Which Anti-acid?

Contents: Survey, practical work and questions on consumer testing of anti-acids.

Time: 2 periods or more, depending on number of parts attempted.

Intended use: GCSE Chemistry and Integrated Science. Links with work on acidity and alkalinity, reactions of acids with carbonates and hydroxides, and titrations.

Aims:

- To complement and revise prior work on acidity and alkalinity
- To develop consumer awareness including the critical evaluation of commercial products
- To develop appreciation of the problems and decisions involved in manufacturing a commercial product
- To develop awareness of the limitations of simple tests in evaluating a commercial product
- To provide an opportunity to practise certain laboratory skills, and skills in data analysis.

Requirements: Students' worksheets No. 709. Packets of three (or more) different commercial anti-acid tablets. See notes in Part 3 for practical requirements.

Part 1 Looking at labels — comparing costs

The work in this part requires a certain amount of mathematical skill. Teachers may prefer to omit this part for some students.

Interpretation of ingredients lists on the labels of anti-acids can be difficult, since the names are frequently abbreviated and non-systematic. If possible, choose anti-acids whose ingredients are listed simply and clearly. The smaller the number of different ingredients the better.

Even so, less able pupils may need help interpreting the ingredients and quantities, and working out the cost of 1 gram of active ingredients.

Students might be interested to know the prices of the pure ingredients if bought from a chemical supplier. These prices can be found from laboratory suppliers' catalogues, though the prices for small quantities will be considerably higher than for bulk supply.

The labels do not always give information about the 'additives' — those materials which, after the anti-acid ingredients, make up the mass of material. These include sugar and flavouring ingredients.

Part 2 Making more comparisons

The intention of this part is to get students to consider the decisions needed in bringing a product such as an anti-acid to market. Encourage students to examine the results of these decisions with the same analytical, critical attention expected in observing and testing materials in 'normal' science.

Apart from costs, manufacturers' decisions have to include:

- The size, shape and taste of the tablets, and the rate at which the ingredients dissolve.
- How the tablets should be packaged — in plastic, metal foil or paper, in boxes or tubes; how many tablets per package. If the tablets contain materials which deteriorate with time (for example, because they are hygroscopic), suitable packaging can increase their shelf-life.
- How easily the tablets may be removed from the packaging — remembering safety aspects, particularly with regard to small children who may think the tablets are sweets.

- How to make the packets convenient for handbag, pocket or cupboard.
- The instructions to customers about the contents and use — how technical is the language, how informative and easy to use?
- The appearance of the package — colours, lettering and advertising.

Part 3 A chemical way of comparing anti-acids

This part is intended for students who have already acquired the skills of titration and the ability to interpret the results. With very able students it could be used as a problem-solving exercise, that is without the help of instructions. Hydrochloric acid is used for the titration: this acid is of course naturally present in the human stomach, at a concentration of about 0.1M.

Requirements

Each group will require:

hydrochloric acid, 1.0M ($50cm^{3}$)
anti-acid tablets (at least three different brands; one tablet of each brand per group)
methyl orange indicator
pestle and mortar
beaker ($100cm^{3}$)
conical flask ($250cm^{3}$)
burette, stand and funnel
eye protection

The merits and demerits of this type of testing should be discussed. It can tell us exactly how much active anti-acid ingredients we are buying and can check the manufacturer's figures, but it cannot tell us if the tablets actually relieve pain without side effects. This could lead to discussion of the feasibility, problems and ethics of testing drugs with animals or human volunteers.

Further activities

1 Investigation of 'sparkling' anti-acid products — for example:
   (a) Testing the gas given off
   (b) Comparing the volume of gas given off by different products
   (c) Making 'sparkling' anti-acid mixture (which should of course *not* be tasted).

2 Cation and anion tests to find the products of neutralization

3 Investigation of rates of reaction of different tablets with acid

4 Designing a poster to advertise an anti-acid product.

WHICH ANTI-ACID?

We are all consumers and we have to make decisions about which products to buy. Scientific tests can help us find out more about these products.

In this unit the products are 'anti-acids'. Anti-acids are taken to relieve pains caused by excess acid in the stomach. They work by neutralizing the acid. Which anti-acid gives the best value?

The unit is in three parts:

Part 1 Looking at labels — comparing costs
Part 2 Making more comparisons
Part 3 A chemical way of comparing anti-acids.

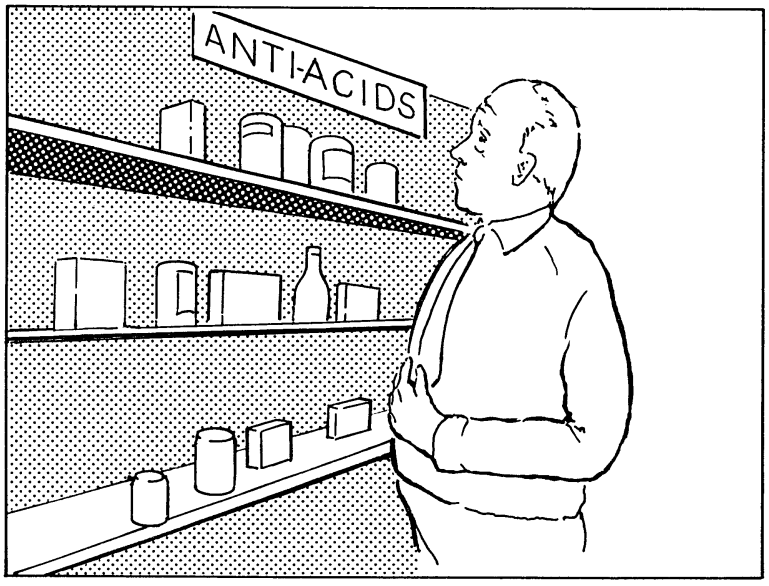


Figure 1

Part 1 Looking at labels — comparing costs

Draw up a table like Table 1 below.

Table 1

A Name of tablet	B Active ingredients	C Mass of active ingredients per tablet/gram	D Mass of one tablet/ gram	E Cost of packet	F Number of tablets per packet	G Cost per tablet	H Cost of 1 gram of active ingredient
TUM-TUM	CALCIUM CARBONATE MAGNESIUM CARBONATE	0·8	1·5	60p	20	3p	3·75p

You are going to fill in the information in the table for several different types of anti-acid tablet. You can use the information given on the label. Figure 2 on the next page gives an imaginary example which has been entered in the table.

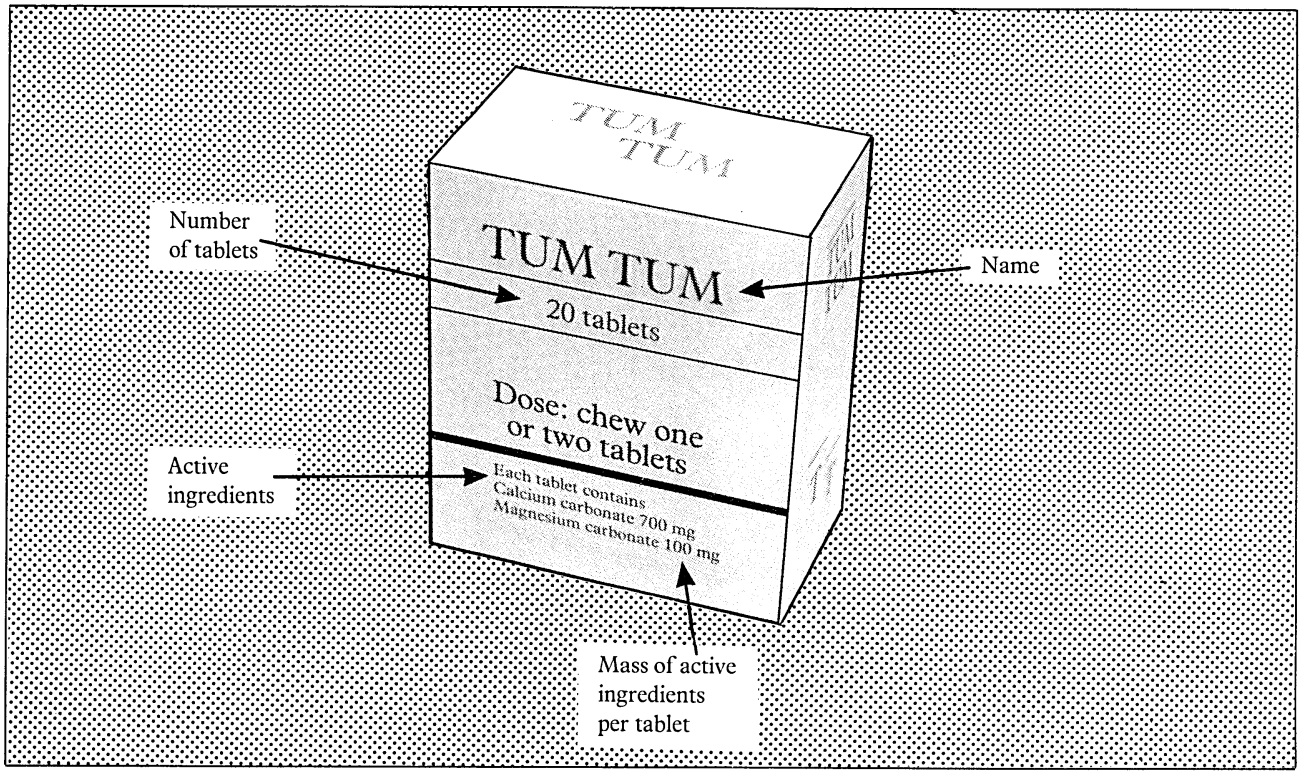


Figure 2

Work through steps **A** to **H** below for each type of tablet.

A Put the brand name of the tablet in column **A** of Table 1.

B Find the active ingredients which can neutralize acids. Put this information in column **B**.

C Find the total mass of all the active ingredients in one tablet. (If there is more than one active ingredient, add their masses together.) The mass may be given in milligrams (mg), which are thousandths of a gram. Convert this to grams and enter it in column **C**.

D Weigh one of the tablets. Write its mass in grams in column **D**.

E Find the cost of the whole packet. Put this in column **E**.

F Find the number of tablets in the full packet. Put this number in column **F**.

G Use the information in **E** and **F** to work out the cost of one tablet. Put this in column **G**.

H Finally, use the information in **C** and **G** to work out the cost of 1 gram of the active ingredient. We will call this the **unit cost**.

When you have done all this for each of the different anti-acids, answers questions 1 to 4.

Questions

1 *For* one *of the tablets, say what products you think would be formed when the active ingredients react with acid.*

2 *Some anti-acids produce carbon dioxide when they react with stomach acid. What happens to this carbon dioxide?*

3 *For* one *of the tablets, compare the mass of active ingredients per tablet with the total mass of the tablet. Is there a difference? If so, what might it be due to?*

4 *Compare the unit costs (the cost of 1 gram of active ingredients) of the different tablets. Which do you think gives the best value for money? (Assume they are all equally effective at relieving indigestion.)*

Part 2 Making more comparisons

Carefully examine two or three different types of anti-acid tablets. Look at their packaging and the shape and size of the tablets. Then answer questions 5 to 7.

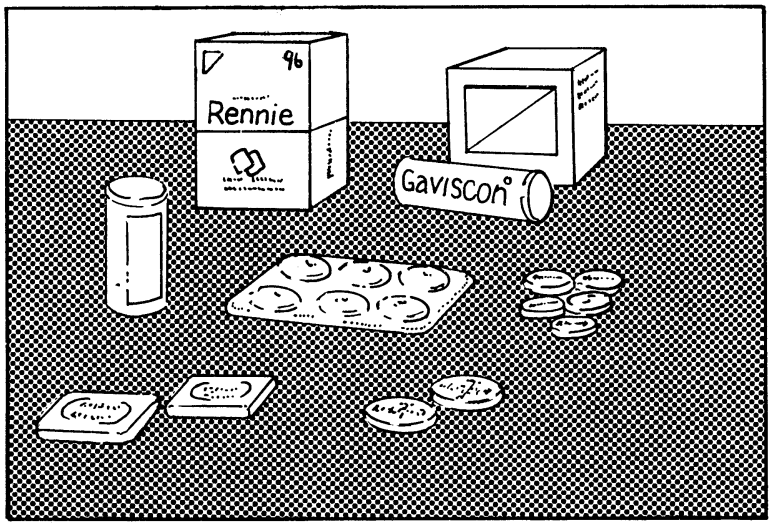


Figure 3

Questions

5 *Manufacturers have to sell products which are as easy to use and as attractive as possible. What have the manufacturers done to make sure of these points?*

6 *Apart from cost, which features of the tablets and packaging influence* you *most in your own choice? What advice would you give to a company which is considering marketing a new anti-acid?*

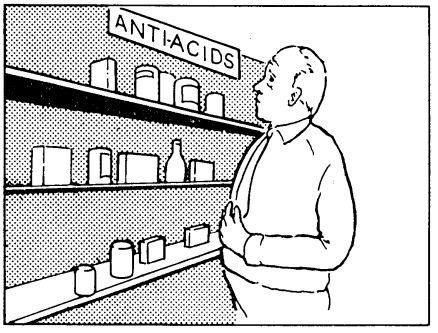
7 *When all the costs to the manufacturers and retailers are taken into account, are consumers generally getting good value? Or are the prices we pay unreasonable?*

Remember that manufacturers' costs will include:

The costs of research and development of new products
Raw materials for the tablets and their packaging
Equipment, factory buildings and transport
Staffing in production, offices, management, distribution and sales
Advertising, taxes and repayment of loans.

Retailers also have costs to cover in running their shops. These costs have to be paid for from sales. Both manufacturers and retailers will also expect to make some profit.

Part 3 A chemical way of comparing anti-acids



We can use titration to compare the amount of active ingredients in different anti-acid tablets. Hydrochloric acid of standard concentration is used. This acid is added to the anti-acid tablet, with an indicator present. The acid will be neutralized until all the anti-acid is used up. At this point the indicator will change colour.

The directions on the packet usually tell you to chew the tablet before swallowing. We can imitate chewing by crushing up the tablet before adding acid.

What you do

CAUTION Wear eye protection, Avoid getting acid in contact with your skin.

A Crush one anti-acid tablet to powder, using a pestle and mortar.

B Transfer *all* the powder to a conical flask.

C Add 5 drops of methyl orange indicator. What colour does the indicator turn?

D Fill a burette with hydrochloric acid. The acid contains 1 mole of HCl per dm^3. Read off the volume of acid in the burette.

E Add acid to the anti-acid powder in the flask. Add it gradually, in small amounts. Swirl the flask vigorously after each addition. What colour does the indicator turn when the acid is added? What happens to the colour on swirling?

Go on adding acid and swirling until no more colour changes occur. When you think the colour has stopped changing, leave the flask to stand for a minute to make sure it does not change again. Finally, read off the new volume in the burette.

F Work out the volume of hydrochloric acid which was neutralized by the tablet. Record your result.

G Repeat for other anti-acids.

Answer questions 8 to 10.

Questions

8 *Why do anti-acid tablets work better if they are chewed before swallowing?*

9 *Using the results of your experiments, decide which anti-acid is the best neutralizer of acid. If you have done Part 2, use information from Table 1 to help you decide which anti-acid is best value.*

10 *Remember that anti-acids are meant to be taken internally by humans. Are chemical tests alone a fair way of measuring their effectiveness? What other kinds of tests might be necessary?*

What is Biotechnology ?

Contents: Reading and questions on the history and nature of biotechnology, including case studies.

Time: 1 to 2 periods, depending on number of case studies used.

Intended use: GCSE Biology, Chemistry and Integrated Science. Links with work on microbiology, enzymes, genetics and extraction of metals.

Aims:

- To complement work on microbiology, etc.
- To give a simple introduction to biotechnology and to illustrate its wide scope
- To develop awareness of some of the ways science, in particular biological science, can be used to meet human needs
- To provide opportunities to practise skills in reading, comprehension and application of knowledge.

Requirements: Students' worksheets No. 710

Suggested use of the unit

It is suggested that all students should use the first part, but teachers may wish to use the case studies selectively. Case 2, on metal extraction, may be of more interest to students who are following chemistry courses.

Notes on some of the questions

Q.1 It is thought that a beer-like drink was first made by accidental fermentation of a cereal-water mixture — a kind of fermented porridge.

Q.3 Like all enzymes, the digestive enzymes used in washing powder are sensitive to temperature. However, strains have been developed which can tolerate quite high temperatures and the alkaline conditions produced by detergents.

Q.7 People are often reluctant to try novel foods, particularly when the origin, taste and texture are unusual. The commonest way round this problem of acceptance is to make the microbial protein into 'analogues' — burgers, rissoles, pie fillings, etc. Pruteen is in fact only used as animal feed, partly because its relatively high RNA content may cause gout in some humans. An example of microbial protein that can be used for human consumption is myco-protein (see SATIS 102, *Food from Fungus*).

Q.9 'Heap-leaching' of copper ores has in fact been practised for hundreds of years, but it is only recently that the microbial basis of the process has been recognised. The bacteria involved are commonly of the thiobacillus (sulphur metabolizing) type. This group includes the remarkable bacteria which live at temperatures up to 100°C in the waters of hot springs.

The students' notes consider only the simple case of copper(II) sulphide ore (covellite), CuS. Other ores, particularly copper pyrites $CuFeS_2$, are more common. The reactions are complex and involve many stages, but the basic outcome is the same — the conversion of insoluble copper ore to soluble copper sulphate.

The advantages of this 'microbial mining' method over conventional smelting include:

(a) Very low grade, low concentration ores can be used. Indeed, the method is applied to spoil heaps which would otherwise go to waste.

(b) Unlike smelting, sulphur dioxide is not released into the atmosphere. In fact, sulphur bacteria have been proposed as a way of removing sulphur from coal prior to combustion.

(c) Energy costs are much lower than for smelting.

Qs 10 and 11 There are in fact a number of different interferons. The main types are alpha, beta and gamma, though alpha interferon is actually a mixture of at least twelve different sub-types. Most testing has been done on alpha interferon, and although results are not yet clear, it seems that early claims for interferon as a 'miracle drug' will not be substantiated. Nevertheless interferon does have measurable activity in some types of cancer, and is free from the distressing side effects of many anti-cancer drugs. If interferons are found to be of real medical value, it is likely that their price will drop as large-scale production methods are developed.

Further resources

A number of industrial organizations produce literature on biotechnology topics, most of them free:

ICI, *1. Pruteen 2. Biotechnology 3.Bio-products.* ICI Agricultural Division, PO Box 1, Billingham, Cleveland TS23 1LB.

NOVO, *Enzymes at Work.* NOVO, Ringway House, Bell Road, Daneshill East, Basingstoke, Hampshire.

Shell, *Biotechnology.* Shell UK Education Services, Shell-Mex House, Strand, London WC2.

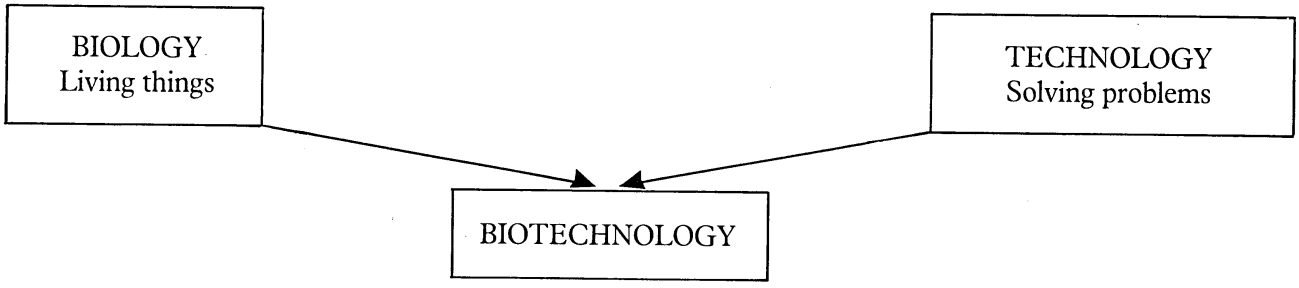
Tate & Lyle, *Biotechnology in the 80s.* Tate & Lyle, Philip Lyle Memorial Research Lab, White Knights, Reading, Berkshire.

Unilever, *Bioltechnology: What is it — Where is it Going?* Unilever Ltd, Unilever House, Blackfriars, London EC4P 4BQ.

Acknowledgements Figure 1 supplied by The Brewers' Society; Figure 2 supplied by Proctor & Gamble Ltd; Figure 3 reproduced by permission from *Science* by Graham Hill and John Holman (Nelson); Figure 6 reproduced by permission from STEAM No. 2; Figure 8 supplied by Warren Spring Laboratory; Figure 9 supplied by Wellcome Biotech.

WHAT IS BIOTECHNOLOGY?

Biology is the study of living things. Technology is about solving problems to provide the things we need. So biotechnology uses living things to make and do the things we need.



More precisely, **biotechnology is the use of biological processes to provide goods and services**. These goods include chemicals, foods, fuels and medicines. Services which depend on biotechnology include waste treatment and pollution control.

Biotechnology uses microbes or cells from plants and animals. Microbes are tiny living things which can only be seen by using a microscope. In some ways, biotechnology is the 'factory farming' of cells.

Milestones in biotechnology

6000BC: The first beer is brewed

Traditional biotechnology started before 6000BC when the Babylonians brewed the first beer. Brewing uses biotechnology to turn sugar to alcohol. Later, about 4000BC, the Egyptians discovered that yeast caused dough to rise during bread-making. Wine is mentioned in the Old Testament of the Bible.

Beer, bread and wine all depend on the fact that yeast cells can live without oxygen. They produce carbon dioxide and alcohol in the process called **fermentation**.

Another ancient fermentation process uses bacteria to turn alcohol to acetic acid in the manufacture of vinegar. Lactic acid bacteria are used to preserve milk in the form of yoghurt. Many types of bacteria and moulds convert milk to cheese. This traditional biotechnology was really an art, rather than a science.

Question

1 *The Babylonians did not know about yeast. How do you think they discovered how to brew beer?*

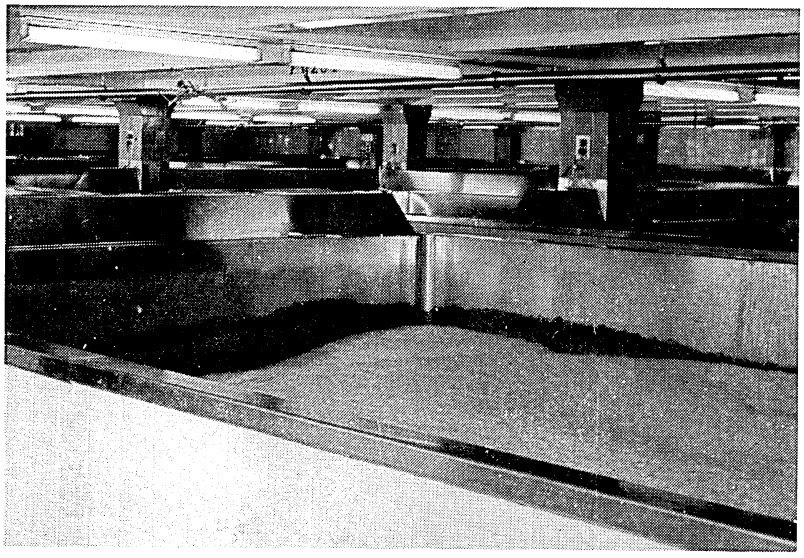


Figure 1 The containers have changed but the process of making beer remains the same. This is a fermenting vessel in a brewery. You can see the yeasty head on top.

Seventeenth century: microbes are discovered

Microbes provided food and drink for many years before they were actually identified. Then in the seventeeth century Anton van Leeuwenhoek used one of the first microscopes to look at microbes.

Many people at the time thought that living things could grow of their own accord from non-living things. They thought, for example, that animals came directly from mud. This was called the theory of spontaneous generation. In the nineteenth century Louis Pasteur disproved the idea of spontaneous generation. He showed that microbes could only come from other microbes. Later, Pasteur used his ideas to prevent wine and milk going sour. His method is still used today, and is called pasteurization.

1897: Enzymes are discovered

In 1897 Edward Buchner showed that you do not need whole yeast cells to make alcohol. *Parts* of the cells will do the job. We now know these are the parts which contain **enzymes**.

Enzymes are biological catalysts. They are made by cells to speed up and control biological reactions. Enzymes are present inside the cells of all living things. They control all life processes. Since 1897 many useful enzymes have been obtained from cells of microbes, plants and animals. Enzymes are commonly used in industry and in the home. Enzymes are used in things as different as biological washing powders and barbecue sauce.

Question

2 *What invention was vital before microbes could be discovered?*

Figure 2 Biological washing powders contain enzymes which break down protein stains

Question

3 *Why is the biological action of enzyme washing powders not effective in very hot water?*

1928: Penicillin — biotechnology makes the wonder drug

Penicillin is an antibiotic that can control many diseases. It was discovered by Alexander Fleming in 1928. Later it was made on a large scale during the Second World War. At that time it was considered to be a wonder drug, and it saved the lives of many wounded soldiers. Penicillin was made by growing a mould, *Penicillium*, on the surface of nutrient jelly in glass flasks. After the war penicillin was made in larger quantitites by growing the mould in a liquid broth inside large fermenters.

Since then many more antibiotics have been made using biotechnology.

1953: DNA — the blueprint of life

Each living cell contains a nucleus. This controls the activities of the cell and tells the cell how to make a copy of itself.

If you observe cells dividing under a microscope, long threads called chromosomes can be seen inside the nucleus. Chromosomes are made of many units called genes. A gene is one unit in the long chromosome thread.

Each gene decides a particular characteristic of the cell or organism. Chromosomes and genes are made from a complicated chemical called DNA. In 1953, scientists working at Cambridge University discovered the nature of DNA (Figure 3).

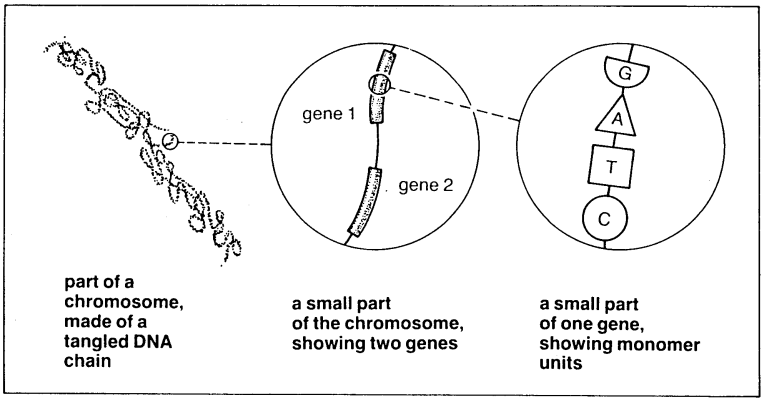


Figure 3 Chromosomes, genes and DNA

DNA is the 'blueprint of life' which controls the way characteristics are passed on from one generation to the next. Understanding the nature of DNA opened the way for genetic engineering.

1970s: Genetic engineering is developed

Genetic engineering can be used to 'persuade' microbes to make products they would not normally make. Genes, made of DNA, are transferred from one type of cell to another completely different type. For example, genes from humans can be transferred to microbial cells (Figure 4). Once inside the microbes, these human genes control the microbial cells. This causes the microbes to produce something they would not normally make in nature. For example, microbes can be persuaded to make human insulin.

Although biotechnology has been with us for many years, the discovery of genetic engineering brought it to the forefront.

During the 1970s biotechnology started to hit the headlines. It still does, because bio-industries are becoming increasingly important.

Question

4 *Why was genetic engineering not possible until the nature of DNA had been discovered?*

Figure 4 Genetic engineering — the basic method

Who are biotechnologists?

The bio-industries need both scientists and engineers. Working together as a team, microbiologists, biochemists and engineers put scientific ideas into practice.

Many people think that biotechnology can help solve some of the world's problems, such as disease, hunger and shortage of resources.

Question

5 *Which of the following are examples of biotechnology?*

(a) Producing compost from rotting plant matter
(b) Refining oil to make petrol, diesel fuel, fuel oil, etc.
(c) Using bacteria to turn glucose to fructose (a very sweet sugar)
(d) Making biogas from decomposing household and farm waste
(e) Making steel from iron ore.

Some case studies of biotechnology

Case 1 Food from bacteria

Biotechnology can be used to make a protein-rich food called Pruteen. It is made from squashed, dried bacterial cells. As in many biotechnology processes, the original research and development was lengthy and expensive. It took fifteen years, lots of effort and expertise and millions of pounds to put an original idea of 'food from bugs' into practice.

The bacteria are grown on a chemical called methanol. Methanol can be made cheaply from North Sea gas. For rapid growth the bacteria are also supplied with water, ammonia, mineral salts and air. They also need warmth. Conditions must be sterile so no other microbes are present. This is easier said than done as the growth vessel used is the largest in the world. It is the size of a large block of flats.

A 'continuous culture technique' is used in Pruteen manufacture. Once the process is started up the bacterial cells reproduce rapidly. Bacteria are continuously removed and replaced with starting materials. This means that the process can continue non-stop for up to six months (Figure 5).

Pruteen is used to feed animals such as pig and cows.

Biotechnology can be used to make other 'microbial' foods. For example, fungi can be used to make a high-protein food for humans.

Questions

6 *Why is it vital that no other microbes are present in the Pruteen fermenter, apart from the bacteria being grown?*

7 *What problems do you think there might be in persuading people to eat novel foods like these? How might these problems be overcome?*

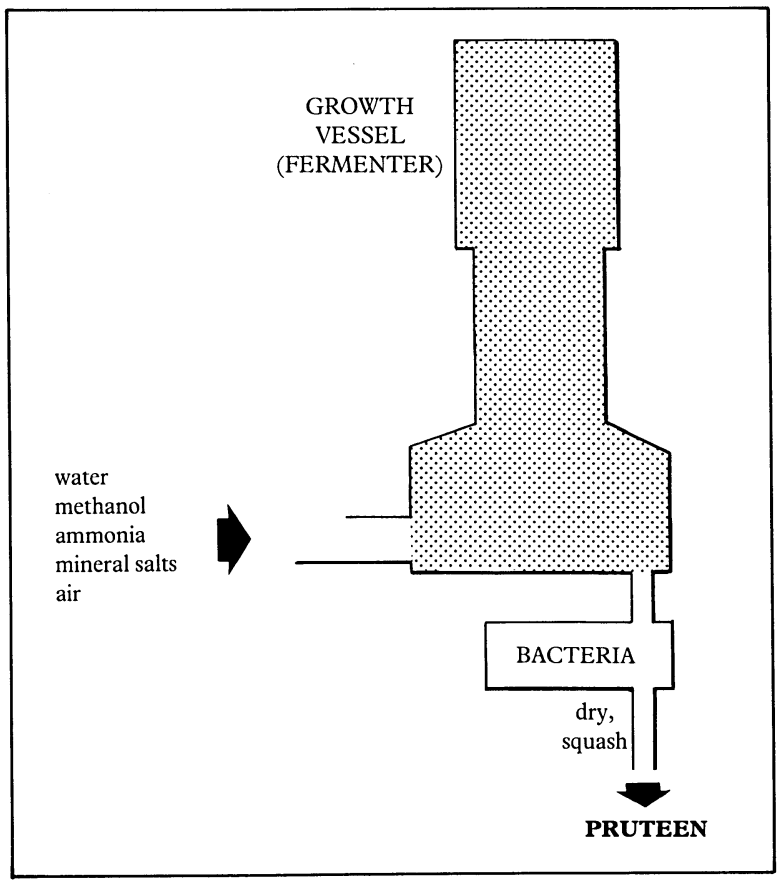


Figure 5 Growing bacteria to make Pruteen

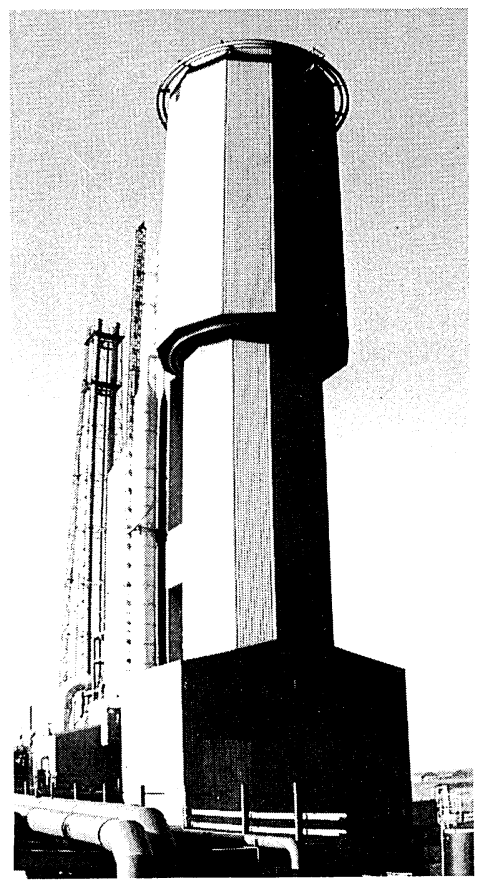


Figure 6 The fermenter used to make Pruteen

Case 2 Using bacteria to extract metals from ores

Copper is a valuable metal. It is extracted from copper ores. These ores contain copper combined with other chemical elements, especially sulphur. The ore is mixed with a lot of worthless rock. Sometimes the amount of copper ore is so small that it is difficult and costly to get the copper out.

This is where bacteria can help. Certain bacteria can use air to oxidize copper sulphide ores. This turns the insoluble copper sulphide into soluble copper sulphate.

$$\underset{\text{copper sulphide ore}}{CuS_{(s)}} + \underset{\text{oxygen from air}}{2O_{2(g)}} \xrightarrow{\text{bacteria}} \underset{\text{copper sulphate solution}}{CuSO_{4(aq)}}$$

(In most cases the formula of the copper sulphide ore is more complicated than CuS, but the general idea is the same.)

The bacteria involved enjoy nasty living conditions. They like acidic water, and high temperatures. They can tolerate copper compounds, which are poisonous to most organisms. They are sometimes called 'rock-eating bacteria'.

Figure 7 shows the method that is used.

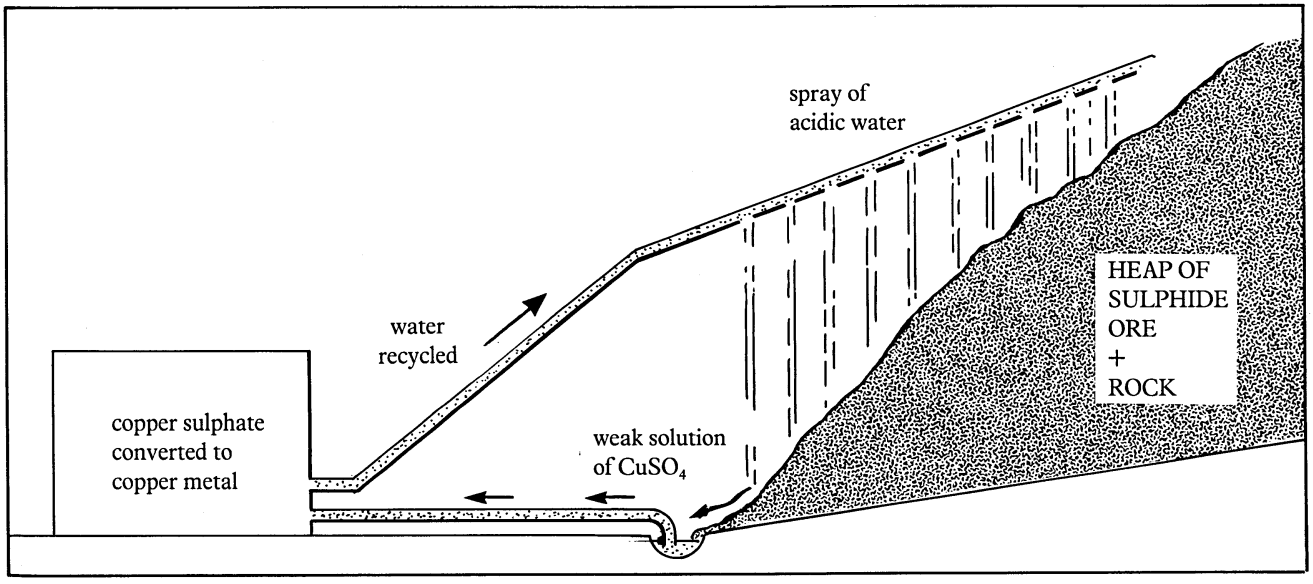


Figure 7 Using bacteria to extract copper

The bacteria are already present in the heap of crushed rock and ore. All that is needed is a spray of acidified water to encourage them to grow. As they grow, they oxidize copper sulphide ore to copper sulphate. A weak solution of copper sulphate trickles out at the bottom of the heap.

The copper metal is then extracted from this solution. This is usually done by adding scrap iron to the solution. The more reactive iron displaces the copper.

$$\underset{\substack{\text{copper}\\\text{sulphate}\\\text{solution}}}{CuSO_{4(aq)}} + Fe_{(s)} \longrightarrow FeSO_{4(aq)} + \underset{\substack{\text{copper}\\\text{metal}}}{Cu_{(s)}}$$

The water is recycled back to the heap.

The heaps are huge, as big as a small mountain. They may contain billions of tonnes of rock. The oxidation reaction is exothermic — it gives out heat. The temperature at the centre of the heap may get very high, but the bacteria flourish at these temperatures.

Ten per cent of all the copper produced in the USA is made by this method. In the future, biotechnologists may be able to use genetic engineering to make the bacteria more efficient. For example, they might be able to make them work faster.

Questions

8 *The process goes faster if the ore in the heap is crushed into small pieces. Explain why.*

9 *The usual method of producing copper is to roast the sulphide ore in air. This produces copper and sulphur dioxide. Some of the sulphur dioxide inevitably escapes into the air.*

Give two *advantages of the biotechnological method compared with the usual method.*

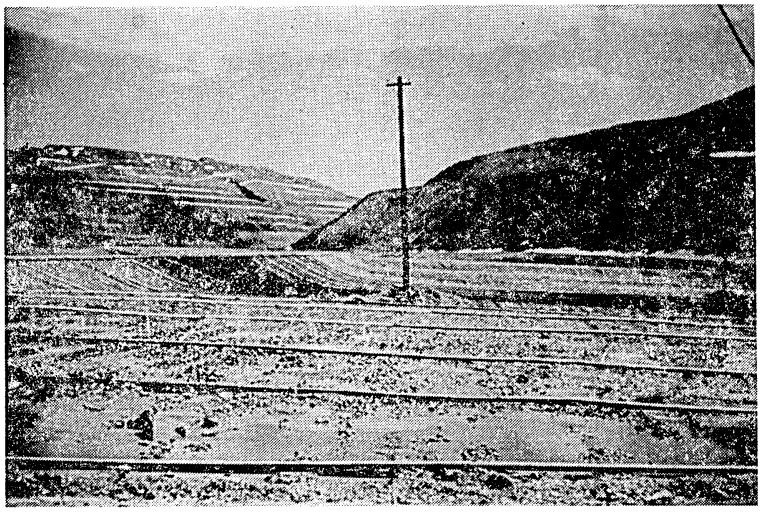


Figure 8 Extracting copper from a heap of ore in the USA. The spray of acidified water comes from the pipes in the foreground

Case 3 Making interferon — 'Nature's Wonder Drug'

Interferons were discovered in 1957. They are proteins produced by the human body. They are part of the body's natural defences against viruses and other disease-causing agents.

Interferon has been called 'Nature's Wonder Drug'. Doctors believe it may be able to cure many diseases, from the common cold to cancer. But all this is very uncertain, because until recently there was not enough pure interferon to test properly.

In the 1970s, human white blood cells were the only source of interferon. The entire world's supply was only a few milligrams. But now biotechnology is being used to make it in larger quantities.

The trick is to use genetic engineering. Human interferon can only be made by genes from human white blood cells. But these genes can now be carefully removed from white cells. They can be transferred to bacteria cells. The interferon gene is joined on to the bacteria's own genes. The bacteria will then make interferon just like a human white blood cell.

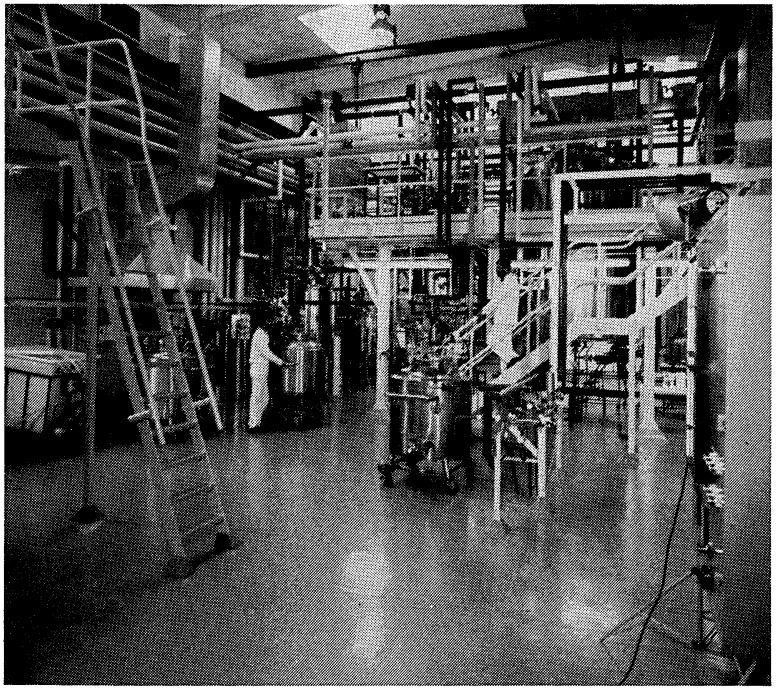


Figure 9 A cell culture plant used to make interferon

Scientists can choose a particular type of bacteria which they know will grow quickly. The bacteria are grown in a fermentation tank or **bioreactor**. Once they have been given the interferon genes, the bacteria will produce interferon to order. Even so, it is still produced in very small quantities and needs a lot of purification.

Thanks to this method, doctors now have enough interferon to carry out tests on patients. It is still too soon to know whether interferon really is 'Nature's Wonder Drug'. But some types of cancer, particularly leukaemia, do seem to be controlled by treatment with interferon. And interferon is the most effective drug for preventing colds that has yet been found.

Questions

10 Interferon is one of the most expensive substances in the world. It costs about £10 million per gram.

(a) Why is it so expensive?
(b) Is its price likely to increase or to decrease in the future? Why?

11 Suppose interferon is found to be a powerful cure for cancer. It is so scarce that only a few people can be treated with it. How should doctors decide which patients to use it on?

INDEX

This index includes, in a single list, references to science syllabus topics (eg acceleration, acids), to social and technological topics (eg advertising, agriculture) and to types of activity (eg data analysis, discussion).

Entries give unit and page numbers (eg 101/1). A list of unit titles can be found at the front of this book.

Where the reference is to the whole unit, the number is given in italics (eg *301*).

References to the Teachers' Notes are in small roman numerals as in the units (eg 709/ii). In a few units the Teachers' Notes only cover one unnumbered page. These pages are indexed as 't' (eg 101/t).

SATIS 7 and Index

List of units in this book

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