SATIS 14-16 12 Science & Technology in Society

14-16

SATIS 12

Science & Technology in Society

SATIS

About SATIS

Science and Technology in Society (SATIS) is a project of the Association for Science Education, funded by charity and by industry.

This new publication forms part of the revision and extension of the SATIS project for students in the 14 to 16 age range. It is a set of ten resource units linking major science topics to important social and technological applications and issues. Each unit usually takes one to two hours to complete.

SATIS units are intended to support science courses. Many have found wider application within the school curriculum.

There are now twelve books of ten units. Each unit is numbered in a system giving the number of the book followed by the number of the unit within it. Thus the first unit in the first SATIS book is numbered 101 and the last in the twelfth book is 1210.

The revision and extension of the original SATIS Project has been made possible by a generous grant from the Gatsby Charitable Foundation and by the people from schools, universities, industry and the professions who volunteered to write, develop and trial it.

SATIS 12

List of activities in this book

First Published 1991 by the Association for Science Education.

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

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Material for students aged 14 to 16 (or 17)

SATIS units

Copyright-waived material for photocopying

SATIS 1 to 7	(published 1986)
SATIS 8 to 10	(published 1988)
SATIS 11 and 12	(published 1991)
General Guide for Teachers	(published 1986)

SATIS Audiovisual

Tape-slide programmes

1 *Acid from the air* – a programme about acid rain
2 *More wheat for better bread* – a programme about the impact of science and technology on agriculture
3 *More and more people* – a programme about human population growth
4 *Dams, people and the environment* – a programme about the environmental effects of dams
5 *Radiation around us* – a programme about low-level radiation
6 *Bridges* – a programme about the design and construction of bridges

SATIS topics 14–16

Audio tapes

A series of 24 topics, each lasting 7 minutes or so, which were originally broadcast by BBC Schools Radio in 1989–90. They were devised to support and enhance SATIS printed material. These programmes are now available on C-60 audio cassettes from the ASE.

109	Nuclear Power
206	Test-tube Babies
207	The Story of Fritz Haber
302	Living with Kidney Failure
304	A Medicine to Control Bilharzia
307	Chemicals from Salt
309	Microbes make Human Insulin
402	DDT and Malaria
406	Blindness
407	Noise
409	Dam Problems
502	The Coal Mine Project
504	How Safe is Your Car?
601	Electricity on Demand
602	The Limestone Inquiry
603	The Heart Pacemaker
607	Scale and Scum
801	The Water Pollution Mystery
802	Hypothermia
806	Stress
807	Radiation – how much do you get?
903	What are the Sounds of Music?
907	Your Stars – revelation or reassurance?
1010	Can it be done? Should it be done?

Teachers' programme

The SATIS Atlas *(publication 1992)*

The SATIS Atlas comprises a set of copyright-waived maps giving information and data linked to the science curriculum with associated questions for students to answer.

SATIS materials are available from

ASE Booksales,
The Association for Science Education,
College Lane, Hatfield, Herts AL10 9AA
Tel. 0707 267411 Fax 0707 266532

List of units in the SATIS 14–16 series

Science National Curriculum attainment targets

The following list suggests how SATIS units may be linked with the attainment targets of the Science National Curriculum. Many units link with several attainment targets. The brackets indicate links with only a minor part of that unit.

AT 1	*Exploration of science*	110 201 205 208 209 210 405 505 509 606 706 709 801 807 809 904 907 910 1001 1004 1007 1008 1009 1101 1103 1104 1105ab 1106 1110 1201 1203 1205 1208
AT 2	*The variety of life*	102 201 (208) 210 304 402 404 505 (703) 906 1004 1009 1201
AT 3	*Processes of life*	102 104 108 110 (201) 203 206 208 302 (304) 309 401 402 503 506 508 509 603 606 (608) (609) 703 707 802 (803) 805 806 901 909 1002 (1005) 1101 1204 1210
AT 4	*Genetics and evolution*	309 807 901 (1004) (1103) 1202 1204
AT 5	*Human influences on the Earth*	301 304 308 310 401 402 404 409 410 502 602 605 (607) 708 801 803 902 1001 1103 1106 1201 1203 1210
AT 6	*Types and uses of materials*	101 (405) 408 410 506 604 (910) 1104 1106
AT 7	*Making new materials*	102 103 105 207 (305) 307 310 405 502 505 510 604 (607) 709 810 (904) 1001 1003 1004 1103 1106 1204
AT 8	*Explaining how materials behave*	(109) 204 205 (305) 608 807 808 (1004) 1105ab
AT 9	*Earth and atmosphere*	(602) 1107 1205 1206
AT 10	*Forces*	501 504 705 (708) 809 (1006) (1009)
AT 11	*Electricity and magnetism*	701 704 804 908 1007 1008 (1101) 1108 1109 1208
AT 12	*IT and microelectronics*	306 507 (603) 610 905 906 (1101) 1102 1108 1109 1208
AT 13	*Energy*	106 107 109 201 202 303 308 403 409 502 504 508 702 704 705 (706) 802 807 808 809 908 (1006) (1101) 1109
AT 14	*Sound and music*	407 705 903 1102
AT 15	*Using light and electromagnetic radiation*	209 303 306 406 (704) 1207
AT 16	*The Earth in space*	1209
AT 17	*The nature of science*	207 305 (306) 309 509 510 609 805 (810) (901) 907 1108 1202 1204 1208

Subject areas

The following are units with strong links to specific subject areas.

Biology	102 104 108 110 201 203 204 206 208 209 210 301 302 304 305 308 309 401 402 404 406 407 409 503 506 508 509 606 609 703 707 801 802 803 805 806 901 902 906 909 1002 1004 1005 1006 1009 1010 1101 1102 1103 1104 1105a 1201 1202 1204
Chemistry	101 103 105 110 203 204 205 207 210 301 305 307 308 310 401 402 404 405 408 410 502 505 506 510 602 604 607 702 706 709 801 810 902 904 910 1001 1002 1003 1004 1010 1103 1104 1106 1203 1204 1210
Physics	106 107 109 202 204 205 209 303 306 308 403 404 407 501 504 507 508 601 603 608 610 701 702 704 705 706 708 802 803 804 807 808 809 903 905 907 908 1006 1007 1008 1009 1010 1101 1102 1105ab 1106 1108 1109 1207 1208 1209
Geography	106 107 109 110 208 301 304 403 404 409 502 505 602 604 605 708 901 902 1001 1105a 1107 1109 1203 1205 1206
Sixth-form General Studies	102 104 105 106 107 108 109 110 203 204 206 207 208 301 302 308 309 404 405 407 409 502 503 507 508 509 605 607 608 610 703 802 803 806 807 808 901 902 905 906 907 908 909 910 1002 1003 1005 1010 1101 1105a 1109 1110 1202
Technology	102 103 104 106 107 108 201 202 205 208 303 305 306 308 404 405 407 410 501 503 506 507 603 605 610 707 708 802 803 905 906 1006 1010 1101 1103 1106 1110

Cross-curricular themes

Many SATIS units include cross-curricular themes. This list is for general guidance only and was compiled before National Curriculum Council publications were available.

Health Education	102 104 108 203 204 206 208 209 302 304 305 309 401 402 404 406 407 503 506 508 509 603 606 608 609 703 707 708 709 802 803 805 806 807 901 904 909 910 1002 1005 1007 1010 1002 1005 1007 1010 1101 1102 1104 1105a 1202 1210
Environment	101 107 108 201 202 210 301 307 308 402 404 407 409 410 502 505 508 602 605 703 801 803 902 1001 1010 1103 1106 1201 1203 1205 1206
Careers	507 610 905
Citizenship	104 109 203 206 207 302 406 407 409 502 503 504 507 508 602 605 607 608 705 807 905 1002 1003 1005 1106
Economic and Industrial Understanding (listed as 'Economic Awareness' in the text)	102 103 105 106 202 208 210 302 307 310 403 408 503 604 605 610 701 703 704 709 904 905 908 1001 1004 1010 1001 1004 1010 1103 1106 1201 1204 1210

AGROCHEMICALS and the ENVIRONMENT

Science content
Agriculture, fertiliser, fungicide, organic farming.

Science curriculum links
AT 1 Exploration of science
AT 2 The variety of life

Syllabus links
- GCSE Science, Biology

Cross-curricular themes
- Environment
- Economic Awareness

Lesson time
1–2 hours
(homework possible)

Links with other SATIS materials
110 Hilltop
210 The Pesticide Problem
505 Making Fertilizers
703 Vegetarianism

SATIS Audiovisual
More Wheat for Better Bread

NERIS
Search on
AGRICULTURAL CHEMICALS and AGRICULTURE
Or on
FERTILISERS and AGRICULTURE

SUMMARY

A look at the economic and environmental implications of the use of fertilisers and fungicide for growing wheat and the possibilities of organic farming.

STUDENT ACTIVITIES

- ☐ Information and questions about the benefits and problems caused by the use of nitrogen fertiliser and fungicide.
- ☐ Translation of data into graphical form: fertiliser application and yield.
- ☐ Data handling: profit and yield.
- ☐ Questions for small group discussion: organic farming.

AIMS

- ☐ To link with work on environmental issues concerning agriculture
- ☐ To introduce students to the economics of intensive farming and to the balance of profit against environmental considerations

USING AND ADAPTING THE UNIT

- ☐ Worksheets are provided for Q4, Q7 and Q8 (graphs 1 and 2 and table 3).
- ☐ Weaker students may need support with part B. The figures to complete table 3 may be given to students who find the mathematics a stumbling block.
- ☐ Parts A and B are suitable for independent work or for homework.
- ☐ Students could be asked to calculate the figures in tables 2 and 3 with a spreadsheet.
- ☐ For part C, groups of students could be asked to tackle different questions, reporting their answers to the class.
- ☐ Designing an advertisement (optional) may be a group or individual activity.

Author **Rachel Young**

First published 1991

Teaching notes

The unit provides a range of activities from which teachers can select those most appropriate to their students. If all parts (A, B and C) are used, they should be done in sequence.

The SATIS Audiovisual (a tape-slide presentation), *More Wheat for Better Bread*, deals with intensive farming technology – plant breeding, fertilisers, pesticides, herbicides, fungicides, growth regulators and agricultural machinery. The sound commentary contains a great deal of information. Teachers may prefer to select slides from the pack and use the commentary script themselves, unless they have particularly able students. Alternatively, each group of students may be given a few slides and a copy of the printed commentary and asked to give their version of the commentary as the slides are shown.

Discussion questions

1 Suggestions may include the ideas that organic crops are somehow better for your health, do not contain toxic residues of fungicides and insecticides, that organic farming practices help to conserve the environment, or ideas based on a romantic perception of the countryside.

2 Answer about £140 per tonne. (You might accept lower profits for environmental benefits.)

This figure assumes that the farmer would want the same profit margin as he gets for inorganic wheat (using agrochemicals), that is, **£194 per hectare**. (Graph 2 shows this is the maximum profit margin, obtained at a fertiliser rate of 200 kg / ha.)

The yield without fungicide and fertiliser is 4.6 tonnes per hectare. He spends nothing on agrochemicals, but his standing costs remain at £465 per hectare.

Substituting into the formula

$$\pounds 194 = ([4.6 \text{ tonne / ha}] \times \text{price}) - (\pounds 0 + \pounds 465)$$

$$\text{Price} = (\pounds 194 + \pounds 465) / 4.6 \text{ tonne}$$

$$= \pounds 143 / \text{tonne}.$$

3 As a source of organic nitrogen the farmer could use farmyard manure, compost, sewage sludge, etc.

The problems with organic nitrogen sources include: transportation, higher cost, variable composition, storage and disease.

4 Fertilisers and agrochemicals linger in the soil. At present there is no legal definition of 'organically grown food', but food grown two years after the last application of agrochemicals is a definition that many accept. The United Kingdom Register of Organic Food Standards (UKROFS) defines a national set of organic standards, a code of production practice and a symbol.

Farmers tend to convert their farms a field at a time, continuing to sell inorganically grown crops from the rest of the farm.

5 There would need to be considerable improvement in organic farming yields to produce enough food at a reasonable price. Perhaps advances in organic farming may come through the genetic engineering of disease-resistant strains of wheat which need less fertiliser.

Acknowledgements

Dr Nigel Paul of the University of Lancaster assisted the author with the preparation of this unit.

C. E. Flint, Director of the Association for Agriculture, read and commented on the draft of this unit.

Figure 1 is reproduced by permission of Martin Dohrn, Science Photo Library.

Answers to the questions

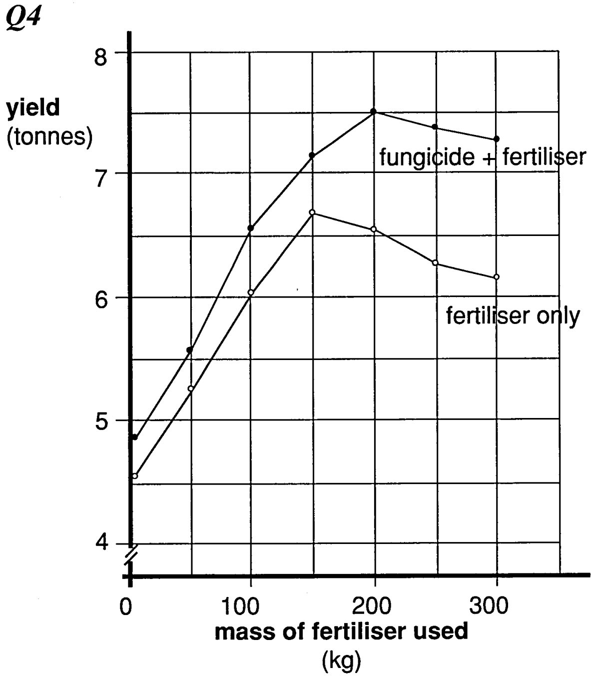
Q1 *Today's high yields are due to improved varieties of wheat which have the genetic potential to produce a high yield when combined with the use of agrochemicals and fertilisers.*

Q2 *Fertiliser promotes plant growth. Closer contact between plants facilitates the spread of disease.*

Q3 *(a) Nitrates can pollute ground water, rivers and streams.*

(b) Fungicides can be toxic to wildlife and may have harmful effects on humans.

Q4



All figures given are per hectare. Teachers may prefer their students to draw smooth curves.

(a) 4.6 tonnes / hectare.

(b) The effect of disease can be measured from the difference between the two graph lines (assuming fungicides kill all disease).

(c) The mass of fertiliser needed to give the highest yield (i) is 150 up to 170kg / ha (ii) with fungicide is about 200 kg / ha.

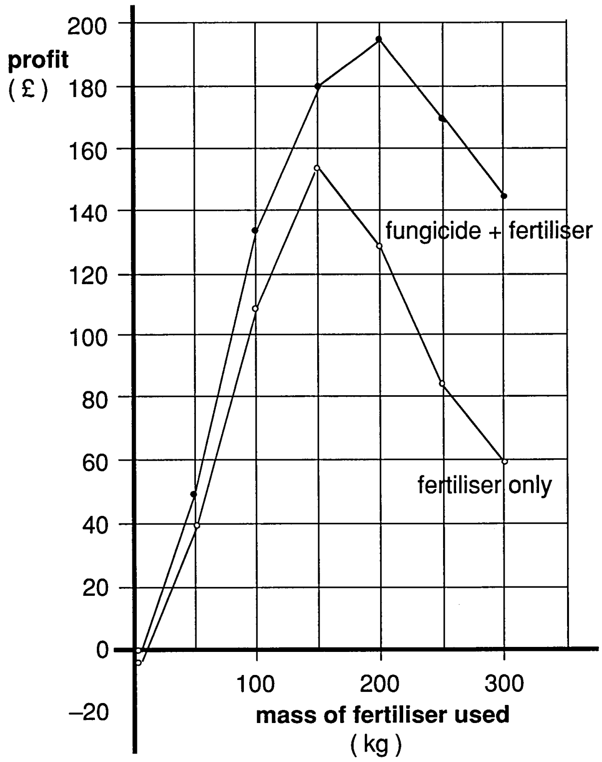
(d) (i) (7.5 – 4.6) kg / ha = 2.9 kg / ha

(ii) (2.9/4.6 × 100)% = 63 %

Q5 *A loss of £5 per hectare.*

Q6 *£59*

Q7 *About 150 kg / ha.*



All figures given are per hectare.

Q8 *Column 2 Total cost of applying fertiliser per hectare (at 30 p / kg and £6 / ha to apply) and fungicide (£25 / ha) is £25, £46, £61, £76, £91, £106, £121.*

Column 4 The total costs are 490, 511, 526, 541, 556, 571, 586.

Column 6 The value of the wheat (income) in £ is 490, 560, 660, 720, 750, 740, 730.

Column 7 The farmer's profit per hectare when using both fertiliser and fungicide together is £0, £49, £134, £179, £194, £169, £144.

(a) Fertiliser with fungicide is more profitable.

(b) 170 kg/ha.

Q9 *In a low disease year, the farmer would not have any fungicide costs. The lower graph line would move towards the upper graph line and give a similar profit margin to high disease years when fungicide is used. The farmer could avoid spraying with fungicide until a high disease year was predicted, but he is taking a risk.*

AGROCHEMICALS and the ENVIRONMENT

Part A – More and more wheat

Wheat harvests only dreamed of 25 years ago are now a regular event. New varieties of crops give high yields, especially when grown with the use of **fertilisers** and **agrochemicals**. Such farming is called **intensive farming.**

Farmers use fertilisers and agrochemicals like fungicides to improve the quality and quantity of their crops. But these chemicals have disadvantages – they are expensive to apply and can escape into the environment.

In this unit you will look at the effect of nitrogen fertiliser and fungicide on the yield of wheat and consider a few of the difficult decisions that farmers face.

Part A Information, questions and graphical work about agrochemicals.

Part B Data handling and graphical work about the economics of intensive farming.

Part C Discussion questions on organic farming. Designing an advertisement for an organic loaf.

Figure 1 Modern arable farming produces high yields of wheat

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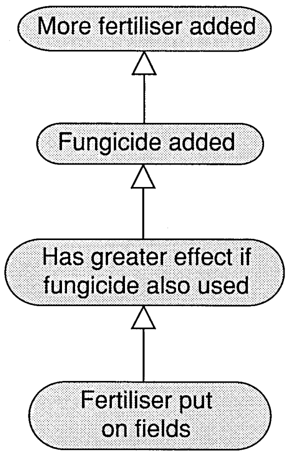


Figure 2 High yields depend on the use of both nitrogen fertiliser and fungicide

Fertiliser and fungicide – the advantages

Plants need nitrogen to grow. Applying nitrogen fertiliser to a crop like wheat makes it grow more. The closer together plants grow, the greater is the contact between them. If disease is present, it is able to spread more quickly. In fact diseases may spread so much that yields of crops go down.

Fungicide kills the fungi that damage crops. Fungal diseases of cereal crops, such as yellow rust and powdery mildew, increase greatly when farmers apply nitrogen fertiliser. To protect their crops, farmers spray with fungicide and usually apply extra nitrogen fertiliser as well.

Fertilisers and fungicides – the disadvantages

Both fertiliser and fungicide affect the environment. Ploughing the ground allows nitrates from nitrogen fertilisers and manure to drain away (leach) into the soil, polluting ground water, rivers and streams. In areas of intensive crop farming, water taken up for human use may have dangerously high levels of nitrates.

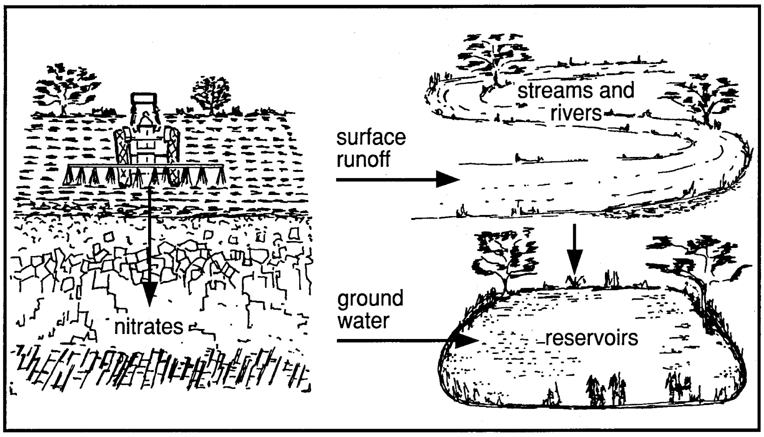


Figure 3 How nitrates from fertilisers can enter the water supply

> *Q1 Why have yields of wheat increased in recent years?*
>
> *Q2 Explain why fungal diseases in crops may increase when the farmer applies fertiliser.*
>
> *Q3 What are the undesirable effects of using too much*
> *(a) nitrogen fertiliser,*
> *(b) fungicide?*

Agrochemicals, which include fungicides, insecticides, weed-killers and growth regulators, can be toxic to wildlife and pass into the food chain. There may be dangerous side-effects for humans as well.

Fertilisers and agrochemicals need to be applied correctly. There is concern that their over-use can change the structure of the soil and reduce its fertility.

Making a living off the land

The yields of wheat the farmer can expect from applying fertiliser or both fertiliser and fungicide are shown in table 1.

Table 1 How the yield of wheat per hectare varies with the use of fertiliser or fertiliser and fungicide. (These figures are for a year with high levels of fungal disease.)

Mass of fertiliser used (kg)	**Yield** (tonnes)	
	fertiliser only	fungicide + fertiliser
0	4.6	4.9
50	5.25	5.6
100	6.1	6.6
150	6.7	7.2
200	6.6	7.5
250	6.3	7.4
300	6.2	7.3

Q4 Plot graphs of the data in table 1, showing how the yield of wheat varies with the use of (i) fertiliser only and (ii) fertiliser with fungicide.

Label both graphs clearly.

The fertiliser graph is shown below.

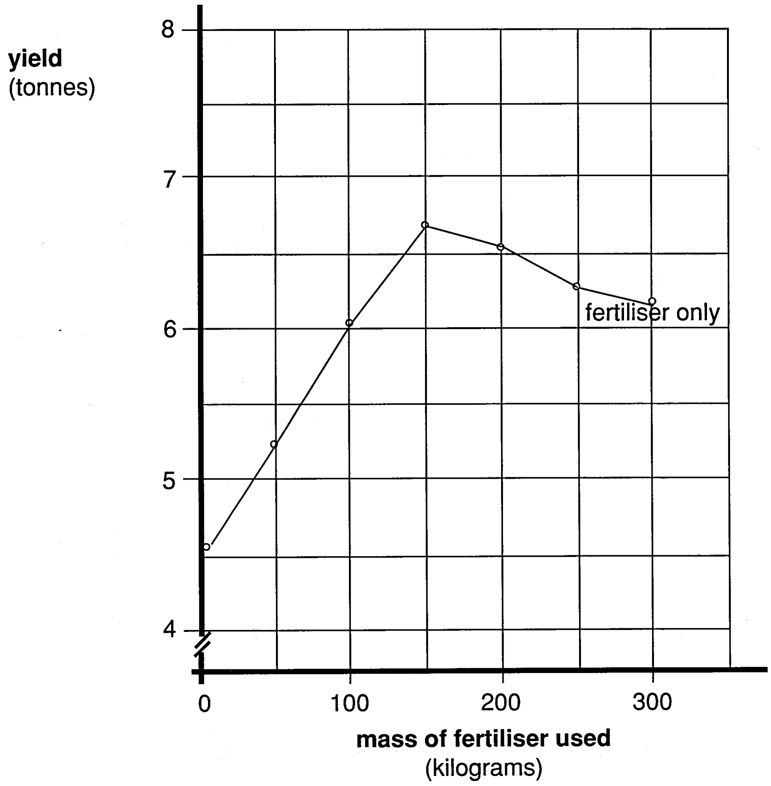
(a) What yield can farmers expect if they use no fertiliser or fungicide?

(b) How does the effect of disease show up on the two curves?

(c) How much fertiliser must farmers use to get the highest yield, if they use (i) fertiliser only, (ii) fertiliser and fungicide together?

(d) (i) How many more tonnes per hectare can the farmer get by using fertiliser and fungicide compared with using neither? (ii) What percentage increase in yield is this?

Graph 1 How the yield of wheat per hectare varies with the mass of fertiliser used. (You may prefer to interpret it as a smooth curve.)



An outline of this graph is available on a worksheet.

Fertilisers and fungicides are expensive. If farmers could make the same *profit* using less chemicals, they would be able to reduce the environmental problems caused by their use.

Farming costs

INCOME
Selling price of wheat
= **£100 per tonne.**

EXPENDITURE
Fixed costs
= **£465 per hectare**

Variable costs:
Nitrogen fertiliser
= **30p per kilogram** to buy
= **£6 per hectare** to apply

Fungicide (including the cost of applying it)
= **£25 per hectare**

Part B – High yields, high profits?

A wheat farmer's profit depends on

(a) **income** from selling the crop. This depends on the mass of wheat produced and its market price.

(b) **expenditure** which is of two types. The **fixed** costs include *labour, machinery, rent, rates, repairs, insurance etc.* The **variable** costs include the cost of *fertilisers and fungicides.*

$$\text{PROFIT} = \underbrace{(\text{yield} \times \text{wheat price})}_{\text{INCOME}} - \underbrace{\left(\text{variable costs} + \text{fixed costs}\right)}_{\text{EXPENDITURE}}$$

Table 2 How a farmer's profit varies with the mass of nitrogen fertiliser used. All figures are per hectare; no fungicide

Mass of fertiliser used (kg)	Variable costs (£)	Fixed costs (£)	Total costs (£)	Yield from table 1 (tonnes)	Value of wheat (£)	Profit (£)
0	0	465	465	4.6	460	–5
50	21	465	486	5.25	525	39
100	36	465	501	6.1	610	109
150	51	465	516	6.7	670	154
200	66	465	531	6.6	660	129
250	81	465	546	6.3	630	84
300	96	465	561	6.2	620	?

Example calculation

When the farmer uses 250 kg fertiliser per hectare and no fungicide:

Fixed costs = £465

Variable costs (the cost of fertiliser and applying it)
= (£0.30 × 250) + £6
= £81

Total expenditure
= £465 + £81
= £546

His profit
= (6.3 tonne × £100) – (£81 + £465)
= £630 – £546
= £84

Q5 *What does a 'profit' of '–£5' mean to a farmer?*

Q6 *Work out the farmer's profit using 300 kg of fertiliser per hectare.*

Q7 *Plot a graph (graph 2) showing how the farmer's profit depends on the mass of fertiliser used.*

Find from the graph how much fertiliser the farmer needs to use to get the highest profit margin.

Using fungicide with fertiliser produces slightly higher yields of crop, but does it produce more profit for the farmer?

Table 3 How the farmer's profit varies with the mass of fertiliser used with fungicide at £25 per hectare

Outlines of table 3 and graph 2 are available on a worksheet.

Mass of fertiliser used with fungicide (kg)	**Variable costs** (£)	**Fixed costs** (£)	**Total costs** (£)	**Yield** from table 1 (tonnes)	**Value of wheat** (£)	**Profit** (£)
0	25	465	490	4.9	490	0
50	46	465		5.6	560	49
100		465	526	6.6		
150	76	465		7.2		179
200		465		7.5		
250	106	465		7.4		169
300		465		7.3		

Q8 *Calculate the figures missing from table 3.*

Plot a graph to show how the profit varies when using fertiliser with fungicide. Plot it on the same graph as you used for Q7 so that you can compare both curves.
(a) Which is more profitable – using fertiliser alone, or using fertiliser with fungicide?
(b) Suppose fertiliser starts to leach into the ground when the farmer uses more than 170 kg per hectare. How much fertiliser would you recommend the farmer uses?

Q9 *Mild winters and wet summers increase the amount of fungus like yellow rust in crops. The figures given are for a year in which disease levels were high.*
(a) Could a farmer make more profit in low disease years? Explain how.
(b) It is difficult to forecast whether disease levels will be high in any year. Do you think a farmer should spray with fungicide regardless of whether it is likely to be a high disease year or not? Explain your answer.

Part C – Do we need agrochemicals?

'Organic farming' is the term now used to describe growing crops without manufactured fertilisers or agrochemicals. No weedkillers, fungicides, pesticides or growth regulators are used. Organic methods produce lower yields and crops may be blemished by insects or disease.

Organic fruit and vegetables sell at higher prices. At present, the market for organic food is small, but for the few farmers who practise it, organic farming can be a profitable business.

Organising the discussion

- Work in small groups.
- Appoint somebody to chair the group and to report back to the class if required.
- Note down the answers you decide on.

Questions for discussion

1 Suggest why people are prepared to pay more for organically grown crops. Do you think they are better? Would your family pay more for an organic loaf of bread?

2 Organically grown wheat can be sold for a higher price than wheat grown with agrochemicals.

If inorganic wheat fetches £100 per tonne, what would be a reasonable price for organically grown wheat? Justify your answer.

3 Suggest what sources of organic nitrogen a farmer could use to increase his yield of organic wheat.

4 Suppose a farmer decides to change over to organic farming after using intensive farming methods for many years. How long after the last application of fertiliser and agrochemicals to a field, would you describe a crop grown on it as organic?

Suggest how farmers could try to stay in business while they convert to organic farming.

5 Do you think that farmers should change to organic farming methods?

6 Are there any organic farmers near you?

Activity

Design an advertisement for an organic loaf of bread.

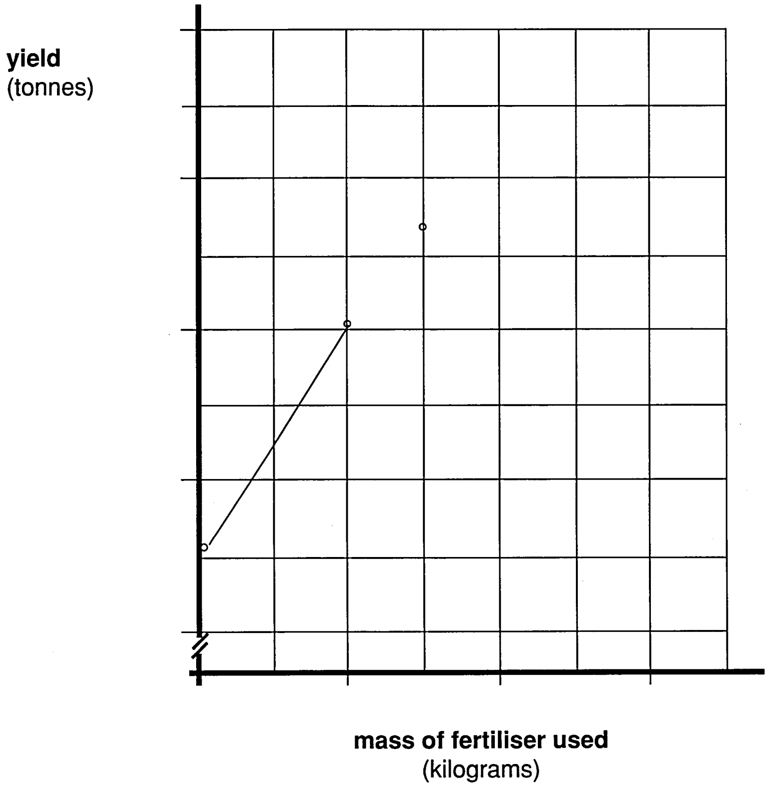
Answers to the questions are given in the *Teachers' Notes.*

Name ______________________________

Question Q4

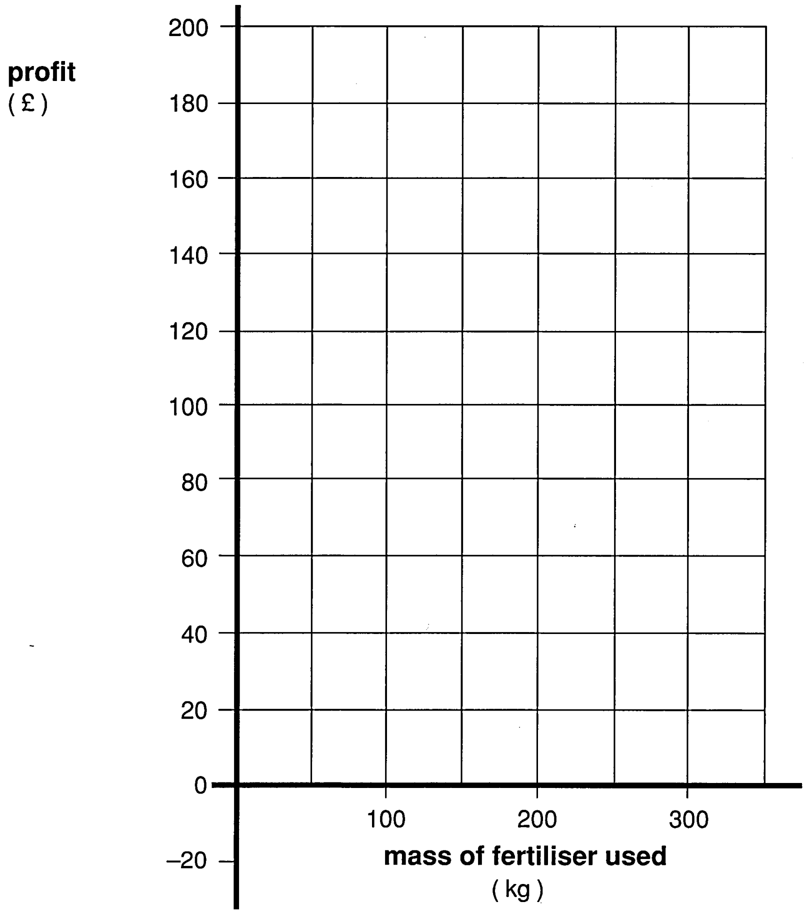
Graph 1 How the yield of wheat per hectare ______________________
(complete the title)

____



Question Q7 and Q8

Graph 2 How the farmer's profit margin per hectare depends on the mass of fertiliser used



Question Q8
Table 3 Fertiliser used with fungicide: how the farmer's profit varies with the mass of fertiliser

Mass of fertiliser used with fungicide (kg)	Variable costs (£)	Fixed costs (£)	Total costs (£)	Yield from table 1 (tonnes)	Value of wheat (£)	Profit (£)
0	25	465	490	4.9	490	0
50	46	465	.....	5.6	560	49
100	.....	465	526	6.6	.....	.....
150	76	465	.....	7.2	.....	179
200	.....	465	.....	7.5	.....	.....
250	106	465	.....	7.4	.....	169
300	.....	465	.....	7.3	.....	.....

Mapping the Human Genome

Science content

Inheritance, genes, genetic diseases, DNA, bases, genetic engineering.

Science curriculum links

AT4 Genetics and evolution
AT17 The nature of science

Syllabus links

- GCSE Science, Biology

Cross-curricular themes

- Health Education

Lesson time

1–1½ hours
(including homework)

Links with other SATIS materials

309 Microbes Make Human Insulin
609 Hitting the Target
1204 From Babylon to Biotechnology

NERIS

Search on
DNA and UPPER SECONDARY
or on
GENES and UPPER SECONDARY

SUMMARY

The unit describes the aims and complexity of the Human Genome Project, the costs and timescale and possible benefits to society. Students are asked to consider some of the project's moral implications.

STUDENT ACTIVITIES

- ☐ Reading, answering questions and making a glossary.
- ☐ Small group discussion of the moral implications.

AIMS

- ☐ To link with work on heredity
- ☐ To provide an understanding of an important scientific endeavour requiring unprecedented international cooperation
- ☐ To show students a developing area of science whose progress they may follow during subsequent years
- ☐ To provide a forum for discussion of the moral and ethical implications of this research

USING AND ADAPTING THE UNIT

- ☐ The unit draws together many of the concepts of genetics and is thus more appropriate for students towards the end of their GCSE work.
- ☐ The reading activities are suitable for independent study and may be done for homework.
- ☐ The discussion activities provide students with an opportunity to reflect on, share and evaluate their opinions. These questions may best be tackled in small groups with time afterwards for groups to share their thoughts with the class. The issues involved may impinge upon sensitive family matters and need sympathetic handling.

OTHER RESOURCES

- ☐ The progress of the Human Genome Project is often reported in the *New Scientist* magazine.

Author **John Holman**

First published 1991

Answers to the questions

The information in brackets, [....], is not given in the text.

Q1 *Base, gene, chromosome, cell.*

Q2 *Finding the sequence of bases and positions of genes in the human genome.*

Q3 *3000 million bases*

(a) at 1980 prices (£5 per base) = $£1.5 \times 10^{10}$ *or £15,000 million*

(b) at 1990 prices (£1 per base) = $£3 \times 10^{9}$ *or £3,000 million*

(c) using automatic machines (£0.10 per base) = $£3 \times 10^{8}$ *or £300 million*

Q4 *Colds, sore throats and measles are diseases which you catch when infected by bacteria or viruses. Haemophilia and Huntingdon's chorea are hereditary diseases which are passed from parent to child in the genes.*

Q5 ***Genes** are responsible for inherited characteristics. They form parts of the DNA in cells. [Each gene is responsible for the production of one protein.]*

***A defective gene** may give rise to a hereditary disease. [It is one which has an error in the groups of atoms, or in the sequence of bases of which it is composed.]*

***Characteristics** are the features like eye colour, height, etc., which distinguish one individual from another.*

***Chromosomes** contain the genes. [They can be seen when the cell divides. Humans have 46 chromosomes arranged in 23 pairs.]*

***DNA** (deoxyribonucleic acid) is a polymer molecule [with two helical strands linked by the four base-pairs. Its structure allows it to make faithful copies of itself.]*

***Human genome** is the sequence of genes that gives a human being its characteristics.*

***Sequencing** is finding the order of the bases and also the location of each gene on the DNA.*

***Mapping the human genome** – the result of sequencing: finding the detailed structure of human DNA.*

***Moral implications** – distinguishing between the good and bad outcomes of this research.*

Discussion questions

Here are some possible answers.

1 **a** C; **b** B; **c** A; **d** B; **e** C; **f** C; **g** A.

2 Not much – the similarities between human genes will be much greater than any differences.

3 This is very much a matter of opinion. However, insurance companies might ask for the information as part of an insurance agreement (as they do regarding the risk of AIDS) or offer lower premiums to those who provide the information.

4 Personal opinions.

5 Personal opinions.

6
- How financial profits from this research may be distributed.
- Who should be allowed access to an individual's genome map.
- How society should decide and regulate the uses to which genome information is put.
- Whether individuals should have their genome sequenced at birth.
- Whether doctors should be able to withhold genome information from individuals.
- What developments will and will not become possible once the human genome has been mapped.
- How to prevent this information being used immorally – for example, breeding a submissive class of servants.

Acknowledgements

Sir Walter Bodmer, FRS, of The Imperial Cancer Research Fund read and commented on the draft of this unit.

Figure 3 by permission of The Lawrence Berkeley Laboratory, Human Genome Center.

Figures 2, 4 and on page 5 by Joyce Curtis.

Mapping the Human Genome

Project HUGO

This unit contains reading, questions and material for group discussion.

John is a haemophiliac. If he cuts himself, he will bleed to death unless he is given special treatment. He has haemophilia: his blood cannot clot.

John inherited haemophilia from his mother. She passed on a defective gene that stopped his blood clotting.

Imagine if doctors had known exactly what was wrong with the defective gene. Then they would have been had a much better chance of treating John's haemophilia successfully.

That's just one of the dreams of the scientists on Project HUGO – the Human Genome Project.

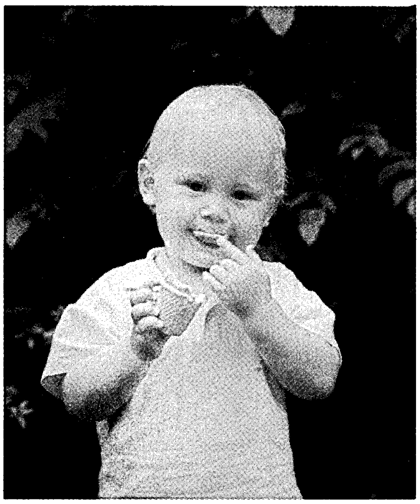
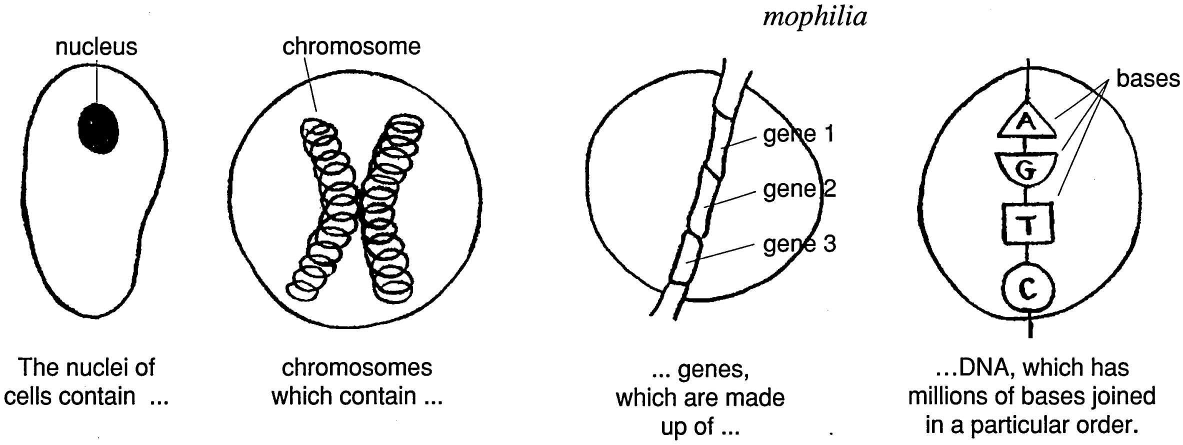


Figure 1 John suffers from haemophilia

What are they trying to do?

The goal of the HUGO project is to draw an exact map of all the genes that make up a human. Figure 2 shows what this means.

Figure 2



You get your characteristics – eye colour, height, features and so on – from your parents. You inherit **chromosomes**; 23 from your mother and 23 from your father. The chromosomes carry genes, and each gene decides a particular characteristic. So there are genes for eye colour, hair colour and so on. You have your own set of up to 100 000 genes with copies in every cell.

Genes and chromosomes are made of a chemical called **DNA** (deoxyribonucleic acid). DNA is a polymer, and it's made of parts called nucleotides which carry four different **bases** joined together in a particular order. The bases make up a code – the genetic code which decides your characteristics.

Q1 *Arrange the following in order of size:*
- *a gene,*
- *a base,*
- *a human chromosome,*
- *a human cell.*

If you joined together all the genes in a human being end to end you would make a string of 3000 million bases. This is the **human genome**. It is so long that if you printed it the result would fill 200 large telephone books. The molecule itself would be two metres long if you stretched it out.

At the moment we can't print out all the bases in the right order. That's what HUGO is about – *to find the exact order, or sequence, of all the bases that make up the human genome.* Finding out the order of bases is called **sequencing**. But it doesn't simply mean finding the sequence of bases. It also means finding where each gene is, and the sequence of bases in each gene.

It's like finding the recipe for a complete human being.

How are they doing it?

Scientists already know how to map parts of the human genome. In fact, some of the work has been done already. Several million bases of human DNA have been mapped – but that still leaves 99.9 per cent to do! If scientists continued working on the problem at this rate, it would take them 500 years.

However, the aim of HUGO is to complete the map by the year 2005. That means an enormous research effort by thousands of scientists. HUGO is too big to be done in a single laboratory. It will involve dozens of laboratories all around the world.

Basically, the method is to chop up the DNA into short pieces using special enzymes. Then the bits are pieced together to make the full sequence, like doing an enormous jigsaw puzzle. The problem is, the jigsaw has several thousand million pieces! Just keeping track of it all is a huge job, involving enormous computer systems (figure 3).

The scientists will spend much of the first five years developing their sequencing technology and finding out where each gene is. They will practise on simpler organisms like yeast, worms and mice. As they improve their skills and technology they will become quicker and more accurate at sequencing DNA.

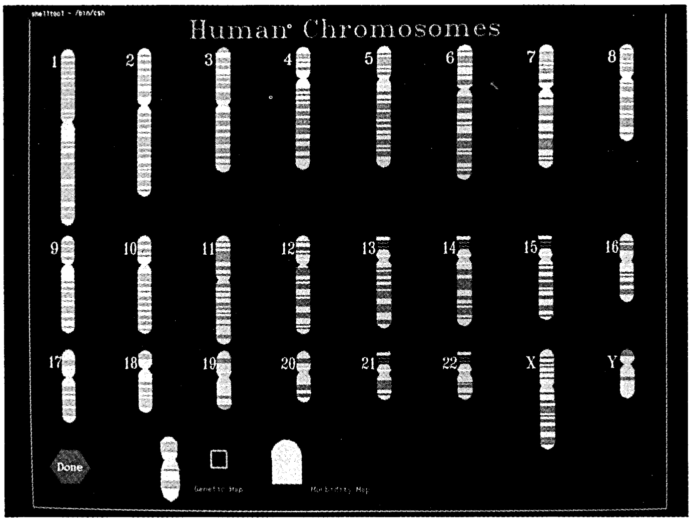
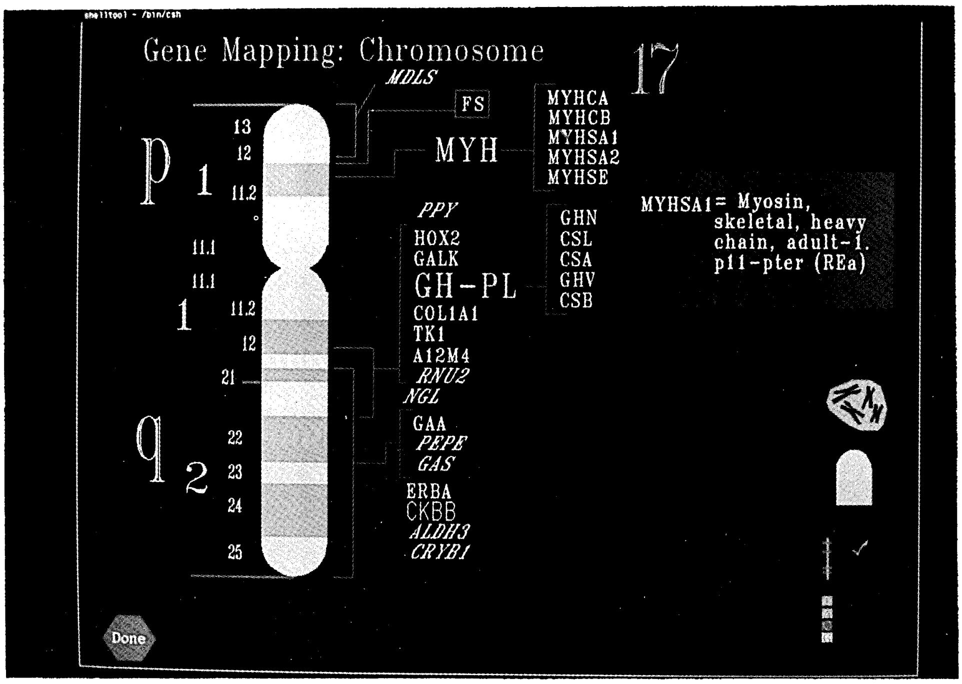
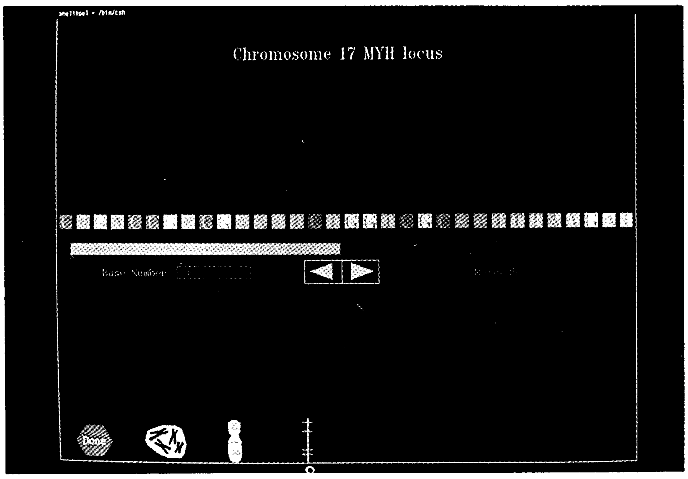


Figure 3 Scientists working on the human genome project are developing computer workstations so that they can share information.





The pictures show how a scientist is able to home in on a particular chromosome.

And the cost?

The project will be enormously expensive. In 1980 the cost of finding the sequence of a fragment of DNA was about £5 per base. So a fragment of DNA 100 bases long cost £500 to sequence. There are 3000 million bases in the human genome. You can see it's an expensive business!

Fortunately, as scientists do more of this work, they get better at it. They can do it quicker – and more cheaply. In 1990, the cost was under £1 per base – and scientists are developing automatic machines that can do it for about £0.10 per base.

Q2 What is Project HUGO is trying to achieve?

Q3 What would be the cost of mapping the human genome
(a) at 1980 prices,
(b) at 1990 prices,
(c) using automatic machines?

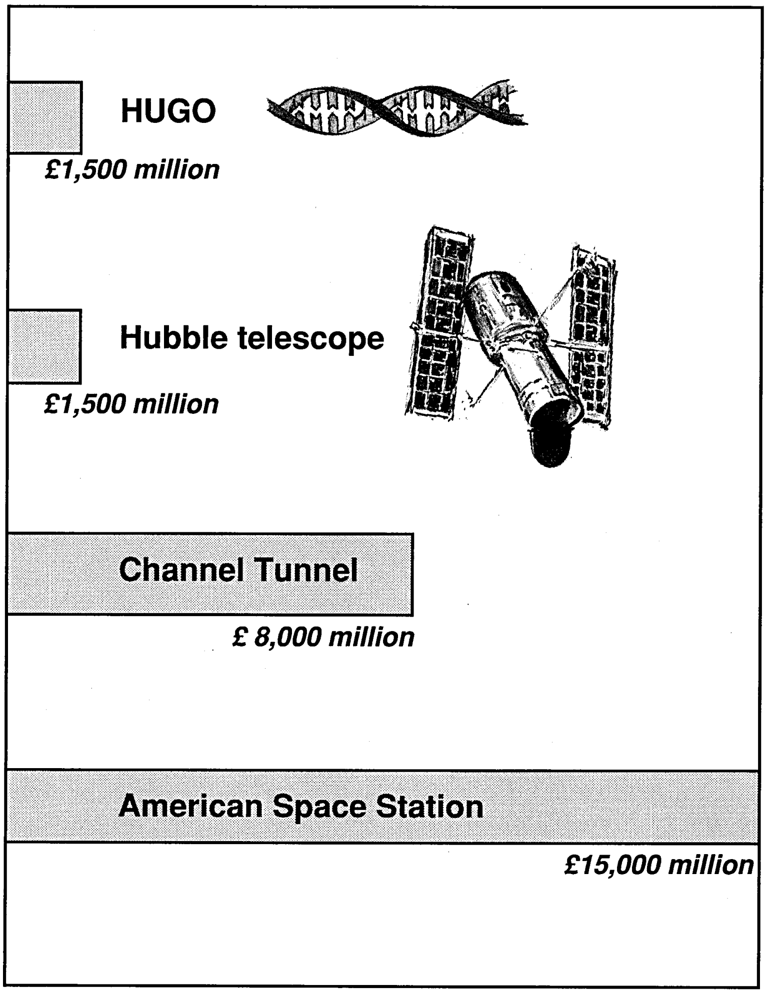


Figure 4 The costs of large research projects for comparison

The HUGO project is expected to cost about £1,500 million altogether. Figure 4 shows how this compares with the cost of other big projects. It sounds expensive, but it's actually only about one twentieth of the annual cost of the National Health Service.

What does the money buy?

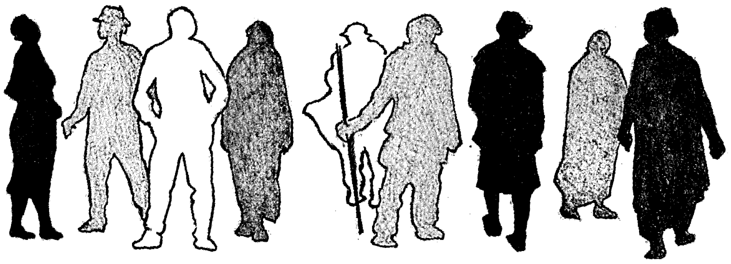
A map of the human genome could be the key to curing hundreds of genetic diseases like haemophilia and Huntingdon's chorea – where the patient suffers mental deterioration and early death.

Many common diseases like heart disease, mental disease and arthritis have a genetic link, so that people who inherit a particular gene may be more likely to suffer from the disease. Mapping the genome would make it possible to investigate this. And most scientists agree that the key to cancer is an understanding of the human genome.

And there are many other possibilities. What if parents who were short wanted a tall child? What if parents wanted to produce a child that would become the fastest sprinter or the greatest leader? If scientists knew what all the genes did, they might be able to grant parent their wishes . . . at a price.

Some time in the future, it might be possible for everybody to have their own genome mapped at birth – or before. This would be a plan for a copy of that person. Think of the implications of *that*. You will be able to think of many other possibilities – and you can discuss them later.

The scientists who are organising the human genome project are very concerned about its moral implications. They have decided to set up groups to discuss the issues, such as the way genetic information about people could be misused.



The moral implications

Why are people concerned about the moral implications of mapping the human genome?

Once you have mapped the genome, you have the complete plan for a person. You could change it . . . . You might be able to design human beings to order.

That possibility is a long way off. But right now there are tricky problems to sort out. For example, suppose doctors discover that a patient has a gene which makes it more likely he will get heart disease. Who should be given the information? You can see there are some tricky things to decide.

Q4 From what you know of diseases like colds, sore throats and measles, explain how they are different from diseases mentioned in the unit – haemophilia and Huntingdon's chorea.

Q5 New ideas and discoveries need new words to describe them.
Look at how these words and phrases are used in the unit

- *gene*
- *defective gene*
- *characteristics*
- *chromosomes*
- *DNA*
- *human genome*
- *sequencing*
- *mapping the human genome*
- *moral implications.*

Make a glossary of the terms above – that is an alphabetical list of words or phrases with their definitions or explanations. You could add more scientific words used in the unit.

(You may find it useful to use a dictionary or any reference books you may have to hand.)

> **Organising the discussion**
> - Work in a small group.
> - Appoint someone to chair the group and to report back to the class if required.

Some questions to discuss

1 Here is a list of suggestions for things that *might* become possible if we had a full map of the human genome.

- **a** Making people live forever
- **b** Making sure your children are born intelligent
- **c** Curing genetic diseases like haemophilia
- **d** Curing AIDS
- **e** Making it possible for humans to fly (without help)
- **f** Making it possible to live without food
- **g** Finding out if a person is particularly likely to develop arthritis

Say whether each one

- ***A*** *almost certainly could be done,*
- ***B*** *possibly could be done,*
- ***C*** *definitely could not be done.*

2 Would it matter which particular person's genes the scientists chose to map for the HUGO project?

3 Suppose doctors discover that a patient has a gene that makes heart disease more likely. Who should be told?

- a The patient.
- b The patient's close relatives.
- c The patient's employer.
- d The patient's insurance company.

4 Suppose that, some time in the future, you are the parent of a new baby. And that by then every individual can have their own genome mapped at birth.

(a) Would you have your child's genome mapped?

(b) Who should be allowed to see and use that map? What might happen if it got into the wrong hands?

5 If genome mapping becomes available, would you want to see your partner's genome map before you planned to have a child?

6 Scientists are investigating the moral implications of mapping the human genome. List five questions you would want them to consider.

Answers to the questions are given in the *Teacher's Notes.*

Prospecting by Chemistry

Science content

Minerals, iron, mineral prospecting, chemical analysis.

Science curriculum links

AT 1 Exploration of science
AT 5 Human influences on the Earth
AT 7 Making new materials

Syllabus links

- GCSE Science, Chemistry
- Geography
- Geology

Cross-curricular themes

- Environment

Lesson time

1 hour
plus homework and follow-up

Links with other SATIS materials

110 Hilltop
604 Metals as Resources
1001 Chocolate Chip Mining

NERIS

Search on METALLIFEROUS MATERIALS

SUMMARY

Chemical analysis of water samples for iron is used in a simulated geochemical exploration for iron ore. The results are followed-up by a map-work plotting exercise and discussion.

STUDENT ACTIVITIES

Part A Reading introductory information, discussing answers to the questions.

Part B Experimental investigation, writing a report.

Part C Data handling and interpretation.

Part D Questions for discussion.

AIMS

- ☐ To recognise the application of chemical analysis to mineral prospecting (for iron)
- ☐ To plan, carry out and report on an investigation
- ☐ To use maps in a problem-solving exercise
- ☐ To consider some of the social and economic implications of mineral extraction

USE

- ☐ The laboratory investigation may be used to follow or simulate fieldwork. The unit is 'self-contained'. Students need to be able to follow the instructions for the simple testing procedure. Some may need initial guidance. The investigation is suitable for use in practical assessment.
- ☐ Parts A and B or part C may be used independently.

REQUIREMENTS

- ☐ Each student will need copies of pages 1 to 4 stapled together *to read*, with separate copies of the report form and map of Baldwin's Brook *to write on*. The map and report form may be printed back to back.
- ☐ Each pair or group of students will need the apparatus and materials for the practical investigation (listed overleaf).

Author **John Collins**

First published 1991

Teaching notes

The unit illustrates how geochemists can detect the presence of certain minerals in the rocks by the analysis of stream water. Although it is possible to prospect for iron in this way, it is not currently being carried out in Britain. Most prospecting activity in Britain is for gold.

Britain had a large iron ore mining industry from the eighteenth century until the 1960s, when it was replaced by imports.

The practical investigation (which is suitable for use in practical assessment) is best carried out in pairs or in small groups.

Apparatus and materials required for each pair of students:

- five test tubes
- one test-tube rack
- two 5 cm^3 graduated teat pipettes / syringes / pipettes
- potassium thiocyanate (or ammonium thiocyanate) solution
- five water samples made up as described

The following quantities are suitable for ten groups of students.

1 Make up 250 cm^3 of 0.2 M iron (III) nitrate solution. (Dissolve 20.2 g of $Fe(NO_3)_3.9H_2O$ in 250 cm^3 of distilled water.) This will be pale yellow in colour and should be decolourised using 5–10 cm^3 of concentrated nitric acid.

2 Dilute this solution (*measuring cylinder accuracy is sufficient*) to produce the following samples:

0.2 M solution – label as sample D
0.1 M solution – label as sample B
0.05 M solution – label as sample A
0.025 M solution – label as sample E
Distilled water – label as sample C

100 cm^3 of each of these samples is sufficient for all ten groups, each group only requiring 5 cm^3 of each sample to test.

3 Make up 300 cm^3 of 0.002 M potassium thiocyanate (or ammonium thiocyanate) solution. (This strength is equivalent to 0.152 g/l of NH_4CNS and 0.194 g/l KCNS.) Each group will require 30 cm^3 of this solution.

Part A

A specimen of an iron ore such as hematite (Fe_2O_3) would be useful, but not essential.

Students may not realise that 'iron' can be dissolved in water as Fe^{3+} or Fe^{2+} ions. They could be reminded about rust and rusty water and the fact that domestic water supplies may be discoloured by iron. The water seen draining from bogs and marshes is often discoloured with iron since the iron becomes naturally concentrated under the stagnant, acid conditions found there. It may be useful to compare a water sample with rusty water to show students that they will be trying to detect very small quantities of iron.

Part B

The investigation involves students testing five water samples for the presence of iron to determine qualitatively the amount of iron in each sample. The samples will give a range of colours from red/orange to yellow. This is a very sensitive reaction for iron (III) ions.

Results The students should find that samples A, B, D and E contain iron, and that sample C contains no iron. They should also find that the decreasing order of iron content is D, B, A, E.

(Students may ask to test tap water for iron. If this is done, it will be helpful to discuss the importance of this type of investigation to water authorities, etc.)

The *report form* may be used for writing up the investigation, or, students could write a full report using a word processor.

The report might include the following:

A summary of the investigation

Conclusions Sample D from Baldwin's Brook contained the highest amount of iron, so it is in this area that there is likely to be a source of iron.

Suggested action Carry out a more detailed study of the area of Baldwin's Brook with suggestions such as:

(a) collect water samples from all the small streams in the Baldwin's Brook catchment area.

(b) collect stream sediment samples.

(c) collect soil samples.

(d) carry out geophysical work on magnetism (to identify magnetic deposits of minerals), gravity surveys (to identify deposits that conduct electricity) or a seismic survey of the area (to identify density changes underground).

(e) examine the exposed rocks of the area.

(f) examine the unexposed rocks by drilling, trenching or by digging pits.

(g) test any iron-rich mineral deposits found for the amount of iron they contain.

(h) investigate, the area, volume and value of any iron-rich mineral deposits found.

(i) investigate any problems associated with mining or quarrying the deposit, such as removing unwanted soil and rock, access to the area, the facilities necessary to recover the iron from the ore, transport distances to the nearest facilities and to the nearest market, conservation, reclamation, views of the local farmers and inhabitants, and so on.

Part C

Data from a more detailed study of Baldwin's Brook is provided. Students are asked to produce an iron 'concentration' map. They will need to decide how to indicate iron concentration. Colour coding or using bars of different length are possibilities.

Part D

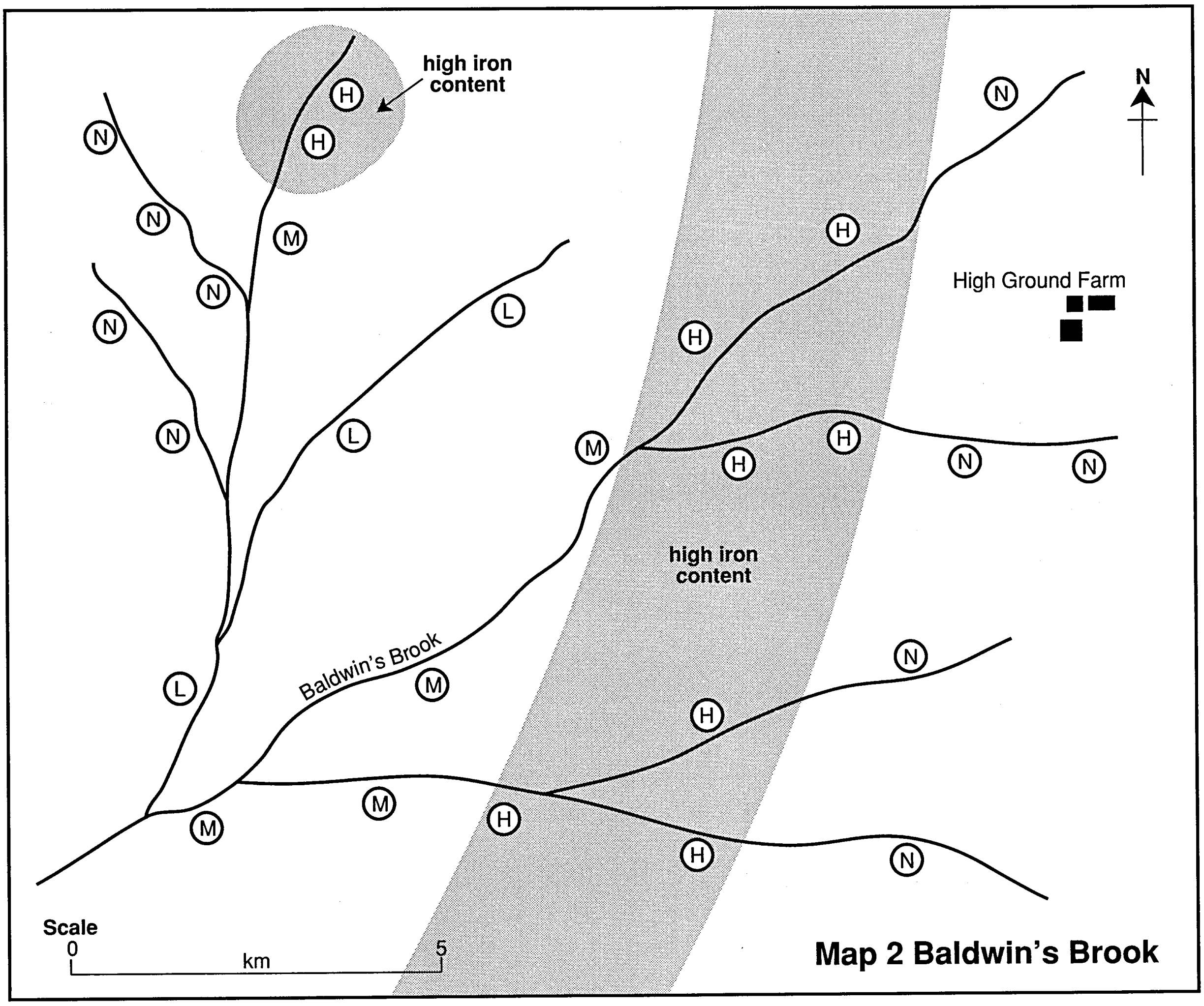
Provides an opportunity to review the scope of geochemical prospecting. Students are asked to use their prior knowledge to consider the social and economic implications of mineral extraction.

Acknowledgements

The original text for this unit was provided by the Earth Science Teachers' Association.

Tim Colman of the British Geological Survey read and commented on the draft of this unit.

Figure 1 reproduced by permission of GSF.



Map 2 Baldwin's Brook

Answers to the questions

A1 *galena – lead sulphide*
gypsum – calcium sulphate
calcite – calcium carbonate
rock salt – sodium chloride
sulphur – sulphur
zinc blende – zinc sulphide

A2 *Rust-coloured stains in streams, rust-coloured rocks and known iron-bearing rock formations, unusual magnetometer readings, satellite imaging systems, all can detect iron.*

A3 *Upstream. (Assume gold-bearing rock upstream has been eroded and the gold transported by the stream.)*

A4 *Streams with a high concentration of dissolved iron would have passed over iron-bearing rocks.*

B1

Water sample	Colour	Iron content
A	yellow	L
B	orange	M
C	none	N
D	orange/red	H
E	pale yellow	L

B2 *D*

B3 *Yes, C*

B4 *E*

B5 *To prevent cross-contamination.*

B6 *Fair test – to keep the concentration of the iron testing solution the same after mixing.*

C1 *See map on Teachers' notes page 3.*

C2 *Ditto*

C3 *(a) 2*
(b) 1 km radius = 3 km^2 approx.
3.5 km wide = 50 km^2 approx. Pointing south towards the mine.
(c) Downstream - water is diluted by that from other streams
(d) No

C4 *Suggestions (d) to (i) from 'Suggested action' in part B.*

D1 *No. Magnetometer probably best (or suggestions (a) to (i) of Teachers' notes pages 2 and 3).*

D2 *It is only applicable for minerals which have some solubility in water e.g. zinc, copper and uranium. (Chromium and nickel are found in sewer water – derived from electroplating works and not from natural sources.)*

D3 *Suggestions may include:*
(a) Destruction of scenic environment, disturbance by trucks or trains transporting the mineral, noise from blasting, dust, etc.
(b) High profitability through increased price for ore, difficulty in importing ore (war?), etc.

Prospecting by Chemistry

Part A – What's it all about?

Prospecting for minerals

You are going to take the part of a geochemist working for the British Geological Survey.

The British Geological Survey provides advice to the Government, industry and the public. It gathers information on all aspects of geology by doing scientific surveys. The team you work with is prospecting for minerals.

Prospecting means looking or exploring. In this unit your team will be prospecting for minerals containing iron.

A **mineral** is a chemical element or compound which occurs *naturally* in the Earth's crust. It has a definite chemical composition and is often found as crystals. For example, hematite (Fe_2O_3) is a mineral from which the metal iron is obtained. Rocks containing valuable amounts of minerals are called **ores**.

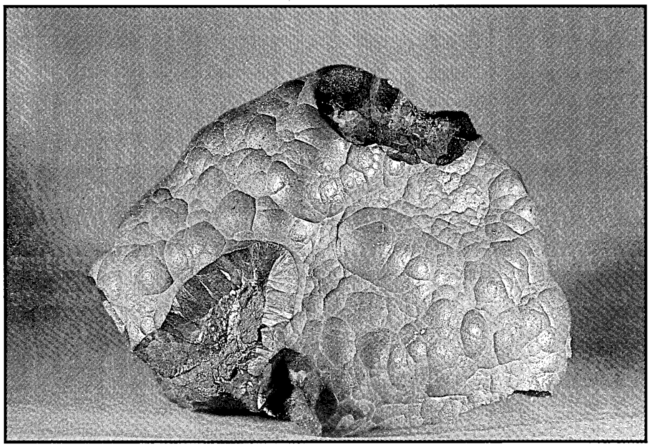


Figure 1 Hematite is a mineral containing iron

The prospector's problem

Minerals are usually found in very small amounts. Occasionally, you can find quantities large enough to be worth digging out of the ground.

Minerals are mined in many areas of Britain. The prospector's problem is to find *new* areas with deposits of minerals worth digging up.

Prospectors often look at areas where mining has been carried out in the past. They hope to find minerals which miners have missed before. Or minerals may have been left in the ground because they were too difficult to extract. As prices rise it may become worthwhile mining lower grade ores with less mineral content.

Part A introduces prospecting for minerals.

Part B is a practical investigation using a chemical test for iron.

Part C is a data-handling exercise.

Part D is a class discussion (optional).

A1 Here are the names of some minerals:

galena, gypsum, calcite, rock salt, sulphur and zinc blende.

These are their chemical names but not in the same order:

calcium carbonate, calcium sulphate, lead sulphide, sulphur, sodium chloride, zinc sulphide.

(a) Match the names to the minerals.
(b) Which mineral is an element?

A2 What clues might a geologist look for when prospecting for minerals containing iron?

A3 If you found grains of gold in a stream bed where would you look for more, up-stream or downstream?

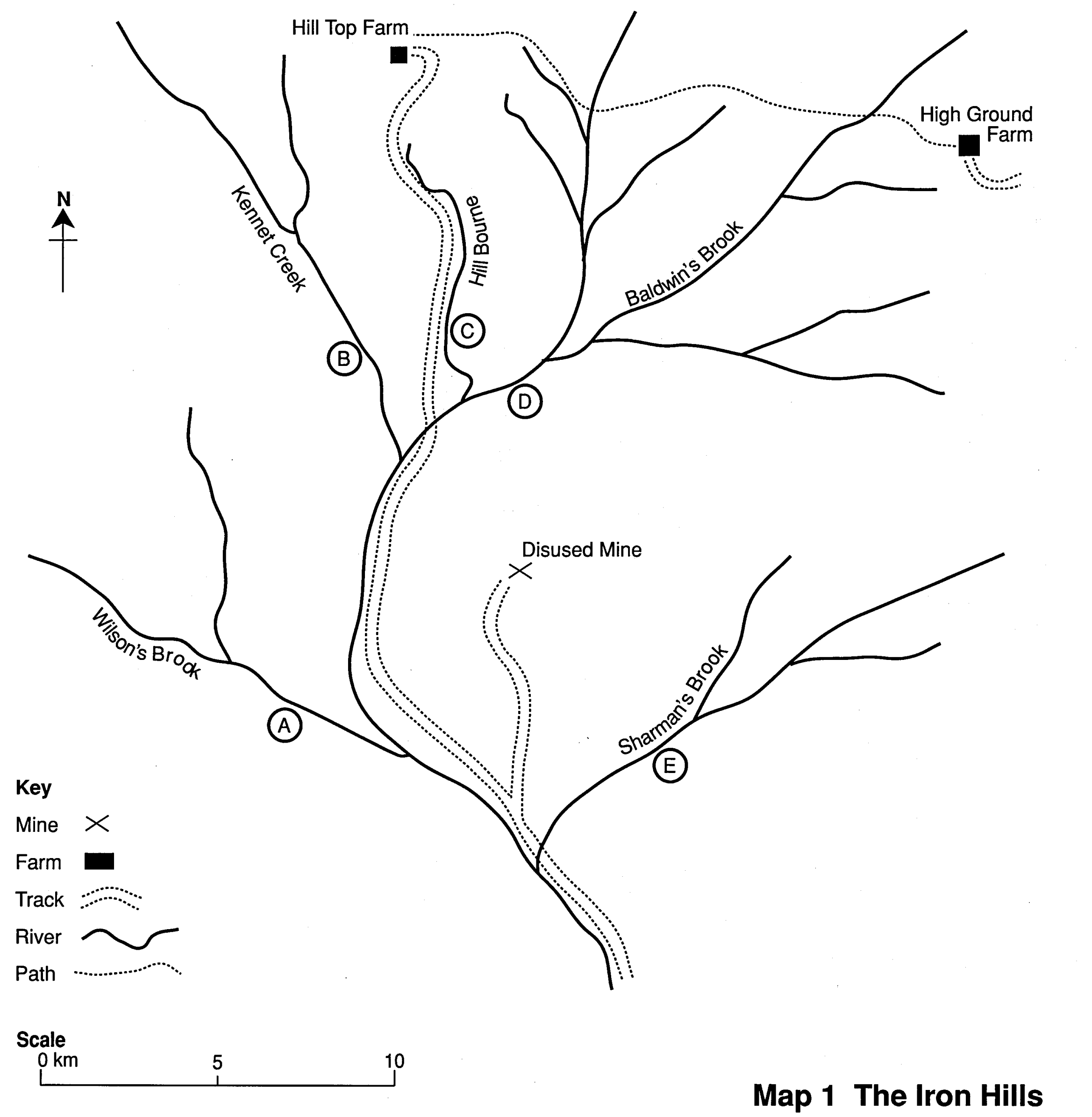
A4 How might a study of water in the streams help to find iron in the Iron Hills?

The task – prospecting in the Iron Hills

The team has been asked to investigate the *Iron Hills*. (See **Map 1**.) It is an area where iron ore was mined in the past. Mining stopped when no more could be found. Using new methods the team may be able to find sources of iron that were not discovered before.

The Iron Hills cover a large area. Much of it is woodland. There are few places where you can see bare rocks. Several streams flow through the area and streams can give clues about the rocks they pass over.

The team will investigate the streams first. Your task is to look for compounds of iron dissolved in the water. If the tests show large amounts of iron, you may advise the team to carry out further exploration of the area.



Map 1 The Iron Hills

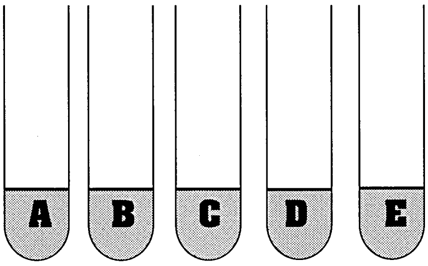
Part B – Testing water samples for iron

You have taken samples of water, **A, B, C, D** and **E** from five streams in the Iron Hills. The samples were taken at the points shown on **Map 1.**

You will need to find out if any of these samples has iron dissolved in it.

The test described on this page can detect iron in water. *Try it on sample A first.*

Repeat this test with the other water samples, B, C, D and E. Use a clean test tube each time.



B1 *Make a table of your results with headings:*
Water sample Colour Iron content
Use it to answer questions B2 to B6.

B2 *Which stream had the highest iron content?*

B3 *Did any stream contain no iron at all?*

B4 *Which stream contained iron in the smallest detectable quantity?*

B5 *Suggest why you were advised to rinse the pipette with distilled water.*

B6 *Explain why you had to use the same volumes of each water sample and iron-testing solution each time.*

Test for iron

Eye protection must be worn.

1. Add 5 cm^3 of the water sample to a test tube with a pipette or syringe.
2. Rinse this pipette with distilled water immediately after use.
3. Using a second pipette, add 5cm^3 of the iron-testing solution to the test tube in the same way.
4. Rinse the pipette.
5. If iron is present the colour will change. The colour you get depends on the iron content in the sample, as follows:

Colour	Iron content	
colourless	No iron	(N)
yellow	Low iron	(L)
orange	Moderate iron	(M)
orange/red	High iron	(H)

Reporting your findings

You will need to report on your findings to your boss at the British Geological Survey.

You may do it on a **report form** or write a more detailed report on paper. You should include
(a) a summary of your investigation,
(b) the conclusions you have come to,
(c) what the next course of action should be.

Part C – The follow-up

As a result of your exploration of the Iron Hills area another geologist did a follow-up investigation of Baldwin's Brook.

The geologist took water samples from the sites shown on **Map 2**. These were analysed for iron, and the results are shown in the table.

Table 1 Results of the follow-up survey

Sample number of	Iron content
1	L
2	N
3	N
4	N
5	N
6	N
7	M
8	H
9	H
10	L
11	L
12	M
13	M
14	H
15	H
16	N
17	H
18	H
19	N
20	N
21	M
22	M
23	H
24	H
25	N
26	H
27	N

Key to iron content

H = high
M = moderate
L = low
N = none

C1 *Plot the data from table 1 on a copy of Map 2 using colours. Decide how you are going to represent different iron contents.*

C2 *Carefully draw lines on the map to outline the areas of high iron content. Shade these areas lightly. Add a key to your map.*

C3 *Describe the pattern shown by the map.*
(a) How many areas are high *in iron content?*
(b) Roughly, what are the sizes and shapes of the areas of high iron content? Can they be related to the disused mine?
(c) Where are the areas of medium *iron content – upstream or downstream of the high iron content areas? Why does this happen?*

C4 *Suggest further investigations that could now be carried out in this area.*

Part D – Questions for discussion

D1 If deposits of iron ore are buried well below the surface, would you be able to detect them with the technique used in this unit? What other methods may be used for prospecting?

D2 Suggest the names of two other metals which you might look for using chemical tests on stream water.

D3 Imagine that a new deposit of iron ore is discovered around the town of Tunbridge Wells in Kent, south of London. The area is well-populated but most of the ore is under scenic countryside. The ore which is of good quality would be expensive to mine.

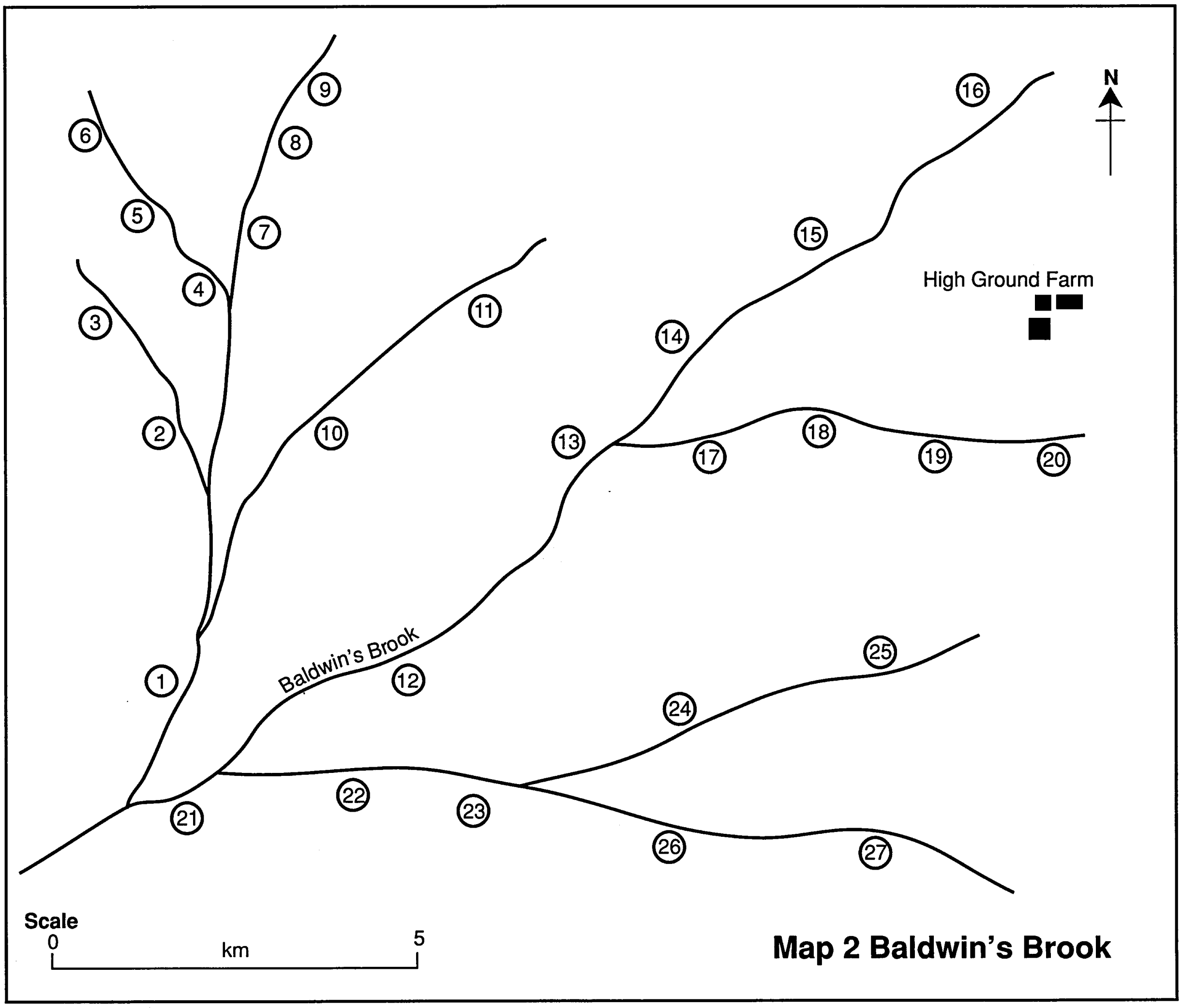
(a) Suggest what objections local people might raise against mining in their area.

(b) In what circumstances might mining go ahead?

Answers to the questions are given in the *Teachers' Notes.*

Part C

Follow-up study of Baldwin's Brook area



Signed ....

BRITISH GEOLOGICAL SURVEY

CHEMICAL ANALYSIS REPORT

From ....Senior Geochemist

Date......................

To: F E Isenberg, Head of Mineral Prospecting.

Summary of Investigation: **Iron Hills area**

Conclusions

Suggested Action

Signed ....