Lesson Created by Ashley Grapes

Title of Lesson: Transpiration

Grade: 10th grade Biology

Duration: 60-70 minutes

Purpose: The purpose of this lesson is to use engaging and differentiated instruction to introduce the concept of transpiration to 10th grade Biology students. This lesson works collaboratively with a chapter text to enhance reading, understanding, and elaboration of the book. Student's will think critically about movement of water through a plant, learn the anatomy and function of transpiration apparatus, and investigate capillary action and cohesion mechanisms through demonstrations. Students will use both their prior knowledge of experimental design and critical thinking skills to design an experiment with hypothetical materials. Lastly, they will be evaluated on the accuracy of their design and follow-up questions that require acquired knowledge from a text and elaboration.

SOL's:

BIO.1 The student will plan and conduct investigations in which
- b) hypotheses are formulated based on direct observations and information from scientific literature;
- c) variables are defined and investigations are designed to test hypotheses;

BIO.3 The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include
- a) the capture, storage, transformation, and flow of energy through the processes of photosynthesis and respiration.

BIO.5 The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals including humans. Key concepts include
- d) analyses of their responses to the environment;
- e) maintenance of homeostasis;

NSES Standards:
C.2.a.
8. Organization and functions of cells and multicellular systems.
9. Behavior of organisms and their relationships to social systems.
10. Regulation of biological systems including homeostatic mechanisms.
11. Fundamental processes of modeling and investigating in the biological sciences.

Materials & Resources:
Biggs, Alton, W.C. Hagins, and C. Kapicka. 2005. Biology: The Dynamics of Life California Edition. Chapter 22 Plant Structure and Function. McGraw-Hill/Glencoe.ISBN 0078665809
Transpiration video: http://www.youtube.com/watch?v=YKJbunDt_uw
Transpiration Results video: http://www.youtube.com/watch?v=YKJbunDt_uw
Transpiration in plants: http://www.youtube.com/watch?v=U4rzLhz4HHk
Capillary tubes (one per student)
Colored water
Computer
Penny's for each student
Plastic droppers

Comment [G1]: On page 645 there is a short paragraph on transpiration. It is a very important concept that explains the travel of water up a plant for photosynthesis. Elaborating on transpiration is a great way to pull information from other parts of the chapter and put it together in a "big picture" kind of way. This lesson is also sub-disciplinary as it pulls concepts from chemistry and biochemistry.

Comment [G2]: This lesson allows every student to feel involved, and it gives offers many different avenues for learning including; video, ppt, pictures, hands on activities, and critical thinking.

Safety Precautions: the capillary tubes are very thin glass tubes that break easily. Warn students of their fragility and have a first aid kit available in case of broken glass injuries.

Procedure (based on 5-E model):

Engage (2 minutes): Show youtube videos, "Plant Transpiration Video" and, "Results for Transpiration Video."

Explore (15-20 minutes): Use a think/pair/share strategy to talk about what happened in the video. The following questions may be asked to initiate classroom discussion.

What happened to the water level in the jar with the plant?
Why did he put a layer of oil on the water?
When you have to water a plant in a pot, where did the water go?
How does the water get into the plant and travel up the plant?
Do plants have veins?
Why do plants even need water?
How do plants loose the water?
How can water travel up a plant against gravity if plants don't have 'muscles'?

Explain (15- 20 minutes): Give a powerpoint on transpiration in plants. Cover the atanatomy and function of roots, stems and leaves including the xylem, stomata, guard cells, and capillary action. Show the video entitled, "transpiration in plants" clicking on the "stomata" option to explain transpiration. Give one capillary tube/student along with a petri dish of dyed water. Tell the students to place the tip of the tube into the water and explain that it is capillary action that enabled the liquid to move against the force of gravity.

Elaborate (40 minutes): Give the student's the activity sheet entitled, "Water Transport in Plants: Transpiration." Have the students work in groups of 2-3 to design the experiment. Students should already have a good grasp on experimental design from the beginning of the year. This is a hypothetical experiment, but teachers may choose to carry out the investigation if time and materials allow. The second part explores cohesion, elaboration questions, and a capstone question on the path of water through a plant.

Evaluate: Students will be assessed on their experimental design and answering the follow-up questions using the rubric provided.

Comment [G3]: Engaging a student with a discrepant event plays a large role in building curiosity and eventual motivation to learn

Comment [G4]: This allows all students to be engaged at once, and give less confident students a chance to share their ideas

Comment [G5]: These types of questions are not directly explained yet, but probing students prior knowledge is essential to building an understanding of the content they will eventually learn. It also continues to get them thinking in an environment where they are free to express their ideas, no matter how crazy they think they are!

Comment [G6]: A very important concept for the SOL's. 10th graders don't get into too much detail but the concept is essential to life on the planet!

Comment [G7]: This is the 2nd video shown. Both the first video and the 2nd video give show concept through experimental design. This is a core objective for this lesson as the students will be designing an experiment later. Modeling is a great tool for students to learn.

Comment [G8]: Instructors spend way too much time lecturing, when instead lessons should be more student-centered. The students have been given a ppt, watched a video, and now are able to have hands-on experience. This is differentiating instruction for the sake of different learning styles.

Activity Sheet: Water Transport in Plants, Transpiration

Part 1: Experiment Design

Based on what you now know about plant structure and function, formulate a hypothesis for the question listed below. Once you have your hypotheses, you will work in groups of 2-3 to design experiments to test your hypotheses. Be sure to identify the independent and dependent variables.

These are the **ONLY** materials will be available to you:

- 6 test tubes
- A beaker of tap water containing 5-6 bean plants (roots exposed)
- 1 graduated cylinder (25mL)
- 1 pair of scissors

Question: Which force is more important to water movement through a plant – the roots absorbing water or water evaporating from the leaves?

Hypothesis for question 2:

Supporting evidence for hypothesis:

Dependent Variable:
Independent Variable:
Experimental Design:

1. Do you think a cactus has the same transpiration design as a bean plant? Why? Name 2 special adaptations a cactus might have including number of stomata and epidermis structure. (pg. 646)

Comment [G9]: This activity is a "double-whammy" because students are able to apply their knowledge of transpiration and experimental design. Science students should be practicing formulating and designing experiments throughout the school year.

Comment [G10]: Again, this is so that every student plays a role in a group. Students can "bounce" their ideas off one another and build up to their design together.

Comment [G11]: This seems like a very "open-ended" assignment when in fact there is only one way to design the two questions below with these materials. Eventually, all students should reach the same experimental design.

Comment [G12]: This is yet another chance for students to show me their design "their way" – some will explain through writing, others through drawing.
A good hypothesis asks a student to think beyond what will happen to why something will happen.

Comment [G13]: They should know from the reading that a plant with no leaves will not have a driving force. This is a great opportunity for the students to take what they have learned and think critically about the consequences of manipulating the required apparatus.

Comment [G14]: Very important SOL stuff!

Part 2: Cohesion and Follow-up Questions

You have been given a penny, water, and a plastic dropper. Place one drop of water on the penny. Predict how many drops it will take for the water to "spill" off of your penny. _____ drops

Now count how many drops it actually takes. Record your answer here: _____ drops

2. Was there a discrepancy between your predicted and actual number of drops? Explain.

3. This phenomena is called cohesion. It is when water molecules have a slight attraction to one another, causing them to stick together. Do you think cohesion is important for the process of transpiration? Why?

4. The capillary tubes we used in class were very thin. Do you think transpiration would still work if the tubes were thicker in diameter? Why do you think this?

5. Pretend you are a water droplet in the soil about to enter a plant root on a very sunny day. Use the book to help you describe your path through the roots, up the stems, and out of the leaves. Include the following words: root hairs, osmosis, epidermis, cortex, parenchyma cells, endodermis, xylem, phloem, capillary action, transpiration, petiole, guard cell, and stomata.

Comment [G15]: This is a great discrepent event! Please see this: http://www.youtube.com/watch?v=8O8PuMkiimg

Comment [G16]: This is a great way to integrate chemistry into biology. It requires the student to make connections and elaborate on what they know about transpiration, capillary action, and the movement of water against gravity.

Comment [G17]: By phrasing a question with "why do you think" instead of "why" a student feels less pressured to find the one right answer. The important thing is to think like a scientist, not to be correct.

Comment [G18]: This is a capstone question because it requires them to use learned vocabulary and think systematically about it as they explain how water travels through a plant. This requires searching through the text because the text does not put it "in order" like they are required to write it. This will be a true test of mastery of the concepts and is a great way for the students to sort information in a text and use it by putting it in their own words.

Water Transpiration in Plants Rubric

	0	1	2	3
Hypothesis and support of hypothesis	Left blank	Hypothesis not written as if/then/because; hypothesis not justified with evidence from chapter	Hypothesis written as if/then/because; uses chapter for evidence but may not make sense	Hypothesis written as if/then/because statement; hypothesis supported using text
Variables experiment	No variables identified	Variables identified but not correct	Variables identified but not in correct order	Variables identified in both correctly
Experiment	Very unclear; Cannot see organized thought or experiment; Did not use materials provided	Between 0 and 2	Clearly written/diagramed; Experiment uses one material not available; Missed element in experimental design	Clearly written/diagramed; Experiment correct
Questions 1-4 3 points each	Leaves 2 blank; all questions are incomplete or do not demonstrate thoughtfulness	Leaves one blank; three questions are incomplete or do not demonstrate thoughtfulness	Answers all questions; two questions are incomplete or don't demonstrate thoughtfulness	Answers all questions; Demonstrates thoughtfulness in 3-4; Answers questions completely
Question 5	0	5	10	15
Question 5	Uses less than 5 of the words; makes greater than 4 mistakes in order water droplet takes	Uses 5-8 words; makes three or four mistakes in order water droplet takes	Uses 9-11 words; one or two mistakes in order water droplet takes	Uses 11-12 words; droplet follows correct path