ANSWER KEY

Modeling an Adaptation *to Climate Change*

WILT IT BE PRODUCTIVE?

TEAM MEMBER ROLES

MATERIALS MANAGER
SCALE OPERATOR
LIGHTS OPERATOR
DATA RECORDER

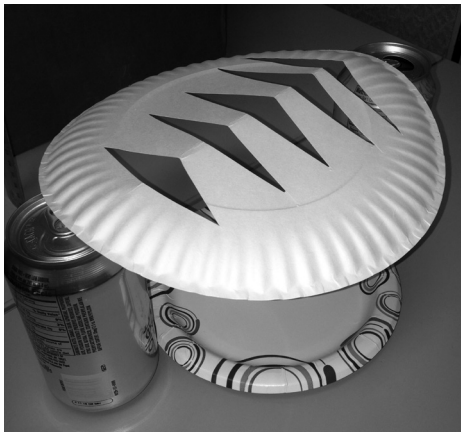

Figure 1. Experimental set up of shade treatment with plates and soda cans

MATERIALS

- 2 dessert-sized paper plates containing spinach leaves
- Calculator

EXPERIMENT SET UP

1. Please work with your instructor to assemble into teams of 4.
2. Complete the prediction below.
3. Each team member will choose a role from the list of team member roles.
4. Materials manager, collect two paired spinach plates.
5. All team members, take the plates and spinach to a station with two lights.
6. Lights operator, place the spinach plates on the table under each of the lights. Do not adjust the distance of the lights from the table, and do not turn the lights on.
7. Lights operator, set up the shade treatment by placing a soda can on each side of the spinach plate labeled "Shade." Balance the dinner plate with cutouts on top of the two soda cans (Figure 1).
8. Lights operator, under the other light, leave the spinach plate un-shaded; this is the open treatment.
9. All team members, follow the procedures on page 2.

PREDICTION

I predict that the water loss of the ___*student answers will vary*___ treatment will be **higher**.

A. SHADE **B. OPEN** **C. NEITHER (THEY WILL BE THE SAME)**

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PROCEDURES

1. Scale operator, carry the two spinach plates to the scale, and data recorder, take this handout to the scale.
2. Scale operator, place an empty dessert plate on the scale, press the tare button, and then remove the empty plate.
3. Scale operator, take the mass of each of the spinach plates, and data recorder, record it in the starting mass column of the data table on page 2 of this handout.
4. Scale operator, carry the two spinach plates to the light station.
5. Lights operator, place the spinach plates back under the lights, being sure to place the plate labeled "Shade" under the shade structure and the plate labeled "Open" under the open light.
6. Lights operator, when instructed by your teacher, turn both lights on at the same time.
7. Leave the spinach under the lights for 30 minutes.
8. All team members, after 30 minutes, return to the station, and lights operator, turn off both lights at the same time.
9. Scale operator, carry the two spinach plates to the scale and data recorder, take this handout to the scale.
10. Scale operator, tare the scale with an empty dessert plate, and then remove it.
11. Scale operator, take the mass of each of the spinach plates, and data recorder, record it in the ending mass column of the "Your Group" table below.
12. All team members, calculate the percent change of each treatment, fill in the "Whole Class" table on page 3 of this handout, and answer the results and conclusions questions.

DATA & ANALYSIS

YOUR GROUP		
	STARTING MASS (G)	ENDING MASS (G)
SHADE		
OPEN		

student answers will vary

Calculate the percent change in order to make a fair comparison. Value may be negative.

SHADE TREATMENT

$$\frac{(\text{Ending Mass}\ \_\_\_\_\_\text{g} - \text{Starting Mass}\ \_\_\_\_\_\text{g})}{\text{Starting Mass}\ \_\_\_\_\_\text{g}} \times 100 = \textit{will vary}\ \%\ \textbf{Change in Mass}$$

OPEN TREATMENT

$$\frac{(\text{Ending Mass}\ \_\_\_\_\_\text{g} - \text{Starting Mass}\ \_\_\_\_\_\text{g})}{\text{Starting Mass}\ \_\_\_\_\_\text{g}} \times 100 = \textit{will vary}\ \%\ \textbf{Change in Mass}$$

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WHOLE CLASS – CHANGE IN MASS OF SPINACH		
GROUP	**SHADE (%)**	**OPEN (%)**
GROUP 1		
GROUP 2		
GROUP 3		
GROUP 4		
GROUP 5		
GROUP 6		
GROUP 7		
GROUP 8		
MEAN		

student answers will vary

RESULTS

1. In **your group**, the percent changes in the mass of spinach that you calculated were:

A. POSITIVE **B. NEGATIVE**

Why were your calculations positive or negative?

The mass of the spinach declined over the experiment, and the negative value denotes a decrease.

2. In **your group**, which treatment had a **greater percent change in mass**? In other words, which treatment lost a larger percentage of water?

This is usually the case

A. SHADE TREATMENT **B. OPEN TREATMENT**

3. In the **whole class**, the _____ treatment had a **greater mean percent change**.

This is usually the case

A. SHADE **B. OPEN**

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CONCLUSIONS

4. Turn back to the first page and review your prediction. Was your prediction correct? Use your answer to question 3 above regarding greater mean percent change.

student answers will vary

A. **B. NO**

5. Considering the results of this experiment, does shading tend to reduce the amount of water lost from plant leaves?

This is usually the case

A. YES **B. NO**

6. Imagine that the spinach leaves in this experiment are a model for the leaves of a tomato plant. Under climate change conditions, in which treatment would you expect a tomato plant to produce more tomatoes?

This is usually the case

A. SHADE TREATMENT **B. OPEN TREATMENT**

7. List one or more challenges to using shade structures for crops as an adaptation to heat.

Student responses may include any of the following or any other valid ideas: Agricultural fields tend to be very large. Constructing shade structures over them would be very costly and require a great deal of labor, materials, and time.

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DON'T BE A LOSER!

MATERIALS

- Set of game cards
- Calculator

SCENARIO

Reality: the climate is changing due to increasing levels of atmospheric carbon dioxide.

Science fiction: you are a farmer that has the ability to miniaturize and monitor the microscopic stomata on your tomato leaves. Your hope is that your tomato plants are conserving enough water that they will not wilt.

Over a 9-day period, every day at 12:00 pm, you visit the same stoma on the same tomato leaf to determine whether it is open or closed and how much water is being conserved or lost. You assume that the stoma that you observe is giving you a reasonably good idea about how the rest of the stomata on the plant are behaving and how much water the plant is conserving or losing. You also consider the temperature at that time each day relative to the historic temperature average of the previous 30 years.

GAME INSTRUCTIONS

1. Shuffle the game cards and place them in a pile with the A side up.
2. Begin by drawing a game card to play round 1.
3. Read the A side of the card to determine the climatic conditions and the position of the stoma. The card will indicate the carbon dioxide level and temperature (°C) relative to the historic level.
4. Turn the game card over to the B side, and read how many water points you gained or lost in this round.
5. On your scorecard on page 6 of this handout, for this round, record the relative temperature (°C) and whether it was above or below the historic level, the position of the stoma (open or closed), and how many water points were gained or lost.
6. Play rounds 2-9 by repeating steps 2-6.
7. Add up all of the water points that were gained during the game and all of the water points that were lost during the game, and record them in the last row of the scorecard.
8. Subtract the number of water points lost from the number of water points gained to determine the net water points for the game.
9. Answer the results and conclusion questions.

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SCORECA

student answers may be in different order

			WATER POINTS	
	EMP (°C) / HISTORIC	STOMA	GAINED	LOST
	0.5 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**		1
2	1 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**		2
3	1.5 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**		3
4	2 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**		5
5	2.5 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**		7
6	0.5 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**		1
7	1 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**	2	
8	1.5 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**	3	
9	2 **ABOVE** / **BELOW**	**OPEN** / **CLOSED**	4	
		TOTAL	9	19

ANALYSIS: WATER POINTS DIFFERENCE

9	–	19	=	-10
Gained		**Lost**		**Net**

RESULTS

1. In your analysis, did you find that the net water points result was positive or negative?

A. POSITIVE **B. NEGATIVE**

2. Over the 9-day observation period, did your tomato leaf conserve more water than it lost or lose more water than it conserved?

A. CONSERVED MORE WATER THAN IT LOST **B. LOST MORE WATER THAN IT CONSERVED**

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CONCLUSIONS

Consider the equation for **photosynthesis** to answer the following questions.

$$6CO_2 + 6H_2O \rightarrow 6O_2 + C6H1_2O6$$
Carbon dioxide + Water → Oxygen + Sugar

3. What two chemical compounds do plants need to undergo photosynthesis? In other words, what are the two reactants in this chemical reaction?

   Carbon dioxide (CO_2) and water (H_2O)

   a. Which of the two chemical compounds listed above is available in increased abundance under climate change conditions?

      Carbon dioxide (CO_2)

4. Given your answer to question 2 regarding the amount of water conserved or lost by your tomato leaf, do you think that your tomato plant had enough water to photosynthesize efficiently?

   No

5. One of the products of photosynthesis is sugar, which is used as energy for the plant or to build other carbohydrates that make up plant structures such as leaves, stems, and fruit. If your tomato plant is not photosynthesizing efficiently, will it be able to build carbohydrates to produce tomatoes (the fruit of the plant)?

   A. YES **B. NO**

   Why or why not?

   If the plant has insufficient water for photosynthesis, it will not be able to produce the sugars that are used as building blocks to make fruits and other structures.

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