Quantitative Reasoning Exercise - Plant-Water Relations

Name _____
Group #: _____

Question 1:
Stomata control the exchange of water vapor and CO_2 between plant leaves and the atmosphere. Stomata face a major dilemma, when they are open, water is lost which can ultimately lead to death by thirst, but if they remain closed, CO_2 cannot be drawn in, leading to death by starvation.

1) Can you construct a diagram of a cross section of a leaf and illustrate the journey of water molecule from the mid-vein (i.e., xylem tissue) of the leaf to the atmosphere. Make sure to include the following terms in your diagram: water vapor concentration outside of the leaf (W_a), water vapor concentration within the leaf (W_i), Stomatal conductance to water vapor (g_{sw}), and transpiration (E).

Question 2:
Stomatal conductance to water vapor (g_{sw}) is a diffusion flux representing the ease of water vapor movement from a region of high moisture concentration to a region of low moisture concentration across the stomatal pore. As plant physiologists, we know that Fick's first law of diffusion can be used to theoretically model the diffusion of water in a leaf.

$$J = g(X_2 - X_1)$$

1) Using your diagram, can you substitute the terms in Fick law to better represent water diffusion in a leaf (i.e., substitute with the appropriate plant-water relation symbols defined above).

Question 3:
Recently, plant-water status has been a growing concern due to the greater frequency of high-temperature events during the summertime. As air temperature increases, leaf-level transpiration is expected to increase as well, which could potentially result in significant water loss and a reduction in yield. As plant physiologist, we want to investigate whether plants can maintain their water-status by quantifying transpiration rates in *Encelia farinosa* (heat-tolerant; native to the Mojave Desert) and *Solidago altissima* (temperate; native to Michigan open prairies) across a variety of temperatures. We are given the following data:

Species	Temperature	W_i	W_a	g_{sw}
Encelia farinosa	10	7.5	0.71	0.18
Encelia farinosa	20	7.5	1.16	0.20
Encelia farinosa	30	7.5	2.08	0.24
Encelia farinosa	40	7.5	2.89	0.28
Solidago altissima	10	7.5	0.71	0.24
Solidago altissima	20	7.5	1.16	0.27
Solidago altissima	30	7.5	2.08	0.33
Solidago altissima	40	7.5	2.89	0.42

1) Using the model you developed above, solve for the transpiration rate (*E*) and plot the temperature response of transpiration in the space below (label the axis with the proper units)?

2) Based on the transpiration rate of *Encelia farinosa* and *Solidago altissima*, can you infer any strategy either of these species have adapted based on their growth environment?

Confidence Questions:

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1. I have the biological cognition to develop a conceptual diagram for plant physiology processes.

Strongly disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Optional: Can you explain why you rank the question like this?

_____

_____

2. I am capable of reasoning with mathematical models and can identify/substitute the relevant variables needed to represent plant physiological processes.

Strongly disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Optional: Can you explain why you rank the question like this?

_____

_____

3. I can deploy mathematical model(s) to answer plant physiological questions.

Strongly disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Optional: Can you explain why you rank the question like this?

_____

_____

4. I can determine trends in data and defend those trends using biological arguments.

Strongly disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Optional: Can you explain why you rank the question like this?

_____

_____

5. Working through quantitative reasoning exercise in small, collaborative groups is preferred over working through the exercise by myself (i.e., independently).

Strongly disagree	Disagree	Agree	Strongly Agree

1	2	3	4

Optional: Can you explain why you rank the question like this?

_____

_____

6. I understand the value of quantitative reasoning and would like to develop better skills in it.

Strongly disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Optional: Can you explain why you rank the question like this?

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7. Do you have any other comments, concerns, or feedback that you would like to share?

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