Nutrients, nodules and nitrogen: Recycled!

Kate Andrews
Lorraine Bruce
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Marjorie Smith

The Scottish Government
Riaghaltas na h-Alba

SOCIETY OF Biology

SSERC
Advancing science, technology and safety

Principles and Big Ideas of Science Education
Ed. Wynne Harlen, (ASE) 2010

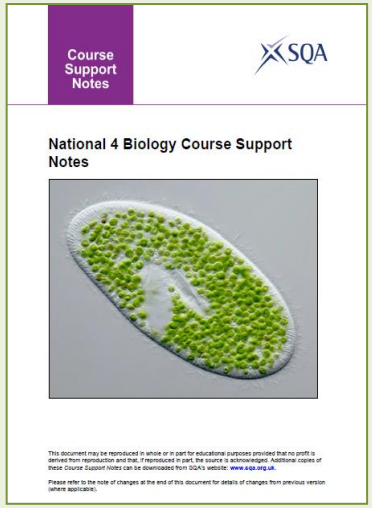
Science education has multiple goals. It should aim to develop:

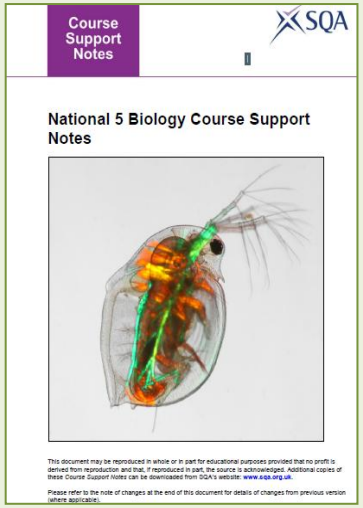
~ understanding of a set of big ideas in science which include ideas *of* science and ideas *about* science and its role in society

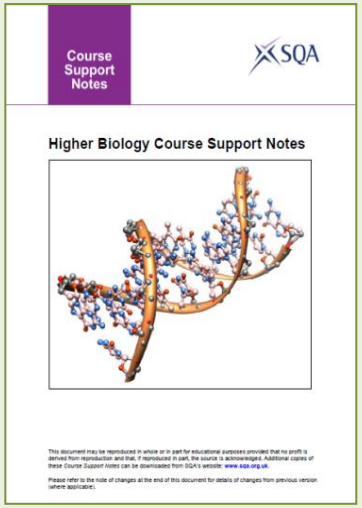
~ scientific capabilities concerned with gathering and using evidence

~ scientific attitudes.

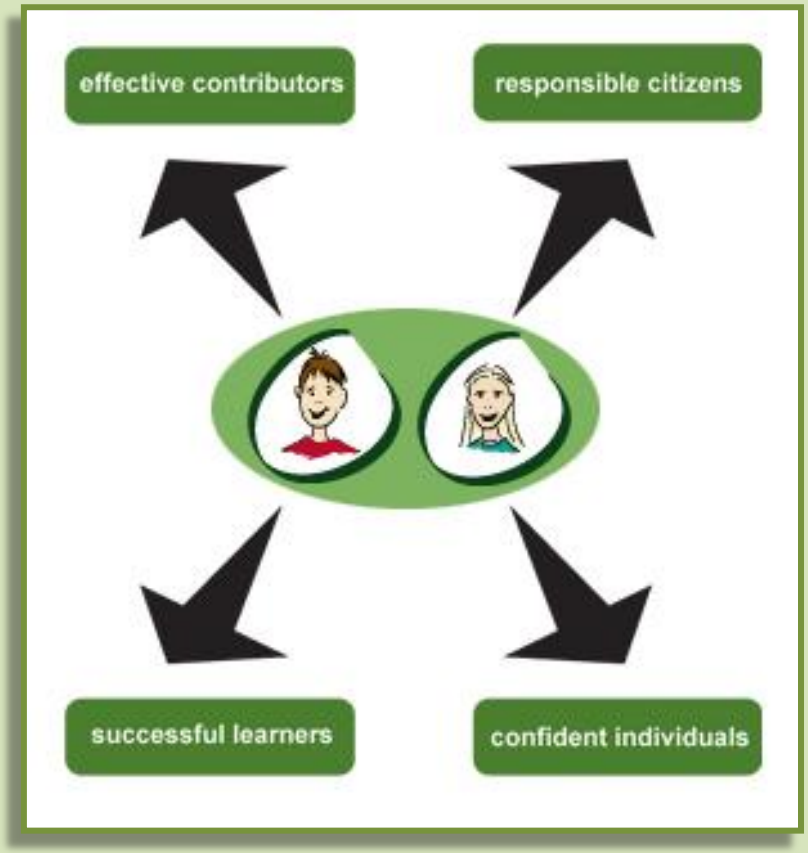
The broad theme of food security runs through our Curriculum for Excellence.







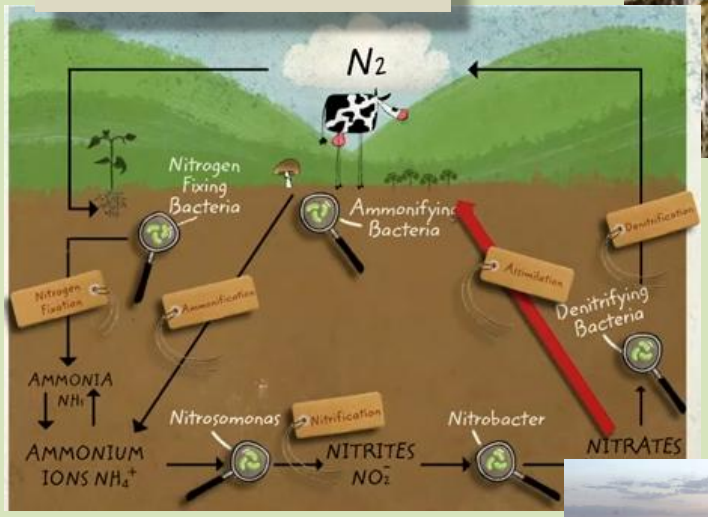
And at the same time……!

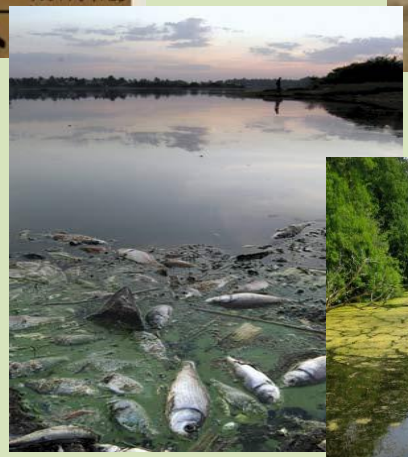


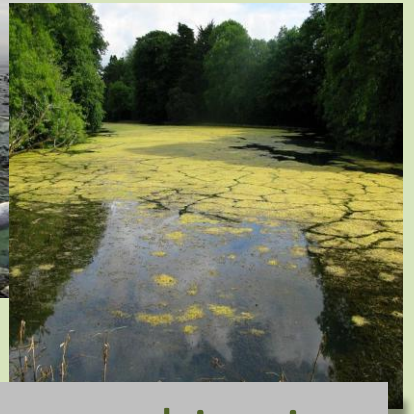
microorganisms

impact of fertilisers

nitrogen cycle



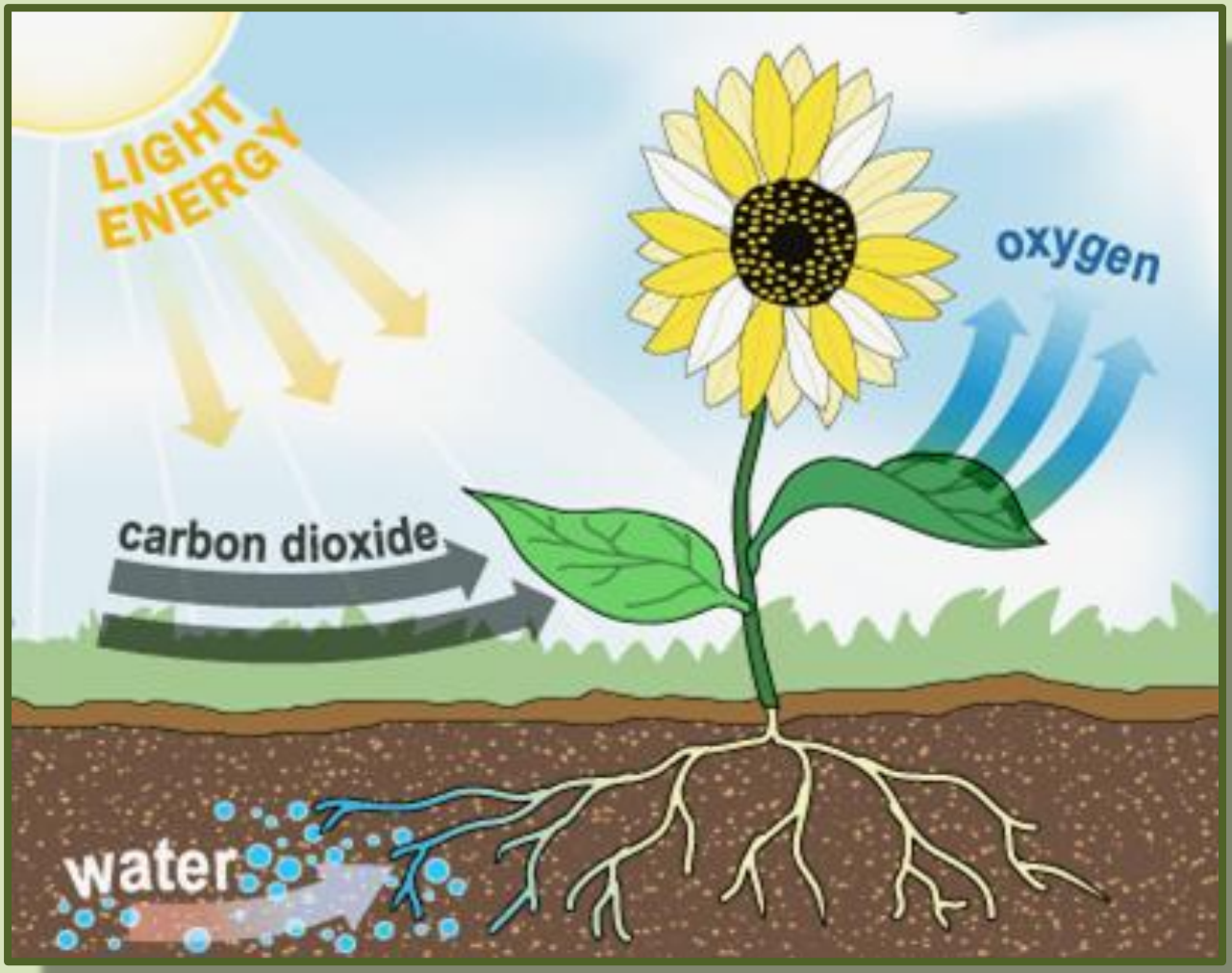




genetic modification

decomposition

eutrophication


LIGHT ENERGY
oxygen
carbon dioxide
water

Nutrients are essential for plant growth and yield.....

Sach's water culture solutions can be used to investigate nutrient deficiency in algae

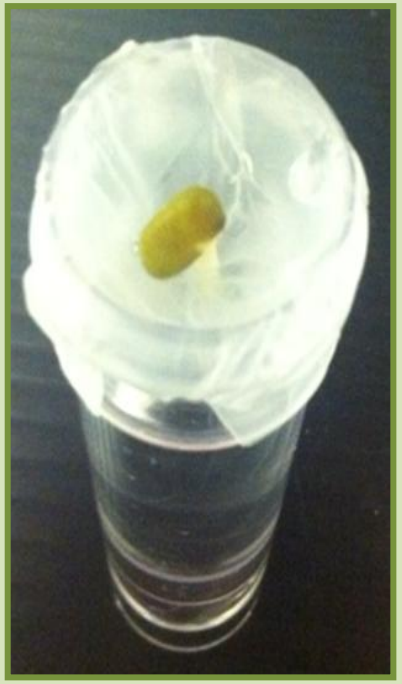
Scenedesmus quadricauda

Investigating Plant Nutrient Deficiency using Mung Beans


CC
10 days
CC
7 days
CC
3 day

Your turn.....


Distilled water
PARAFILM "M"
LABORATORY FILM
NEENAH, WI 54956




CC
3 day

Sach's water culture solutions can be used to investigate nutrient deficiency in mung beans

iPhone_time_lapse.mp4

Mung_Beans.mp4

Culture medium		Complete medium	No Nitrogen (N)	No Phosphorous (P)	No Potassium (K)	Distilled water	Appearance
Growing time	3 days						roots
							shoots
							leaves
	7days						roots
							shoots
							leaves
	10 days						roots
							shoots
							leaves
Overall comment/ measurements							

Nitrogen Deficiency

N Nitrogen
Atomic Number: 7
Atomic Mass: 14.01

- deficiency usually appears on older leaves first
- because nitrogen is a part of the chlorophyll molecule, a major deficiency symptom is chlorosis (yellowing of leaf)
- slow growth and stunted plants
- lower protein means fewer leaves
- reduced yield

Potassium Deficiency

K Potassium
Atomic Number: 19
Atomic Mass: 39.10

- deficiency usually appears on older leaves first
- yellowing along leaf margins
- decreased disease resistance
- slow growth and poorly developed root system
- small and shrivelled grain or fruit reduced yield

Phosphorus Deficiency

P Phosporus
Atomic Number: 15
Atomic Mass: 30.97

- deficiency usually appears on older leaves first
- leaves turn a dark green or purple in colour
- overall stunting of plants especially roots
- roots often turn red or purple in colour and likely to suffer from root-rot

Fertilisers

http://tinyurl.com/NPK-fertiliser

http://tinyurl.com/RHS-Fertilisers


Levington
TOMORITE
LIQUID TOMATO FERTILISER
With Seaweed Extract
For Top Quality, Full Flavoured Tomato
Westland
garden health
Growmore
Garden Fertiliser
Balanced nutrients for healthy gardens
Westland
garden health
Fish, Blood & Bone
All Purpose Plant Food
For healthier flowers, fruit & vegetables
ORIGINAL FORMULA
Miracle-Gro
azalea, camellia & rhododendron
continuous release plant food
BETTER BLOOMS

'Design' a fertiliser – a different approach

Risa

http://tinyurl.com/IRRI-fertilisers

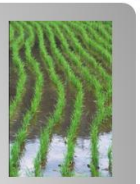
Fred

http://tinyurl.com/UKA-Wheat

Hermione

http://tinyurl.com/VGO-Tomatoes

Risa the Rice Farmer



Risa lives in Indonesia on the island of Java and she grows rice close to her village.

If she has a good year she will be able to harvest 3 rice crops per year.

rice padi

Risa the Rice Farmer

Risa's field is in an area where the soil is quite rich in minerals because of volcanic eruptions in the past. Risa needs to try to make sure the yield of rice is high but she does not want to use more fertiliser than she needs to as it is so expensive.

Last year she had a lot of damage of her crop from insect pests and she knows that the soil in her padi is low in potassium.

Risa the Rice Farmer

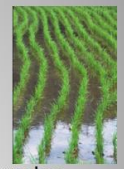
Getting 3 rice crops this year is essential to Risa but she knows that she could have a problem with low nitrogen levels in the soil.
Before she makes all her plans she will be considering all the alternatives and taking advice. She might try growing mung beans in the dry season – that has been good in the past.

Germinating mung beans

This website might help Risa.

http://webapps.irri.org/nm/id/_0js.php

Risa the Rice Farmer



Your job is to list all the factors which Risa needs to consider. You will need to think about the type of soil she has; why she might have had problems with insect pests; why she might grow mung beans; what strain 3 rice crops might put on her soil and the costs of fertilisers. What might be the best fertiliser mix (NPK)?

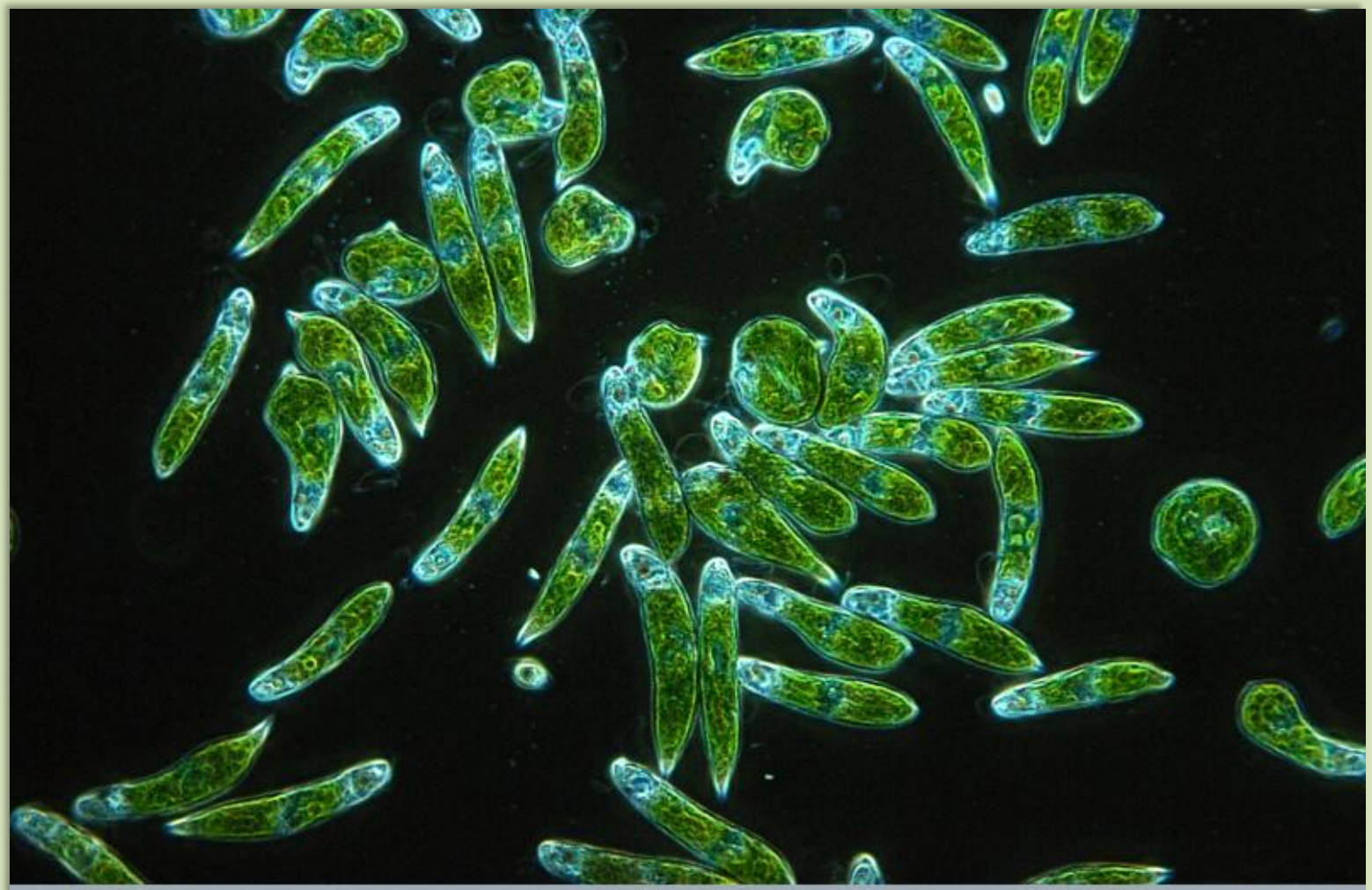
Advice for Risa

Other effects of nutrients.....

Eutrophication

- Investigate the effects of a plant fertiliser on the growth of algae
- Compare algal populations using a colorimeter to measure absorbance
- Compare algal populations by using a light microscope

Euglena gracilis



Wellcome Images

On your doorstep……

Eutrophication

A case study

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

- Overview
- Pressures
- Management responses
- Monitoring the environment
- Environmental responses

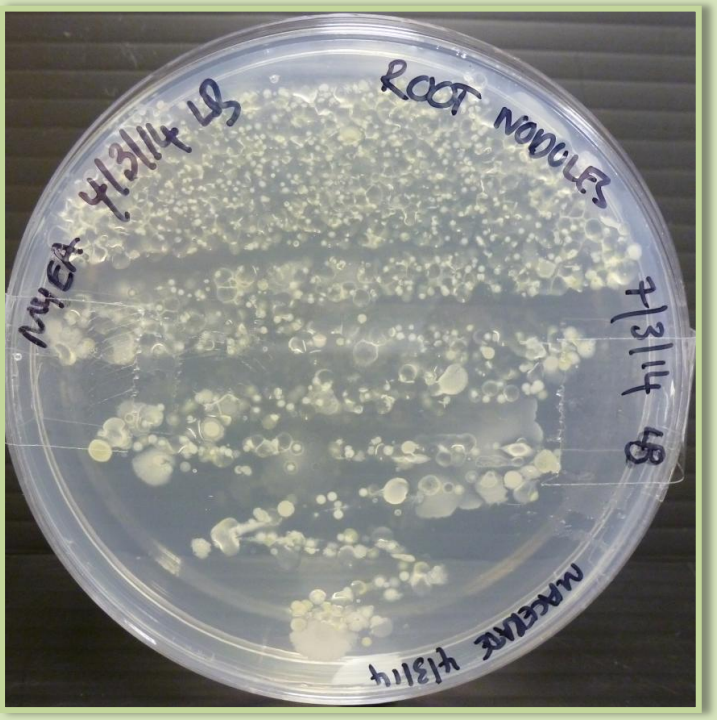
Nodules are involved in nitrogen fixation

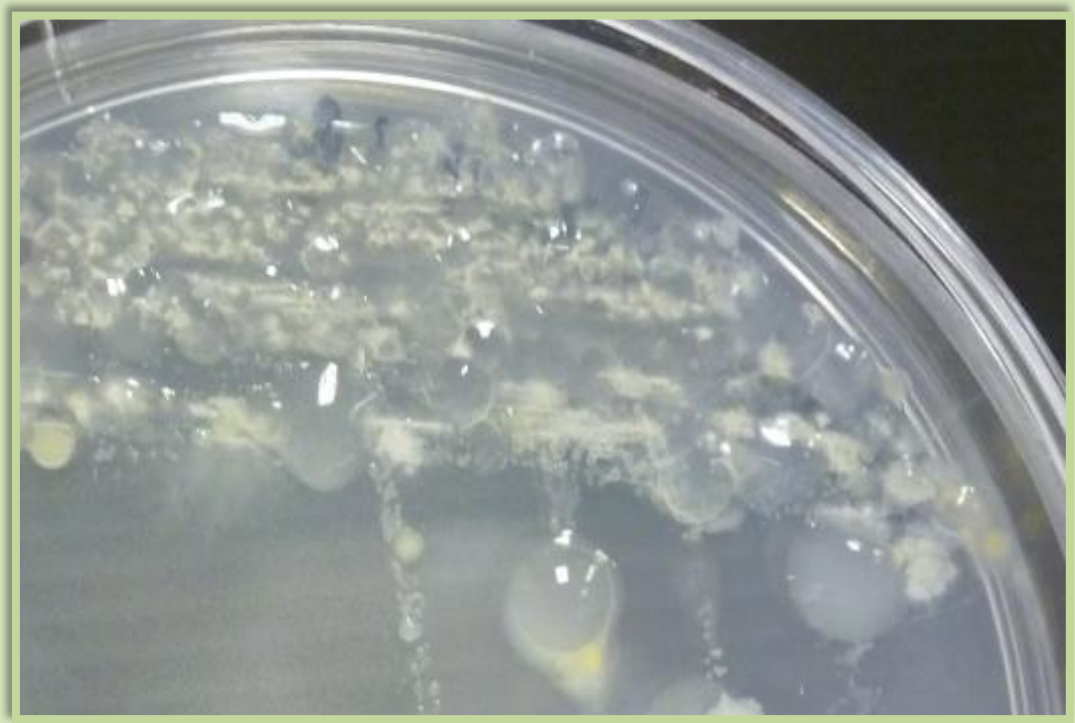
Let's hear it for the legumes!

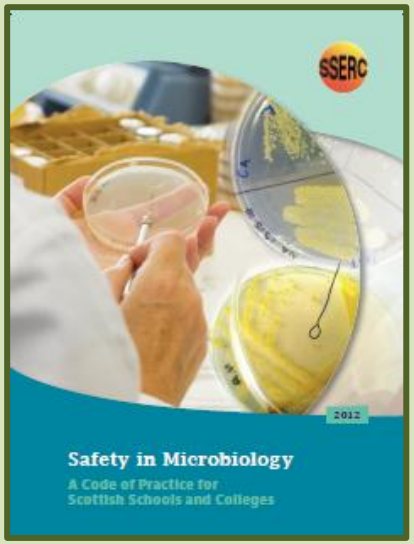
The mighty mung bean...!

Isolating nitrogen-fixing bacteria from the root nodules of leguminous plants

The purpose of this activity is to allow pupils to culture the nitrogen-fixing bacterium *Rhizobium* from root nodules of leguminous plants and to reinforce understanding of the role of bacteria in the nitrogen cycle..







Demonstrate that root nodules contain Rhizobia by isolating and growing them on an agar medium.

Nitrogen is necessary.....and interesting!

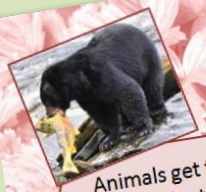
OMG, not the nitrogen cycle……!

OMG, not the nitrogen cycle.....!

Nitrogen and Living Things – a very important story.....

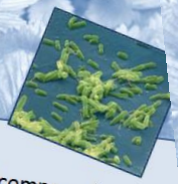
Nitrogen is a vital component of the protein structures that make up animals and plants. However, animals and plants are unable to use nitrogen gas directly from the air.

Decomposers (bacteria and fungi) break down animal waste and dead animal and plant proteins returning the nitrogen compounds they contain back into the soil.



Animals get the nitrogen they need by eating plants and animals which are made of protein.

Plants take in nitrogen from their surroundings (to make protein) through their roots in the form of nitrogen compounds called nitrites and nitrates.



The nitrogen (ammonium) compounds produced by the break down of animal waste and dead animals and plants are used by **nitrifying bacteria**, which live in soil, to produce nitrites and nitrates.

The high temperature of **lightning** causes some of the nitrogen and oxygen in the air to combine forming nitrogen compounds. These dissolve in rain and are washed into soil where they form compounds called nitrates.

Nitrogen in the atmosphere

Rhizobium

Nitrogen fixation

AMMONIUM

Nitrifying bacteria

AZOTOBACTER

break down of animal waste, dead animals & plants

NITRATES

Nitrites

Denitrifying bacteria

Where next for nutrients, nodules and nitrogen...?

Making a nodule.....

John Innes Centre **News**

Professor Giles Oldroyd

Major investment to persuade bacteria to help cereals self-fertilise

http://tinyurl.com/JIC-News

GENETIC dilemmas

GM plant dilemmas

Turbocharged rice

1

Around a billion people live on less than a dollar a day and spend half their income on food. Each day about 25,000 people die from hunger-related causes.

GM plant dilemmas

Turbocharged rice

2

Rice is the stable food for millions of these poorest people and a GM project is looking at ways of increasing the yield of rice by around 50%.

The project involves taking genes from maize and putting them into rice. The rice would then photosynthesise in a similarly efficient way to maize.

GM plant dilemmas

Turbocharged rice

3

Rice uses a C_3 photosynthetic pathway, which is in some ways is much less efficient than the C_4 pathway used in plants such as maize.

Rice already has all the components required for C_4 photosynthesis, but they are arranged differently. By rearranging the photosynthetic structures within the leaves using genetic modification, it is theoretically possible to switch rice over to C_4 photosynthesis.

GM plant dilemmas

Turbocharged rice

4

The project will take a long time, is very expensive and a lot of research is needed. It is being funded by Bill and Melinda Gates and the UK government.

GM plant dilemmas

Turbocharged rice

5

Some people think that the UK government would be better spending money on projects which would benefit people in the UK.

Nutrients, nodules and nitrogen: Recycled!

The most exciting bit……

The Gap Task

The Activity

Nutrient deficiency in plants experiment

Farmer fertiliser issues discussion activity

Design a tailored fertiliser activity

Impact on Learning

Although the experiment didn't work as expected, it led on to a class discussion about experimental practice and evaluation.

Fertiliser design reinforced fertiliser ratios and the importance of fertilisers to real people.

Pupils are now more comfortable discussing ratios and can now identify the order and importance of each element confidently.

Challenges

Teaching fertilisers to a difficult group of S4 National 4 pupils.

Results of experiment didn't work as expected.

Pupils found discussion activity difficult.

Solving Problems

Activity made a dry topic more engaging and pupils worked well through all activities.

Gathered a good example of each nutrient deficiency which gave an over all picture of expected results.

Next Steps

Task is going to be adapted for both National 4 and 5 courses.

It will be differentiated more for National 4 by taking the areas of difficulty into consideration. Designing the bag could be linked with art when this section is taught for BGE in S3.

For National 5, it will be incorporated into the learning outcomes which cover fertiliser use. However, the pupils will not take part in designing the fertiliser bag as this is not relevant to the outcomes.

Gathered Results

Examples of Pupil Work

TOMORITE

LIQUID TOMATO FERTILISER

Tomorite® is a liquid feed for tomato plants which encourages high yields of top quality full-flavoured tomatoes. It is also ideal for other special food crops such as sweet peppers and aubergines.

TO MAKE UP FEED

Use measure provided. Dilute 20ml in 4.5 litres (1 gallon) of water.

HOW TO USE

Apply diluted feed to base of plant, avoiding foliage.
Under Glass: When first truss of tomatoes has set, feed at alternate waterings.
Outdoors: When second truss has set, feed every 7-14 days. Use 4.5 litres for two plants.
Growing Bags: Use 4.5 litres per bag. Feed once a week. Under glass increase to twice a week when second truss has set.

STORE OUT OF DIRECT SUNLIGHT IN A COOL PLACE
Store between 5 and 30 degrees C.

UK FERTILISER DECLARATION NPK FERTILISER SOLUTION	N 4.0 P 3 K 8.0	
Nitrogen (N) total	4%	
Ureic nitrogen	2.1%	
Phosphorus pentoxide (P_2O_5) soluble in neutral ammonium citrate and water	3.0%	(1.3%P)
Potassium oxide (K_2O) soluble in water	8%	(6.6%K)

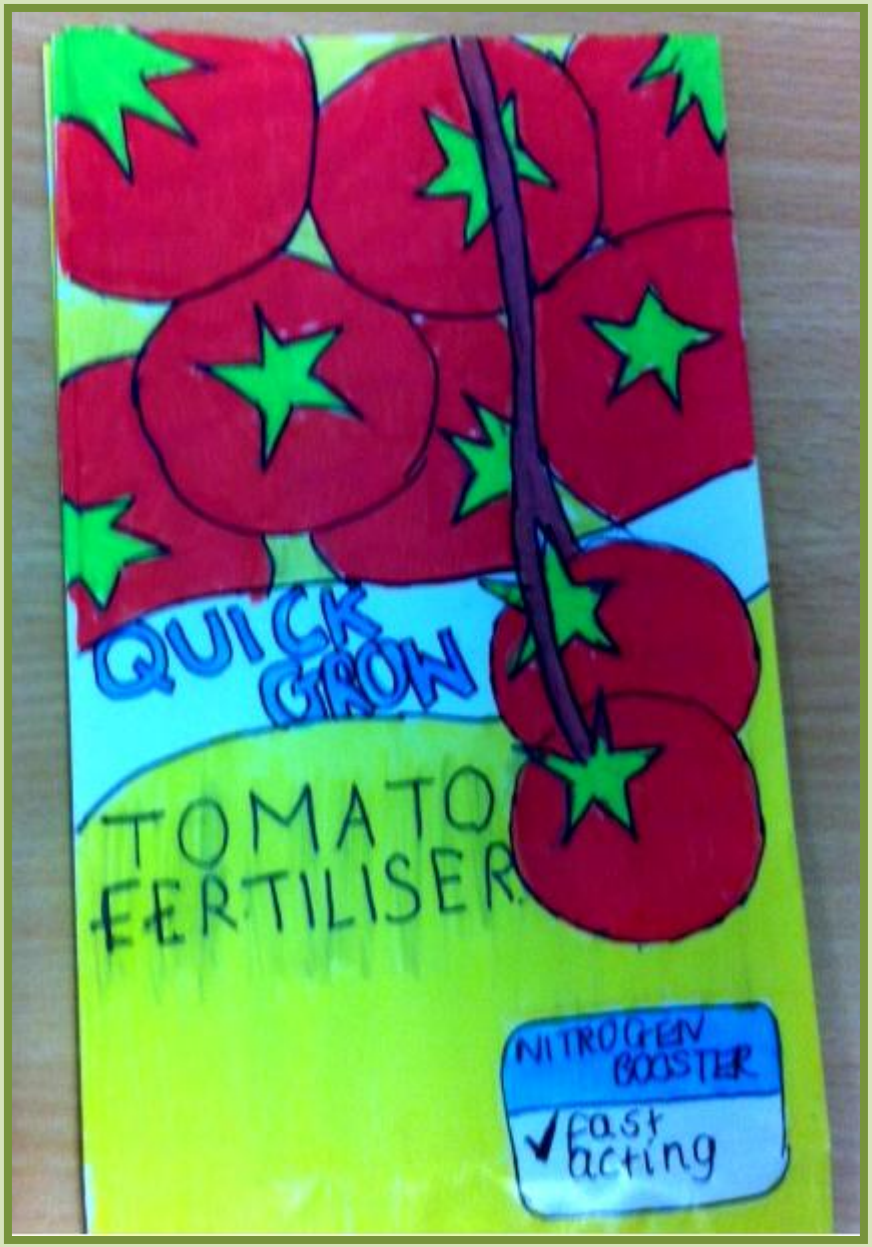
ROI FERTILISER DECLARATION LOW NUTRIENT FERTILISER NPK COMPOUND	N 4.0 P 1.3 K 6.6
Nitrogen (N) total	4%
Ureic nitrogen	2.1%
Phosphorus (P) soluble in water	1.3%
Potassium (K) soluble in water	6.6%

757608

for more information visit lovethegarden.com or call 0845 190 1881

Net weight: 1100g 1 Litre e

5 010272 064483



Nitrogen - 4%
Phosphorus - 3%
Potassium - 3%.

Nitrogen - for active leaf and growth.
phosphorus - for strong/ healthy rooting.
potassium - for healthy growth, flowering, fruit development and disease resistance.

This fertiliser attracts ladybirds that eat types of bugs which keeps the tomatoes healthy and safe.

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Gap Task

Activity: Design a Fertiliser

Prior Learning

- S2 What's under our Welly Boots?
(Soil structure and how soil is made)
- S3 Nature Detectives
(Cycles, plant nutrient deficiencies practical, plant nutrients NPK, fertilisers)

Activity: Design a Fertiliser

- What am I going to learn?
Today we will apply what we have learned about plant nutrients and soil types to design the perfect fertiliser.
- How will I know I have learned?
  - I can use the knowledge I have gained so far to suggest a design for a fertiliser.
  - I can use my literacy skills to produce an eye-catching poster/leaflet full of relevant information.
  - I can effectively work in a group.

Co-operative learning groups

Groups and roles
Pupils worked in their home base teams. Each member of the group was given a particular role.

- Time keeper
- Encourager
- Resource manager
- Air traffic controller

Designing a Fertiliser

- Your poster or leaflet should include:
  - Who your farmer or gardener is
  - Where they are
  - What they grow
  - What their problem is
  - What your solution is e.g. Which type of fertiliser? Natural or chemical? Possible NPK ratio?

Make sure your poster is eye-catching!

Where to start?

- Read your case study and discuss in groups
- Each one will have a website that can help you.

Your challenge!

Discover some of the issues surrounding growing different crops in different areas and work out what the fertiliser needs are.

Peer assessment

Expert Gallery Tour

- ✓ Students have worked in teams of 4
- ✓ Divide the class into four groups, with all 1's in one group, all 2's in another group etc
- ✓ Groups move from project to project with each group member explaining his/her team's project when the group visits that project
- ✓ Group members can give feedback
- ✓ Teammates return to home team and discuss feedback and additional information.

Positives

1. Pupils responded well to the characters.
2. Some took their research one step further and included pest control methods.
3. Provided a great opportunity to consolidate learning and for pupils to develop their problem solving skills (predicting, analysing & selecting information).

Negatives

1. Some pupils found it quite challenging to pick out the problems and link them to a fertiliser design.

Next steps

1. Cross curricular links
2. Give pupils a wider scope when it comes to there final presentation e.g. could they produced/present an advert for their final fertiliser design?
3. Link to St Paul's new school initiative Reciprocal Reading by focusing on the reading skills required for the task (predicting, questioning, clarifying, summarising).

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Where will you take this now?

I would like to turn this into a proper investigation for the National 5 class, with the scope of it being their Outcome 1 write up. I hope to complete this next year with the new group of National 5s.

Fred the Farmer

Fred fa
Fred's f

Hermione the Horticulturalist

Herm
near
which

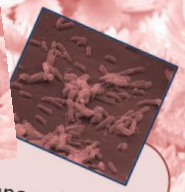
Risa the Rice Farmer

Risa lives in Indonesia on the island of Java and she grows rice close to her village.

If she has a good year she will be able to harvest 3 rice crops per year.

rice padi

Nitrogen and Living Things – a very important story.....



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- small and shrivelled grain or fruit reduced yield

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“I could see the experiment in my head when I was writing the answer....”