SMART BRICKS FOR SMART PLANTS

A science investigation pack for teachers of 7-9 year olds

CENTRE *for* INDUSTRY EDUCATION COLLABORATION

Supported by the Gatsby Charitable Foundation

Contents

Introduction

AGE RANGE

The activities in this book provide opportunities for children in Year 6 to revise the needs of healthy plant growth and the functions of different parts of a plant. It will also extend their understanding, showing the effect of different nutrients on different parts of the plant. The unit links with the QCA scheme of work by (i) revising unit 3B Helping plants grow well (ii) addressing the plant sections of unit 6A Interdependence and adaptation. It can also be used as a transition unit between Year 6 and 7 with a basic introduction to cells.

This material provides suggested activities that can be adapted to suit the needs of the children, staff and the planning requirements of the school.

CONTEXT

The activities use a real life context, that of a plant food (nutrient) research and nutrient product manufacturer, who needs to test how different nutrients affect different parts of a plant in order to produce plants useful for different purposes e.g. edible plants often require bigger healthier leaves, or roots depending on the crop.

The context is closely related to the challenges faced by companies that make crop nutrition products. Crop nutrition and fertilizer companies can produce nutrient products for a vast range of crops from cereals and root crops, to all types of fruit. They aim to develop the products that supply the right nutrients at the right time and in the most effective way. Crop nutrition is very important to all plant growing industries, farmers, cultivators, etc. If plants get the correct nutritional balance, it will help keep plants healthy and make them less susceptible to disease. Companies may also test different plant nutrient deficiencies in order to produce nutrient products beneficial to growing healthy plants. For example one test measures/ observes the effect of nutrient deficiency by growing plants in nutrient free sand. They then provide either one, or a combination of the twelve essential nutrients for plant growth (see Appendix 1). They analyse the data this provides and use it to produce plant feed that will benefit different parts of the plants. In their laboratories, they measure the nutrient levels in soils, leaves and fruits and can identify problems, and recommend the best treatment. They advise the customer of the nutrient needed for the best possible harvest.

ALTERNATIVE INDUSTRIAL LINKS

The fictional company in this pack is a nutrient product manufacturer based on a well-known crop nutrition company.

The table overleaf shows other possible industries that use scientists to analyse or monitor the growth of plants and either make nutrient products or benefit from their use.

Industry	Link with activities
Cultivation industry	The unit links to the cultivation industry, as the children investigate the nutrients that benefit different plants in different ways, e.g. flower suppliers for florists.
Farming industry	The unit links to the farming industry as the children investigate what nutrients benefit different plants in different ways and why farmers require this.
Fertigation industry	The unit has a direct link to the plant nutrient product manufacturers, as children investigate how different nutrients affect plants.
Plant research	There are research organisations that study specific plants, for educational purposes and to inform industry.
Textile industry	Weaving of fibres in stems, e.g. hemp products, requiring strong, well developed, fast growing stems.
Pharmaceutical industry	The unit links to the pharmaceutical industry for those that use plant matter in their products. The children investigate how to grow plants for different purposes, e.g. plant alternatives to chemicals in products like herbal toothpastes.

ACTIVITIES

The activities are timetabled for four sessions each of 1-2 hours duration, with optional preparatory and extension activities. The activities should be completed in the order given, for they develop an investigation from identification of a problem, through investigating, to a solution. However, each activity can be adapted to suit the needs of the children or the school. Due to the focus on plant growth, this unit is best suited to the late spring or summer terms.

It is advised that children work in mixed ability groups of 4 children. Some of the sessions (particularly activities 2 and 3) would benefit from additional adult support such as teaching assistants or parent helpers.

The activity sheets included provide an initial stimulus and help guide children through the investigation process; planning, recording ideas, observations and measurements and drawing conclusions. By providing a suitable framework, this should improve children's understanding of all that is involved in the investigation process, as well as increasing children's enjoyment of science by solving real life problems. They are also intended to support differentiated teaching in the classroom and should be used according to need, planning requirements or adapted depending on time requirements.

ACTIVITY SUMMARY

Title	Description	Timing
P. Plant growth[1] (optional preparatory activity)	Children set up a test and observe plant growth in different substances. Alternatively, appropriate data is provided for children to interpret.	2 hours
1. Smart bricks	This session starts with short activities outlining the needs of plants and the function of their parts. The main activity focuses on smart bricks (cells) as the building blocks of all the different parts of plants. Children make models of these and test their strengths. The activity ends with the children considering what information about healthy plants is required for different uses of the plants in industry.	2 hours
2. Healthy leaves	This session starts with a letter from a fictional company to investigate plant growth and nutrients needed for different parts of the plant. It explores the functions of leaves and the role of leafy plants in a range of industries. Children construct a giant model leaf using the cells from the smart bricks activity. The class tests the leaf for strength and survival against mini- beast attacks to simulate the aims of farming industries when growing plants.	2 hours
3. Robust roots	This session explores the function of roots to anchor or draw up water and nutrients. The children create a model root system and explore the nutrients that help a root stay healthy and link this to roots in an industrial context.	2 hours
4. Nutrient test and report to company	Children compare the effect of different quantities of a plant nutrient product on plant growth. They use one of a number of ways to report their findings back to the industry. This provides an ideal assessment opportunity.	1 hour

1 The option on Activity sheet A should be set up at least three weeks before starting the Main Activities 1-4.

Resource requirements

Quantities are given per group of 4 children, unless otherwise stated:

PREPARATORY ACTIVITY

- Activity sheet A-B (per child)
- 3 different plant growing substances, e.g. compost, clay, sand or
- 3 types of soil, e.g. sandy soil, clay soil or loam 3 small plant pots (or yoghurt pots)
- 3 equal sized seedlings, e.g. radish or sunflower
- *or* Activity sheet C-D (per child)

ACTIVITY 1

- Activity sheet 1a-b (per group: optional)
- Activity sheet 1c (for lower ability children)
- Activity sheet 1d (per child: optional)
- Collection of different plant matter, e.g. a range of flowers, stems and roots
- 1 seed (per class)
- 1 bottle of water (per class)
- Plant pot containing soil (per class)
- Ball of string (per class)
- Long, thin balloons (at least two each)
- *either* 2 pieces of 50 x 30 cm (approx.) plastic mesh/netting (per child) *or* 2 large bird feed nets or orange or onion nets(brought in by children or bought from garden centres)
- Flat thin wooden board (at least 50 x 50 cm)
- Weights (6 x 500 g or 3 x 1 kg)

ACTIVITY 2

- Activity sheet 2a, 2d
- Activity sheet 2b and 2c (per child) A selection of leaves (optional)
- Magnifiers (each) or the Intel microscope (optional)
- One pair of large scissors (see safety note)
- One straw, knitting needle, or other spike
- To make one class leaf:
- One set of the smart bricks made in the previous session A roll of double sided sticky tape
- 3 x 2m of bubble wrap

Safety note

Children should be supervised closely with sharp object.

ACTIVITY 3

- Activity sheet 3
- Activity sheet 2d
- 3 or 4 buckets or large containers (per class) To make each root (half the class):
- The remaining smart bricks (Activity 1)
- A ball of string

ACTIVITY 4

- Activity sheet 2a
- Activity sheet A (per child)
- Plant nutrient product (from garden centre or DIY store) Radish, geranium or sunflower seedlings
- Equal-sized plant pots containing equal amounts of compost

Preparatory activity (optional)

1-2 hours

Children set up a test and observe plant growth in different substances. This is an optional activity that needs to done at least three weeks in advance of the other activities. alternatively, appropriate data is provided for children to interpret.

OBJECTIVES

- Y3 Explore the requirements of plants for life and growth (air, light, water, nutrients from the soil and room to grow).
- Set up simple practical enquiries, comparative and fair tests.

APPROXIMATE DURATION

1-2 hours (plus 15 minutes observation time per week for 3 weeks.)

RESOURCES

(Per group of 4 children unless otherwise stated)

- Activity sheet A-B (per child)
- 3 different plant growing substances, e.g. compost, clay, sand or 3 types of soil, e.g. sandy soil, clay soil or loam
- 3 small plant pots (or yoghurt pots)
- 3 equal sized seedlings, e.g. radish or sunflower
- *or* Activity sheet C-D (per child)

ADVANCE PREPARATION

This should be set up at least three weeks before starting the activities 1-4. Activity sheet 1c has been provided as an alternative route into the topic.

INTRODUCING THE ACTIVITY

Explain to the children that they are going to compare the growth of plants in different substances. The investigation has already been planned, so the children are going to carry out the activity, interpret the results and provide possible explanations for them.

ACTIVITY

The children use the investigation framework provided (Activity sheet A) to set up a fair experiment to compare plant growth in different soils. Discuss the sheet, explaining the investigation process. Start with the investigation question: 'Which soil is best for plant growth?' which the children need to complete the appropriate box. They then need to decide what they will change (the soil), and what they will measure (the height of the plant).

Next they need to consider what they will keep the same to make it a fair test (amount of soil, the times and measurements of watering, etc.) Following this, the children complete the diagram and set up three parallel investigations. After three weeks, they draw a conclusion as to the best type of soil for plant growth.

Note : If you are unable to complete this activity, the children could use Activity sheets C-D to plan an investigation and draw conclusions from the data provided. They answer questions about predictions, fair tests, graphic evidence and accuracy, and reliability.

PLENARY

Discuss the children's responses and ask them what they think makes certain soils better for plant growth than others, e.g. permeability, particle size, different nutrients/minerals in the soil, etc.

Activity Sheet A: Plant Investigation Planning Frame

Investigation Question

Our question is:

Plan

We will change:

We will measure:

Fair Test

We will keep these things the same:

Prediction

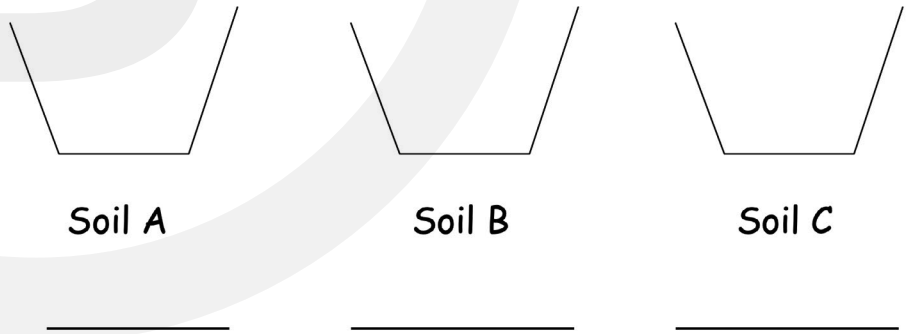
I think . . .

Because. . .

Activity Sheet B: Plant Growth

Diagram

Complete the diagram below, including labels:



Results

Name of Soil	Height (cm) After		
	1 Week	2 Weeks	3 Weeks
Soil A:			
Soil B:			
Soil C:			

Conclusion

Which soil is best for plant growth?

How do your results show you this?

Activity Sheet C: Plant Growth Data

Investigation Question

Which soil is best for plant growth?

A class carried out an investigation into which type of soil was best for plant growth. They changed the soil type and tested 3 soils - loam, clay soil and sandy soil. They measured the height of the plant at the end of each week, over a period of three weeks.

Plan

What did the class change?

What did the class measure?

Fair Test

List what you think they kept the same, to make it a fair test:

Activity Sheet D: Results

These are the results that the class recorded.

	Height (cm) After		
	1 Week	2 Weeks	3 Weeks
Soil A: Loam	10.5	11	11.5
Soil B: Clay Soil	10	10.75	11.25
Soil C: Sandy Soil	10	10.5	10.75

Conclusion

Which soil is best for plant growth?

How do the results show you this?

1. Smart bricks

2 hours

Children think about the needs of plants and how the different parts of a plant are made up of 'smart bricks' (cells). They make and test model cells and then consider what parts of the plant are used by different industries.

OBJECTIVES

- Y3 Identify and describe the functions of different parts of flowering plants, roots, stem, trunk, leaves and flowers
- Y3 Explore the requirements of plants for life and growth (air, light, water, nutrients from the soil and room to grow)
- Set up simple practical enquiries, comparative and fair tests

RESOURCES

(Per group of 4 children unless otherwise stated)

- Activity sheet 1a-b (per group: optional)
- Activity sheet 1c (for lower ability children)
- Activity sheet 1d (per child: optional)
- Collection of different plant matter, e.g. a range of flowers, stems and roots
- 1 seed (per class)
- 1 bottle of water (per class)
- Plant pot containing soil (per class)
- Ball of string (per class)
- Long, thin balloons (at least two each)
- Either 2 pieces of 50 x 30 cm (approx.) plastic mesh/netting (per child) or 2 large bird feed nets or orange or onion nets (brought in by children or bought from garden centres)
- Flat thin wooden board (at least 50 x 50 cm)
- Weights (6 x 500 g or 3 x 1 kg)

ADAPTING RESOURCES

Ideally, each group makes two model cells (smart bricks) to use in activities 2 and 3. If this proves difficult, make less smart bricks and adapt the activities. You could either run activity 2 and 3 concurrently or complete as a whole class activity. The resource quantities will need to be revised accordingly. Make sure at least 15 smart bricks are made.

REVISION ACTIVITIES

The introductory activities below are optional and revise plant needs and the functions of plant organs. These are useful as revision activities for national tests. They can be used separately to the lesson if this is more appropriate.

a) Plant needs

Use the concept cartoons (Activity sheet 1a-b) to revise what the children have previously learnt about plant growth, and to provide the opportunity to tackle any misconceptions. This can be done by children circling the pictures/statements that they believe to be correct. If done individually, this can be a useful formative assessment/elicitation activity.

Children can then discuss their ideas in pairs, then two pairs discuss, leading to whole class discussion.

b) Functions of plant organs

Provide a collection of different plants. Children make careful observations by dissecting the plant and describing the texture and how the plants feel inside and out.

Discussion questions can include:

- What do you think they are made of?
- How do you think they grow?
- What does each part do?
- What does a healthy plant look like?
- What does an unhealthy plant look like?

c) 'Plant Consequences'

This is a game to revise the functions of different plant organs. The aim of the game is to produce 'the ultimate plant' that will remain healthy in different conditions.

To play the game, the first member of the group draws the roots and folds the paper, leaving a small section of the drawing showing. The second draws the beginning of the stem. The third draws a stem with a leaf and the fourth draws the top of the stem with a flower. They reveal the whole plant and each member describes the function of their part and reasons why they drew it in such a way.

This can lead into a whole class discussion to establish:

- The root is for anchorage and to draw up water and nutrients.
- The stem is to hold the plant up and to transport water and nutrients to different parts of the plant.
- The leaves are to use sunlight to produce sugars/food and to get rid of waste products.
- The flower is for reproduction.

Activity sheet 1c provides a close activity for the lower ability children to establish the function and different parts of the plant.

INTRODUCING THE ACTIVITY

To introduce the concept of plant cells (or 'smart bricks'), show the class a small seed, a bottle of water and a pot of soil (containing nutrients). Ask the children how they would produce a 1 m high structure using those three materials, sunlight and carbon dioxide from the air. Establish that this is impossible for humans to do, but that plants do it all the time.

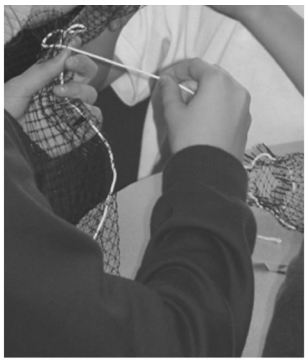
Explain that we use bricks to build tall structures and that plants do exactly the same. They build themselves by making smart bricks, or cells.

There are two main parts of the cell; an inner wall or skin (membrane) to hold fluid, and an outer wall to give it shape. Both of these are strong, but flexible.

MAIN ACTIVITY

Ideally, children build two smart bricks each using a long balloon (to represent the inner wall or membrane) and a netting tube tied together at both ends (to represent the restraining outer cell wall).

1. Create a tube with the netting by folding the piece of netting in half and threading the two ends together with string.



2. Seal one end of the tube with string.

3. Push a partially filled balloon into the open end of the net tube and inflate it.
4. Tie a knot to seal the balloon and seal the open end of the netting tube with string. This is your smart brick or cell.

If smart bricks or cells hold plants up, they need to be strong. The children now investigate the cell strength, either in groups or as a whole class. They do this by placing a board on top of the smart brick, and adding 3 or 4 kg weights gradually to it. They record the results in a table. The more adventurous could attempt to stand on it with support! With strong netting the cell should hold up to about 75 kg (12 stone).

Safety note

The children will need support when standing on the 'smart brick'.

PLENARY

Explain that plants are made of millions of these smart bricks.

Discuss the following questions:

- Why does it need to be so strong? To hold the plant up and for protection.
- What might the smart brick contain instead of air? Fluid: mainly water.
- What happens to plants when they go without water? Why? They wilt because the smart bricks are empty and not as strong and rigid.

Establish that the full balloon provides strength and that cells are similar but contain fluid (mainly water) instead of air. If cells are full, the plant stands upright; if the cells are empty the plant becomes weaker and wilts. Thus the plant needs water to stay strong, robust and healthy. Remind children of the moistness of dissected plants (optional activity b).

Using the children's ideas, produce a mind map of the types of companies that might grow, use or sell plants (see Appendix 2 for an example).

- *What do these industries need from the plants?*
- *Do they all require the same thing from the plants they need?* No, e.g. flower cultivators want bright, healthy, long-lasting flowers. Cabbage growers need strong, healthy, but tender leaves. Potato growers need large, strong, healthy roots etc.

Children cut the cards out and set out the title cards: *root, stem, leaf, flower/fruit.* They then match the types of industry to the parts of the plants used. There are blank cards for children to fill in any other relevant industries. This activity could be given as a homework activity if preferred.

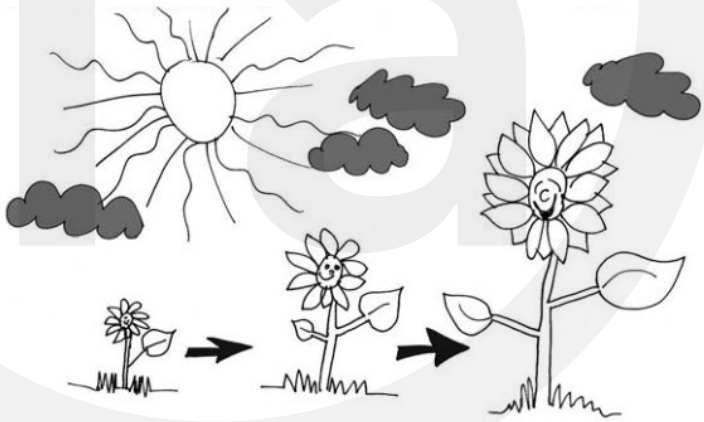
This table shows possible answers.

Root	Stem	Leaf	Flower/fruit
Sugar Beet	Asparagus grower	Lettuce grower	Strawberry growers
Potato farmer	Hemp making industry	Herb grower	Tomato grower
Domestic plant cultivator	Domestic plant cultivator	Domestic plant cultivator	Market gardener
Herbal medicine company	Herbal medicine company	Herbal medicine company	Flower cultivator
Natural dye industry		Natural dye industry	Grain farmer
			Olive tree grower
			Domestic plant cultivator
			Herbal medicine company
			Natural dye industry
			Cotton industry

EXTENSION ACTIVITY

Take a slide of a plant stem or leaf, or peel off the membrane from an onion and look at it under the Intel microscope to look at the smart bricks or cells and make observational drawings.

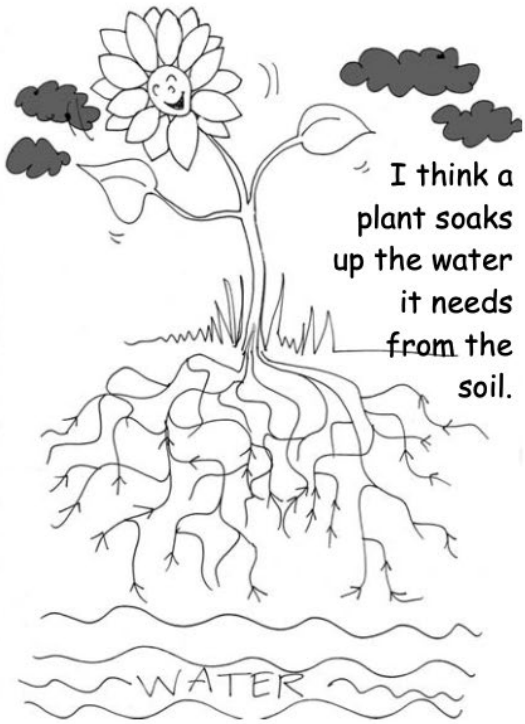
Activity Sheet 1a: What do plants need for healthy growth?



I think a plant only grows in the daytime.

I think a plant needs water to grow healthy.

I think a plant needs to stay warm to grow healthy.



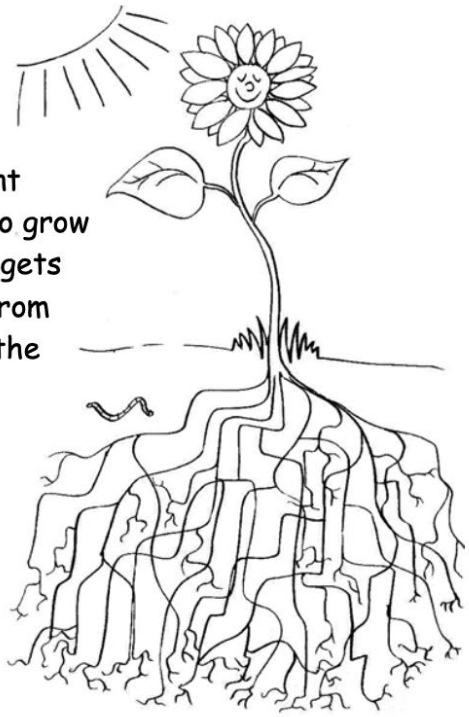
I think a plant soaks up the water it needs from the soil.

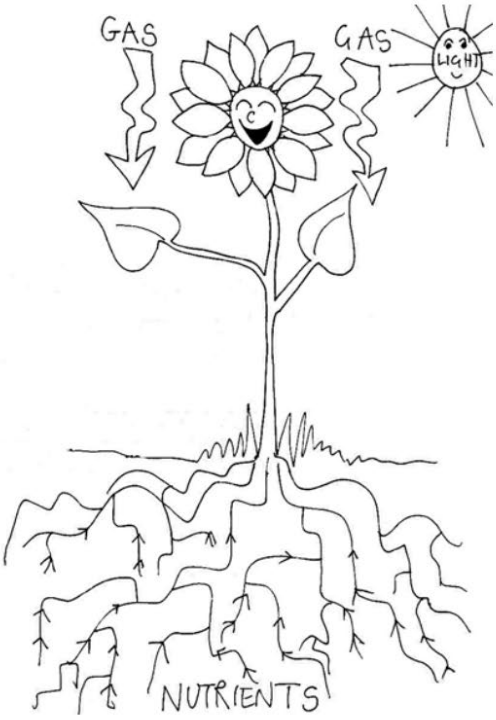
I think a plant gets its water from the rain soaking into the leaf and stem.

Activity Sheet 1b: What do plants need for healthy growth?

I think a plant needs light and healthy leaves to make its own food.

I think a plant needs light to grow healthy, and gets all its food from nutrients in the ground.





I think a plant makes its own food out of materials like gas from the air, nutrients from the ground, and light from the sun.

Activity Sheet 1c: Plant Parts and functions

The _____ anchors the plant and draws up _____ and nutrients from the soil.

The _____ holds the plant up and carries water and nutrients from the roots to the other parts of the plant.

The _____ uses the sunlight and gas from the air to make food for the plant to grow. This process is called _____

The _____ allows the plant to produce fruit and reproduce.

The _____ help the plant to fight illness and grow healthily and strong.

photosynthesis | root | flower | leaf

stem | water | nutrients

Activity Sheet 1d

Root	Stem
Leaf	Flower/fruit

Tomato grower	Strawberry growers	Sugar beet farmers
Flower cultivators	Domestic plant growers	Potato farmers
Asparagus growers	Lettuce growers	Grain farmers
Oil seed rape growers	Olive tree farmers	Herb growers
Cotton industry	Natural dye industry	Herbal medicine
Hemp fibre industry	Market gardener	

2. Healthy leaves

2+ hours

Children respond to a letter from a fictional company to investigate plant growth. They construct a giant model leaf using the cells from the smart bricks activity which they then test for strength and survival against mini beast attack. They consider the importance of this to farming industries.

OBJECTIVES

- Ask relevant questions and use different types of scientific enquiries to answer them
- Use straightforward scientific evidence to answer questions or to support their findings

RESOURCES

(Per group of 4 children unless otherwise stated)

- Activity sheet 2a, 2d
- Activity sheet 2b and 2c (per child)
- Selection of leaves (optional)
- Magnifiers (each) or the Intel microscope (optional)
- One pair of large scissors
- One straw, knitting needle, or other spike
- To make one class leaf:
- One set of the smart bricks made in the previous session Roll of double sided sticky tape
- 3 x 2 m of bubble wrap 3 x 2 m of bubble wrap

Safety note

Children should be supervised closely with sharp object.

INTRODUCING THE ACTIVITY

Read the letter from the company (Activity sheet 2a). A company wants to produce a nutrient product that will help crops produce healthy leaves, roots and fruit.

Show the children the pictures of the different stages of growth of a healthy maize plant (corn) (Activity sheet 2b). Children draw pictures to predict the way the plant would have grown if its leaves were removed. Establish that without leaves plants would not grow tall and eventually die because the food in the seed has been used up. Remind children that leaves use sunlight to make their own food for growth. This is useful for revision for national tests.

Remind the children of the different industries that use leaves and require them to be strong and healthy (see card sorting activity from activity 1), and ask the following questions:

- *What does a company growing lettuces, or cabbages require from the leaves of the plants it grows?* Large, strong, healthy, appetising and nutritious leaves that are undamaged by insect bites.
- ***What does a company growing herbs require?*** Strong, healthy, undamaged leaves which are full of flavour.

Establish that plants naturally produce leaves that are strong and healthy for survival and weaker plants do not survive.

Plant companies want to grow large numbers of strong healthy plants to make larger profits.

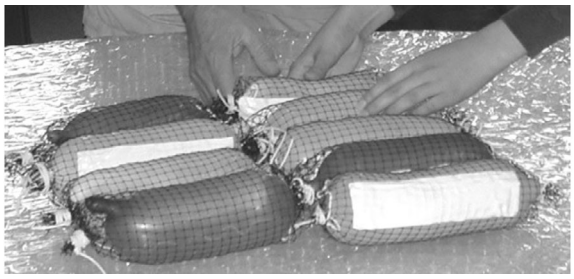
How does a plant produce that kind of leaf? It takes in certain nutrients (minerals) and they help it to strengthen the smart bricks in the leaves and protect them from disease.

Look carefully at a selection of leaves using magnifiers or the Intel microscope. Children note the structure, e.g. central vein, radiating veins, colour, shape, etc. They use observations to draw a labelled diagram of the leaf. They could then look carefully at, and compare, examples of healthy and unhealthy leaves.

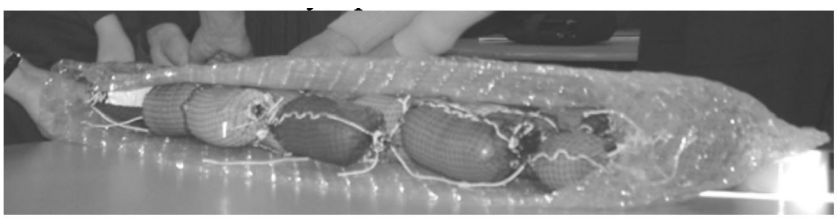
MAIN ACTIVITY

Use one set of their smart bricks from activity 1 to construct a giant leaf, by joining them together with a skin (bubble wrap). You could produce one or two leaves for the whole class depending on their size and the number of smart bricks that you have made.

1. Attach double-sided sticky tape to two opposite sides of the smart brick.
2. Stick the smart bricks down in rows onto the bubble wrap leaving a border at the edges and enough excess bubble wrap on one side to fold over and cover the smart bricks.



3. Fold over the excess bubble wrap and seal the smart bricks in with sticky tape to create the leaf.



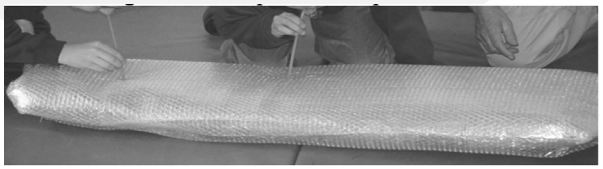
After the leaf or leaves are completed, the children use Activity sheet 2c to consider what would happen to the leaf if it was put under pressure from rain or hail, or attacked by mini-beasts. Children look at the photographs to see that aphids use a proboscis that sticks into the leaf and sucks out the liquid, and a caterpillar bites the leaf with scissor like jaws.

Safety note

Children should be supervised closely with sharp object.

Test the strength of the leaf by asking a volunteer to lie on it. Explain that leaves are a flat cushioned structure, strong enough to withstand weather conditions and the weight of small animals. They are flexible enough to bend and not to snap under the strain.

They then test how the leaf responds to aphid attack by puncturing the leaf. One child could take the role of the aphid and attach a straw to their nose and attack the leaf or use a knitting needle or equivalent to puncture it.



To test protection against the bite of caterpillars, simulate their bite by cutting the leaf with scissors.

PLENARY

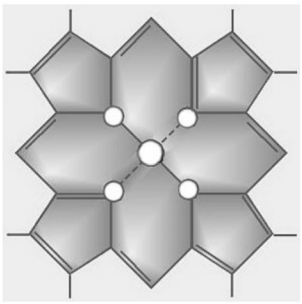
Draw a conclusion. In both of these tests, some of the cells become damaged but many remain intact. The structure of the leaf is compartmentalised; so even when one section becomes damaged, the leaf can still produce new food for plant growth by making more cells. Damage in one part of the leaf hardly matters to the overall plant.

Refer back to the letter and the idea of industries making nutrient products to help growth. Ask the children:

- If plants protect themselves so well naturally, why do they need nutrient products?

Establish that some soils lack the nutrients necessary to produce healthy leaves (due to many years of growing crops) and that crop producers use nutrient products to ensure a higher percentage of plants grow healthily.

Examine the labels from the packages of different fertilizers (Activity sheet 2d). Explain that nitrogen is a key nutrient in helping leaves grow strong and healthy (Appendix 1 provides further information for teachers). The children then match the nutrients from this information to those named on the fertilizer labels. Establish which fertilizer would promote the best leaf growth and why.



Chlorophyll UK

Sunlight House
Photosynthesis Industrial Estate
Yorkshire

Plant Research Manager:
B N Picking

7th July

Dear Research Group

We produce fertilizer and other nutrient products for a range of plant crops. These crops include cereals, potatoes and different types of fruit.

We know that if the plant gets the right balance of nutrients, it will grow and be healthy, and produce good crops for the farmer.

We are interested in investigating the growth of root crops (like radishes and carrots), flowering crops (such as sunflowers) and leafy crops (e.g. such as spinach and cabbage).

We want to make a product that will give all the essential nutrients to these plants, to make the roots, leaves and flowers grow healthily, so that farmers can produce healthy and strong crops.

To do this, we need you to:

Compare different types of soil to find out which help root crops, flowering crops and leafy crops grow the best.
Research what different nutrients do to different parts of a plant.
Find out how different amounts of nutrients affect the growth of root crops, flowering crops and leafy crops.

We look forward to hearing from you with your results.

Yours faithfully

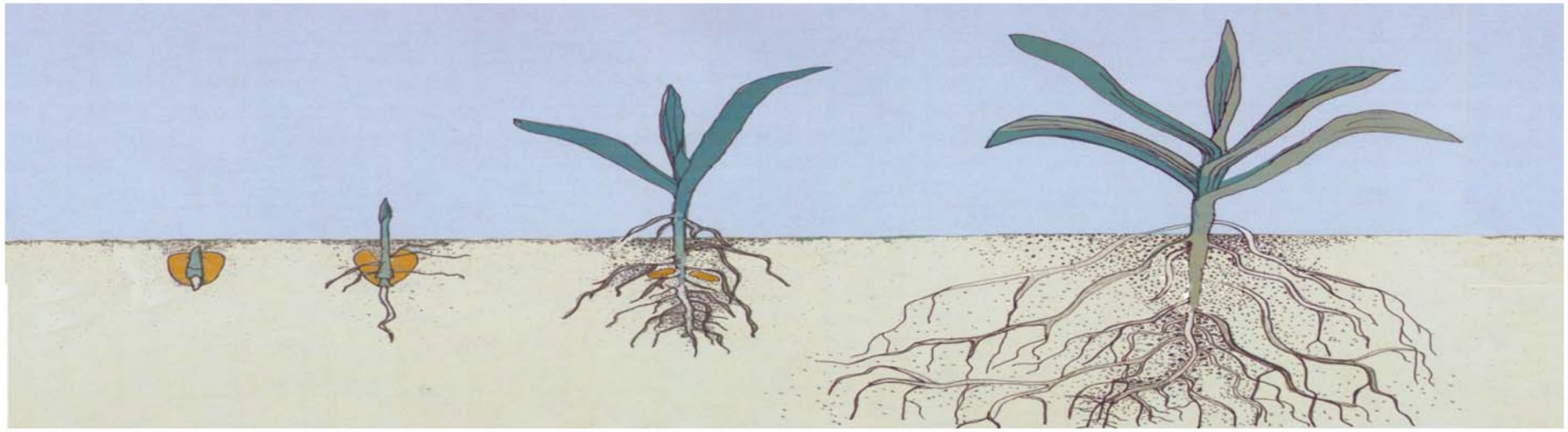
B N Picking

B N Picking

Plant Research Manager

The function of leaves

Here are some pictures of the different stages of plant growth of a healthy maize plant

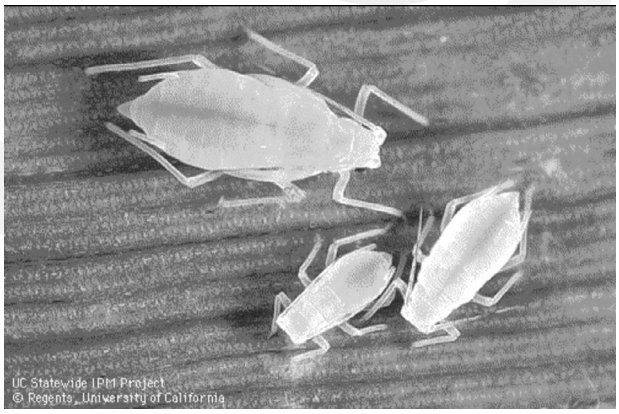


In the boxes below, draw how you think the plant would have grown with its leaves removed.

Activity Sheet 2c: Leaves

For a plant to survive, its leaves have to withstand harsh weather and attack from mini-beasts. Think about how the leaf is protected from harsh weather such as rain, hail and harsh winds.

Look at these photographs of different mini-beasts. They all feed off leaves, but they do it in different ways. Look carefully to see the two different methods.



The aphid has a spike (proboscis) that they plunge into the leaf and use to suck out the juices.

The caterpillar and grasshopper have scissor-like jaws to cut the leaf.

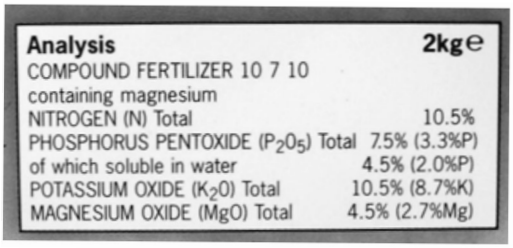
How do you think the leaf is protected from aphid, grasshopper, or caterpillar attack?

Now recreate harsh weather conditions and mini-beast attack on the leaf you made.

What happened to your leaf?

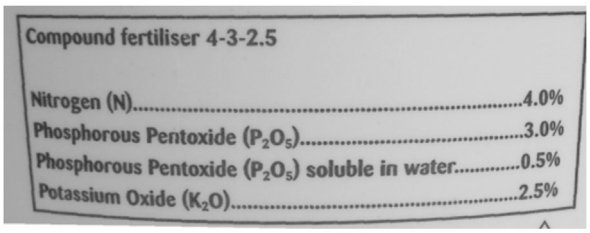
How was it protected?

Activity Sheet 2d: Fertilizer labels



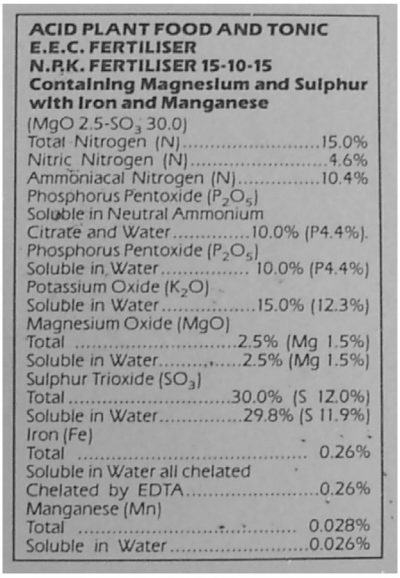
Analysis	2kg e
COMPOUND FERTILIZER 10 7 10	
containing magnesium	
NITROGEN (N) Total	10.5%
PHOSPHORUS PENTOXIDE (P_2O_5) Total	7.5% (3.3%P)
of which soluble in water	4.5% (2.0%P)
POTASSIUM OXIDE (K_2O) Total	10.5% (8.7%K)
MAGNESIUM OXIDE (MgO) Total	4.5% (2.7%Mg)

Fast Plant Fertilizer



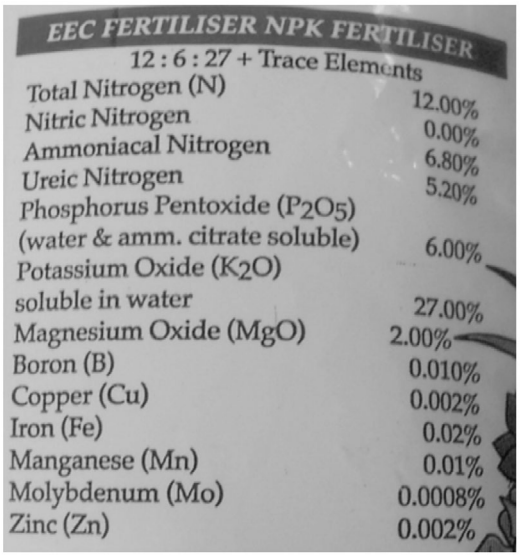
Compound fertiliser 4-3-2.5	
Nitrogen (N)	4.0%
Phosphorous Pentoxide (P_2O_5)	3.0%
Phosphorous Pentoxide (P_2O_5) soluble in water	0.5%
Potassium Oxide (K_2O)	2.5%

Rooster Organic Chicken Manure Pellets



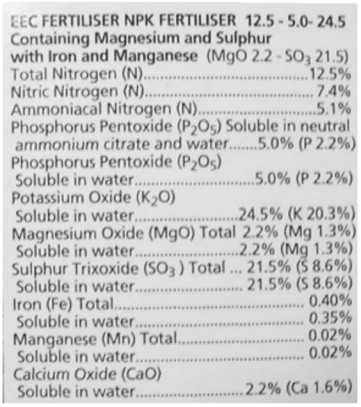
ACID PLANT FOOD AND TONIC E.E.C. FERTILISER N.P.K. FERTILISER 15-10-15 Containing Magnesium and Sulphur with Iron and Manganese	
(MgO 2.5-SO_3 30.0)	
Total Nitrogen (N)	15.0%
Nitric Nitrogen (N)	4.6%
Ammoniacal Nitrogen (N)	10.4%
Phosphorus Pentoxide (P_2O_5) Soluble in Neutral Ammonium Citrate and Water	10.0% (P4.4%)
Phosphorus Pentoxide (P_2O_5) Soluble in Water	10.0% (P4.4%)
Potassium Oxide (K_2O) Soluble in Water	15.0% (12.3%)
Magnesium Oxide (MgO) Total	2.5% (Mg 1.5%)
Soluble in Water	2.5% (Mg 1.5%)
Sulphur Trioxide (SO_3) Total	30.0% (S 12.0%)
Soluble in Water	29.8% (S 11.9%)
Iron (Fe) Total	0.26%
Soluble in Water all chelated Chelated by EDTA	0.26%
Manganese (Mn) Total	0.028%
Soluble in Water	0.026%

Muck and Magic Fertilizer



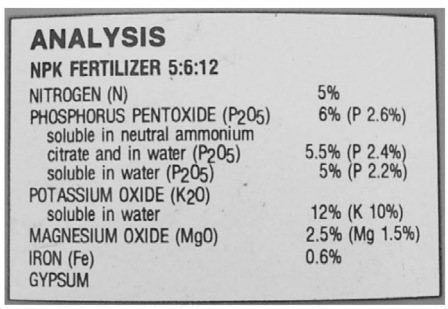
EEC FERTILISER NPK FERTILISER 12 : 6 : 27 + Trace Elements	
Total Nitrogen (N)	12.00%
Nitric Nitrogen	0.00%
Ammoniacal Nitrogen	6.80%
Ureic Nitrogen	5.20%
Phosphorus Pentoxide (P_2O_5) (water & amm. citrate soluble)	6.00%
Potassium Oxide (K_2O) soluble in water	27.00%
Magnesium Oxide (MgO)	2.00%
Boron (B)	0.010%
Copper (Cu)	0.002%
Iron (Fe)	0.02%
Manganese (Mn)	0.01%
Molybdenum (Mo)	0.0008%
Zinc (Zn)	0.002%

Fruitful General Purpose Fertilizer



EEC FERTILISER NPK FERTILISER 12.5 - 5.0 - 24.5 Containing Magnesium and Sulphur with Iron and Manganese (MgO 2.2 - SO_3 21.5)	
Total Nitrogen (N)	12.5%
Nitric Nitrogen (N)	7.4%
Ammoniacal Nitrogen (N)	5.1%
Phosphorus Pentoxide (P_2O_5) Soluble in neutral ammonium citrate and water	5.0% (P 2.2%)
Phosphorus Pentoxide (P_2O_5) Soluble in water	5.0% (P 2.2%)
Potassium Oxide (K_2O) Soluble in water	24.5% (K 20.3%)
Magnesium Oxide (MgO) Total	2.2% (Mg 1.3%)
Soluble in water	2.2% (Mg 1.3%)
Sulphur Trioxide (SO_3) Total	21.5% (S 8.6%)
Soluble in water	21.5% (S 8.6%)
Iron (Fe) Total	0.40%
Soluble in water	0.35%
Manganese (Mn) Total	0.02%
Soluble in water	0.02%
Calcium Oxide (CaO) Soluble in water	2.2% (Ca 1.6%)

Speed Grow Fertilizer



ANALYSIS NPK FERTILIZER 5:6:12	
NITROGEN (N)	5%
PHOSPHORUS PENTOXIDE (P_2O_5)	6% (P 2.6%)
soluble in neutral ammonium citrate and in water (P_2O_5)	5.5% (P 2.4%)
soluble in water (P_2O_5)	5% (P 2.2%)
POTASSIUM OXIDE (K_2O) soluble in water	12% (K 10%)
MAGNESIUM OXIDE (MgO)	2.5% (Mg 1.5%)
IRON (Fe)	0.6%
GYPSUM	

Hercules Fertilizer

3. Robust roots

2+ hours

Children explore the function of roots to anchor or draw up water and nutrients. They create a model root system and explore the nutrients that help a root stay healthy and link this to roots in an industrial context.

OBJECTIVES

- Y3 Identify and describe the functions of different parts of flowering plants, roots, stem's trunk, leaves and flowers
- Y3 Explore the requirements of plants for life and growth (air, light, water, nutrients from the soil and room to grow).

RESOURCES

(Per group of 4 children unless otherwise stated)

- Activity sheet 3
- Activity sheet 2d
- 3 or 4 buckets or large containers (per class)
- To make each root (half the class):
- The remaining smart bricks (Activity 1) A ball of string.

INTRODUCING THE ACTIVITY

Discuss the functions of plant roots with the class by asking the following questions:

- How do plants find water and nutrients? The roots spread through the ground to find water/nutrient sources.
- How do plants get the nutrients from the soil and fertilizers? They draw them up through the roots.
- How do they get the water they need? They draw water that is held in the soil through their roots.
- How do they transport both of these to the parts of the plant that need them? They transport the water and nutrients to other parts of the plant via veins in the stem.

Establish that roots are necessary to (i) anchor the plant to prevent it falling over or being carried away in more extreme weather conditions; (ii) take up water and mineral nutrients.

The children compare tap and spreading root systems by examining photographs (Activity sheet 3) and making careful observations. They relate the photographs to the functions of the root (anchoring and drawing up nutrients) and establish the type of root that is best suited to each function.

Explain that phosphorous and potassium are nutrients that help plants produce healthy roots (Appendix 2). Children look again at fertilizer ingredients (Activity sheet 2d) to find out which fertilizers are best to promote growth in the roots.

Discuss which crop producers or other industries would be interested in the roots of a plant and establish what they would require from the root, e.g. potato, carrot and beetroot farmers, or sugar manufacturers (link to the plenary of activity 1).

MAIN ACTIVITY

Use buckets placed in different parts of the classroom to represent sources of water and nutrients. The only way to reach them is for the smart bricks (cells) to link up in several chains. These represent the growth of root hairs. Using the smart bricks left over from the first session, the children build roots by joining together the cells with string. Half the class build a tap root system and the other half build a spreading root system to reach the sources of water. Explain that although the roots, made by the children, may have one cell thickness, the roots of a plant have millions of cells.

PLENARY

Discuss the two types of root built, and how they might be used by different industries. Discuss what different industries are looking for in the roots of the plants they grow. Use the following questions to aid discussion.

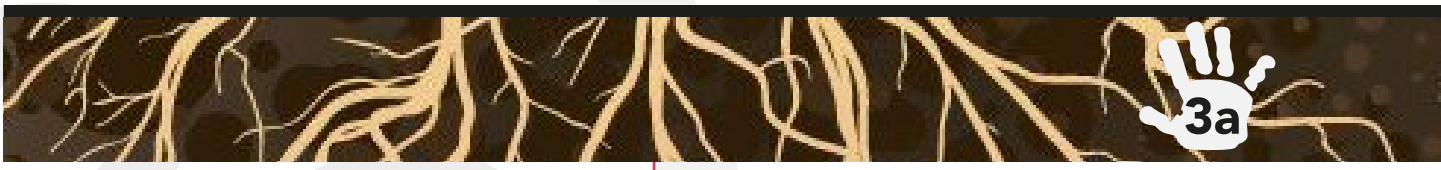
- Which root type is the most successful for reaching scarce sources of water and nutrients? The spreading root, as its roots spread through a larger area, e.g. a tree's roots cover the same area as its branches.
- Which root type would anchor the plant best? The tap root is large and strong and would lodge itself firmly in the ground.
- Which root type would be most useful for industries, e.g the most edible? The tap root produces more edible material, e.g. carrots.

EXTENSION ACTIVITY

Children could observe and draw the roots using either magnifiers or the Intel microscope.

Alternatively, they could research root systems and root hairs on the Internet.

Activity Sheet 3a



Tap roots

Spreading roots

4. Nutrient test and report to company

Children explore the function of roots to anchor or draw up water and nutrients. They create a model root system and explore the nutrients that help a root stay healthy and link this to roots in an industrial context.

OBJECTIVES

- Y3 Identify and describe the functions of different parts of flowering plants, roots, stem's trunk, leaves and flowers
- Y3 Explore the requirements of plants for life and growth (air, light, water, nutrients from the soil and room to grow).

APPROXIMATE DURATION:

1 hour (plus 3 weeks of observations + measurements)

RESOURCES

(Per group of 4 children unless otherwise stated)

- Activity sheet 2a
- Activity sheet A (per child)
- Plant nutrient product (from garden centre or DIY store)
- Radish, geranium or sunflower seedlings
- Equal-sized plant pots containing equal amounts of compost

ADVANCE PREPARATION

Decide whether you are going to carry out the investigation as a class activity or as group activities and revise the resource amounts appropriately.

Priory to photocopying, you may wish to complete aspects of Activity sheet A for lower ability children.

If you use a sandy soil containing few nutrients or nutrient gel, the investigation results will be more pronounced. Some garden centres provide nutrient gel this would mean you could observe root growth.

INTRODUCING THE ACTIVITY

Re-read the letter from the company (Activity sheet 2a). Discuss the findings over the last few sessions. Ask the children:

Have the industry's queries been answered?

Discuss different ways in which the information could be reported back.

MAIN ACTIVITY

The children plan and carry out parallel plant investigations to test the effect of nutrient products on the health of the plant.

Work through the investigative process with the children providing the appropriate support or opportunity for independent work as you see fit using planning frame (Activity sheet A).

All children should have the opportunity to plan the investigation. However you could either set up one class investigation or each group could set up their own. The following steps of the investigation can provide a focus, or direction given by the teacher.

- Consider the investigation question, e.g. What is the effect of a nutrient product on the growth of the plant? Or, How does the concentration of a nutrient product effect the height of a plant? Or, Which parts of the plant are affected most by a given nutrient product?
- Think about what they will change in order to test the question e.g. the amount (volume) of the nutrient product, or the concentration of the nutrient product. They should record this on the planning sheet.
- Think about what they will measure or observe in order to find out the effect of the nutrient on the plant, e.g. measure the height of each plant in millimetres, or the number of leaves on the plant, or observe the colour and size of the leaves. They could explore the growth of all the plant organs by measuring them all. Record this on that planning sheet.
- Fair Test: Think about the factors they will keep the same in order to make it fair. Discuss possibilities, e.g. amount and type of soil, plant pot, amount of water/ liquid the plants are given, the time they are fed, etc.
- Consider the time period of the experiment, e.g. three weeks; the times to water or feed the plant, e.g. once every 3 or 4 days; and the times to measure or observe the plant, e.g. once or twice a week at the same time every day. Record these in the appropriate sections on the sheet.
- Children set up the parallel investigation using at least three different plants. Each plant should be the same type, in the same conditions (soils, pot size, amount of light etc.), and roughly the same size. Geranium, radishes or sunflower seedlings are appropriate.

When the experiment is completed, children should graph numerical data (they could use an ICT data- handling package).

Children then need to draw a conclusion by returning to the investigation question and answering it using the results. If a pattern has been found try and ask the children to write the conclusion in a sentence using comparative adjectives, e.g. the more nutrients, the taller the plant.

PLENARY

The children reply to the company e-mail (Activity sheet 2a), answering the questions and explaining what they have discovered in one of the following ways:

- Power point presentation
- Writing a letter or e-mail
- A written report
- An individual or group poster
- A cartoon strip
- A video presentation.

Depending on the class, they could be given the freedom to choose one of the above methods, or the choice could be limited. This provides an ideal opportunity for assessment.

The children compile a list of questions that they would like to find out about nutrition products, plant growth/research industries and the role of scientists in these companies.

A site visit could be arranged to a plant nutrition product company, research organisation or cultivating industry. Here the children could observe the manufacturing process, find out what the scientists do in the company, and compare these to the plant investigations they set up and carried out in the classroom. The children could try and find the answers to the questions. Or, if this is not possible, a representative from a company could visit the school to describe the manufacturing and testing of nutrient products, the growing of healthy plants for commercial sale and the jobs of scientists. Some of the children's work could be passed on to the company.

If a link with an industry is not possible, the children could research answers to their questions on the internet or in the library.

Appendix 1

Further Information for Teachers about Plant Nutrients, Soils and Nutrient Products

What nutrients do plants need?

Most living organisms have three basic requirements for survival: food, water, and air.

Through photosynthesis ('making things with light'), plants use energy from the sun to change carbon dioxide and water into starches and sugars. These starches and sugars are the plant's food.

Since plants get carbon, hydrogen, and oxygen from the air and water, there is little farmers and gardeners can do to control how much of these nutrients a plant can use. However, whilst all green plants make their food by photosynthesis, they also need to get nutrients from the soil for growth. These dissolve in water and are taken up by the roots of the plant. Amounts of these in the soil can be controlled more easily by farmers and gardeners.

Plants need both non-mineral nutrients, which they get from the air and water, and mineral nutrients, which they get from the ground. The non-mineral nutrients are hydrogen, oxygen and carbon.

The twelve mineral nutrients, which come from the soil, are dissolved in water and absorbed through a plant's roots. There are not always enough of these nutrients in the soil for healthy plant growth. This is why many farmers and gardeners use fertilizers to add the nutrients to the soil.

Mineral Nutrients

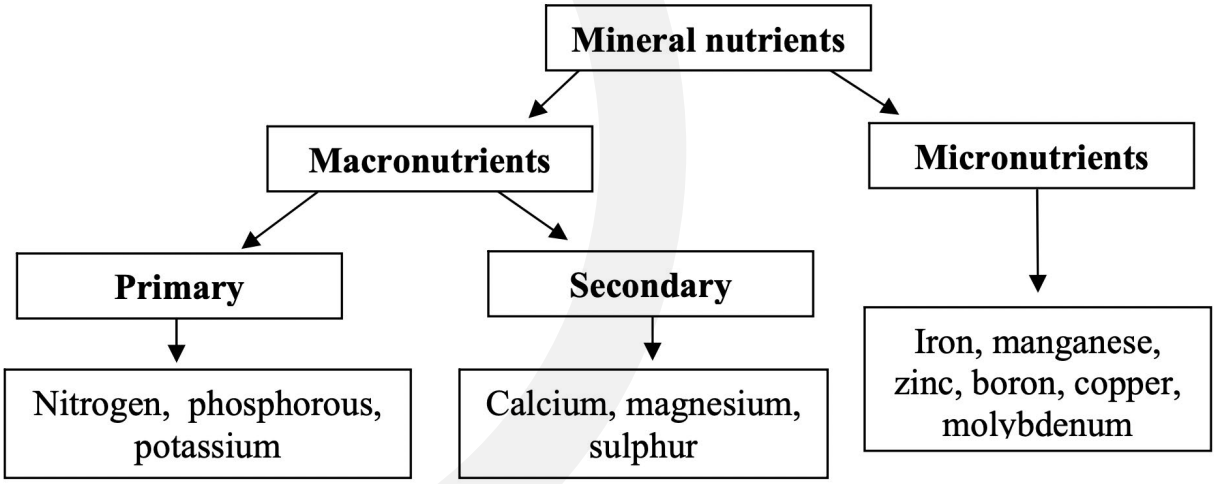
There are twelve essential mineral nutrients which plants must take up from the soil.

Nutrient	Symbol
Nitrogen	N
Phosphorus	P
Potassium	K
Calcium	Ca
Magnesium	Mg
Sulphur	S
Iron	Fe
Manganese	Mn
Zinc	Zn
Boron	B
Copper	Cu
Molybdenum	Mo

They are divided into two groups: macronutrients and micronutrients. Although they are all equally important to the plants health, the plant needs much more of a macronutrient than a micronutrient. A shortage of any one will result in poor crop growth.

Macronutrients can be broken into two more groups: primary and secondary nutrients. Nitrogen, phosphorous, and potassium are primary nutrients. Because plants need so much of these, this can lead to a deficiency in some soils. Calcium, magnesium, and sulphur are secondary nutrients. There are usually enough of these nutrients in the soil so fertilisation is not always needed. Also, large amounts of calcium are added when lime is applied to soils. Sulphur is usually found in sufficient amounts from the slow decomposition of soil organic matter.

Micronutrients are essential for plant growth but are needed in only very small amounts. They are boron, copper, iron, manganese, molybdenum and zinc.



How do the nutrients help the plant?

Nutrient	Part of the plant it affects	How it helps the plant
Nitrogen	Leaves	This helps above-ground leafy growth and gives a dark green colour to leaves.
Phosphorous	Roots, flowers and seeds	This encourages plant cell division. Without phosphorous, flowers and seeds could not form. It helps root growth and protects plants from disease.
Potassium	Roots and leaves	This increases the plant's resistance to disease and encourages root growth. It is needed for the making of chlorophyll.

Recycling organic matter is an excellent way of providing macronutrients and micronutrients to growing plants.

How important is the soil type?

Most plants absorb water and nutrients from the soil as part of the growing process. The nature of the soil is important in determining how much of a nutrient the plant can retrieve. Most soils contain a combination of sand, silt, clay, and organic matter. The soil texture and acidity determine the extent to which nutrients are available to plants.

Soil texture is important for water and nutrient retention. Clays and organic soils hold nutrients and water much better than sandy soils. As water drains from sandy soils, it causes leaching (ridding the soil of nutrients), as it carries nutrients along with it. An ideal soil contains equivalent portions of sand, silt, clay, and organic matter.

The acidity or alkalinity of the soil is also important in determining the availability of nutrients. Acidic soils tend to have less macronutrients and alkaline soils tend to have less micronutrients. Lime can be added to the soil to make it less acidic and also supplies calcium for plants to use. In neutral soils nutrients are more readily available to plants. Microbes convert nitrogen and sulphur to forms that plants can use. This process is necessary for the plant to receive its essential nutrients. Lime also enhances the physical properties of the soil that promote water and air movement.

Are all fertilizers the same?

There are many types of fertilizer and nutrient products available. The type of fertilizer ideal for a crop depends on the type of crop, the soil texture, the acidity or alkalinity of the soil and the nutrients already available in the soil. Farmers will regularly send samples of soils and organic matter to laboratories to analyse their nutritional content, and will use certain nutrient products depending on the diagnosis.

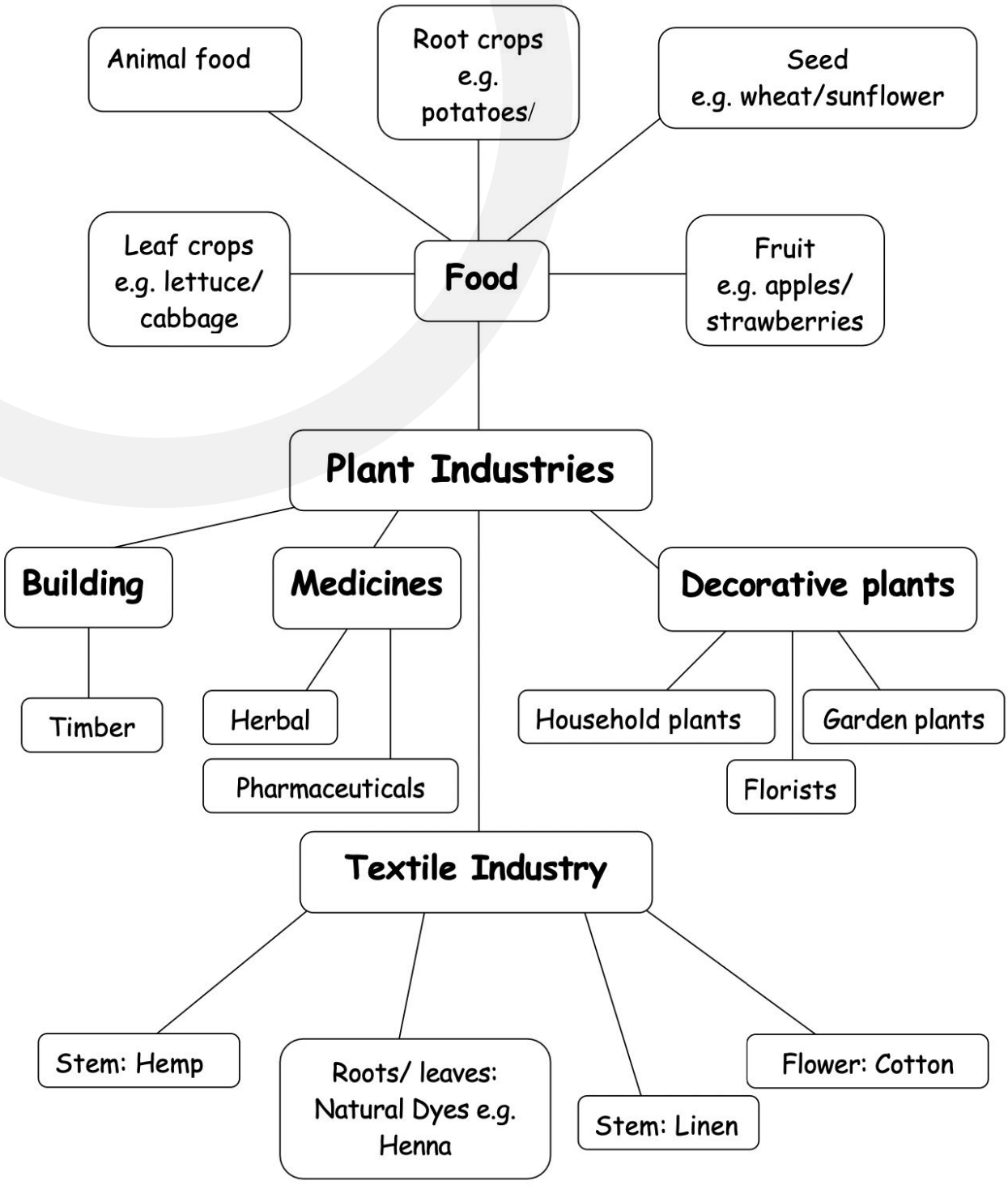
There are three main ways of distributing fertilizer. They are:

- broadcasting (a uniform distribution over the whole cropped field)
- placement (applying the fertilizer in bands or areas near the plants or plant rows)
- foliar sprays (the fertilizers are sprayed, covering the plants, and are absorbed into the leaves).

Plant growth without soil

Glass house production of vegetables is often without soil. Instead, plants can be grown in water or soil-less media (which are inert, water retentive, give support and have good aeration and moisture balances), e.g. sand, peat or vermiculite. Nutrient solutions are added to provide the essential nutrients for healthy plant growth. This process is called hydroponics. (Aeroponics is similar, but plant roots are suspended in a dark chamber and sprayed with the nutrient solution.)

Appendix 2: Plant Industry Mind map



COMMON MISCONCEPTIONS FROM CHILDREN REGARDING PLANT NUTRITION[1]

Misconception	Fact
Plants get their food from the soil and roots are organs for feeding.	Plants make their food. They make it from simple substances from the environment. The first step is by photosynthesis.
Plants have multiple sources of food: e.g. by photosynthesis as well as the environment.	Raw materials come from the environment but they make all of their food.
Water, minerals, carbon dioxide and sunlight are all food for plants.	Plants take in gases and liquids that are chemically changed into solids.
Water is for plant drinking and carbon dioxide is for plant breathing and these substances remain unchanged.	An analogy for plant nutrition is a factory. The plant takes in raw materials to make the food product.
Photosynthesis is a way for plants to make food for the benefit of animals and people, rather than for the plant itself.	Plants need food to grow. They grow to make new plants usually by producing seeds.
Plants need heat and light from the sun for photosynthesis.	It is the light that drives photosynthesis but plants cannot survive below a critical temperature.
Plants need light to grow.	Plants need light in order to produce food for it to grow.

1 Sourced from: Leeds National Curriculum Science Support Project

Smart Bricks for Smart Plants: Healthy Leaves
Experimental and investigative science: Assessment of performance

	Level 1	Level 2	Level 3	Level 4	Level 5
Planning Asking questions	To begin to carry out ready planned tests.	With guidance, make suggestions about how they could collect evidence or data to answer questions. *"We need to grow plants to see if that happens."*	Put forward their own ideas about how to find the answers to questions. Recognise and explain a fair test. Describe what they think might happen. (Predict)	To begin to offer an appropriate approach to answering a question. Plan a fair test by describing which factors to keep the same and which to change. *"We need to make sure they all have the same water ."*	To identify an appropriate approach to answer scientific questions. Recognise key factors to consider when carrying out a fair test. Make predictions using scientific evidence.
Obtaining Evidence Systematic Observations	To begin to make measurements. To begin to fill in a table to collect data	To begin to make measurements. To begin to fill in a table to collect data.	Make measurements using equipment provided with relevance to the task. Fill in a table to collect data.	Make accurate measurements with direct relevance to the task. Record data using tables.	Take repeated measurements to ensure reliability. Make a decision of what to measure. Create their own table to record data. *Think about the differences between height and leaf size.*
Considering Evidence Explain observations and measurements	With support, say what has happened.	Say what has happened and whether it was what they expected.	Begin to offer explanations for what they have found out. Explain what they see and begin to identify patterns in recorded measurements. *"They have all grown but this one started first and grew best"*	Relate their conclusion to scientific knowledge and understanding. *"The ones in loam grew best because it has more things in it."* Suggest improvements in their work, giving reasons.	Draw conclusions that are consistent with the evidence. Relate evidence to scientific knowledge and understanding. Make practical suggestions as to how their working methods could be improved. *"We need to do this with more plants and see what happens over a longer time."*

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or contact:

Centre for Industry Education Collaboration
CIEC Department of Chemistry
University of York
York
YO10 5DD

01904 322523

ciec@york.ac.uk

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Author – Peter Heale

Editor – Joy Parvin

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