A Content Secondary Science Newsletter from the
Southern Nevada Regional Professional Development Program

Science Dissected

Do All Plants Require the Same Amount of Water?
Model-Evidence Link Diagram (MEL)

Plants are an important part of our environment. We use plants for food, shelter, clothing, medicines, and they provide even the air we breath. All plants require water to live, however, do all plants require the same amount of water to live?

This issue of Science Dissected provides an instructional resource for teachers to present students with the opportunity to examine several pieces of evidence compiled about the amounts of water plants need to survive, given the: type of plant, effects of weather on the plant, and effects of the water cycle (transpiration).

Model A:

All plants require the same amount of water to live.

Model B:
Certain plants require different amounts of water to survive.

Evidence #1: The graph shows that when plants are under or over watered they do not grow well. This is shown by the bell shaped curve of the graph.

Evidence #2: Plants growing in soil that is too wet suffer from a lack of oxygen which leads to death of roots.

Evidence #3: Some plants transpire water at different rates. Some plants can conserve water by transpiring less water than other plants.

Evidence #4: The Saguaro Cactus soaks up rain water and holds it in its ribs. The ribs on the plant can expand to hold more water.

The following is a suggestion for using this MEL with students:

1. Hand out the Plants Model Evidence Link Diagram (page 2). Instruct students to read the directions, descriptions of Model A and Model B, and the four evidence texts presented.
2. Handout the four evidence text pages (pages 3-11).
3. Instruct students to carefully review the Evidence #1 text page (page 3), then construct two lines from Evidence #1; one to Model A and one to Model B. Remind students that the shape of the arrow they draw indicates their plausibility judgment (potential truthfulness) connection to the model.
4. Repeat for Evidence #2-4 (pages 4-11).
5. Handout page 3 for the students to critically evaluate their links and construct

Once students have completed page 2, they can then engage in collaborative argumentation as they compare their links and explanations with that of their peers. Students should be given the opportunity to revise the link weighting during the collaborative argumentation exercise. If time permits, have students reflect on their understanding of plants and create questions that they might explore in the future.

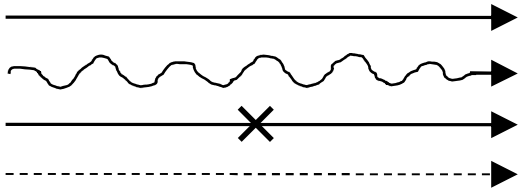
Archived Issues of Science Dissected, *http://www.rpdp.net/link.news.php?type=sciencedis*. ***Instructional Resource resulting from Plausibility, It's All About Connecting the Models Workshop co-sponsored by CPDD and SNRPDP Science March 6, 2012***

Written by: Murray DeLaFontaine

Name:_____ _____ **Period:**_____

Directions: draw two arrows from each evidence box. One to each model. You will draw a total of 8 arrows.

Key:



The evidence **supports** the model

The evidence **STRONGLY supports** the model

The evidence **contradicts** the model (shows its wrong)

The evidence has **nothing to do with** the model

Standard: L.8.C.3

Evidence #1
The graph shows that when plants are under or over watered they do not grow well. This is shown by the bell shaped curve of the graph.

Model A
All plants require the same amount of water to live.

Evidence #3
Some plants transpire water at different rates. Some plants can conserve water by transpiring less water than other plants.

Evidence #2
Plants growing in soil that is too wet suffer from a lack of oxygen which leads to death of roots.

Model B
Certain plants require different amounts of water to survive.

Evidence #4
The Saguaro Cactus soaks up rain water and holds it in its ribs. The ribs on the plant can expand to hold more water.

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

A. Write the number of the evidence you are writing about.
B. Circle the appropriate descriptor (**strongly supports | supports | contradicts | has nothing to do with**).
C. Write the letter of the model you are writing about.
D. Then write your reason.

1. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

2. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

3. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

4. Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)									Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

5. Circle the model which you think is correct. [Only circle one choice below.]

Very certain that Model A is correct	Somewhat certain that Model A is correct	Uncertain if Model A or B is correct	Somewhat certain that Model B is correct	Very certain that Model B is correct

Evidence #1: The graph shows that when plants are under or over watered they do not grow well. This is shown by the bell shaped curve of the graph.

Plant Growth as a Function of Inches of Rain Per Week

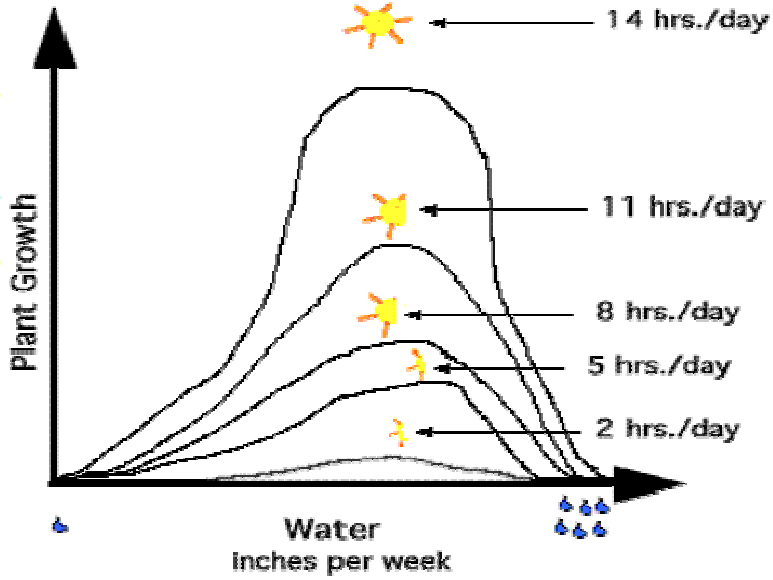


Fig. 3 - How the amount of water affects plant growth with different amounts of sun per day.

This graph illustrates plant growth as a function of inches of rain per week. The independent variable water (in inches per week) is located on the x-axis. The dependent variable, plant growth, is located on the y-axis. Note, there are five two dimensional line graphs plotted in the figure. The five different curves represent the different growth rates when plants were exposed to a specific number of hours of sun per day. One can see that the plants grow best with a medium amount of water and 14 hours of sun per day. Also note that the plant growth increased each time the amount of sunlight increased.

Our common knowledge about plant growth can explain the figure; when plants are under or over watered they do not grow well. This is shown by the bell-shaped curve of the graphs. Plants do not grow well when they are under-watered because they do not have enough nutrients. Over-watered plants do not grow well because excess water in the soil does not allow air into the soil, resulting in the roots not being able to "breathe".

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Evidence #2: Plants growing in soil that is too wet suffer from a lack of oxygen which leads to death of roots.

Overwatering

This creeping juniper (*Juniperus*) died from overwatering

Over watering is one of the more common causes of plant problem. Heavy and poorly drained soils are susceptible to becoming waterlogged. Roots growing in waterlogged soil may die because they cannot absorb the oxygen needed to function normally. The longer the air is cut off, the greater the root damage. The dying roots decay and cannot supply the plants with nutrients and water. Damage caused by over watering is frequently misdiagnosed as pest damage. However, pest damage rarely causes roots to concentrate near the surface of the soil. Plants stressed or injured by waterlogging

can become abnormally susceptible to certain fungal pathogens. *Phytophthora* spp. for example, cause root rot most often in soils that are periodically waterlogged.

Symptoms and Diagnosis

Plants growing in soil that is too wet suffer from a lack of oxygen which leads to the death of roots and a loss of vigor in the plant. Stunted slow growth with yellowing leaves is a symptom of over watering. Plants may suffer from leaf scorch or leaf burn. Water soaked spots and blisters (Oedema) may appear on stems and leaves. The crown of the plant may rot. Damaged roots have little defense against the entrance of rot causing soil organisms. And so the plant dies of root rot.

Integrated Pest Management Strategies

1. **Deep watering encourages roots to go deep down in the soil to where it is moist and a lot cooler**. Water less frequently but for longer periods, so water reaches deep into soil. Good thorough watering promotes healthier plants.

2. **Investigate using water conserving drip emitters or soaker hoses on a timer**. Adjust watering frequency and amounts based on season, temperature and amount of rainfall. Overhead watering uses more water and can promote fungal disease. Also make sure you don't have leaking irrigation pipes or downspouts that are keeping the soil too wet in a location.

3. **Add mulch to individual plants or beds**. Add organic matter such as compost or rotted manure to plantings ---organic matter can improve drainage in heavy clay soils. Take care to keep mulch away from stems.

4. **Use appropriate plants**. Evaluate your site for new plantings. Choose plants with the appropriate water and cultural needs that will thrive on your site. Use water loving plants for moist poorly drained soils. Also consider native plants, which generally adapt better, have lower water demands and fewer pest problems.

5. **Water only when necessary**. Most plants will normally wilt in hot sun and may recover on their own later in the day as the sun moves. Make sure soil is not too wet based on the needs of particular plants before watering; you may end up by over watering.

6. **A dry surface is not always a sign of water need**. The surface generally dries out first and is not a true indicator of what is going on down deep near the plant root. Make use of a hand trowel or soil probe to check for moisture. Check for overwatering by digging into root zone or knocking a small potted plant out of its container. Soil that has been too long without oxygen usually smells sour or rotten.

7. **Give priority to watering newly planted trees and shrubs**. Young plants have not had sufficient time to establish deep root systems, and depend on surface water for survival. Do not let the root balls of newly planted trees and shrubs dry out completely or become too saturated. Before watering use a soil probe or a hand trowel. Remember that when plants are fully established, they will require less water.

Overwatering causes the roots of St. Augustine lawns to rot. *Texas Cooperative Extension photo by Dr. Karl Steddom*

Evidence #3: Some plants transpire water at different rates. Some plants can conserve water by transpiring less water than other plants.

The Water Cycle: Transpiration

http://ga.water.usgs.gov/edu/watercycletranspiration.html

What is transpiration?

Transpiration is the process by which moisture is carried through plants from roots to small pores on the underside of leaves, where it changes to vapor and is released to the atmosphere. Transpiration is essentially evaporation of water from plant leaves. Transpiration also includes a process called guttation, which is the loss of water in liquid form from the uninjured leaf or stem of the plant, principally through water stomata.

Studies have revealed that about 10 percent of the moisture found in the atmosphere is released by plants through transpiration. The remaining 90 percent is mainly supplied by evaporation from oceans, seas, and other bodies of water (lakes, rivers, streams).

Transpiration and plant leaves

Credit: Ming kei College, Hong Kong

Plants put down roots into the soil to draw water and nutrients up into the stems and leaves. Some of this water is returned to the air by transpiration (when combined with evaporation, the total process is known as evapotranspiration). Transpiration rates vary widely depending on weather conditions, such as temperature, humidity, sunlight availability and intensity, precipitation, soil type and saturation, wind, land slope, and water use and diversion by people. During dry periods, transpiration can contribute to the loss of moisture in the upper soil zone, which can have an effect on vegetation and food-crop fields.

How much water do plants transpire?

Plant transpiration is pretty much an invisible process, since the water is evaporating from the leaf surfaces, you don't just go out and see the leaves "sweating". Just because you can't see the water doesn't mean it is not being put into the air, though. During a growing season, a leaf will transpire many times more water than its own weight. An acre of corn gives off about 3,000-4,000 gallons (11,400-15,100 liters) of water each day, and a large oak tree can transpire 40,000 gallons (151,000 liters) per year.

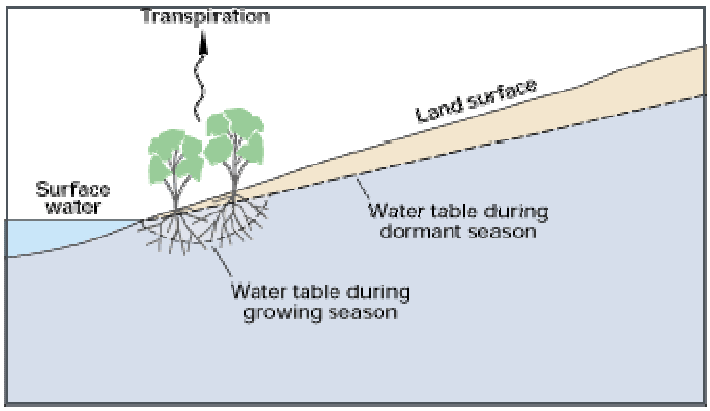
Atmospheric factors affecting transpiration

The amount of water that plants transpire varies greatly geographically and over time. There are a number of factors that determine transpiration rates:

- **Temperature:** Transpiration rates go up as the temperature goes up, especially during the growing season, when the air is warmer due to stronger sunlight and warmer air masses. Higher temperatures cause the plant cells which control the openings (stoma) where water is released to the atmosphere to open, whereas colder temperatures cause the openings to close.
- **Relative humidity:** As the relative humidity of the air surrounding the plant rises the transpiration rate falls. It is easier for water to evaporate into dryer air than into more saturated air.
- **Wind and air movement:** Increased movement of the air around a plant will result in a higher transpiration rate. This is somewhat related to the relative humidity of the air, in that as water transpires from a leaf, the water saturates the air surrounding the leaf. If there is no wind, the air around the leaf may not move very much, raising the humidity of the air around the leaf. Wind will move the air around, with the result that the more saturated air close to the leaf is replaced by drier air.
- **Soil-moisture availability:** When moisture is lacking, plants can begin to senesce (premature ageing, which can result in leaf loss) and transpire less water.
- **Type of plant:** Plants transpire water at different rates. Some plants which grow in arid regions, such as cacti and succulents, conserve precious water by transpiring less water than other plants.

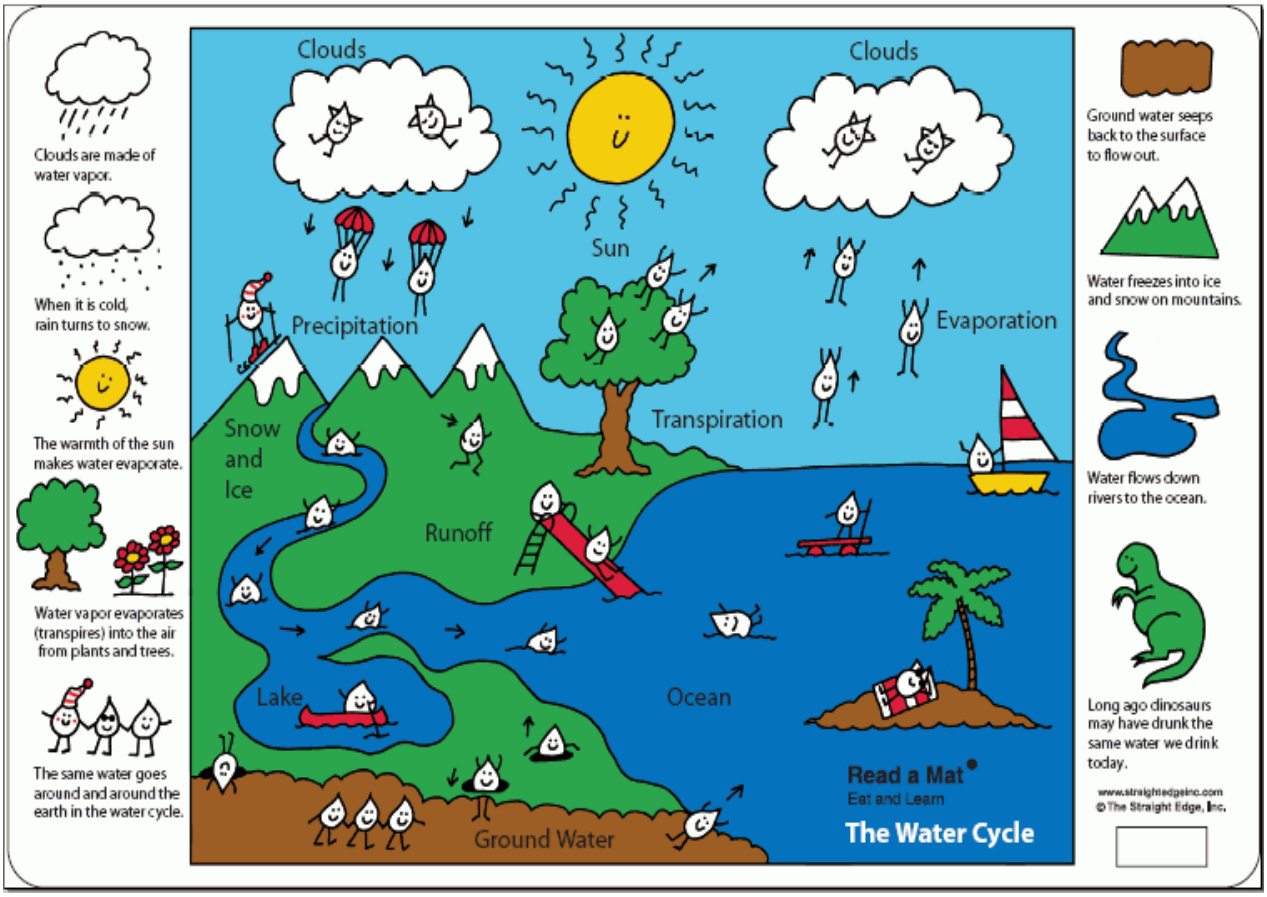
Transpiration and groundwater

In many places, the top layer of the soil where plant roots



are located is above the water table and thus is often wet to some extent, but is not totally saturated, as is soil below the water table. The soil above the water table gets wet when it rains as water infiltrates into it from the surface, But, it will dry out without additional precipitation. Since the water table is usually below the depth of the plant roots, the plants are dependent on water supplied by precipitation. As this diagram shows, in places where the water table is near the land surface, such as next to lakes and oceans, plant roots can penetrate into the saturated zone below the water table, allowing the plants to transpire water directly from the groundwater system. Here, transpiration of ground water commonly results in a drawdown of the water table much like the effect of a pumped well (cone of depression).

- The Water Cycle, NASA Earth Observatory
- A Primer on Water, by Leopold, Luna, and Langbein, Walter, U.S. Geological Survey General Purpose Publication, 1960



Evidence #4: The Saguaro Cactus soaks up rain water and holds it in its ribs. The ribs on the plant can expand to hold more water.

Saguaro Cactus by Alice H. 2001

Genus: Carnegiea
Species: gigantean
http://www.blueplanetbiomes.org/saguaro_cactus.htm
The Saguaro Cactus has a smooth and waxy skin and is covered with two-inch spines that are located on the tree's vertical ribs. In May and June, the Cactus bears creamy white flowers with yellow centers that measured about three inches. The Saguaro Cactus flower can be found on the end of the branches. The flower only opens on cooler nights and is closed during the heat of midday. The stem of the cactus can be 18 to 24 inches in diameter, The Cactus and its branches grow upright as do all cacti in the southwestern U.S. When it rains the Saguaro Cactus soaks up water and holds it in its ribs. Since it does not rain a lot in the desert, the cactus uses the water that it stores when it doesn't rain. The Saguaro Cactus is Arizona's state flower. The average lifespan for a Saguaro cactus is about 200 years.

The Saguaro Cactus lives in an especially rocky terrain consisting of desert slopes and flats. The Saguaro cactus also lives in bajadas or lowlands. The cactus likes a hot, dry climate. It does not need a lot of water to survive. The Saguaro Cactus lives only within the Sonoran Desert of southeastern

California, southern Arizona, and northwestern Mexico. In the Sonoran Desert, the Saguaro Cactus can grow in very limited areas below elevations of 3,500 feet.

The Saguaro Cactus can absorb a lot of water because the ribs on the plant can expand. The Saguaro Cactus has an amazing root system. The root system is very shallow for such a tall, heavy plant. The Saguaro Cactus has one tap root that is only about three feet long. It also has two sets of radial roots. One is a thick root system, which is only about one foot long, and there is also a thinner root system that grows to a length equal to the height of the Saguaro Cactus.

The Saguaro Cactus has a very strong framework consisting of three different structural features. There is a woody tissue that runs parallel up and down the Saguaro to form a cylindrical shape. There is also a thick whitish pith, and a fleshy tissue. Downward pointing spines make it easier to direct rainwater into the depressions of the cactus. The spines help to cool the outer skin. The spines also help redirect the wind and insulate the plant. Many animals eat the Saguaro Cactus; the Long-Nosed bat, bees, wasps, ants, and butterflies drink the nectar of the Cactus flower. Small animals such as the Pack Rat, and Pocket Mice will come to eat the Cactus. Gila woodpeckers like the interior of the Saguaro Cactus because it is the only plant it can hollow out for their nest in the desert. The woodpecker will drill 2 to 3 holes before it decides to live in one. It will peck right into the soft tissue that is used to store water. The cactus will fix the damage by sealing up the inside with "callous scar tissue" and that stops water loss. The Saguaro Cactus is

protected by the United States government, because the Saguaro Cactus was beginning to disappear from the landscape. There is a national park to protect the Saguaro Cactus. The name of the park is Saguaro National Park.

Cactus growth in the 15 meters and weighing several tons in Spanish called Saguaro (Saguaro), but in Russian – Carnegie giant. Find this amazing herb in the U.S. (in Arizona and California) and northern Mexico. Age giant can reach 150 years.

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