Introduction:

¶In my investigation I plan on conducting an experiment to find out what effect the surface area has on the rate of transpiration.

¶Plants are autotrophic i.e. they make there own food (energy) through the process of photosynthesis.

$6CO_2 + 6\,H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

¶For the above process plants require carbon dioxide and water as well as sunlight. They get the carbon dioxide from the air and water is absorbed from the soil through the process of osmosis.

¶Plants add considerable volume of moisture to the atmosphere. After absorbing water trough their roots, the water travels up the stem to the leaves where over 90% of the absorbed water is lost through the process named transpiration. The sun provides the energy required turning the water in the leaves to vapour, and then vaporised water diffuses out of the plant in to the atmosphere through stomata in the leaves.

The diffusion of water out of plant reduces the pressure at the top of the plant, but a high pressure is created at the bottom of the plant so the water moves up the stem into region where it is needed. The loss of water vapour from the plants is called Transpiration. It is a passive process.

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Water from the plant may be lost from three sites;

- Leaves:
- Flowers:
- Stems (herbaceous, lenticels on woody stems):

¶Most of the water loss occurs through the stomata in the leaves. There is also some water loss through the cuticle of leaves, it is only less than 10%, but this depends on the thickness of the waxy layer and on different plants.

Plan:

In my investigation I will be looking at the effect of the leaves surface area on the rate of transpiration. From the scientific knowledge, preliminary work and background research I have made the following prediction.

Hypothesis:

¶ The rate of water up take is directly proportional to the surface area of the leaves on the plant. As the surface area is reduced the time taken for the water to travel the stem over the same distance will increase.

The reason I will be monitoring the rate of water up take is that the apparatus available to me is a potometer; this device measures the water uptake in a plant. Rate of water up take is approximately the same as the transpiration as 99% of the water is lost through evaporation and only 1% is used in plant's metabolic reactions.

Justification of Hypothesis:

¶Leaves have stomata, water evaporates though the stomata, when there are more leaves the density of stomata will increase i.e. the larger the surface area of the leaves, more stomata will be present so more water will evaporates. More water loss mean higher the rate of transpiration so water uptake will be more this will be seen on the potometer.

There are many other factors other than Leaves surface area that affect the rate of transpiration, these are listed below and explained how they will be controlled.

1) Light: The light does not have a direct affect on transpiration, stomata openings depend on light intensity so increase in light intensity mean more stomata are open so more water evaporation will take place meaning high rate of transpiration.
I will carry out the experiment in the lab, where light intensity will not change as no lights will be switched on or off during the experiment.
2) Temperature: when the temperature increases the plant gets warmer and it loses more water too cool down so transpiration increases. Increase in temperature also increases the capacity of the air so it absorbs more water from the leaves thus increasing transpiration.
I will carry out the experiment at room temperature so this variable can be controlled and reliable results can be obtained.
3) Humidity: Increase in humidity means that air can only take in little water from the plants so transpiration slows down. But at drier day the transpiration is rapid. Humidity will have very little or no effect on my experiments as it will be carried out in the lab where humidity will remain very much constant all the time.
4) Wind and Atmospheric pressure: These can vary the rate of transpiration. Wind takes water molecules away from the plant so this prevents air around the plant becoming saturated so the transpiration does not slow down.
Lower atmospheric pressure means high rate of transpiration, for this reason plants at high altitudes have high rate of transpiration. Plants have adaptation this prevents extreme water loss.
These factors will be very little of importance, as my experiment will be carried out in a lab where there will be no change in wind or atmospheric pressure.
5) Water supply: This factor is also very important as plant depend on the water supply to transpire. Plant should have an adequate water supply for transpiration to continue. When water supply to plant cannot continue the stomata will close consequently reducing the transpiration.
6) Stomata Density: The greater the stomata density for a given area the higher the rate of transpiration. This factor is very important as transpiration almost entirely relies on the stomata openings. The stomata openings can differ according to temperature and rate of photosynthesis as well as light density.
In my experiment I will make sure that the water supply to plant remains constant all the time during the experiment.

Pilot:

I pilot was carried out to help choose the apparatus and come up with a method for the original experiment.
There was a choice of two potometre: a simple potometer and a complex one with more syringes. Both were used in the pilot but simple potometre was preferred as it gave the reliable result and it was simple to set up. The pilot was carried out by the following procedure.

1. First of all a small branch with few leaves was cut and put in water so the xylem tunes don't become dried. A potometer was filled with water.
2. A small piece was cut from the stalk of the branch so damage or dried xylem tubes can be removed. Then the stalk was attached to the potometer under water. Making sure there were no air bubbles present in the potometer.
3. One bubble was introduced this will be used as a marker. The distance for the air bubble to move was set at 5 mm at first trial. Time for air bubble to move this distance be recorded. Then one leaf was removes and same procedure was repeated and time was recorded.

Pilot Results

Number of leaves	Distance moved (mm)	Time taken for the distance to move (s)	
		1st trial	2nd trial
9	5	157.5	157.3
8	5	162.4	162.7
9	1	31.0	32.0
8	1	45.1	44.5
9	2	71.3	71.3
8	2	58.0	56.0

The time taken for the air bubble to move a distance of 5mm was 157 secs, and for the distance of 1mm it was 31secs so it was decided to set the distance at 2mm so reliable results can be obtained.

Control experiment was also set up where there were no leaves on the plant. This was to see that it is the leaves that are affecting the rate of transpiration. The air bubbled moves a very little in the control. This was because there was still some transpiration-taking place through the stem of the plant.

Apparatus:

- Simple potometer
- Stop Clock
- Cherry Laurel, Prunus Laurocerasus (Plant)
- Retort stand

Justification for the apparatus

A potometer was chosen because it can measure the rate of water up take that is roughly the same as transpiration rate. And this device was the only thing available in the college lab as it is cheap and pretty accurate.

Stop clock was chosen as it measures the time very accurately. **Cherry Laurel** was chosen, as it was the only plant available on the experiment day in the lab. This plant is an evergreen shrub native to Eastern Europe. It has glossy green leaves and is adapted to cold weather conditions.

Method: (main experiment)

Step1

Take a simple potometer fill it up with water completely; make sure there are no air bubbles in the system. Bump out all the air bubbles in the potometer using the syringe.

Step2
Cut a leafy shoot off a plant. As it is under tension cutting the shoot will cause air to enter the xylem so, if possible cut the shoot under water. If this is not viable it will be essential to trim the stalk of the shoot before attaching it to the potometer.
Step3
Attach the leafy shoot to the rubber tubing of the potometer under water. Make sure there are no air present between the shoot and the water in the rubber tubing. Also make sure leaves are not wet. Remove the apparatus from the water.
Step4
Seal the joint around the rubber tube with Vaseline to keep the apparatus watertight. Now introduce an air bubble in the water column by using the syringe. Make sure air bubble is on the zero mark. Position of the water bubble can be adjusted using the syringe.
Step5
When the shoot is dry. Open tap so water can move in to the leafy shoot and start the time. Record the time for the bubble to move a distance of 2mm.
Step6
Now take one leaf off and repeat step 5 until all the leaves from the shoot has been removed. Record the results in a nice table.
To measure the area of the leaves print the leaves on to a 1cm ruled graph. Count the 1cm boxes; this would give the area in cm^2 divide it by 10^4 to get the area in m^2.
Plot the graph of the results.
Safety and fair test: As in every experiment safety is important. But in this experiment no toxic or harmful substances are involve so no extra precautions are needed but the lab rules should be carried out accordingly.
To make the experiment a fair test only one variable will be changed and the rest will be kept constant as explained above.

Results

Raw data table.

No of Leaves.	Time Taken (for 2mm of distance moved). (secs)			Average Time. (secs)
	1st trial	2nd trial	3rd trial	
9	71.1	71.1	70.7	71.0
8	58.2	56.6	58.1	57.6
7	55.0	55.0	55.0	55.0
6	50.4	51.0	51.0	50.8
5	57.2	56.4	57.1	56.9
2	63.0	62.4	63.0	62.8
3	71.0	71.0	71.0	71.0
2	74.1	76.0	76.0	75.4
1	82.0	82.0	82.0	82.0

Calculated data table.

Area of the leaves (m^2)	Average time taken (to move 2mm) (secs)	Rate of transpiration (1/s)
0.017	71.0	0.014
0.015	5706	0.017
0.013	55.0	0.018
0.012	50.8	0.020
0.010	56.9	0.018
0.008	62.8	0.016
0.006	71.0	0.014
0.004	75.4	0.013
0.002	82.0	0.012

Analysis:

¶A graph was plotted from the results, which shows a positive correlation except for the last three readings which could be considered anomalies. Looking at the graph we can make a simple conclusion that as the surface area of the leaves increases so does the water up take meaning high rate of transpiration. Water up take I roughly the same as transpiration.

¶The graph shows a positive correlation but the line is not straight passing through the origin, meaning it is not directly proportional as predicted. I will explain why the results desired were not obtained as I analyse the data.

Summary tables.

Number of leaves on the shoot	Average time taken (to move 2mm) (secs)
9	71.0
8	57.6
7	55.0
6	50.8
5	56.9
4	62.8
3	71.0
2	75.4
1	82.0

Area of the leaves (m^2)	Number of leaves	Rate of transpiration (1/s)
0.017	9	0.014
0.015	8	0.017
0.013	7	0.018
0.012	6	0.020
0.010	5	0.018

0.008	4	0.016
0.006	3	0.014
0.004	2	0.013
0.002	1	0.012

I said in my prediction that bigger the surface area of the leaves faster the rate of transpiration due to the more stomata available. But this was found not be true as we can see in the above summary table that when there were nine leaves and area was $0.017m^2$ the transpiration was slower than when there were six leaves on the shoot and total leaves surface area was 0.012m2. So the part of the graph marked A can be considered uncharacteristic. But we can also prove that these three readings (A) are true.

¶Leaves are plants food producing organ.