NATIONAL GEOGRAPHIC™

6+

MANUAL WITH EDUCATIONAL INFORMATION AND EXCITING EXPERIMENTS

GEWÄCHSHAUS
GREENHOUSE

BRESSER

NATIONAL GEOGRAPHIC™

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- Some parts of this kit may present sharp edges that should be handled with care.
- The seeds must be kept away from mouth, nose and eyes. In case of contact with eyes or mouth rinse immediately with plenty of running water. Seek medical assistance if irritation persists.
- Contact the emergency services immediately should any warning symptoms not mentioned in this manual appear.
- All experiments should be conducted under adult supervision.
- This kit presents no real danger, however, small irritations or injuries can result if the materials are not used correctly. Please read the instructions carefully before attempting any experiment.

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Description of problem:.....

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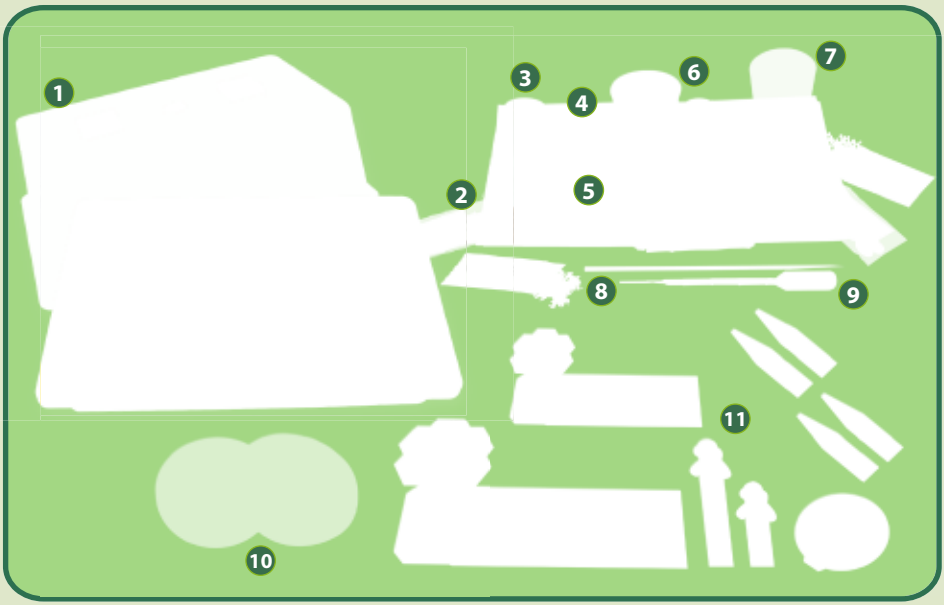
Kit contents

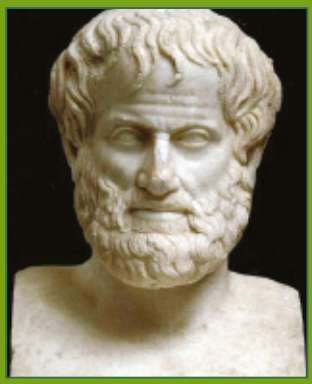


Description:	Quantity:
1. Greenhouse	1
2. Seed packets	5
3. Small measuring cup	1
4. Plastic bag	1
5. String	1
6. Flowerpots	2
7. Large measuring cup	1
8. Wooden stick	1
9. Pasteur pipette	1
10. Petri dish	1
11. Cardboard sheets: seed meter, plant support, species tags	1

Index

1. Plant classification

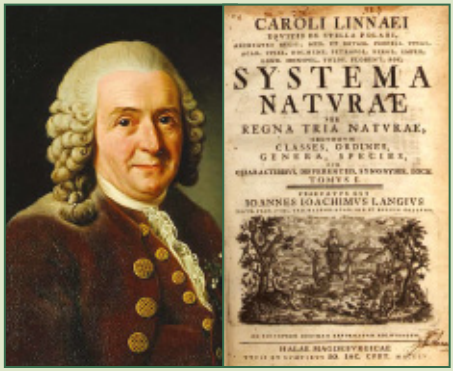
DID YOU KNOW...
Aristotle (4th century BC) developed a system for identifying living beings. Everything was categorized as either an animal or plant. Animals were further divided into the categories of blood and bloodless and plants into trees, shrubs, and herbs, according to their size.



Aristotle.

Throughout history, human beings have divided organisms into groups according their physical and behavioral characteristics. They have most often done so in order to help them identify organisms they should avoid. The categories of venomous, inedible, and dangerous were created for this reason.

Scientists have also categorized organisms, in order to study them. Over time, they have come to adopt a standardized set of classification rules.



The book 'Systema Naturae' (on the right), written by Linnaeus (on the left).

DID YOU KNOW...
That Carl Linnaeus was a naturalistic botanist from the 18th century, which became well known for creating the binomial nomenclature?
Binomial nomenclature is the classification system for assigning names to organisms that is most commonly used throughout the world today.

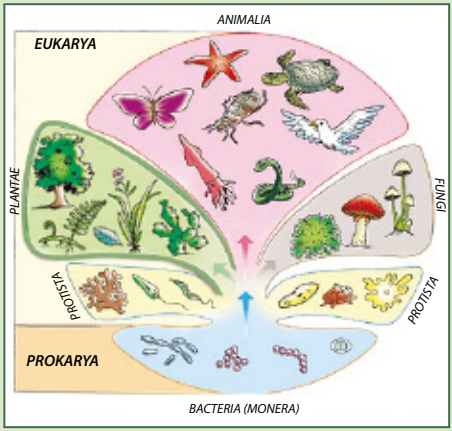
In the same way that established scientific principles are re-examined and updated from time to time, these classifications are periodically reviewed and altered. Linnaeus grouped organisms into two kingdoms: animals and plants, both of which were consecutively divided into smaller groups down to the species level.

In the middle of the 20th century, ecologist Dr. Robert H. Whittaker grouped living beings into five groups: Plantae, Animalia, Fungi, Protista, and Monera.

5 Kingdoms	Characteristics of living things
Animalia	Multicellular organisms; Generally locomotive; They feed on other living things
Plantae	Multicellular organisms; Not locomotive; Have chlorophyll and produce their own food
Fungi	Usually multi-cellular but sometimes uni-cellular; Not locomotive; Do not have chlorophyll and feed on organic matter
Protista	Usually unicellular but some can be multicellular; Cells have a well-defined and organised nucleus
Monera	Unicellular organisms; Cells do not have an organised nucleus

Chart 1. Taxonomy (classification) of Robert Whittaker.

We can therefore say that, with a few exceptions, plants belong to the single kingdom Plantae.



The five kingdoms, with the Kingdom Plantae highlighted.

2. What is a plant?

2.1. Cell – basic unit of life

DID YOU KNOW...
Scientists estimate that there are more than 350,000 species in the Plantae kingdom.

Like all organisms, plants are composed of cells.

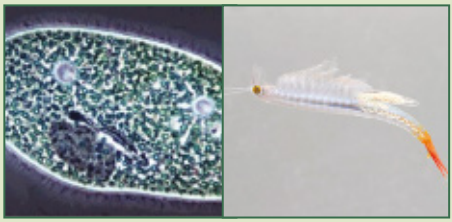
Whittaker's classification scheme was heavily influenced by the development of Cell Theory, which had first come to influence biological thought around the time that he was working.

Formulated by botanist Schleiden and zoologist Schwann, this theory states that cells are the basic unit of life and compose all living beings.

DID YOU KNOW...
That a botanist is a scientist specialised in the study of plants?
A zoologist is a scientist specialized in the study of animals.

Together cells form tissues which form organs which form organ systems. At the peak of complexity is the organism.

It's possible for an organism to consist of only one cell. This is called a **unicellular organism**. When an organism consists of more than one cell, it's called **multicellular** (multi=more than one).

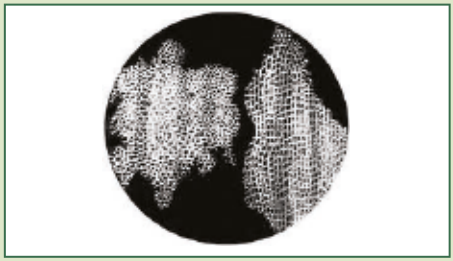


Unicellular organism (*Paramecium spp.*) and multicellular organism (*Branchinella thailandensis*), from left to right.

Multi-cellular organisms often have a variety of different types of cells.

A cell's physiology depends the function it serves in the tissue it belongs to.

DID YOU KNOW...
The first cells observed under a microscope were cork cells. In 17th-century England, natural philosopher Robert Hooke observed a piece of cork under a microscope and saw that it was divided into thousands of very small rectangular sections. He called these sections cells because they reminded him of the monk cells that compose a monastery. This name has been used by scientists ever since.



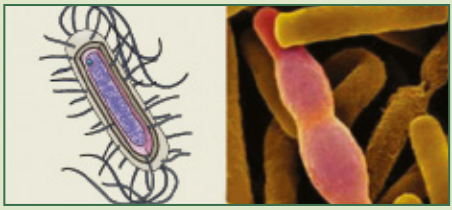
Cells observed by Robert Hooke.

Cells belonging to all of Earth's organisms can be divided into two categories: **eukaryotic** and **prokaryotic**.

The genetic material of eukaryotic cells is housed in a membrane-bound nucleus. Prokaryotic cells lack a nucleus.

a) Prokaryotic cell

Prokaryotic cells are simpler cells, in which genetic material is stored inside a structure without the protection of any membrane. The best example of this type of cell is bacteria.

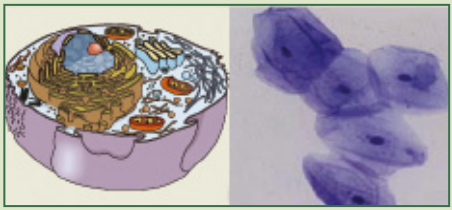


Prokaryotic cells.

b) Eukaryotic cell

On the other hand, eukaryotic cells are larger cells, generally more complex, with a well defined and organised nucleus, where the genetic material is stored.

Additionally, inside the cellular structure are several organelles which have specific functions.



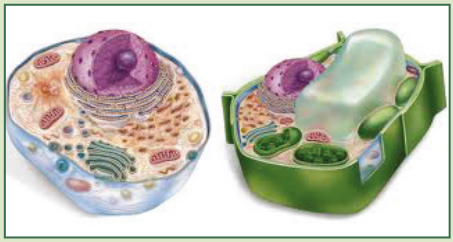
Eukaryotic cells.

2.2. Plant cells

Plant and animal cells belong to the eukaryotic category.

Perhaps the most important difference between these two cell types is the presence of a **cell wall** in the plant cell.

This wall supports the cell, by conferring it with a rigid structure. Plant cells also uniquely have chloroplasts, which contain pigments essential to a process called **photosynthesis**.



Eukaryotic cells: animal (on the left) and plant (on the right).

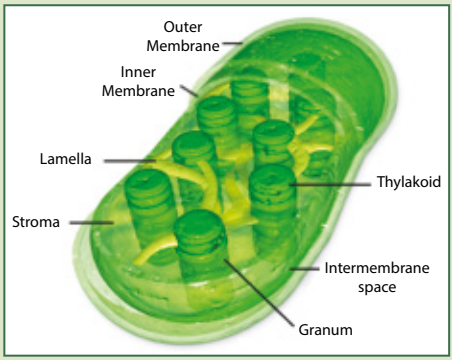
Organisms composed of eukaryotic cells are called **eukaryotes** and those made up of prokaryotic cells are called **prokaryotes**.

A plant can therefore be considered a eukaryote. The genetic material of each of its cells is contained within a membrane-bound nucleus.

Eukaryotic cells have a number of other specialized structures in addition to a nucleus. They are called organelles.

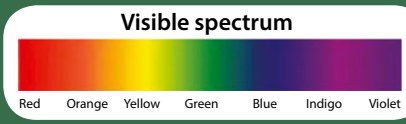
Let's now learn about plant cell organelles:

● **Chloroplast:** This organelle has a green pigment called chlorophyll that absorbs the Sun's heat and converts it into a chemical energy that keeps the plant alive. Chlorophyll gives plants leaves their green colour.

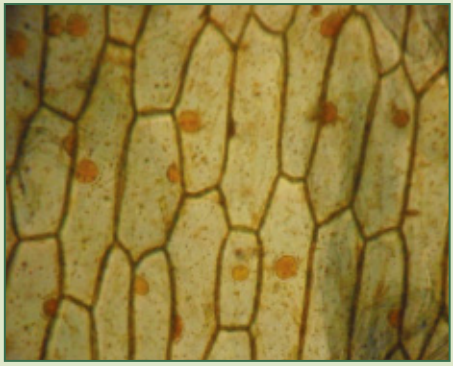


Inside a chloroplast.

White light comes from the sun. It contains within its white colour a variety of constituent colours that make up what we call a spectrum.



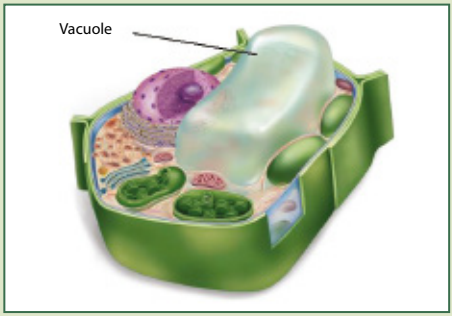
● **Cell wall:** The interior of a plant cell is enveloped by a rigid cell wall, which is composed of a material called cellulose. The collective strength of the cell walls belonging all of a plant's cells gives the plant its structural integrity.



Onion cells with its cell wall in detail (darker lines).

DID YOU KNOW...
Plants cells may contain a variety of other pigments in addition to chlorophyll, such as carotenes, xanthophylls, and phycobilins. A pigment's colour depends on how much of the sun's white light it absorbs.

● **Vacuole:** This organelle is found often in plant cells and sometimes in animal cells. It is usually responsible for isolating and exporting from a cell waste and potentially harmful substances.



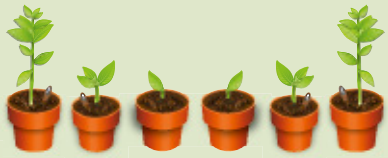
Plant cell with vacuole in detail, similar to a water filled sac.

3. What is photosynthesis?

Organisms that produce their own food are called autotrophs. Plants are autotrophs and produce their own food using a process called photosynthesis.

Photosynthesis is a critical process for plant survival.

Plants need soil/substrate, water, the Sun and air to survive, to carry-out their functions, namely the production of their own food.



DID YOU KNOW...
Photosynthesis is essential to the survival of both plants and organisms that get their energy by eating plants.

It also helps keeps Earth's atmosphere healthy by absorbing carbon dioxide.

Photosynthesis is the mechanism by which plants transform solar light energy, carbon dioxide, dietary minerals, and water into sugars that give them energy.

The Amazon rainforest is considered one of our planet's lungs, as the vast number of trees makes the production of oxygen very high there.

Glucose is a monosaccharide (a simple sugar) and is used as a source of energy for many living beings. It is one of the products of photosynthesis.

Grapes are a fruit very rich in glucose.

Photosynthesis converts simple molecules in plant cells into more complex ones.

From glucose, plants obtain energy and produce other substances essential for their functioning.

Plants sometimes store nutrients that they produce in excess. These reserves may be used to feed the plant in more difficult times when the plant is unable to produce.

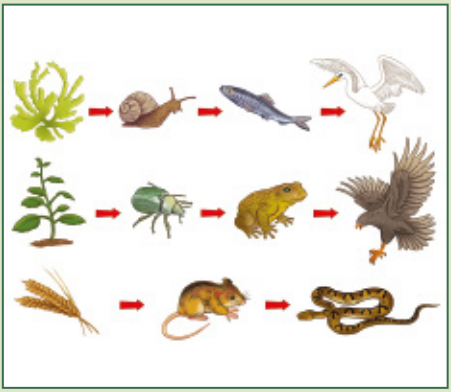
They may accumulate these reserves in roots, stems, or even leaves.

Potatoes are roots where large amounts of excess nutrients have been stored.

4. What is the importance of plants to ecosystems?

4.1. Plants as a food chain base

Plants are usually found at the base of ecosystems and food chains as they do not consume other organisms to get energy. Instead, they produce their own food.



Food chain, in which plants are the base.

All living beings being that follow in the food chain, after plants, are considered heterotrophic because they get their energy from ingesting other organisms.

The elephant is herbivorous.

The African lion is carnivorous.

Animals that feed on plants are herbivorous. Animals that feed on other animals are carnivorous. Animals that feed on both plants and animals are omnivorous.

Forest is a habitat.

4.2. What abiotic factors influence a plant's growth?

Abiotic factors are physical parts of the environment that influence the behaviour of living organisms and ecosystems.

The most important abiotic factors for plants are:

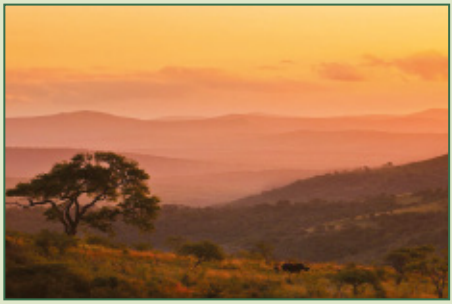
- **Light:** The presence of light is essential for plant growth. They need it for photosynthesis.

- **Water:** Water is necessary for the survival of all living things.

- **Humidity:** The ability of a plant species to develop adequately often depends on the amount of water vapor in the air.

- **Temperature:** Different plant species develop better in different temperatures.

It is important to remember that that an ecosystem's characteristics vary according to its location on earth.

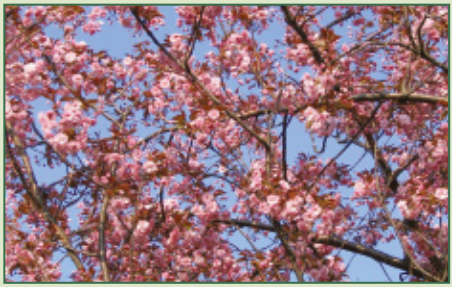


Habitat: African savannah.

Habitat: Arctic ice caps.

5. The different parts of a plant

A plant has many parts, each of which serves a unique function. All parts function interdependently.



A tree in bloom.

5.1. Roots

A root is the part of the plant normally found underground. Its primary functions include anchoring the plant in one place and absorbing water and dissolved minerals.

Substrate is the material in which a plant takes root. In the wild, it is usually soil and consists of sediments and nutrients.

Depending on the environment they grow in, roots can be any of a variety of different types. Below are a few different types:

- **Underground:** These roots are buried in a substrate.

Example of an underground root.

- **Aerial:** These roots are suspended in the air.

Hedera or ivy.

Ivy is an example of a plant with aerial roots. They allow the plant to cling strongly to other plants for structural integrity.

- **Aquatic:** These roots are immersed in water.

Aquatic buttercup.

The aquatic buttercup is a plant with aquatic roots, but, as is visible in the above photograph, the flower blooms at water's surface.

Roots can also be classified in terms of shape. They can be **fibrous** or **taproot**.

- **Fibrous:** These roots are thin, and moderately branching. They often look like hair.

- **Taproot:** The taproot is the main root from which other roots sprout laterally.

Carrots have taproots.

We eat some types of roots. For example, carrots are taproots.

Lettuce root is fibrous.

Lettuce has very fibrous roots because there is no central root.

5.2. Stems

The stem is an important part of a plant. It contains vascular bundles responsible for transporting sap, including both xylem sap and phloem sap.

In plants we find two types of **sap: xylem** and **phloem**. Xylem consists of water and nutrients that the plant collects from the substrate and phloem includes the food the plant developed on its leaves (from photosynthesis). Both are distributed to all plant parts.

The above three images show three types of stems. By order of appearance, they are bamboo, potato, and a tree trunk.

5.3. Leaves

Leaves are an important part of the plant. They are the location of photosynthesis.

Roots absorb water and nutrients transported by vascular bundles to leaves. The leaves then capture sunlight and carbon dioxide. As the water, nutrients, sunlight, and carbon dioxide mix, photosynthesis takes place.

Plants are divided into two categories according to how they manage the growing of their leaves. **Perennial** plants have leaves that last all year. When any fall they are immediately replaced by new ones. **Deciduous** trees lose their leaves in winter, leaving their trunks and branches exposed.

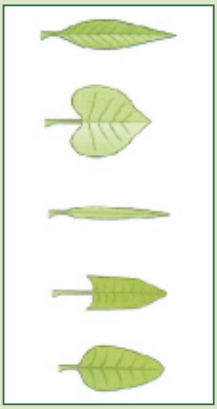
Pine tree.

This pine tree has perennial leaves.

Oak tree.

This oak tree has deciduous leaves. It loses all of its leaves during winter. They grow back in spring.

Leaves come in a variety of different shapes.



The leave shapes shown above are called, from top to bottom, linear, cordate, acicular, spear, and ovate.

5.4. Flowers and fruits

DID YOU KNOW...
Not all plants are flowered. Some plants do not need flowers to reproduce. For example, gymnosperms and bryophytes do not flower. Gymnosperms produce naked seeds and bryophytes reproduce using spores.

Bryophytes are mosses. The word bryophyte comes from the Greek *bryon*, which means moss and *phyton*, which means plant. This type of plant lives primarily in humid and dark places. They are simple, without vascular tissue.

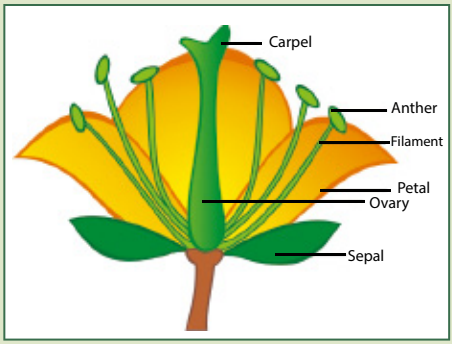
Flowers have an important role: They enable reproduction. Flowers contain the organs necessary for a plant to reproduce. Some plants contain both male and female organs. These are called **hermaphrodites**.

Flowers bear fruit. Fruits contain the seeds responsible for producing a new organism.

DID YOU KNOW...
That Holland is well known for its tulip cultivation? It has large tulip plantations that have flowers of many different colors.

Tulip cultivation, Holland.

Flowers have reproductive cells called gametes that enable fertilization.



Different parts of a flower.

The male gamete is called pollen. It is located in the filaments. During fertilization it is transported to the ovary, location of the ovule.

Pollen grain, collected by bees and used by humans.

Pollen transportation is enabled by wind, insects, or animals.

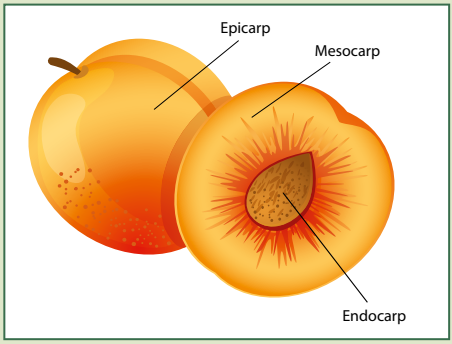
DID YOU KNOW...
That the name 'pollinating insects' is given to insects that help reproduce.

Flowers have beautiful scents, shapes and colours to attract these insects. Bees are perhaps the best-known pollinating insects.

When an ovule is fertilised it transforms into an egg that then develops into a fruit.

Fruits primarily consist of three parts. These are, from the inside out:

- **Endocarp:** The seed
- **Mesocarp:** The middle layer, which is the part that is usually eaten
- **Epicarp:** The fruit's outermost layer: it's skin.



A fruit scheme, labelled with its three parts.

Fertilisation is the word used to describe two gametes coming together, to originate an egg.

The fruit serves an important role: It feeds the seed during its initial life stages. The embryo doesn't yet have roots or leaves of its own, so it's unable to carry-out photosynthesis and produce its own food.

Soon after an embryo has germinated, it develops its first root. The root fixates the embryo and allows it to begin capturing nutrients from the substrate.


Germination of French beans, by its seed, the bean.

6. The use of plants by Humans

In prehistoric times, humans developed agriculture, which allowed them to intentionally cultivate plants for food.


People working the soil.

They learned that seeds can be planted.

DID YOU KNOW...
That it is possible to purchase and plant small seedlings that have already sprouted?

The photograph below shows one example, small lettuces.

After purchasing one, you can plant it in a small flowerpot in your home.

In modern times, agriculture carried-out by individual farmers isn't enough to feed an entire human population. Mass production alternatives have been invented.

6.1. The greenhouse

A greenhouse.

A greenhouse is usually made from metal, wood, or PVC. It can be large or small, depending on its purpose. It protects the plants growing inside it from external threats, like heavy rainfalls and strong winds.

Greenhouses are designed to retain the sun's heat, even during winter. This allows them to maintain a temperature optimal for the growth of the plants they house.

PVC is a kind of hard plastic used to make pipes. The abbreviation stands for polyvinyl chloride.

Lighting is very important in a greenhouse. The best building material is one that allows for the greatest amount of window space, permitting the greatest amount of sunlight to enter the greenhouse.

Greenhouse of ornamental plants.

A greenhouse's interior watering system also helps it maintain an optimal humidity level and temperature.

DID YOU KNOW...
That, just like humans, plants sweat. Plants absorb carbon dioxide and release oxygen and water vapor.

Plants develop better when the temperature/humidity heat index is suitable because they need water to grow.

A greenhouse is capable of enabling a proper environment for plant growth, allowing for a great variety of species to develop side-by-side.

In order for plant growth to take place, the greenhouse's internal conditions must be kept more or less stable.

Mass produced plants for sale.

A greenhouse must be cleaned frequently to keep its plants safe from plagues, contamination, and diseases.

A plant with a plague.

Many different plants can be produced in a greenhouse, ranging from plants grown to be eaten as food like legumes and vegetables, to flowers and other plants grown for decorative purposes.

Ornamental plants for sale.

Aromatic plants are perfumed or scented. They give off chemicals capable of activating the human olfactory system.

Lavender is an aromatic plant.

Medicinal plants contain a compound called an active ingredient that can be used to relieve or cure a disease.

The active ingredient in the plant that is used to produce coffee can be used in the manufacturing of pharmaceutical products.

7. Experiments

Before we begin, let's talk about the correct use of a Pasteur pipette.

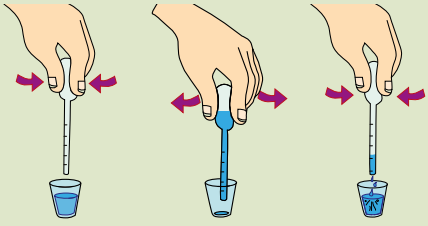
Pipettes are measuring instruments used in laboratories to add liquids to solutions drop by drop.

Before starting the experiment, we recommend that you practice using a Pasteur pipette.
Begin by filling a small measuring cup with water.

1. Press and hold the upper part of the pipette, and put the tip in the liquid.
2. Slowly release the upper part of the pipette. Observe the rise of the liquid in the pipette.
3. Remove the tip of the pipette from the liquid and press the upper part lightly.

Drops will begin to come out of the pipette. Add the number of drops desired.

Pasteur pipettes.



Advice for the proper use of Pasteur pipettes.

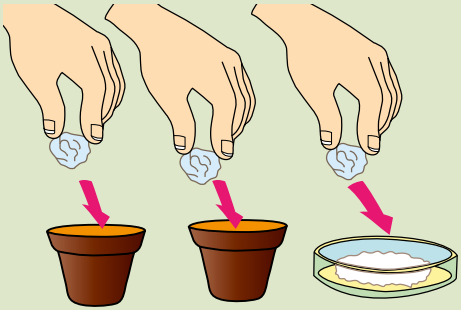
Experiment 1
What do plants need to grow?

What can be done to help plants to grow optimally?

We are going to plant one and observe its growth.

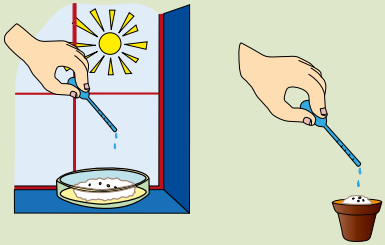
What you will need:
- 2 Flowerpots
- 1 Petri dish
- 1 Packet of watercress seeds
- Pasteur pipette
- Water
- Cotton wool

Steps:
1. Place a piece of damp cotton wool in each of the two pots and in the Petri dish.



Adding cotton wool to the pots and Petri dish.

2. Put some watercress seeds (not all of them, as they are needed for other experiments) in the flowerpots and in the Petri dish.

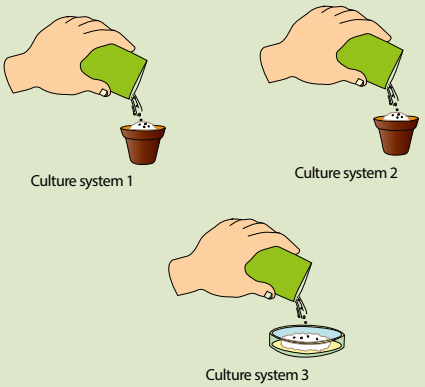


Placing the watercress seeds in two pots and Petri dish.

3. Create different growing conditions for each of the different cultures:
a) Place one of the flowerpots near a window that allows for large amounts of sun exposure, using the pipette to keep the cotton damp (1).

b) Place the other flowerpot in a dark area, keeping the cotton damp (2).
c) Place the Petri dish next to a window that exposes it to the sun, but don't keep it damp (3).

4. Observe the plant growth taking place in the three containers over the course of the next eight days.



Culture systems 1, 2 and 3.

Explanation:

The external conditions surrounding the plant will affect its growth. As you have probably already noticed, water and light significantly impact the growth of plants. In the absence of light or water, plants do not grow.

However, please keep in mind that plants die when they are overwatered.

In order to keep plants healthy we must provide light and water favourable for their growth.

Tip: Use a pipette to dampen the cotton wool.

Table of plant growth

	Culture 1	Culture 2	Culture 3
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			

Experiment 2
Do plants move?

Charles Darwin, an English naturalist and biologist, together with his son Francis Darwin, conducted several experiments in which gramineae seeds, primarily oat, were used.

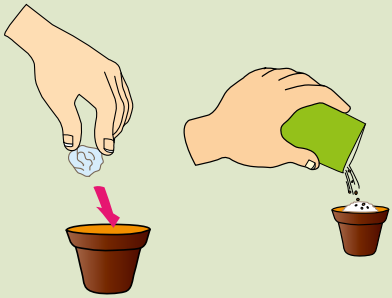
Through these experiments, Darwin tried to discover the reason some plants lean towards light, a phenomenon called **phototropism**. The findings were published in his book 'The Power of Movement in Plants' (1881).

Using Darwin's experiments as a guide, we are going to observe the degree to which watercress demonstrates phototropism.

What you will need:
- Flowerpots
- Watercress seeds
- Pasteur pipette
- Small measuring cup
- Cotton wool
- Water

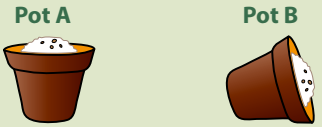
Steps:

1. Put cotton wool in two pots and add some watercress seeds.



2. Fill the measuring cup with water and with the pipette water the seeds.

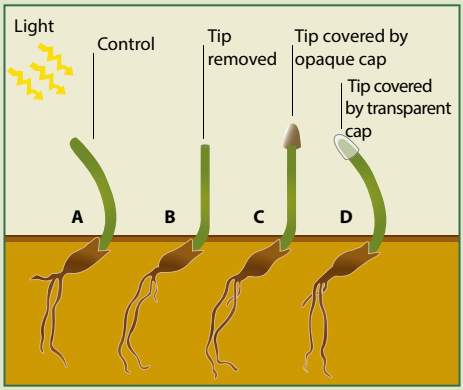
3. Place the pots near a window with sun exposure, as shown in the image.



4. Wait a few days and see what happens. Remember to water the seeds.

Results obtained by Darwin:

Charles Darwin conducted several experiments in which he submitted the plant's leaf tips to different treatments, obtaining the results illustrated below.



Results obtained by Darwin. A - It bends; B and C – Do not bend; D – Even covered, bends toward the light.

Explanation:

Plants whose tips are cut off cannot receive light and thus don't bend towards it. In other words, they do not demonstrate phototropism.

Darwin concluded that plants produce substances (phytohormones) that influence their own behaviour and growth.

Darwin concluded from observation that when plants are submitted to sideward light, the sunlight's energy is transmitted from the upper part of the plant to the lower part, which causes the plant to bend in the direction of light.

Experiment 3
The mystery of growth

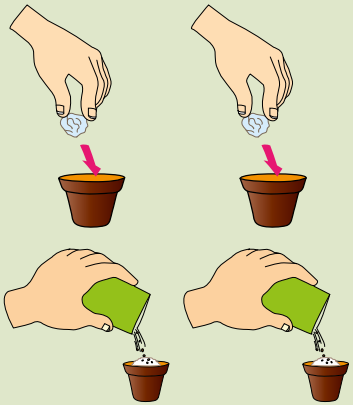
Now let's try to understand the growth of stems and roots.

What you will need:

- Bean seeds
- Watercress seeds
- Grass seeds
- Petri dish
- Large measuring cup
- Flowerpots
- Small measuring cup
- Cotton wool
- Water
- Scissors
- Pasteur pipette
- Wooden stick
- Absorbent paper

Steps:

1. Put the cotton wool in the flowerpots and add some grass seeds in a pot and watercress seeds in another pot.



2. Fill the measuring cup with water, and, with the help of the pipette, water the seeds.

3. Place the flowerpots close to a window exposed to the sun.

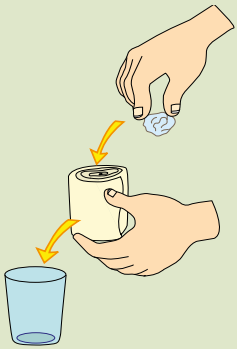
4. Wait until they grow five centimetres (two inches) and cut them with the scissors, as is shown in the below image.

5. Set it aside for several days and observe its development.

6. Fill the small cup with water and add some bean seeds.

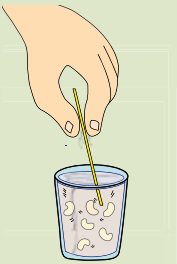
7. Let it sit for a night.

8. Make a roll and a ball with two pieces of absorbent paper. Place the roll inside the large cup and put the ball in the roll.

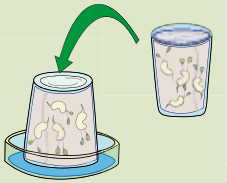


9. With the help of the pipette, fill the large cup with water until the absorbent paper is completely soaked.

10. With the help of the wooden stick, put the seed between the pot walls and the soaked paper. Place the flowerpot in a place exposed to the sun.



11. After four to five days, when you begin observing the germination of roots and stems, turn the cup over in the Petri dish.



12. Wait a few days and see what happens to the bean seeds and what's happening with the watercress and grass.

Note: keep the paper dampened with the help of the pipette.

Explanation:

After cutting, did the watercress grow again? And what about the grass?

The grass keeps growing after being cut, but the watercress doesn't. This can be understood by more closely examining the direction of growth - the place where much of the cellular division takes place, and from where the plant develops.

In grass, the direction of growth is found close to the soil, so the cut does not interfere with its growth.

In watercress, the line of growth is found just below the flowers. A cut, therefore, stops the plant from growing further.

What happened to the bean seeds?

Gravity affects the behaviours of humans, animals, plants and others.

A bean's roots always grow in the direction of gravity. Their stems grow in the opposite direction. When we turn over a cup, we change the conditions of its growing direction and we can see that the direction of growth of the roots has changed. This occurs because the plant is adapting to new conditions.

Experiment 4

Growth of plants without seeds

What you will need:

- Petri dish
- Carrots with leaves
- Water
- Knife

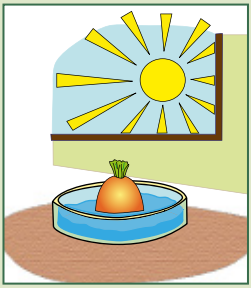
Steps:

1. Cut off the top part of a carrot with a knife.

Note: Use the knife carefully, and, if necessary, ask for help from an adult.

2. Fill the Petri dish with water and put the cut piece of carrot in water. The water must surround the carrot.

3. Put the Petri dish with the carrot in a warm place, exposed to the sun. Watch what happens.



Explanation:

With this experiment we have proven that seeds aren't necessary for plants to grow. Given the proper water, light, air and nutrient conditions, some plants have the capacity to grow from pieces of an original plant.

Experiment 5
Coloured plants

Transport in plants:
In this experiment you will learn how plants create their food. How do they absorb water and minerals (which give them a lot of strength) from the earth? You will have the opportunity to watch a white flower change colour.

What you will need:
- Food colouring
- White flowers (daisies, carnations and hyacinths)
- Glass cup

Steps:
1. Fill a glass halfway with water.

2. Put about ten drops of food colouring in the water.

3. Place the flowers inside the cup.

4. Wait 24 to 48 hours and check the flowers.

Explanation:
You will see that the flower's petals have begun changing to become the same colour as the dye you added to the water. This is because there are vases (or channels) inside the stem, called xylem. This transport, called translocation, allows the flowers to remain hydrated and healthy.

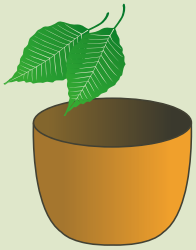
Coloured flowers.

Experiment 6
Chromatography

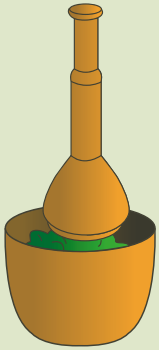
In this experiment you will learn about the cell organelle that enables photosynthesis: the **chloroplast**.

What you will need:
- Five Fresh leaves of the same plant (spinach, for example)
- Flat plate
- Ethyl alcohol
- Filter paper
- Pestle and mortar
- Thin sand
- Scissors

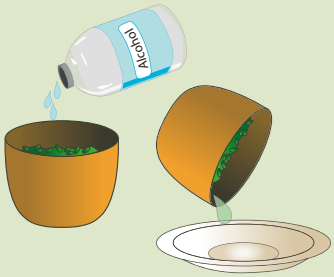
Steps:
1. Cut the leaves into pieces and place them in the mortar.



2. Add sand and crush the mixture with the pestle.

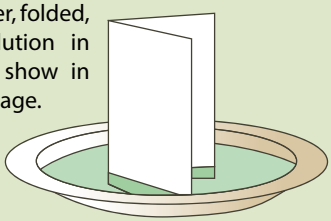


3. Add a small portion of ethyl alcohol and pour it carefully into the flat plate.



4. Cut off a rectangle from the filter paper.

5. Put the filter, folded, into the solution in the manner show in the below image.



6. Wait a few minutes and see what happens.

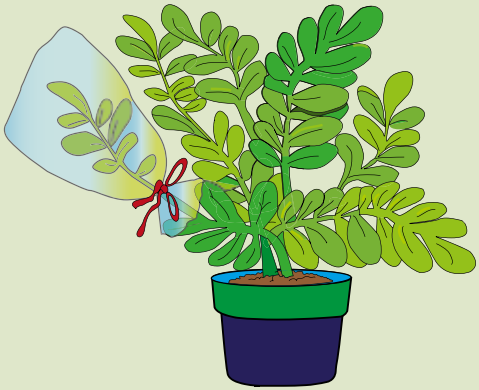
Explanation:
Chloroplasts contain different pigments like chlorophylls, carotenes, and xanthophylls. When you put filter paper in a solution, you can watch a few different color bands form. This happens because you've separated different plant pigents present in the raw chlorophyll solution using a technique called paper chomatography.

These pigments are dissolved in alcohol that, in turn, rises on the paper, transporting them. The heaviest settle first and the lightest move with the alcohol to the top of the paper.

Experiment 7
Plants also sweat

What you will need:
- Transparent plastic bag
- Leafy plants you have at home

Steps:
1. Place a transparent plastic bag around a leaf or branch with leaves and tie it with a cord.



Plastic bag tied to a branch.

2. Observe the plant. The time needed to effectively observe changes will depend on the season of year.

Explanation:
Plants absorb water and nutrients through their roots. Water vapour escapes in the form of drops, though small holes in the leaves.

Water vapour typically dissipates through soil and air. However, a plastic bag prevents this from happening, and water drops can be observed as a result of transpiration.

Experiment 8
Automatic watering system

Let's create two automatic watering systems and understand the amount of water plants need when cultivated inside and outside the greenhouse.

What you will need:

- Woollen yarn
- Small measuring cup
- Large measuring cup
- Flowerpot
- Watercress seeds
- Water
- Scissors
- Glue
- Cardboard support (large)
- Cardboard support (small)
- Greenhouse
- Soil
- Large seed meter
- Small seed meter
- Adhesive tape

Steps:

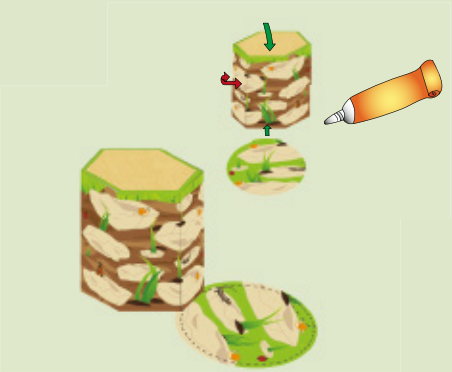
1. Put a small portion of soil in a pot and in a seedbed from the greenhouse (up to half the height of both containers).

2. Add some watercress seeds to the pot and seedbed and cover with soil. The seeds must be covered over about 1 cm (0.4 in) of soil.

Note: if you have watercress seeds already planted from previous experiments, you can simply transfer them to the seedbed, adding soil, and replacing the cotton wool by soil, in the pot.

3. Now, add soil to the seedbed located next to the one where you've planted the watercress. But this time fill it completely.

4. Assemble the plant support, in accordance with the below image. Then, put the pot containing watercress seeds near the support, over the cardboard circle.



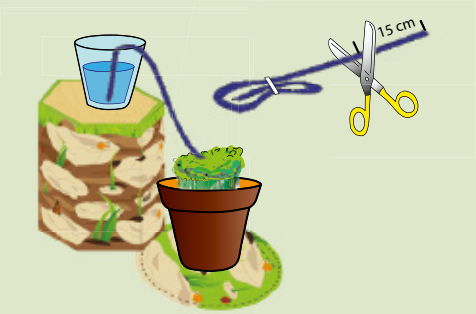
5. Next assemble the watering support that will be used in the greenhouse. Place this support on the seedbed you filled with soil.

6. Fill the small cup with water up to the 25 ml (0.9 UK fluid ounces) mark. Transfer the water to the large cup.

7. Fill the small cup with water to the 25 ml (0,9 UK fluid ounces) mark once more.

8. Place the small cup over the support located in the greenhouse and put the large cup over the support containing the watercress pot.

9. Cut two yarns that are about 15 centimetres in length, and for both water systems, put one of the yarn ends in one of the cups holding water. Put the other end in the pot/seedbed, creating a connection between the plants and the cups.



10. Cut off the two seed meters, the large and small, and place the large one in the large measuring cup and the small one in the small measuring cup, with the help of adhesive tape. This seed meter will allow you to know the amount of water in the cup at a variety of different time intervals.

11. Place the greenhouse and pots near a window with sun exposure.

12. Take notes on the results in the following table.

Time	Water level (small cup)	Water level (large cup)
Start		
After 10 hours		
After 15 hours		
After 20 hours		
After 30 hours		
After … hours		
After … hours		
After … hours		

Explanation:

The watering system allows the plant to be supplied water, thanks to two properties: adhesion and cohesion. Adhesion develops due to the attraction between different particles. In this case, the water molecules adhere to those of the yarn. When the water's mass becomes heavy enough it starts to slide along the yarn, falling, in the form of drops, into the flowerpot.

Cohesion refers to the interaction between different particles. In the experiment described, the water molecules are absorbed by the yarn and are at the same time attracted to each other. This generates a force that 'pulls' the water towards the flowerpot, supplying the plant with water, until the cup empties.

In turn, plants absorb an amount of water according to their needs. Seed meters allow us to determine the amount of water absorbed, but it's important to also consider the amount of water that has evaporated.

As we have seen, the amount of water absorbed by the plant in the greenhouse was lower than the amount of water absorbed by the plant that was in open air.

This result confirms one of the great advantages of raising plants in a greenhouse: they need less water to grow there. The interior of a greenhouse is a controlled environment that is not directly influenced by sunlight and wind, and less water there evaporates than outside the greenhouse. Furthermore, as plants come to sweat less and the environment inside the greenhouse is more humid, plants must absorb less water from the watering system.

Experiment 9
Acid rain

This experiment simulates the phenomenon of acid rain to provide a better understanding of how the phenomenon influences agriculture.

What you will need:
- Material from the previous experiment
- Flowerpot
- Grass seeds
- Vinegar

Steps:

1. Repeat steps 1 to 5 from the previous experiment and prepare a new pot with soil, adding some grass seeds.

2. Add soil to a seedbed of the greenhouse that's located near one of the watercress and the support. Add grass seeds.

3. With the help of the small cup, measure 25 mililitres (0,9 UK fluid ounces) of vinegar and transfer it to the large cup.

4. Measure out the same amount of water as vinegar and transfer it to the large cup. Place this cup over the large support.

5. Wash the small cup and add 25 mililitres (0,9 UK fluid ounces) of water. Place this cup over the small support inside the greenhouse.

6. Reuse the two yarns from the previous experiment, which will now be used to create the watering system of the greenhouse. Put the end of each string inside the cups holding water and the end of one of the strings inside the watercress seedbed and the end of the other string in the grass seedbed.

7. Cut two more yarns 15 centimetres each. Repeat the same procedure this time for the pots located outside the greenhouse.

8. Place the greenhouse and pots near a window that allows for sun exposure and on the following table take notes on the result.

Time	Growth level (inside the greenhouse)	Growth level (outside the greenhouse)
After 5 hours		
After 10 hours		
After 15 hours		
After 20 hours		
After 30 hours		
After … hours		
After … hours		
After … hours		

Expected results:
In this experiment we submitted two cultures (watercress and grass) to an acid watering in order to simulate the phenomenon of acid rain. However, the plants cultivated inside the greenhouse continued to be watered with normal water.

Inside the greenhouse, it's expected that the germination occurs normally. Nevertheless, outside the greenhouse it's expected that the level of germination is lower. In these pots, the germination will have very superficial roots, and leaves and stems underdeveloped. It's also expected that, in this case, the germination occurs in the pot's sides, where the acid rain might not be so intense.

Explanation:
Acid rain is formed by chemical reactions that occur in the atmosphere. Water, as a natural element, already contains some acidity, which results in reactions between carbon dioxide and water.

When it suffers reactions in which compounds of reactive nitrogen and sulphur are active ingredients, the acidity level rises to rates above those considered normal. This happens because from these reactions, results sulphur and nitric acid which have a quite negative and devastating effect.

Mainly, the level of these compounds in the atmosphere results from the emission of pollutants, caused by human activity, that affect human health, agriculture (cultures and soil), water and buildings.

As it was possible to demonstrate with this experiment, plants that were inside the greenhouse present a normal growth, opposite to what happened with the plants submitted to acid rain.

Besides proving the serious consequences that this phenomenon causes in agriculture, we also could emphasize the importance of greenhouses nowadays, as we can control the conditions to which plants are exposed.

Experiment 10
Cloning plants – plant cutting

With this experiment you'll learn how to clone plants that you have at home.

What you will need:
- Flowerpots or greenhouse
- Plant to clone (viola, vine, geraniums, begonia, and others)
- Soil
- Large measuring cup

Steps:
1. Cut some of the plants leaves you've chosen.

2. Fill in the measuring cup with water and put the leaves inside it.

Note: in case you've chosen large leaves that don't fit the cup, you may use other flasks or a normal cup, where they may fit.

3. Wait until they start to develop roots.

4. Choose where you want to grow the plants, pots or greenhouse, and add soil to it. Transfer the new plants to the chosen container. Don't forget that the roots need to be covered with soil.

5. You have just colonized a plant, which will be the same as the original one. Remember to water the plants so they may keep healthy.

African violet.

Explanation:
In the case of some plants, it's possible to remove a part and colonize through a process called striking. This method consists of the planting of small stem cuttings, roots or leaves that, when planted in a damp area, develop into new plants.

Cassava rose tree and sugar cane are two plants grown by means of stem cutting. The sweet potato is an example of a root cutting and violet is an example of a leaf cutting.

Experiment 11
Coriander seedbed

What you will need:
- Soil
- Greenhouse with seedbed
- Coriander seeds
- Water

Steps:
1. Put a small portion of soil in two openings of the seedbed, filling it halfway.

2. Add two or three coriander seeds to each opening and cover them with soil. The seeds must be covered with about one centimetre (.4 inches) of soil.

3. Place the seedbed inside the greenhouse and then take it outside. Place it in an area where both light and shadow are present.

4. Please keep the soil damp but not too damp.

Note: Spring and summer are the best seasons to grow coriander, because the heat of summer accelerates the growing process and the coriander quickly becomes spindly.

Explanation:
Coriander is a shrub-shaped aromatic herb, whose leaves are arranged somewhat like those of a clover and whose flowers are delicate and white. Coriander are famous for their spicy seeds, which are filled with essential oils and organic acids. Its leaves are used for cooking.

Coriander leaves can be harvested anytime. Nevertheless, the ideal method is to wait until the bottom part of the plant has grown about ten centimetres, making it possible to obtain from the plant leaves all of their scent. Collect the old leaves, allowing for the new ones to have more time to mature.

As the new leaves mature, flowers will bloom among them. The flowers release seeds. Save the seeds and plant them!

Coriander seeds.

Experiment 12
Parsley seedbed

What you will need:
- Greenhouse with seedbed
- Parsley seeds
- Water

Steps:
1. Immerse the seeds in water for 24 hours.

2. Remove the seeds from the water and place them on a cloth for one hour.

3. Put a small portion of soil in two openings of the seedbed until it is halfway full.

4. Add two or three parsley seeds to each opening and cover them with soil. The seeds must be covered with about one centimetre (.4 inches) of soil.

5. Press the soil with your hands and then water it.

6. Place the seedbed inside the greenhouse and then take it outside.

Explanation:
Parsley is an aromatic herb with a shrub-shaped plant. Its leaves can be flat or slightly curly and have a slightly spicy flavour.

Parsley seedlings must be planted between March and August, in places where winter isn't too severe. In temperate zones it can be cultivated all year.

Parsley contains mineral salts, as well as vitamins A and C. It is often used in Mediterranean cuisine. Once flourished, the seeds mature and the plant dies.

Collect the seeds and plant them again!

Now that you've learnt how to plant coriander and parsley, use your greenhouse and create an herbarium, by adding other aromatic plants!

Parsley seeds.

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