PUPIL RESEARCHER INITIATIVE

Clear Solutions

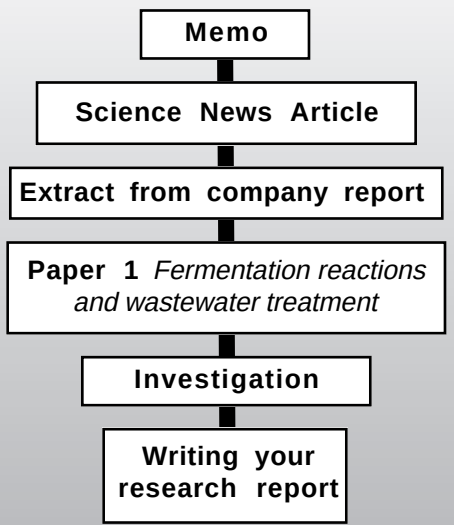
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- ❑ yeast cells convert sugar into carbon dioxide and alcohol by a process called fermentation
- ❑ fermentation is used to produce alcohol in beer and wine
- ❒ materials decay because they are broken down (digested) by microorganisms
- ❑ microorganisms digest materials faster in warm, moist conditions
- ❑ many microorganisms are more active when there is plenty of oxygen
- ❑ living things remove materials from the environment for growth and other purposes

Route through the Brief



Introduction

This Brief takes its inspiration from a real research project being carried out by a group at the University of Leeds looking into the use of microorganisms to remove dyes from waste water.

In this Brief, pupils undertake an investigation to determine the effectiveness of using immobilised yeast columns to extract dye. In designing and carrying out their investigation, pupils will collect data for analysis allowing them to draw conclusions and make suggestions about the effectiveness of this method of dye extraction.

Experimental and investigative skills

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

Prior knowledge

Pupils should be familiar with the basic characteristics of enzymes and microorganisms.

Pupil Research Brief

Teachers' Notes continued

Running the Brief

Pupil grouping

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

Initial briefing	-	whole class; teacher-led introduction, setting the context for the Brief
Analysis of Memo	-	individual or pairs
Analysis of the Researcher Article	-	individual or pairs
Analysis of Project 3A	-	in pairs, or individually if the work is to be assessed
Carrying out investigation	-	pairs or groups of 4 (depends on equipment availability)
Analysis of results	-	in pairs, or individually if the work is to be assessed
Communication	-	compilation of written reports (individual) and whole group or class discussion of results

Timing

This Brief should take between 3 - 4 hours of classroom time, with extra time being needed to write up individual investigation reports if these are to be used for examination assessment purposes.

Activities

The teacher should issue pupils with the **Study Guide** which provides them with a summary of what they should produce as they work through the Brief. It can also act as a checklist for pupils to monitor their own progress. The **Memo** sets the scene and together with the extract from **The Researcher**, gives the pupils a focus for their work. Pupils need to read these papers carefully and any queries about the background to the research can be addressed by the teacher at this point. This could be carried out as an individual or paired activity. Following this, the pupils should be referred to the **Project 3A** paper and the **background paper** on **Fermentation reactions** to help them plan their investigations. It will also be necessary to have available the article by **A. Baker** (1992) from the *Catalytic Traps* Brief.

Depending on the availability of equipment, the pupils will now be ready to carry out the investigation in pairs or groups of 4.

Following the investigations, the pupils will need to complete an individual **written report** - important if the work is being assessed - and take part in a whole group discussion to analyse the various findings of each of the working groups.

Investigation details

The work in this Brief requires good practical skills. The pupils are required to learn the technique of producing alginate beads containing yeast and how to assemble and operate the continuous-flow apparatus, although the teacher may decide to pre-prepare the alginate beads to save time. A. Baker's paper from the *Catalytic Traps* Brief gives some details of this, however more specific instructions are given in the following Technical details section. Pupils will need to be aware of the importance of experimental control so that reliable results are obtained.

The report extract lists five possible investigations for pupils to carry out. These are:

1 does the yeast break down the dye or just absorb it?
2 does the alginate absorb the dye?
3 is there any link between the amount of yeast in the alginate beads and dye removal?
4 what conditions produce the fastest growth of yeast?
5 what is the best feedstock for the yeast cells?

Investigations 1, 2 and 3 are concerned with the process of dye removal. Investigations 4 and 5 look into the growth of yeast. The teacher may wish pupils to carry out one investigation from each of these two groups, although allocation of tasks will depend on the time available.

For investigations 1 and 2, if after trickling the coloured solution through the alginate bead column, the solution becomes clear, the pupils should conclude that something is removing the dye. It will be possible to establish if this is the yeast cells by microscopic examination. The cells will be coloured if they are responsible for the dye absorption. Pupils may suggest trying to remove dyes with alginate beads containing no yeast. This could show whether the alginate was responsible for any dye removal. Taken together, investigations 1, 2 and 3 would provide sufficient evidence as to the feasibility of using immobilised yeast columns. If pupils only carry out one (or two) of these investigations, the teacher

Teachers' Notes continued

may wish to add a plenary session (oral presentations or poster display) so that pupils can learn from the work of other groups in the class.

For investigation 4 (varying the amount of yeast in the alginate beads) the teacher may decide to have the class working in groups, with each group having beads containing different amounts of yeast, and comparing the results.

The same approach could be used for investigation 5, where pupils investigate the best conditions and feedstock for yeast growth. This would then require the pupils to 'pool' their results. The growth of yeast cells can be monitored by counting yeast cells, using a microscope or by comparing turbidity using a colorimeter or light sensor.

Using IT. Light meters could be used to monitor the removal of dyes from the liquid emerging from the immobilised yeast columns (investigations 1, 2 and 3), and to measure the growth of yeast by monitoring turbidity changes over time (investigations 4 and 5).

Technical details

Method for the production of entrapped yeast cells in sodium alginate

- Gently warm 50cm^3 of distilled water in a small beaker on a stirrer hotplate.
- Weigh out 2g of sodium alginate, add this to the warm water and allow it to dissolve with constant stirring.
- Suspend 2.5g of brewer's yeast in 50cm^3 of distilled water.
- Dissolve 1.4g of calcium chloride in 100cm^3 of distilled water and place the solution in a 250cm^3 beaker.
- Add the alginate solution to the yeast suspension with constant stirring.
- Clamp a 50cm^3 plastic syringe body approximately 10cm above the surface of the calcium chloride solution in the beaker.
- Add 25cm^3 of the yeast/alginate mixture to the syringe, allow it to drop into the calcium chloride solution drop by drop.
- When most of the mixture has left the syringe, top-up the syringe with another 25cm^3 of mixture, and allow it to drop into the calcium chloride solution.
- Allow the beads to stand in the calcium chloride solution for 20 minutes so that they fully gel.
- The beads can be removed from the calcium chloride solution by straining through a sieve or tea strainer.

  Note: Some types of yeast, eg. Vitamin Yeast tablets (Boots Chemist), contain a coloured component that will colour the calcium chloride solution. In such cases, the beads should be thoroughly washed with distilled water before they are used for experimental purposes.
- The beads can then be used to remove dye from aqueous solutions or digest carbohydrates such as sucrose.

Absorption of aqueous methylene blue solution using yeast entrapped in sodium alginate beads.

- Attach a 5cm length of plastic tubing to the outlet at the bottom of a 50cm^3 plastic syringe body. Close a Hoffman clip, or a similar clamping device, around the plastic tubing.
- Prepare a second syringe in the same manner.
- Place a small wad of glass wool in the bottom of one of the syringes.
- Clamp this syringe arrangement to a retort stand and fill to the 50cm^3 mark with yeast/alginate beads.
- Place a beaker below the syringe.
- Fill the syringe body with distilled water and open the Hoffman clip.
- As the water drains through the beads, gently tap the syringe body. This should help to pack the beads more closely.
- Close the Hoffman clip.
- Adjust the height of this syringe such that a series of test tubes can be passed just below the end of the plastic tubing to collect eluent.
- Clamp the second syringe arrangement directly above the first with the tip of its plastic tubing in the opening at the top of the lower syringe.
- Ensure that the Hoffman clips on both syringes are closed.

Teachers' Notes continued

- Prepare a 1% solution of methylene blue and add 25cm^3 of this to the upper syringe.
- Place a test tube (capacity approx. 10cm^3) below the tip of the plastic tubing on the lower syringe arrangement.
- Fully open the Hoffman clip on the lower syringe.
- Slowly open the clip on the upper syringe and allow the methylene blue to drop onto the column of beads in the lower syringe at a rate of one drop every 10 seconds.
- Collect approximately 5cm^3 of the eluent in the first test tube, then exchange that for an empty tube and collect 5cm^3 more.
- Repeat this procedure until you have collected 5 samples of eluent of 5cm^3 each.
- Compare the colour of the 5 samples of eluent collected with the colour of the original 1% methylene blue solution. A significant change in the intensity of the blue colour should be observed in the solutions that have passed through the column beads.

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.

Dyes: minimal hazards in general - refer to specific advice on dye packaging.

If swallowed: wash mouth and give water to drink. Seek medical attention as soon as possible.
If in eyes: flood eye with flowing tap water for at least 10 minutes. Seek medical attention.
If on skin: flood area with water and then wash. Remove contaminated clothing.

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

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

Each of the five possible investigations provide sufficient scope in terms of the range of factors to be taken into account and the issues related to the validity and reliability of the evidence to allow high marks in each of **Skill Areas P, O, A and E**.

Scottish syllabus coverage

Standard Grade Biology - *Biotechnology*
Standard Grade Chemistry - *Carbohydrates*

Further pupil research opportunities

The suggested approach in this Brief is for pupils to carry out only some of the possible investigations. Given sufficient time, pupils could carry out all the investigations.