Name……………………………………….. Date……… Period………….

Student Laboratory Packet
Transpiration
A Laboratory Activity for the Living Environment

Introduction

The amount of water needed daily by plants for the growth and maintenance of tissues is small in comparison to the amount that is lost through the process of **transpiration** and **guttation**. If this water is not replaced, the plant will wilt and may die. The transport up from the roots in the xylem is governed by differences in **water potential** (the potential energy of water molecules). These differences account for water movement from cell to cell and over long distances in the plant. Gravity, pressure, and solute concentration all contribute to water potential and water always moves from an area of high water potential to an area of low water potential. The movement itself is facilitated by osmosis, root pressure, and adhesion and cohesion of water molecules.

The overall process: Minerals actively transported into the root accumulate in the xylem, increase solute concentration and decrease water potential. Water moves in by **osmosis**. As water enters the xylem, it forces fluid up the xylem due to hydrostatic **root pressure**. But this pressure can only move fluid a short distance. The most significant force moving the water and dissolved minerals in the xylem is upward pull as a result of **transpiration**, which creates a negative tension. The "pull" on the water from transpiration is increased as a result of cohesion and adhesion of water molecules.

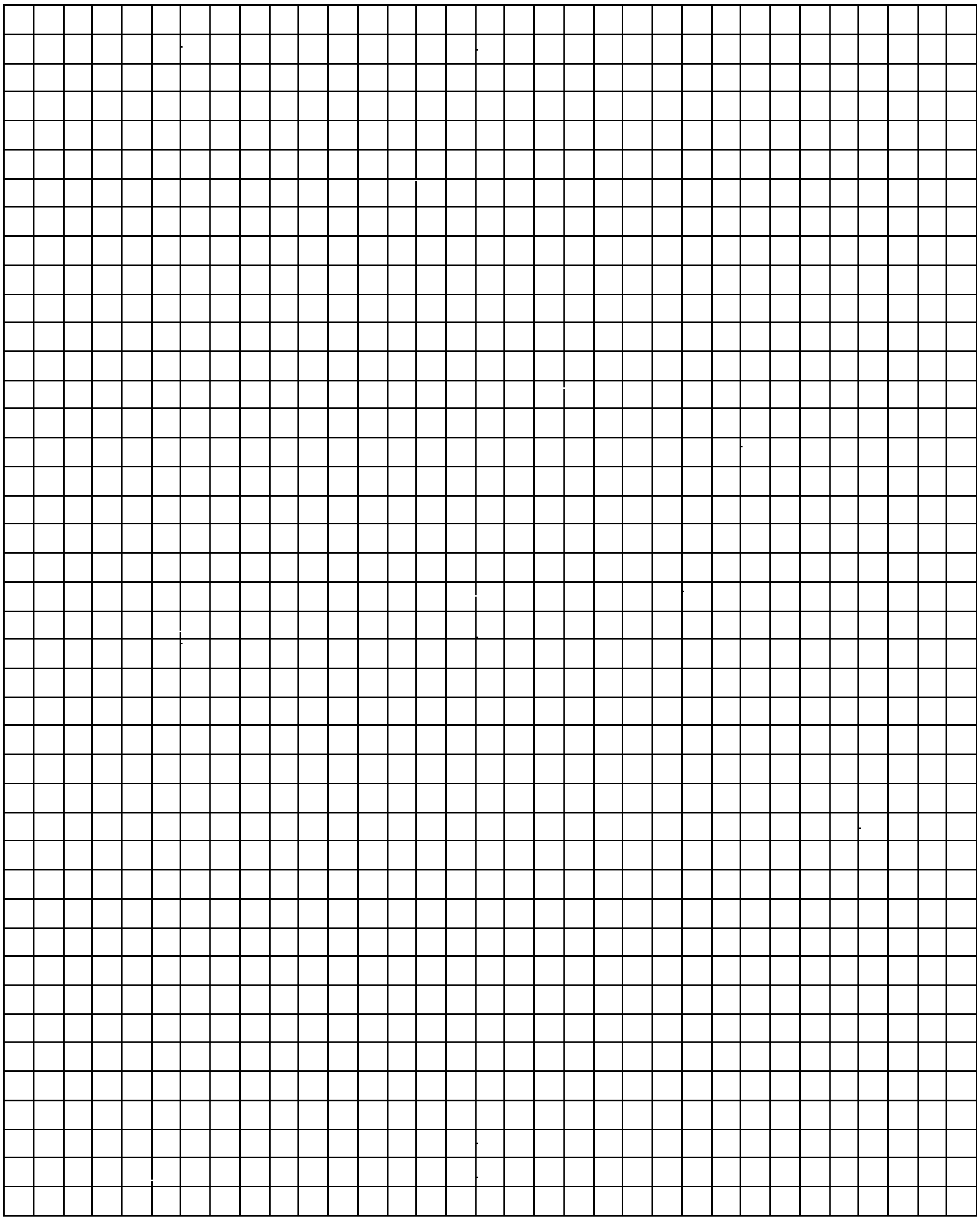
The details: Transpiration begins with evaporation of water through the stomates (stomata), small openings in the leaf surface which open into air spaces that surround the mesophyll cells of the leaf. The moist air in these spaces has a higher water potential than the outside air, and water tends to evaporate from the leaf surface. The moisture in the air spaces is replaced by water from the adjacent mesophyll cells, lowering their water potential. Water will then move into the mesophyll cells by osmosis from surrounding cells with the higher water potentials including the xylem. As each water molecule moves into a mesophyll cell, it exerts a pull on the column of water molecules existing in the xylem all the way from the leaves to the roots. This transpirational pull is caused by (1) the **cohesion** of water molecules to one another due to hydrogen bond formation, (2) by **adhesion** of water molecules to the walls of the xylem cells which aids in offsetting the downward pull of gravity. The upward transpirational pull on the fluid in the xylem causes a **tension** (negative pressure) to form in the xylem, pulling the xylem walls inward. The tension also contributes to the lowering of the water potential in the xylem. This decrease in water potential, transmitted all the way from the leaf to the roots, causes water to move inward from the soil, across the cortex of the root, and into the xylem. Evaporation through the open stomates is a major route of water loss in the plant. However, the stomates must open to allow the entry of CO_2 used in photosynthesis. Therefore, a balance must be maintained between the gain of CO_2 and the loss of water by regulating the opening and closing of stomates on the leaf surface. Many environmental conditions influence the opening and closing of the stomates and also affect the rate of transpiration. Closed stomates can result in water conservation but can also can reduce the exchange of gases which inhibits the rate of photosynthesis. Some conditions which could cause an increase or decrease in transpiration include; temperature; increased water loss because of greater evaporation, light intensity; increases water loss because of increased leaf temperature, air currents; results in increased water loss because there is less still air at the surface, and increased humidity; decreases water loss because of decreased water potential. Different plants also vary in the rate of transpiration and in the regulation of stomatal opening. Adaptation to reduce water loss include reduced number of stomates, and thicker leaf cuticles

Procedure

Leaf Trace Method:

A photo of a maple leaf will be provided. Cut out the leaf (with scissors) and place on the grid below. Trace an outline of your leaf on the grid. Count all of the squares that are completely within the tracing and estimate the number of squares that lie partially within the tracing. The grid has been constructed so that a **square of four blocks equals 1 cm^2**. The total surface area can then be calculated by **dividing the total number of blocks covered by 4.** Record the value below

Leaf surface area…………………………………… cm^2



Leaf Mass Method:

- Determine the mass of your leaf on a digital balance
- Multiply the section's mass by 10,000 to calculate the mass per square meter of the leaf. (g/m^2)
- This value is the leaf mass per square meter of leaf
- Record this value below
-
- **Leaf mass**……………. **g/m^2**

Calculate water lost per square meter:
To calculate the water loss per square meter of leaf surface, divide the leaf mass by the leaf surface area you calculated.

Leaf mass…………………. **g/m^2** **(divided by)** **Leaf surface area………………… cm^2 =**

Water loss per square meter of leaf surface…………………………**mL/m^2**

Analysis of Results

Using the first page of the lab for information

1. Explain why each of these conditions could cause an increase or decrease in transpiration.

Conditions	Effect	Reasons
Increased room temperature		
Air currents		
Light		
Increased humidity		

2. What is the advantage to a plant of closed stomata when water is in short supply? What are the disadvantages?

3. Describe several adaptations that enable plants to reduce water loss from their leaves. Include both structural and physiological adaptations.