

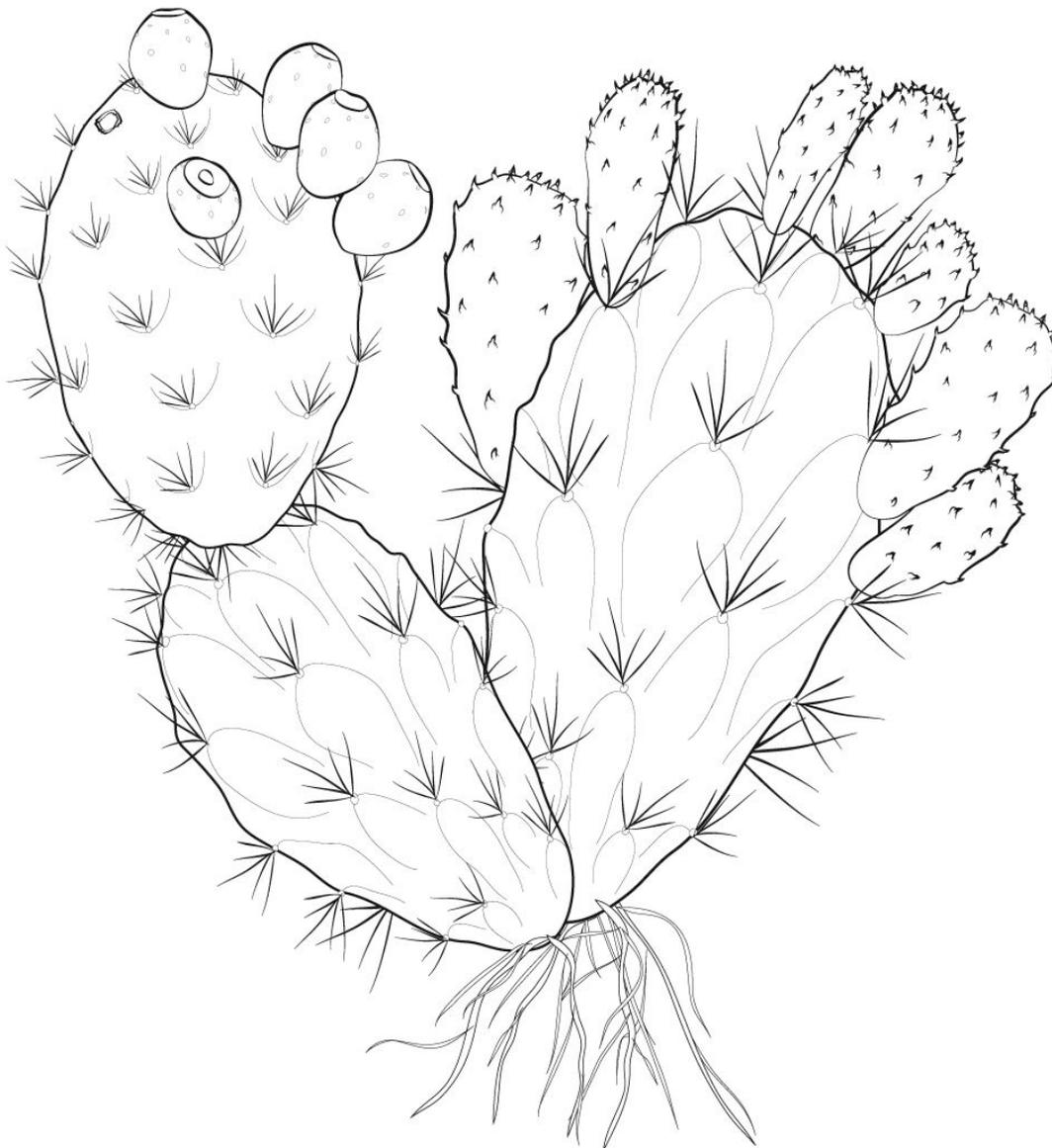
Activity 6.1: Grading Prickly Pear Worksheet

*This worksheet has “grading” in the title because at this point, students can be held accountable for correct answers. Level 4 (correct) responses to the questions are in **blue bold italics** below.*

Red italics suggest ways to grade student responses by giving them points for correct or partially correct answers. There are 14 points total on this worksheet.

Draw and label arrows that represent the molecules that carbon atoms are in as they move into, through and out of the Prickly Pear as it moves and grows.

Label each arrow to show the kind of molecules that the carbon atoms are in: large organic molecules (LOM), small organic molecules (SOM), or carbon dioxide (CO₂).



Your ideas about a Prickly Pear's needs. Four things that Prickly Pear's need to live and grow are water, soil nutrients, air, and sunlight. What are your ideas about what happens to those four things *inside* a Prickly Pear?

What happens to *water* inside a Prickly Pear?

Level 4 responses could mention two main functions that water has inside the Prickly Pear: 1) *Water is a key reactant in the process of photosynthesis. The H atoms in glucose (and all other molecules in plants) come from water.* 2) *Water carries materials to plant cells; soil minerals move through the roots to all the cells of the plants dissolved in water; sugars move from leaf cells to all the cells of the plants dissolved in water.*

What happens to *soil nutrients* inside a Prickly Pear?

Level 4 responses could mention that soil nutrients are non-organic minerals, that soil minerals dissolved in water move through the roots to all cells of the Prickly Pear or that cells combine the atoms in soil minerals (N, K, P, S, etc.) with glucose molecules to make proteins and other large organic molecules.

What happens to *air* inside a Prickly Pear?

Level 4 responses could describe two main functions that air has inside the Prickly Pear: 1) *Carbon dioxide is a key reactant in the process of photosynthesis. The C and O atoms in glucose come from CO₂.* 2) *Oxygen is a key reactant in cellular respiration. All plant cells get their energy from the energy that is released when oxygen reacts with glucose and other organic molecules.*

What happens to *sunlight* inside a Prickly Pear?

Level 4 responses will identify light as the ONLY source of energy for the Prickly Pear and describe how the energy in light is converted to chemical energy through the process of photosynthesis.

1 point for each correct response. 4 points total.

A. Investigating how a Prickly Pear grows and functions

A class is investigating how Prickly Pears grow. The teacher asks the students, "Where does most of the mass of a Prickly Pear come from?"

a. Three students shared their ideas about what happened. Do you agree or disagree with what each student claims?

Agree	Disagree¹	Todd: "I think a growing Prickly Pear gains most of its mass from nutrients in the soil."
Agree	Disagree	Maria: "I think a Prickly Pear gains most of its mass from gases in the air."
Agree	Disagree	Adan: "I think a Prickly Pear gains most of its mass from the sunlight."

1 point for each correct response. 3 points total.

¹ *On the basis of their studies in the Plants unit, students should know that soil minerals provide only a small part of a plant's mass. But Todd's hypothesis is reasonable, so you may want to give students credit if they agree.*

b. Provide an explanation. Why did you agree or disagree with each student's claim that you did?

Level 4 responses disagrees with Adan because matter cannot be converted into energy; agrees/not sure with Maria that air/gases can provide mass to plants; agrees or disagrees with Todd because soil nutrients and/or water provide mass to plants. Level 3 responses says: i) sunlight is a source of matter for plants (agrees with Adan) AND/OR ii) disagrees with Maria's claim that air could account for the tree's increased mass. Level 2 responses only reason about 1 or 2 of the claims. Level 1 responses reason about the claims in a force-dynamic way; e.g., i) the plant needs light, soil, water to grow, ii) air/gas cannot provide mass to the plant.

c. The class does an experiment to investigate how Prickly Pears grow. They started by selecting six **identical** Prickly Pears. Three of those Prickly Pears grown in regular soil. The other three plants had extra soil nutrients added to the soil in the pots. They put all six plants under **identical** conditions (i.e., the same light conditions, the same watering conditions) and let them continue growing for one month. At the end of the month, the class weighed each of the six Prickly Pears and recorded their weights in the table below. They also recorded the weight of the soil nutrients added to three of the pots.

Prickly Pears with regular soil		
Plant	Mass of nutrients added (grams)	Mass gained by plant (grams)
1	0	50
2	0	51
3	0	49
Average	0	50

Prickly Pears with regular soil plus soil nutrients		
Plant	Mass of nutrients added (grams)	Mass gained by plant (grams)
4	3	78
5	3	71
6	3	77
Average	3	75

Whose idea do you think is best supported by the data? (Circle one choice.)

- a. Todd's
- b. Maria's**
- c. Adan's

1 point for correct response

Explain how the patterns in the data support the claim that you chose.

Level 4 responses recognize there is an unaccounted for matter pool between the amount of soil nutrients added and their increase in growth; uses this mass discrepancy to explain why Maria's claim is correct. Level 3 responses identifies all matter pools, or recognizes missing pools, but agrees with Adan's claim that violates principles (Matter to Energy conversion), agrees with Todd's claim which is inconsistent with the data, or agrees with Maria's claim but has flaws in his/her reasoning. Level 2 responses choose Todd's because the mass of the plant growth with added soil nutrients is greater than the increase in mass of the plant growth without soil nutrients. Level 1 responses explain that the more soil nutrients, the more it grew, recognizes relationships among some matter pools but doesn't relate them to the claims (may provide an explanation about food use for rationale), and /or uses the presence of a matter pool (i.e., added soil nutrients) to justify a claim.

1 point for correct response

d. What additional evidence would you collect to help you show that the claim you chose is the best claim?

Level 3 responses propose questions that target limitations in the data (recognize there is an unaccounted for matter pool, i.e., gas); they focus on matter tracing and are constrained by principles such as matter to energy conversion. Level 2 responses propose evidence that partially address limitations in the data. Level 1 responses identify aspects of the system that students are curious about independent of the data, they critique the experimental design, or do not recognize that additional evidence needs to be collected.

1 point for appropriate response

B. A question about how Prickly Pears grow and function

When a Prickly Pear is alive, it has energy stored in its living parts (roots, green body, spines). When the Prickly Pear dies all the parts are still there. How much of the energy stored in the living Prickly Pear is still there in the dead Prickly Pear?

a. ALL of the energy

b. MOST of the energy

c. SOME of the energy

d. A LITTLE of the energy

e. NONE of the energy

1 point for correct response (either all or most of the energy).

Explain your answer.

What kinds of energy are stored in the living Prickly Pear? Where did they come from?

Level 4 responses suggest the Prickly Pear stores chemical potential energy in the bonds of the organic molecules in the leaves, body, and roots of the cactus. This energy remains in the living tree until the tree dies and decomposition occurs and the decomposers release the energy as heat during cellular respiration. Level 3 responses may suggest that the energy is stored in the body/leaves of the cactus and that it came from the soil, sun, water, and air. Level 2 responses may suggest that the cactus doesn't have energy, or that the cactus has energy everywhere because it is a living thing.

1 point for correct response

What kinds of energy are stored in the dead Prickly Pear (if any)? How are they connected to the energy in the living Prickly Pear?

Level 4 responses recognize that potential chemical energy is stored in the bonds of the organic molecules that make up the mass of the dead cactus. This is the same energy that was stored in the living cactus. Level 3 responses recognize that the dead cactus has energy but are unclear about what kind of energy it is. Level 2 responses associate energy with life, and think that energy disappears when things die.

1 point for correct response

C. Something interesting about Prickly Pears

What is something interesting that you learned about Prickly Pears that makes this plant different from the radish plants you grew?

1 point for appropriate response