Stimulus 1

Albino redwood trees are white-leafed parasites that can grow only if they are attached to a host tree, as shown in Figure 1. Normal redwoods can live without a host.

A group of scientists conducted an investigation to explain why normal redwoods can live without a host but albino redwoods cannot. First, the scientists identified how normal redwoods used matter from the carbon and nitrogen cycles. Figure 2 shows the role of normal redwoods in the carbon cycle. Figure 3 shows how normal redwoods use the products of the carbon and nitrogen cycles to form proteins.

Figure 1. Albino Redwood Growing on Normal Redwood

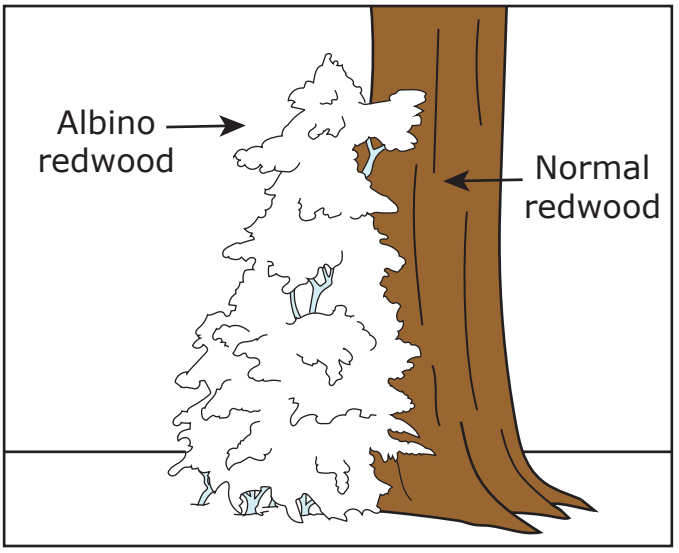
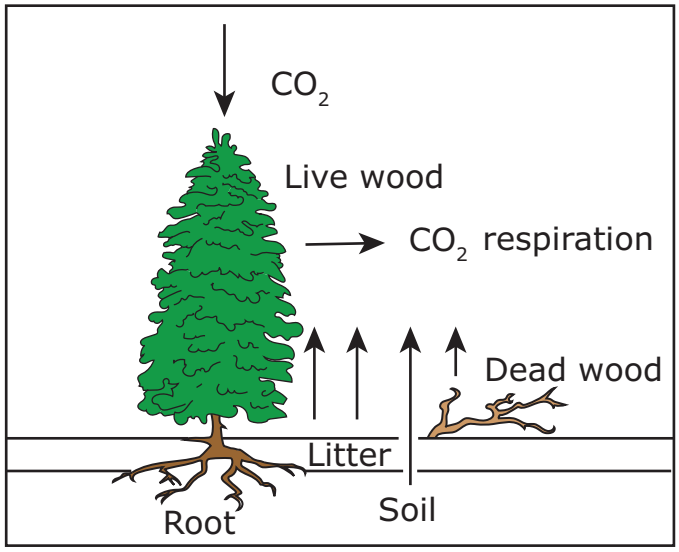
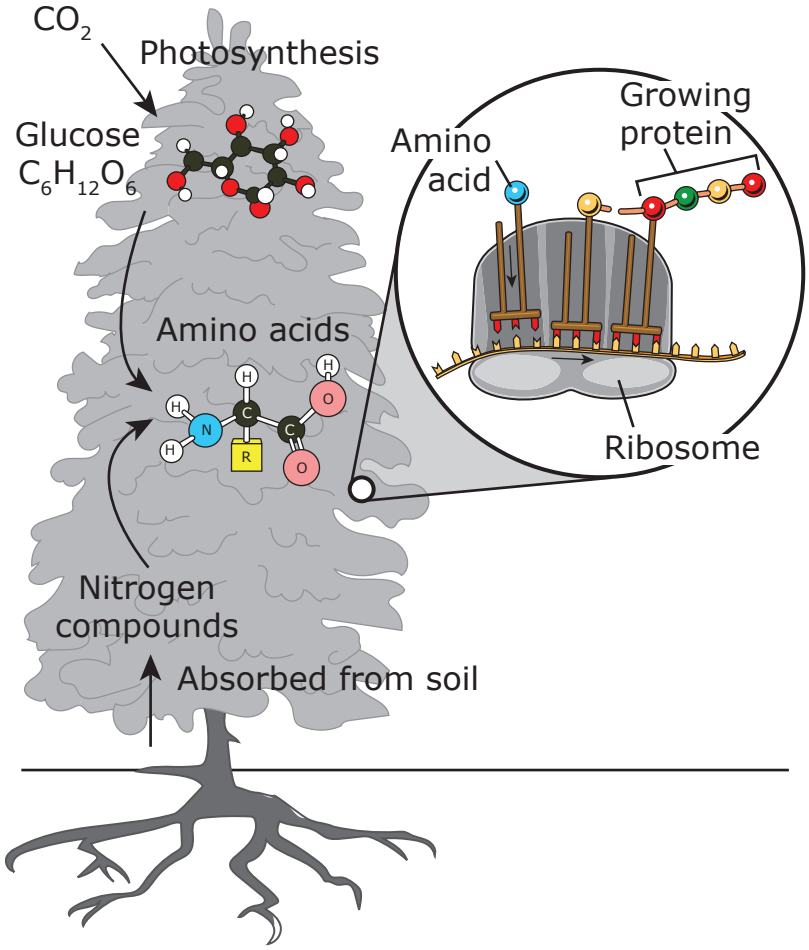


Figure 2. The Role of Normal Redwoods in the Carbon Cycle



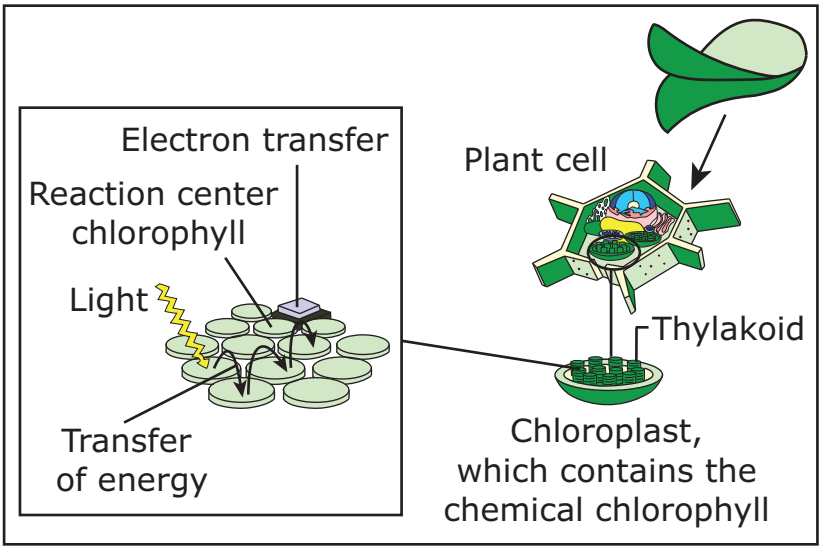
Source: C. Potter, *Open J. Ecol*, 2012

Figure 3. Production of Proteins in Plants



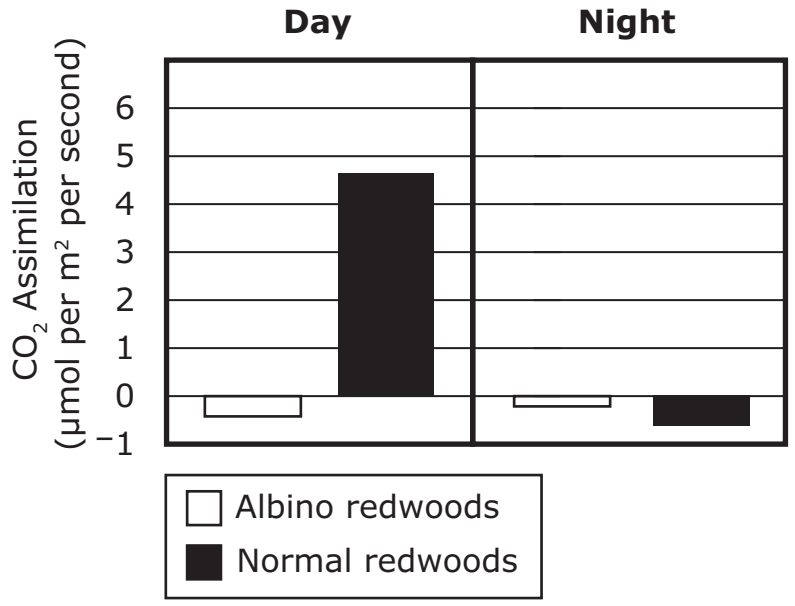
The scientists then compared the traits and anatomy of albino and normal redwoods. Albino redwoods have white leaves that are caused by a genetic mutation that blocks the production of chlorophyll. Normal redwoods have chlorophyll. Figure 4 shows the function of chlorophyll in plants.

Figure 4. The Role of Chlorophyll in Photosynthesis



Finally, the scientists investigated how the difference in levels of chlorophyll affected the assimilation of carbon by the two types of trees. Carbon assimilation is the amount of carbon dioxide a plant uses during photosynthesis. A negative carbon assimilation means that the plant released more carbon dioxide than it used. Figure 5 compares carbon assimilation of albino and normal redwoods during the day and night.

Figure 5. Carbon Assimilation of Redwoods



Source: Pittermann et al., *PLOS One*, 2017

Item 1

Based on the information in Figure 4, which statement best explains how the lack of chlorophyll affects energy and matter cycling in albino redwoods?

- A. Albino redwoods cannot use chemical energy, so they use carbon dioxide directly to make proteins.
- B. Albino redwoods cannot absorb or transfer light energy, so they cannot use carbon dioxide to produce glucose.
- C. Albino redwoods can produce chemical energy only during the nighttime, so they absorb carbon dioxide only at night.
- D. Albino redwoods can store light energy for only a short time, so they absorb more carbon dioxide than normal redwoods do.

Item 2

Based on Figure 3, how does carbon dioxide in the environment relate to the production of proteins in plants?

A. The atoms in carbon dioxide are used to form glucose, and glucose reacts with nitrogen to form the building blocks of proteins.

B. The carbon dioxide molecules react with glucose to form ATP, and ATP is used as energy to form the building blocks of proteins.

C. The atoms in carbon dioxide are destroyed during photosynthesis, and these atoms are replaced by nitrogen during protein synthesis.

D. The carbon dioxide molecules provide energy to produce glucose, and glucose reacts with nitrogen compounds during protein synthesis.

Item 3

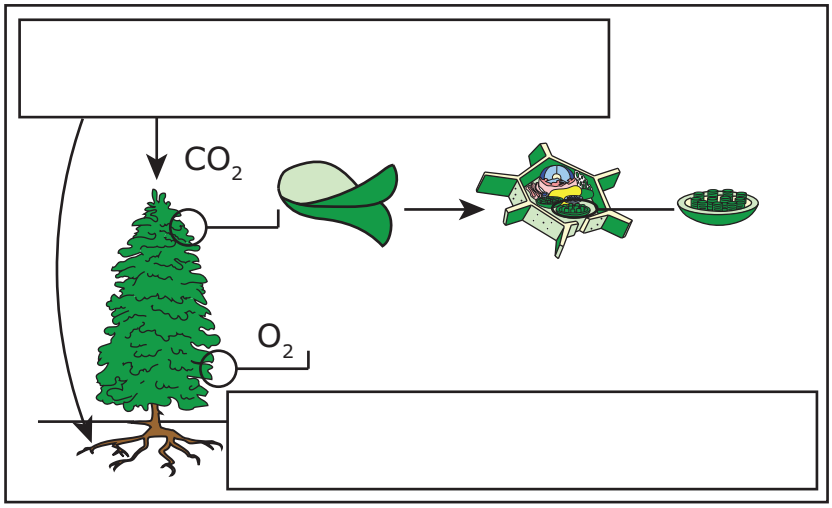
The scientists use a model to explain how the evidence in Figure 3 and Figure 4 relates to carbon cycling in normal redwoods during the day.

Complete the model with the process that occurs at each stage.

Write the correct answer in each box. Not all answers will be used.

Intake of light, CO_2, and H_2O increases.
Intake of light, CO_2, and H_2O decreases.
Intake of light increases. Intake of CO_2 and H_2O decreases.
Carbon assimilation increases. O_2 release increases.
Carbon assimilation decreases. O_2 release decreases.
Carbon assimilation increases. O_2 release decreases.

Photosynthesis During the Day



Item 4

Based on Figure 4 and Figure 5, explain the trends for the normal redwood trees at night.

Circle the correct answer from each list to complete the sentence.

Carbon dioxide release in normal redwoods during the nighttime

increases
decreases
stays the same

compared to release during the daytime because the trees produce

a greater amount of glucose than
the same amount of glucose as
a smaller amount of glucose than

they use.

Rubric	
Score	Description
1	Carbon dioxide release in normal redwoods during the nighttime **increases** compared to release during the daytime because the trees produce **a smaller amount of glucose than** they use.
0	The response is incorrect or irrelevant.

Item 5

Based on Figures 3, 4, and 5, determine how each type of redwood tree obtains the matter and energy needed to synthesize protein.

Write the correct answer in each box. Not all answers will be used.

A. produce glucose and oxygen from carbon dioxide, light, and water

B. consume glucose from other organisms and absorb oxygen from the air

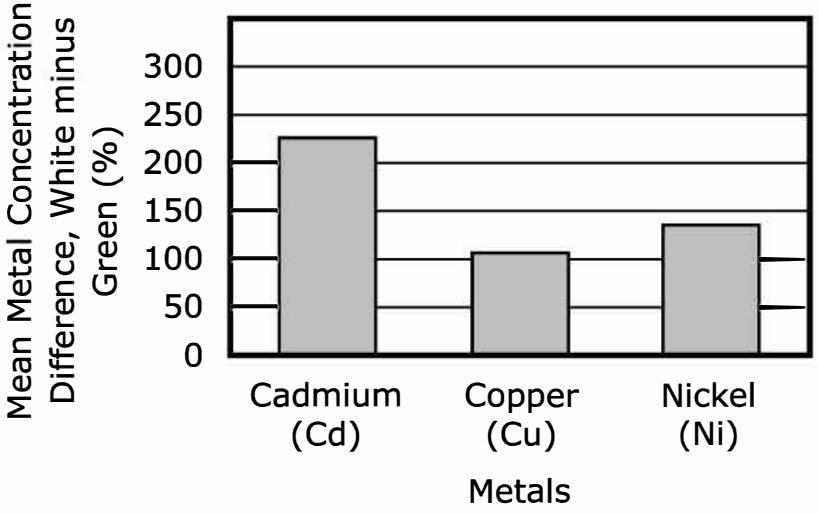
C. absorb glucose, oxygen, and water directly from the environment

To obtain matter and energy for protein synthesis, albino redwoods [ ], while normal redwoods [ ].

Rubric	
Score	Description
1	To obtain matter and energy for protein synthesis, albino redwoods **consume glucose from other organisms and absorb oxygen from the air**, while normal redwoods **produce glucose and oxygen from carbon dioxide, light, and water**.
0	The response is incorrect or irrelevant.

Item 6

Figure 6. Metal Concentrations in White Leaves Relative to Green Leaves



Source: Colorado State University, 2016

Redwood trees absorb cadmium, copper, and nickel from the soil through their roots. At high levels of absorption, these metals can build up in the leaves and cause damage to the chloroplasts.

A scientist investigated whether albino trees affect the cycling of toxic metals in their hosts. For this investigation, the scientist studied half-albino redwoods, which are trees that have both white leaves and green leaves. The scientist examined how half-albino trees distributed toxic metals by comparing the metal concentration in the white leaves with the concentration in the green leaves. The scientist then calculated the percentage difference in metal concentration. Figure 6 shows the results of the study.

The scientist wants to relate these data to albino redwoods that attach to a host tree. Use the information to complete the following tasks:

- Based on Figure 6, make a claim about the absorption of toxic metals in relation to albino redwood trees and normal redwood trees. Provide evidence to support your claim.
- Predict how the growth of an albino tree affects the health of the chloroplasts and how the health of the chloroplasts affect the tree's ability to produce protein and energy.
- Explain how the growth of the albino tree changes the flow of matter and energy into and out of the host plant.

Analyze the information carefully. Then write your response in the space provided. Support your answer with details.

Scoring Rubric	
Score	**Description**
3	The student answers all 3 parts correctly.
2	The student answers any 2 parts correctly.
1	The student answers any 1 part correctly.
0	The response is blank, incorrect, or irrelevant.
	• Albino redwoods absorb more toxic metals in their leaves than do normal redwoods. This is supported by the graph. which shows that the white leaves of the half-albino plants absorbed higher levels of toxic metals than the green leaves of the same plant. • When the albino tree grows on the host plant, it could absorb and retain more toxic metals from the environment, which prevents damage to the chloroplasts in the host plant. Preservation of the chloroplasts is vital for matter and energy flow because chloroplasts are organelles in cells that take in light, carbon dioxide, and water and produce glucose and oxygen. This glucose is used to make biomolecules needed by the entire plant, including amino acids, which are the building blocks of protein. Glucose is used to produce energy so that the plant cells can perform vital life functions. • Since albino trees cannot perform photosynthesis, they absorb some of the glucose that normal trees make. The host plant takes in carbon dioxide, water, and light energy to produce glucose. However, the host plant (the normal redwood) does not store or use all of the glucose it makes because some glucose is transferred to the albino redwood.