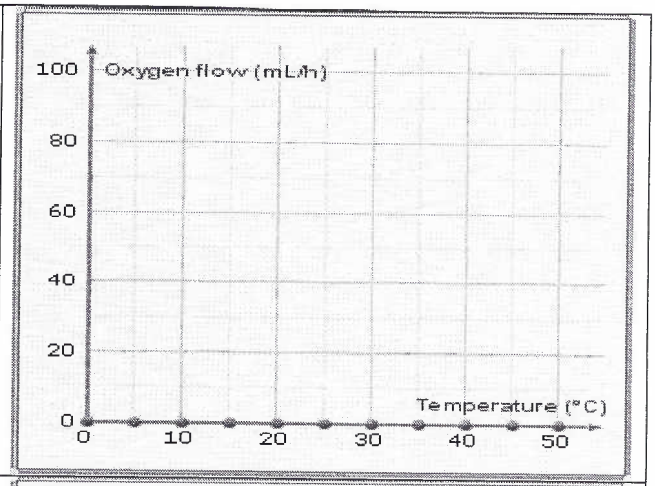


I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
0	50	500	W	0
10	50	500	W	0
20	50	500	W	0
30	50	500	W	0
40	50	500	W	0
50	50	500	W	0
60	50	500	W	0
70	50	500	W	0
80	50	500	W	0
90	50	500	W	0
100	50	500	W	0

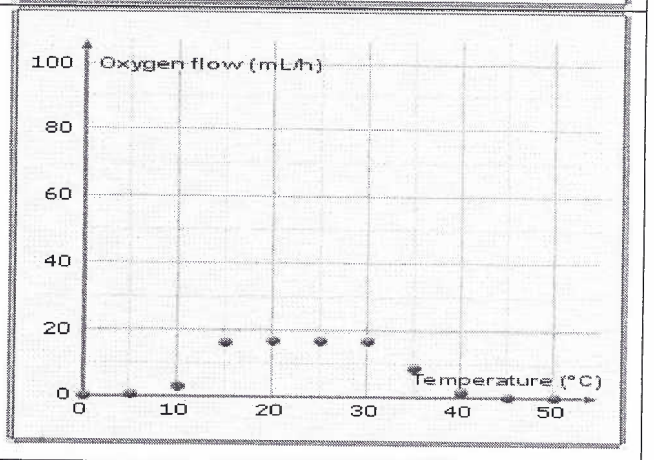


Oxygen Flow (mL/h) versus Light Intensity (%)

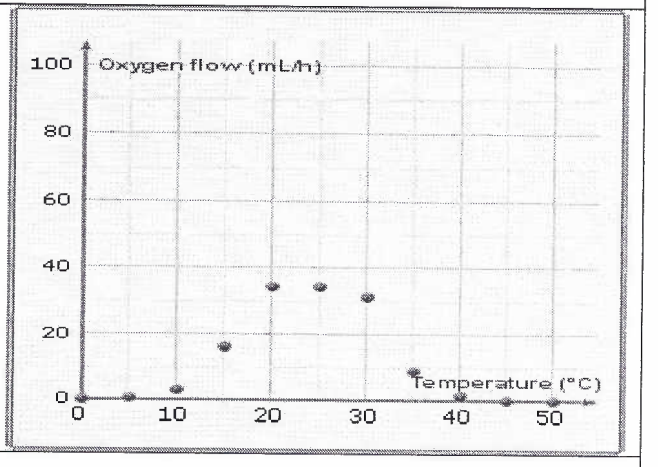
I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
0	0	500	W	0
0	5	500	W	0
0	10	500	W	0
0	15	500	W	0
0	20	500	W	0
0	25	500	W	0
0	30	500	W	0
0	35	500	W	0
0	40	500	W	0
0	45	500	W	0
0	50	500	W	0



I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
20	0	500	W	0
20	5	500	W	0.3
20	10	500	W	3.1
20	15	500	W	16.4
20	20	500	W	17.1
20	25	500	W	17.1
20	30	500	W	17.1
20	35	500	W	9.2
20	40	500	W	1.3
20	45	500	W	0.1
20	50	500	W	0

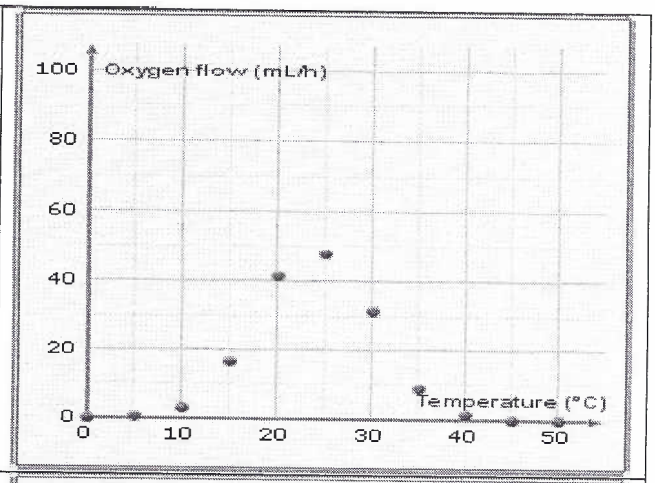


I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
40	0	500	W	0
40	5	500	W	0.3
40	10	500	W	3.1
40	15	500	W	16.4
40	20	500	W	34.7
40	25	500	W	34.7
40	30	500	W	31.3
40	35	500	W	9.2
40	40	500	W	1.3
40	45	500	W	0.1
40	50	500	W	0

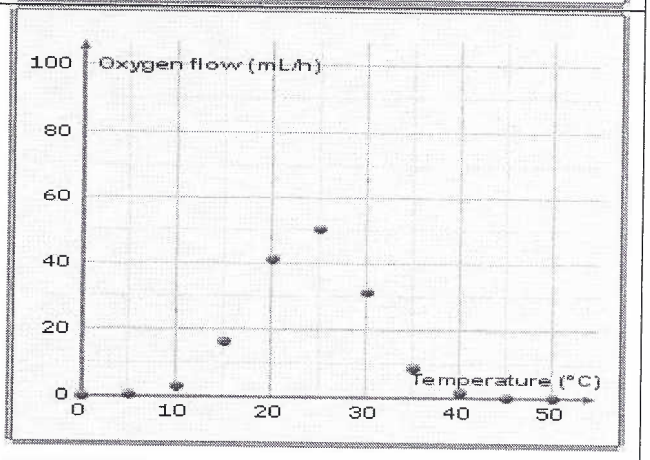


Oxygen Flow (mL/h) versus Temperature (C)

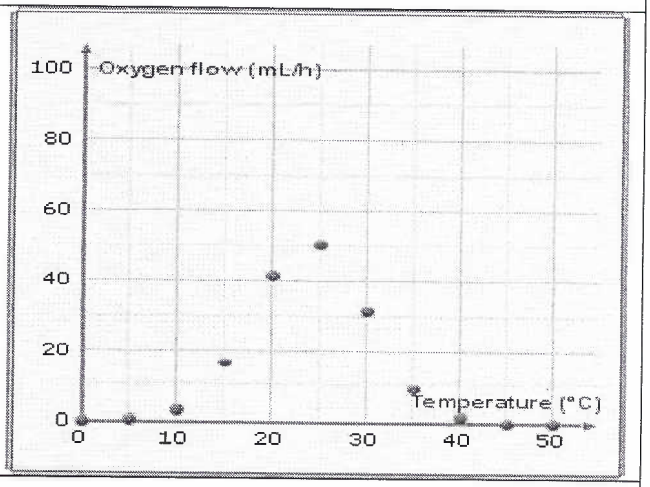
I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
60	0	500	W	0
60	5	500	W	0.3
60	10	500	W	3.1
60	15	500	W	16.4
60	20	500	W	41.7
60	25	500	W	48.1
60	30	500	W	31.3
60	35	500	W	9.2
60	40	500	W	1.3
60	45	500	W	0.1
60	50	500	W	0



I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
80	0	500	W	0
80	5	500	W	0.3
80	10	500	W	3.1
80	15	500	W	16.4
80	20	500	W	41.7
80	25	500	W	50.4
80	30	500	W	31.3
80	35	500	W	9.2
80	40	500	W	1.3
80	45	500	W	0.1
80	50	500	W	0



I (%)	T (°C)	CO_2 (ppm)	Color	O_2 (mL/h)
100	0	500	W	0
100	5	500	W	0.3
100	10	500	W	3.1
100	15	500	W	16.4
100	20	500	W	41.7
100	25	500	W	50.4
100	30	500	W	31.3
100	35	500	W	9.2
100	40	500	W	1.3
100	45	500	W	0.1
100	50	500	W	0



Oxygen Flow (mL/h) versus Temperature (C)

Photosynthesis is a chemical reaction that relies on the availability of variety of reactants (carbon dioxide and water), a source of energy (light), and environmental conditions. Considering what you learned from the analysis of this data set, describe the conditions in which photosynthesis is maximized. Cite evidence from the data set and relevant science to justify your response.

Given the conditions you described above, which variable, light intensity (assuming light intensity is NOT 0%) or temperature, acted as the limiting factor for photosynthesis in this model? Cite evidence from the data set and relevant science to justify your response.

Name _____ Per _____ Date _____

Day1

Biology Lab Investigation: Transpiration

How do environmental factors (light intensity, temperature, wind, and humidity) and anatomical features (leaf surface area) affect the rate of transpiration in plants?

Introduction. Plants just like other organisms must be able to transport materials from one part to another. Plant transport systems consist of two large tubes made of vascular tissue that basically run from the roots through the shoots (stems) and to the leaves of the plant. Sugars produced through the process of photosynthesis are transported through plants from leaves to roots via the vascular tissue known as the phloem. Cells use these sugars to produce the energy needed for the rest of the plants functions. Sugars move through the plant because they are in greatest concentration in the leaves, where photosynthesis takes place, and in least concentration in the roots. Many plants will store excess sugars in specialized root structures called tubers.

Water is transported in plants from the roots to the leaves through the vascular tissue known as the xylem. The water then enters the leaves and is either used in the process of photosynthesis or is released back into the atmosphere through stomata in the process of transpiration. About 1% of the water taken up by plants through their root system is used for metabolic functions such as photosynthesis. The other 99% exits the stomata without ever being used by the plant. In a tree, such as the giant redwood of California, water must ascend over 300 feet to reach the highest leaves. The water moves through the plant via osmosis because the concentration of water is greatest in the roots of a plant and the least in the leaves.

Transpiration, or the evaporative loss of water from the stomata (singular: stoma) of leaves, helps to create a lower concentration of water (or lower osmotic potential) in the leaf. The differences in water concentration are also responsible for the movement of water from the xylem to the mesophyll layer of the leaves and subsequently out of stomata to the atmosphere in the hydrologic cycle. (See Figures 1 and 2).

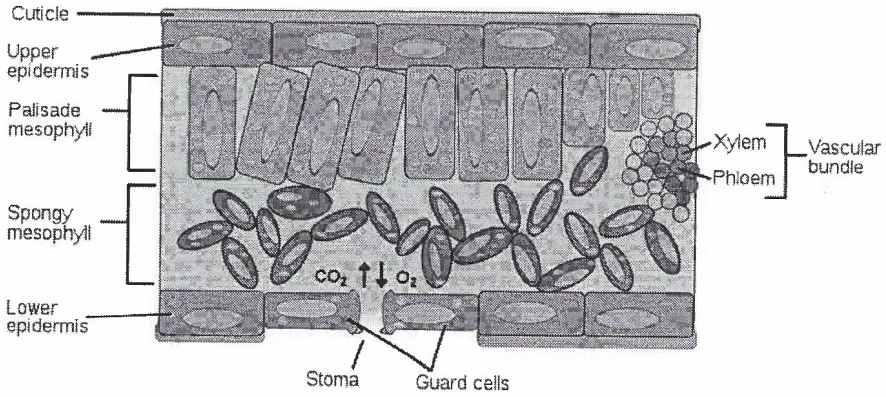


Figure 1. The structure of a leaf featuring the major tissues; the upper and lower epidermis, the palisade and spongy mesophyll and the guard cells of the stoma. Vascular tissue (veins), made up of xylem and phloem are also shown. The light green circles within cells represent chloroplasts and indicate which tissues undergo photosynthesis.

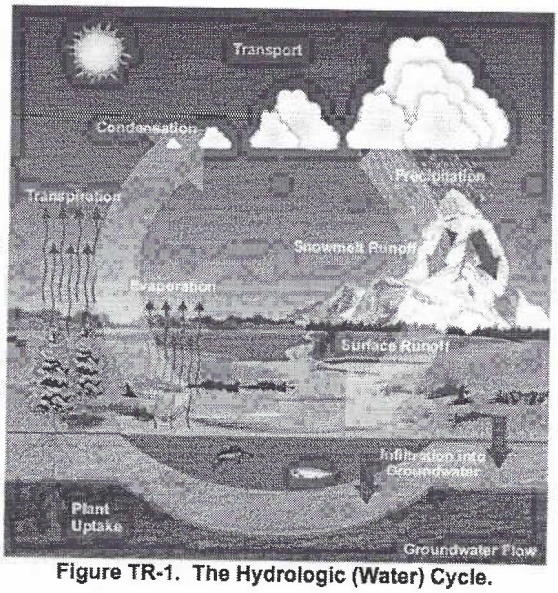


Figure TR-1. The Hydrologic (Water) Cycle.

Figure 2: The Hyrdrologic (Water Cycle)–Water vapor is released into the atmosphere at the leaf surface through stomata. This process, known as ***transpiration****, is ecologically vital. It is one of the most important ways that water travels from the soil and back into the atmosphere, where it can then return to earth as life-giving precipitation.*

Stomata also play an important role in photosynthesis and the carbon cycle. When stomata are open, carbon dioxide enters the plant from the atmosphere to drive photosynthesis, and oxygen is released back into the atmosphere as a by-product of photosynthesis. (See Figure 3)

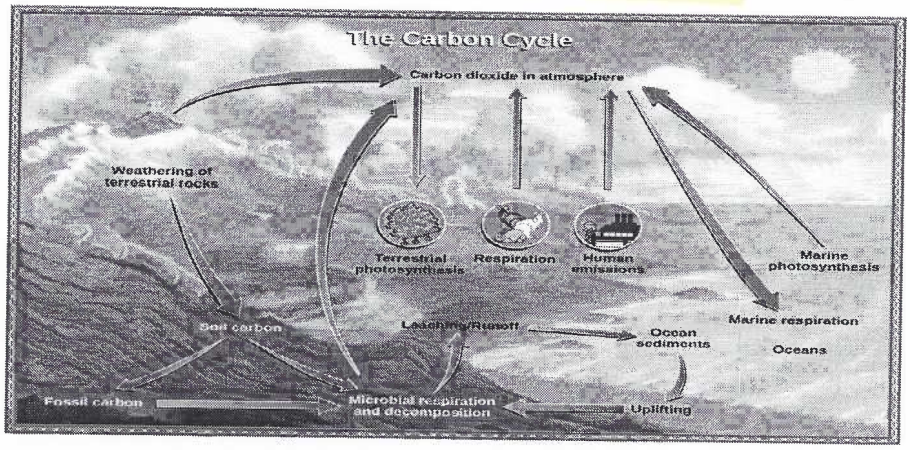


Figure 3: The Carbon Cycle—Carbon dioxide is removed from the atmosphere by terrestrial plants and marine phytoplankton as a necessary reactant for photosynthesis. Terrestrial plants take in carbon dioxide through open stomata in their leaves.

The transpiration rate of a plant (or how quickly water is lost from the leaves due to evaporation) is influenced by a number of environmental factors (such as light intensity, temperature, wind, and humidity) as well as anatomical factors (leaf surface area).

Your Task: Determine if there is a relationship between one of these variables and the plant's transpiration rate.

The development of this laboratory activity was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A100909 to the Florida State University

Transpiration Lab Using the Claim—Evidence—Justification (CEJ) Model of ADI

Using the data provided, use the CEJ template below to address the prompt.

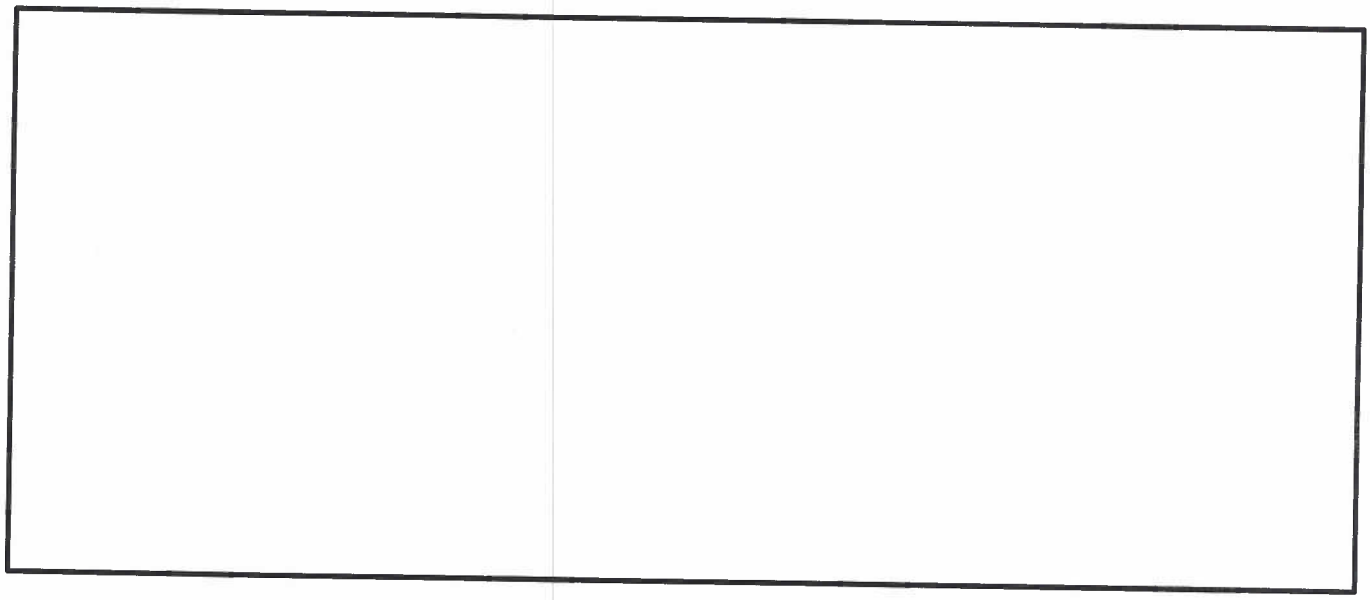
Guiding Question: *How do environmental factors (light intensity, temperature, wind, and humidity) and anatomical features (leaf surface area) affect the rate of transpiration in plants?*

Variable	Evidence (HOW)	Justification (WHY)
Light Intensity		
Temperature		

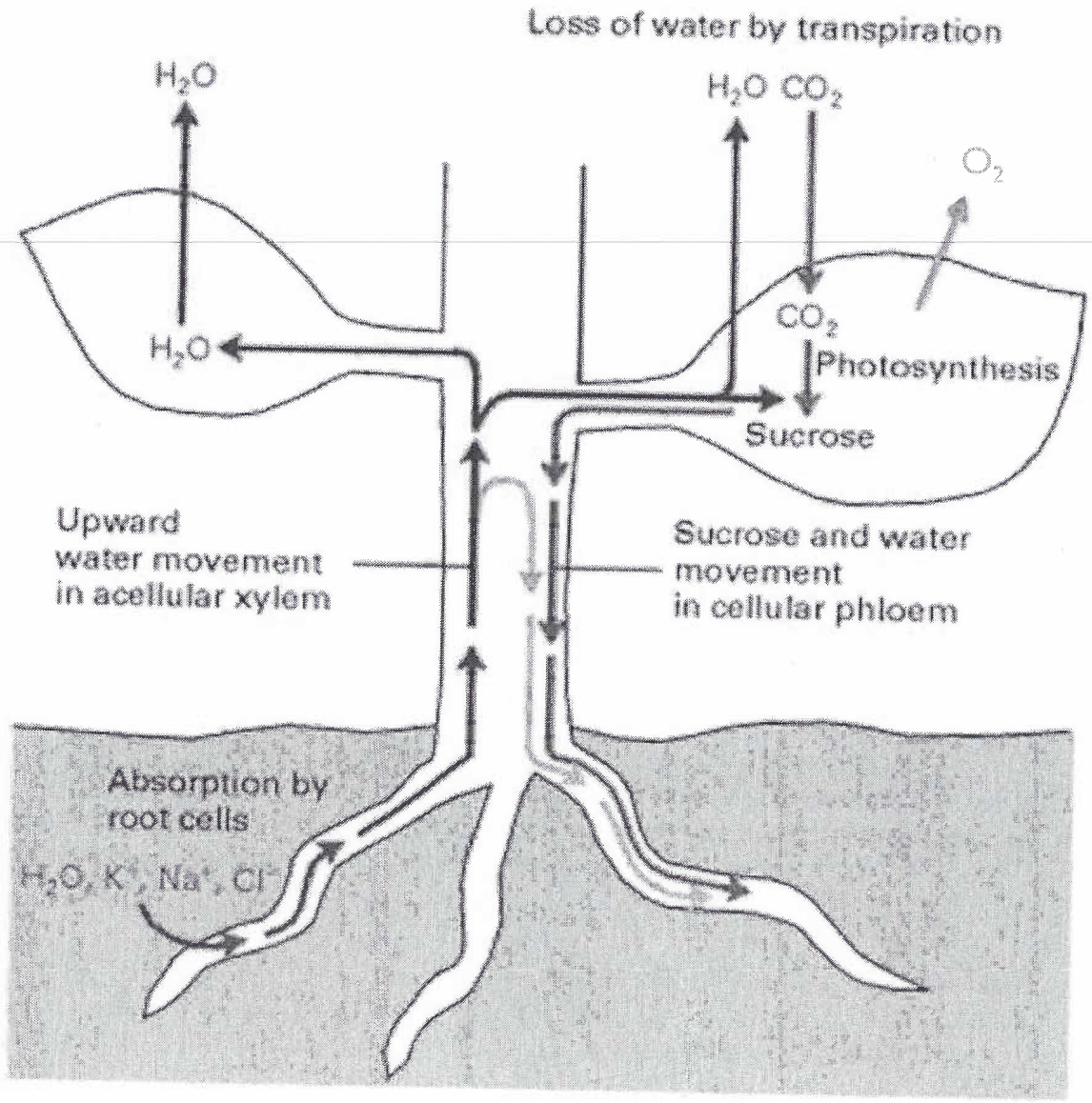
Variable	Evidence (HOW)	Justification (WHY)
Wind		
Humidity		
Surface Area		

Question 3

An aspiring botanist claims that increasing leaf surface area, wind, and humidity will increase the rate of transpiration from the leaf surface. Explain the error in his claim, and justify your explanation with scientific concepts.



Transport of Matter in Plants

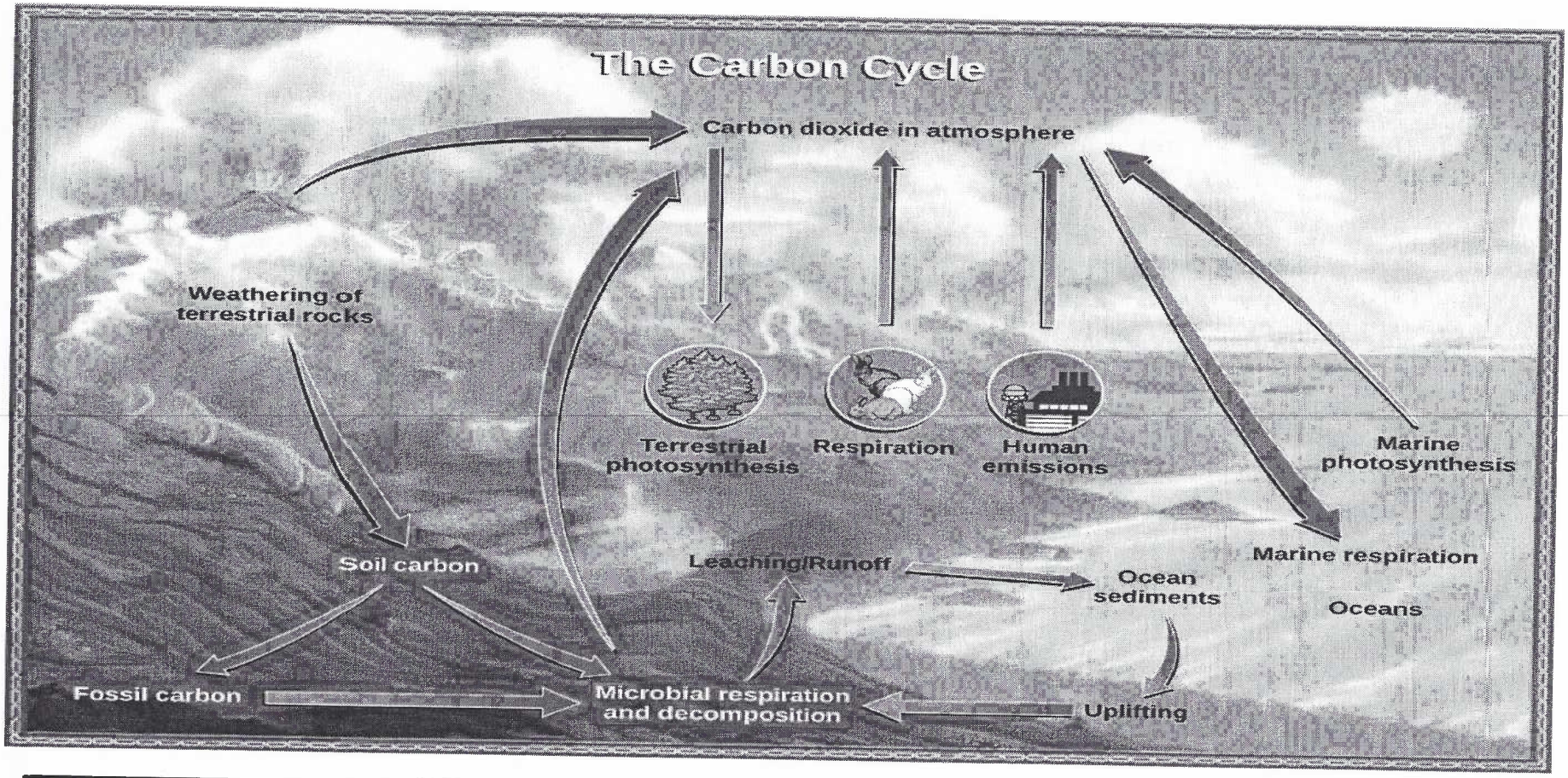


This diagram shows the movement of matter during the physiological processes of photosynthesis and transpiration in plants.

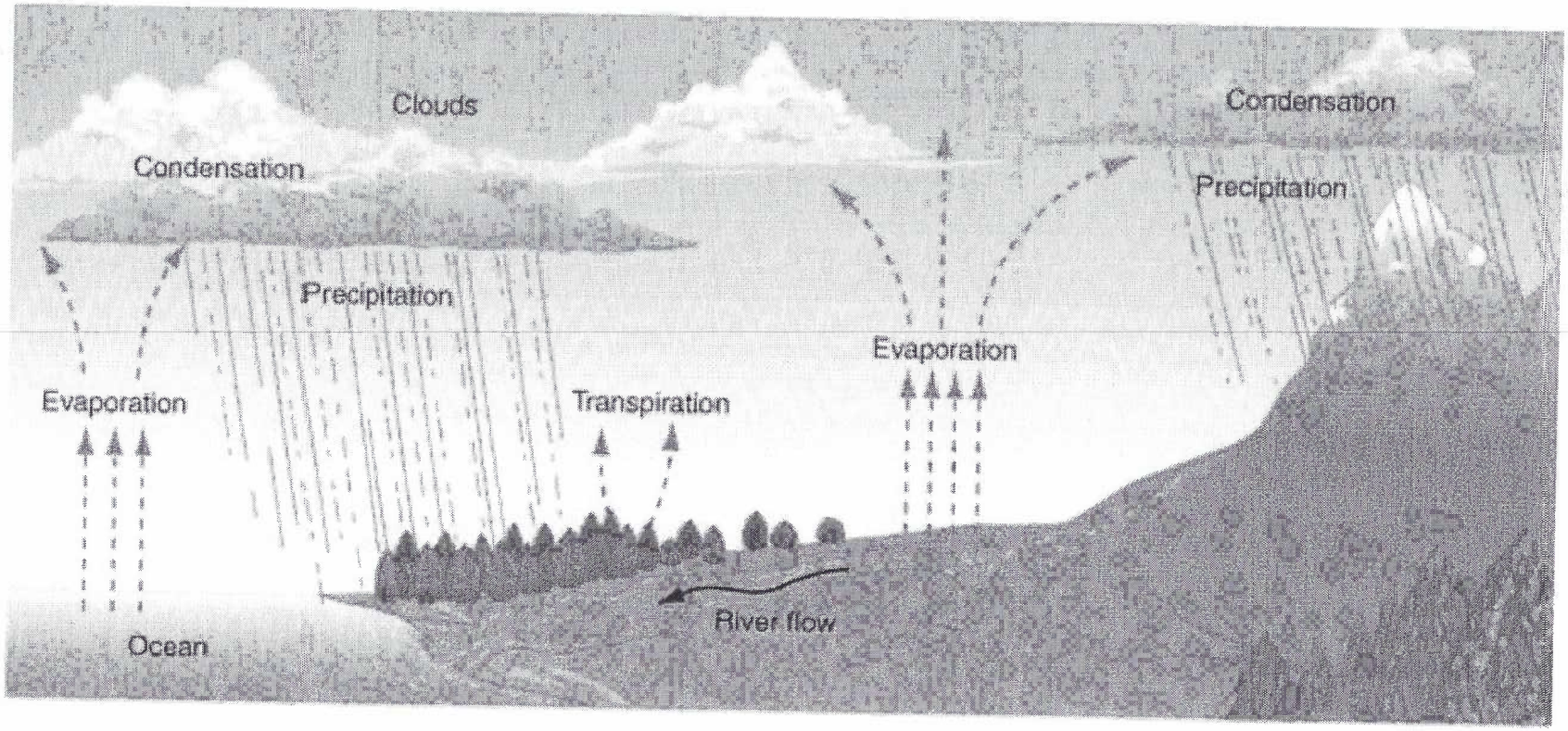
Now that you have a better understanding of water properties and plant structure and function, describe what's happening in this diagram using your new vocabulary, making connections with water properties, photosynthesis and transpiration.

Partial Example:

Water is an important reactant for photosynthesis and is released during transpiration. Plants take in water via osmosis through their roots. Root epidermal cells are covered in root hairs, which increase the surface area for absorption of water and minerals. After water passes osmotically from the soil through the root's epidermal cells, it enters the cortex and the vascular cylinder of the root. The vascular cylinder is composed of xylem and phloem....



What's a plant's role in the carbon cycle?



What's a plant's role in the hydrologic (water) cycle?