

Not all shade is the same

Note:

This task is designed so that it can be solved with the incremental hints.

The hints are available on the media portal for printing, or the students can use them online on a tablet or smartphone via the QR code included on the worksheet.

The worksheet for the students and the hints for printing are available as separate files on the media portal of the Siemens Stiftung. General information on using tasks with incremental hints in the classroom is provided in the “Tasks with incremental hints – an introduction” document, which is also available on the media portal.

1 Topical aspects

The task is related to the energy balance during the transition between the states of aggregation, and it specifically addresses the evaporation of water from the leaves of a plant.

2 Learning prerequisites and level of difficulty

First, the students must already know that plants absorb water through their roots and release most of the water via the stomata of their leaves. This is usually one of the first topics in biology or science class in grades 5 and 6. The students learn about the states of aggregation of water in elementary school. Students at the beginning of the intermediate grades are familiar with the phenomenon that energy must be added for each transition from the solid to the liquid state and from the liquid to the gaseous state. However, they may not be familiar with the scientific law. If the teacher is not sure whether all students have this prior knowledge, other experiments can simply be conducted before this task, for example, the evaporation of water under different conditions, or the comparison of evaporation from an uncovered bowl with the evaporation of water via a green plant, such as basil.

Under the conditions mentioned, the level of difficulty of the task is medium. The students must link two principles together – the energy balance during evaporation and water transport in plants – and draw the appropriate conclusions.

3 Background on the task

The difference between a patio umbrella covered with fabric and the leaf canopy of a tree is mainly that the tree constantly evaporates water and the umbrella does not. Because energy in the form of heat must be added to the process of water evaporation, this heat is extracted from the surroundings. The air under the leaf canopy is therefore cooled off. However, this effect cannot be observed with a very small tree because the air is exchanged quickly. Therefore, it really is cooler in the shade under a leaf canopy than under a patio umbrella, but only if the trees are larger.

4 The task

In the simplest form, the task can be formulated as follows:

Explain why on hot summer days it is usually cooler in the shade of a tree with a thick canopy of leaves than in the shade of a patio umbrella covered with fabric.

Because the context from which a task is developed fosters learning, depending on the teacher's assessment, a contextual scenario can be developed, such as the following:

After a bike ride, everybody looks for a place in the shade. Some sit under the patio umbrellas in front of the youth hostel, while others sit in the shade of the nearby beech tree.

“Come sit with us,” Meike calls to her friend Johanna. But Johanna doesn’t want to trade her place under the tree. “You come over here. It’s a little cooler here than under your umbrella!” Meike can’t believe that. How could it be cooler under a tree than under such a colorful umbrella?

The goal of working on this task is to find a reason for the different effects of a leaf canopy and a patio umbrella.

5 Variations

Depending on the learning group, the number of hints can be decreased or increased; the information about photosynthesis and about changing the state of aggregation can also be expanded. The question of whether the detailed context story should be used depends on the teaching conditions.

6 Overview of the hints

Note: The hints have been prepared as a separate file for printing or can be used online via the QR codes on the worksheet.

<p>Hint 1 Explain the task to each other again in your own words. State what you understood the task to be and what is still unclear to you.</p>	<p>Answer 1 We’re supposed to find an explanation for why it is cooler in the shade under the leaf canopy of a tree than under a patio umbrella.</p>					
<p>Hint 2 How it is possible that it can be cooler in the shade just because the “roof” providing the shade is different? Think what could cause this!</p>	<p>Answer 2 When it is cooler in a certain kind of shade, something there must be making the air cooler. This must be related to the “roof” overhead.</p>					
<p>Hint 3 Make a list of things that a leaf canopy and a patio umbrella have in common. Explain how they differ. You could create a table.</p>	<p>Answer 3</p> <table border="1" data-bbox="770 1444 1444 1704"> <thead> <tr> <th data-bbox="770 1444 1090 1478">Patio umbrella</th> <th data-bbox="1090 1444 1444 1478">Leaf canopy</th> </tr> </thead> <tbody> <tr> <td data-bbox="770 1478 1090 1704"> <ul style="list-style-type: none"> ▪ Protects from direct sunlight ▪ Fabric covering ▪ Fabric is “dead” </td> <td data-bbox="1090 1478 1444 1704"> <ul style="list-style-type: none"> ▪ Protects from direct sunlight ▪ Leaves ▪ Leaves on a tree are “alive” </td> </tr> </tbody> </table>		Patio umbrella	Leaf canopy	<ul style="list-style-type: none"> ▪ Protects from direct sunlight ▪ Fabric covering ▪ Fabric is “dead” 	<ul style="list-style-type: none"> ▪ Protects from direct sunlight ▪ Leaves ▪ Leaves on a tree are “alive”
Patio umbrella	Leaf canopy					
<ul style="list-style-type: none"> ▪ Protects from direct sunlight ▪ Fabric covering ▪ Fabric is “dead” 	<ul style="list-style-type: none"> ▪ Protects from direct sunlight ▪ Leaves ▪ Leaves on a tree are “alive” 					
<p>Hint 4 Apparently, the cooling under the leaf canopy has to do with the fact that the leaves are “alive.” Remember: What do you know about leaves?</p>	<p>Answer 4 Photosynthesis takes place in leaves; water evaporates via the stomata of the leaves.</p>					
<p>Hint 5 Which of the leaves’ functions is most likely the cause of cooling?</p>	<p>Answer 5 The release of water via the leaves is most likely the cause. Water is released as water vapor, which requires energy.</p>					

Hint 6

Now you have all the information you need to answer the question of why it can be cooler in the shade of a tree than under a patio umbrella.

Answer 6

Plants release large amounts of water into the air via their leaves. The energy that is required to change water from the liquid state to the gaseous state is extracted from the surrounding air in the form of heat. The air under the leaf canopy cools off.