Name: _____( ) Class: _____ Date: _____

The Tallest of Them All

Topic: Nutrition and Transport in Flowering Plants | *Student's Handout*

➢ Aims

At the end of this lesson, you should be able to…

- explain how the structure of the xylem enables water to move up the plant,
- explain how the leaves are responsible for moving water up the plant,
- identify the surface of the leaf that plays a bigger role in moving water up the plant
- explain how the number of stomata affects the rate of transpiration in the plant.

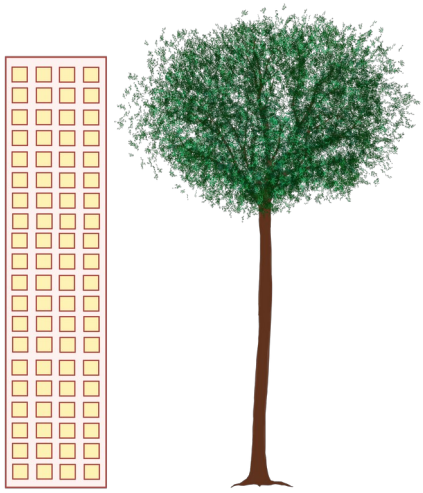
➢ Safety

Handle capillary tubes with care. Inform your teacher immediately if there is any breakage. Refrain from handling the broken glass pieces on your own.

➢ Activity

Handout A: Investigating How Water Travels Up a Plant

The tallest tree in Singapore is found in Bukit Timah Nature Reserve. Known as the Seraya tree (*Shorea curtisii*), it can grow up to a height of 60 m, which is equivalent to a 20-storey HDB block!



How is water able to travel against gravity, from the roots, through the xylem to the leaves at the top of such tall trees?

In this activity, you will be investigating the features that enable water to travel up a plant.

Investigation 1: How does the structure of the xylem enable water to move up the plant?

In this investigation, the straws and capillary tube are used to model the xylem.

Materials

- 1 large straw
- 1 regular straw
- 1 capillary tube
- 1 half of a petri dish
- 10 mL of coloured water
- 1 ruler
- 1 marker

1. In Table 1.1, trace the circumference of the large straw, regular straw and capillary tube.
2. Use the ruler to measure the diameter of the outline you have drawn. Record your measurements in Table 1.1.
3. Fill the petri dish with the coloured water.
4. Place the large straw into the petri dish with one end firmly on the base of the petri dish (Fig. 1.1).

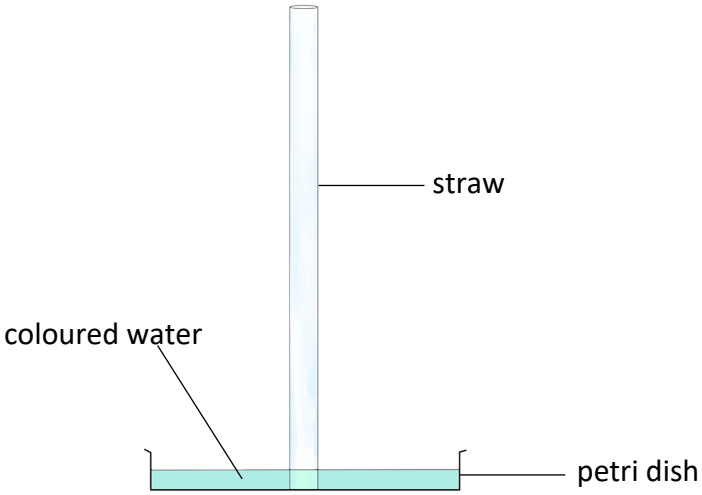


Fig. 1.1

5. Using the marker, mark out the height that the coloured water travels up to (i.e. height of the coloured water column) in the large straw.
6. Use the ruler to measure the height of the coloured water column. Record your measurement in Table 1.1.
7. Repeat steps 4 to 6 with the regular straw and capillary tube.

See

- What is the diameter of each straw/tube?
- What is the height of the coloured water column in each straw/tube?

Table 1.1

	Circumference outline	Diameter (cm)	Height of coloured water column (cm)
Large straw			
Regular straw			
Capillary tube			

Think

- What is the relationship between the diameter of the straws/tube and the height of coloured water column?
- Which straw or tube best represents the structure of a xylem? Why?

Wonder

- How does a tube with a narrower lumen allow water to travel up the plant?
- How well does this model illustrate the function of the xylem?

Investigation 2: How are the leaves responsible for moving water up the plant?

Setups **X** and **Y** were set up and left overnight. The water levels in both syringes started at 1 mL.

Materials

- Setup **X**
- Setup **Y**

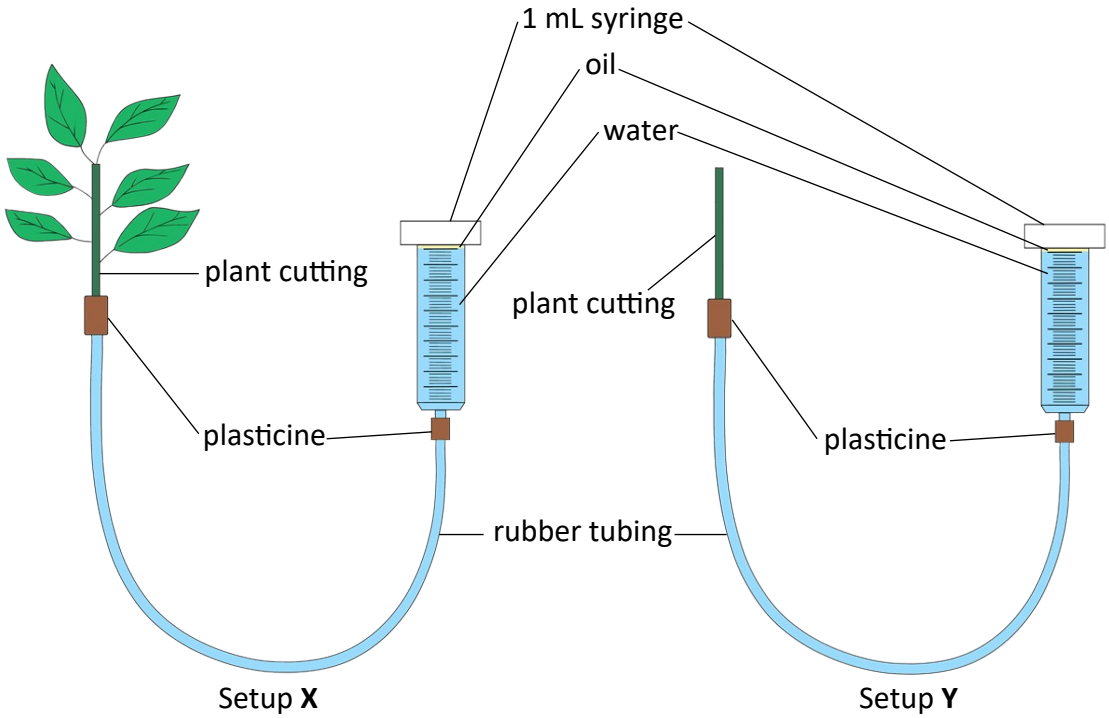


Fig. 2.1

1. Compare setups **X** and **Y**.
2. Record the water level in the syringes in both setups in Table 2.1.

See
What are the water levels in the syringes in setups **X** and **Y** after leaving them overnight?
Table 2.1

	Water level in syringe before experiment (mL)	Water level in syringe after experiment (mL)	Difference in water level in syringe (mL)
Setup **X**			
Setup **Y**			

Think

- What do the differences in water levels in the syringes indicate?
- Compare the results for setup **X** and **Y**. Suggest a reason for the difference(s) observed.
- What is the purpose of setup **Y**?
- What is the purpose of the oil and plasticine used in the experiment?

Wonder

- How can this experiment be modified to investigate the rate of transpiration?
- Since the presence of leaves allows a greater rate of water loss in a plant, how does this link to the adaptations of different plants in different climates?

Investigation 3: Which surface of the leaf plays a bigger role in moving water up the plant?

Materials

- 1 potted plant (at teacher's desk)
- 2 pieces of blue cobalt (II) chloride paper
- Transparent adhesive tape
- 1 pair of scissors
- 1 stopwatch

1. Use the pair of scissors to cut off one leaf from the potted plant. Identify the upper and lower surfaces of the leaf.
2. Cut one strip of transparent adhesive tape about 2 cm long.
3. Place a piece of blue cobalt (II) chloride paper on the upper surface of the leaf. Blue cobalt (II) chloride paper turns pink in the presence of water.
4. Seal the cobalt (II) chloride paper onto the leaf's surface using a strip of transparent adhesive tape (Fig. 3.1).

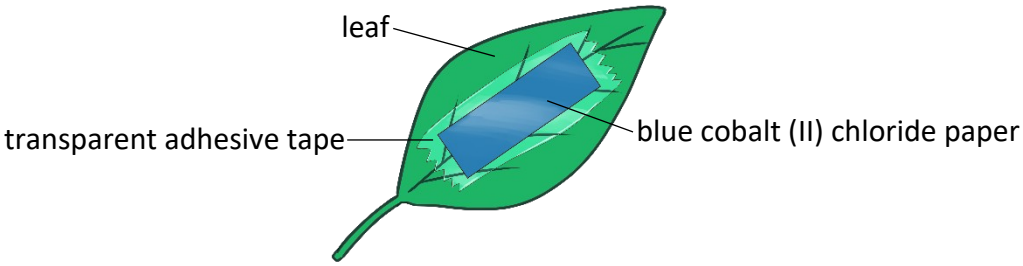


Fig. 3.1

5. Repeat steps 2 to 4 on the lower surface of the leaf.
6. Using the stopwatch, take note of the time taken for each piece of the cobalt (II) chloride paper to turn completely pink. Record your results to the nearest minute in Table 3.1. You may work on the next investigation while waiting for the cobalt (II) chloride paper to change colour.

See

How long does each piece of cobalt (II) chloride paper take to turn from blue to pink?

Table 3.1

	Position of cobalt (II) chloride paper	
	Upper surface of leaf	Lower surface of leaf
Time taken for cobalt (II) chloride paper to turn from blue to pink (min)		

Think

- Which surface of the leaf plays a bigger role in moving water up the plant?
- Why do you think so?

Wonder

- What is a potential limitation of this experiment?
- Suggest improvements to this experiment to minimise the limitation.

Investigation 4: How does the presence of stomata enable water to move up the plant?

Materials

- 2 microscopes, each with a prepared sample of the **upper** surface of a leaf labelled **P** and **Q**
- 2 microscopes, each with a prepared sample of the **lower** surface of a leaf labelled **R** and **S**

Note: The microscopes have been set up for viewing of the upper and lower surfaces of four leaves. Do not adjust the focusing or the positions of the slides.

1. Observe leaf sample **P** under the microscope.
2. Count the number of stomata on leaf sample **P** and record your results in Table 4.1.
3. Repeat steps 1 and 2 for samples **Q**, **R** and **S**.
4. Calculate and record the average number of stomata on the upper and lower surfaces of the leaves respectively.

See

How many stomata are there on the upper and lower surfaces of a leaf?

Table 4.1

	Upper surface of leaf		Lower surface of leaf	
Sample	**P**	**Q**	**R**	**S**
Number of stomata observed				
Average number of stomata				

Think

- How does the presence of stomata affect the movement of water up a plant?
- Compare the number of stomata on the upper and lower surfaces of the leaves. Suggest a reason for the difference (if any).

Wonder

- Are stomata always found in greater abundance on the underside of leaves of all plants? Provide instances where this may not be true.

Handout B: Key Takeaways

Consolidate your learning by identifying the key takeaway(s) from each investigation.

Investigation 1: How does the structure of the xylem enable water to move up the plant?
Investigation 2: How are the leaves responsible for moving water up the plant?
Investigation 3: Which surface of the leaf plays a bigger role in moving water up the plant?
Investigation 4: How does the presence of stomata enable water to move up the plant?

Handout C: Check Your Understanding

Using your understanding of capillary action and transpiration, answer the following questions.

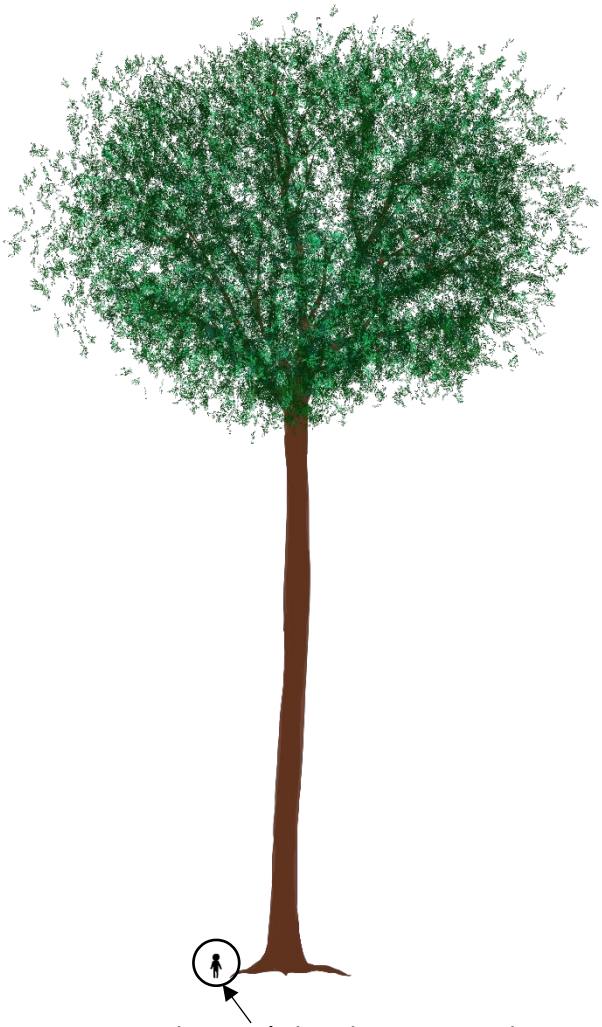
1. Use the helping words to fill in the blanks. Each word may be used once, more than once, or not at all.

push	narrow	wide
weaker	pull	loss
stomata	gain	stronger

Capillary action is the ability of a liquid to flow through _____ spaces without any assistance and even against gravity. It occurs when the adhesive forces between the liquid and the walls of the space are _____ than the cohesive forces between the liquid molecules. This helps water to move up the _____ xylem vessels of plants.

While water is taken into plants through their roots, it is also evaporating through the _____ of the leaves. The _____ of water vapour through the _____ is known as transpiration. As transpiration occurs, a suction force is created, drawing water up from the roots to the leaves. This force is called transpiration _____.

2. How much do capillary action and transpiration each contribute to the movement of water up the Seraya tree? Shade the bars to estimate how high water will move up the tree with each individual factor.



An average human's height compared to the height of a Seraya tree

With capillary action only

With transpiration only

3. Carbon dioxide is one of the most abundant greenhouse gases in the Earth's atmosphere. As more fossil fuels are burnt, more carbon dioxide is released into the atmosphere. How will a large increase in atmospheric carbon dioxide concentration affect the rate of transpiration in plants? Why?

4. After going through the investigations, what questions do you have about the transport of water in plants?

QR Codes

Investigation 1: How does the structure of the xylem enable water to move up the plant?	Investigation 2: How are the leaves responsible for moving water up the plant?
Investigation 3: Which surface of the leaf plays a bigger role in moving water up the plant?	Investigation 4: How does the presence of stomata enable water to move up the plant?

Lesson format

Time	**Activity**
10 min	Briefing and settle down, form groups of 3
20 min	Conduct the practical assigned (Inv 1/2/3 **and** 4), fill up the worksheet and Padlet check-in
8 min	Presentation round 1 (Member 1) - 3 minutes of sharing - 2 minutes of Q&A - 2 minutes of jotting comments on Padlet
8 min	Presentation round 2 (Member 2) - 3 minutes of sharing - 2 minutes of Q&A - 2 minutes of jotting comments on Padlet
8 min	Presentation round 3 (Member 3) - 3 minutes of sharing - 2 minutes of Q&A - 2 minutes of jotting comments on Padlet
5 min	Final de-brief and consolidation Students are to use the collective work done on Padlet to consolidate their learning at home; Complete the worksheet on hard copies for submission the following day.