

wrong	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
right	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	
score	100	99.0	97.9	96.9	95.8	94.8	93.8	92.7	91.7	90.6	89.6	88.5	87.5	86.5	85.4	84.4	83.3	82.3	81.3	80.2	79.2	

Water Relations

Name _____

Water plays an important role in plants. For many, water comprises 90% or more of their weight. It serves to dissolve and bring in minerals from the soil, it is the solvent for sugars from photosynthesis being carried throughout the plant, it maintains the turgor pressure in the cells, and it cools the leaves as it evaporates. Today you will investigate some of the roles of water in plants.

Hydroponics

Observation. Plants are usually seen with their roots in soil. Soil probably provides the nutrients needed for plant growth.

Question. When plants have no soil available with the usual minerals bound to clay or humus particles, how much mineral nutrition is needed?

Hypothesis #1: Pure water is ideal for plants

Hypothesis #2: A certain amount of mineral nutrients is ideal for plants

Hypothesis #3: Plants can take as much mineral nutrient as you can give.

Prediction. Plants grown under various nutrient concentrations should show varying degrees of plant growth and development.

If H1 is true, then plants will grow best, when given distilled water.

If H2 is true, then plants will grow best, when given some intermediate concentration of nutrients.

If H3 is true, then plants will grow best, when given the highest concentration of nutrients.

Experiment: Earlier in the semester, you planted radish seeds in perlite in plastic cups and added fertilizer at different concentrations until the cup was almost full. Now it is time to examine the plants to see the effect of different concentrations of nutrients in water on plants.

Locate the four cups that belong to you. They should be labeled 10x, 1x, 0.1x, and 0x. These numbers represent the concentrations of 20-20-20 fertilizer relative to the normal (1x) 12 grams per liter. Each solution was also given 1ml/L of MS-micronutrient Stock Solution.

Relative Concentration	Grams per Liter 20-20-20	Percent
10x	120	12
1x	12	1.2
0.1x	1.2	0.12
0x	0	0

If there are more than five plants in a cup, **thin them down to the five most-typical**. Examine the plants and record the following information. Please note, in filling in the charts, **do not put a 0 when there is no plant to measure! Use an X instead!**

Concentration

	10x	1x	0.1x	0x
# Germinated Plants				
Height of Plants (cm)				
round to nearest whole cm				
(Record for Each Plant)				
Average Height of Plants (cm)
Number of True Leaves				
(Record for Each Plant)				
Average Number of True Leaves
Hypocotyl Color				
Cotyledon Color				
True Leaf Color				

Analysis: Calculate the averages requested in the table above. **Circle the best colors!**

Decision. Use the data from the experiment and the analysis above to decide about each hypothesis. Explain the basis of your decision.

HYPOTHESIS #1: Pure water is ideal for plants

is cannot be rejected ***because plants in 0x concentration:***
 were taller shorter than plants in other concentrations.
 had more fewer leaves than plants in other concentrations.

HYPOTHESIS #2: A certain amount of mineral nutrients is ideal for plants

is cannot be rejected ***because plants in an intermediate concentration:***
 were taller shorter than plants in other concentrations.
 had more fewer leaves than plants in other concentrations.

HYPOTHESIS #3: Plants can take as much mineral nutrient as you can give.

is cannot be rejected ***because plants in 10x concentration:***
 were taller shorter than plants in other concentrations.
 had more fewer leaves than plants in other concentrations.

Effect of nutrients on plant tissue

Observation. You have observed that plants do not grow well in high concentrations of nutrients. It might be easy to understand why some nutrients are needed and why distilled water would not support optimal growth.

Question. Why did high concentrations of nutrients inhibit growth? From your study of water relations with cells, you might know that distilled water is hypotonic to cells and leads to turgor pressure. Perhaps the high nutrient concentration inhibited growth by destroying turgor pressure. Was the 10x solution strongly hypertonic?

Hypothesis. The 10x fertilizer solution was strongly hypertonic.

Prediction. If the 10x fertilizer solution was strongly hypertonic, then plant tissue will lose water and therefore lose weight, when placed in the 10x fertilizer solution.

Experiment. Rinse the four cups from Hydroponics and refill them $\frac{2}{3}$ full with the four fertilizer solutions: 10x, 1x, 0.1x, and 0x. Be sure to label the cups clearly!

The instructor will provide potato sticks cut on a french-fry cutter. Trim the sticks so they are of equal length and will fit into the cups submerged completely in the solution.

Blot each stick dry with a paper towel. Weigh four sticks as a group, keeping track of this group of sticks. Put one group of sticks in each cup of fertilizer solution.

	Fertilizer Concentration			
	10x	1x	0.1x	0x
Initial Weight of 4 sticks (g)

Wait one hour but swirl the cups periodically during the hour.

Blot each stick dry with a paper towel. Weigh each group of sticks again and record as before:

	Fertilizer Concentration.			
	10x	1x	0.1x	0x
Final Weight of 4 sticks (g)

In trying to assess crispness, attempt to break a stick in half. Crispy sticks break cleanly but with some force required, flaccid sticks bend easily but do not break cleanly if at all.

	10x	1x	0.1x	0x
Crispness	crispy moderate flaccid	crispy moderate flaccid	crispy moderate flaccid	crispy moderate flaccid
Color	dk blue mod blue lt blue white	dk blue mod blue lt blue white	dk blue mod blue lt blue white	dk blue mod blue lt blue white

Decant the liquids into the waste container, then discard the potato sticks, trimmings, and cups in the trash.

Analysis. Calculate the percent weight change for each group of sticks using the formula:

$$\frac{(\text{final weight} - \text{initial weight}) \times 100}{\text{initial weight}}$$

	Fertilizer Concentration				
	10x	1x	0.1x	0x	
Percent Weight Change	_____ %	_____ %	_____ %	_____ %	<u>round to whole percent</u>

The concentration that is most hypotonic is x.

The concentration that is most hypertonic is x.

The concentration that is most isotonic is x.

Decision. The hypothesis: “The 10x fertilizer solution was strongly hypertonic”

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The effect of water level

Observation. Plants need water to survive.

Question. In a typical soil, how much water is needed?

Hypothesis. The more water is available, the better it is for the plant.

Prediction. If the hypothesis is true, then plants will grow more strongly, when given unlimited water supply than plants given a more restricted water supply.

Experiment. Earlier in the semester you planted radish seeds in pots. The pots were placed inside other empty pots to elevate them, and the stacks of pots were placed in a flat filled with water. Locate your pots in the greenhouse. If there are more than 5 plants in a pot, **thin to the five most typical.** Examine the plants and record the following information (remember when to use X!):

	<u>Number of Outside Pots</u>		
	18	12	0
# Germinated Plants			
Height of Plants (cm)			
round to nearest whole cm			
(Record for Each Plant)			
Average Height of Plants (cm)	.	.	.

	Number of Outside Pots		
	18	12	0
Number of True Leaves (Record for Each Plant)			
Average Number of True Leaves	.	.	.
Widest True Leaf (cm) round to nearest whole cm (Record for Each Plant)			
Average Widest True Leaf (cm)	.	.	.
Hypocotyl Color			
Cotyledon Color			
True Leaf Color			
Soil Moisture	soggy moist dry	soggy moist dry	soggy moist dry

Analysis: Calculate the averages requested in the tables above. Circle the best colors.

The **tallest** plants were found in: soggy moist dry soil.

The plants with the **most leaves** were found in: soggy moist dry soil.

The plants with the **widest leaves** were found in: soggy moist dry soil.

The plants with the **best colors** were found in: soggy moist dry soil.

Decision. The hypothesis: “The more water is available, the better it is for the plant”

is cannot be rejected.

Discard the plants, soil, and pot labels in the trash.
Rinse out the pots and leave them in the designated area.