MODULE 9

Water movement in plants - Experiments at the Botanic Garden

TIMING
1 hour 30 min

MATERIALS *per group*
Labels with water drops and water clouds
Living plants showing all parts
A bowl with water and waterlily leaf and stalk
Flip chart paper
Bucket of water
T-shirt
Science notebook
Pencils and markers
Magnifying glasses
Sticks with straws
Leaves of beech and weeping fig
KOH (potassium hydroxide) solution 10%
Jar, pot
Hot plate
Glass stick
Bleach
Photocopies of sheet E16

MATERIALS *per child*
Toothbrush
Paper tissues
Protective glasses gloves, clothing
Envelopes
Microscope

SKILLS
Observation
Argumentation
Working like a scientist

KEYWORDS
Water transport
Plant veins
Leaf skeleton

CROSS CURRICULAR ACTIVITY
Art

Overview

Children learn how water moves in plants and how it is transported to the leaves for photosynthesis. They explore living plants around them, and look for water transport routes (vascular bundles) in leaves. Vascular bundles allow the channelling of sugar and water to different parts of the plant.

The students prepare their own leaf skeletons in the classroom. This module works best in a Botanic Garden or other natural environment where there are plenty of plants to observe.

Aims

To understand how water transport takes place in plants.
To observe closely water transport routes in the appropriate plant parts, e.g. veins.
To learn to conduct an experiment by following detailed instructions.

Preparation

Prepare the following teaching aids:

- 'Cooked' leaves. See Teachers' Notes.
- A pot with water with a freshly cut waterlily leaf and stalk placed in it. Bear in mind that as soon as they are cut, waterlilies close their stomata rather quickly.
- A bucket filled with water with a submerged T-shirt in it.
- 2 labels per child, 1 with a drawing of a water drop and 1 with a little cloud on it.
- Sticks with a piece of a straw glued on it. Each group should be given 2-3 of these sticks.

Teaching sequence

1. Distribute plants so that children can touch them and look at them closely. Ask them to name the various parts (roots, stem, flowers, leaves).
2. Show the students stomata by blowing into the waterlily stalk while keeping the leaf under water. Make sure that all children can see the bubbles coming out from the upper side of the leaf. Tell them that stomata are usually found on the lower side of the leaf. However, waterlilies and some other plants have stomata on the upper side of the leaf.
3. Divide the children into pairs and ask them to draw a big picture, on a very large sheet of paper, of part of a plant so that both of them can stand inside the lines. Each pair uses a different colour for its parts. Remind the artists not to forget the stomata in the leaf surface.

Water transport in plants

4. Take the T-shirt out of the water and ask the children what they think will happen when it is put on a washing line. Ask them how it will become dry.
5. Ask the children how they think water gets from the ground into the leaves of land plants. Tell them that some trees are more than 100 metres high – so how does the water travel that far?
6. Ask the children how they think water plants carry out photosynthesis and where they get the ingredients for this process.
7. Go back to the plant sketch and ask the children to form a chain. Some children should stand on the roots, some on the stalk and some on the leaf. Ask each child to pin a label with a water drop on it to their clothes.
8. Take a child who is standing near the stomata by the hand and pull it out of the leaf. Tell the children that water molecules always stick together (ask the children to hold hands). As soon as one child is pulled out of a stomata the others follow. As soon as each child has left the stomata they should pin on the water cloud label. The water drop has changed and is now in the air.
9. Continue to pull the children out of the leaf, one by one. All the water molecules in the plant have reached the leaf. Finally all the water drops have changed and are in the cloud.

Water transport routes in plants

10. Divide the children in groups of four. Each group gets 2 or 3 straw–sticks, a magnifying glass, a science notebook, a pencil and activity sheet E16.
11. Ask the children to search for plants where they think they can see water transport routes with their magnifying classes (veins / vascular bundles). They should mark the selected plant with the straw-stick and fill in their activity sheets. Each group should find 2-3 plants.
12. After finishing this activity the whole group examines the selected plants and the groups explain why they chose the plant and where they saw the leaf veins.

Prepare a leaf skeleton

13. Children should wear something to protect their clothes, e.g. lab coat, large old T-shirt. Protective glasses are needed to prevent any liquid reaching their eyes. Gloves are needed to protect skin from the bleach.
14. Each child gets a paper tissue, a soft toothbrush and a precooked leaf.
15. The leaf is put on the paper tissue. Each child gently brushes the leaf to remove the tissue between the veins. Start at the central vein and brush outwards towards the edge of the leaf.
16. Turn the leaf over and do the same on the other side.
17. As soon as the skeleton can be seen properly, the leaf is put into a bowl with bleach. The leaf can remain in the bleach until the colour changes from brown to yellow and finally, white.
18. Remove the leaf from the bleach and dry it between two sheets of paper tissue.
19. Put it under a microscope or observe it with a magnifying class.
20. Hand out envelopes. Ask children to write their name on it, put the leaf skeleton in to it and take it home.

Use the PowerPoint in the Media Gallery Experiments with plant growth M9 Leaf skeletons.

Teacher / Botanic Garden educator notes

To prepare half a litre of 10% KOH (potassium hydroxide) solution, take a one litre glass beaker, weigh in 50 g of KOH and fill with tap water until you will have 500 g of KOH solution. The solution gets warm as soon as KOH dissolves.
CORROSIVE and IRRITANT. Use a water bath and open a window while boiling the leaves in 10% KOH solution.

Without children present, cook *Fagus sylvatica* (beech) or *Ficus benjamina* (Benjamin´s or weeping fig) leaves in 10% KOH for about 45 min. This should be done in a jar that has been put into a water bath because KOH will ruin metal pots. KOH is not volatile so this experiment does not require a fume cupboard. However, it is advisable to open a window if possible while cooking. Use at least two leaves per child because many children will want to work on more than one leaf.

After 45 min of cooking, take one leaf out and try to remove the tissue with a soft tooth brush (see pictures of process in Media Gallery Experiments about plant growth M9 Leaf skeletons). If the tissue does not come away, cook the remaining leaves for another 15 min. Take all the leaves out and put them in a bowl of water.
Water transport in plants is based on the evaporation of water from the stomata. Plants balance the need to open their stomata to take carbon dioxide in and carry out photosynthesis with the need to shut the stomata to prevent water loss.
It is the surface tension between water molecules that make them 'stick together' and a continuous water flow takes place in plants as soon as stomata are open.
If the water column breaks due to a lack of water in the ground (because the ground is frozen) a particular vein is not able to maintain the water flow. Depending on the plants' morphology, some are able to refill these veins whereas others have to compensate for the loss.
Each plant vein (vascular bundle) consists of three parts: xylem, which is responsible for transporting water, phloem where products like sugars are channelled and cambium which is the group of dividing cells from which both the xylem and phloem grow. Veins are often strengthened by fibres, which help keep their shape. These fibres enable us to see veins on the stalks and leaves of plants. If the wood is cut across you can see the water transporting vessels (xylem), seen in tree rings. Some timbers like ash and oak have very large rings that can be seen even without a magnifying glass.

Health and Safety

KOH solution can damage and stain skin and clothes (it is an irritant and turns skin and clothes red).
While working with KOH wear protective gloves, glasses and clothing. Stains of KOH on clothes are invisible once they are dry, but will cause holes after washing.
Children wear protective glasses only to prevent them from putting their fingers into their eyes by accident.
They do not come into contact with KOH solution because the leaves are washed in water before they are given to them.
However, they will work with bleach which also hurts the eyes and will produce stains on their clothes.

Observation Protocol

Place:

Date:

Names:

Plant name: .....

In which area of the Botanic Garden does the plant grow?

On which parts of the plant do you think the water transport routes (veins/vascular bundles) are visible?

Write down anything else you want to remember about your plant

Plant name: .....

In which area of the garden does the plant grow?

On which parts of the plant do you think the water transport routes (veins/vascular bundles) are visible?

Write down anything else you want to remember about your plant