14-16

SATIS 11

Science & Technology in Society

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.

List of units in this book

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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

Breast or Bottle?

Science content

Nutrition and health, microbes and disease, electrical circuits, thermostatic control.

Science curriculum links
AT1 Exploration of science
AT3 Processes of life
AT11 Electricity and magnetism
AT12 IT including microelectronics
AT13 Energy

Syllabus links
- GCSE Science, Biology, Physics
- Sixth-form General Studies
- Technology

Cross-curricular themes
- Health Education

Lesson time
1 hour or more
(depending on parts done)

Links with other SATIS materials
104 What's in our Food?
910 Disposable Nappies

NERIS
Search on
BREAST FEEDING
or on MILK and HEALTH EDUCATION

SUMMARY

This unit deals with the nutritional aspects of breast and bottle feeding in Great Britain and the developing world. A design brief enables students to explore the possibilities of thermostatic control.

STUDENT ACTIVITIES

☐ **Part A Why milk?**
Reading and answering questions, producing a comparative table, data handling, research and discussion, role-play situations.

☐ **Part B Bottle feeding in the developing world**
Devising a short play, writing a story for children, discussion.

☐ **Part C Design a baby's bottle warmer**
A design brief: 12 V circuits, measurement of volume/mass and temperature rise, simple thermostatic control.

AIMS

☐ To raise awareness and promote discussion of the nutritional aspects of breast and bottle feeding

☐ To provide opportunities for developing graphical communication and role-play skills with mini role-play activities

☐ To provide design opportunities within the context of infant nutrition

USING AND ADAPTING THE UNIT

☐ This unit links with work on health and nutrition and on child care. Part C links with work on control and the heating effect of a current.

☐ The unit may be adapted for a range of abilities by selecting appropriate parts and activities.

APPARATUS REQUIREMENTS FOR PART C

If work is linked to current electricity: 12 V a.c./d.c. power supplies (which cannot deliver more than 12 V), immersion heaters or nichrome wire, connectors, bimetal strips, thermometers (0–100 °C), use of beakers/cans/calorimeters, measuring cylinders (0–250 ml); if linked to work on microelectronics: components for control circuits including thermistor and relay will also be needed.

Author **Ann Fullick**
Part C **Stephen Marsh**
Drawings **Joyce Curtis**

First published 1991

Notes

Teachers need to select appropriate activities from this unit. (Some activities overlap and it is not intended that students should do them all.)

Questions Q1 to Q7 are designed provide reading activity for average ability students. Most questions are based on the text. Questions which ask students to *suggest* answers call upon general knowledge.

General information

Medical authorities are concerned by the prevalence of bottle feeding and this unit aims to raise awareness of the nutritional value of human milk in the context of AT 3 in the Science National Curriculum. The emotional benefits of breast feeding are not dealt with in the text, though teachers might wish to add this in discussion.

There is a fairly substantial body of evidence showing that breast fed babies tend to be less overweight, less vulnerable to a wide range of infections, less likely to develop problems with allergies, less likely to die in a cot death and generally healthier than a similar sample of bottle fed babies.

Answers to the questions

Q1 *Baby whales need fat to form blubber. (This is a layer of fat under the skin which provides insulation. Whales are warm-blooded.)*

Q2 *Proteins for growth of rabbits (and humans!).*

Q3 *The baby obtains its energy from carbohydrates – fats and sugar in the case of milk. (It is also possible to use proteins for energy.)*

Q4 *To make it more like human milk.*

Q5 *(a) Contains antibodies.*

(b) The antibodies in cows milk are for the diseases of cattle and, in any case, are destroyed during the processing of infant formula.

Q6 *Ordinary cows milk contains too much casein and the mineral level is far too high.*

Q7 *(a) To kill bacteria.*

(b) To raise it to the same temperature as human milk (although some babies like cold milk).

(c) Bacteria multiply quickly in warm milk and would make the baby ill.

Q8 *(a) % bottle fed: 36, 45, 49, 62, 74, 79, 89. (These figures assume that babies are not being given their milk from a cup or spoon.)*

(b) The time scale may be done in months, a week being taken as one quarter of a month. Students can be encouraged to consider a variety of ways of representing these figures, from graphs to pictures of babies or bottles drawn to scale.

(c) The % of babies breast fed drops and the rate of decline increases with time, or, the rate of change to bottle feeding increases as the baby gets older.

Activity two

A1 Babies were fed on flour and water, gruel, slippery elm (from elm bark) or something similar. Some people added chalk to give the appearance of milk. Needless to say, if a mother could not breast feed her baby it was unlikely to thrive and would probably succumb to disease and die. Rich families would employ a wet nurse, a woman whose baby may have died or, if alive, would be spoon fed on gruel etc. Wet nurses were well looked after to ensure the survival of employers' babies.

A2 Scientific discoveries provided knowledge – the existence of bacteria, killing bacteria by boiling the bottle for 20 minutes and later sterilisation by soaking the bottle in a chemical solution (hypochlorite). This made possible the use of the first plastic bottles which could not be boiled. The use of refrigerators meant that the formula could be made up in advance. The scientific understanding of infant nutrition made it possible to modify cows milk to make it more suitable for young babies.

A3 In a recent survey of 400 Liverpool boys and girls 15 per cent thought breast feeding made people think of 'page 3 girls'. This may explain why only 30 per cent of the city's mothers breast feed their babies at birth, compared with 67 per cent nationally. Dr Jacqueline Gregg, of Sefton General Hospital, writing in the *British Medical Journal* (1989) suggested that because so few of the teenagers were breast fed themselves (only 70 of them) and less than half had ever seen a relation breast feed a baby, schools should take some of the responsibility of trying to educate them not to be embarrassed.

The survey also showed 11 per cent thought breasts were 'rude' and 8 per cent thought breast feeding was, too. At the same time, three quarters thought breast feeding was 'healthier' than bottle feeding.

Many of the girls interviewed for the survey who expected to breast feed their babies would not consider doing so outside their homes, because of the embarrassment.

A previous survey carried out in 1980 showed the following reasons for women choosing positively either to breast feed or bottle feed their first child.

Reasons given for choosing to breast feed

	%
Best for baby	87
More convenient	38
Breast feeding is natural	26
Closer bond to baby	24
Cheaper	22
Best for mother	8
Can't overfeed baby	3
Influenced by friends	2
Influenced by hospital staff	2
No particular reason	1

Reasons given for choosing not to breast feed

Other people can feed baby	43
Don't like idea of breast feeding	18
Can see how much baby eats	18
No particular reason	10
Other reasons	6
Returning to work soon	5
Persuaded by others	3
Medical reasons	2

The percentages add up to more than 100 as some mothers gave more than one reason. These points may be helpful to aid pupils in their discussions. Interestingly the choice to bottle feed tends to be made on arguments against breast feeding and not for bottle feeding. In contrast, there were very positive choices for breast feeding rather than points against bottle feeding.

Useful sources of further information are local branches of the National Childbirth Trust and the La Leche League (Tel. 071-404 5011 for national headquarters and information sheets in a variety of languages). These do, however, tend to place much more emphasis on the emotional bonding and the practicalities of establishing and maintaining successful breast feeding than the more nutrition-based approach used here.

Part B Bottle feeding in the developing world

Group discussion

Groups of three to five are suitable for discussion work. For further ideas see the General Guide for Teachers and SATIS UPDATE 91.

Bottle feeding continues to put the health of babies at risk in many developing countries. Some people blame the advertising campaigns of the large formula milk companies. The companies promoting infant formulas say it is a mother's own decision whether she choses to use formula milk. When a mother cannot breast feed, it may save the infant's life. However, many mothers (in both developed and developing countries) tend to worry that they have insufficient milk and do not realise how quickly they will lose their milk, if they supplement feeds with formula milk.

Part C

The design brief may be used separately to link with work on quantities of heat, current electricity and control. It provides an opportunity to practice experimental and design skills.

Acknowledgements
Dr. P. Clarke of the DHSS and Gill Fine of the British Nutrition Foundation read and commented on the trial version.

Breast or Bottle?

Part A – Why milk?

Producing babies is what life is all about. All living things create more of their own kind.

Producing offspring is one thing, making sure they survive is another. Mammal mothers produce milk for their young. This gives their offspring a better chance of survival.

Each type of mammal has milk suited to its own young – the rate at which they grow, the make up of their bodies and many other things. Whale milk is very rich in **fat,** richer than double cream, because baby whales need to form blubber quickly to protect them from the cold. Rabbit milk is high in **protein** (14 %), because baby rabbits grow fast. Donkey milk is similar to human milk.

The following student activities may be selected from this unit.

Part A Why milk?
- answering questions
- producing a comparative table
- data interpretation
- research and discussion
- role-play situations

Part B Bottle feeding in the developing world
- devising a short play
- writing and illustrating a story
- discussion

Part C Design a baby's bottle warmer
- a design brief

Q1 Whale milk is very rich in fat – why is this important to the survival of baby whales?

Q2 Which nutrient is important for the growth of rabbits?

Human mothers, just like any other mammals, produce milk for their newborn babies. Many choose not to use this milk and instead feed their infants on milk of another mammal – the cow. The use of cows milk for human babies has become common only in the last fifty years or so and mainly in the Western world. There are many complicated reasons for this change. But bottle feeding can have advantages – not least, in that fathers can then feed their babies too!

Today cows milk is scientifically modified for human infants and often called 'infant formula'. But is cows milk better than human milk? This unit describes some of the differences between human milk and infant formulas for feeding human babies.

Milk – what's the difference?

Some of the good points about breast milk have been known for a long time. It is germ free and at the right temperature for baby to drink. Other differences between human milk and cows milk have now been discovered.

All milks contain **proteins, sugars (carbohydrate), fat, vitamins, minerals, water,** hormones, enzymes, antibodies and more.

Milk contains a lot of **water.** Cows milk is 88% water, but the amount of water in human milk varies. During the feed, human milk begins by being thin and thirst quenching, becoming more nourishing as the baby feeds. In hot weather a baby needs more fluids and its mother's milk becomes more dilute, responding to its needs.

Human milk contains about 1.2 % **protein** and cows milk has 3.3 % protein. An important protein found in milk is casein and cows milk contains six times more than breast milk. Casein turns into solid curds in a baby's stomach. In infant formula milks the casein is treated to make it more digestible. Some babies are unable to cope with cows milk protein. They are said to suffer from an 'allergy' and may have symptoms such as asthma and eczema. (Such babies may be given special formula milks.)

A special **sugar** found in milk is lactose. Human milk contains much more lactose than cows milk, which makes it taste quite sweet. Extra lactose is now added to formula milks because when it is digested it helps to make the covering for nerve fibres.

Human milk has a higher proportion of **unsaturated fats** than cows milk. Manufacturers of infant formula milks have tried to alter this by adding vegetable oils.

Cows milk has a much higher **mineral content** than human milk. Pure cows milk would put a strain on a small baby's kidneys. Formula milks have been processed to make their mineral content more like human milk.

There is more of **vitamins** A, C, and E in human milk than in cows milk but less vitamin K. Human milk also provides vitamin D. As long as mothers who breast feed have a well balanced diet, their babies should get all the vitamins they need. Bottle fed babies normally obtain enough vitamins from infant formula.

Many **hormones** are found in human milk, several of which are not found at all in cows milk.

Breast milk contains **antibodies** from the mother, giving her baby protection against many different diseases. Of course there are antibodies in cows milk too, but they are against the diseases of cattle and are destroyed by heat during manufacture of formula milks. The protective effect of human milk is very important in areas of the world where you find infections such as cholera and dysentery.

An **enzyme** which also occurs in tears is lysozyme. It is very effective in killing bacteria. There is 300 times more of it in human milk than in cows milk! Fully breast fed babies in Britain almost never get gastroenteritis (sickness and diarrhoea – a very serious condition).

Any drugs, including alcohol, a mother takes while she is pregnant or breast feeding are likely to reach her baby. A mother who is breast feeding should not take medicines before consulting her doctor.

Human milk supplies the needs of human infants perfectly. In spite of this, relatively few British mothers feed their babies solely on breast milk during the first few months of their lives.

Activity one

Produce a table or chart with the information on pages 2 and 3, that compares human milk with cows milk and which could form part of a leaflet given to new parents.

Questions

Q3 Suggest which nutrients in milk provide a baby with energy.

Q4 Why is extra lactose (the special milk sugar) added to cows milk in all formula milks?

Q5 (a) How does breast milk help to protect a human baby from disease?
(b) Why does cows milk not give the same sort of protection?

Q6 Explain why babies should not have ordinary, untreated cows milk until they are at least six months old.

Q7 Suggest why
(a) a baby's bottle should be sterilised before use,
(b) many parents warm the milk in their baby's bottle,
(c) milk in babies' bottles should not be kept warm for long periods of time, but heated up when needed.

How many babies are breast fed or bottle fed? The table below shows the percentage of babies being breast fed in Great Britain in 1985.

Table 1 Percentage of mothers breast feeding in Great Britain in 1985

Age of baby	% breast fed	% bottle fed
Birth	64	
1 week	55	
2 weeks	51	
6 weeks	38	
4 months	26	
6 months	21	
9 months	11	

Q8 *(a) Copy table 1. Find the percentage of bottle fed babies.*
(b) Draw a graph or chart of these figures that helps to explain them in an interesting way.
(c) What do the figures tell you about breast feeding and bottle feeding?

Activity two

Find out about and discuss in groups

A1 What happened to babies who could not be breast fed before bottle feeding became a safe alternative? What were wet nurses?

A2 What developments for sterilising bottles, storing and warming milk have made bottle feeding safer and easier today?

A3 The World Health Organisation recommends that all babies should be breast fed for at least a year. Many women in the West do not try to breast feed, or they change to bottle feeding very quickly. Give reasons why you think this may be so.

Activity three – situations

Consider the point of view of somebody in one of these situations. Take a few minutes to jot down the advantages of your point of view. You might like to try acting out the scene.

Scene one

A: You are a mother-to-be who is not keen on breast feeding.
B: You are her doctor.

Scene two

A: You are a father-to-be whose wife intends to bottle feed.
B: You are A's father. You are trying to convince your son, who was breast fed, of the benefits of breast feeding.

Scene three

A: You are a mother who wants to return to work and continue to breast feed your baby.
B: You are her employer.

Scene four

A: You are a mother-to-be who wants to breast feed.
B: You are the father-to-be who feels it might be embarrassing.
C: You are a family friend/older sister/mother who favours breast feeding.

Scene five

A: You are a mother-to-be and want to put your baby on the bottle so that you may return to work.
B: You are the father-to-be who thinks the baby should be breast fed if possible.

Scene six

A: You are a breast feeding mother out shopping in a department store whose baby is crying with hunger.
B: You are a shop assistant.

Scene seven

A: You are on holiday with your husband in a remote part of Morocco where bottle feeding is unknown. You have a baby six months old which you have left at home with your mother. You show a picture of your baby to the tour guide.
B: You are a local tour guide. You have never heard of bottle feeding. All babies where you live are breast fed well into their second year. You want to know how the grandmother feeds the baby.

Part B – Bottle feeding in the developing world

During the 1970s formula milks were widely promoted in developing nations. New mothers frequently received free samples as part of advertising campaigns as did hospitals and doctors. Many mothers tried out the formula milks on their babies. But when the free sample was finished they found that their own milk had gone. (Once a mother stops breast feeding her body quickly adjusts and she soon loses her milk.)

Health workers became concerned when babies began suffering from malnutrition and disease in some areas. They found many mothers had stopped breast feeding.

Some countries decided to educate parents in the advantages of breast feeding. And others took further action. In Sri Lanka, no mother was permitted to bottle feed in hospital without a doctor's permission. In Papua New Guinea, feeding bottles and teats were put on prescription and in Micronesia, school children had to calculate the cost of bottle feeding for a year.

Breast feeding has another advantage too – it inhibits ovulation; a mother who is breast feeding is less likely to become pregnant.

However, many mothers have to work to support their families and cannot take their babies with them. 'Western' formula milk may appear an attractive option.

Sarah lives with her in-laws in a remote village in a developing country. She has a young baby which she bottle feeds. This is how she goes about it.

- Fetch firewood and make a fire.
- Fetch water from a dirty barrel or polluted pond.
- Use precious fuel to boil the bottle for 10 minutes to sterilise it.
- Find a clean surface on which to prepare the feed.
- Work out what the instructions on the label say – not easy, because she cannot read.
- Boil more water and make up feed. (Remember that it is very expensive but try to resist the temptation to dilute it more than the instructions say to save money.)
- Cool the mixture. (Resist the temptation to pour it into an unsterilised cold container.)
- Feed baby.
- Throw away any leftover feed. (Baby formula is so expensive that she is tempted to keep any leftover for another feed.)

Sarah does this several times a day, using up precious firewood, without a refrigerator to store made up formula and without being able to afford chemicals for sterilisation.

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

Activity four

Devise a short play about Sarah with the following characters:

Sarah,
her mother-in-law,
her husband.

You may add more characters if you wish.

Activity five

Write and illustrate a story for primary school children which describes how Sarah prepares her baby's bottle.

Questions for group discussion

- *Should free samples of formula milk be given to new mothers?*
- *What should large milk companies do to improve the health of babies in developing countries?*
- *Should the advertising of formula milks be banned or restricted?*

Part C

ParentCare

TravelBabe

> **You are a member of the ParentCare™ plc design team. A new product you are working on is the TravelBabe: a heater to warm a baby's bottle of milk in a car, using the car's dashboard lighter socket (which supplies 12 volts d.c.) as a power source.**
>
> - **You are to design the heater.**
> - **Make and test a prototype, finding out how long it takes to heat up the milk to the correct temperature.**

Activity six – Design a baby's bottle warmer

1 Produce a design proposal for the product, including an estimate of

- ☐ how much milk will be heated,
- ☐ what the temperature rise should be.

2 Draw a sketch of the baby's bottle warmer as it might finally look.

3 Draw a diagram or sketch of how you would make a working prototype in the laboratory, using the sort of equipment that you are used to. Make a list of everything you will need.

4 Draw a circuit diagram showing how you would connect up the heater to make it work. Get your plans checked by your teacher.

5 Make your prototype.

6 Test it to see if it performs to your original specification. (Decide what measurements you will need to take before you start.)

7 Did your prototype meet its design specifications? If not, suggest ways of improving the design.

A Special Type of Hearing Aid

Science content

Working of the human ear, defects of hearing, (analogue and digital signals).

Science curriculum links
AT12 IT including microelectronics
AT14 Sound and music

Syllabus links
- GCSE Science, Biology, Physics

Cross-curricular themes
- Health Education

Lesson time
$1\frac{1}{2}$ hours

Links with other SATIS materials
407 Noise
903 What are the Sounds of Music?

NERIS
Search on
DEAFNESS
and UPPER SECONDARY

SUMMARY

The unit invites students to explore some of the problems associated with deafness and describes the functioning of the ear and a cochlear implant.

STUDENT ACTIVITIES

- ☐ Activity A: students simulate deafness and ask each other for objects.
- ☐ The story of Alison: reading material about deafness and the functioning of both the ear and a cochlear implant with associated questions Q1 to Q8.
- ☐ Activity B: short role-plays.
- ☐ Activity C: information and questions for discussion or writing on deafness induced by loud noise.

AIMS

- ☐ To complement work on the ear and hearing
- ☐ To illustrate an application of electronics in medicine
- ☐ To develop awareness of the problems associated with deafness
- ☐ To provide opportunities for role-play and discussion

USING AND ADAPTING THE UNIT

- ☐ This unit links with work on the ear.
- ☐ The unit may be adapted for a range of abilities by selecting appropriate activities. Teachers may wish to omit page 5 with younger or less able students.

First published 1991

Teaching notes

In January 1990, the National Health Service was given £3 million for a hearing implant programme to help the deaf. There are an estimated 5000 people in the UK who would benefit.

Multi-channel implants using several electrodes are available in Australia and the US where 5000 people have had the operation.

Alison Heath, who has campaigned for the availability of cochlear implants says, 'Currently implants are available to adults who have some memory of hearing. It would be wrong to raise any hopes of implants helping children at present. The operation would have to be performed very early in life – at the age of three – if they are to benefit from it and acquire language and speech more normally.'

'People who become deaf suffer tremendously as they adjust to the loss of many things they took for granted. The born deaf child has other problems and parents are traumatically affected as the full implications of the handicap become apparent. Deafness in a child is an enormous educational handicap and the acquisition of language is slow and difficult. Many people born profoundly deaf never acquire a good command of English and need to use a sign language to communicate effectively.'

Answers to questions

Q1 *OUTER EAR*
EAR DRUM
EAR BONES
COCHLEA
AUDITORY NERVE
BRAIN

Q2 *Hearing aids amplify the sound and help where there are conduction losses in the middle ear. Alison had inner ear deafness – no signal from the cochlea. No amount of amplification would help.*

Q3 *MICROPHONE*
PROCESSOR
TRANSMITTER
RECEIVER
ELECTRODE

Q4 *So that the wearer may disconnect the microphone/processor box.*

Q5 *Personal answers – no doubt dealing with the emotional stresses of a total change of life style.*

Q6 *Use telephone message system such as BT Telecom Gold with a personal computer and modem, teletext for subtitled TV programmes, etc.*

Q7 *The brain would not have learned how to interpret the signal.*

Q8 *Graph A – digital, graph B – analogue.*

Activity B

This activity need not take long especially if students work in groups of four or five and a strict time limit is put on each scene – say, four minutes. Preparation could be a form period or homework activity.

Suggestions for organising mini role-plays are given in UPDATE 91.

Some scenarios are

- Danger – on the roads
- Missing out – conversation, watching TV, listening to music
- Job – being interviewed, answering the telephone.

Activity C

C1 Especially f, j, p, t.

C2 Damage to hearing depends both on the intensity of sound and on the length of time during which a person is exposed to high levels. Personal stereos put all their sound energy directly into the ear and so the intensity (energy / m^2) is high. They tend to be used for long periods of time and hence the risk is increased.

C3 People who listen to personal stereos, loud pop music, workers in certain industries where there are high levels of sound (e.g. using a pneumatic drill, bottling plants, metal stamping, or where the acoustics of the building lead to high levels etc.) Workers are advised to wear ear protectors and have a limited period of exposure.

Acknowledgements

The activities were developed by Sylvia Camberlain.

This unit is based on an article, *Electrode helps deaf mum to hear*, by Bob Perrin in the *Bucks Free Press* on 26 May 1989.

Figures 1 and 4 are reproduced by permission of the Bucks Free Press Group.

Figure 3 is based on an illustration supplied by the RNID.

A Special Type of Hearing Aid

Total silence

Sit still for a moment and listen. Try to imagine total silence. Think how you would cope if you were deaf.

Nearly one person in five has some loss of hearing. About one in twenty is deaf, that is two and a half million people in Britain. Some people are born deaf while others may lose their hearing through accident or disease.

This unit is about a type of deafness of the inner ear and the functioning of a cochlear implant. The activities for groups of students include:

- a lip-reading activity
- a short role-play, simulating some problems encountered by deaf people
- discussion
- questions based on information in the text.

Activity A

- ☐ Provide yourselves with a collection of at least 20 objects (or the cards provided with this unit). There can be duplicates.
- ☐ Work in a group of 4 or 5. Do this activity in total silence.
- ☐ One person should start by mouthing the name of one object. The person who recognizes it may remove the object.
- ☐ That person mouthes the name of another object.
- ☐ See who collects the biggest pile.

The story of Alison Heath

What is life like for someone who cannot hear the door bell, traffic, music and voices?

Alison Heath was eight years-old when she fell ill with meningitis. Her illness left her unable to hear with her right ear. Two years later she lost the hearing in the left ear too.

At the age of ten, Alison's world became totally silent. She was classed as profoundly deaf. Alison had to go to a school for deaf children. Her whole life was transformed.

Although she learned to lip-read, being deaf brought problems that it is hard for people with hearing to imagine.

'It isn't bad lip-reading one-to-one, but it's not very good when you're in a group. When you're totally deaf, you're not sure who, if anyone, is talking.'

But in spite of deafness, she grew up to lead a 'normal' life. She went to university and studied modern history. She married and had children. When they grew up she took a job in London.

Figure 1 Mrs Heath with the sound processor that sends signals to the electrode in her inner ear

How does a deaf mother cope with children? 'When they were very young', she recalls, 'I kept them in the room with me, wherever I was in the house. At night, of course, my husband had to get up when they cried, because I couldn't hear. When they got older, they'd run off to other parts of the house, if they fell over and hurt themselves, I wouldn't know anything about it till they came to me, tugged my skirt, demanding comfort.'

Activity B

Work in groups.

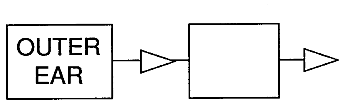
Make up and act a scene in which a deaf person is:

- in more danger than a hearing person,
- 'missing out' on an enjoyable activity,
- applying for a job.

Q1 *These are parts of the hearing system:*

AUDITORY NERVE
EAR BONES
BRAIN
COCHLEA
EAR DRUM
OUTER EAR

Link them together in a flow chart to show how a sound signal passes to the brain. The flow chart has been started for you.



How does the ear work?

The ear consists of the outer ear, the middle ear and the inner ear. The **outer ear** merely collects sound waves and funnels them along the ear canal. This is where the sound waves hit a piece of skin called the **eardrum** and make it vibrate. The **middle ear** contains a lever system of three little bones, called the hammer, anvil and stirrup. They are connected together in a way that amplifies the signal to the **inner ear**. The **cochlea** of the inner ear is shaped like a snail shell and is filled with a watery fluid.

When sound makes the eardrum vibrate, the vibrations pass through the three little bones across the air-filled middle ear.

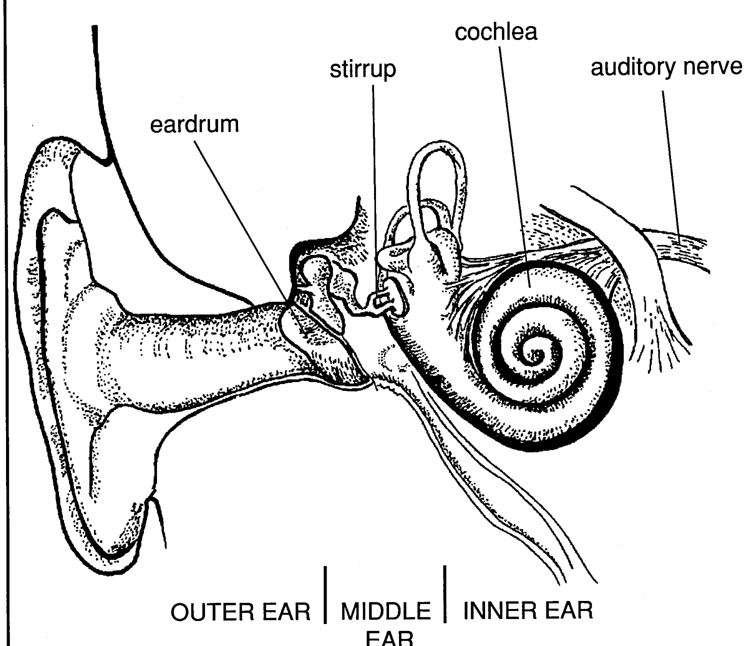


Figure 2 The main parts of the ear

The bone called the **stirrup** presses against the cochlea and pumps the fluid inside it to and fro across little hair-like nerve cells making the hairs move. The nerve cells turn these movements into **electrical signals** and pass them along the **auditory nerve** to the **brain**. The brain decodes the electrical signals and interprets them as sound.

Alison's operation

Deafness is usually due to damage to the middle or inner parts of the ear. Many people suffer from **conduction deafness.** They lose their sensitivity to sound. They can be helped by wearing a hearing aid which makes the sound louder. Hearing aids cannot help people with total **sensori-neural** deafness which is due to damage in the inner ear.

In Alison's case, vibrations from sounds were reaching as far as the inner ear and the auditory nerves to her brain had survived her illness. However, the hair cells in the cochlea were not sending any signals to the auditory nerve.

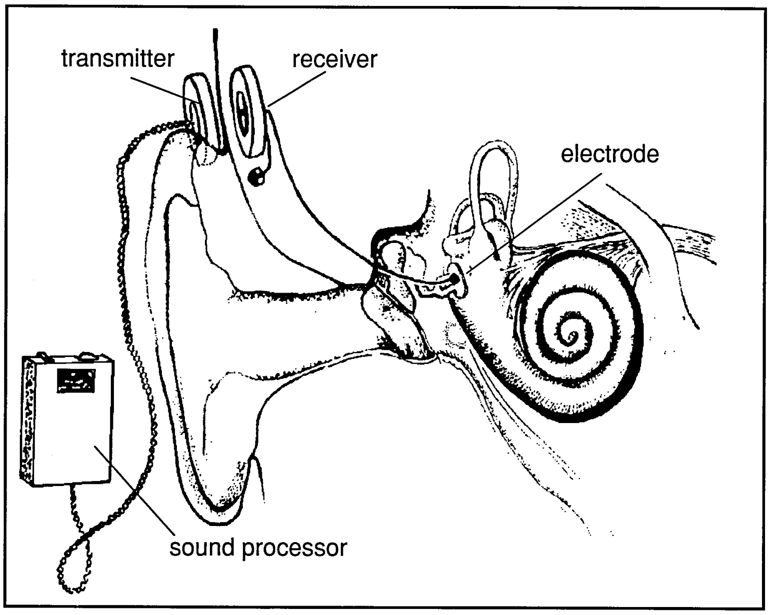


Figure 3 How the sound signal reaches the cochlear implant

In the mid-1980s Alison Heath was one of the first people to have her hearing partly restored by a new operation. Doctors put an electrode on the cochlea in her inner ear. It was to bypass the cochlea and send a tiny current along the auditory nerve to her brain. The electrode was connected to a receiver coil that doctors implanted just under the skin behind her ear.

How would this tiny current be produced? She wears around her neck a box the size of a personal stereo, containing a microphone, a processor and a battery. The microphone turns the sounds it picks up into an electrical signal. The signal is processed and passed to a transmitter worn behind the ear. It is picked up by the receiver coil under the skin. The signal passes then along a wire to the electrode on the cochlea.

Q2 Explain why Alison could not use an ordinary hearing aid, worn in the outer ear, for her kind of deafness.

Q3 Here are the parts of a cochlear implant hearing system:

ELECTRODE,
MICROPHONE,
PROCESSOR,
RECEIVER,
TRANSMITTER.

Make another flow chart to show how the sound signal reaches the brain.

Q4 Suggest why the electrode is connected with the microphone via a transmitter and receiver.

Cochlear implants, as they are called, are successful for some people but others get less benefit. Would the artificial signal give her a sensation of hearing? After 30 years of silence, there was an anxious four week wait before 'switch on'.

'At first', she said, 'my noise tolerance was very low, I couldn't stand the sound of London traffic and would switch off when travelling in a car or on a train. I'll never forget the first time I met a police car on an emergency call!'

'It took me time to identify background noises. They didn't sound as I remembered them. Animal voices, the chinking of china and footsteps on the stairs were among the first sounds I learned to recognise. After a few weeks, I could recognise pitch changes when my husband played the piano.'

Q5 If you were to lose your hearing, what do you think you would find most distressing?

Q6 What aids could deaf people use to make life easier
(a) at home,
(b) at work,
(c) at leisure?

It has taken her five years to make full use of the cochlear implant. She can now recognise speech in a quiet room without lip-reading. Listening to the radio or talking on the telephone is impossible. Television still needs sub-titling.

Figure 4 Mrs Heath uses the computer that tunes her into the telephone service

More about cochlear implants

Cochlear implants cannot give normal hearing. Alison's implant used just one electrode on the outside of the cochlea. How it works for deaf people is not fully understood. Of course a lot depends on whether the nerve fibres in the auditory nerve (there are about 30 000) still work, but also on whether the brain can interpret the electrical impulses.

People who might benefit from a cochlear implant are those who have some memory of sound and hearing. That means they must be people who were born with hearing but became deaf after they had learned to talk. Without this memory they would be unlikely to make sense of the signals from the implant.

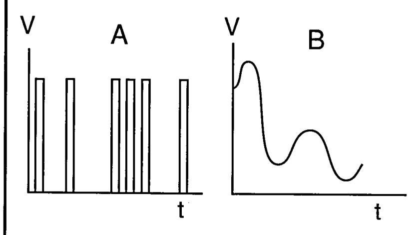
As the technology improves, it is hoped that some born deaf children will be able to have implants, learning through regular use of the implant to make sense of the sounds they hear.

The operation takes between two and four hours. It needs sound engineers to test the hearing threshold of each patient and electronic experts to program the system to the patients' individual needs. The greatest benefit is for patients to be able to hear their own voices so they can control how loudly they speak. After many years of deafness, patients forget how to do this and need intensive speech therapy.

There are more complex implants that enable patients to distinguish between high-pitched and low-pitched sounds. One Australian digital implant has 22 electrodes and some totally deaf people can even use the telephone with it. On the other hand, the Americans are getting similar results with a simple four electrode analogue implant. So the designers of the very complicated Australian implant have not solved the mystery.

Q7 People who are born deaf are unlikely to benefit from a cochlear implant. Explain why.

Q8 Which graph of voltage (V) against time (t) could be
(a) a digital signal,
(b) an analogue signal?



Activity C

For discussion or writing

Loud noise can damage tiny hair-like nerve cells in the cochlea. Deafness caused by loud noise often starts with a loss of hearing of high-pitched sounds. These sounds enable you to understand speech, especially conversations over the telephone.

C1 People who lose their hearing in this way cannot distinguish the sounds of consonants like 's', which have a lot of high pitch sounds in them.

Try out the *sounds* of the consonants in the alphabet. Which other letters would be difficult to hear?

C2 Personal stereos do not produce loud sounds, but can cause this sort of deafness. Explain how this might happen.

C3 Which groups of people might be in danger of damaging their hearing from loud sound? What could be done to prevent this happening?

SATIS No. 407 Noise, *describes examples of the deafening effects of loud noise.*

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

elephant	brother
tennis ball	supermarket
apple tree	horse
banana	dog
washing machine	car

Buckingham Palace	**computer**
fish	**loaf of bread**
bicycle	**sister**
carpet	**telephone**
baby	**laboratory**

Save the Salmon!

A problem of pH

Science content

Acids, alkalis, carbonates, water purity and pH, (breeding and natural selection).

Science curriculum links
AT 1 Exploration of science
(AT 4 Genetics and evolution)
AT 5 Human influences on the Earth
AT 7 Making new materials

Syllabus links
- GCSE Science, Biology, Chemistry
- Technology

Cross-curricular themes
- Environment
- Economic Awareness

Lesson time
¾ to 2 hours

Links with other SATIS materials
801 The Water Pollution Mystery
902 Acid Rain
1210 Bottled water

NERIS
Search on
WATER POLLUTION and SALMON
or on WATER POLLUTION and FISHES

SUMMARY

This unit is about acidity and includes practical work. It begins with information about the salmon, its economic value and its life cycle. The practical activities involve measuring pH and making polluted 'river' water less acid.

STUDENT ACTIVITIES

- ☐ Reading and questions about the salmon.
- ☐ Activity A Questions and practical work for individuals or small groups: pH and neutralisation.
- ☐ Activity B Collaborative problem-solving: suggesting how to make a river less acid.
- ☐ Activity C Teacher demonstration or practical work: modelling and testing solution(s).
- ☐ Questions for group discussion about Activity C.

AIMS

- ☐ To complement work on acids
- ☐ To apply the measurement of pH to a 'real' problem
- ☐ To show some of the practical constraints accompanying the solution of real-life problems
- ☐ To provide opportunities for collaborative problem-solving

USING AND ADAPTING THE UNIT

- ☐ This is a short unit unless part C is done.
- ☐ Parts may be selected to adapt it for students of a range of abilities. Activity A is revision of work on acids and designed to cue students into Activity B.
- ☐ To save time, teachers may wish to demonstrate a solution to part C.

APPARATUS REQUIREMENTS

Part B Usual laboratory apparatus for work on acids and pH.

Part C Lengths of plastic guttering (with end stops) to model a river, crushed limestone or marble chips.

A list is given in the teaching notes.

Author **Paul Phillips**

First published 1991

Teaching notes

Page 1 provides background information. Questions Q1 to Q6 are to aid students' comprehension of the text and could be omitted. **It is suggested that students are not given page 3 until they have completed pages 1 and 2.**

Activity A

Activity A is designed to revise ideas needed to solve the problem posed in B. Students may need to try out the ideas for themselves or see them demonstrated. Able students could be set this part as a written exercise for homework.

Requirements if practical work is undertaken:
- test tubes,
- universal indicator or narrow range pH paper,
- dilute sulphuric acid,
- dilute sodium hydroxide,
- calcium carbonate / limestone,
- eye protection.

If students are familiar with their use:
- pH meter,
- burettes, conical flasks.

Activity B

It is envisaged that students will work in groups of 2 to 5 with a strict time limit (say 15 minutes). Reporting back to the class is probably best kept very brief.

Some possibilities for 'saving the salmon' could be:

- diluting the acid by adding water. However, this would be difficult because a large amount of water would be needed very quickly and there was a drought when the incident in the newspaper article happened.
- adding alkali to neutralise the acid.
- adding limestone (calcium carbonate) to neutralise the acid is perhaps the best suggestion. Limestone is cheap, readily available and effective. The limestone could be dumped in 20 tonne loads into the river every 0.5 kilometres. It has proved very effective in other rivers, being insoluble it cannot add excess alkalinity.

Activity C

Students will need to devise an accurate method of measuring pH, preferably an electrical method.

Apparatus requirements will depend on the solutions proposed. If the limestone method is used suggestions include:

- sulphuric acid and means of measuring pH,
- crushed limestone (garden centres may give away pieces which are too small for rockeries). Marble chips are fine and every laboratory has them.
- lengths of plastic guttering with end stops,
- plastic funnels,
- jubilee clips,
- rubber/plastic tubing to connect to funnels / taps,
- constant head devices (these are sometimes used for A-level physics but can be made by a technician from tin cans).

General information

Fishing and fish farming of the Atlantic salmon (*Salmo salar*) make major inputs to the economy of rural areas. The licensing of anglers is more profitable than commercial netting of fish. Poaching is so profitable that the Inland Revenue has decided to tax illicit earnings. Fish farming is largely located in Scotland and has grown exponentially over the last decade.

The salmon's life cycle is remarkable, though only outlined in the unit. The young freshwater salmon parr looks very different from the mature salmon and was believed to be a separate species, similar to the trout. It was not until 1840 that the parr were confirmed to be the young of salmon. The length of time that salmon spend in their home river and at sea may be considerably longer than given in the unit, but seems to depend on water temperature.

Atlantic salmon migrate to the waters around Greenland to feed on sand eels, capelin and large zooplankton. Their method of navigation is still not fully understood but salmon are able to sense electric fields and it is thought that they detect the electric potential set up by the ocean currents and the earth's magnetic field. It is believed they identify their home river by 'smelling' its chemical constituents.

Answers to the questions

Q1 *Income from fishing licences, employment as wardens, tourist industry, commercial fishing, fish farming, etc.*

Q2 *Poaching, pollution and disease given in the text. Other reasons include the extraction of water from rivers, hydro-schemes and afforestation.*

Q3 *No – exceptional drought could not have been foreseen; lack of money to take preventative measures; the cause of acid pollution may not be understood (hence the confused explanation in the newspaper article).*

Q4 *No – but the reading might have been beyond the range of the instruments.*

Q5 *No – the account is confused. It talks about sulphuric acid and then mentions nitrates from adjoining farmland. In fact the chemistry of acidification is not simple. It was unlikely that the acid was mostly 'sulphuric', although some sulphate ions may have been present from ammonium sulphate, a common fertiliser. Nitrate ions, giving rise to a 'nitric acid', will also be present. An excess concentration of hydrogen ions with a variety of anions were the 'acid' in the river.*

Q6 *Salmon returning to the same river to spawn have adapted to its conditions over many generations and developed a unique gene pool (genetic bank in the article). Salmon rivers have been restocked with hatchery fish but important genetically-based behaviours like the timing of migration and spawning have been lost and hence the concern expressed in the newspaper extract.*

Activity A

A1 *pH 7.*

A2 *Use universal indicator, a pH meter, by titration with an alkali.*

A3 *(a), (b) and (c) its pH increases, [in (c) carbon dioxide is given off].*

A4 *Unpolluted water has a pH somewhat less than 7 due to dissolved gases, such as carbon dioxide, coniferous woodland and peaty soils. Carbonate rocks may make some waters slightly alkaline.*

Questions C

C1 *(Students should include ideas they subsequently rejected.)*

C2 *(Individual answers.)*

C3 *(Individual answers.)*

C4 *(See Science AT1 level 6e, 10a and Technology AT4.)*

C5 *(Science AT1 level 10b, Technology AT4.)*

C6 *Rate of flow of river, cost of materials, labour, transport, maintenance.*

C7 *Provide running costs, calculate economic value of having fish in the river, draw attention to environmental benefits etc.*

C8 *Legislation or effective enforcement of existing anti-pollution laws; changes in farming practices (if this was found to be the cause); extraction of water from the river and nearby aquifers could be stopped.*

Acknowledgements

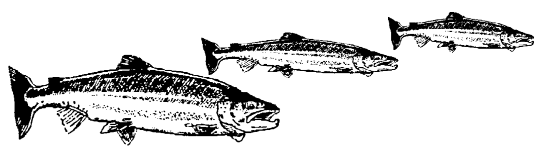
The extract on page 1 is reproduced by permission of the *Daily Express*.

Save the Salmon!

A problem of pH

Salmon rivers are big business. Anglers will pay more than £50 a day for a *rod*, that is, for permission to fish for salmon. Salmon are also harvested by netting wild fish but most of the fresh salmon you see in supermarkets is reared by fish farming.

A 5 kg freshly caught fish costs around £60 and salmon fishing brings employment to many rural areas. The fishing of wild salmon in Scotland, for example, is worth £100 million per year.



The wild salmon lays its eggs in fast-flowing streams where there is very pure water. Scientists have found that salmon will not spawn when the pH of the river is less than 4.5.

On hatching, young salmon stay in the river for about a year before migrating across the Atlantic Ocean towards Greenland. After about three years they return to lay their eggs and die in the river where they hatched. Since salmon return to the same river to breed, each river is stocked with fish well adapted to its conditions.

Sadly, salmon have disappeared from many rivers, due to poaching, pollution and disease.

The activities in this unit include:

- reading
- questions
- practical work on acidity
- deciding how to reduce acid pollution in a river
- modelling and testing the solution.

From the Daily Express, October 1989

Acid kills off trout in fishing paradise

By James Davies
environment correspondent.

Pollution has killed more than 100,000 salmon and trout in a West Country river.

Last night river authority chiefs were under fire for failing to prevent "this wholly avoidable tragedy".

One conservation campaigner said after checks: "It was effectively sulphuric acid in the water, and I was told it nearly blew the tops off the instruments."

It is thought that acids from nitrates on adjoining farmland were washed into the river by rainfall. Because water levels were low following the long, hot summer, they were not sufficiently diluted.

"We have lost virtually the whole genetic bank of salmon and brown trout for the Torridge because this was the only successful spawning tributary."

Questions about the text and newspaper extract

Q1 *How may salmon fishing bring employment to an area?*

Q2 *Why have salmon disappeared from many rivers?*

Q3 *Was it fair to suggest that the death of the salmon was 'wholly avoidable' in the newspaper article?*

Q4 *Would river water really 'blow the tops off instruments'?*

Q5 *Does the newspaper explain how acid got into the river?*

Q6 *(a) What is meant by the term 'genetic bank'?*
(b) Explain why the River Torridge cannot be restocked with salmon from the same genetic bank.

Activity A

The strength of an acid is measured on the pH scale.

Use textbooks or carry out experiments to help you answer the following questions. (Remember that practical work must be supervised by a teacher. Wear eye protection.)

A1 What is the pH of very pure water?

A2 How could you find the pH of the solution of an acid? (Hint: there is more than one way to do this.)

A3 What happens to the pH of an acid solution when these substances are added to it?
(a) water
(b) an alkali
(c) a carbonate (e.g. calcium carbonate)

A4 Suggest why unpolluted water in rivers and ponds may have a pH ranging from 4.5 to 8.

Activity B – How would you save the salmon?

You are scientists working for the National Rivers Authority. What should be done to save the salmon in the River Torridge?

1 ☐ Work in small groups.

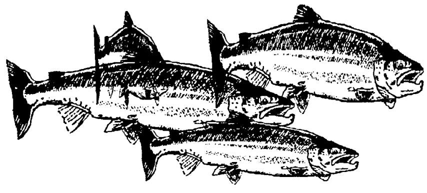
☐ Spend about 15 minutes on this part.

☐ You are to think of a method to save the salmon from acid pollution. Assume the pH of the river water is around 3. Aim to increase the pH to between 4.5 and 7.0.

☐ Although the members of the group may have different ideas try to come to some agreement quite quickly on a good method.

2 Work out some details. For example, draw sketches, work out quantities or chemical equations.

You will need to think of a method which
- is cheap and works on a large scale,
- does not depend on piping more water into the river in times of drought,
- you could test out in your school laboratory.



3 How could such a scheme be paid for? (E.g. would you charge the taxpayers, the local council, the fishermen, the farmers, etc?)

4 Elect a spokesperson to tell the class about your plan.

Activity C Will it work?

Build a working model of your idea and test it.

Measure the pH of the water before and after treatment and record any results that you take.

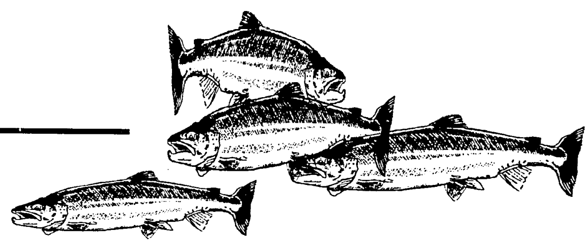
There are a few points to remember.

☐ Safety – always consult a teacher first.

☐ The water must be 'running water', so you cannot just use a beaker.

☐ You need an accurate means of measuring if the water is suitable for fish.

☐ You cannot use live fish. This might be cruel.



When you have finished activity C, try answering these questions to explain how you did it.

C1 *What ideas did your team have for solving the problem?*

C2 *Which design did you use? Draw a diagram of your model and explain how it worked.*

C3 *How did you measure the pH of the water?*

C4 *Evaluate your model – did it work as you predicted? Could you improve the design in any way?*

C5 *What changes might be necessary to scale up your model to full size?*

C6 *What information would you need to work out the running cost of the full scale scheme?*

C7 *What could you do to persuade people that your scheme should be adopted?*

C8 *Suggest other ways of saving the salmon.*

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