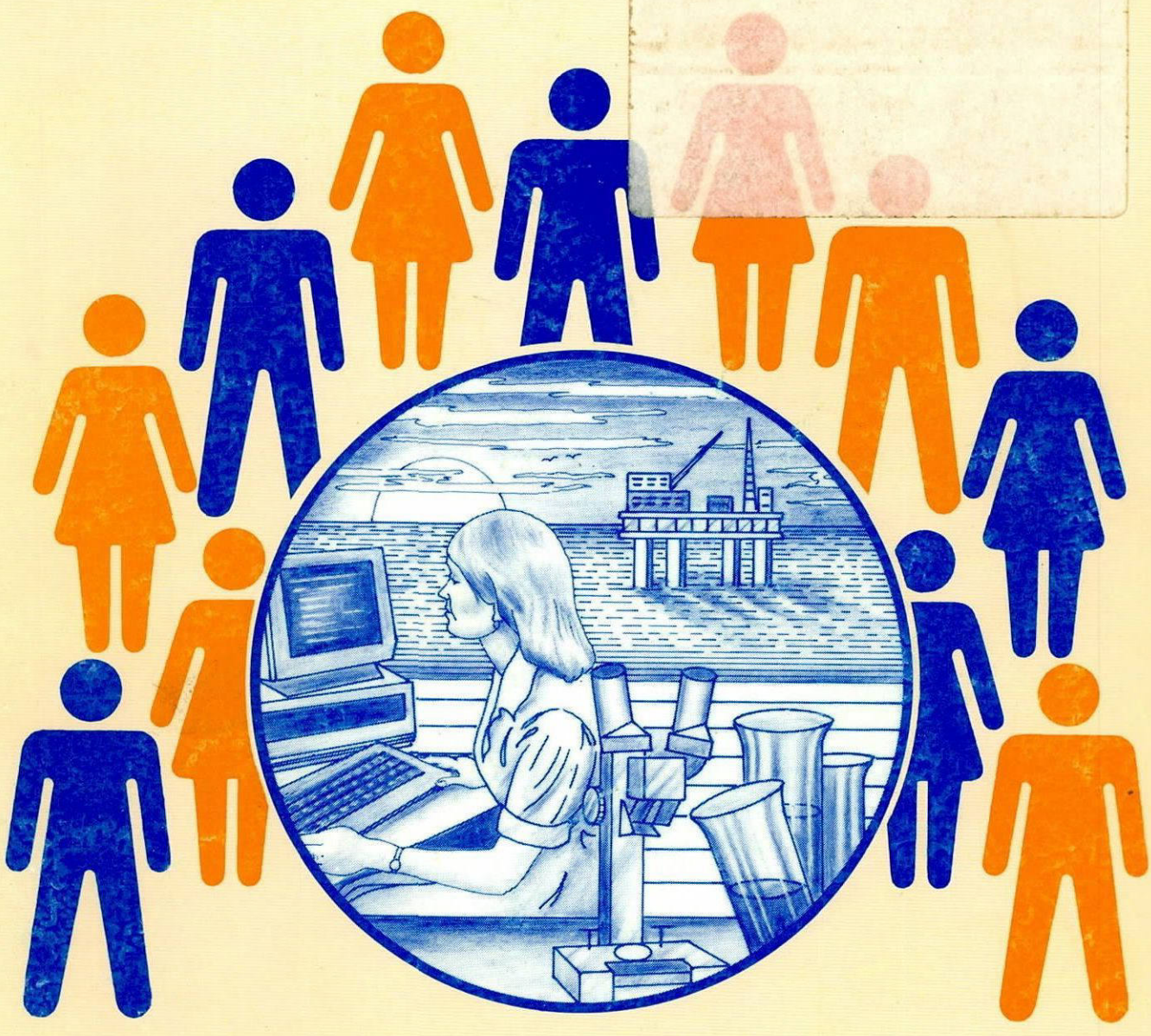
SCIENCE & TECHNOLOGY IN SOCIETY

10

& INDEX



SATIS

ABOUT SATIS

Science and Technology in Society units are designed to be used in conjunction with conventional science courses, particularly those leading to GCSE examinations. Each unit has links to major science topics as well as exploring important social and technological applications and issues.

The units are self-contained and generally require about 2 periods (around 75 minutes) of classroom time. Each unit comprises Teachers' Notes (blue sheets) and Students' materials (white sheets). Full guidance on use is given in the Teachers' Notes accompanying each unit, which also include background information and suggest further resources.

Each SATIS book contains ten units. The units are numbered in a system giving the number of the book followed by the number of the unit within that book. Thus the first unit in the first SATIS book is numbered 101.

In addition to the SATIS books, there is a *General Guide for Teachers* which gives guidance on some of the teaching techniques involved as well as ideas for further activities.

Many people from schools, universities, industry and the professions have contributed to the writing, development and trials of the SATIS project. A full list of contributors appears in *General Guide for Teachers.*

The names of contributors to this particular book are given on the inside of the back cover.

First published 1988 by The Association for Science Education

Designed by P & PS (Cambridge) Ltd.

SATIS 10 and Index

List of units in this book

EVALUATION OF SATIS UNITS

Users of the units in this book are invited to evaluate them by completing the questionnaire on the next page. Such feedback is of great value in helping to revise and improve the units and in determining future policy.

The Association for Science Education
College Lane
Hatfield
Herts AL10 9AA

ISBN 0 86357 080 1

List of units in the SATIS series

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Evaluation of SATIS units

Your opinions as an experienced teacher will help to revise and improve the SATIS units in this book and to influence the style of future units.

Please
- Complete a response table (overleaf) for any unit you have used. If you need more response tables, please make photocopies.
- Return the completed sheet(s) to:

  SATIS Evaluation, ASE, College Lane, Hatfield, Herts AL10 9AA

Information about your school

Name of SATIS contact person: .....

Role: .....

Name of school: .....

Address: .....

.....

Type of school *(Please circle):*

Comprehensive Grammar Secondary Modern Independent Other

Boys only Girls only Mixed

Age range: ..... Total school roll: .....

Your opinions about the SATIS units in this book

The aspects for comment are listed below and we have provided response tables on the other side of this sheet. For each unit:

Please
- Complete the headings
- Tick the box which most closely reflects your opinion about each aspect of the unit you have taught
- If you have 'no opinion', or do not wish to give one, please tick the box on the extreme right.

Aspects for comment

(a) Relevance for GCSE courses (Is the unit relevant to your course?)
(b) Students' apparent interest (Did the unit stimulate interest in your students?)
(c) Language level (Is the unit written at a suitable level for your students?)
(d) Concept level (Were the conceptual demands appropriate?)
(e) Suggested amount of time (Was there enough time to complete the unit?)
(f) Recommended teaching/learning method (Was this appropriate for the unit?)
(g) Presentation (layout, diagrams, photos, print size) (Was all this suitable?)
(h) Teachers' notes (blue sheets) (Did you find these useful?)
(i) The teaching sequence in the unit (Was the unit organised suitably?)
(j) Requirements for students' response (Did the unit require suitable activities and feedback from students?)

I intend to use the following units again without revision. (Please quote unit number only.)
I intend to use the following units again, with revision.
I do not intend using the following units again.

SATIS unit number ....

Years and abilities used with ....

(a) Relevance for GCSE	Very relevant	Relevant	Little relevance	Not relevant	No opinion
(b) Students' apparent interest	Very interested	Interested	Little interest	Bored	No opinion
(c) Language level	Very suitable	Suitable	Quite difficult	Very difficult	No opinion
(d) Concept level	Very appropriate	Appropriate	Not appropriate	Completely in-appropriate	No opinion
(e) Suggested amount of time	Very satisfactory	Satisfactory	Difficult to meet	Badly estimated	No opinion
(f) Recom-mended teaching/learning method	Very appropriate	Appropriate	Needs improving	Not at all appropriate	No opinion
(g) Presentation (Layout, dia-grams, photos, print size, etc.)	Excellent	Good	Needs improving	Poor	No opinion
(h) Teachers' notes (the blue sheets)	Very useful	Useful	Need improving	Of little use	No opinion
(i) The teaching sequence in the unit	Very suitable	Suitable	Needs some reorganising	Needs much reorganising	No opinion
(j) Requirements for students' response	Very suitable	Suitable	Need improving	Unsuitable	No opinion

Further comment:

SATIS unit number ....

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(j) Requirements for students' response	Very suitable	Suitable	Need improving	Unsuitable	No opinion

Further comment:

Chocolate Chip Mining

Contents: A practical activity linked to analysis of data about copper mining.

Time: 2 to 3 periods.

Intended use: GCSE Chemistry and Science. Links with work on metal extraction with special reference to the environmental problems associated with the recovery of minerals.

Aims:

- To show the economic importance of the fact that mineral resources are not evenly distributed in the Earth's crust
- To develop awareness of the environmental impact of mining and the difficulty of reclaiming mined areas
- To provide an opportunity for open-ended problem solving
- To provide an opportunity to practise the skill of interpreting data.

Requirements: Students' worksheets No.1001. Suggested equipment for Part 1 is listed below.

Author: Andrew Hunt

Suggested use

This unit is in two parts. Each part is self-contained.

Part 1 Mineral processing

This is a practical activity which should have a wide appeal. It uses the problem of 'mining' chocolate chips in a biscuit as an analogy for the difficulties involved in developing mineral resources.

Part 2 Copper mining

This is a data-analysis exercise which is designed to show the real-life importance of the analogy used in Part 1. With some pupils it may be more appropriate to give Part 1 more meaning by showing a film, slides or a video (see below under 'Further resources').

Notes on Part 1

Safety

There is little doubt that some students will be tempted to eat the results of their 'mining' and so this activity should not take place in a laboratory if at all possible. In any case normal laboratory equipment should not be used unless it can be guaranteed that no one will eat the output of their processing operations. One way round the practical problems is to set this activity for homework but students will then miss the benefits of discussing the results with others. Alternatively students can be asked to bring their own 'mining equipment' from home.

Requirements

Each group of students will need:

2 chocolate chip biscuits (which should be stored in a refrigerator or other cool place before use)
clean containers, e.g. margarine tubs, or yoghurt pots
access to a variety of equipment and materials such as:
- knife
- spatula
- sieve or strainer
- water bath
- a balance
- measuring cylinder
- oven

This exercise could be used as an opportunity to introduce some simple statistical ideas. Students could be asked to plot a histogram to show the range and variation of the quantities of chocolate 'mined' from biscuits by the groups in the class.

Answers to questions in Part 2

Q.1 80 times more concentrated

Q.2 (a) 500 kg
(b) 8 kg
(c) 2 kg

Q.3 (a) 25%
(b) 0.4%
(c) 0.2%

Q.4 0.2%

Further resources

Background reading for the teacher is included in:

Science in Society, Book G, *Mineral Resources,* Heinemann Educational Books, 1981.
Revised Nuffield Advanced Chemistry, *Mineral Process Chemistry,* Longman, 1984.

Information on films or videos about the extraction and uses of metals is available from:

Viscom Limited (for British Steel and RTZ Group films), Audio Visual Library, Unit B11, Park Hall Road Trading Estate, London SE21 8EL. (Tel: 01-761-3035)

TV broadcasts for schools also include programmes about the extraction and uses of metals.

Booklets, wall charts and other printed information about metal extraction are available from:

British Steel Corporation, 9 Albert Embankment, London SE1 7SN (Tel: 01-735-7654)
Institute of Metals, 1 Carlton House Terrace, London SW1Y 5DB (Tel: 01-839-4071)
RTZ Services Limited, Intermail Ltd, Unit 2, Fleming Road, Newbury, Berkshire RG13 2DE

Acknowledgements Part 1 of this unit is based on an idea from 'Outlook', a programme for environmental education enrichment from the Iowa Department of Public Instruction, USA. Figure 3 in Part 2 supplied by RTZ Ltd.

CHOCOLATE CHIP MINING

This unit is in two parts. Part 1 is practical. You have to try and extract a useful 'mineral' from a 'rock' sample. Part 2 describes some of the problems of copper mining.

Part 1 Mineral processing

You are a research scientist for a mining company. You work in a laboratory which investigates methods for getting useful minerals from rocks. You have just been sent a sample of rock which seems to have small pieces of a valuable mineral mixed up with unwanted waste material. The mineral is dark brown. The waste is paler.

Research brief

- Find a method for separating the valuable mineral from the rock sample.
- Measure the amount of mineral and the amount of waste. Compare your results with those obtained by other working groups. Does the amount of the valuable mineral seem to be about the same in each rock sample?
- Compare the volume of waste rock with the volume of your original sample. Is it likely to be possible to put the waste back into the hole made during mining?
- If a second rock sample is available, try to see if you can extract the mineral more efficiently.
- Carry out any further investigations which you think may be helpful and then write a report for the directors of your company.

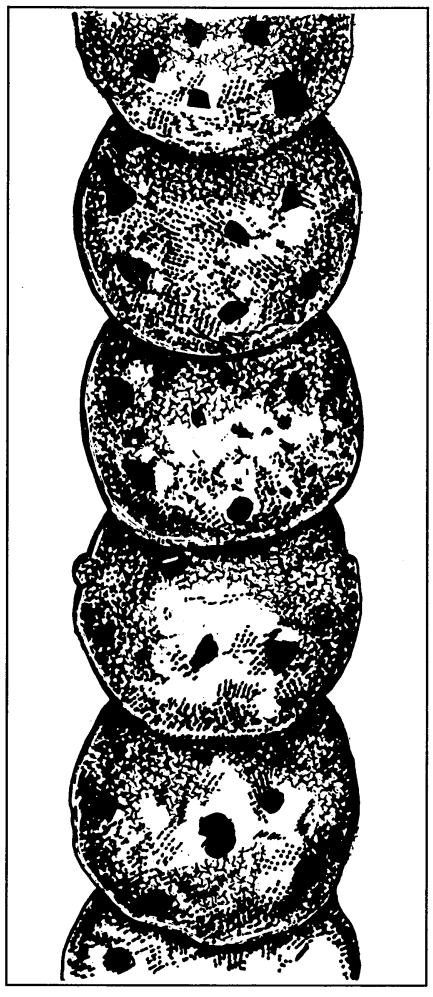

Figure 1 A typical 'rock' sample

Part 2 Copper mining

There is very little of some metals in the crust of the Earth. Look at the table below — the centre column gives the average percentage of five metals, including copper. Fortunately minerals are not spread evenly through the Earth's crust. There are places where valuable minerals are concentrated as ores.

The right-hand column in the table shows you the percentage of the metals in ores which are economical to mine. Below these percentages the ore is not worth mining because it costs more to get the metal out than the metal is worth.

Look at the table and answer question 1.

Table 1

Metal	*Average percentage in the Earth's crust*	*Percentage of the metal in ores which can now be mined economically*
Aluminium	8	30
Iron	5	17
Copper	0.005	0.4
Lead	0.001	2
Gold	0.000 000 4	0.000 8

Question

1 *How much more concentrated is the copper in an ore than the average concentration of the metal in the crust of the Earth? (See table.)*

You can see from the table that some ores contain very little of the metal. This means that a huge amount of waste has to be mined to get at the valuable metal. The mining company has the problem of getting rid of the waste.

There is a big open-pit copper mine on the island of Bougainville in Papua New Guinea (see Figures 2 and 3). About 220 000 tonnes of ore and waste rock are mined each day. The ore from the mine is used to produce about 500 tonnes of copper metal a day.

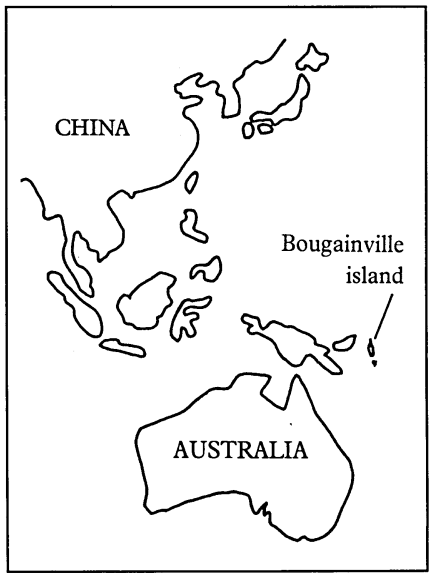

Figure 2 The position of the island of Bougainville

Figure 3 Mining copper ore at Bougainville

Waste rock with no ore in it is dumped. The ore with the copper in it is crushed and ground to a powder. Then the valuable mineral which contains the copper can be separated from the rest of the waste.

Powdered wastes from the separating plant are washed into the Kawerong river. Some of the waste ends up along 35km of the river system. The rest is making a delta where the river flows into the sea. In the future it is planned to take these wastes out to sea, via a pipeline.

The Bougainville mine is only economic because the ore also contains traces of gold and silver. There is about 0.6**g** of gold and 1.6**g** of silver in each **tonne** of the ore. Even with such tiny amounts, for every £1.00 earned by the mine in 1984, 45p was from sales of gold, 2p from silver and 53p from copper.

Study Figure 4 and then answer questions 2 to 4.

Questions

2 *This question is based on Figure 4.*
   (a) How much metal ore is obtained for each tonne (1000 kilograms) of rock dug from the mine?
   (b) How much of the valuable copper concentrate is obtained from 1000 kilograms of rock dug from the mine?
   (c) How much copper metal is obtained from 1000 kilograms of rock (ore and waste) dug from the mine?

3 *Work out the answers to this question with the help of Figure 4 and your answers to question 2.*
   (a) What is the percentage of copper in the copper concentrate?
   (b) What is the percentage of copper in the metal ore?
   (c) What is the average percentage of copper in the rock in the ground?

4 *Compare your answers to question 3 to the information given about the Bougainville mine. What is the percentage of copper in the 220 000 tonnes of rock which are mined each day?*

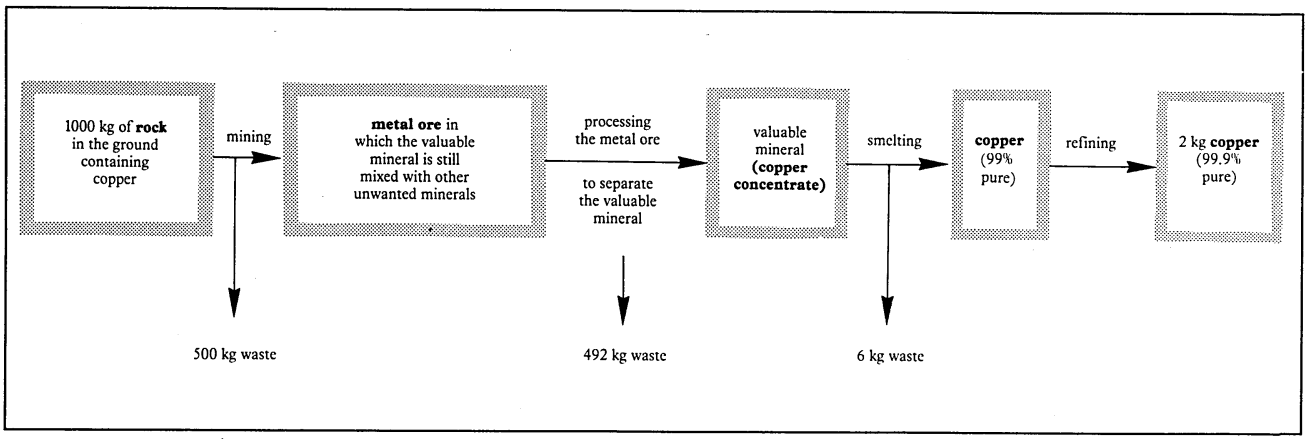

Figure 4 The main stages in the mining and processing of a copper ore

Quintonal — an industrial hazard

Contents: A simulation role-play exercise concerning industrial safety.

Time: 2 to 3 periods.

Intended use: GCSE Chemistry, Biology and Science. Links with work on disease, and the effect of chemicals on cells.

Aims:

- To complement work on disease and the effect of chemicals on cells
- To develop awareness of some of the problems of industrial safety, and the idea of an acceptable level of risk
- To show that there may be conflicting interests where industrial safety problems are concerned
- To provide an opportunity to practise communications skills, in particular assembling and presenting an argument, and to provide experience of speaking formally in front of others.

Requirements: Students' worksheets No.1002. General Briefing (Sheets GB) — one copy per student. Role cards (see below).

Author: Julian Cohen

There are eight roles, representing the different people attending the meeting at Wilsons Plastics Company. They are:

John/Joanne Wilson, Managing Director
Frances/Frank Taylor, Trade union shop steward
Jackie/Jack Hilton, Company Safety Officer
Dr Barbara/Brian Rose, Local GP
Pauline/Paul Jones, Company nurse
Sally/Sam Green, Local councillor
Dr Anne/Alan Arnold, Industrial chemistry consultant
Tracey/Trevor Graham, representative of local tenants association

The role notes are in the students' worksheets and can be reproduced on card or paper, and cut up into individual role cards.

It is best to have *two* students per role if possible. Students can then prepare the role together, share in presenting their point of view, and confer before answering questions.

If there are more students in the group than are needed to fill the roles, there are a number of possible procedures:

- Have only 16 students playing roles; the remainder can be a participating audience.
- Have more than two students per role.
- Devise additional roles, for example, factory worker, trade union safety officer, etc.

Background to the simulation

The simulation exercise is based on a meeting at Wilsons Plastics Company.

Wilsons employ 350 people and make plastic food containers. Quintonal is a chemical used during the manufacturing process. No trace of quintonal is left on the finished product, due to reactions that have taken place.

The following item has just appeared in the local newspaper.

DANGEROUS CHEMICAL USED AT WILSONS

This month's edition of an American medical journal carries an article linking the chemical quintonal with bladder cancer. Scientists found that 80% of the rats given large doses of quintonal developed bladder cancer. More research is being carried out but Dr Armit, one of the report's authors, said 'There is increasing evidence that quintonal may cause bladder cancer. We can't be 100% sure yet but the results point that way'. Quintonal is used by the Wilsons Plastic Company of Broadoak Road. A company representative said that there was no cause for concern but some workers have expressed worries about their health. A meeting is taking place at Wilsons this afternoon and will be followed by a press statement.

Note The issues addressed in this unit are important but can be sensitive and a little difficult to handle. Cancer can be an emotive topic, and the question of carcinogenic chemicals is one where there are many unknowns and it is difficult to prove links between cause and effect.

Procedure

1 Give the students the background information sheet on cancer. This could usefully be read for homework before the exercise is to be carried out.
2 Tell the students the background to the simulation as described above, and read out the newspaper item.
3 Explain that they will be simulating the meeting to be held at Wilsons to decide what action, if any, needs to be taken.
4 Distribute the role-play cards.
5 Tell participants to prepare their roles by making notes or writing out a speech. Encourage them to *develop* the role by adding relevant points and information.
6 Hold the meeting. This can be done in a number of ways. One good way is to let the participants speak in turn and after each speech allow questions. On concluding the discussion, take a vote (in role) on possible proposals (for example, to halt production immediately, to step up safety measures) to see if there are at least some areas of agreement.
7 After the meeting discuss what happened (out of role). Some questions could include:
   (a) What did you think of the character you were playing?
   (b) Which point of view did you most/least agree with?
   (c) What do you think should be done in such situations in real life?
   (d) What scientific information is needed on which to base opinions and decisions about these matters? How can this information be obtained?
   (e) Did all the characters get their facts right?

Acknowledgements Figure 1 supplied by the United Kingdom Atomic Energy Authority; Figure 2 supplied by Sally and Richard Greenhill.

QUINTONAL — an industrial hazard

General Briefing: Background information notes on cancer

What is cancer?

Cancer occurs when some of the cells in the body become abnormal and act in an uncontrolled way. Normally, cells divide to create new cells to carry out growth and repairs. Occasionally something goes wrong and some cells begin to multiply uncontrollably.

The body is made up of many different types of cell. Any of these types of cell may go wrong, so there are many different types of cancer. It not a single disease. For example, there is cancer of the lung, stomach cancer, breast cancer, bone cancer.

The group of abnormal cells is called a growth. The cells do not work properly as part of the organ or tissue where they began to grow. As cells multiply they take up more room, and the group of abnormal cells may invade nearby parts of the body, and prevent them from working properly. This is called *local invasion.* Often cancer cells break away and travel, for example, through the blood-stream, to other parts of the body where they may form new groups of abnormal cells. These groups are called *secondary growths* or *metastases.* They too can prevent the organs where they are growing from working properly.

How many people die of cancer in the UK?

In 1984, 157 884 people died of cancer in the United Kingdom. This was 24 per cent of the people who died in the UK that year.

Can cancer be cured?

Many forms of cancer can be cured, especially if the disease is detected at an early stage. However, the success rate for complete cure is not very good among many of the most common cancers.

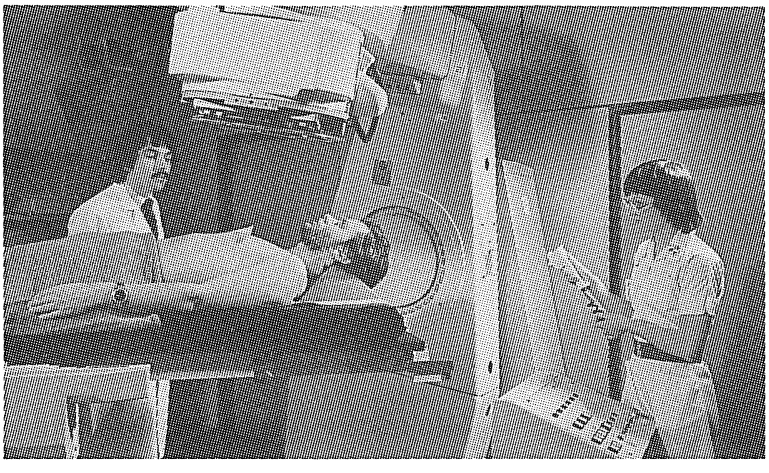

Figure 1 Treating cancer using radiation

How is cancer treated?

Three main types of treatment are used:

1 Surgery — where cancerous cells are cut away.

2 Radiotherapy — radiation treatment to try to destroy cancerous cells.

3 Chemotherapy — treatment with drugs to try to destroy cancerous cells.

The type of treatment used will depend on the type of cancer and the person involved. All three treatments can lead to very unpleasant side-effects.

What causes cancer?

Cancers sometimes take many years to develop. This makes it difficult to know exactly what causes cancer.

We know some of the things that cause cancer:

- *Cigarette smoking* causes several types of cancer, particularly lung cancer. It is the most important cause of cancer in Britain, and is responsible for about a third of all cancer deaths.
- *Several chemicals* are known to cause cancers. Cancer-causing chemicals are called **carcinogens.**
- *Radiation* can cause cancer (as well as being used to treat some forms of cancer). Radiation includes X-rays and the rays from radioactive elements.
- *UV light* can cause skin cancer. This may affect people who sunbathe for long periods.

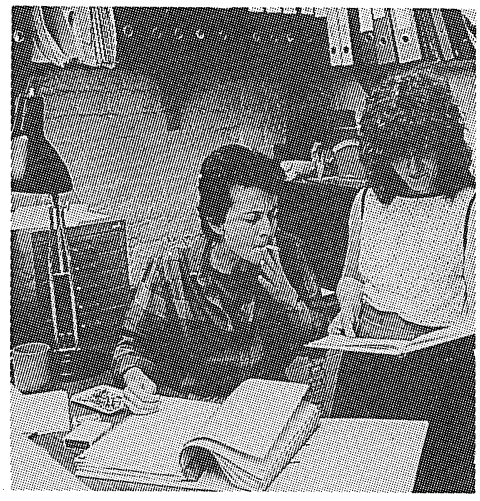

Figure 2

Two other suspected causes are:

- *Viruses* are suspected of causing some cancers. They work in a complex way, often with other factors involved as well. You cannot 'catch' cancer by contact with a cancer patient.
- *Unhealthy diet* is thought to cause some cancers, though this is not proved. Many doctors suspect diets which are high in fat and low in fibre, fruit and vegetables.

Cancer in industry

A number of chemicals used in industry have been connected with cancer. The table below gives some examples.

Chemical	*Type of cancer*
Vinyl chloride	liver
Arsenic	skin, lung
Refining of nickel	lung and nose
Manufacture of some chromium compounds	lung
Some tars and soots	skin, lung
Asbestos	lung
Some chemical dyestuffs	bladder

Most *known* industrial carcinogens have either been withdrawn or controlled, but there are many industrial chemicals which have not yet been tested. Some of these *may* be carcinogenic but we do not yet know.

Role card 1

John/Joanne Wilson, Managing Director

You are very worried that the problem could lead to bad publicity for your company. You want to avoid risking the health of your workforce, but do not want to halt production just because quintonal *could* be harmful.

The company is already having financial difficulties. Cheap imports are being subsidised by foreign governments. The imports are being sold in Britain at prices below those at which Wilsons have been selling in the past. If this problem is not handled carefully the company might not recover. If it is closed many workers would lose their jobs.

Safety precautions are already in force for all chemicals used in the factory, including quintonal, but you are willing to look into improved safety precautions and training. The necessary measures will be taken by the company but workers must follow the safety rules.

You want everyone to keep calm about the situation. They should not panic just because some scientists have given large doses of quintonal to rats and some rats have developed cancer. You are seeking expert advice and are consulting the Health and Safety Executive. Your records show no cases of bladder cancer among employees.

Role card 2

Frances/Frank Taylor, trade union shop steward

A lot of workers you represent work on a productivity scheme on the production line. This means they have to work very quickly to earn enough bonus to get a decent wage. You believe this puts them under so much pressure that it is not possible to keep to all the safety rules. For safety's sake the productivity scheme should end and workers should be paid a decent basic wage.

You are a heavy smoker.

You have held a well attended meeting of union members in the factory. That meeting wanted:

1 An immediate halt in production until the risk is fully dealt with. In the meantime the workforce should receive full pay.
2 No workers to be put at risk at any time.
3 All workers to have a medical examination immediately and any necessary treatment given.
4 The problem to be dealt with at source. It is not enough for workers to wear protective clothing.
5 The company to find a safe substitute for quintonal.

Role card 3

Jackie/Jack Hilton, Company Safety Officer

You have worked at Wilsons for over thirty years, starting off as a messenger. You believe the company has improved its safety standards over the years but there is still a lot to be done. Workers do not, in your view, take safety seriously enough. They do not always put the safety guards on the machines or wear the goggles and gloves that are provided. Safety precautions need to be stepped up and regulations must be obeyed.

With regard to quintonal you believe people should not panic. If people obey the safety rules and the company looks into the purchase of better protective clothing, there should be no health risk. To make doubly sure you have asked the local University Department of Community Medicine to try to find out whether there has been any risk of bladder cancer in the workforce. Quintonal has been in use at Wilsons for over twenty years and your records show no cases of bladder cancer among employees. Quintonal worries you but so do many other safety problems, and so would the consequences of the factory closing.

Role card 4

Dr Barbara/Brian Rose, local GP

Your practice is near the factory and a lot of your patients work at Wilsons. Some of them have come to you for your opinion about quintonal. You are worried about quintonal and want strict safety measures, including use of protective clothing, regular medicals and rotation of jobs which involve close contact with the chemical. You also feel present and past workers should be checked for bladder cancer.

However, you have had very few patients with bladder cancer but a lot with lung cancer. The main cancer threat is smoking. You are very against smoking and feel smoking is a great threat to smokers and non-smokers alike. Many of the Wilsons workers smoke. Why don't the company ban smoking in the factory and canteen? It is all very well to deal with quintonal, but if it is people's health we are concerned about all steps must be taken to stop smoking.

Role card 5

Pauline/Paul Jones, company nurse

You are worried about the long-term health risk of quintonal but feel it is part of a larger health and safety problem involving use of machinery, electrical equipment and general hygiene and safety. You feel this very strongly because you *see* what can happen: you have to treat people who are injured working at Wilsons. You do not know much about quintonal itself but you feel a lot could be done by stepping up normal safety arrangements. Protective clothing (coats, goggles and gloves) is provided but often not used by workers. If safey rules were obeyed any threat from quintonal could be minimised.

You want everyone at the factory to go on a half-day health and safety training course to make sure rules are understood and followed. At least the problem of quintonal might make people take safety seriously. It is about time they did. One last point: people should bear in mind the stress and strain that workers could suffer during any period of closure of the factory.

Role card 6

Sally/Sam Green, local councillor

You represent the area in which the factory is. You are very concerned about the workers' safety but feel no rash decisions should be taken. Quintonal has been used for a number of years and there does not seem to be a lot of ill health among the workforce. Your advice is to keep working normally, with proper safety precautions, while the problem is investigated. The area cannot stand losing any more jobs. Many local families are already without a breadwinner. There is growing unemployment and poverty in the area and the closure of Wilsons would be a disaster for local people. The company's economic difficulties and the health risks of poverty must be taken into account.

Role card 7

Dr Anne/Alan Arnold, consultant industrial chemist

You are familiar with quintonal. It has been used for a number of years without its safety being questioned. People should not panic about it now. The first thing to be done is to check the American study. For example, were the animal experiments properly carried out? What is the new research? Is any other information available?

The rats were given large doses of quintonal. Workers at Wilsons only come into contact with the chemical in small quantities. Wherever possible the company should tighten the safely regulations over quintonal. However, you do not see any reason why work should halt.

No firm decision can be made until more information is available. You will make immediate enquiries to see if there is any other evidence about quintonal. You will seek expert advice about the results of the American experiments. You will be making an estimate of the risk to the workers. If you find evidence that quintonal is harmful you will ask the company to stop using it.

Role card 8

Tracey/Trevor Graham, representative of local tenants association

You do not work at Wilsons but you live just along the road. Members of your association who work at Wilsons have told you about their worries over quintonal. You want to know whether it could affect the local community. Can it get out of the factory into the community? You have contacted the local Environmental Health Office and asked them to make measurements to see if any quintonal has escaped from the factory. The results are not available yet.

Some of your members want production halted immediately until there is a guarantee that there is no danger. Other local people are concerned about the loss of jobs if the factory closes. You believe that your association will want to organize its members to protest if Wilsons does not do something quickly.

A Big Bang

Contents: A decision-making activity based on a case-study of a fire and an explosion in a warehouse.

Time: 2 periods or more, depending on number of activities attempted. Homework time could be used.

Intended use: GCSE Chemistry and Science courses. Links with work on burning, fuels and oxidation.

Aims:

- To complement work on burning, fuels, the fire triangle, and oxidation reactions
- To develop awareness of the need for safety precautions when dangerous chemicals are being stored
- To provide opportunities to develop skills involved in analysing evidence, interpreting data and communicating technical information.

Requirements: Students' worksheets No.1003. Some students may want access to a book of data or a catalogue giving more information about the chemicals referred to in the unit.

Author: David Ward

This unit is based on a real incident which happened in Salford on the 25th September 1982. The information is taken from the report by HM Factory Inspectorate. The essential details of the incident have been retained but the place and the characters' names in the students' worksheets are fictional.

Suggested use

Before reading the information, students should be aware of the decisions they have to make. These are described on page 4. The decision-making tasks are best tackled in small groups.

Background information on the incident

This information is based on the report of HM Factory Inspectorate.

1 For many years there had been a serious problem of vandalism in the area. Vandalism increased when older buildings near the site were cleared. There were many examples of fires being started deliberately in empty properties.

The inquiry held after the incident decided that the fire was started by vandals outside the warehouse. Previously the vandals may have damaged containers of flammable liquids, spilt them and mixed them with other chemicals.

There was probably a flammable atmosphere at low level in the warehouse. This allowed the fire to spread quickly to the sodium chlorate which exploded violently. Once the fire reached the east end of the building the evidence suggests that the sodium chlorate stacked on wooden pallets exploded in less than a minute.

There was not enough evidence to allow the investigators to decide on the cause of the explosions. They came up with three theories. All three theories involve the drums containing sodium chlorate. The drums were made of steel with an inner lining of polythene.

Theory 1 The explosion happened very quickly. There was only time for the outside of the metal drums to get hot. The polythene liners melted and reacted violently with the sodium chlorate. Hot sodium chlorate released oxygen which then began to react with the steel of the drums.

Theory 2 The heat of the fire burst the drums. Sodium chlorate scattered on the floor and mixed with the vapour of flammable liquids which had been spilt by the vandals.

Theory 3 The vandals mixed the chemicals and contaminated the sodium chlorate with flammable carbon compounds, making a mixture of an oxidiser with a fuel. When the fire reached this mixture and heated it there was an explosion.

2 The haulage firm was not aware of the the guidelines published by the Health and Safety Executive for the storage of both sodium chlorate and flammable liquids.

There were 35 tonnes of sodium chlorate stored in the warehouse. It was packed in steel drums lined with polythene. Stored near the sodium chlorate there were large amounts of various carbon compounds. These compounds were highly flammable. Most of them react violently with sodium chlorate.

These arrangements for storing chemicals were in breach of the regulations. Sodium chlorate should be stored away from sources of ignition either in the open air or in a fire-resistant building. It should not be stored with other chemicals, or near things which will burn such as wood. The guidelines about storing flammable liquids warn that closed containers can burst violently when heated if they contain liquids. Such liquids should also be stored either in the open air or in a separate fire-resistant storeroom.

The chemical company were happy with the service they were receiving. They assumed that the haulage company would have the necessary knowledge about the chemicals and take suitable precautions when storing them. When staff from the chemical company visited the warehouse they did not comment on the way the chemicals were stored.

Following police investigations five people were charged with burglary. Two of them were also charged with arson.

Further activities

Useful follow-up work might include bringing in a local Fire Officer, or a Health and Safety Officer from the local authority.

One trial school used a computer to produce a 'front page' mock-up for the 200-word newspaper article.

A BIG BANG

This unit is about a fire and explosion in a warehouse. The accident happened in a town in the north of England. We will call the town Norton. There were 2000 tonnes of chemicals in store at the time.

The fire and explosion was at a warehouse owned by the Norton Haulage Company. The map in Figure 1 shows you where the warehouse was. The haulage firm was storing and supplying chemicals for a company we will call HGB Chemicals.

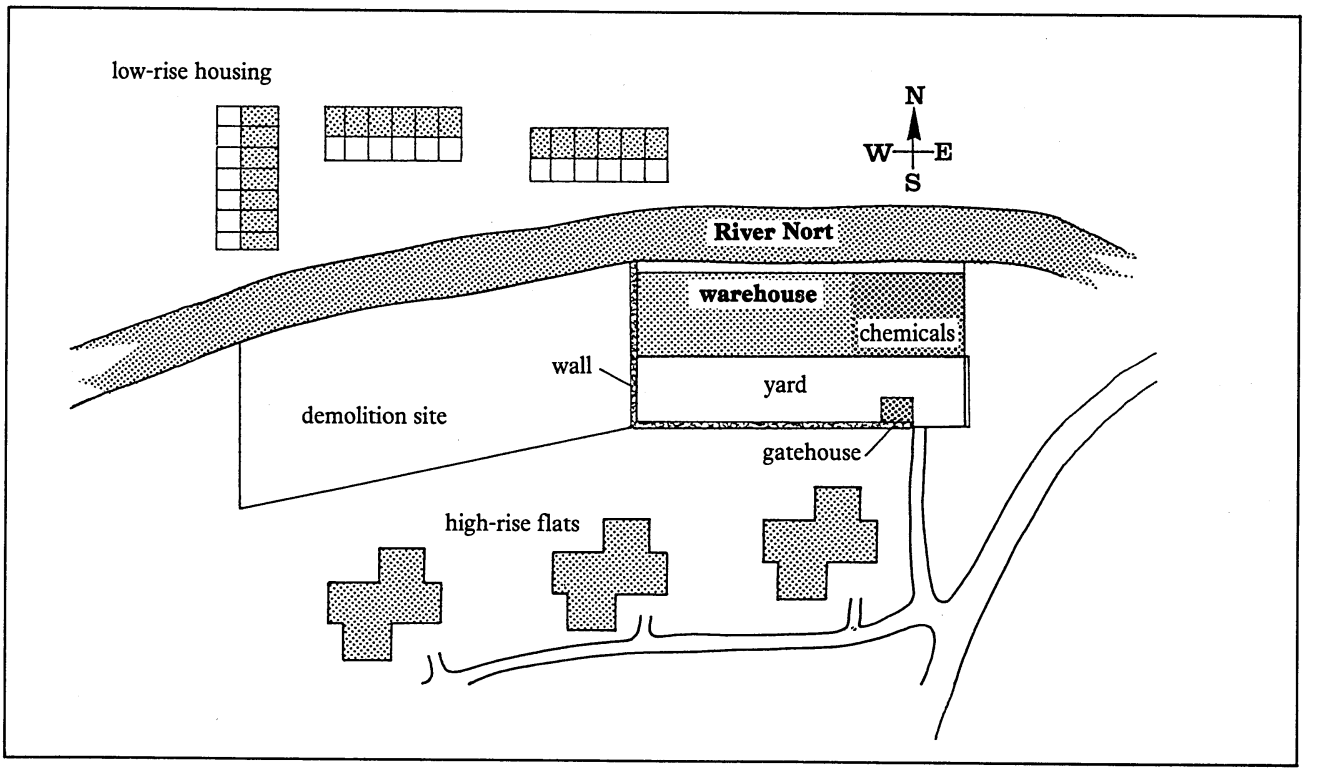

Figure 1

The explosion destroyed the warehouse. Many flats and houses nearby were damaged and several hundred people had to be evacuated from their homes.

About sixty local people went to hospital within three days of the incident. Most of them were suffering from the effects of breathing smoke and fumes. They were also suffering from shock. Nine people were treated for cuts, one for an eye injury and four for nausea and vomiting. Later about a hundred people went to the hospital complaining of chest ailments, sore throats, and the effects of fumes.

The explosion was so serious that there was an inquiry afterwards. In this unit you can read the stories from witnesses who were interviewed during the inquiry.

Your job is to try to decide what caused the fire and explosion, and who was to blame.

Summary

Time:	23.30 hours
Place:	Norton
Situation:	A warehouse near the old docks.
Incident:	A fire and explosion

Figure 2 The warehouse after the explosion

The evidence

Mr David Gray, Managing Director of Norton Haulage Company

'At the time of the explosion we had large stocks of chemicals in the warehouse. All our records were destroyed in the fire but we have managed to produce a list of the chemicals which we think were in store at the time (see Information sheet).

'All the chemicals were in bags or drums. They were stacked on wooden pallets (trays). All the chemicals were together at the east end of the warehouse.

'HGB Chemicals were quite happy with the service we gave them. Their people visited us and never commented on the way we stored the chemicals.'

Mr Winston Carter, Security Guard

'It was my job to patrol the warehouse and yard at night and weekends. We've had a lot of trouble with vandals at this warehouse. It's next to a demolition site, and the kids climb through a gap in the wall into the yard. Sometimes they manage to get into the warehouse.

'On the night of the explosion I arrived late in the afternoon as usual. In the early evening I saw some kids around the warehouse and I chased them away.

'When I'm on duty I walk round the yard at least once an hour. That night I went into the yard to look round at about 11.20. On my way back to the gatehouse I heard a noise like thunder followed by a very loud bang. I thought I was falling. I can remember turning and seeing flames shooting out of a hole in the roof of the warehouse.'

Mr Gerald Wright, local Police Officer

'We've had a lot of problems in this area since they started knocking down the old buildings. Children could get into the yard. A barrier was built to stop this but it was burnt down ten days before this incident.

'There were other fires between then and the day of the incident including one started using rubber tyres.'

Mrs Ivy Green, resident in nearby flats

'I live on the sixteenth floor. My bedroom window overlooks the warehouse. At about half past eleven I looked out of the window before going to bed. I saw smoke and flames coming from the end of the warehouse next to the demolition site — that's the west end. I went to phone the fire brigade at once.

'When I got back from the phone I saw the fire had got much bigger and I think I saw two people running away. The fire moved towards the other end of the warehouse — the east end. Suddenly there was an enormous explosion. It was followed by several more explosions.'

Mr George Douglas, officer in local fire brigade

'We received a 999 call at 11.30 pm. We were at the warehouse within three minutes. The warehouse was blazing and there were explosions from time to time. It took eight hours to get the fire under control.

'When the fire was out we inspected the warehouse. The damage was extensive. Most of the chemicals were destroyed or damaged by fire and water. We found two big holes in the floor at the east end of the warehouse. They must have been caused by explosions. We reckon the force of the biggest explosion was the equivalent of one tonne of TNT.

'The roofs and windows of nearby flats were damaged.'

Mrs Susan Foster, officer of the Health and Safety Executive

'I am a specialist on the safe storage of chemicals. The Health and Safety Executive have strict guidelines for chemical stores. Any company which keeps chemicals is obliged by law to follow our guidelines. Our rules are designed to protect workers and the public.

'Norton Haulage were not storing chemicals safely in the warehouse. They were not following our rules for safe storage.

'As far as fire risks are concerned, oxidizing agents and flammable liquids are particularly dangerous. They should always be stored apart from each other.'

You decide

1 Work in a group to try to decide what caused the fire and explosion. Your explanations should be as detailed as possible.

- **How do you think the fire started?**
  Try to think of as many ways as possible.
  Remember the fire triangle (Figure 3).
- **How did the fire spread?**
  Why do you think the fire spread so quickly once it started?
- **What caused the explosions?**
  Why do you think there was an explosion when the fire reached the area where the chemicals were stored? Which of the chemicals do you think were involved?

2 When you have a theory to explain the fire and explosion, try to decide who you think was to blame. What responsibility — if any — do you think the following people had for the fire and explosion: vandals, the security man, the managers of the haulage firm, the managers of the chemical company using the chemicals?

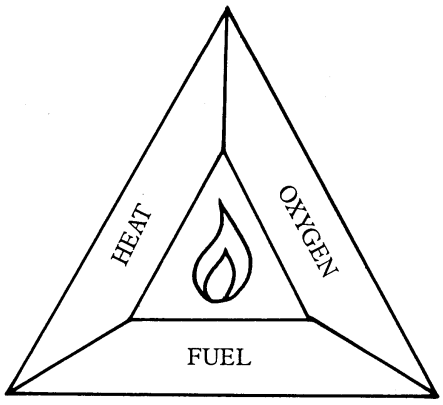

Figure 3 The Fire Triangle. The three things needed to make a fire.

Further questions and activities

1 If you were the Managing Director of HGB Chemicals, what would you do to stop this type of accident happening again?

2 What could other bodies, like the police, the fire service and the Health and Safety Executive, do to stop this type of accident happening again?

3 Write a 200-word article for the local newspaper about the incident.

List of chemicals stored in the warehouse of Norton Haulage at the time of the fire

Chemical	*Packaging*	*Total quantity*	*Properties*
Titanium dioxide	Bags	950 tonnes	A white pigment which is used to make paint. It is not flammable.
Aluminium chloride	Steel drums 275 kg in each drum	450 tonnes	A solid which will react with water to release hydrogen chloride gas. Hydrogen chloride is a choking, acid gas. Aluminium chloride and hydrogen chloride are both non-flammable.
Paradichlorobenzene (1,4-dichlorobenzene)	Sacks 50 kg in each sack	300 tonnes	A flammable solid
Orthodichlorobenzene (1,2-dichlorobenzene)	Steel drums 250 kg in each drum. Some of the drums were badly damaged and had been leaking.	120 tonnes	A colourless, flammable liquid.
Lead chromate	Bags	90 tonnes	A yellow pigment which is often used for road marking. Highly poisonous. Not flammable.
Sodium chlorate	Steel drums lined with polythene. 50 kg in each drum.	35 tonnes	A powerful oxidizing agent. It gives off oxygen when heated above 265 °C.
Xylene (dimethylbenzene)	Steel drums 1.70kg in each drum	10 tonnes	A flammable liquid which evaporates easily.