PUPIL RESEARCHER INITIATIVE

Feed the World

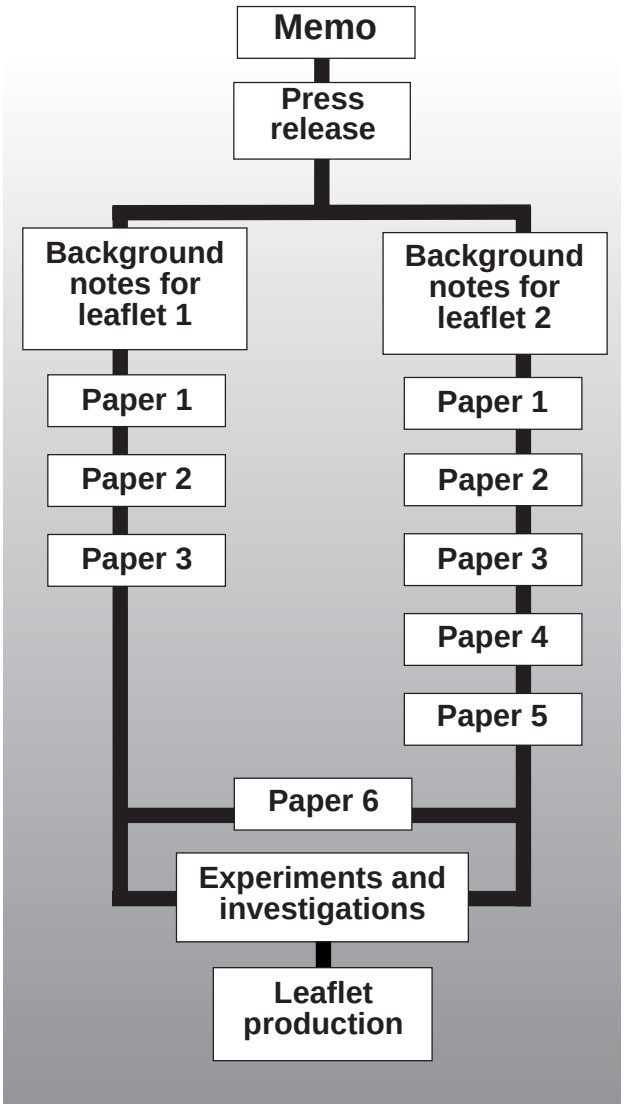
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- ❑ air is almost 80% nitrogen
- ❑ nitrogen can be used to manufacture several important chemicals, including nitrogen-based fertilisers
- ❑ nitrogen-based fertilisers are important in agriculture for increasing the yield of crops
- ❑ ammonia is manufactured in the Haber process
- ❑ ammonium nitrate fertiliser is made by the neutralisation reaction between ammonia and nitric acid
- ❑ materials are returned to the environment either in waste or when living things die and decay
- ❑ materials decay because they are broken down (digested) by microbes
- ❑ the constant cycling of nitrogen is called the nitrogen cycle. In the nitrogen cycle green plants absorb nitrogen in nitrates from the soil. Plants use these nitrates to make proteins
- ❑ nitrifying bacteria convert ammonia compounds to nitrates

Route through the Brief



Introduction

In this Brief pupils take on the roles of researchers in a university chemistry department research team working on the development of fertilisers. Following a press release by the World Food Commission (WFC) announcing the setting up of an educational programme for use in a number of developing countries, the research team has been asked to produce two educational leaflets. The leaflets, covering the same topic, should be aimed at two different audiences; farmers and teachers. They should explain what fertilisers are, why they should be used and how they work. To enable these leaflets to reflect both the work of the department and other current research work, the researchers have to read a series of background papers and carry out experiments and investigations on the production of ammonium nitrate and its effects on plant growth. They then plan and produce an A4 size leaflet to address the issues outlined in their briefing sheet.

Teachers in Northern Ireland should not use the parts of the Brief which involve practical work with ammonium nitrate.

This Brief has differentiated routes. Lower-achieving pupils will produce the leaflet for the farmers and thus carry out the tasks relating to the production of

that leaflet. Higher-achieving pupils will produce the leaflet for teachers and carry out the higher level tasks relating to the production of that leaflet.

Experimental and investigative skills

- planning experimental procedures
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Before attempting this Brief pupils should have basic knowledge and understanding of natural cycles, acids and alkalis, indicators, and using equations to represent chemical reactions.

Running the Brief

Pupil grouping

Pupils could work in a number of groupings during this Brief. Suggestions are:

Initial briefing	-	whole class; teacher led
Memo	-	individuals, pairs or small groups
Background papers	-	individuals or pairs
Experiments and investigations	-	pairs or small groups
Analysis of results	-	individuals, pairs or small groups
Production of leaflet	-	individuals, pairs or small groups

Timing

The Brief should take 3-4 hours of classroom time. The production of the leaflet could be carried out as a homework activity. Extra time may be needed to write up individual investigation reports if these are to be used for examination assessment purposes. The optional investigation may add two hours or more, particularly if used for project work.

Activities

Pupils should be issued with the **Study Guide**, which provides them with a summary of what they should produce as they work through the Brief. It can also be used as a checklist so that they can monitor their own progress.

It is worth spending a little time at the start to set the scene. Then give out the **Memo,** the **Press release** and **Briefing notes for Leaflet 1**, with **Papers 1,2** and **5** for those groups producing the leaflet for the farmers. Also give out the Memo, the press release and **Briefing notes for Leaflet 2**, with **Papers 1, 2, 3, 4** and **5** for the groups producing the leaflet for the teachers in the developing countries. Pupils may ask for **Paper 6** if they have problems getting started with the investigations. (Note: the second and third paragraph of the 'handwritten' note at the bottom of the page should be deleted for those pupils producing Leaflet 1 for farmers).

Pupils are guided through the Brief by the memo and the briefing notes for the leaflets which are fairly prescriptive so that they can work systematically and pay attention to detail. **Paper 1** provides background information on the nitrogen cycle and how current research on it could influence future industrial processes. **Paper 2** outlines the Haber process and makes brief reference to a field irrigation channel system which could develop from current research. **Paper 3** introduces the higher-achieving students to the concept of equilibrium and how the effects of pressure and temperature on it are applied in the Haber process. Current research into the use of enzymes as a possible lower energy alternative is also outlined. **Papers 4** and **5** provide relevant pupils with the experimental details of two techniques for making ammonium nitrate which they carry out and evaluate for inclusion in their leaflet. **Paper 6** provides the experimental details for comparing the effects on plant growth of using or not using a fertiliser. Paper 6 can be used where pupils have difficilty planning the investigation. The details described in the paper will need to be adapted by the pupils to carry out investigations on the effects of nitrogen on plant growth. Following all this, the pupils finally produce their leaflet for their respective target group.

Using IT. Pupils could use a pH probe instead of universal indicator when making the ammonium nitrate.

Investigation details

The Brief suggests two methods for making ammonium nitrate in Papers 4 and 5 for the pupils to evaluate. Method 1 outlined in Paper 4 describes a more accurate titration technique, whilst Paper 5 describes a simpler method (Method 2). Pupils producing the leaflet for farmers follow Method 2, whilst those producing the leaflet for teachers follow both methods and then evaluate them to decide which to include in their leaflet.

Pupil Research Brief

Teachers' Notes continued

Pupils producing the leaflet for farmers in developing countries are asked to investigate the effects on plant growth of using or not using a nitrogen-based fertiliser (ammonium nitrate). This they can carry out by adapting the method described in Paper 6 for investigating the effects of using or not using a general fertiliser containing a variety of minerals as well as ammonium nitrate. All they have to change in the method is the use of ammonium nitrate (same concentration, i.e. 4g in 100 cm^3) instead of fertiliser. For further details please refer to Paper 6. However, some pupils might suggest that they should test for the effect of nitrogen by using culture solutions (see *Technical details* section below): one with all necessary minerals for plant growth, and a second with all necessary minerals except nitrogen (the *all minus one* approach). This is a more valid way of assessing the effect of removing nitrogen from the plant's mineral intake, since merely providing it with water only would deprive the plant of all essential minerals, thereby making it impossible to isolate the effect of nitrogen removal.

Pupils producing the leaflet for teachers in developing countries are asked to carry out the same investigation as described above, with the optional extension to investigate the effects of varying *concentrations* of ammonium nitrate on plant growth. This can also be achieved by adapting the method provided in Paper 6, i.e. by substituting varying concentrations of nitrogen (ammonium nitrate) instead of fertiliser. Again, some pupils might suggest a variation on the *all minus one* approach. They can also use this technique to carry out the optional additional investigation of the effects of different minerals on plant growth, where different minerals are removed from the plant, which still has all other essential minerals provided. Teachers in Northern Ireland should substitute ammonium sulphate for ammonium nitrate.

Technical details

Most of the information required, such as apparatus, solutions, experimental method, etc. is given in Papers 4, 5 and 6.

Where experiments using culture solutions are undertaken, Sach's Mineral Difficiency Water Culture sets can be used. These can be obtained from Philip Harris.

When using seedlings to demonstrate the effects of mineral deficiency, best results are obtained if the remains of the seed are removed from the seedling before putting it into the solution. The seed (cotyledons or endosperm) contains a supply of minerals for use by the plant in the early stages of growth. Failure to remove this store results in little visible difference regardless of the culture solution used.

Safety issues

PLEASE NOTE: It is also important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Nitric Acid
0.1M to 0.5M Irritant
above 0.5M Corrosive.

If swallowed do NOT make pupil vomit. Wash mouth and give water to drink. Seek medical attention as soon as possible.

If inhaled remove to fresh air. Seek medical attention even if no symptoms can be seen.

If in eyes flood eye with flowing tap water for at least 10 minutes. Seek medical attention.

If on skin flood area with water. Remove contaminated clothing. Seek medical attention if area is large or blistering occurs.

Wear eye protection.

Ammonia solution
3M to 6M Irritant
above 6M Corrosive.

If swallowed do NOT make pupil vomit. Wash mouth and give water to drink. Seek medical attention.

If in eyes flood eye with flowing tap water for at least 10 minutes. Seek medical attention.

If on skin flood area with water. Remove contaminated clothing. Seek medical attention immediately if area is large or blistering occurs.

Wear eye protection.
Ventilate area.

Ammonium Nitrate Oxidising agent.
Can explode on heating if impure. (Do not contaminate with organic matter nor grind it.)

If swallowed wash mouth and give water to drink. Seek medical attention if more than very small amount swallowed.

If in eyes flood eye with flowing tap water for at least 10 minutes. Seek medical attention.
If on skin: Flood area with water. Remove contaminated clothing.

Wear eye protection.

Pupil Research Brief

Teachers' Notes continued

Assessment issues for *Experimental and Investigative Science* (National Curriculum for England and Wales)

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

This Brief provides opportunities for pupils to gain high marks in all skill areas. The amount of guidance given to planning by Paper 6 will have to be considered when assessing **Skill Area P**.
The methods for making ammonium nitrate outlined in Paper 4 and Paper 5 are not suitable for assessment purposes. The investigation into the effect of nitrogen on plant growth based on Paper 6 can be carried out in several ways. If pupils plan a simple 'with and without nitrogen' procedure, they are likely to restrict themselves to low to middle marks. If they plan to vary the amount of nitrogen available to the plant they could reach middle to high marks, although to do this they should take control the availability of other nutrients, i.e. use a full culture solution and a 'full culture without nitrogen' culture solution.

Assessment issues for *Experimental and Investigative Science* (Northern Ireland Curriculum)

P	Planning	O	Obtaining evidence
I	Interpreting and Evaluating		

See notes for England and Wales.

Scottish syllabus coverage

Standard Grade Chemistry: *Fertilisers*

Further pupil research opportunities

Pupils could investigate the effects of fertilisers on waterways and their consequent eutrophication by investigating the effects of fertilisers/ammonium nitrate on the growth and reproduction of duckweed. Five duckweed plants should be placed in each experimental beaker containing 200 cm^3 of a fertiliser solution of varying concentrations and placed on a sunny window. The pupils should count the duckweed plants and observe the condition of the duckweed in each beaker over several weeks, and draw conclusions based on their knowledge of the stages leading to eutrophication.