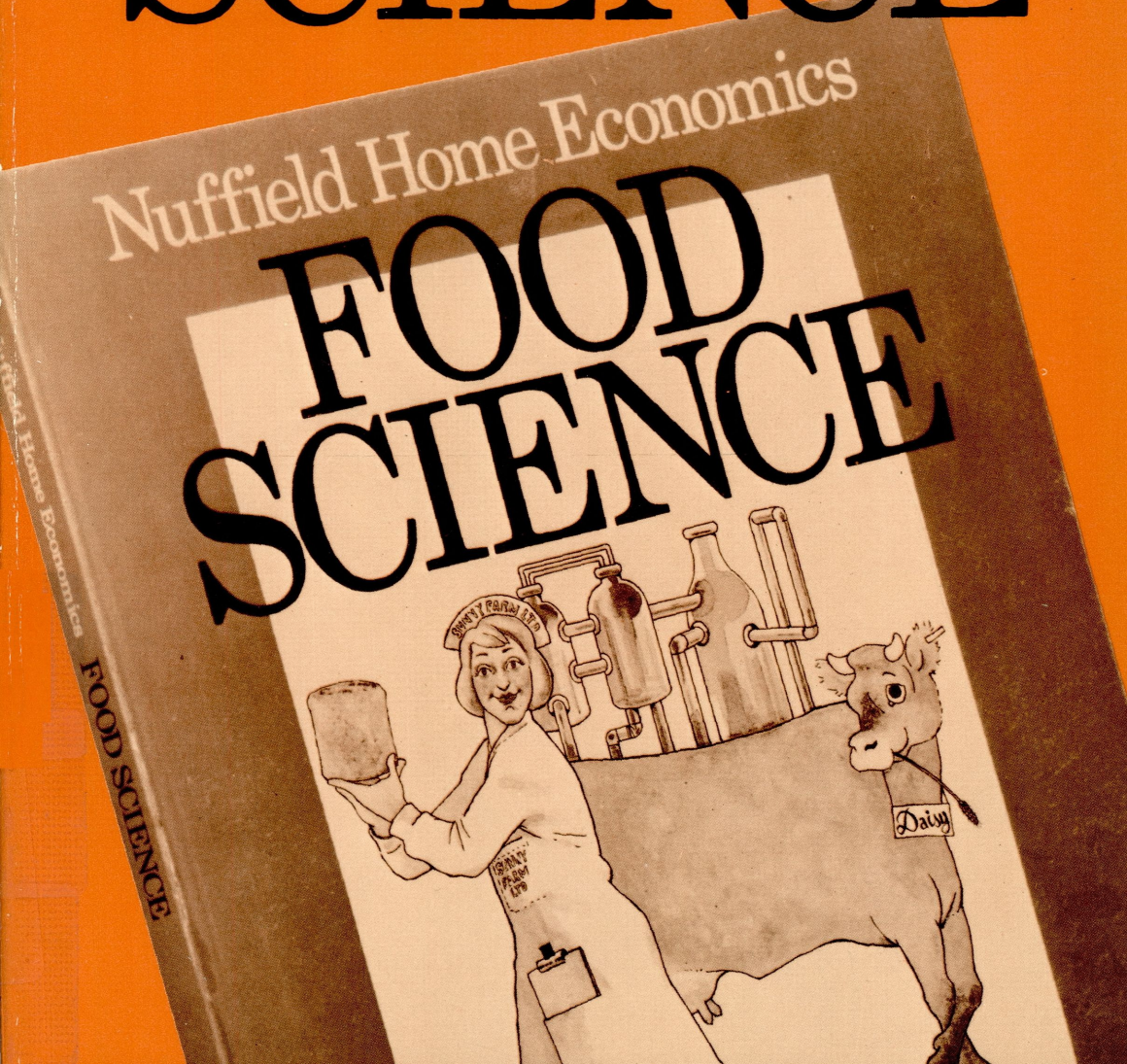
Nuffield Home Economics

TEACHERS' GUIDE

FOOD SCIENCE



Nuffield
Home Economics

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FOOD SCIENCE

Science Learning Centres
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Preface

It is particularly fitting that the first major series of publications to be issued under the name of the Nuffield-Chelsea Curriculum Trust should be a new series in home economics. The Nuffield-Chelsea Curriculum Trust, founded in September 1979, arose out of the work of the Nuffield Foundation in the renewal of the curriculum in the sciences and mathematics. One of the foremost aims of this work has been to develop in pupils a realization of the applications of their classroom learning and its significance to the world of industry and everyday living. Home economics is, above all, the discipline in which the principles of natural laws can be seen most clearly and closely in their application to the needs of living.

This new Nuffield Home Economics project had its origins in a series of in-service courses organized by the Centre for Science and Mathematics Education at Chelsea College. These courses were set up for home economics teachers who asked for help in deepening and refreshing their awareness of aspects of scientific knowledge which are needed in the teaching of home economics.

From an initial survey of Nuffield science curricula it became clear that a wholly new project devoted to the subject of home economics was required. The Foundation granted the funds for establishing this project. A Consultative Committee under the chairmanship of Professor Harold Baum, Professor of Biochemistry at Chelsea College, was set up with a membership drawn from the Inspectorate and other experts in the field from universities, industry, and schools to guide the course of the project from its beginnings, through its trials, and its progress to publication.

The Trust owes a deep dept of gratitude to many institutions, groups, and individuals for advice and practical support: to the Inspectorate at the national and local levels for their encouragement and interest; to the local authority home economics advisers who have met regularly for progress reports on the project and who have played a central role in the trials of draft materials; to the teachers and pupils in schools in over twenty authorities who carried out the trials and gave us so much help and constructive criticism; to the colleges where courses have been held and whose members have played an active part in the development of the materials; to the Examination Boards who have shown an interest in the project; to Professor Baum and the members of the Consultative Committee; and to our many friends in the public and private industries, most notably Unilever which provided a grant enabling us to carry out much of the preliminary work and British Gas for their support in the

dissemination of the project. To the organizers of the project, Sharon M. Mansell and Harry Faulkner, who have been responsible for the origination of all the materials, for their trials in schools, and for all the attendant business of the project in the period 1977—81, in addition to being the general editors of *The Basic Course*; to Marie Edwards, who is in charge of the dissemination of the project and who is general editor of the later materials; and to Beryl Hammond and Clive Robertson the editors and authors of this book, I must specially record the thanks of the Trust. I also have the pleasure of thanking Professor Paul Black, academic adviser to the Trust, William Anderson, our publications manager, the editors Sarah Codrington, Deborah Williams, and Frank Kitson who have worked on the books, the designers and artists, and finally our colleagues in Hutchinson Education who have given us such encouragement and support during the period of origination and production of the materials.

K.W. Keohane
Chairman, The Nuffield-Chelsea Curriculum Trust.

Introduction

Food science is designed to help pupils understand the scientific principles underlying the practical work they do in preparing and cooking food. They learn about the activities of enzymes and micro-organisms, and ways of preserving food; about different methods of heat transfer and cooking — their effect and their cost; and about what food manufacturers do to foods to make them easy to prepare and cook. The pupils experiment with foods and equipment and learn to interpret the results of their investigations.

An important theme running through the book is the production of food which is good to eat: of optimum appearance, flavour, texture, and consistency. Scientific principles needed to understand and control the changes occurring during preparation and cooking, and to make informed choice of raw materials, equipment and methods, are introduced *at their points of application*. Science has always been seen as part of Home Economics and *Food science* makes its relevance immediately obvious to pupils.

The Basic Course introduced teachers to ways of carrying out experimental work in Home Economics lessons and this approach continues in *Food science*. In cookery lessons it is generally expected that food produced must be edible, and teachers and pupils do not like 'failures' (such as under- or over-cooked foods) as this is seen to be wasteful. An experimental approach requires the effects of different variables to be investigated, such as different cooking temperatures, and this may result in products of less than optimum eating quality! The effect of the variable is clearly illustrated, however, and the pupils' understanding of its importance encouraged through practical experience. The two approaches should not be mutually exclusive. Cookery and science are not always compatible. Detailed investigations of foods in the science laboratory may leave food inedible or even dangerous to eat. As a matter of safety, food should not be consumed in science laboratories. Such experiments would be out of place in the Home Economics laboratory, and the experiments in *Food science* give products which are edible or 're-useable'. Indeed, a prime concern is the influence of variables under investigation upon eating quality.

The pupils' book is one of the four inter-related texts in Nuffield Home Economics prepared for the post-thirteen age group. These books aim to develop the approach to Home Economics which *The Basic Course* provided for the earlier years. The four areas of study are:

Food science	Fibres and fabrics
Nutrition	People and homes

Each area of study has a separate pupils' text and teachers' guide. A pack of worksheets and assessment cards is also available for each area.

The pupils' text
The pupils' book has been designed to give the greatest possible flexibility. The chapters follow a logical sequence, but each one is a separate unit and they can be done in any order to fit the local curriculum. Some ways of using the text are:

a as a course, alternating *Food science* and practical cooking
b as a course, using *Food science* as an examination syllabus
c as a basis for topic work (for instance, fruit preservation would use Chapters 2, 3, 6, and 9)
d as a resource to answer problems as they occur in cookery lessons
e as group work to allow for a variety of ability in the pupils
f as a framework for linking Home Economics and science.

There are many opportunities for links to be made with other areas of study in the Nuffield Home Economics project. For instance, cooking methods are discussed in *People and homes*, and the effect of cooking on the nutritional value of food is discussed in *Nutrition*.

Practical work has been designed to use foods easily available and reasonable in cost. Instructions for carrying out the experiments include all the equipment and materials needed, the method to use, and the method of recording results. As time is limited it is unlikely that all pupils will do all the experiments. After the opening discussion, the class could be divided into groups, each group carrying out one experiment. Pupils should be encouraged to report their findings to the whole class and to show their results.

Questions are asked throughout the text which reinforce the ideas being discussed and encourage pupils to evaluate the results of their experiments. All sections are numbered so that they can be identified quickly by teacher and pupil.

At the end of each chapter of the pupils' text is a piece of Background reading on some aspect of the work covered. These are intended to broaden the pupils' knowledge of the wider aspects of the subject — historical, social, and international — and to expand their imaginative grasp of the jobs connected with the various topics.

Accompanying the books is a pack of worksheets and assessment cards. The worksheets are intended to develop many of the ideas in the text and to offer pupils more information which will reinforce the concepts they have already worked on. They may be duplicated and used both in the classroom and for homework. The use of the assessment cards is explained below.

The teachers' guide

The teachers' guide is designed to give all the support required in using the materials. The book conforms to a pattern which makes cross-reference with the pupils' text easy for the teacher. Each chapter in the pupils' text has a corresponding chapter in the teachers' guide. Each one begins with a short introduction to the topic, time allocation, and a list of extension work and worksheets. Each section starts with a summary of the main ideas. Likely answers to questions and results of experiments are explained, and areas where problems might occur are pointed out. There are lists of apparatus and materials needed for pupils' investigations; warning is given where there is a safety risk. There are notes on illustrations in the pupils' text. Ideas for homework and extension work are described. (References to figures in the pupils' text are given in italics. Links with other areas of study are given thus: *Nutrition*, Chapter 9. References to any area of study in *The Basic Course* are given thus: *The Basic Course*, Chapter 14.) Reference material lists sources of further information and teaching aids which would be useful.

Processes and skills are noted in the margins throughout this teachers' guide. A list is given below.

1 Observing
Measuring
Estimating

2 Analysing
Classifying
Deciding criteria
Identifying causes
Interpreting graphs
Using statistics

3 Planning
Suggesting and designing tests
Suggesting hypotheses
Selecting equipment
Practical skills (dexterity and manipulation)
Reasoning logically

4 Assessing
validity
relevant factors
accuracy
references

5 Communicating:
graphs
writing
speech
diagrams
maths

6 Applying knowledge
Assessing ideas
Evauating results

Assessment

At the end of each chapter is a Summary table. The processes and skills covered by each section are listed together with possible tasks and activities which should demonstrate the level of understanding achieved by the pupils. They are written in ascending order of difficulty and are intended to offer further opportunities for pupils to practise the associated skills. Tests can be conducted by asking for written answers, for homework, or orally working

in small groups or with the whole class. They are intended to provide teachers with a formative assessment strategy.

The assessment cards which are part of the package of work-sheets are planned to provide ideas for summative assessment. They offer the teacher a variety of tests and projects for each chapter and will help towards effective assessment of pupils' performance. They are aimed to give flexibility in use. They could be used on an OHP or duplicated either in part or in their entirety for an end of term test or when a topic has been completed. In most cases, the pupils will require paper on which to answer the questions. The questions are varied and include objective questions, structured questions, and questions using mathematics. Each card includes a suggestion for a project or course work investigation. Many of the questions have no one right answer. Pupils should be encouraged to consider a range of possibilities. For this reason no answers are provided for questions on the assessment cards.

This is a pattern of assessment common to the four texts in the Nuffield series which together form a complete assessment strategy for Home Economics.

CHAPTER 1

How much food do we waste?

Before looking in detail at changes taking place during storage, preparation, and cooking of various foods, it would be useful for pupils to take an 'overview' of foods as a resource. This first chapter aims to remind pupils that part of our food is not consumed by humans. It shows how food waste occurs and how it may be reduced. It also indicates how food waste may be utilized or disposed of in an acceptable way. This chapter has some links with *Nutrition* Chapter 1.

Time allocation
Section 1.1: 5 minutes; 1.2: 20 minutes; 1.3: 20 minutes; 1.4: 20 minutes; 1.5: 10 minutes; 1.6: 5 minutes; 1.7: 5 minutes (total 85 minutes). To tackle this work within a lesson of 70 minutes, sections 1.2, 1.3, and 1.4 could be organized as group work.

Extension work in this chapter
Section 1.1: further calculations on feeding waste food to pigs.
Section 1.3: comparing different methods of preparing salads and soups.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM15 Food packaging
FSM16 Quality assurance
FSM17 Assessment card

1.1
POTATO PEEL, PIGS, AND PEOPLE

Main idea in this section

Waste food can be recycled.

This section introduces the concept of food waste and its potential as a foodstuff for animals. An experiment carried out at Caterham School, Surrey is briefly described. Pupils in the school's ecology group reared pigs using food waste from the kitchen as a source of food. The pigs were finally slaughtered, butchered, and used by the school kitchens to provide school meals, so the waste was recycled. The four carcasses weighed a total of 218 kg.

Q 1

Applying knowledge

Dry matter remains when all the moisture has been drawn off from the food or food waste. This is normally done by drying it in an oven. The nutrients will include proteins, fats, carbohydrates, vitamins, and minerals.

Q 2 and table 1.1

Communicating (maths)

Age of pigs: 10 weeks
Dry matter required: 1.2 kg per day
Amount of food waste required: $\frac{1.2}{20} \times 100$ kg
= 6.0 kg per day
= 42.0 kg per week
Amount required for 4 pigs = 168.0 kg per week

In the experiment, each pig consumed on average about 1.4 kg of dry matter per week, obviously eating more food as they grew larger.

Extension work

Using references

Table T1.1 may be used with *table 1.1* to answer questions like these:

How many kilograms of the following foods are needed to provide 1 kg of dry matter? boiled cabbage; boiled peas; boiled potatoes.

If you were feeding 10 pigs, with body weights of 59 kg each, how much of the following materials would you require? bread; apples; boiled beans.

Table T1.1
The percentage of dry matter, protein, and fat in various foods.

Food	Dry matter (%)	Protein (% of dry weight)	Fat (% of dry weight)
White bread	60.0	14.5	2.1
Rice (polished)	30.0	5.5	0.0
Cheese	63.3	42.1	52.6
Milk	13.3	25.0	27.5
White fish (cooked)	23.0	91.3	4.3
Leafy vegetables (boiled)	10.0	30.0	0.0
Potato (boiled)	26.6	8.0	0.0
Peas or beans (boiled)	20.0	25.0	0.0
Peas or beans (dry)	86.6	27.0	0.0
Apples	45.8	0.9	0.0

Which combination of food waste offers the best feed value?
Boiled potato and rice
Applying knowledge — Boiled peas and rice pudding with milk
Boiled cabbage and apples.

A fruit farmer had a large excess of windfall apples and decided to buy some 10-week-old pigs to eat them. Would the pigs thrive on this diet?

1.2
WHAT IS WASTE?

Main ideas in this section

There are a number of different categories of rubbish, including food waste.

Packaging used for food has functional and non-functional attributes.

Different categories of people consume (or do not consume!) different types of food.

People may eat both 'fresh' and processed food.

The aim of this section is to use a novel approach to stimulate the pupils into discussing the above ideas and to consider the reasons why food is wasted. It should stimulate the discussion of questions concerning the use of the family budget and food preferences as well, which links with *Nutrition* Chapter 1.

Interpreting data — *Figure 1.2 and Q 3*
Food waste is at least 18 per cent of total household waste.
Assessing (validity) — Packaging accounts for over half the waste. The pupils should criticize the method of classification and realize its arbitrary nature.

Q 4
Reasoning logically — The pupils should question whether packaging is needed for its functional properties alone. Worksheet FSM 15 may be useful.

Figure 1.3
Assessing (references) — Note the following points.
1 A number of similar types of food are eaten by many different categories of people.
Classifying — 2 There are differences in the preferences of different categories of people.
Communicating (speech) — 3 Processed foods are eaten by people from all districts.
4 People may throw away 'untouched' food. Discuss why people throw food away.
Reasoning logically — 5 If edible food is wasted, it costs money and it produces more waste for disposal by the local authority.

Assessing (validity)

The limitations of this type of survey should be understood. Some families may make and eat 'jacket potatoes' with virtually no waste, and there would be no obvious signs that these had been chosen. The choice of dustbins and their contents are a random example taken by the reporter. Pupils could discuss the point that this may not show the complete range of types of food eaten, and that a much larger survey would be needed to produce statistically significant results. The areas in the survey provide a crude geographical and socio-economic spread.

Q 5

Communicating (maths)

This bar chart develops the idea of staple foods that are consumed by many people.

Q 6

Assessing (relevant factors)

a People may decide their food purchases taking a number of factors into account: preference, cost, availability, and so on. Fresh foods may be cheaper in season, but they take longer to prepare and are not always available.

Analysing (data)

b Processed vegetables (canned, frozen, and dried) are eaten by a lot of people.

Q 7

This explores the reasons for food being thrown away.

Q 8

Reasoning logically

The higher the wastage, the less food is available for consumption. To consume the same amount will cost more if wastage is high. Wasted food has to be disposed of, and this may cost money.

WHAT IS THROWN OUT AS RUBBISH IN A HOME ECONOMICS LESSON?

Practical skills

This practical exercise allows pupils to undertake their own waste survey. The ideas developed previously are reinforced. Safety and hygiene should be stressed. Hand washing and clearing up are important. Preferably, fresh waste should ⚠ be examined. Certainly it should be no older than one day. If it is necessary to store it overnight, it should be kept at a low temperature.

You will need for the class

Rubber gloves
Plastic sheet or newspaper
Plastic rubbish bags
Scales

Q 9

Communicating (speech)

The answer will depend on the pupils' own results. Discuss the waste of food in processing, such as scraps of unwanted raw pastry.

1.3
MEASURING WASTE FROM VEGETABLE AND FRUIT PREPARATION

Main ideas in this section

The preparation of fruits and vegetables produces waste.

The amount of waste depends on the type of vegetables and fruit used and the method of preparation.

You will need for each pair of pupils

500 g potatoes
Washing-up bowl
Vegetable brush
Scales
Vegetable knife
or peeler
or electric mixer with potato-peeling attachment

Designing tests

By measuring the weight of potatoes after washing and again after peeling, pupils can compare the contributions of dirt (inedible) and skin (might be eaten if clean, depending upon cooking method) to preparation waste.

Measuring

Peeling methods should be selected to show differences in yield. As skill in the use of a knife or peeler can vary amongst pupils and affect results, the class should discuss how this factor might be overcome. Methods giving high yields may not be the quickest, and a discussion about priorities may be necessary.

Deciding criteria

Analysing (data)

The figures from *table 1.2* can be used to compare class results for potatoes and to demonstrate the wide range of preparation waste amongst vegetables and fruits. The limitations of these comparisons should be pointed out to pupils. We know nothing, for example, about the preparation methods used or the weight and condition of the starting material.

Assessing (validity)

Reasoning logically

Class discussion can be extended to include other factors which influence yield of potatoes, such as size of potatoes (surface area : volume ratio), and the fact that new potatoes can usually be scraped so the percentage yield might be expected to be higher than from old potatoes.

Q 10 and Q 11

Answers will depend on pupils' own results. Worksheet FSM 1 should be useful here.

Q 12

Evaluating

This introduces the consideration of speed in preparation.

Extension work

Designing tests

More able pupils could carry out exercises on preparation of salads and soups. They could compare percentage yields. Comparisons of different raw materials and preparation methods could be made.

1.4
USING CANNED FRUITS OR VEGETABLES

Main ideas in this section

The waste involved in the production of a dish varies depending on whether fresh or prepared ingredients are used.

The cost, appearance, and food value also vary.

Practical skills

You will need for each pair or group of pupils

2 oranges
2 grapefruit
Vegetable knife
Chopping board
Jug
Can of mandarin oranges
Can of grapefruit segments
Can opener
6 bowls
Scales
Strainer

Q 13

There is no inedible material in a can, although excess syrup may be thrown away, if it is not used for other dishes. The can itself becomes waste.

Q 14, Q 15, and Q 16

Assessing (relevant factors)

Evaluating

When the food manufacturer prepares a product there is increased convenience (less preparation time, less washing up) but usually greater cost per unit of edible fruit. The eating qualities of the processed product will be different from those of the fresh product. These may or may not be equally acceptable, depending upon individual taste. This idea is developed further in Chapter 3. Many fresh fruits and vegetables are not always available whereas processed forms are.

Reasoning logically

Bearing these facts in mind, pupils can discuss when they would use fresh or processed fruits and vegetables.

Applying knowledge

Analysing data

Manufacturers have preparation waste as well, but their machines are designed to give maximum yield whereas preparation losses at home will vary because of differences in the skill of the 'cook'. Pupils may also calculate the inedible waste from the table. This may be used to stimulate a discussion on what is edible and inedible, and food likes and dislikes.

1.5
PLATE WASTE

Main ideas in this section

There is an inverse relationship between the popularity of a food and its plate waste.

The more popular a food is, the less the plate waste will be.

This is important in the case of vegetables.

Portion control is a form of quality control and can help to cut down waste, which saves food resources and money. Portions should vary according to customers' requirements.

Table 1.3
This shows how popular various vegetables are. ('Scalloped potatoes' are sliced, put in a flat dish with cheese on top and milk added, and baked.)

Q 17

Analysing (data)

This question encourages pupils to draw inferences from *table 1.3*.

Q 18

Classifying

This encourages pupils to see that the various methods of preparation and cooking of a popular vegetable, the potato, have a considerable influence on plate waste.

Q 19

Suggesting hypotheses

More information may be necessary if correct conclusions are to be drawn from a table of figures. The high percentage plate waste for macedoine may be due to over-generous portions being served or to its being unpopular. More than likely a combination of both factors is involved.

Q 20

The introduction of the idea of portion control is important. This may be developed into the general concept of quality control which is applicable to all areas of home economics. This also applies to the idea of varying the quantity and type of product according to the needs and wants of the consumer. Worksheet FSM16 may be useful here.

Q 21 and Q 22

Designing tests

To measure plate waste, pupils will need a balance. They may use the following method.

Measuring

1 Weigh each item of food after a portion of it has been put on the plate and record the weight as shown in table T1.2.

Organizing data

2 After each course has been eaten, weigh the plate waste from each separate item and record the result.

Communicating (maths)

3 Calculate the plate waste as a percentage of the item as served.

$$\frac{\text{Plate waste of item}}{\text{Weight of item before eating}} \times 100 = \text{Plate waste as a \% of item as served.}$$

Table T1.2

Item	How cooked	Weight when served (g)	Weight of plate waste (g)	Plate waste (%)
Potato	boiled	160	20.0	12.5
Potato	chipped	150	1.5	1.0
Peas	boiled	50	7.0	14.0

Pupils should be able to see the advantage of carrying out a more representative survey over several days. Worksheet FSM 1 would encourage consideration of the method used to measure waste.

1.6
FOOD THAT NEVER GETS TO US

Main ideas in this section

Some fruits and vegetables are not sold because they are the wrong size or shape or because the cost of harvesting would not be recovered from sales.

Some vegetables and fruits are damaged by machinery and equipment.

Disease may cause loss of food crops.

Food may also be wasted if incorrectly stored.

Q 23

Applying knowledge

Communicating (speech)

Pupils should consider whether storage of vegetables in a warm kitchen provides optimum conditions. Some pupils may discuss the length of time that these commodities can be stored when fresh, canned, or frozen at various temperatures. Extended shelf-life might also be discussed as an aspect of convenience. (See *The Basic Course*, Chapter 7.)

You could discuss the so-called 'mountains' and 'lakes' of surplus food produced within the E.E.C. at this point.

1.7
RECYCLING WASTE

Main ideas in this section

Waste may be recycled by using it as animal feed.

Vegetable waste may be made into compost.

Compost will enrich the soil for future crops.

Processes and skills	Pupils may be able to:
1.1 *Potato peel, pigs, and people* Assessing (relevant factors). Assessing and interpreting reported or recorded data. Applying knowledge.	 Recognize that food waste can be recycled and used as animal feed. Calculate the amounts of waste used. Recognize that the percentages of protein and fat content in the dry matter in food waste vary, and that this can affect the growth of pigs.
1.2 *What is waste?* Interpreting data, classifying information. Assessing reported or recorded information. Designing tests, deciding criteria. Using practical skills, estimating, measuring, communicating (writing).	 Identify the types of rubbish collected in the newspaper survey of dustbins. Classify it into two groups: food waste and non-food waste. Discuss the reasons for the varying amounts of food waste recorded. Discuss the social implications of the evidence. Carry out a survey of own kitchen waste and compare it with a media report.
1.3 *Measuring waste from vegetable and fruit preparation* Measuring, recording data, expressing observations in mathematical terms. Performing practical work skillfully, efficiently, and safely. Drawing conclusions from observations.	 Identify what is wasted during production and preparation of potatoes. Discover that varying methods and degrees of efficiency and skill can affect the percentage of waste. Apply this knowledge to other systems of food preparation and production.

Processes and skills	Pupils may be able to:
1.4 *Using canned fruits or vegetables* Measuring, recording data, and translating observations into mathematical terms. Observing objectively and distinguishing between observation and inference.	Recognize that there is waste involved in the use of canned foods. Compare the percentage waste of canned foods with that of fresh foods. Discuss and compare costs, convenience, and acceptability of fresh and canned foods.
1.5 *Plate waste* Identifying and suggesting possible explanations for trends in data, and fallacies that might lead to misleading conclusions. Designing practical, workable, and reliable experiments.	Recognize that food which is not eaten (*i.e.* plate waste) is wasted food. Compare the measured plate waste of selected vegetables from a school canteen. Suggest reasons for this waste, and how it might be reduced. Set up experiments to monitor plate waste in other situations.
1.6 *Food that never gets to us* Identifying causes, using references, reasoning logically, applying knowledge.	Recognize that waste is an inevitable factor in food production. Trace possible causes of waste from farmer to consumer. Discuss ways of reducing this waste.
1.7 *Recycling waste* Applying knowledge.	Design a flow diagram showing possible recycling of waste. Relate knowledge of the feeding of pigs to that of feeding other animals. Explain the making and use of compost.

The utilization of kitchen waste for animal feed has been introduced in section 1.1. The idea of recycling is extended to include composting (illustrated by *figure 1.6*), and the ploughing back of crops.

Link with school science
Pupils may already have learned about carbon and nitrogen cycles in chemistry or biology. You could draw on this to explain compost making and ploughing back. The idea of complex food webs may also have been introduced elsewhere and could be useful here. (See also the Background reading for this chapter.)

Q 24
Compost will enrich the soil, by adding nutrients. It will also help it to hold moisture. This promotes the growth of future crops.

Q 25
The activity of micro-organisms in decaying vegetable matter will result in the release of energy as heat. The higher temperatures which result will promote the activity of the micro-organisms and hence rotting.

Q 26 and Q 27
Applying knowledge
Some of the sources of food waste described in section 1.6 are reintroduced here. In general, these materials may be ploughed back or otherwise reincorporated into the soil, or converted into animal feed. Crops may be ploughed back when too much of a particular commodity is produced and the farmer cannot sell it at an economic price.

Q 28
Pig swill is waste material which has been boiled for an hour to kill off pathogenic bacteria such as *Salmonellae*. Usage of swill is determined by economic factors such as availability, transport, and costs of sterilizing. The heat treatment of swill in the United Kingdom is required by the *Diseases of Animals (Waste Food) Order*, 1973. References to the experiment described in section 1.1 may be made at this point and the need to boil up kitchen waste before it was fed to the pigs.

Idea for homework
Ask pupils to check the waste that their own household produces, and to suggest some ways of reducing it.

Suggesting hypotheses
The Background reading is about what happens to food that is thrown away. The pupils will probably have learned about food webs in biology. They could be asked to find out (or speculate about) what happens to food they themselves throw away.

CHAPTER 2

Unwanted changes in fruits and vegetables

This chapter investigates the activity of enzymes in foods, particularly fruits and vegetables. An understanding of the characteristics of enzymes and the methods of controlling them is developed.

Time allocation
Sections 2.1 and 2.2: 20 minutes each (with observations continuing until the end of the lesson); 2.3: 30 minutes; 2.4: 15 minutes; 2.5: 15 minutes (with final assessment after a few weeks); 2.6: 15 minutes (total 115 minutes).

Sections 2.1, 2.2, and 2.3 are experiments which may be carried out either in sequence or concurrently.

Sufficient time must be allocated to section 2.4, as it ties together the loose ends from previous sections. This might be done after sections 2.1, 2.2, and 2.3. Alternatively it could introduce the sections on blanching (2.5) and food preservation (2.6). More time will be required for sections 2.4, 2.5, and 2.6 if pupils are unfamiliar with enzymes or when the accompanying worksheets are used.

Extension work in this chapter
Section 2.1: making a fresh fruit salad.
Section 2.2: testing the effect of citric acid on apple browning.
Section 2.3: testing whether water helps to slow browning when liquidizing.
Section 2.4: looking at cell structure.
Section 2.6: examining food labels to see which foods contain sulphur dioxide.

Worksheet and Assessment card Masters
FSM2 Acids, bases, pH
FSM6 Proteins
FSM8 Enzymes
FSM14 Taste panels
FSM18 Assessment card

2.1
WHICH FRUITS AND VEGETABLES TURN BROWN?

Main ideas in this section

The cut surfaces of some raw fruits and vegetables go brown.

Browning happens at different rates for different fruits and vegetables.

Fruits and vegetables which have gone brown look unsightly.

Traditional methods used to prepare fruits and vegetables may help to stop or slow down browning.

Pupils work with a selection of fruits and vegetables and compare their browning rates.

You will need for each pair or group of pupils

Different fruits and vegetables, depending on what is available	Kitchen knife Chopping board

Choice of ingredient will partly depend on cost, season, and availability. Less familiar fruits and vegetables might be included to increase the pupils' experience of foods, and because some of them brown more rapidly than cheaper materials.

Practical skills

Observing

Assessing (relevant factors)

Measuring

Browning rates can be unexpectedly slow, so if possible the cut material should be examined after several hours. When time is short, select material carefully to make it easier to differentiate degrees of browning. If several pupils or groups of pupils work with the same food they can check their results. Ensure that the same variety of fruit or vegetable is used throughout, as browning rates can differ between varieties. For example, Bramley apples brown more rapidly than Granny Smiths. Before starting the experiment, pupils should discuss how to describe the extent of browning. B.S.I. standard No. BS 3999: Part 5C (shade chart), includes coloured cards ranging from pale to deep brown which could be helpful. Alternatively, a comparison chart using coloured cut-outs or poster paint might be devised beforehand. It is essential to measure time and record results accurately.

Q 1

Evaluating results

Discuss the practical significance of very slow browning rates in the culinary preparation of fruits and vegetables. Oranges, grapefruit, and cucumbers do not brown at all and can be prepared long in advance.

Extension work

Designing tests

Do apples and pears go brown in fresh fruit salad? This investigation links well with practical food preparation.

You will need for each pair or group of pupils

Applying knowledge

Apple (red-skinned)
Pear
Banana
Grapes (optional)

for the syrup
125 ml water
50 g sugar
Juice of one lemon
Lemon rind parings

Pupils could also investigate fruit salad made with and without lemon juice. Keeping qualities and flavour could be examined.

Q 2 and Q 3

Applying knowledge

Covering peeled potatoes and apples with water does slow down browning. Lemon juice also slows down browning. This is further investigated in section 2.2.

Q 4

Identifying causes

Apple sauce, when properly prepared, has no brown colour. Perhaps cooking, or sugar, or both, stop the enzymic browning process? (Prolonged heating may cause sugar in the sauce to caramelize and brown. This should be distinguished from enzymic browning.)

2.2
CAN BROWNING BE SLOWED DOWN?

Main idea in this section

Enzymic browning can be controlled by immersion in water and by immersion in different solutions *e.g.* lemon juice, sugar syrup, and sulphur dioxide in water.

Link with school science

The investigation provides a good illustration of the usefulness of the pH concept and, at a different level, of the action of enzymes. Metabolic pathways are defined by the activities of many enzymes, each of which is usually specific to a particular substance or reaction. The investigation gives an indication of the sensitivity of enzymes to small changes in ambient conditions.

Assessing (references)

The pupils investigate the effects of water and other solutions on the browning rate of apples. These methods of controlling browning are related to domestic food preparation.

You will need for each pair or group of pupils

Apple (large)
Lemon
50 g sugar
Universal Indicator solution
½ Campden tablet (sulphur dioxide)
Self-adhesive labels
Kitchen knife
2 chopping boards
Plate for waste
4 10-ml (dessert) spoons
4 500-ml beakers or measuring jugs
4 test-tubes and rack

Bramley cooking apples brown rapidly. If possible, the samples should be left for one day before final examination. The term pH may need clarification. Worksheet FSM 2 could be used. The colours are best viewed with a white backing when testing pH.

Practical skills

Designing tests

The need for a control against which the results of different treatments can be compared is introduced. Pupils should measure the browning time of apple samples treated with water alone and completely untreated.

Deciding criteria

Evaluating results

Table T2.1
The likely pH of the test solutions.

Solution	Colour with Universal Indicator	pH
Tap water	yellow—green	7
Sugar syrup	blue—green	8
Lemon juice	red	3
Sulphur dioxide	red	3

Q 5

Observing

The apple can be expected to brown in the following order: untreated in water, in sugar syrup, in lemon juice, in sulphur dioxide. These results should be confirmed by several sets of results showing the same pattern, and by leaving the experiment for as long as possible.

Q 6

Applying knowledge

Yes. Peeled potatoes and sliced apples are stored under water (or salted water). It acts by excluding air.

Suggesting hypotheses

Identifying causes

Substances dissolved in the water reduce its capacity to dissolve air, so sugar syrup helps to control browning as well as contributing to taste. Lemon juice is used in making fruit salad and for stopping discolouration of avocado pears. It is effective for a number of reasons. It contains water. Citric acid and other weak food acids in it give acidity (low pH). Ascorbic acid (vitamin C) is an effective anti-oxidant. The acids present, together with essential oils, impart a flavour which is acceptable to most people.

Campden tablets contain sodium metabisulphite, and when dissolved in water give a solution of sulphur dioxide. This is a preservative which is widely used in the food industry to inhibit micro-organisms and enzymic activity. Campden tablets are used in home wine and beer making to 'sterilize' equipment and to kill yeast cells and spoilage micro-organisms once fermentation has ceased.

Extension work

Testing the effect of citric acid on apple browning: this experiment isolates the effect of one ingredient of lemon juice. The effect of citric acid at different concentrations can easily be determined. Follow the procedure given in section 2.2. Citric acid is effective because it has a low pH value in solution. The optimum for browning enzymes is between 5 and 7.

2.3
DOES CUTTING METHOD AFFECT BROWNING?

Main idea in this section

The way a raw fruit or vegetable is divided affects the speed at which it browns.

Pupils investigate the relationship between the process used to divide apple and the speed at which it browns.

You will need for each pair or group of pupils

3 medium cooking apples
3 self-adhesive labels
3 white soup plates
Vegetable peeler
Chopping board
Food liquidizer

Designing tests

Bramley cooking apples are suitable. Two apples for purée are suggested to avoid difficulty with small quantities in the liquidizer. Adding water makes liquidizing easier but alters the conditions of the experiment. This is a point for the pupils to discuss. The extent of browning is estimated as before.

Assessing (relevant factors)

Q 7

Observing

a The apple can be expected to brown in the following order: liquidized sample, cut surface, broken surface. Broken surfaces will normally brown more slowly than cut surfaces because the breaks tend to occur between cells and so their contents are not exposed to air.

Suggesting hypotheses

b At this stage, enough evidence has accumulated to attempt to explain the browning of raw apple. Damaging the tissues and/or opening them to air are obvious suggestions. (Note that bananas brown readily without being cut, and apples go brown when they are bruised.) Liquidizing apple shows that the greater the division of the tissue and the greater the exposure to air, the greater the extent of browning. However, some fruits and vegetables do not brown on cutting and exposure to air. Is there something in tissues which brown which is absent in non-browning fruit and vegetables? This discussion is extended in section 2.4.

Communicating (speech or writing)

Extension work

Does the addition of water and other solutions help to slow browning when liquidizing? The procedure is the same as in section 2.3. Before starting, the pupils should appreciate the following points. The same weight of apple (prepared by the same procedure) is necessary for each experiment. A measured volume of water is used. The same volume of water plus weighed solute is used. A control is important.

Designing tests

Reasoning logically

Liquidizing breaks up the tissues very finely. Water protects them from the surrounding air to some extent. Browning is controlled very effectively by water and ascorbic acid since the latter combines with oxygen in its role as an anti-oxidant and so removes oxygen. The natural acidity of apples does not protect raw apple from browning rapidly when liquidized.

2.4
WHY DO SOME FRUITS AND VEGETABLES TURN BROWN?

This is a difficult section. It reviews the previous three sections and experiments.

Main ideas in this section

Fruit and vegetable tissue has a cellular structure.

Damage to the cell wall exposes the cell contents to air (oxygen).

Polyphenols in the contents react with atmospheric oxygen. Polyphenol oxidase enzymes catalyse this reaction.

Reactions which follow this change end with the production of brown substances.

Observing

Assessing (relevant factors)

In this section pupils learn that damage is done to apple cell structure by liquidizing it. They appreciate, in simple terms, what happens when browning takes place. This enables them to explain the results of earlier experiments. *Figure 2.4* shows photomicrographs of apple cells. Worksheet FSM8 should be introduced to reinforce the importance of enzymes in the browning reaction and to aid explanation of methods of control. Worksheet FSM6 is also appropriate.

Extension work

Observing

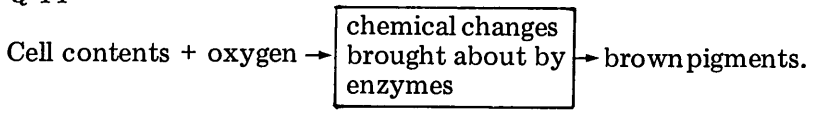
Cell composition is looked at more closely in Chapter 3, but pupils could learn about cell structure in other fruits and vegetables now. Onion tissue is very easy to work with.

Q 8, Q 9, and Q 10

Identifying causes

These introduce the idea that cell damage has occurred and that cell contents are brought into contact with oxygen in the air. This may explain the results of the experiment in section 2.3.

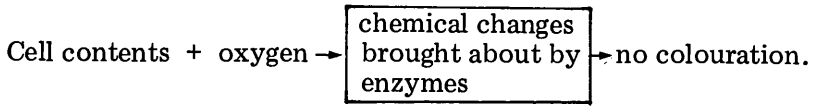
Q 11



Q 12 and Q 13

Reasoning logically
Deciding criteria

There are two methods of controlling browning. These are the exclusion of reactant (oxygen) and slowing or stopping enzyme activity. This information may be superimposed on the previous diagram.



Suggesting hypotheses

The non-browning of some fruits and vegetables might be explained by the absence of the necessary enzymes or of particular components of the cell contents.

Q 14

Communicating (writing)

By way of reinforcement, pupils may now be asked to describe in their own words the process of enzymic browning and to explain the methods used for its control. They could do this for homework.

2.5
BLANCHING FRUITS AND VEGETABLES

Main idea in this section

Blanching improves the storage life of frozen vegetables by inactivating enzymes which eventually would spoil the food and by killing micro-organisms.

Practical skills

The pupils are given practical experience of blanching and freezing Brussels sprouts. The effect of blanching on the vegetable's organoleptic qualities is emphasized, and the principles are applied to other vegetables.

You will need for each pair or group of pupils

250 g fresh Brussels sprouts
2 freezer bags and seals to hold the prepared Brussels sprouts
2 labels
Large bowl half-filled with cold water and ice cubes
25 g salt
Kitchen knife
Chopping board
Large saucepan with lid
Blanching basket
Colander
Timer
Access to deep freeze

This is an opportunity for pupils to follow written instructions exactly. The need to control times, temperatures, and quantities accurately is brought out. The blanching time for sprouts

Designing tests

depends on their size. The inactivation of enzymes in the centre of large sprouts will take longer than small ones. Discuss this before starting practical work. If Brussels sprouts are not

Communicating (speech)

available, peas and beans provide a suitable alternative for freezing. Discuss the method to be used. Peas and beans would be less suitable for organoleptic evaluation as they spoil more

Deciding criteria

slowly. Assessment of the blanched and unblanched samples can be a comparison of overall acceptability. Alternatively, separate aspects (colour, smell, taste, texture, and overall acceptability) can be scored.

Evaluating results

The link between organoleptic quality and blanching is easy to establish using Brussels sprouts, since unblanched frozen sprouts deteriorate quickly. Changes include loss of bright green colour, development of browning and 'off' flavours, and softening. Worksheet FSM14 will help with the assessment of quality.

Q 15

Observing

The fruits and vegetables in *figure 2.5* have been spoiled by micro-organisms. They are most commonly attacked by moulds, but bacteria rot and yeasty fermentations sometimes cause problems. In each case, the microbe digests the host plant by secreting enzymes.

Q 16 and Q 17

Blanching greatly reduces the microbiological flora on the surface of the fruit or vegetable. Reductions of initial microbial loads as high as 99 per cent have been claimed.

Q 18

Designing tests

Since apples brown so readily, they are especially difficult to freeze. Pupils could be asked to consider the following recipe.

Communicating (speech)

1 Peel and core apples, removing any blemishes.
2 Slice them into salt solution (1 20-ml spoon of salt to 2 litres water). Do not leave them in this solution for more than 10 minutes. Rinse well on removal.
3 Cook apples in sufficient water to prevent sticking.
4 Cool and then pulp the apples. Sweeten to taste, stirring in the sugar very gently.
5 Fill moisture- and vapour-proof containers to the top. Seal and freeze.

Table 2.1

This shows the blanching times for some vegetables.

Q 19

Applying knowledge

a A longer time would be needed to penetrate a beetroot than a runner bean because it is thicker.
b The time depends on the size.

Q 20

Selecting equipment

These questions show that specialized equipment and materials are not essential.

Q 21

In addition to inactivating enzymes, the surface micro-flora of vegetables is partially destroyed on blanching. This improves the quality and storage life of frozen vegetables.

Interpreting data

From *figure 2.7*, unblanched frozen peas and carrots store well. Unblanched Brussels sprouts do not. Blanched vegetables all store better.

Another oxidase enzyme whose activity it is important to stop is ascorbic acid oxidase. This decreases vitamin C content. Other types of enzymes which are affected by blanching include pectinases. They break down pectin, causing the fruit or vegetable to become softer and overripe. The texture of fruits and vegetables is further discussed in Chapter 3.

2.6
ENZYMES AND FOOD PRESERVATION

Main idea in this section

The methods used by the food manufacturer to control enzyme activity are based on the same principles as those used in the domestic kitchen.

Enzymes are made of protein which is denatured at temperatures above about 65 °C. Their activity then ceases. The temperature of optimum activity is usually between 30 °C and 40 °C. Activity is reduced at lower temperatures, and at −30 °C their effect has almost ceased.

Deciding criteria

Applying knowledge

Frozen foods are usually stored at −18 °C or below. Enzymes can continue to act at low temperatures, so they may cause problems in frozen foods. The storage temperature for chilled foods is between 0 °C and 5 °C. We generally regard chilled foods as 'fresh', not preserved, and we do not expect them to stay in good condition for long. Usually no attempt at all is made to control enzymic activity in chilled foods. But chemicals may be used, for instance, to preserve some fruits in making fruit yoghurts.

Q 22

Canned and bottled foods are mentioned in the pupils' text. These are processes involving the denaturation of enzyme protein by the application of heat. (See worksheet FSM 8.) During these processes, canned and bottled foods will be partly cooked.

Dried fruits and vegetables are also mentioned. Enzymes are active only when they are completely surrounded by water. Live cells are often as much as 95 per cent water. Enzymes act more slowly as the material they are in gets drier. When foods are dried they may contain less than 5 per cent water.

Applying knowledge

Q 23

Many drying processes themselves provide ideal conditions for enzymic activity. When foods are dried in the sun, or in hot air tunnels, the foods get warmer as the water in them evaporates. At temperatures below 65 °C enzymic activity can be very fast, so for many foods it is necessary to inactivate the enzymes first. This is done either by blanching the food or by treating it with an enzyme-inhibiting chemical, usually sulphur dioxide. Without these pre-treatments, dried potato and apple would be brown and not very good to eat. Chemical preservatives may stop enzymic reactions by inactivating the enzyme or by 'removing' one of the reacting chemicals.

Identifying causes

Figure 2.8

This photograph shows commercial products in which enzymic activity has been prevented by the use of sulphur dioxide.

Extension work

Pupils could examine the contents labels for a wide variety of fruit products. In the following lesson, pupils could gather the data together and identify the products likely to contain sulphur dioxide for the control of enzymic activity.

Analysing (data)

Table T2.2
Some foods commonly preserved using sulphur dioxide, and the legally prescribed limits to its use.

Food	Sulphur dioxide not exceeding (mg/kg)
Candied peel	100
Cider	200
Grapes	15
Fruit juices	350
Fruit (not fresh)	350
Garlic (powdered)	2000
Jam	100
Potatoes (raw, peeled)	50
Cabbage, dried	2500
Potato, dried	550
Fruit yoghurt	60

Q 24

Communicating (writing)

Pupils should be able to complete the table of methods of controlling enzymes (see table T2.3). Draw attention to the

Processes and skills	Pupils may be able to:
2.1 *Which fruits and vegetables turn brown?* Observing and measuring. Performing practical tasks efficiently and safely. Reasoning logically, observing, evaluating results.	Prepare for study and observe the browning rates in a variety of fruits and vegetables. Compare the results. Link this knowledge with the previous practical experience of preparing fruits and vegetables.
2.2 *Can browning be slowed down?* Observing, applying knowledge. Designing and carrying out reliable experiments; separating variables and testing them individually.	Recognize that there are factors which affect the browning rate in fruits. Suggest practical steps which might be taken to inhibit browning during the preparation of food. Control the rate of browning of fruit and vegetables by increasing the acidity or the strength of the sugar solution, or by the use of sulphur dioxide (Campden tablets).
2.3 *Does cutting method affect browning?* Performing experimental work efficiently and accurately. Suggesting hypotheses, designing tests, communicating (writing).	Observe the effect of various methods of breaking, cutting, and liquidizing apples. Recognize that there are variations in browning rates between fruits when they are cut or broken in different ways. Discover that the greater the area of the cut surface, the more browning occurs.

Processes and skills	Pupils may be able to:
2.4 *Why do some fruits and vegetables turn brown?* Selecting and organizing data. Suggesting hypotheses, identifying causes. Using reported information.	Examine cells of vegetables and fruits under the microscope. Observe that browning takes place when cut surfaces of apple come into contact with air. Understand that this browning is the result of changes brought about by enzymes and oxygen. Apply this knowledge of enzymic activity to previous sections of this chapter.
2.5 *Blanching fruits and vegetables* Designing and performing practical work safely and efficiently. Observing, evaluating, applying knowledge, reasoning logically, drawing conclusions.	Blanch fruits and vegetables efficiently. Appreciate the reasons for varying lengths of blanching times. Apply this knowledge to the blanching of sprouts. Test this by setting up an experiment with blanched sprouts and untreated sprouts.
2.6 *Enzymes and food preservation* Observing, identifying causes. Reasoning logically, using practical skills, applying knowledge.	Know that enzymes control the chemical reactions in living plant cells, *e.g.* browning. Recognize that these reactions include ripening followed by decay of the food, and apply this knowledge to the process of freezing. Carry out blanching and freezing of a variety of fruits and vegetables. Be able to use sulphur dioxide in the form of tablets. Apply their knowledge of blanching to fruit and vegetables.

widespread application of relatively few controlling methods. Worksheet FSM8 will again be useful.

Table T2.3

Method of controlling enzyme	Examples
Destroying (denaturing) by heating	blanching, canning, bottling, pasteurizing
Using low temperatures	refrigerating, chilling, freezing
Changing the pH	using lemon juice with apples, pickling fruits and vegetables in vinegar
Removing reactants, *e.g.* oxygen	vacuum packing, using antioxidants *e.g.* ascorbic acid, covering with water
Adding preservatives	using sulphur dioxide
Removing water	drying fruits and vegetables, preserves

Evaluating results

The relationship between an understanding of enzymes and control of enzymic activity at both commercial and domestic levels should be the main themes for a concluding discussion of the chapter.

Idea for homework

Using references

Ask pupils to find recipes for preserving fruits and vegetables in the home.

Question 14 is suitable for homework.

Using references

The Background reading tells pupils more about the ways in which fruit and vegetables are treated to ensure that they are fit to be sold. Pupils could find out about how fruits such as pineapples and bananas are grown, processed, and transported. Enzymic activity in pawpaws and pineapples is discussed again in Chapter 5, in relation to the tenderizing of meat.

CHAPTER 3

Cooking fruits and vegetables

In this chapter, the changes brought about in cooking fruits and vegetables are investigated. An understanding of the control of quality of the cooked product is developed. (This topic was introduced in *The Basic Course*, Chapter 1.)

Time allocation
Section 3.1: 10 minutes; 3.2: 25 minutes; 3.3: 15 minutes; 3.4: 15 minutes; 3.5: 20 minutes; 3.6: 15 minutes (total 100 minutes).

Section 3.6 might be given as homework if the tasting session were eliminated, but it requires adequate discussion.

Extension work in this chapter
Section 3.4: investigating the changes in the pigments in cabbage when cooked in water with various pH values; investigating carrots in the same way.
Section 3.6: visiting a fruit and vegetable processing factory.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM2 Acids, bases, pH
FSM4 Carbohydrates II
FSM7 Cells
FSM14 Taste panels
FSM16 Quality assurance
FSM19 Assessment card

3.1
CHANGES WHEN FRUITS AND VEGETABLES ARE COOKED

Main idea in this section

Raw and cooked vegetables have different textures and may have different flavours and colours. Both may be incorporated in menus.

The aim of this section is to help the pupils to appreciate these differences and to be aware that some fruits and vegetables can be acceptable either cooked or raw.

Q 1 and Q 2 and figures 3.1, 3.2, and 3.3
These encourage discussion of the differences between raw and cooked vegetables.

3.2
WHAT IS THE EFFECT OF COOKING ON VEGETABLES?

Main ideas in this section

The principal texture change in vegetables on cooking is a softening caused by breakdown of cell structure.

The time factor in cooking is critical.

You will need for each pair or group of pupils

125 g shredded cabbage, diced potato, or diced carrot
500 ml tap water
½ 5-ml (tea) spoon salt
5 saucers, labelled A, B, C, D, and E
Medium-sized saucepan
Cooking tongs
Spoons
Stopclock
Balance

Practical skills

This experiment could be carried out using shredded cabbage, diced potato, or sliced carrots by different groups of pupils within the same class. They should ensure that the cooking water simmers constantly throughout the experiment.

Q 3

Assessing (relevant factors)

Observing

The disadvantage of subjective judgments needs to be carefully considered here. The pupils should be encouraged to consider their *actual results* and not use preconceived ideas. A pupil may always have eaten cabbage which has been cooked for fifteen minutes and never tried cabbage cooked for a shorter time. Worksheet FSM14 is relevant at this point.

Nutritional values should also be considered: the longer cabbage is cooked the more vitamin C is lost. (See *Nutrition* Chapter 12.)

Q 4

Applying knowledge

Assessing (relevant factors)

The answer to this question can be obtained by considering the three sets of results from the different vegetables used. Pupils could also look at recipe books and compare recommended cooking times for root and green vegetables.

3.3
TEXTURE CHANGES DURING COOKING

Main ideas in this section

Fruits and vegetables are made up of microscopic cells.

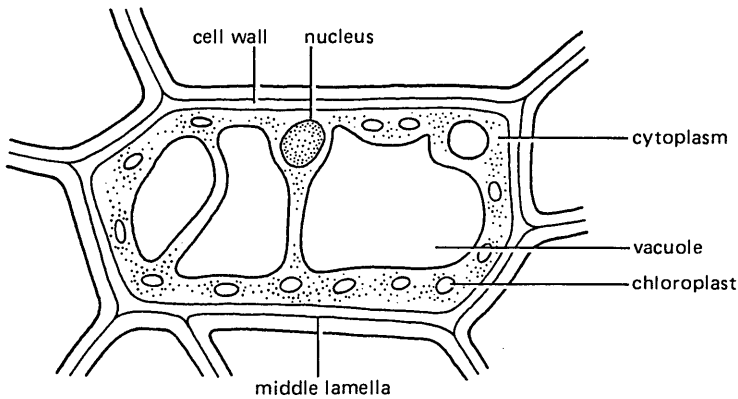
These are affected by the cooking process.

Background information

Fruits and vegetables are made up of cells like the one in figure T3.1. The contents of the cell are surrounded by a cell wall.

Inside the cell is the cytoplasm containing structures essential for life. These include the nucleus, the chloroplasts, the chromoplasts which carry the colour pigments of the plant, and starch granules which serve as a food store. Also within the cytoplasm are enzymes which act as catalysts for the chemical reactions taking place in the cell. In the very young plant, cells are divided by a thin cell wall called the middle lamella. As the cells get older, the wall thickens and becomes more rigid. The chemical components of the cell wall which are important in cooking are cellulose and pectin. The pectin forms at an early stage in growth. The cellulose, in the form of fibres, is mainly responsible for later thickening.

Figure T3.1



The contents of plant and animal cells are compared in *Nutrition* Chapter 2. Worksheet FSM7 provides background information on cell structure.

Link with school science
The changes in the cells of plant and animal tissues as they are cooked should give an insight into their structure.

Q 5

Communicating (writing) The pupils should measure the cells in *figure 3.6* in order to work out the size of the cabbage cells from the magnification.

Figures 3.6 and 3.7
These illustrate the changes taking place in cooking at a cellular level. The drawings show pupils what to look for in the photomicrographs.

Q 6

Reasoning logically The answer to this question should include a discussion of the softening of cellulose and the breakdown of the cell wall. Starch granules swell in water, the extent of swelling being determined

Assessing (relevant factors)

Identifying causes

by the temperature of the water. As the temperature of the potato rises, water molecules penetrate the tightly packed starch molecules, until eventually many of them are leached out into the bulk of the water. The starch granules at this stage look like swollen sacs. Beyond this stage they completely lose their identity. The result is a much softer product. This change in the granules is called gelatinization.

Figure 3.8 and Q 7
The gelatinization of starch granules is shown in the photomicrographs. See also worksheet FSM4.

Q 8
Discuss the effect of cooking on texture such as the softening of cabbage and potato, summarizing the change to the cell wall and the gelatinization of starch.

3.4
COLOUR CHANGES DURING COOKING

Main idea in this section

Pigments found in the cell plastids are responsible for the colour of fruits and vegetables. These may be affected by the cooking process.

Figure 3.9
This electronmicrograph shows plastids which carry the colouring pigments within plant cells, in this case chloroplasts which contain chlorophyll, a green pigment.

Background information

Observing

Chlorophyll is insoluble in water, but its stability is affected by pH. The chlorophyll molecule has a magnesium ion at its centre. During cooking this magnesium ion may be replaced by hydrogen ions from the water, so bringing about a change in colour. It takes place more readily at low pH and the olive brown pigment which results is called pheophytin.

Extension work
Pupils could investigate the changes in the pigments in cabbage when cooked in water with various pH values. Worksheet FSM2 refers to pH and may be useful here.

You will need for each pair or group of pupils

100 g green cabbage
pH test papers
White vinegar
Sodium bicarbonate (solid)
4 small pans (same size, with lids)
Chopping board
Sharp knife
4 250-ml beakers
4 plates (white)
Colander
5-ml (tea) spoon
Stopclock

Designing tests

This work is suggested in the pupils' text, but no instructions are given. The pupils could be encouraged to design this investigation for themselves. This is what they should do.

Deciding criteria

1 Wash and shred cabbage and divide it into four 25-g portions, labelled a, b, c, and d.
2 Treat each portion as follows, testing the pH of the liquid before they start:
a Cook in 250 ml boiling water for 10 minutes (control).
b Cook in 250 ml boiling water for 1 minute.
c Cook in 250 ml boiling water containing 1 5-ml (tea) spoon of sodium bicarbonate for 10 minutes.
d Cook in 250 ml boiling white vinegar for 10 minutes.
3 Drain each portion of cabbage after treatment, retaining the cooking liquid.
4 Test the liquid with pH paper.
5 Label all the samples of cabbage and liquid and note the colour of each.

Applying knowledge

Expected results would be as follows.
a Slight softening but still firm, colour slightly paler than when raw.
b Very little texture change but owing to expulsion of air bubbles from the structure, colour appears darker.
c Extreme texture change and brightening of the original colour.
d Slight softening but a noticeable colour change from green towards yellow.

Q 9
Tap water has a pH of approximately 7. When soda is added the pH increases, indicating that the solution is now alkaline. The change can be easily demonstrated using indicator papers which change colour in solutions of different pH. Worksheet FSM 2 might be useful here.

Q 10
When vinegar is added to tap water the pH decreases, indicating that the solution is now acidic.

Q 11
The answer to this question requires an understanding of the effect of change in pH on chlorophyll. The green colour is preserved by adding soda, but the disadvantages are that vitamin C is lost and the cellulose is softened. If the above extension work has not been carried out, you could demonstrate the effect of high pH by doing instruction *2 a* (the control), and comparing this with *2 c* (using sodium bicarbonate).

Q 12

Using knowledge

This question introduces the carotenoids. Pupils will probably remember from experience that carrots do not change colour during cooking. The following extension work shows this.

Extension work

Reasoning logically

Pupils could investigate the changes in the pigments in carrots when cooked in water with various pH values. Follow the instructions in the previous extension work, but cook for ten minutes only.

The pupils should find that the colour of carotene in carrots is not affected by cooking or by pH changes in the cooking water.

Q 13

Communicating

Red cabbage contains anthocyanins which appear red in acidic solutions, and purple to greyish in alkaline solutions. (Anthocyanins contribute to the colour of raspberries, blackberries, cherries, and many other soft fruits.)

3.5 CHANGES IN FLAVOUR AND SMELL DURING COOKING

Main ideas in this section

Appreciation of cooked fruits and vegetables is affected not only by colour and texture but also by aroma.

This arises when volatile compounds which are present in the plant cells are released into the air.

Volatile compounds will only escape from the plant cell when it has been damaged.

The application of heat, as in cooking, may increase the rate at which these volatiles are given off and also bring about reactions which create new volatiles. Longer cooking time leads to a stronger aroma.

You will need for each pair or group of pupils

100 g green vegetable	Medium-sized saucepan
500 ml tap water	Saucer
½ 5-ml (tea) spoon salt	Spoons

Q 14 and Q 15

The table compiled from the results of the pupils' experiment can be used to develop a discussion leading to the answers to these questions.

Figure 3.10

This diagram shows the structure of the nasal and buccal (cheek) cavity and should help the pupils to trace the progress of volatile compounds. It is important that pupils understand that the flavour and aroma of foods are closely linked.

Figure 3.11

Interpreting (graphs)

This graph should provide the basis for a discussion summarizing the work covered in this section. It should emphasize the need to avoid over-cooking which alters flavour, colour, and texture too much. At the same time it should show that it is important to cook vegetables sufficiently for the texture, flavour, and colour to be acceptable.

Communicating (speech)

3.6 PEAS IN PACKETS AND CANS

Main idea in this section

The manufacturer can manipulate the organoleptic properties of processed fruits and vegetables in order to satisfy consumer demand.

Reasoning logically

Remind pupils of the processing methods outlined in section 2.6. The three notable characteristics which may be altered are colour, texture, and flavour. These may be assessed experimentally for a range of convenience foods.

The size of peas is another characteristic which has been seen to be of value in marketing and is controlled by the manufacturer. Small sweet peas picked when they are young and tender have quite different selling points from large marrowfat peas.

Worksheet FSM14 will be useful when organizing the tasting session.

You will need for the class
Samples of cooked peas: frozen, canned, dehydrated, and fresh (if available)

Saucers and teaspoons

Extension work
A visit to a fruit and vegetable processing factory could help to illustrate the points made. This would help to develop the topic beyond the example used in the text and encourage discussion of processing of a wider range of fruit and vegetables.

Figure 3.13
The 'tenderometer' is a device used to determine the best time to harvest peas for processing. A sample of peas is crushed between two metal grids and the resistance of the peas to crushing is indicated on a scale. This is taken as a measure of tenderness. When peas have reached the required level of tenderness they can be harvested and processed, as the Background reading to this chapter describes. Worksheet FSM16 indicates the importance of quality assurance.

Processes and skills	Pupils may be able to:
3.1 *Changes when fruits and vegetables are cooked* Observing. Reasoning logically. Identifying causes.	Recognize that some vegetables are acceptable raw (*e.g.* in salads), and that some are unacceptable raw (*e.g.* potatoes). Describe and compare the eating qualities of a variety of raw fruits and vegetables.
3.2 *What is the effect of cooking on vegetables?* Performing practical tasks skillfully, efficiently, and safely. Making careful and accurate observations, evaluating results. Applying knowledge, reasoning logically, communicating (writing).	Recognize that cooking fruit and vegetables affects their colour, texture, and flavour. Compare methods of preparation and cooking and assess the results. Select and carry out the method which will produce the most acceptable results.
3.3 *Texture changes during cooking* Using recorded information. Estimating. Assessing (relevant factors), applying knowledge.	Look at photomicrographs of cells before and after cooking and observe the changes in cell structure during cooking. Observe the changes in starch grains during cooking (*i.e.* the process of gelatinization). Apply this knowledge to the cooking of a potato.

Processes and skills	Pupils may be able to:
3.4 *Colour changes during cooking* Designing experiments, relating cause and effect. Applying scientific concepts.	Recognize that the green colour in vegetables is provided by the pigment chlorophyll which is found in chloroplasts. Observe that the pH of the cooking water will affect the colour of the vegetable. Recognize that there are a variety of colour pigments in vegetables and that these are affected by pH and cooking.
3.5 *Changes in flavour and smell during cooking* Performing practical tests skillfully and efficiently. Observing, reasoning logically.	Recognize that taste (flavour) and smell are closely linked. Observe how these senses are used in assessing the cooking of vegetables. Apply this knowledge in deciding the optimum time for cooking vegetables.
3.6 *Peas in packets and cans* Selecting information to support a point of view. Identifying causes.	Recognize that when peas are preserved, the colour, texture, and flavour are affected. Compare preserved foods with their fresh counterparts and understand how the changes came about. Discuss how the preferences of the consumer influence the choice of preserved peas.

Q 16 and Q 17
These questions extend discussion to other fruits and vegetables which are available in canned, frozen, or dehydrated form. The convenience value of these products has been introduced in Chapter 1, and the processes involved in Chapter 2.

From this chapter pupils should appreciate the difficulties of achieving acceptable texture, flavour, and colour in processed foods. Fruits and vegetables are often changed, but new qualities may be enjoyed in their own right. Dried fruits, processed peas, and canned fruits are examples.

Ideas for homework
Pupils could investigate the different ways in which people prepare and cook cabbage.

They could find out the countries of origin of canned fruits and vegetables at home, and which ones contain added colour.

Assessing (relevant factors)

The Background reading encourages pupils to think about the different methods that are used to harvest fruits and vegetables. The amount of mechanization may depend on the scale of the operation, the form of growth of the plant (tree, bush, vine, and so on), the fragility of the fruit, and whether ripening occurs all at once. Ask pupils to think about how they would organize the picking of cabbages or raspberries efficiently on a large scale.

CHAPTER 4

Meat and fish

This is the first of three chapters which investigate the characteristics of meat and fish. It examines the relationship between the structure and composition of meat and fish and changes which occur during cooking. Take care not to offend pupils who do not eat meat.

Time allocation
Section 4.1: 5 minutes; 4.2: 10 minutes; 4.3: 7 minutes; 4.4: 15 minutes; 4.5: 15 minutes; 4.6: 8 minutes; 4.7: 8 minutes; 4.8: 7 minutes (total 75 minutes).

Extension work in this chapter
Section 4.5: comparing the results of cooking fish put in cold water and boiling water.

Worksheet and Assessment card Masters
FSM6 Proteins
FSM7 Cells
FSM8 Enzymes
FSM9 Micro-organisms
FSM20 Assessment card

4.1
ONE MAN'S MEAT . . .

Main ideas in this section

Consumption of meat and fish is widespread.

A wide variety of fish and meat products are available in the Western World.

Taboos and traditions influence food habits.

Q 1, Q 2, and Q 3
Identifying causes
Discuss the food habits of different people. This topic could be developed in project work and homework.

4.2
BLOOD AND GUTS, SKIN AND BONE

Main ideas in this section

Animals and fish need to be 'dressed' or butchered before being sold.

A percentage of the whole animal or fish is inedible or not normally consumed. The inedible parts may be put to other uses.

Classifying
Organizing data

The calculations required in questions 4 and 5 are based on data given in *table 4.1* and serve as a basis for discussion of these ideas. Group discussions of the numbers to be substituted into the following formulae is an essential first stage. Pupils should be able to devise the formulae themselves.

Q 4

Applying knowledge

a Percentage edible turkey =

$$\frac{\text{Live weight} - \text{inedible material}}{\text{Live weight}} \times 100$$

b Insulin may be prepared from bovine or porcine pancreas; blood and bones are recycled as fertilizers and bone meal (see Chapter 1); gelatin is made from hides, skin, and bone; pillows can be filled with feathers.

Q 5

a They have been killed and the feathers, head, feet, and viscera have been removed.

Communicating (maths)

b Percentage of live weight purchased =

$$\frac{\text{Live weight} - \text{materials removed before selling}}{\text{Live weight}} \times 100$$

c Percentage of dressed turkey which is edible =

$$\frac{\text{Weight of dressed turkey} - \text{material not consumed}}{\text{Weight of dressed turkey}} \times 100$$

Q 6, Q 7, and Q 8

Reasoning logically
Assessing (relevant factors)

Only a proportion of a carcass is edible. The 'killing out' percentages, that is, the ratio of carcass weight to the weight of the live animal, vary. The value is low for beef and lamb because, as ruminants, they have large digestive systems. The amount of waste in converting live animal to carcass is one of the influences on price. You could discuss other market influences at this point.

Figure 4.3 and Q 9

Using references

The section concludes with a look at the British way of butchering meat. Compare this with the practice in other countries. Table T4.1 on the next page answers question 9.

Q 10

Applying knowledge

This draws attention to the preparation of fish for sale by the fishmonger.

Table 4.1
The cuts of meat shown in *figure 4.3*, and their percentage weight of the carcass.

Cut	Weight of carcass (%)
1 Neck	6.3
2 and 3 Clod and sticking	3.7
4 Shin	3.7
5 Shoulder	22.1
6 Brisket	4.7
7 Middle ribs	12.6
8 Flank	3.7
9 Ribs	6.8
10 Sirloin	1.3
11 Rump	7.4
12 Buttock	7.4
13 Leg	15.2

4.3
RIGOR MORTIS

Main ideas in this section

Rigor mortis is a complex change which takes place after the death of animals and fish.

It causes muscle tissue to be stiff and tough, a condition which may last for a few hours in poultry or a few days in beef.

Rigor mortis involves the enzymes present in the muscle. The proteins actin and myosin, which in life are involved in muscle contraction, link together to form a rigid complex, actomyosin. Glycogen is converted, in the absence of a supply of oxygen to the muscle cells, into lactic acid, and the pH of the muscles decreases from about 7.0 to about 5.5. This acidity influences the ability of the meat to hold water (its 'water-holding capacity'), its resistance to micro-organisms, and its tenderness.

Rigor mortis is followed by a softening process as the carcass is 'hung' or 'aged'. The process is complex and is not, as yet, fully explained. Enzymic activity is involved and the links between neighbouring actomyosin units have been shown to become broken. Flavour compounds are formed by the enzymic breakdown of some of the constituents of muscles. Revision of enzymes using worksheet FSM8 might be appropriate.

Q 11 and Q 12

Reasoning logically — Rigor mortis must be allowed to pass so that the tenderness of meat is developed. These changes should take place at a low temperature so that the activity of micro-organisms is inhibited. Discuss the development of flavour during hanging.

Applying knowledge — Unlike meat, fish rapidly passes through rigor mortis and does not require ageing. Glycogen is rapidly depleted and a pH of 6.5 is achieved. This higher pH means that fish are more liable to microbial spoilage than meat. They are stored in ice or may be processed on board ship. They should be consumed or processed when as fresh as possible. Worksheet FSM9 may be useful at this point.

4.4
WHAT IS MEAT MADE OF?

Main ideas in this section

To understand the changes which take place when meat is cooked, a knowledge of the structure of meat is essential.

A chicken leg consists of skin, fat, connective tissue, and muscles, as well as tendons, bones, and blood vessels (pupils should be able to identify these).

You will need for each pair or group of pupils

Practical skills

Chicken leg	Sharp knife
Rasher of bacon	Tweezers

Q 13

Observing — *a* The skin will be fatty being attached to, or partially removed from, a layer of subcutaneous fat. It is also elastic.

Communicating (writing) — *b* Muscles can be clearly seen, bound together by connective tissue and with a surface of subcutaneous fat in evidence.

Q 14

Having carefully dissected an individual muscle from the leg using tweezers and a sharp knife, or perhaps a scalpel, pupils should discover that the internal structure of the muscle is fibrous and that the muscles are attached to bone by tendons.

Figures 4.5 and 4.6

These show a photomicrograph and diagram of muscle fibres. The fibres are held together in bundles by connective tissue. The bundles are also held together by connective tissue, to form muscles. Worksheet FSM7 may be useful.

Link with school science

Pupils may have carried out a similar dissection in science, where the objectives would have been to make clear the structure of muscle and of a joint capsule; and the variety of different tissues which make up an animal limb.

Q 15
a The bacon rasher is introduced in this investigation to reinforce understanding of the composition of meat. A picture of a slice of bacon from an advertisement could be substituted. Skin, fat, and muscle can be identified. The muscles have, of course, been thinly sliced, but their fibrous nature is still apparent. Individual muscles can be clearly seen.
b Discuss the different types of bacon available.

4.5 COOKING MEATS

Main ideas in this section

Cooked meat has eating qualities not found in raw meat.

The changes may be classified in terms of appearance, texture, and flavour.

Pupils should now be able to appreciate the changes which take place as meat and fish are cooked. These changes are investigated in an experiment and in the rest of this chapter. (Stress that pathogenic organisms such as bacteria which cause food poisoning are killed by cooking. This idea is developed in Chapter 6.)

Q 16
The pupils can discuss the differences between raw and cooked meat.

INVESTIGATING CHANGES OCCURRING DURING COOKING

You will need for each pair or group of pupils
6 small cubes of beef (2.5 cm^3)
4 small saucepans
Thermometer, –10 to 110 °C
Cooker
Measuring jug

Practical skills
Observing
Communicating (writing)

The meat cooked from cold will show frothing and scum formation as the temperature rises. At 55 °C to 60 °C proteins begin to become denatured and liquid diffuses out of the meat, rising to the surface to form scum. Frothing results from air being trapped by the scum. The colour of the meat will change from the red/brown of the raw meat to the grey/brown colour of cooked. The meat will be quite firm in texture but probably rather dry.

The meat cooked in boiling water does not produce scum and frothing. Rapid denaturation of proteins at the surface helps to reduce liquid loss although it does not, of course, seal the meat

completely. The meat will change colour and will probably be more tender and juicy than the first sample. Worksheet FSM6 provides information on denaturation of proteins.

Q 17

Observing
Communicating (writing)

The experiment illustrates how cooking method affects the eating quality of meat. In the case of sample A, a longer cooking period causes increased protein denaturation and toughness. Water is lost from the sample so it is less juicy than sample B. Vitamins, minerals, and flavour compounds will also diffuse out of the meat. In both cases fat will melt as the meat is cooked and contribute to the juiciness of the product. It will also escape into the surrounding liquor, particularly in sample A.

Reasoning logically

Pupils' ability to explain the observed changes will be limited at this stage, and it is sufficient that they should distinguish between the effects of two cooking methods and offer sensible explanations. More detailed treatment of cooking changes is given in section 4.8.

Extension work

Pupils could do a similar experiment using fish.

4.6 COOKING TIMES AND TEMPERATURES

Main ideas in this section

Connective tissue binds together fibres and bundles of fibres.

In order for meat to become more tender this structure has to be 'opened up'. The binding can be thought of as being loosened.

Q 18

Identifying causes

At 60 °C the protein collagen in connective tissue is denatured and becomes shorter and thicker. This can be thought of as opening up the structure of the meat, which may take on a plump appearance, and will have a tenderizing effect. Worksheet FSM6 will extend discussion of protein denaturation.

At higher temperatures the collagen is converted into soluble gelatin. Again, the binding material in the meat has been affected, with a resulting increase in tenderness. The conversion of collagen to gelatin takes place in both dry and moist cooking methods.

Q 19

Analysing (data)

Other proteins in the meat fibres shrink and toughen on heating, so cooking methods should be chosen to minimize denaturation of these proteins but maximize the softening of connective

Applying knowledge

tissue. This concept is developed in *figure 4.7* and question 20. See also worksheet FSM6.

Roasting at low temperatures ensures softening of connective tissue without reaching the temperatures at which other proteins are denatured and toughening results.

Q 20

Identifying causes

a After one hour at 100 °C the meat has reached a temperature of about 20 °C and so will be tough and not cooked.
b After four hours the meat will have reached about 52 °C and will not be tender. Connective tissue will not become softened and the meat tender until the internal temperature reaches 60 °C.
c At 180 °C the meat reaches 60 to 65 °C in about two hours and will be tender.
d Further cooking at the higher temperature leads to denaturation of muscle fibre proteins and increased toughness of the meat.

4.7 DIFFERENT COOKING METHODS FOR DIFFERENT CUTS

Main idea in this section

Cooking methods are chosen with meat structure in mind.

Applying knowledge

Pupils should understand that there is a link between meat structure and changes during cooking. The pupils' text suggests that they should review cooking methods used for different cuts of meat and put their results in a table.

Assessing (relevant factors)

Tender cuts of meat contain smaller amounts of connective tissue and require sufficient heating to produce flavour, give colour, and maximize tenderness. Long cooking periods and/or high temperatures will only serve to toughen these cuts of meat.

Reasoning logically

On the other hand, tough cuts of meat containing large amounts of connective tissue require sufficient cooking to soften the collagen as well as to produce flavour and colour. Moist heat methods may be more suitable for these cuts as the high temperatures which would cause toughening are avoided.

Q 21 and Q 22

Reasoning logically

Fish contains much less connective tissue than meat and so cooking methods are normally less rigorous. The muscle fibres are shorter than those in meat and have their ends embedded in connective tissue. When the fish is cooked the connective tissue softens and is converted to gelatin. The fibres separate, giving a flaky appearance.

Applying knowledge

Cuts of meat with lots of connective tissue are those in which a prolonged low temperature method is recommended, normally a moist heat method.

4.8
CHANGES IN MEAT DURING COOKING: SOME DETAILS

So far, most consideration has been given to the tenderness of meat. Obviously, there are many other changes which occur during cooking and this section looks at some of them.

Main ideas in this section

Meat is said to have a high water-holding capacity.

About 75 per cent of the weight of meat is water and this is contained within the structural organization of the meat proteins and muscle fibres.

Disruption of this organization reduces water-holding capacity.

Q 23

Suggesting hypotheses

Cooking reduces the water-holding capacity and water is released. The meat becomes more juicy as it is cooked. Cooking losses result as water drips out of meat or evaporates from it. The water will contain nutrients and flavour.

Q 24

Identifying causes

Lower roasting temperatures reduce cooking losses although cooking times are increased. Losses are increased if high temperatures are reached by the meat.

Fat is distributed in meat in spaces within the connective tissue and along the small blood vessels. This distribution is referred to as 'marbling' and could be demonstrated at this point. There is also a layer of surface fat. Marbling is taken to indicate good quality meat, but a relationship between fat content and tenderness has not been shown.

Q 25

Applying knowledge

During cooking, melted fat permeates between and around the muscle fibres. It gives flavour to the meat and stimulates the flow of saliva, thus affecting juiciness. Recent evidence suggests, however, that surface fat does not significantly influence flavour.

The colour of meat also changes during cooking. The predominant meat pigment is myoglobin which is similar to haemoglobin. This is a purple/red colour. The pigment may be oxygenated (combined with oxygen) to give a bright red colour. This is the colour of freshly cut meat. On standing, however, the meat becomes brown/red in colour as the myoglobin is oxidized. On cooking, the protein part of the myoglobin, the globin, is denatured and the remainder of the molecule is converted into the brown colour which is typical of cooked meat.

Processes and skills	Pupils may be able to:
4.1 *One man's meat . . .* Identifying relevant factors, communicating (writing).	Identify the main sources of meat and fish in Britain. Recognize that taboos and traditions influence the choice of meat and fish for consumption in Britain and other countries.
4.2 *Blood and guts, skin and bone* Interpreting data, reasoning logically, communicating (maths). Using references, handling numerical data.	Recognize that the edible parts of meat and fish vary but are an important factor (approximately 50 per cent of live weight). Use data provided to classify the weights of different parts of a turkey. Calculate the waste (*i.e* non-edible parts) of a turkey. Suggest ways in which the waste might be used.
4.3 *Rigor mortis* Identifying causes, reasoning logically.	Recognize that when animals and fish are killed, rigor mortis occurs: *i.e.* the flesh stiffens. Explain that in the process of hanging or ageing, the muscles eventually become tender due to the action of enzymes.
4.4 *What is meat made of?* Performing practical tasks skillfully and safely. Making and recording observations, organizing data.	Dissect a chicken leg. Identify the macro-structure. Observe the tendons attaching the muscle to the bone and the bundles of fibres held together by connective tissue. Compare a diagram of a cross-section of muscle with a rasher of bacon.

Processes and skills	Pupils may be able to:
4.5 *Cooking meats* Performing practical tasks skillfully and safely. Observing and recording observations. Reasoning logically.	 Cook samples of meat and observe the changes taking place. Compare the effects of cooking or not on appearance, flavour, and texture. Explain the reasons for the changes brought about by cooking.
4.6 *Cooking times and temperatures* Observing patterns in numerical data. Selecting and organizing relevant information.	 Recognize that heat changes connective tissue from protein collagen to gelatin. Recognize that heat changes the proteins in muscle fibre, causing them to shrink and harden (denaturation). Use graphs to compare the relationship of cooking times and temperatures.
4.7 *Different cooking methods for different cuts* Using references, reasoning logically, applying knowledge. Communicating (writing).	 Classify the cooking methods normally used for meat and fish. Use recipe books to compare time and temperature in cooking various types of meat and fish. Recognize that tough meat contains a lot of connective tissue which can be softened by moist heat and longer cooking time.
4.8 *Changes in meat during cooking: some details* Selecting and organizing information, reasoning logically. Applying knowledge.	 Recognize the importance of the capacity of meat to hold water. Select the correct method and time of cooking so that the meat is cooked but still remains juicy. Recognize that cooking changes the colour of meat, from red (rare) at temperatures up to 65 °C, to brown at higher temperatures. Recognize that volatiles give aroma.

Q 26

a This colour change occurs at 65 °C so that the meat can retain its red colour and be tender, connective tissue having been softened at about 60 °C. Thus meat cooked 'rare' may be more tender than when it is further cooked because further cooking may cause toughening (see section 4.6).

Reasoning logically

b Because rare meat remains red, its temperature cannot have risen above 65 °C.

c Obviously only meat with small amounts of connective tissue can be cooked rare. Meats with large amounts of connective tissue require longer cooking times and higher temperatures to convert collagen into gelatin and make them tender. The myoglobin will be converted into its cooked, brown form.

Flat steaks can be cooked rare, transfer of heat being rapid and temperatures necessary to soften the connective tissue being reached before the red colour of the meat is lost. Roast meat can also be cooked to retain an internal pink colour by controlling cooking times and temperature so that the temperature reached by the centre of the meat is kept below 65 °C.

Q 27

During cooking, flavour compounds are developed in meat. These are volatile and escape into the air, hence the aroma of meat as it cooks. They result from the breakdown of some of the constituents of meat.

Q 28

Communicating (speech)

The detail developed in this section should now enable a review of the conclusions drawn from the experiment in section 4.5 (question 17). There are changes in the appearance, texture, water-holding capacity, protein denaturation, development

Evaluating

of flavour, and changes in myoglobin.

Ideas for homework

Pupils could investigate the eating habits of different people (see questions 1, 2, and 3).

They could carry out an investigation at home to discover how much meat or fish is wasted in preparation and as plate waste.

They could compare cuts of meat available in a supermarket with those available in a butcher's shop.

Deciding criteria

The Background reading tells pupils about an industry relatively new to modern Britain — fish farming. A visit to a trout farm might prove interesting.

CHAPTER 5

Burgers, bangers, bacon . . .

This chapter continues the study of meat and fish begun in Chapter 4. Understanding of the structure of the meat and fish gained in this chapter is used to explain the tenderizing effects of mincing, beating, marinating, and using tenderizers. The chapter ends with discussion of preservation of meat and fish. The characteristics and handling requirements of frozen products are further investigated in Chapter 6.

Time allocation
Section 5.1: 20 minutes; 5.2: 7 minutes; 5.3: 20 minutes; 5.4: 8 minutes; 5.5: 15 minutes (total 70 minutes).

Extension work in this chapter
Section 5.1: surveying ingredients on commercial products.
Section 5.3: investigating the enzyme activity of fresh and canned fruit.
Section 5.4: comparing marinated meat or fish with untreated samples.
Section 5.5: smoked foods.

Worksheet and Assessment card Masters
FSM2 Acids, bases, pH
FSM6 Proteins
FSM8 Enzymes
FSM9 Micro-organisms
FSM13 Heat and temperature
FSM14 Taste panels
FSM21 Assessment card

5.1
MAKING BEEFBURGERS

Main idea in this section

Mincing allows tougher cuts of meat containing relatively large amounts of connective tissue to be used.

Applying knowledge
Designing tests

The pupils make beefburgers from minced meat and compare their eating quality with meat which has not been minced. The experiment enables pupils to revise what they have learned about meat structure in Chapter 4. Discuss the effect of mincing on this structure and thus on tenderness. Use the cheapest cuts of meat for the experiment.

You will need for each pair or group of pupils

Lightly beaten egg	Mixing bowl
150 g chuck steak	Mincer
Salt and pepper	Knives and forks

Q 1

The burgers should be tender to eat. The meat which has not been minced remains tough.

Q 2

Reasoning logically

The egg is added as a binder. During cooking the egg proteins become denatured and bind together the particles of minced meat. (See worksheet FSM6.)

Q 3

Mincing breaks muscle fibre and connective tissue and so has a tenderizing effect. There is then no need to rely on the tenderizing effects of long cooking times and high temperatures.

Q 4, Q 5, and Q 6

Observing

Mincing reduces the water-holding capacity of meat. More able pupils may notice this when they are mincing, or as weight loss during cooking. Salts and other ingredients used in the manufacture of burgers, sausages, and similar products help to retain water and to stop drying out.

Applying knowledge

Egg is used in the recipe in the pupils' text to bind the burger together. Other binders used domestically and commercially include dried milk, cereals, and soya protein. These materials also 'fill' or give body to products.

Organizing data

Burgers manufactured for fast food operations do not contain cereal as a filler as it would burn during the griddling process. Porridge oats can be used successfully to fill and bind burgers made at home.

Extension work

Analysing data

Pupils could compare the ingredients listed on different commercial products.

Q 7

Applying knowledge

Commercially made beefburgers and sausages have minimum meat contents prescribed by law. The remainder is made up of fillers and binders, salts, flavours, flavour enhancers such as monosodium glutamate, colours, and emulsifying agents. Texturized vegetable proteins may also be used (see Chapter 15). Some manufacturers put more than the legal minimum amount of meat in their products and usually advertise this fact. Beefburgers containing 100 per cent beef have no additives or binders but are obviously more expensive than those containing less meat.

Q 8

Applying knowledge

The products made from minced or ground meat include burgers, sausages, faggots, meat balls, and croquettes as well as luncheon meat, spam, corned beef, and similar products.

Cheaper, tougher cuts of meat can be cooked quickly when minced, without the long cooking times which would otherwise be required to tenderize them. Cottage pie is an example of such a dish.

Identifying causes

Fish does not provide the problems of toughness that meat does, having relatively little connective tissue. Fish products comparable to the meat products described in this section would be fish cakes and fish fingers. In this case, however, mincing or grinding the fish serves more to allow mixing with other ingredients than to tenderize.

Assessing (relevant factors)

Recipes and lists of ingredients on commercial fish products could also be investigated. Manufacturers will advertise high fish content and a named fish (such as cod), but these products will tend to be relatively expensive.

5.2
STEAK COOKED IN A MINUTE

Main idea in this section

Another physical method of tenderizing meat is beating or rolling it flat. (The tenderizing effect of these methods are explained in terms of their effect on meat structure.)

Q 9, Q 10, and Q 11

Observing

Identifying causes

The flattened meat allows rapid transfer of heat and shorter cooking times. The beating or rolling has the effect of forcing apart fibres and bundles of fibres and breaking down connective tissue. The structure of the meat can be thought of as being opened up, thus becoming more tender. Worksheet FSM13 discusses heat transfer.

5.3
TENDERIZERS

Tenderizers available from the supermarket are investigated in this section.

Main ideas in this section

Tenderizers contain enzymes, extracted from plants, which are capable of breaking down proteins.

The most commonly used enzyme is papain which is extracted from the pawpaw (papaya) plant. Ficin, from figs, and bromellin, from pineapples are also used.

These proteolytic enzymes act on the proteins of connective tissue and muscle fibres. This facilitates the separation of fibres and their rupture and so has a tenderizing effect. Worksheet FSM8 would be useful here as it identifies the characteristics of enzymes.

Link with school science
Enzymes designed to break down proteins act on animal as well as vegetable proteins. This is because all proteins are formed from the same basic units (amino acids). Pupils learn something about enzymes in biology. The ones most commonly studied are those in the human digestive system.

You will need for each pair or group of pupils

100 g stewing steak	2 small saucepans
Bottle of meat tenderizer	Plate, knives, and forks

The experiment compares the tenderness of meat treated with tenderizer with untreated meat. Use cheaper cuts of meat and follow the instructions on the label. The two meat samples are cooked in exactly the same way and then compared.

Deciding criteria

Three methods for assessing tenderness are suggested and a numerical score for meat texture is asked for. Ideally, such scores are arrived at using highly trained assessors, but the idea that the eating characteristics of food can be quantified is usefully introduced at this point. If pupils score tenderness independently, the fluctuation in scores within the group for the same piece of meat, and the subjective nature of this type of assessment can be discussed. Worksheet FSM14 will be useful in organizing the tasting session.

Observing

Evaluating

Q 12

Assessing (relevant factors)

The meat sample treated with tenderizer should be discernibly softer than the untreated sample. Tenderizers may be used effectively in preparing meat for fondue where short cooking times are essential.

Contact between enzyme molecules and protein molecules is essential if tenderizers are to be effective. Surface application may give only surface softening, and forking the meat helps to distribute the enzyme.

Normally the treated meat is allowed to stand for a short time before cooking, to allow enzyme activity. Shorter periods of time allow less softening, while long periods may cause over-softening, particularly at the surface.

Q 13
The activity of papain increases at warm temperatures to an optimum at 60 to 70 °C. Thus it is active as meat is cooked and

Identifying causes

tenderizing continues until higher temperatures are reached. At higher temperatures the enzyme is denatured and its activity ceases. If raw meat is held at warm temperatures, over-tenderization and mushy texture may result.

Q 14

Applying knowledge

This requires integration of the understanding of enzymes gained in Chapter 2 and of meat structure and tenderness in Chapter 4 to explain the effect of tenderizers on meat.

Assessing (relevant factors)

As might be expected, traditional recipes are usually founded upon interaction between ingredients to improve the eating qualities of the finished product.

Q 15 and figure 5.4

Identifying causes

Fresh pineapple cooked with gammon supplies the enzyme papain in its juices, which helps to tenderize the meat. Canned pineapple does not have the same effect, its enzymes having been denatured at the high temperatures used in canning. The use of canned pineapple with gammon is thus for reasons of flavour, although it is derived from the use of pineapple to tenderize meat.

Suggesting hypotheses

Extension work

Designing tests

An experiment to investigate the enzyme activity of fresh and canned fruit might be carried out at this stage. Samples of gammon could be treated *a* with fresh pineapple juice, *b* with the juice of canned pineapple, and *c* left untreated. The eating qualities, tenderness, and flavours of the products could then be assessed.

Assessing (ideas)

Alternatively, if gammon with pineapple is to be prepared as a dish, fresh pineapple could be used instead of canned pineapple in some cases and the products compared.

Table T5.1 provides information which may be used to extend discussion.

Table T5.1
Proteolytic enzymes and their effects on different tissues.

Enzyme	Muscle fibre	Collagen	Elastin
Ficin	very good	very good	extremely good
Papain	good	fair	good
Bromellin	fair	very good	fair

Commercial tenderizers contain a mixture of bromellin, papain, monosodium glutamate, salt, and other seasonings. Ficin, although more effective, is more expensive to produce.

5.4
MARINATING AND PICKLING

Main ideas in this section

Marinades and pickles are traditionally used to tenderize meats and fish, preserve them, and give distinctive flavours.

Marinating involves soaking meat or fish in an acidic solution, usually containing lemon juice or vinegar.

Proteins in the meat or fish become denatured at the low pH of the marinade and this has a tenderizing effect.

The effect of low pH on proteins may already have been discussed in Chapter 2, in particular the effect of acidity on enzyme protein. It is a fundamental concept and will be referred to again. You could also discuss or revise protein denaturation using worksheets FSM2 and FSM6.

Using references

Q 16

This requires a survey of recipes which may be done as homework.

Q 17

Organizing data

The acid ingredients such as lemon juice, vinegar, and, perhaps yoghurt should be easily identified.

Q 18

Identifying causes

This requires an explanation of the tenderizing effect of marinades. Protein denaturation will have an 'opening up' and thus tenderizing effect on meat or fish structure. The lower pH will also make proteins more readily denatured during cooking and thus enable shorter cooking times.

Extension work

Designing tests

Assessing (ideas)

An experiment to compare marinated meat or fish with untreated samples might be carried out at this stage. The experiment should be designed to compare samples taken from the same piece of meat or fish: *a* treated with marinade, *b* treated with water, and *c* left untreated. The samples should be cooked identically and then compared for tenderness and flavour. Samples *b* and *c* are controls.

Q 19

Applying knowledge

As in the case of fruits and vegetables (Chapter 2), enzymes which cause spoilage are denatured at low pH. Bacteria and other spoilage micro-organisms are, for the most part, inhibited in acidic conditions.

Pickled products are usually sterilized by heating to a high temperature to ensure a long shelf-life. Roll-mops, a Scandinavian delicacy, are herrings pickled in vinegar and salt and can be bought in jars in which they have also been heat-treated.

5.5
PRESERVING MEAT AND FISH

Main ideas in this section

Foods may be preserved by canning or freezing.

Foods are 'cured' by being treated with common salt.

This slows down the activities of the enzymes and micro-organisms which cause spoilage.

Link with school science
Pupils learn about enzymes and about bacteria and other micro-organisms in biology and can apply that knowledge here.

Identifying causes

The next questions encourage a discussion of spoilage and preservation. Chapter 2 introduced a range of preservation methods for fruits and vegetables and so pupils should already be familiar with this topic.

Communicating (speech)

Changes in meat during hanging or ageing have been discussed in Chapter 4. Enzyme activity, if allowed to continue, would lead to the further degradation of proteins and fats, the production of unpleasant flavours and aromas, and changes in texture. Micro-organisms, particularly bacteria, are present in raw meat and fish, and will bring about degradative changes and spoilage. Their activity is usually detected by unpleasant aromas and flavours, undesirable texture changes, and changes in appearance such as surface slime. Worksheet FSM9 can be used to extend discussion.

Organizing data

Reasoning logically

It should also be noted that pathogenic organisms, including those which cause food poisoning, can be expected in raw meats and fish. They do not cause spoilage and so their presence is not detected. Care must always be taken to ensure that these bacteria are not transferred from raw meat and fish to cooked products.

Q 20
Refrigeration slows down enzyme activity and inhibits bacteria, but does not stop spoilage. It allows short-term storage of raw meat and fish.

Q 21

Suggesting hypotheses

Freezing stops the growth and multiplication of micro-organisms but does not kill them. They will become active again when food is thawed. Enzymes, too, are inactivated by freezing.

Applying knowledge

Freezing is thus a good method of preventing spoilage and extending shelf-life. However gradual flavour changes may occur during storage; bacon fat and oily fish may become rancid.

Q 22

Pupils will be familiar with canned meat and fish products. During canning the products are heated to high temperatures which kill micro-organisms and destroy enzymes. They are thus preserved against spoilage until opened, and have a long shelf-life. The high temperatures used in sterilizing these products will, however, bring about changes in colour, flavour, and texture.

Q 23

Classifying — This question may be carried out as homework. Pupils are asked to make lists of meat and fish products and to classify them according to the method of preservation used (*figure 5.5*). At this stage only low-temperature and high-temperature preservation methods are included. Cured products have not yet been introduced although these are normally further preserved using low or high temperatures. Sausages are refrigerated or frozen, and ham may be canned.

Q 24 and Q 25

Assessing (relevant factors) — Cured meats and fish are liable to spoilage unless salt is used in very high concentrations. The concentration of salt will obviously influence the acceptability of a product to the consumer. Normally relatively low concentrations are used.

Classifying — Cured meats may, therefore, be further preserved by chilling. Examples are sausages, salami, luncheon meat, ham, bacon, and pork pies. They may also be frozen (*e.g.* sausages) or canned (*e.g.* corned beef, spam). Many of these products may have been included in the table the pupils made earlier. You could refer to it here.

Organizing data — Some attempt to classify cured products could be made as follows:

Communicating (writing) —
a Products made from comminuted meat, such as spam, corned beef, sausages, and luncheon meat. The meat is normally mixed at low temperatures with 'dry' curing salts and seasonings.
b Products soaked in or injected with brine such as ham and bacon. Hams are traditionally shoulders of meat but are nowadays often formed by pressing pieces of cured meat into a 'ham' shape. Ham may also be canned, or vacuum packed and chilled. Bacon is obtained from the sides of the pig soaked in brine. Sliced bacon may be vacuum packed and chilled.

Q 26

Applying knowledge — This requires an understanding of the way in which salting preserves foods.

The safety of nitrites and nitrates has been the cause of some concern. Nitrites have been found to combine with substances called amines, which occur naturally in foods, to form nitroso-amines. These are known to be carcinogenic. Certainly,

Processes and skills	Pupils may be able to:
5.1 *Making beefburgers* Designing and carrying out experiments, using practical skills. Reasoning logically.	Make beefburgers using a variety of recipes. Compare results. Observe the effect of mincing on meat structures and eating quality. Apply the knowledge obtained from these observations to the making of similar products, *e.g.* sausages.
5.2 *Steak cooked in a minute* Identifying, selecting, and organizing relevant factors.	Recognize that the physical forcing apart of muscle fibres and breaking down of connective tissue will aid cooking and tenderizing meat. Observe that this may be done by flattening or beating (in the home) and spiking and rolling (at the butcher).
5.3 *Tenderizers* Performing practical tasks skillfully and efficiently. Observing, deciding criteria, comparing results, and suggesting explanations. Applying knowledge.	Use a variety of proteolytic enzymes to tenderize samples of meat. Taste, judge, and compare results of the tests. Discuss the possible applications of this knowledge to other similar situations.
5.4 *Marinating and pickling* Using references. Designing tests, deciding criteria, comparing results, organizing data. Applying knowledge.	Use reference material to study the use of marinades in cooking meat. Design and carry out an experiment to observe the effect of marinades on the cooking of meat.

Processes and skills	Pupils may be able to:
5.5 *Preserving meat and fish* Identifying causes. Organizing data, reasoning logically.	Compare knowledge of spoilage or preservation of fruits and vegetables (Chapter 2) with that of meat in this chapter. Recall knowledge of enzyme activity in hanging meat. Recognize that if this continues, it will produce further degradation of proteins and fats, and unpleasant flavours and aromas. Recognize that these processes can be slowed by refrigeration or freezing. Recognize that the use of salt is an effective method of preserving meat because it removes some of the water from bacteria (osmosis) and makes water unavailable to them.

nitrites should be used in very small amounts (200 mg/kg is the maximum amount permitted by law in meat products), and any risk must be weighed against their effectiveness against *Clostridium botulinum* which produces a lethal toxin, and the occurrence of nitroso-amines from other sources such as the use of nitrate fertilizer.

Extension work

Communicating (speech) Smoked foods have not been described in the pupils' text but a discussion could be included at this point.

Smoking is a traditional method of preserving meat and fish and is commonly associated with salting. It provides foods with distinctive colour and flavour.

Smoke consists of hundreds of volatile substances and its constituents will vary according to the source of the smoke. Some of these constituents kill bacteria. The safety of other constituents has caused some concern and so the effects of traditional smoking processes are being simulated using synthetic smoking flavours and food colours.

Ideas for homework

The pupils could find out what kinds of beefburgers are available locally.

They could make a historical study of methods of preserving meat and fish.

Questions 16 and 23 are suitable for homework.

Communicating (speech)

Assessing (ideas)

Reasoning logically

Identifying causes

The Background reading is about takeaway foods. This could be expanded into a discussion of the reasons why people buy takeaway foods instead of preparing foods in the home. (Convenience? Pressure of advertising? No-one at home to spend any length of time cooking?) This topic was introduced in Chapter 2 of *The Basic Course*. You could also discuss franchises with the pupils. Many takeaway foods come from well-known outlets which are organized on a franchise basis. The companies concerned are extremely reluctant to give away any details of how their products are designed and made so uniformly.

CHAPTER 6

Freezing and thawing

This chapter investigates the freezing and thawing of meat and meat products in particular. Obviously, much of the theoretical material is appropriate for other foods, and could be adapted if required.

The correct handling of frozen poultry and the risks of food poisoning from improperly thawed birds are discussed. This leads to a discussion of prepared frozen dishes both from the food manufacturer and made at home.

Time allocation
Section 6.1: 5 minutes; 6.2: 20 minutes; 6.3: 20 minutes (introduced in lesson time with conclusion in subsequent lesson); 6.4: 7 minutes; 6.5: 20 minutes (collection of results extends outside lesson time); 6.6: 8 minutes (total 80 minutes).

Extension work in this chapter
Section 6.6: preparing a dish for freezing.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM8 Enzymes
FSM9 Micro-organisms
FSM13 Heat and temperature
FSM15 Packaging materials
FSM22 Assessment card

6.1
USING FROZEN MEAT, FISH, AND POULTRY

Main ideas in this section

Our food consumption patterns demand the constant availability of a large variety of foods.

The chilling and freezing of raw and cooked foods allows this demand to be satisfied. The freezing of food is a relatively economical process (compared with canning).

Link with school science
Pupils study micro-organisms and enzymes in biology and should be encouraged to see the relevance of this work here. (See also *The Basic Course*, Chapter 7.)

Q 1 and Q 3

Applying knowledge

Often the centres of food production and manufacture are some distance from cities. Freezing of the food produced extends its shelf-life and so distribution is possible. New Zealand lamb is an example.

Assessing (relevant factors)

Freezing a food in season can make it possible for it to be consumed when it is out of season, *e.g.* frozen Brussels sprouts, frozen turkeys, strawberries.

Q 2

One of the biggest advantages today of frozen foods is their convenience. Ready prepared portioned meals and frozen pieces of poultry or fish eliminate the inconvenience of preparing the raw food. They also make it easier to control the quantity of food served.

Communicating (speech)

Encourage the pupils to think about and discuss the choices to be made between fresh and prepared foods. Fresh foods eaten in their season are unsurpassable.

Assessing (relevant factors)

Choices to be made between fresh and prepared foods are mentioned in *The Basic Course* Chapters 2 and 11, and in *Nutrition* Chapter 2.

6.2 PROBLEMS IN HANDLING MEAT AND FISH

Main ideas in this section

Bacteria are always present in food. Some types can cause food poisoning.

Food poisoning results from the contamination of food by bacteria which increase in number to the point where they become dangerous.

Examples of bacteria that cause food poisoning are *Clostridium botulinum*, *Staphylococcus aureus*, and *Salmonella typhimurium*. Worksheet FSM9 will be useful in this section.

Q 4

Identifying causes

Food spoilage is caused by the activity of micro-organisms and enzymes.

Not all bacteria are harmful. Some useful ones include those used in making cheese and yoghurt. Other types of micro-organisms such as moulds are also used to make cheeses like Stilton. Yeasts are used to make bread, beer, and wine. (Foods will spoil, of course, when excessive growth of micro-organisms occurs.)

Q 5

Applying knowledge
a Appropriate conditions for growth of micro-organisms are a warm temperature, not too acid a food and, sometimes, enough air.

Reasoning logically
b Growth of micro-organisms may be controlled by removing suitable conditions for growth.

There are hundreds of different types of *Salmonella*, but not all of them are harmful. They may be found in the intestines of Man and animals and are present in raw meat, including frozen meat.

It is very easy to transfer bacteria such as *Salmonella* from people to food or from raw to cooked foods, by handling raw and cooked foods, or by cross-contamination via knives, cloths, or equipment. Animals such as domestic pets may also carry *Salmonella* and so are another potential source of contamination. Cooking should destroy *Salmonella* but there is always the risk of re-contamination of the cooked food.

Q 6 and Q 7

Organizing data
These allow a discussion of hygiene standards and the risk of cross-contamination, as well as reinforcing the fact that raw meats contain *Salmonella*.

Figure 6.4 and Q 8

Interpreting (graphs)
Approximately 70 per cent of all poultry will carry *Salmonella*. *Figure 6.4* illustrates this occurrence in chickens.

Suggesting hypotheses
In plucking and eviscerating chickens, micro-organisms are spread over the carcass and between birds. The gut cavity contains high numbers having housed the prime source of bacteria, the intestines. Cooking kills bacteria. Prolonged freezing

Reasoning logically
will cause a reduction in numbers. During thawing, as the temperature rises, an increase in the number of bacteria is recorded.

Table 6.1, Q 9, and Q 10

Using statistics
The table of *Salmonella* food poisoning outbreaks can be interpreted graphically. The increasing numbers of outbreaks are probably associated with increased consumption of poultry,

Communicating (graphs)
particularly frozen poultry. *Salmonella* poisoning could increase in the future if present trends continue. Steps are being taken to reduce this risk by increased hygiene in methods of preparation, and by using feedstuffs free of *Salmonella*. The improper handling of frozen poultry is a possible cause of food poisoning.

Reasoning logically
This is further discussed in section 6.4. It is important to distinguish between cases of food poisoning which are reported and those which are not. Increased reporting and public

Assessing (validity)
awareness may also be a factor influencing trends shown by the data.

Q 11
Cooking should be sufficient to kill *Salmonella* and a temperature of at least 65 °C should be reached to achieve this.

6.3
THAWING OR DEFROSTING

Main ideas in this section

The thawing of foods is dependent upon many factors. One of the main ones is the ambient temperature. The warmer the room in which the frozen food is thawing, the faster it will thaw.

If the food is packaged it will take longer to thaw.

A large mass of solid food with a small suface area will take longer to thaw than the same mass of food with a large area.

Designing tests

The pupils are asked to carry out a survey on the thawing of frozen chickens. Worksheet FSM13 will be useful in discussing heat transfer.

Q 12 and Q 13

Observation v inference

These can be used as a basis for discussion of changes occurring during thawing, correct thawing procedure, and the need to plan ahead to allow adequate thawing time for frozen meats and poultry.

Assessing (ideas)

The thawing of food begins when heat from the outside of the food penetrates into it. During this process the frozen liquid within the carcass melts. This liquid is known as 'drip'. As it defrosts, the outside of the defrosted chicken feels soft. Care should be taken to check that the inside has also defrosted.

Figure 6.5 and Q 14

Interpreting (graphs)

Using statistics

When the outer part of the chicken is thawed, it is still frozen in the middle. The points X and Y on lines A and B indicate the period during which frozen water is changing from ice to liquid; heat is absorbed to bring about this change, but there is no increase in temperature.

Communicating (speech)

Reasoning logically

A chicken cannot be considered as thawed until the centre temperature has risen above 0 °C. This takes some 18 hours according to the graph. Question 14d requires this information to be used in conjunction with thawing recommendations. The chicken probably weighs less than 1.5 kg as it is thawed between 12 and 24 hours.

The chicken temperature will, in time, equilibrate with room temperature, or refrigerator temperature in the case of the graphical data provided.

Link with school science

The pupils may have studied the following relevant topics: heat transfer during phase change; effect on crystal size of rate of growth; thermal conductivity of different materials; food preservation techniques; and the effect on cells of slow freezing. The work gives a good illustration of the use of a wide range of scientific concepts and patterns to explain everyday phenomena.

Q 15

Reasoning logically / Communicating (maths and writing)

The chicken will obviously lose weight as it thaws. The drip will consist of cellular fluid such as blood, protein, amino acids, and fat, and will contain bacteria washed off the skin. Drip can sustain bacterial growth. The volume of drip collected will depend upon how quickly the chicken or other frozen food was frozen. The faster the chicken is frozen, the smaller the ice crystals that will form within it. Slow freezing and large ice crystals result in more liquid loss during thawing. The use of polyphosphates by the food manufacturer to hold more water in frozen poultry and other meat products might be discussed at this point.

Assessing ideas

Separating the frozen meat or chicken from drip whilst thawing will minimize the risk of contamination. A recommended procedure is to put frozen chickens on an upturned plate in a larger tray or dish. This arrangement might be encouraged in the survey. The bacteria present in the drip or chicken will be inhibited if the chicken is defrosted in a refrigerator. However, raw meat or food including frozen or thawing meat must not be allowed to contaminate other food, particularly cooked products. ⚠

Q 16

Freezing methods in the home are never as fast as those available industrially. As a result, large ice crystals are formed, possibly causing cellular damage, changes in texture due to denaturation of protein, and increased drip.

6.4
COOKING FROZEN CHICKEN

Main ideas in this section

If the centre of the chicken is not thawed, due to insufficient time being allowed for thorough defrosting, heat will not penetrate to the centre.

The outside of the bird will then be cooked, probably overcooked, before the temperature at the centre begins to rise.

Interpreting (graphs)

Pupils could be referred back to *figure 6.5* which shows the period X — Y, when there is no temperature rise because latent

Applying knowledge

heat is being absorbed to melt ice. If the centre of the bird has not passed through this period during the thawing process, it will have to be passed through during cooking. Once this period is over the temperature will begin to rise, but meanwhile the outside of the bird will be overcooked.

Organizing data

The results of experiments on cooking chickens are given in the pupils' text and could be interpreted graphically.

Q 17

Interpreting (graphs)

Results from a number of samples must be used to produce representative and reproducible data. Smaller chickens cook faster than larger ones.

Deciding criteria

Q 18

Reasoning logically

A chicken containing stuffing takes appreciably longer to reach 65 °C at its centre than an unstuffed bird of a similar size. This results in an element of risk, as the stuffing has been handled and will be contaminated, possibly with *Salmonella*. The temperature necessary to kill this bacteria is not reached until roasting has continued for 80 minutes.

Q 19

Communicating (writing)

This requires a resumé of the information on thawing, cooking, and food-poisoning bacteria from this and previous sections.

6.5 FREEZING AT HOME

Main ideas in this section

As well as stocking the domestic freezer with products from the food manufacturer, dishes prepared at home can be frozen for reheating and serving at a later date.

Quick freezing and good quality raw materials as well as high standards of hygiene are essential if dishes of high quality are to be served.

Food with a large surface area to volume ratio freezes most quickly, and will thaw or reheat most quickly. Flat slabs of food or portions not more than 4 cm deep freeze rapidly (for instance, fish fingers, beefburgers, peas).

Practical skills

Selecting equipment

Estimating

The experiment in this section investigates the influence of depth of portion on freezing time. *Figure 6.7* shows the apparatus. (A major influence on freezing time is the operating temperature of the freezer. In general, domestic freezers operate at higher temperatures than those used commercially, and without the high velocity of air over and around the food for rapid removal of heat which large-scale manufacturers use in their blast freezers.)

Link with school science
The investigation provides an illustration of the value and function of scientific measurement, and that of good investigative design (for instance, in the control of variables). It also illustrates the use of concepts and patterns mentioned in section 6.3 above.

Measuring
Communicating (writing)

You will need for each pair or group of pupils
'Instant' potato
4 margarine tubs and lids, labelled A, B, C, and D
4 thermometers, −10 °C to 110 °C
or narrow range thermometers, −10 °C to 10 °C
or temperature recorders incorporating thermocouple probes

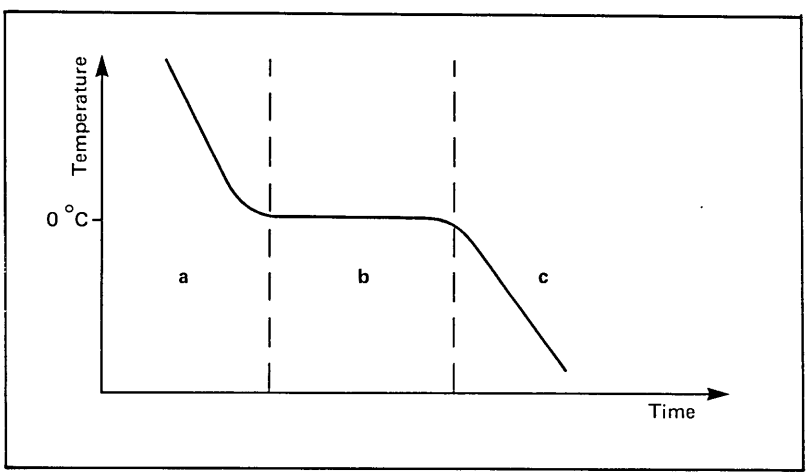
This experiment could also be carried out using minced beef in gravy or mince extended with texturized vegetable protein.

The temperature recording method may be difficult at low temperatures if wide-range thermometers are used. Elastic bands around the thermometer will help to ensure that the bulb is situated in the centre of the food sample. The accuracy of the method can be discussed using worksheet FSM1.

The experiment requires temperatures to be recorded at intervals, which means opening the freezer. This is not a practice to be encouraged and might be a useful discussion point. The rate of freezing will be slow and may need to continue after the lesson.

The results of the experiment should be compared with the normal cooling curve for foods which is shown in figure T6.1.

Figure T6.1



Observation v inference

There are three main areas:
a a period of rapid cooling;
b a period when heat is removed from the food with no decrease

in temperature (latent heat of freezing). During this period water is changing into ice;
c a decrease in temperature to that of the freezer.

Communicating (graphs) Compare the graph with the one given to illustrate thawing (*figure 6.5*). It shows a similar shape although in the opposite direction. Fast freezing ensures that the middle period takes only a short time and so avoids the formation of damagingly large ice crystals. (See also worksheet FSM13.)

Q 20

Assessing (validity) The food sample of least depth should cool and freeze fastest. Domestic dishes to be frozen should be less than 4 cm deep. This ensures quick freezing and quick reheating.

Q 21 and Q 22

Applying knowledge Food in the freezer must be packaged to avoid drying out and possibly irreversible freezer burn. Plastic freezer bags or films and aluminium foil trays are popular, if expensive. The method of reheating the dishes will influence choice of packaging. Air in packages should be minimized to reduce drying out and the risk of fats becoming rancid. It is important to realize that the quality of frozen foods deteriorates during storage, though only very slowly. Worksheet FSM15 will be useful here.

6.6
USING FROZEN FOODS

Main ideas in this section

Frozen foods deteriorate in time.

Manufacturers give instructions on how to store and prepare frozen foods.

Q 23

Applying knowledge *a* The temperature of the freezer influences the length of time which food can be kept without obvious deterioration. This is the basis of the star code used by manufacturers of freezers and frozen foods.

Applying knowledge *b* 'Sell by' dates also help to ensure that frozen foods are used at their highest level of quality. 'Use by' dates might also be appropriate.

c This encourages investigation of information on packets — a recurring theme in the pupils' text. Computer coded 'sell by' dates will be discovered, as well as nutritional information given by some manufacturers. Detailed instructions for reheating the

Communicating (speech) food are given. An interesting discussion point is whether or not the domestic user actually follows instructions on packets. The shape and size of packets is also noteworthy. They are normally

Processes and skills	Pupils may be able to:
6.1 *Using frozen meat, fish, and poultry* Selecting information and forming hypotheses.	Discuss the merits of freezing meat, fish, and poultry. Suggest suitable cooking methods.
6.2 *Problems in handling meat and fish* Reasoning logically, interpreting reported data, applying knowledge.	Recognize that meat and fish decompose due to action of bacteria. Recognize the conditions most favourable to the growth of these bacteria. Recognize that these bacteria can be extremely dangerous — even fatal.
6.3 *Thawing or defrosting* Assessing reported data critically. Interpreting (graphs), identifying causes, applying knowledge. Designing and carrying out a survey. Applying safety precautions.	Compare the rates of contamination of various parts of chicken by bacteria. Draw a graph to show the rise in cases of *Salmonella* poisoning over the last ten years. Discuss the causes and effects of *Salmonella* poisoning. Defrost a chicken and prepare it for cooking. Design and carry out a survey on the defrosting of chickens. Recognize that frozen food loses liquid which is waste when thawed, and that this liquid (drip) varies in rate and quality according to the speed and method of freezing.

Processes and skills	Pupils may be able to:
6.4 *Cooking frozen chicken* Interpreting data.	Recognize that all of the chicken must reach a temperature of at least 65 °C for the bacteria to be destroyed. Calculate the time required, depending on the weight of the chicken and the temperature of the oven.
6.5 *Freezing at home* Organizing and carrying out an experiment. Interpreting results, evaluating results.	Carry out an experiment to plot the rate of cooling/freezing of different depths of a food (*e.g.* potato). Discover that food with a large surface area to volume ratio freezes most quickly.
6.6 *Using frozen foods* Applying information. Identifying relevant factors.	Interpret the instructions and symbols on labels found on frozen foods. Design and make similar labels for their own products. Recognize that optimum time of storage varies, and that this information is available in recipe books and on packet labels.

Assessing (ideas)

flat, to allow for rapid reheating. Lists of ingredients on frozen food packs are also interesting. Look for stabilizers, gums, food starches — all designed to help the product withstand freezing and reheating. These are discussed in later chapters.

Applying knowledge

Q 24 and Q 25
Discuss some important considerations when handling frozen food. Although frozen raw meats, particularly poultry, require thawing before cooking, prepared frozen meats are normally designed to reheat from freezing. Again, it is essential to follow the makers' instructions. Frozen food should never be re-frozen after thawing, except, of course, in the case of frozen meats and poultry which have been thawed and used in the preparation of a cooked dish which is then frozen.

Q 26

Organizing data

Pupils are asked finally to design a label for a product of their own. Beef curry is suggested but any other dish prepared for freezing is suitable. Most important features of the label are:

Applying knowledge

Name of product
Use by date/date of preparation
Reheating method
Suggestions for serving.

Extension work

A link with practical work: the pupils could prepare a dish for freezing and pack and label it correctly.

Ideas for homework

Make a survey of one of the following:

a number of homes with freezers in the class.
b foods most usually stored in home freezers.
c types of fish and fish products stored in home freezers.
d number in class using frozen peas, chicken, or fish fingers during last week.
e number of times frozen food is used by the family in a week.

Ask pupils to make a collage of wrappers from frozen food packets.

They could find out about polyphosphates in meat and meat products.

Question 19 is suitable for homework.

Using references

The Background reading tells pupils about the careful organization involved in the production of frozen foods. Food scientists are employed at various stages in this process. Encourage pupils to think about possible job opportunities in this field.

CHAPTER 7

Mixing ingredients together

Chapter 7 investigates the process of mixing and combining dry ingredients in food preparation. The importance of mixing is emphasized — particularly when small amounts of an ingredient are involved.

Baking powder is used as one example of a mixture and practical experiments are carried out to investigate a variety of mixes. The pupils look at flour as a mixture. They are asked to consider why extractions and additions are made during the process of milling. Then they examine strong and weak flours and test them for gluten content.

Time allocation
Section 7.1: 10 minutes; 7.2: 20 minutes; 7.3: 20 minutes; 7.4: 5 minutes; 7.5: 30 minutes; 7.6: 30 minutes; 7.7: 10 minutes; 7.8: 10 minutes theory and 30 minutes practical work (total 165 minutes).

Section 7.1 and 7.2 could be done as preparatory homework. Sections 7.3, 7.5, 7.6, and 7.8 contain practical work which could be done as group work. Time would then be needed to discuss the results of different groups.

Extension work in this chapter
Section 7.8: investigating modern dough making techniques with weak flour.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM2 Acids, bases, pH
FSM12 Foams
FSM23 Assessment card

7.1
FOOD MIXTURES

Main ideas in this section

Many foods are a mixture of ingredients, even if they appear to be only one ingredient.

Accurate and thorough mixing is an important stage in food preparation.

Cooking will probably change the mixture.

Pupils probably won't realize that many of the foods they buy are in fact mixtures. Some, such as muesli, are obvious, but others are accepted as one ingredient when they are in fact mixtures (*e.g.* custard powder).

Q 1 and figure 7.1

Observing

Pupils are asked to identify the ingredients in pizzas. The photograph should help.

Applying knowledge

Pupils should think about why foods are sold as mixtures. The following reasons could be discussed: to provide interest and variety in colour, texture, and flavour (*e.g.* fruit salad), and to provide a cost-controlled marketable mixture which will give reliable and consistent results (*e.g.* custard powder). The first can be any mixture available, but the second must be carefully controlled for cost and performance.

Using references

Q 2

Remind pupils of their own experience of mixing ingredients. Any recipe book can be used to check the ingredients used to produce the foods.

Next, encourage pupils to think about the changes brought about by mixing ingredients. These ideas will be developed in later chapters (8 to 12). It is important that pupils should begin to realize that mixing changes the foods. (This work links with Chapter 6 of *The Basic Course*.)

Q 3

Identifying causes

French dressing is the only food on the list which is not cooked. This question reminds pupils that cooking also changes mixtures. Draw attention to these changes — particularly the baking of bread. Encourage pupils to think about the changes in colour, texture, and flavour.

7.2 LABELLING MIXTURES

Main ideas in this section

When a mixture is in a can or packet its contents cannot be seen.

Using pictures to describe mixtures is inadequate; legislation requires the food manufacturer to list the ingredients used in order of weight present.

Q 4

Observation v inference

Labelling helps the shopper to make an informed choice. For example, a bottle of orange drink may not contain any real orange. Tell pupils to collect information from labels. This could lead to a discussion of the various additives particularly

Organizing data

used in convenience foods. Chapter 15 gives some information on additives in foods. Food allergies might also be discussed.

A copy of *The labelling of food regulations* can be obtained from H.M.S.O. This provides an opportunity for pupils to do their own investigations. Considerable information is available from local offices of the Trading Standards departments (weights and measures) either locally or at county level. Sometimes talks by trading standards officers can be arranged or films may be available.

Q 5

Assessing (relevant factors)

a Bread sauce mix
b Instant dessert (could be toffee, butterscotch, or coffee)
c Vegetable and beef soup (could also be minestrone soup).

7.3 MAKING AND CHECKING MIXTURES

Main ideas in this section

Mixing methods vary, but must be suitable for the ingredients used.

The effectiveness of the mixture can be assessed by sampling.

Samples should be random and representative.

You will need for each pair or group of pupils
Muesli ingredients (separately):
100 g (8 15-ml (table) spoonfuls) oat flakes or wheat flakes
30 g (1 10-ml (dessert) spoonful) dried fruit
10 g (1 10-ml (dessert) spoonful) dried milk

Large mixing bowl
15-ml (table) spoon and 10-ml (desert) spoon
Balance

Practical skills

Measuring

Muesli has been chosen as the ingredients are easy to identify and to store. The resulting mix can also be eaten. Any mixture of ingredients may be used provided they can be identified easily and are easy to separate.

Q 6

Reasoning logically

Identifying causes

Applying knowledge

a The importance of taking samples is to give an average sample: if these samples vary considerably the reasons for this should be investigated. It will probably be due to the fact that the nuts are heavy and there are few of them.
b The proportion of nuts will vary, especially if they are large. Most muesli mixtures chop the nuts as this gives a better mix.
c This is an easy way of mixing but it is not very thorough, depending on how much space there is in the packet. It also tends to separate the mixtures, the less dense parts rising to the top as the mixture is shaken.

Q 7

Applying knowledge

Food labels give the answer, as pupils learned in section 7.2.

Q 8

Organizing data

Pupils can look at various brands of muesli and compare the ingredients.

7.4 BAKING POWDER: A MIXTURE

Main ideas in this section

Baking powder is a mixture of sodium bicarbonate, an acidic substance, and corn starch.

The substances react when moist to give off carbon dioxide.

Carbon dioxide is a raising agent and makes mixtures light.

The amounts used are small. They must be measured accurately and mixed thoroughly to give good results.

Applying knowledge

Pupils may be familiar with baking powder and may know that it is a mixture. As all the ingredients of baking powder are white powders, it is difficult to identify them.

Link with school science

Some knowledge of the various ingredients of baking powder is important. Check on the work done in chemistry at school.

Sodium bicarbonate ($NaHCO_3$) is white alkaline powder. It gives off carbon dioxide when heated, but leaves a soapy taste and yellow colour which have to be disguised by spices and brown sugar in cake-making.

The acidic substances in baking powder are one or more of those given in table T7.1 on the next page.

A simplified equation for this reaction is:

Sodium bicarbonate + cream of tartar ⟶

$NaHCO_3$ CHOH COOH
CHOH COOK

sodium potassium tartrate + carbon dioxide + water

CHOH COONa + CO_2 + H_2O
CHOH COOK

Q 9

Applying knowledge

a If the baking powder is moist, the sodium bicarbonate and the acidic ingredients will react together slowly, giving off carbon dioxide.

Acidic substance	Properties
Cream of tartar (acid potassium tartrate) $KHC_4H_4O_6$	A white acid powder, it reacts slowly with sodium bicarbonate in the presence of water to give off carbon dioxide when cold, but reacts faster when warmed
Tartaric acid $C_4H_6O_6$	Similar to cream of tartar, but reacts rapidly when moist so much of the gas is lost during mixing
Acid calcium phosphate (A.C.P.) $CaH_4(PO_4)_2$	Has good keeping qualities and is used commercially; delayed action ensures that baking powder does not act too quickly in the oven
Acid sodium pyrophosphate (A.S.P.) $Na_2H_2P_2O_7$	Fairly common and cheap, but reacts when cold; also used in commercial baking powders

Table T7.1
Acidic substances in baking powders.

Designing tests

b If the baking powder is not thoroughly mixed, the ingredients will not react together. The sodium bicarbonate may be converted by heating into sodium carbonate (washing soda) giving an unpleasant flavour.

Identifying causes

c Many cake recipes have baking powder as an ingredient. Batters, pastries, and sauces do not.

d This question is introduced to make sure that the concept of carbon dioxide as a raising agent is understood.

7.5 MAKING AND TESTING BAKING POWDERS

Main ideas in this section

The effectiveness of baking powder (*i.e.* the CO_2 given off) can be measured by mixing it with egg white solution in a measuring cylinder and recording the increase in volume.

Baking powders can be compared by repeating this standard test method.

You will need for each pair or group of pupils

Practical skills

Sodium bicarbonate	100-ml cylinder
Cream of tartar	Glass rod
Corn starch	5-ml (tea) spoon
Commercial baking powder	
Egg white solution (made by mixing equal parts of egg white and water)	

Observing

The carbon dioxide is given off slowly at first. The probable result will be that gas is given off after between one and three minutes and that the 'home-made' baking powder is more effective than the commercial one as this may have been stored for some time.

Q 10

Reasoning logically

a The CO_2 makes the foam rise.

b This depends on the state of the ingredients.

Designing tests

c It is possible that the individual ingredients might give off carbon dioxide. Corn starch and cream of tartar will give a negative control. Sodium bicarbonate will give off carbon dioxide in smaller amounts.

Applying knowledge

(Sodium bicarbonate ➡ sodium carbonate (washing soda) + carbon dioxide + water.)

This reaction is increased when the sodium bicarbonate is heated.

Identifying causes

d The home-made baking powder should produce the greatest volume.

e The cylinders can be placed in a large container of hot water.

Communicating

As the foam warms, the reaction becomes faster and more carbon dioxide is given off, causing a rapid increase in volume. (Note that temperatures above 60 °C would begin to coagulate the egg proteins, slowing down the increase in volume.)

Worksheet FSM12 may be useful here.

7.6
USING BAKING POWDERS

Main ideas in this section

The balance of sodium bicarbonate (bicarbonate of soda) and acidic substance must be correct.

By making test drop scones using different amounts of ingredients, it is possible to find the most effective balance.

Self-raising flour and plain flour plus baking powder can be compared by a simple experiment.

Ingredients and conditions must be carefully controlled if results are to be valid.

You will need for each pair or group of pupils

Practical skills
Estimating
Measuring
Designing tests
Selecting equipment

Plain flour	Scales
Self-raising flour	Sieve
Margarine	Mixing-bowl
Egg	Egg-beater
Sugar	5-ml (tea) spoon
Salt	10-ml (dessert) spoon
Milk and water	Wooden spoon
Sour milk or vinegar	Palette knife
Cream of tartar	Griddle, thick frying-pan, solid hot-plate, or electric multi-purpose cooker
Sodium bicarbonate	Cooling tray
Grease for griddle	Knife

The balance of sodium bicarbonate and acidic substance depends on the 'strength' of the acidic ingredient. This is defined by the amount of sodium bicarbonate which is 'neutralized' by a fixed amount of acid ingredient.

Taking the acid ingredient as 100 parts, cream of tartar neutralizes 45 parts of sodium bicarbonate, and A.S.P. (Acid Sodium Pyrophosphate) 75 parts.

Most recipes simplify this to: one part sodium bicarbonate, two parts cream of tartar, and one part corn starch.

Q 11

Observing
Identifying causes
Evaluating results

Scone A is the basic mixture and should produce a good result.
Scone B has too much acid and should be slightly bitter.
Scone C has too much sodium bicarbonate and should give a soapy taste, darker colour, but good rise.
Scone D depends on how sour the milk is. If possible, leave the milk to sour for a week or add a little lemon juice or vinegar to it. These scones should have as good a colour, texture, and flavour as scone A.
Scone E is made with self-raising flour which should give a medium rise and good colour and flavour.
Scone F has no raising agent and should give very poor rise and poor texture. It should be used as a control.

By putting one scone of A, B, C, D, E, and F on the same cooling tray, it is possible to make a comparison.

7.7
FLOUR: ANOTHER MIXTURE

Main idea in this section

Additions are made to commercial flours during milling.

These additions are made at the following rates:
Chalk: 235 to 390 mg per 100 g.
Iron: 1.65 mg per 100 g.
Thiamin: 0.24 mg per 100 g.
Nicotinic acid: 1.60 mg per 100 g.

These additions are required by law except in the case of wholemeal flour. (The law about nicotinic acid may change.)

Q 12

Applying knowledge

a During the Second World War, the British diet was studied in some depth and it was realized that the majority of us ate white rather than brown bread. This caused some concern as the nutritional value of white bread was considerably lower than that of brown, since the above nutrients were mainly lost during milling and removal of bran and germ. Now it is illegal to produce white flour without these additives. (*Nutrition* Chapter 2 looks at the differences between brown and white flour.)

Applying knowledge

b *Bleaches* are used to improve the appearance of the flour. Consumers expect flour to be white.

c Other kinds of cereals used to make flours are rice and corn. These do not produce gluten when mixed with water. (See question 15.)

7.8 STRONG FLOURS AND WEAK FLOURS

Main ideas in this section

Strong flours are produced from the hard spring wheat grown in Canada and Russia. They have a higher protein content than weak flours and are suitable for bread making.

Weak flours are grown in the United Kingdom and throughout Europe. They are lower in protein and are suitable for making cakes and biscuits.

You will need for each pair or group of pupils
50 g strong (hard) flour (labelled A)
50 g weak (soft) flour (labelled B)

2 basins
Measure or 15-ml (table) spoon
Baking tray
Oven at 230 °C, regulo 8

The pupils may have experimented with different types of flour in *The Basic Course*, Chapter 5. (See also Chapter 12 and worksheet FSM12.)

Applying knowledge

The experiment shows that gluten balls from different types of flour vary in size and elasticity. The gluten complex is formed when the flour is mixed with water and consists largely of protein. Its elasticity allows the dough to accommodate carbon dioxide gas produced by yeasts or by the action of baking powder.

Observation v inference

When a dough is heated, water changes to steam and this, along with the air in the dough, expands blowing the gluten into balloon-like bubbles. On further baking the gluten proteins are denatured and the baked product gains its light airy structure.

Processes and skills	Pupils may be able to:
7.1 *Food mixtures* Identifying and organizing data, classifying, applying knowledge.	Recognize that many products used in cooking are mixtures. Recognize that most commercial mixtures are carefully controlled for cost and performance.
7.2 *Labelling mixtures* Applying knowledge, organizing data, using references, observation *v* inference, communicating (writing).	Interpret the labels on packaged foods. Recognize the relative importance and amounts of the ingredients.
7.3 *Making and checking mixtures* Practical skills, selecting equipment. Measuring, observing, reasoning logically, applying knowledge, communicating (data).	Identify and measure the main ingredients in a muesli mixture. Make a muesli mixture or other similar simple mixture. Compare a variety of muesli mixtures and record findings.
7.4 *Baking powder: a mixture* Using references, observing, applying knowledge, identifying causes.	Recognize the need to use baking powder in order to make mixtures rise. Recognize that baking powder is a mixture of very different white powders, which when water is added react to give off carbon dioxide.

Processes and skills	Pupils may be able to:
7.5 *Making and testing baking powders* Measuring accurately, practical skills, reasoning logically, communicating (writing).	Make a baking powder. Test and compare the effect of the complete baking powder with the effect of the individual ingredients.
7.6 *Using baking powders* Suggesting hypotheses, designing tests. Practical skills, measuring accurately, observing, estimating. Communicating.	Make test scones using the various ingredients of baking powder. Observe the results and compare colour, texture, flavour, and size.
7.7 *Flour: another mixture* Observing, suggesting hypotheses, reasoning logically, using references. Communicating (writing).	Trace the stages in production of flour. Recognize the possible variations in flour including removals and additions. Recognize that flour and bread are staple foods in the British diet and are controlled by law.
7.8 *Strong flours and weak flours* Using references, applying knowledge, using practical skills, measuring accurately. Observation *v* inference.	Extract the gluten from flour, and make dough balls with the gluten extracted from different flours. Compare the results and apply the information to bread making.

Q 13

Identifying causes

Too much gluten will give a tough unpalatable result. To produce a flour with the right quantity of gluten for each purpose, the millers mix together several types of flours of different strengths to produce what is called a mixed grist.

Q 14

Reasoning logically

Soft flours are mixed together to produce a flour with a weaker gluten suitable for cakes and pastry. A mixture of strong wheats makes a flour suitable for bread and most forms of yeast cookery.

Q 15

Communicating (speech)

This question reminds pupils that flours are made from other cereals. Neither cornflour nor rice flour produces gluten, but their uses in cooking could be discussed at this point and compared with those of wheat flour.

Extension work

Modern dough making techniques enable the use of weak flours in bread making, including English flour. Pupils could be asked to find out about the 'Chorleywood process'. Mechanically developed doughs produced by methods like this do not require a long fermentation process. A short period of intensive mixing serves to stretch and develop gluten. Vitamin C is added in the process and becomes converted to dehydroascorbic acid from ascorbic acid by oxidase enzymes. The former acts as an oxidizing agent and improves the flour by helping to develop gluten structure.

Ideas for homework

Sections 7.1 and 7.2 can be done as preparation for the lesson. A survey could be made of labelling, using packages from the cupboard at home or visiting a supermarket.

The pupils could investigate types of wheat grown locally, types of bread available in local shops, or substitution of ingredients and variations in recipes for pastries and cakes.

Assessing (relevant factors)

The Background reading should broaden pupils' ideas about what 'bread' is. They should realize that in many parts of the World foods can only be made from what is produced locally. There is a big variation in people's likes and dislikes in foods. The popularity of wholemeal breads and the question of fibre in the diet could be discussed here.

CHAPTER 8

Mixing fat and flour

This chapter studies the wide variety of fats and oils available for domestic use. A basic knowledge of fats and oils is used to explain the changes during mixing and cooking pastry.

Time allocation
This chapter can be completed in one lesson by doing the experiments in groups. Suggested time allocation is: section 8.1: 5 minutes; 8.2: 10 minutes plus 20 minutes group work; 8.3: 5 minutes; 8.4: 10 minutes plus 20 minutes group work; 8.5: 5 minutes; 8.6: 10 minutes plus 20 minutes group work.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM2 Acids, bases, pH
FSM4 Carbohydrates II
FSM5 Fats and oils
FSM6 Proteins
FSM10 Emulsions
FSM14 Taste panels
FSM24 Assessment card

8.1
LOOKING AT FATS

Main idea in this section

There is a wide variety of fats and oils available to the consumer.

Figure 8.1

Observing
Classifying

It is advisable to complement this picture with a display of containers and labels. The visual stimulation this provides should enable pupils to answer questions 1, 2, and 3.

Q 1

Reasoning logically

The aim of this question is to stir pupils into thinking across a broad spectrum. For example, butter is used as a spread because of its well-liked flavour. Fats and oils for different purposes are now provided by the food manufacturer, from margarines which spread straight from the refrigerator to calorie-reduced spreads and 'all-in-one' cooking fats.

Q 2

Applying knowledge

Compiling the list of ingredients should help pupils to answer this question. Soya margarine by Sainsbury's and Tomer can be

eaten by vegans and Hindu families as neither of these fats contains animal fats. Flora oil, Flora margarine and other brand names of polyunsaturated margarine may be used by people who are advised to eat polyunsaturates. (Polyunsaturates are explained in section 8.3 of the pupils' text.)

Q 3

Observation v inference

Low fat spreads differ from butter and margarine in their high water content.

Organizing data

Cooking fats originated in the United States as a substitute for lard and are sometimes called 'shortenings'. They are usually made from vegetable oils, perhaps with lard added, and they are aerated, containing 10 to 30 per cent trapped air.

Super-glycerinated or high ratio fats have an emulsifier added. The emulsifying agent most frequently used is glyceryl monostearate. These fats are more efficient for creaming and incorporating a high ratio of water into doughs and batters.

Worksheet FSM10 illustrates glycerol monostearate and its use as an emulsifier.

Low fat spreads are made on the same principles as margarine (see below) but a much higher concentration of liquid is added. This accounts for the lower energy density. The low fat spreads are not suitable for cooking and the keeping qualities are not as good as in margarine.

The reasons for producing new types of fat include: cost, availability, ability to spread direct from the refrigerator, dietary reasons such as limited energy intake, a response to current opinion on cholesterol, religious or cultural restrictions, ease of use (*e.g.* mixing), and improvements in texture or flavour.

8.2 MAKING MARGARINE

Main ideas in this section

Margarine is used as a butter substitute. There are many leaflets available giving information on its manufacture.

Suggesting hypotheses

Margarine is a mixture designed by the manufacturer to provide the particular physical characteristics necessary for different culinary purposes.

Assessing (relevant factors)

Its melting point can be controlled and modified during manufacture so that it spreads straight from the refrigerator, or mixes readily with flour, or remains solid in hot climates.

The nature of food emulsions, of which margarine is a good example, is discussed in Chapter 11 and on worksheet FSM10.

Figure 8.2
This shows that a variety of oils are used in making margarine.

Q 4

Assessing (relevant factors)

Butter and margarine should be compared in terms of nutritional value, eating quality, and cost. Margarine is a reasonable source of dietary vitamins A and D; the amounts of these vitamins present are controlled by law. In butter, the amounts of vitamins are variable, being high in summer and low in winter.

Applying knowledge

Pupils could be asked to explain why this should be. They should recognize the relationship between the cows' diet and the quality of the butter.

The pupils try to make margarine themselves.

Designing tests

Selecting equipment

Practical skills

Measuring

You will need for each pair or group of pupils

80 g mixed fats or oils — the following should give good results:
80 g white fat (*e.g.* Cookeen)
60 g white fat and 20 g vegetable oil
20 g white fat and 60 g vegetable oil
40 g suet and 40 g vegetable oil
40 g white fat and 40 g vegetable oil

1 g lecithin (it can be bought at health food shops)
16 g water
Pinch salt
2 drops yellow food colouring
Bread

Scales
Double saucepan
Whisk
Basin
Knife
Access to cooker and refrigerator

Q 5 and Q 6

Communicating (writing and speech)

This seeks to encourage pupils to describe 'mouth-feel' and discourage comments such as 'I like it' or 'I don't like it'. These questions should lead into discussion of the problems of removing unpleasant flavours or of adding acceptable ones.

It also encourages awareness of the difficulty faced by the manufacturer in producing qualities similar to butter, particularly flavour.

8.3
CHEMICAL COMPOSITION OF FATS

Main ideas in this section

Fats may be classified as liquid and solid, the latter being soft or hard at room temperature.

The consistency of a fat is caused by its chemical structure.

Organizing data

As a rule, oils are liquid at room temperature and fats are solid. This distinction is widely accepted, but it should be noted that room temperatures vary. Some oils, for example palm oil, tend to be solid at the prevailing temperature of the British climate.

Deciding criteria

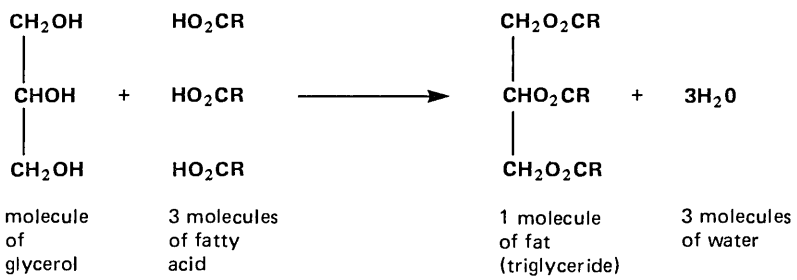
The observations made on the physical characteristics of fats and oils are intended to form the basis for an introduction to their chemical nature. The term *lipid*, which includes fats and oils, has not been used in this text but may be found elsewhere.

Communicating (writing)

Fats belong to the group of substances known as esters. Esters are formed from the reaction of acids with alcohols. In the case of fats, fatty acids form the acid component and glycerol the alcohol. Worksheet FSM2 deals with esters.

Glycerol is called a trihydric alcohol. It has three hydroxyl groups, each one of which can combine with a fatty acid molecule If all the hydroxyl groups combine with fatty acids the term triglyceride is used. This is shown in the form of a chemical equation. (See figure T8.1.) Worksheet FSM5 also illustrates this point.

Figure T8.1



The OH on the glycerol molecule is called the hydroxyl group. The fatty acids are shown as HOOC.R. The OH group of the glycerol reacts with the COOH of the acid, a reaction known as condensation. The result is one molecule of fat (triglyceride) and three molecules of water.

Figures 8.5 and 8.6

Fatty acids may be saturated or unsaturated. The diagrams show the difference between them. Molecular models would help to reinforce this concept. Most pupils should be able to understand the terms saturated and unsaturated fatty acids, as these terms are commonly used in labelling fats, as in 'high in polyunsaturates'. Polyunsaturates are fatty acids with two or more double bonds.

Link with school science

There are clear links with the study of nutrition, specifically with the study of the chemical nature of nutrient compounds and the use of 'ball and stick' or 'space-filling' molecular models to represent them. The work may also be relevant to the comparison of the physical and chemical properties of water with those of other natural liquids in materials science; and to discussion of polymers in the chemistry of organic substances.

Q 7
Butter, lard, hard margarine, and suet are high in saturated fatty acids.

Q 8
Hydrogen atoms can be added to unsaturated fatty acids, making them more saturated. The answer is two.

Q 9
Oils and soft margarine and some low fat spreads are high in unsaturated fats.

Q 10
Applying knowledge
This is a revision question. Hydrogen is added at the double bonds in unsaturated fatty acids to turn an oil into a fat. The concept that various fats and oils can be made into margarine is reinforced. Hydrogenation (the addition of hydrogen) increases the melting-point of an oil, *i.e.* it has a hardening effect which can be controlled by the manufacturer.

8.4
DO ALL FATS MELT AT THE SAME TEMPERATURE?

Main ideas in this section

The melting-point of a fat is an important characteristic and reflects its suitability for different purposes.

The melting-point depends on the type of fatty acids present. If the fatty acids have long carbon chains, or if the chain is saturated with hydrogen, the melting point is increased.

You will need for each pair or group of pupils

5 g each of various fats
Test-tubes marked A, B, C, etc.
Test-tube rack
Thermometer, −10 to 110 °C
Beaker or basin (large)
Bunsen burner or other source of heat
Tripod and gauze

Practical skills
Measuring
Communicating (writing)
The experiment given cannot be very accurate but should give comparisons between the fats used. Important points to check are that: all tubes are warmed to melt the fats but not heated more than necessary, all the tubes are cooled until the fats are solid, and the temperatures when the fats begin to melt and when they are completely melted are recorded.

Suggesting tests
A more accurate experiment can be carried out with more able pupils. The melted fats are introduced into capillary tubes which are then sealed. Each tube is fixed to a thermometer with a rubber band and the melting temperatures and times recorded. The test-tubes or capillary tubes can be prepared before the lesson and stored in the refrigerator.

Applying knowledge

Hard fats have the higher melting-points. Fats do not melt at a precise temperature because they contain a mixture of triglycerides. They melt over a temperature range in which they are said to be plastic, *i.e.* they are soft and spreadable.

8.5 WHAT HAPPENS WHEN FAT AND FLOUR ARE MIXED?

Main idea in this section

Different fats should be used depending upon the mixing method adopted and the desired result.

Figure 8.7
The pupils should consider the inter-relationship between type of fat used, mixing methods, and the characteristics of different types of pastry. Table T8.1 gives some possible answers.

Table T8.1

Name of pastry	Type of fat used	Method of mixing
Short	hard margarine and lard	rubbing fat into flour
Suet	suet	chopping fat and mixing it into flour
Flaky	hard margarine and lard	rubbing in quarter of fat; adding rest of fat in lumps in three rollings
Rough puff	hard margarine and lard	mixing fat into dough in cubes (about 1 cm^3)
Puff	butter or hard margarine and lard	folding fat into dough in one piece
'All in one' pastry	soft margarine	creaming fat with some of the flour and water

Q 11

Applying knowledge

Reasoning logically

The concept of using fat as a shortening is introduced. Short-crust pastry is crumbly, and shortbread even more so, because the latter contains a high fat content and no water. Reference should be made to gluten, introduced in Chapter 7. (See also *The Basic Course*, Chapter 5.) Fat interrupts the formation of a gluten network and so has a 'shortening' effect.

Q 12

Applying knowledge

This is a revision question. The answer is gluten.

When flour and water are mixed, the water combines with proteins present in the flour, and a gluten complex is developed. When baked, this mixture is very tough and chewy. If fat is mixed with flour it forms a protective coating around the flour proteins so that the water cannot combine with the proteins. Gluten development is inhibited and a soft crumbly product results. When pastry is made, a certain amount of gluten is formed because not all the water is stopped from getting to the flour proteins. If this is kept to a mimimum, a soft crumbly pastry results. The more fat used, the more gluten formation is interrupted and the more crumbly (short) the pastry will be. Figure T8.2 illustrates the formation of gluten and the role played by fat.

Reasoning logically

Assessing (ideas)

Figure T8.2

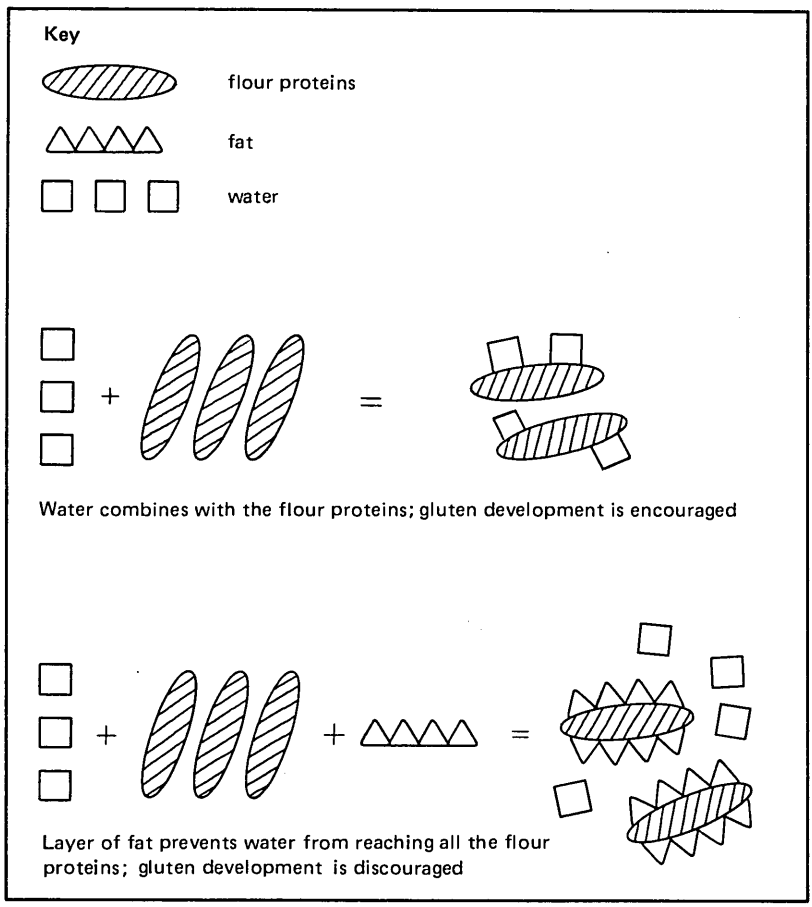


Figure 8.8

Reasoning logically

The 'all-in-one' method for making shortcrust pastry incorporates specially designed soft blend margarines. Hard margarines may also be used in this method. By adding water to half the flour only mixed with the fat, less gluten is developed. This is explained more fully in the 'all-in-one' leaflets for teachers produced by the Stork Advisory Service.

Q 13

Applying knowledge

A very crumbly short pastry.

Q 14

Reasoning logically

Both baked products will be shortened by the fat, but the higher the fat content the shorter the product. Thus short pastry is crisp and scones soft and crumbly.

Q 15

The flour can only take up a certain amount of fat; once this is exceeded the fat will 'oil' and the pastry will be greasy.

Q 16

This is a revision question. To answer it pupils must understand gluten formation and its influence on pastry texture.

8.6 DIFFERENT FATS — DIFFERENT METHODS?

Main idea in this section

There is a relationship between the characteristics of fats and their usefulness in different circumstances.

You will need for each pair or group of pupils

200 g plain white flour
25 g hard margarine marked A
25 g soft margarine marked B
25 g shredded suet marked C
25 g corn oil marked D
4 basins marked A, B, C, D
4 plates marked A, B, C, D
Round-bladed knife
15-ml (table) spoon
5-ml (tea) spoon
Fork
Wooden spoon
Rolling pin
Baking tray
Oven gloves
Oven preheated to 200 °C, Regulo 6, 400 °F
Oven thermometer

Communicating (speech)

To describe the difference in texture between raw and cooked pastries, words like soft, wet, dry, hard, crumbly, crisp, thick, thin, open, or closed may be used. Colour might be described as grey, cream, or golden, and flavour as raw, uncooked, starchy, buttery, fatty, oily, or greasy. Pupils should be encouraged to develop their own descriptions of appearance and eating qualities. Draw their attention to the large number of words available to describe food quality. Worksheet FSM14 may be useful here.

Designing tests

Practical skills

Measuring

Different methods for incorporating fats into flour reflect differences between the fats used. Hard margarine is readily worked into the flour using the fingertips. This quality is referred to as plasticity. Plastic fats spread easily, covering the flour surface efficiently, and have very good 'shortening' power. Soft margarine is difficult to work into flour. Mixing the fat, some of the flour, and all the water initially followed by the addition of the remaining flour is necessary. This procedure ensures that gluten formation is minimal.

Communicating (speech)

Suet is not plastic. It is impossible to work the fat into flour so that the grains are coated with a layer of fat. It is thus necessary to blend the fat and flour together. A knife is a useful tool for this.

Assessing (ideas)

Oil, by virtue of its liquid nature, is not plastic. It is necessary to add this to flour by blending in a similar way to suet. Unsaturated liquid fats have great tenderizing potential in pastry making. This is probably due to a greater spreading of the liquid fat over the flour surface.

Q 17

Organizing data

All these differences in method relate to two characteristics of fat or oil used: the melting point and the degree of saturation.

Q 18

Reasoning logically

Observing

Reasoning logically

During baking, the fat melts and this is absorbed into the flour. This results in the formation of air spaces in the mixture, the original space taken up by the fat now being empty. If the mixture contains a high percentage of fat, more air spaces will be formed. If the fat is present in large pieces, the air spaces will be bigger. This has important implications for the texture of the finished product. The more air spaces there are and the larger they are, the lighter the pastry will be. Flaky and rough puff pastry both have distinguishable layers or flakes due to the high fat content and the large size of the pieces of fat used.

Identifying causes

Some of the water present in the mixture turns into steam. This finds its way into the air spaces left by the fat. The steam expands and causes the air spaces to become even larger, so that the cooked pastry is much thicker than the raw pastry. Water is also absorbed by starch granules as they gelatinize during baking.

Proteins in the flour are denatured during baking. This contributes to the texture of the baked product.

Reasoning logically

Starch granules present in the flour take up water, causing the granules to swell, the process called gelatinization. This must occur if the raw starch flavour characteristic of uncooked pastry is to be eradicated. On heating, starch undergoes further changes which contribute to the golden brown colour of cooked pastry. This process is called dextrinization.

Processes and skills	Pupils may be able to:
8.1 *Looking at fats* Observing, organizing data, reasoning logically, observation *v* inference.	Recognize the wide choice of fats available. Classify these in terms of *a* origin *b* uses. Select an appropriate fat for a variety of different uses.
8.2 *Making margarine* Suggesting hypotheses, assessing (relevant factors), identifying causes, applying knowledge.	Make a type of margarine. Compare 'mouthfeel' of the margarine with commercial products.
8.3 *Chemical composition of fats* Organizing data, deciding criteria, communicating (writing), using references.	Make observations on the physical characteristics of fats and oils. Recognize that the hardness of fats depends on the fatty acids present. Discuss the terms 'saturated' and 'unsaturated' as they refer to fats and oils.
8.4 *Do all fats melt at the same temperature?* Using practical skills, measuring, observing, communicating (writing), suggesting tests, applying knowledge.	Compare the melting points of fats and oils. Apply this knowledge to the making of pastry.
8.5 *What happens when fat and flour are mixed?* Applying knowledge, reasoning logically, assessing (ideas).	Make shortcrust pastry using the all-in-one method. Recognize the effect of fat on the formation of gluten.

Processes and skills	Pupils may be able to:
8.6 *Different fats — different methods?* Designing tests, using practical skills, measuring, assessing data, observing, reasoning logically.	Relate the choice of fat to the type of pastry required. Explain the effect of cooking on the various ingredients. Recognize the cause of common faults and be able to remedy them.

Worksheets FSM 4 and FSM 6 give further treatment of gelatin and protein denaturation.

Ideas for homework

Organizing and analysing data — The pupils could make a study of the different types of fats and oils available, looking at price, type of packaging, shelf-life (if applicable), the suggested method of storage, and the list of contents (if applicable).

Using references — Using recipe books, they could choose a pastry they have not made and describe what happens to the fat, flour, and water during mixing and cooking.

Assessing (ideas) — The Background reading should increase pupils' awareness of the different fats and oils available, where they come from, and why we use the fats we do. For some cooking processes, such as frying, either solid or liquid fats can be used. You could discuss with pupils which they would choose to use, and why. Health considerations should be acknowledged (see *Nutrition*, Chapter 3).

Communicating (speech)

CHAPTER 9

Solutions and crystallization

This chapter looks at the dispersions of molecules or ions in water which are known as 'true' solutions. It provides a link between the 'dry' mixtures of Chapters 7 and 8 and the complex dispersions, or colloids, investigated in Chapters 10, 11, and 12. Salt and sugar are used as examples of substances which dissolve in water and can be crystallized out from solution.

Time allocation
Section 9.1: 15 minutes; 9.2: 20 minutes; 9.3: 10 minutes; 9.4: 20 minutes plus setting time for jelly (assessment of jelly at a later date); 9.5: 40 minutes; 9.6: 10 minutes (total 115 minutes).

Extension work in this chapter
Section 9.3: testing the effect of sugar on the freezing-point of water.
Section 9.4: finding the keeping qualities of different jellies.
Section 9.6: classifying sugar confections; comparing rates of crystallization.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM2 Acids, bases, pH
FSM3 Carbohydrates I
FSM11 Sols and gels
FSM25 Assessment card

9.1
WHAT HAPPENS WHEN THINGS DISSOLVE?

Main ideas in this section

Sugar crystals seem to disappear when added to tea, although their presence is detected by the sweet taste of the tea.

The sugar molecules of which each crystal is comprised have become dispersed in the water to make a sugar solution.

Observing

Suggesting hypotheses

When the tea is drunk, sugar molecules attach to the tongue's surface. This causes messages to be sent to the brain, which interprets the taste of the drink as being sweet (see Chapter 3).

Figure 9.2 and Q 1
The chemical structure of the sugar commonly used in the home (sucrose) is introduced. Although this may appear

formidable at first sight, it is useful for pupils, and teachers, to gain confidence in interpreting the information which such formulae provide. A model of a sucrose molecule would be useful. See also worksheet FSM3.

Link with school science

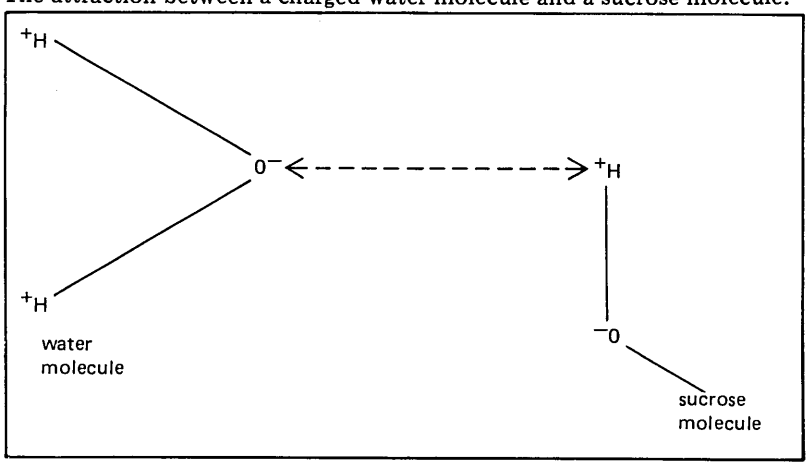
Assessing (relevant factors)

Pupils studying sciences may already know that sucrose is a disaccharide sugar and made up from one molecule of glucose sugar and one molecule of fructose sugar, joined together with the exclusion of a molecule of water. Glucose and fructose are monosaccharides. This is discussed further in section 9.6 and worksheet FSM3.

Figure 9.3

Water molecules have positive and negative charges, so water is a polar solvent. Similarly, sucrose molecules have a number of positive and negative charges. The negatively charged parts of the sucrose molecules are attracted to the positively charged parts of water molecules and vice versa. The molecules in the sucrose crystals become separated and dispersed to give a solution.

Figure T9.1
The attraction between a charged water molecule and a sucrose molecule.



Q 2 and Q 3

Applying knowledge

Stirring encourages the dispersion of sucrose molecules as does an increase in temperature. In both cases the molecules are moving more rapidly and are thus more readily separated.

Figure 9.4

Common salt (sodium chloride) also dissolves in water. The diagram shows that salt crystals are comprised of particles known as ions. Sodium ions are positively charged and chloride ions negatively charged. They are present in equal amounts. The chemical formula for salt may be written Na^+Cl^-. A model of a crystal of salt would be useful.

Q 4

Reasoning logically

In water, the negatively charged chloride ions are attracted to the positively charged parts of the water molecules while the sodium ions are attracted to the negatively charged parts. The salt crystals become broken up and the particles of which they are composed are dispersed. The salt model could be used to illustrate this.

Q 5

Salt and sugar are not the only solutes to dissolve in water and this question introduces more common solutions. It should be emphasized that liquids and gases, as well as solids, will dissolve to form solutions. The pupils could make a table like figure T9.2.

Figure T9.2

Assessing (relevant factors)

Observation v inference

Solution	Solute	Solvent
Brine	salts	water
Vinegar	acetic acid	water
Syrup	sugar	water
Wine	alcohol	water
Fizzy drink	carbon dioxide	water

More able pupils will recognize that other solutes are also dissolved in these products. Fizzy drinks will contain colours and flavours, and curing brine may contain salt, sugar, and other flavour compounds (see Chapter 5).

9.2 FINDING OUT ABOUT SOLUBILITY

Main idea in this section

Solubility is affected by temperature.

Designing tests

Practical skills

The investigation could be organized as group work, each group measuring the solubility of sugar at a different temperature. A greater range of temperatures might be attempted, providing more points to plot on the graph later. Worksheet FSM1 might be useful when designing the investigation.

You will need for each pair or group of pupils

Sugar
Labels
3 glass laboratory beakers
Sugar-boiling *or* digital thermometer
Measuring cylinder
Spoon
3 saucers
Scales
Access to cooker

Q 6 and Q 8

Designing tests

Pupils will face a number of problems in achieving accuracy and these are best discussed before and after the experiment. It is very difficult to maintain a temperature of 40 °C or 60 °C unless

Assessing (accuracy)

a thermostatically controlled water bath is available in which the beakers of water can be placed. Fluctuations in temperature are also to be expected, particularly as the sugar is added, and pupils

Identifying causes

should be encouraged to identify such sources of error (worksheet FSM1).

Deciding criteria

The point at which no more sugar will dissolve is reached when two or three crystals of sugar remain after stirring. To reduce the chances of over-stepping this point, it is important that additions of sugar are made a little at a time.

Q 7

The amount of sugar dissolved in the water is obtained by subtracting the amount remaining in the saucer from the original 100 grams.

Q 9

Communicating (maths)

The concentrations of the solution can be calculated as follows:

$$\frac{\text{weight of solute}}{\text{weight of solution (}i.e.\text{ solute + solvent)}} \times 100$$

e.g. 25 g of sugar dissolved in 100 ml water

$$\frac{25}{25 + 100} \times 100 = 20\ \%\ \text{w/w solution}$$

Concentrations used throughout this chapter are expressed in this way. The suffix w/w indicates this and distinguishes this method of expressing concentration from others such as w/v, where weight of solution is expressed as a percentage of the volume of solution.

Q 10 and Q 11

Communicating (graphs)

Plotted graphically, the results should show an increase in solubility as the temperature of the water is measured. The graph should also enable solubility at other temperatures to be determined, such as the solubility of sugar at 50 °C.

Estimating

Measuring

Because of the inaccuracies involved in the experiment, no 'correct' answer may be given here for question 11. It is important that pupils use their own results to discover the solubility. The results obtained may be compared with the data in table T9.1, collected using more precise methods.

Temperature (°C)	Concentration of saturated solution (% w/w)
20	66
40	70
60	74
80	78

Table T9.1
Concentrations of saturated sugar solutions at different temperatures.

9.3 BOILING SOLUTIONS

Main idea in this section

There is a relationship between the boiling-point of a sugar solution and the concentration of the solution.

Reasoning logically

Applying knowledge

If a non-volatile solute is added to a liquid, the resulting solution has a higher boiling-point than the liquid itself. The degree to which the boiling-point is raised depends on the number of solute particles, molecules or ions, in a given amount of solvent, that is, the concentration of the solution. Sucrose, however, has an even greater effect on boiling-point than might be anticipated. This probably results from the great attraction between sucrose and water molecules which prevents the escape of water as vapour until higher temperatures are reached.

As a sucrose solution is boiled, so water vapour is driven off, the concentration of solution increases, and the boiling-point of the solution is raised. A sugar solution boiled at 105 °C will contain about 68 percent sugar; if boiling is continued to 114 °C, the solution will contain about 80 per cent sugar. In other words, the sugar concentration of a syrup may be predicted by the temperature at which it boils.

Communicating (graphs)

Figure 9.6
This shows the relationship graphically. The graph is derived from the data in table T9.2.

Table T9.2
The relationship between sugar content and boiling-point.

Sucrose (% w/w)	10	20	30	40	50	60	70	80	91
Boiling-point (°C)	100.4	100.6	101.0	101.5	102.0	103.0	106.5	112.0	130.0

Q 12
This introduces the idea that different boiling-points, and resulting sugar concentrations, are required for different types of product. Recommended boiling-points are shown in table T9.3 (with percentage sugar concentrations taken from *figure 9.6*).

Table T9.3

Organizing data

Product	Boiling-point (°C)	Sugar (approximate % w/w)
Marmalade	105	68
Fondant	114	81
Fudge	115	82
Toffee	130	91
Barley sugar	138	93

Figure 9.7
This shows a sugar-boiling thermometer. You could now introduce another dimension to the discussion of sugar confection — the various 'points' on the thermometer. A table like the one below might be compiled.

Table T9.4

Applying knowledge

Sugar-boiling thermometer	Boiling-point (°C)	(°F)	Sugar (approximate % w/w)
Hard crack	155	310	99
Soft crack	138	280	93
Hard ball	121	250	87
Soft ball	118	245	85
Feather	115	240	82
Pearl thread	110	230	75

Q 13
From the graph, the concentration of sugar at 105 °C is 68 per cent, and at 114 °C, 81 per cent. These temperatures are chosen as they are used in jam making and fondant making respectively. Pupils should now know that sugar raises the boiling-point of water.

Evaluating

Q 14
This introduces the depression of freezing-point by dissolved solute. See the extension work described at the end of this section.

Link with school science

Using references

Pupils should already be familiar with the elevation of boiling-point and depression of freezing-point. The practical applications of salting to melt ice or prevent roads freezing and of 'freezing mixtures' of ice and salt are well known.

Extension work

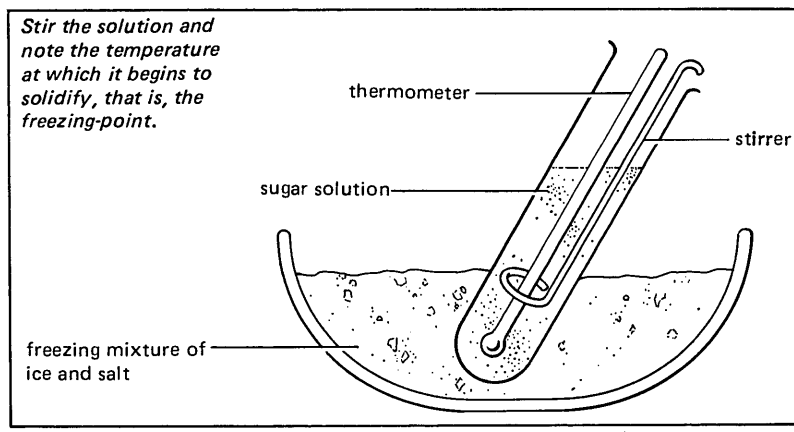
Designing tests

Assessing (ideas)

Communicating (graphs)

Question 14 suggests that pupils design an experiment to test the effect of sugar on freezing-point. This could simply involve freezing syrups of differing concentrations and comparing their texture after 2 or 3 hours' freezing. Water, without added sugar, would be frozen as a control. Alternatively, the temperature at which water freezes can be measured using the apparatus shown in figure T9.3. The experiment is repeated using syrups of different concentrations and the results expressed graphically.

Figure T9.3



Practical skills

A more attractive alternative might be to make fruit sorbets using different concentrations of sugar and to compare their textures.

9.4
MAKING APPLE JELLY
Is the boiling-point important?

Main idea in this section

Boiling-point, and thus sugar concentration, are important in jam making.

You will need for each pair or group of pupils

1 kg cooking apples
Knife
Bowl
2 saucepans
Wooden spoon
Muslin
3 jam jars and covers
Access to cooker

Practical skills
Estimating
Measuring
Assessing (validity)

Group work may be suitable here, each group making jelly using a different boiling temperature. The boiling temperatures must be measured precisely. The jellies must be allowed to set and are then compared in terms of appearance and texture. The three experimental jellies should illustrate the effect of sugar concentration on pectin gel strength. If sugar content is increased, a weaker jel is formed, while if too little is present a tough gel results. The firmness of the gel may be assessed by simply 'prodding' the jellies or spreading each onto a piece of bread. A more objective assessment can be made using the method described on worksheet M13 of *The Basic Course*. Pectin gels are further discussed in Chapter 10 and on worksheet FSM11.

Communicating (speech)

The increased heat treatment required to raise the boiling temperature to 108 °C may cause some of the sugar to caramelize and make the jelly brown. This may be noted in the 'appearance' column of the results table. The texture of the jellies can also be 'seen' before they are spread or otherwise assessed. Important visual clues about the eating quality of foods are obtained before eating. This might be an interesting discussion topic.

Q 15

From their observations, pupils are asked to select the temperature most appropriate for jam or jelly making. Sample B (boiling-point 105 °C) would be expected to give a good jelly but this depends on personal preference.

Q 16

Reasoning logically

This question encourages a summary of the relationship between boiling temperature and sugar concentration.

Q 17

Using references

The sugar concentrations of the jellies can be estimated from *figure 9.8*. A boiling-point of 102 °C gives 50 per cent sugar, while 110 °C gives about 78 per cent.

Q 18

A sugar concentration which is too high may result in sugar crystallization during storage. Insufficient sugar will not preserve the jam as well, and mould is likely to form during storage.

Q 19

Applying knowledge

Pupils should realize that boiling is also a method of preserving. It kills moulds and yeasts which would otherwise cause spoilage. If the jam is filled hot into clean jars and then given an airtight

seal, it will have a long shelf-life without spoilage. Once opened, however, moulds and yeasts enter and, unless there is enough sugar to prevent their growth, may cause spoilage.

Extension work

Designing tests

As a long term activity, pupils could store jellies with different sugar concentrations to find out how well they keep. Make sure that the jellies are stored in a place where they will not contaminate other food. ⚠

9.5 THE CRYSTALS RETURN. . . MAKING FONDANT

Main idea in this section

Crystallization of sugar occurs from a supersaturated solution.

You will need for each pair or group of pupils
Sugar
Small saucepan *or* glass laboratory beaker
Wooden spoon
Sugar-boiling *or* digital thermometer
Casserole dish *or* heat-resistant glass bowl

A concentrated solution is first obtained by boiling to a high temperature. As the solution cools, more sugar remains in solution than would be expected from the results obtained in section 9.2. The solution is *supersaturated.*

Practical skills

The solution is now beaten and crystals of sucrose rapidly separate out. Ideally the fondant is smooth and white and this is achieved if the crystals remain very small and cannot be detected on the tongue.

Q 20

Using references

This requires the estimation of the sugar concentration of the solution from its boiling-point, using *figure 9.6.*

The boiling temperature achieved determines the proportion of sugar which will eventually crystallize out. Too low a temperature will give a low concentration of sugar and a soft product, while too high a temperature gives too much sugar and a hard fondant. A boiling-point of 114 °C gives a concentration of 81 per cent sugar which gives a satisfactory fondant. This stage in making fondant is critical.

Measuring

There is no need to stir during the boiling stage. The boiling temperature should be reached in about 15 to 20 minutes. Great care must be taken in transferring the very hot sugar syrup to a casserole dish. The solution must not be disturbed during cooling, or crystallization will begin too soon and a grainy product will result. ⚠

Q 21

A saturated solution at 50 °C would be expected from section 9.2 to contain about 72 per cent sugar. The difference between this figure and the concentration of sugar in a solution which boils at 114 °C is a measure of the amount of sugar available for crystallization at 50 °C.

As the mixture cools further, so more sugar becomes available for crystallization. Beating of the syrup initiates crystallization. If beating is begun too soon, before the syrup has cooled to 50 °C, large crystals will be formed and the fondant will be grainy. If beating is delayed then the syrup is difficult to beat. As beating continues, tiny crystals of sucrose separate out and the mixture turns white. Beating is essential to ensure that crystals remain small and undetectable.

Practical skills

Q 22

Reasoning logically

a The fondant should be smooth and creamy. A gritty fondant means that the crystals are too large for the reasons discussed above.

Applying knowledge

b Small crystals reflect light and give shiny white fondant. A dull grey mixture suggests large crystals.

c Beating keeps the crystals apart and stops them growing too big.

9.6 CONTROLLING CRYSTALLIZATION

This is the most difficult section in this chapter. It requires an understanding of chemical changes occurring during the making of jams and sugar confections and their influence on the characteristics of the products.

Main ideas in this section

Boiling a solution of sucrose causes some of the sucrose molecules to split in two. They split into the glucose and fructose units of which they are composed.

This splitting requires a water molecule to be incorporated and is an example of hydrolysis.

The splitting of sucrose into glucose and fructose is known as inversion.

The reason for the term 'inversion' is not given in the pupils' text as it is irrelevant to the main issues. For more able and inquiring pupils, however, a simple explanation is possible. A solution of sucrose rotates a plane of polarized light to the right — it is dextrorotatory; while a solution of glucose and fructose rotates a plane of polarized light to the left — it is laevorotatory. Thus direction of rotation is inverted and the hydrolysis causing

this change is called inversion. The mixture of glucose and fructose is called invert sugar.

$$C_{12}H_{22}O_{11} + H_2O \rightarrow \underbrace{C_6H_{12}O_6 + C_6H_{12}O_6}_{\text{Invert sugar}}$$

Sucrose — Glucose — Fructose

Reasoning logically

Inversion of sucrose is also brought about by acidic ingredients such as cream of tartar, which may be an ingredient in fondant making.

Q 23 and figure 9.9

Glucose and fructose molecules both contain 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms. The atoms are arranged differently in the two sugars as shown in *figure 9.9.* This may be demonstrated using a molecular model.

This difference in the arrangement of atoms gives rise to two quite different substances. Fructose is more soluble than glucose and is relatively sweeter to taste. Worksheet FSM3 extends the discussion of sugars and inversion.

Q 24

Invert sugar is formed during boiling.

Q 25

Applying knowledge

The importance of inversion in controlling crystallization is due to the fact that crystallization is less rapid from a solution of mixed sugars than from a solution of a single sugar. Molecules of the same sugar can be thought of as having more difficulty getting together to form crystals in a mixed solution than in a solution of a single sugar.

In fondant making, inversion encourages the formation of small sucrose crystals because the rate of crystallization is slower. Too little inversion is likely to give large crystals and a gritty product, while too much inversion will interfere with sucrose crystallization and lead to a sticky, runny product.

Q 26 and Q 27

Cream of tartar is used to encourage inversion without prolonged boiling. Too much cream of tartar or lemon juice might cause too much inversion. This might also be caused by too long a boiling time.

Q 28

In jam making inversion is brought about by boiling and by the acidic constituents of the fruits used. The presence of invert sugar stops crystallization of sucrose during the cooling period. As the jam sets, pectin gel formation prevents the sucrose molecules combining to form crystals.

Processes and skills	Pupils may be able to:
9.1 *What happens when things dissolve?* Understanding scientific facts. Suggesting explanations.	Explain how sugar dissolves in water. Define solvent, solute, and solution and apply this to sugar solutions.
9.2 *Finding out about solubility* Using practical skills, observing and recording. Using data (graphs), identifying trends or patterns.	Perform practical experiments to demonstrate the increase in solubility of sugar as the temperature of the water increases. Plot a graph showing the results of the experiments.
9.3 *Boiling solutions* Interpreting data, recognizing relationships and trends. Observing. Using references.	Use a sugar thermometer to record boiling-points of products. Recognize that the boiling-point increases as the concentration of sugar in the solution increases.
9.4 *Making apple jelly* Using practical skills, estimating and measuring. Assessing (validity), suggesting explanations.	Make apple jam and take samples as the temperature rises. Observe and compare the samples. Choose the jam giving the best results based on appearance and set.
9.5 *The crystals return . . . making fondant* Using practical skills, measuring. Reasoning logically.	Boil sugar and water to make a fondant. Recognize the changes in the sugar as it boils. Explain the formation of the sugar crystals.

Processes and skills	Pupils may be able to:
9.6 *Controlling crystallization* Reasoning logically, applying knowledge, communicating (graphs).	Observe and explain the splitting up of sucrose into glucose and fructose — *i.e.* the process of inversion. Recognize the effect of adding acid. Control the size of crystals in fondant mixtures.

Q 29
Sucrose will slowly crystallize out during storage if too little invert sugar is present. On the other hand, if too much inversion has taken place, perhaps through overboiling, a honey-like mass of invert sugar may crystallize out during storage. Home-made jams contain 68 to 70 per cent soluble solids, of which 20 to 40 per cent should be invert sugar while the remainder is mainly sucrose.

Because the amount of inversion taking place in making jams and sugar confection is difficult to control, measured amounts of glucose syrup can be used. Glucose syrup has a similar effect on sucrose crystallization as invert sugar.

Extension work
A number of other ingredients are used to prevent or delay crystallization. These include milk, cream, chocolate or cocoa, egg, starch, pectin, and gelatin. They prevent or slow down the growth of sucrose crystals by surrounding them and preventing further sucrose molecules from combining with them, or by increasing viscosity and so preventing sucrose molecules from combining together. The pupils could experiment with making plain and chocolate-flavoured sweets and comparing the crystallization. Highly concentrated sucrose syrups are themselves very viscous and the growth of crystals is delayed or prevented in these conditions.

Reasoning logically

Organizing data

More able pupils may use this additional information and the understanding of crystallization gained in this section to classify sugar confection in terms of *a* its being crystalline or non-crystalline and *b* the methods used to control crystallization. They could compile a table.

Ideas for homework
Sections 9.3 and 9.6 could be studied for homework.

Using references

Communicating (writing and speech)

Applying knowledge

The Background reading begins with a very brief history of sweets and chocolates. Pupils interested in history could find out more about what the Crusaders found in the East and brought back to western Europe from their travels. These included sugar, oranges, and, in general, a desire for a higher standard of living. Pupils could do a similar investigation of what came from America (the list includes chocolate and potatoes). The production of chocolates and sweets is now an important industry in Britain. Careful quality control is needed at every stage. An important job for food scientists in the food industry is in the area of quality control. (See also worksheet FSM16 Quality assurance.)

CHAPTER 10

More mixtures of solids and liquids

This chapter introduces pupils to the importance of thickening agents in making foods palatable. The mechanism of thickening is discussed. The pupils investigate the influence of concentration of thickening agent and of other ingredients on gel formation.

Time allocation
Section 10.1: 5 minutes; 10.2: 10 minutes; 10.3: 30 minutes; 10.4: 10 minutes; 10.5: 10 minutes; 10.6: 5 minutes (total 70 minutes).

Extension work in this chapter
Section 10.4: investigating the effect on thickening of the early or late addition of lemon juice or sugar to lemon pie.
Section 10.6: experimenting with freezing sauces.

Worksheet and Assessment card Masters
FSM2 Acids, bases, pH
FSM3 Carbohydrates I
FSM4 Carbohydrates II
FSM10 Emulsions
FSM11 Sols and gels
FSM26 Assessment card

10.1
THICK FOODS AND THIN FOODS

Main idea in this section

Food texture is important in making a food palatable.

The examples given in the pupils' text could be demonstrated and provide visual impact for the start of the lesson.

Q 1
Pupils should be able to visualize a thin watery stew and the improvement gained in thickening it, probably with cornflour. Of course, if there are potatoes in the stew they will provide a source of starch for thickening. Gelatin from meat might also have a thickening effect.

Identifying causes

Q 2 and Q 3

Applying knowledge

Other foods which are more palatable when thickened are soups, gravies, sauces, and desserts.

10.2
HOW DO THICKENING AGENTS WORK?

Main ideas in this section

Raw starch from flour is in the form of granules.

Water molecules are attracted to starch molecules.

This is a difficult section because it requires pupils to visualize starch gel formation at the level of starch and water molecules. Worksheet FSM4 could be used to augment *figure 10.2.*

Applying knowledge

Starch granules were first introduced in Chapter 3 and their gelatinization was described then. Reference should also be made to Chapter 7.

Q 4 and figure 10.3

The photomicrographs show the granules swelling and absorbing water. This swelling occurs normally between 60 °C and 70 °C, depending on the type of starch, and is initially quite rapid in the case of individual starch granules. Starch molecules are able to migrate out of the granule. As the granule continues to swell it becomes fragile and may rupture, particularly if the mixture is stirred.

Figure 10.2

The resulting viscous suspension of swollen starch granules, fragments of granule, and starch molecules is described in some texts as a *sol*, in others as a paste. *Figure 10.2* introduces the attraction between starch and water and between neighbouring starch molecules. This is described as a network of starch molecules, swollen granules, and granule fragments — or a *gel.*

If only small amounts of starch were used, this network would not form until the mixture cooled, and in extreme cases not even then. This would then more appropriately be called a *sol* when hot and a *gel* would be formed on cooling. The pupils' text assumes a high concentration of starch and the formation of a highly viscous mixture more appropriately called a gel. This also avoids the need to introduce the term sol. (Worksheet FSM11 should be used here. It shows the difference between sols and gels.)

Reasoning logically

This diagram requires pupils to visualize the mixture at a molecular level, which may be difficult for some. This approach is continued in this and subsequent chapters, and so allocation of sufficient time is important here.

Water molecules, which are polar and so have positive and negative charges (see Chapters 9 and 11), are attracted to charged parts of the starch molecules. Similarly, neighbouring starch molecules and granule fragments will be attracted to each other. The result is a network containing or 'holding' large amounts of water. On cooling, more bonding between the components of the network will occur, producing a thicker, firmer gel. The attraction between water and starch is known as hydrogen bonding.

Q 5

a The large size of the starch molecules enables large amounts of water to be 'attached'.

Applying knowledge

b This question revises the thickening effect of starch gelatinization.

c Pupils should understand the importance of water in this process. Insufficient water would not allow granules to swell and gelatinization to take place.

10.3 THE EFFECT OF OTHER INGREDIENTS ON THICKNESS

Main ideas in this section

Starch concentration affects thickness.

Sugar content and the presence of an acidic ingredient such as lemon juice affect the thickening power of starch.

You will need for each group of pupils

Cornflour
Sugar *or* lemon juice
5-ml (tea) spoon
Stirring spoon
Metal cups *or* heatproof tumblers
Frying-pan (large)
Thermometer, −10 °C to 110 °C
Stopwatch
Glass funnel
Cooker

Selecting equipment

The investigation can be carried out by pupils working in groups, each group dealing with one of the three variables, that is samples X, Y, Z; U, V, W; and R, S, T respectively.

Practical skills

Avoid the use of direct heat. Electrically heated water baths could be useful here. The heating process should take the mixture to 85 °C. The thickness of the gels should be compared

Estimating

at the same temperature: 60 °C is suggested in the pupils' text. The importance of this might prove a useful discussion topic.

Measuring

The temperature at which thickness is measured affects the consistency of the gel.

The mixtures should be treated identically, including stirring. This may be continuous or just during the initial period of heating. Whichever is chosen, all samples should be treated in the same way. Identical funnels must be used for the assessment of thickness.

Communicating (writing) Pupils may need to be reminded to retain the samples in order to investigate the changes which occur during cooling.

Q 6

Observing *a* Increasing the concentration of cornflour will increase the thickness of the gel up to a point at which no more water is available to take part in gelatinization. The thicker gel passes more slowly through the funnel.

Reasoning logically *b* Yes — heating should make the mixtures thicker.

c The result obtained if a raw starch and water mixture were subjected to the 'funnel test' would serve as a control experiment.

Suggesting tests

Q 7

Identifying causes Pupils will probably discover that added sugar produces a softer gel, although a very high concentration of sugar could itself increase viscosity.

Q 8

Assessing (relevant factors) Lemon juice, which is acidic, will also have a softening effect on the gel.

The explanations for these findings are treated separately in section 10.4.

Q 9

Communicating (speech) This question is designed to encourage discussion of the uses to which mixtures of different consistencies can be put. Discussion can be extended to the usefulness of simple objective assessment of consistency (the funnel test) and correlation with subjective assessment (the response to the question). A further question might be 'what thickness, measured by the funnel test, is appropriate for a pouring sauce?'

Q 10

Reasoning logically If more starch is present, the swollen granules will be in closer contact on heating and will produce a thicker mixture.

Q 11

This question extends the discussion of sauce consistencies appropriate to different functions and the concentration of starch necessary to produce these consistencies. The ratio of starch to liquid in a range of recipes can be collected and tabulated. This might be useful homework exercise.

Using references

As a starch gel cools, so bonding between neighbouring starch molecules and fragments of granules will increase, thus producing a thicker gel. With a sufficient concentration of starch, the mixture will set into a firm gel.

Q 12

Communicating (writing) Examples might be blancmange, custard, and other cold desserts.

10.4 EXPLAINING THE RESULTS

Main ideas in this section

Sugar molecules have a great affinity for water, an idea already introduced in Chapter 9. Thus less water becomes attached to the starch molecules and this results in a softer gel.

Starch molecules are reduced in length by acid components of lemon juice, notably citric acid. The acid attacks the starch molecules, splitting them into shorter chains of glucose units. The shorter molecules produce a soft, weak gel.

Observation v inference This section explains experimental results using diagrams of the type used in section 10.2. Again, the pupils are encouraged to visualize changes at the molecular level. Worksheet FSM4 might be useful again.

Q 13 and Q 14

Suggesting hypotheses These are answered in the 'main ideas' above. *Figures 10.5* and *10.6* illustrate the effects.

Q 15

Reasoning logically The pupils should be able to explain their experimental results in terms of the formation of a water-holding starch network or gel.

Q 16

Applying knowledge This information can also be used when considering recipes involving starch and other elements such as sugar or acid ingredients.

Assessing (relevant factors) The point at which other ingredients are added will affect the consistency of the finished product. Acidic ingredients added in the early stages of a recipe will produce increased hydrolysis (splitting) of the starch molecule and a very soft gel.

Extension work

Practical skills The pupils could make lemon pie fillings with lemon juice added early and late and compare the consistencies of the resulting mixtures. A similar investigation of early and later addition of sugar could also be made.

Suggesting tests

Assessing (validity) Other factors which affect consistency of starch gels could also be investigated, such as the amount of stirring, the temperature reached, and the length of cooking time.

10.5
OTHER THICKENING AGENTS

Main ideas in this section

Gelatin and pectin are other examples of thickening agents.

Gelatin is a soluble protein which is dispersed in hot water to form a sol.

On cooling, attraction between neighbouring gelatin molecules and water produces a water-holding network — a gel.
Worksheet FSM11 will be useful here.

Q 17

Observing
Using references
Assessing (ideas)

Table jellies contain gelatin as well as sugar, fruit acids, flavourings, and colour, and are made by dissolving in hot water and allowing to cool to form a gel.

Obviously, the correct amounts of gelatin and water must be used to give an acceptable product. Too little water will produce a tough, over-firm gel, while too much will produce a soft, runny one.

Q 18

The ability of gelatin to form a gel is made use of in recipes for mousses, ice-cream, confectionery, meat pies, and so on.

Reasoning logically

Pectin was introduced in Chapter 3 as a component of the cell walls of fruits and vegetables. The chemistry of pectin is complex and not within the scope of this book. You could give a simplified explanation of its properties. Pectin is the name given to a group of polysaccharides which are made up of long chains of units called polygalacturonic acid. In a neutral solution, the pectin molecules are charged and attract water molecules. They are said to be hydrated. In an acidic solution the attraction for water is reduced. A pH of 3.2 is used in jam making. If sugar is present, the affinity between sugar and water further reduces the hydration of pectin molecules. (Worksheet FSM2 describes pH. Pectin gels are referred to on worksheet FSM11.)

Using references

In jam making, the boiling helps to make the pectin in the fruit soluble and it becomes dispersed as a sol. The acidity of the mixture and the presence of sugar reduces the hydration of the pectin and, as the mixture cools, a network of pectin molecules is formed, holding a viscous sugar solution (see Chapter 9). Hydrated pectin molecules remain separate and do not form a firm gel. Very small amounts of pectin can hold large amounts of sugar in a gel.

Q 19

Applying knowledge

Discuss jam making and the role of pectin. Some fruits, such as plums, apples, and currants, contain large amounts of pectin and are used without supplement in jam making. Others contain less pectin and require the addition of purified pectin obtained commercially from citrus peel or apples, or are used in combination with fruits, such as blackberries or strawberries, which are rich in pectin. Over-ripe fruits are not suitable for jam making since pectin degradation occurs during the ripening process. Similarly over-boiling of fruit produces degradation of pectin and a very soft or runny jam is produced.

The need for acidic conditions in jam making is described although not explained in the pupils' text. In jam making the acid is available from the fruit juices and these are present in maximum quantities in under-ripe fruit. Additional acid in the form of lemon juice may be added in some recipes to ensure that a sufficiently low pH is achieved. The effect of pH and

Applying knowledge

boiling on sugar used in jam making was discussed in Chapter 9. Revision may be useful here. Worksheet FSM3 discusses the inversion of sucrose further.

If insufficient pectin is used, a soft, runny consistency will be produced in the resulting preserve. If the boiling-point of the mixture does not reach 105 °C, too much water will remain in the mixture and a soft, runny consistency produced. This revises the boiling-point/sugar concentration relationship introduced in Chapter 9.

10.6 CONVENIENCE FOODS

Main idea in this section

Thickening agents are used by the food manufacturer.

Figure 10.7

Organizing data

Classifying

This illustrates the range of products in which thickening agents are used, ranging from products which require cooking to gelatinize starch (*e.g.* custard powder) to made-up products which have to withstand freezing, and the 'instant' mixes.

Q 20

Analysing data

As in other chapters, pupils can collect information from packets and this could serve as homework. Thickeners which may be identified in this way are starch, gelatin, pectin, alginates, carageenans, and edible gums such as gum tragacanth and gum arabic. The substances are polymers which form water-holding networks or gels and hence thicken and stabilize foods containing them. (See also Chapter 11.)

Processes and skills	Pupils may be able to:
10.1 *Thick foods and thin foods* Identifying causes, suggesting explanations, applying knowledge.	Identify thick foods and thin foods. Explain how foods are thickened. Identify agents used for thickening.
10.2 *How do thickening agents work?* Identifying factors influencing a situation, reasoning logically.	Observe the formation of a gel. Compare starch and water mixtures before and after cooking. Recognize that starch molecules attract water molecules during cooking.
10.3 *The effect of other ingredients on thickness* Using practical skills, estimating, measuring. Making careful, accurate observations, suggesting explanations.	Observe and compare the effect on thickening of various ingredients. Compare the effect of different proportions of flour in sauces.
10.4 *Explaining the results* Using recorded data to explain results. Identifying factors influencing a situation. Suggesting tests, evaluating results.	Explain the effects of adding acid and sugar on the formation of a starch gel. Describe and demonstrate the effect of adding acid and sugar in a variety of recipes.
10.5 *Other thickening agents* Practical skills, using references, relating cause and effect.	Make a jelly. Compare the effect of using different amounts of water. Demonstrate the formation of a gel by the action of pectin in jam making.

Processes and skills	Pupils may be able to:
10.6 *Convenience foods* Identifying factors influencing a situation, reasoning logically, applying knowledge.	Identify the thickening agents in convenience foods. Recognize that by using pre-gelatinized starch it is possible to thicken a mixture without cooking. Recognize that sauces separate when frozen and that modified starches are therefore needed.

Q 21 and Q 22
Starch is most appropriate for thickening foods which are served hot. Cornflour, for example, requires cooking to gelatinize the starch. Pre-gelatinized starches are available, however, which have been pre-cooked to gelatinize the starch granules and then dried. These starches do not require 'cooking out' and disperse readily to thicken hot or cold mixtures. They are used in 'instant' mixes. Like other modified starches, these are referred to as food starch or edible starch on the food label.

Applying knowledge

Starches are also used to thicken sauces for frozen products. Here a problem of separation or 'curdling' can arise. The long chains of starch molecules called amylose tend to 'clump together' during storage at low temperatures, and the liquid which they once held in their gel structure is released onto the surface. This process is called *retrogradation*. One answer is to incorporate chemically modified starches. These have been treated to increase branching and inter-molecular linking. These highly branched starches do not retrograde.

Waxy starches, such as tapioca, waxy maize, or rice contain higher amounts of amylopectin, a second kind of starch molecule which itself has a branching structure. These kinds of starches do not retrograde readily and can be used in frozen products. They are used in the production of chemically modified starches.

Extension work

Designing tests

Processing may pose problems for the food manufacturer. The pupils could experiment with making and freezing sauces. 'Curdling' can be observed on reheating after a few days' or several weeks' storage in the freezer.

The incorporation of modified starches in recipes is the solution employed in the catering industry, where the cook/freeze system has found widespread application. The starches are obtainable

from catering suppliers under a number of trade names including Colflo, Purity 69, and Polagel.

Ideas for homework
Questions 11 and 20 are suitable for homework.

Assessing (relevant factors) Evaluating results

The Background reading draws pupils' attention to the close connection between advertising and the sale of convenience foods. As extension work, the pupils could try making soup (or any other food) similar to a packet one and compare the results for cost, time taken, and palatability.

CHAPTER 11

Mixing liquids

This chapter continues the investigation of food dispersion begun in Chapter 10. It looks at emulsions and encourages an understanding of their behaviour and characteristics based on knowledge of their organization at particular levels, that is, at the level of dispersed oil droplets, layers of surrounding emulsifier, and large polysaccharide molecules between them acting as stabilizers.

Time allocation
Section 11.1: 5 minutes; 11.2: 15 minutes; 11.3: 15 minutes; 11.4: 25 minutes; 11.5: 10 minutes; 11.6: 10 minutes (total 80 minutes).

Extension work in this chapter
Section 11.2: extending the investigation of mixing oil and vinegar.
Section 11.3: looking at some mixtures of oil and water under a microscope.

Worksheet and Assessment card Masters
FSM2 Acids, bases, pH
FSM5 Fats and oils
FSM10 Emulsions
FSM27 Assessment card

11.1
INTRODUCTION TO FOOD EMULSIONS

Main ideas in this section

Mayonnaise and French dressing are examples of food emulsions.

The ingredients used to make them are similar, but their appearance is different. (This comparison is crucial to the development of ideas within the chapter.)

Q 1 and figure 11.1

Reasoning logically

Use a recipe book to check the ingredients used to make the dressings. Alternatively, tell the pupils to look at the ingredients listed on commercial products.

Q 2 and Q 3

Observing
Suggesting hypotheses

Show pupils the difference between the two salad dressings. The pupils experiment with mixtures of oil and water in the next section.

Both dressings contain oil and vinegar in large amounts as well as mustard, pepper, salt, and other seasonings. Mayonnaise contains egg yolk as emulsifier, but commercial brands contain emulsifiers such as glyceryl monostearate or lecithin, and stabilizers such as starch or edible gums. The terms emulsifier and stabilizer are not introduced in the pupils' text until sections 11.3 and 11.5.

Link with school science
There are links with the study of the structure of liquids, liquid systems, liquid/gas systems, and other colloids in materials science.

11.2 WHICH LIQUIDS MIX TOGETHER?

Main ideas in this section

Vinegar and water readily mix. Liquids which mix in this way are said to be miscible.

Water and oil, or vinegar and oil, do not readily mix and such liquids are said to be immiscible.

You will need for each pair or group of pupils
200 ml water
200 ml vinegar
200 ml vegetable oil
3 screw-topped jars labelled A, B, C

Practical skills
Measuring
Suggesting hypotheses

Vinegar consists mainly of a solution of acetic acid in water, and mixing with more water just dilutes this solution. It is a true solution (see Chapter 9). Only a temporary mixture of liquids is produced when oil and water are shaken together, and the time taken to separate into two layers will depend to some extent on the efficiency of mixing. A dispersion of very small droplets of oil will last longer than when larger droplets are obtained.

Q 4 and Q 5

Observing

Oil and water are immiscible. Vinegar and water mix together easily.

Extension work

Communicating (writing)

You could modify this investigation to include an investigation of mixing methods and their effect upon the duration of the mixture, perhaps comparing hand mixing with machine mixing.

11.3
WHAT IS AN EMULSION?

Main ideas in this section

An emulsion is a mixture consisting of a continuous phase and a disperse phase.

The dispersion of oil in water or vinegar is an example of this.

Figures 11.2 and 11.3
These show diagrams of a sample of freshly mixed oil and water and the same after standing for 10 minutes.

Extension work

Observing

Suggesting tests

You could link this section with an observation of samples taken from the mixtures made in section 11.2. Examine a drop of freshly mixed dispersion under a microscope. Compare its appearance with that of a drop taken after 10 minutes' standing and another sample taken after 20 minutes' standing.

To do this simply place a small drop of dispersion on a clean microscope slide and gently lower a coverslip onto it. First look at the sample under the microscope at low power. Tiny droplets of oil dispersed in water or vinegar will be clearly visible.

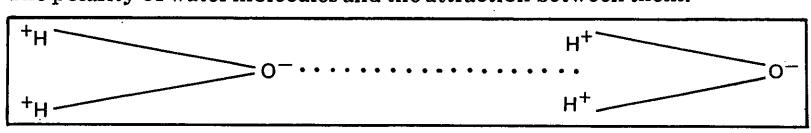
Q 6 and Q 7
A continuous line could be drawn through the water in the diagram but not through the oil.

Q 8, Q 9, and figure 11.3
The droplets coalesce to form larger droplets. This process continues until a complete separation of oil onto the surface is achieved. The same process can be observed in samples taken from the experimental dispersions. Pupils may be able to observe droplets combining together to form larger droplets.

Pupils may ask why the droplets coalesce. The following paragraphs explain this. (Worksheet FSM10 also illustrates the idea.)

Water is a polar molecule. One end of the molecule is negatively charged while the other is charged positively. (This idea was introduced in Chapter 9.) There is an attraction between the

Figure T11.1
The polarity of water molecules and the attraction between them.



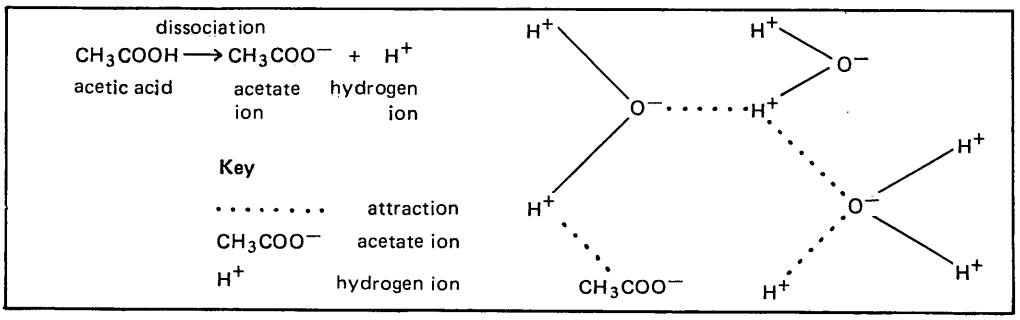
positive and negative parts of neighbouring water molecules. Oil molecules are non-polar and have no attraction for polar molecules such as water.

Observing
Applying knowledge
Communicating (diagrams)

In a mixture of oil and water, the oil molecules arrange themselves so that there is the smallest possible contact with water molecules. The attraction between water molecules can be thought of as squeezing out the oil molecules. If the two liquids are mixed, the oil becomes dispersed as spherical droplets so as to present a small area of contact with water. By coalescing to form larger droplets, the area of contact is further reduced, and recombination of droplets continues until the least possible amount of contact is achieved, that is, when the oil and water are in two separate layers. This may be described in terms of 'interfacial tension'.

Vinegar and water mix readily because of the attraction between charged water molecules, charged acetic acid molecules, and the charged ions into which acetic acid dissociates. This is shown in figure T11.2. (Dissociation is referred to on worksheet FSM2.)

Figure T11.2
The interaction between water molecules and charged ions of acetic acid.



11.4
EMULSIONS WHICH DO NOT SEPARATE

Main idea in this section

The addition of egg yolk to oil and vinegar makes mayonnaise a permanent emulsion.

The emulsions produced in section 11.2 were temporary and soon separated. In section 11.1 a comparison was made between a temporary emulsion (French dressing) and a permanent emulsion (mayonnaise). The comparison is further developed in this section.

Q 10

Applying knowledge

Oil and vinegar are immiscible liquids, but are the main ingredients of both French dressing and mayonnaise.

Q 11

a Recipes show that mayonnaise is made using egg yolks or other emulsifiers and stabilizers while French dressing is not. The terms emulsifier and stabilizer are not introduced until later in the chapter; they are only identified as additional ingredients.

Reasoning logically

b This question introduces the experiment which follows. Pupils can guess that the extra ingredients used in making mayonnaise may be responsible for its difference from French dressing.

You will need for each pair or group of pupils

100 ml malt vinegar
100 ml vegetable oil
Pepper
Salt
Mustard powder
Egg yolk
5 test-tubes labelled A, B, C, D, and E
Test-tube rack
5-ml (tea) spoon
Stopclock

Q 12

It will be found that egg yolk, oil, and vinegar give a permanent emulsion which will probably not separate.

Suggesting tests

Pepper and mustard may slow down separation of the two liquids, compared with the control mixture in the fifth tube.

Selecting equipment

Salt will not improve the stability of the emulsion. It can cause curdling by drawing out moisture and is normally used in small amounts, combined with the vinegar.

Q 13

Practical skills

This question introduces the word emulsifier. Egg yolk, which contains the emulsifier lecithin, is the most efficient emulsifier of those tested. Pepper and mustard also act as emulsifiers but with limited efficiency.

Q 14 and figure 11.4

Observing

The diagram shows how emulsifiers work. Worksheet FSM10 may be used at this point.

Communicating (writing)

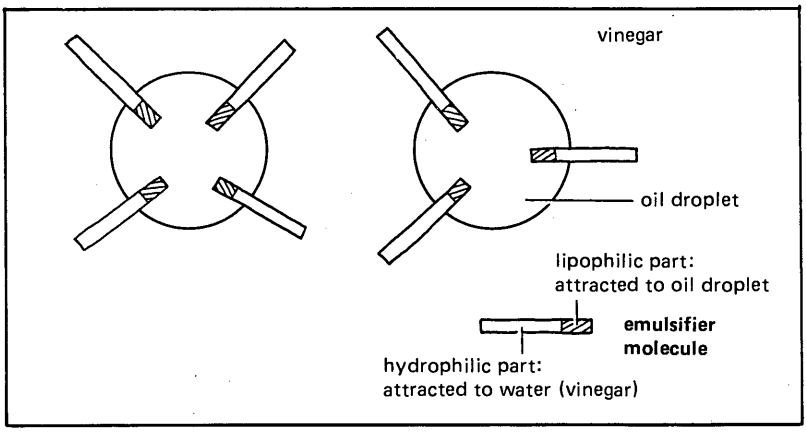
In very simple terms, the emulsifier forms a layer around each oil droplet and so forms a physical barrier between neighbouring droplets and prevents their coalescence. Tiny particles of pepper or mustard attach themselves around the oil droplets and help to slow down separation of the oil and vinegar in a French dressing.

Like other efficient emulsifiers, the lecithin molecules in egg yolk have a fat-loving end (lipophilic) and a water-loving end (hydrophilic). The lipophilic end implants itself in the oil droplet while the hydrophilic end sticks out into the surrounding vinegar.

Reasoning logically

Thus the droplet is surrounded by emulsifier and coalescence of neighbouring droplets prevented. The interfacial tension is reduced. (See figure T11.3.)

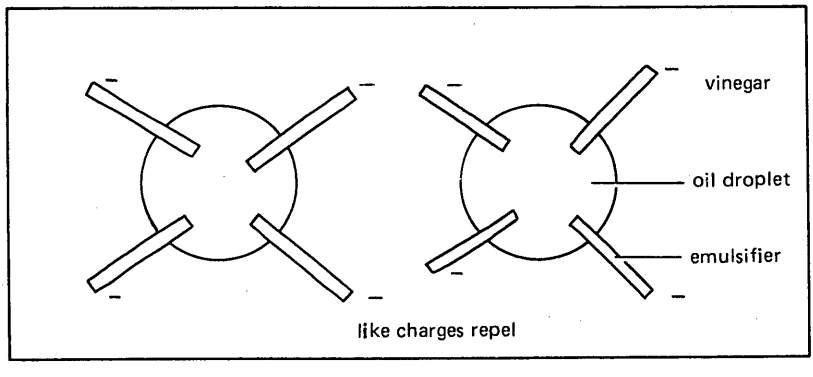
Figure T11.3
The action of emulsifiers in mayonnaise.



Applying knowledge

Commercial products may contain other emulsifiers such as glyceryl monostearate (GMS). The hydrophilic parts of the emulsifier molecules on neighbouring oil droplets may be similarly charged and so repel each other. Again, this helps to keep oil droplets apart and prevent separation. (See figure T11.4.)

Figure T11.4



Reference to detergents might extend this section (see *Fibres and fabrics* Chapter 15, or *The Basic Course* Chapter 22).

11.5
MAKING A MAYONNAISE

Main ideas in this section

Mayonnaise can curdle if made incorrectly (see question 15 below).

Thickening agents such as starches may also be used to thicken mayonnaise.

Pupils now apply their knowledge of emulsions and revise the method of making mayonnaise. Table T11.1 summarizes the recommended procedure. The pupils should visualize what is happening.

Table T11.1

What is done	Why it is done
Add the oil to the vinegar a little at a time	Dispersion of tiny oil droplets is encouraged, each surrounded by a layer of emulsifier.
Use warm oil, not cold	Dispersion is encouraged because the oil droplets will be moving about faster when warm.
Mix the egg yolk and mustard with the vinegar before adding the oil	The emulsifier and vinegar receive the oil and so, as droplets of oil are produced by mixing, emulsifier is readily available to form a surface layer around them; hence the emulsifier is made stable.

Reasoning logically

Applying knowledge

Communicating (writing)

(Assessing) (ideas)

Q 15

Applying knowledge

Introduce the problem of curdling mayonnaise and its recovery. Pupils should now be able to visualize what is happening when mayonnaise curdles (separation of oil droplets due to too rapid addition of oil, inadequate mixing, or insufficient emulsifier), and to suggest a remedy (the re-dispersion of oil droplets).

Using statistics

The remainder of this section introduces the idea that thickening agents such as gums and starches may be used to stabilize commercial mayonnaise and salad creams. Pupils could also investigate salad dressing recipes which include cornflour or other starch

thickeners. A simple explanation of their role is that they form a barrier between oil droplets and, by increasing the viscosity of the mixture, prevent neighbouring droplets coming into contact and coalescing. Remind pupils of the work in Chapter 10 on how the gelatinization of starch affects viscosity.

11.6
OTHER FOODS WHICH ARE EMULSIONS

Main ideas in this section

Dairy products and many other foods are emulsions.

Basic principles can be applied to a wide range of foods.

Figure 11.7
This shows a number of dairy products which are emulsions. The pupils' text describes milk as a dispersion of fat globules in whey.

Applying knowledge

Assessing (ideas)

Pupils may ask about fat globules, since previously it is dispersions of oil droplets that have been described. The distinction between fat, which is solid, and oil, which is liquid is appropriate here. (See Chapter 8 and worksheet FSM5.) The globules are some 3 to 10 μm in diameter and are surrounded by a complex structure known as the fat globule membrane which helps to keep the emulsion stable. Clustering of globules and the resulting separation of a cream layer is thought to be due to interaction between a particular component of the fat globule membrane in neighbouring globules.

Q 16
This requires pupils to list different kinds of milk.

The heat treatment of milk ensures that it is safe to drink.

Applying knowledge

Pasteurized, sterilized, and homogenized milks are briefly described. To homogenize milk, it is first warmed to liquefy the fat and then forced under pressure through a restricted passage. This reduces the size of the globules to less than 2 μm diameter. They are no longer coated with the fat globule membrane but are covered with a layer of protein and membrane remains. Their reduced size also helps to stabilize the emulsion.

Reasoning logically

When cream is made into butter, a fat in water emulsion (cream) is inverted to a water in fat emulsion (butter). Foaming of cream and the risk of overbeating and conversion to butter are described in Chapter 12. When cream is churned, the membrane material becomes removed from the fat globules and they clump together to become the continuous phase. About 16 per cent by weight of water remains as finely dispersed droplets.

Processes and skills	Pupils may be able to:
11.1 *Introduction to food emulsions* Observing, suggesting hypotheses, reasoning logically.	Recognize the differences between different salad dressings. Identify the main ingredients in salad dressings.
11.2 *Which liquids mix together?* Using practical skills, measuring, communicating (writing).	Mix liquids used in salad dressings with water and discover which are miscible and which are immiscible. Identify other mixtures which behave in a similar fashion.
11.3 *What is an emulsion?* Observing, suggesting tests, applying knowledge, communicating (diagrams).	Study photomicrographs of oil and water emulsions and compare the dispersal of the oil droplets after different lengths of time. Explain what happens when emulsions separate.
11.4 *Emulsions which do not separate* Using practical skills, suggesting tests. Applying knowledge, assessing (ideas). Observing, drawing conclusions, communicating (writing).	Compare French dressing which is an unstable emulsion with mayonnaise which is a stable emulsion. Suggest uses for French dressing and for mayonnaise. Compare home-made varieties with purchased ones. Discover the effectiveness or otherwise of egg yolk, pepper, mustard, and salt in making the emulsion of oil and vinegar permanent. Apply this knowledge to the preparation of sauces.

Processes and skills	Pupils may be able to:
11.5 *Making a mayonnaise* Using practical skills, applying knowledge, reasoning logically, assessing (relevant factors), using statistics, communicating (writing).	Explain the causes of curdling in mayonnaise and rectify these when they occur. Use other thickening agents to stabilize mayonnaise and salad cream.
11.6 *Other foods which are emulsions* Applying knowledge, assessing (relevant factors), reasoning logically, communicating (diagrams).	Recognize that milk is an emulsion. Recognize that milk may be heat treated and that this affects the stability of the emulsion. Apply the knowledge of emulsions to making butter and sauces.

Assessing (relevant factors)

Pupils' understanding of emulsions is extended to products which they themselves have made. Sauces incorporating fat or oil are emulsions in which stability is achieved by adequate mixing, high temperature, and the presence of thickening agents, normally starch.

Q 17

A knowledge of emulsions is used in solving a culinary problem. Possible explanations are the addition of too much fat or oil or, conversely, too little thickening agent; insufficient mixing to produce a dispersion of small droplets (large droplets are more likely to separate); and a sauce which has been allowed to cool down (the movement of droplets of oil slowing down and neighbouring droplets coalescing).

Ideas for homework

Applying knowledge

Question 18: pupils should be able to think of four or five dishes in which fat or oil has been dispersed as an emulsion. Mayonnaise, gravy, and other sauces are examples.

Assessing (relevant factors)

The Background reading is about milk production. Encourage pupils to realize how much careful organization and foresight are necessary for success. Milk is an important food for many people in Britain. Pupils can learn more about this in *Nutrition*.

Applying knowledge

Cheese is a gel as well as an emulsion. Pupils could find out about the manufacture of cheeses and try making some.

CHAPTER 12

Frothing and foaming

Chapter 12 completes a series of three chapters which deal with food colloids. This chapter investigates some of the characteristics of foams and their applications in food preparation.

Time allocation
Section 12.1: 5 minutes; 12.2: 15 minutes; 12.3: 5 minutes; 12.4: 25 minutes (plus 2 hours' baking, and assessment at the next lesson); 12.5: 10 minutes; 12.6: 20 minutes (may be done as homework); total 80 minutes.

Extension work in this chapter
Section 12.2: finding out about anti-frothing gadgets.
Section 12.4: investigating the effect of adding sugar at different stages of beating egg white; investigating the effect of adding cream of tartar or the effect of egg yolk in the mixture.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM3 Carbohydrates I
FSM4 Carbohydrates II
FSM6 Proteins
FSM10 Emulsions
FSM12 Foams
FSM28 Assessment card

12.1
BLOWING BUBBLES

Main ideas in this section

Foams are dispersions of gas, normally air, in liquids or solids.

The incorporation of gas during food preparation contributes to lightness of meringues and whipped cream and the characteristic textural qualities of bread and cakes.

As with emulsions (Chapter 11), the surface tension of a liquid must be overcome when incorporating a gas into it.

Foams are unstable and some form of stabilization is necessary.

Q 1

Designing tests

a Blowing through a straw into detergent solution produces a large volume of froth or foam: the air blown into the liquid rises to the surface as bubbles surrounded by a thin layer of solution.

Observing

b Water will not readily foam and any bubbles are short-lived. This is because of the strong attraction between water molecules, discussed in Chapter 11, and its resultant high surface tension.

Suggesting hypotheses

Water will rapidly return to a state providing the smallest surface area.

c The detergent has reduced the surface tension and so enabled foaming to take place.

Q 2

a Milk is a complex dispersion of fat droplets and proteins in a true solution, the whey. It has a lower surface tension than water and is likely to froth if air is introduced.

Observing

b In all cases, the bubbles produced are relatively short-lived and the foams are unstable, the liquids returning to their lowest surface area. In order to make food foams, the foam must be stabilized. Worksheet FSM12 will be useful here.

Q 3 and figure 12.1

The photomicrograph shows bubbles of air surrounded by a thin layer of detergent solution.

12.2 UNWANTED BUBBLES: WHY DOES MILK BOIL OVER?

Main ideas in this section

Milk boils over because proteins in the whey are denatured by heat.

They form a skin on the surface of the milk which traps the air bubbles.

Practical skills

The pupils heat milk and water separately and record any changes which they observe. They note the temperatures at which changes occur.

You will need for each pair or group of pupils

100 ml milk	2 small saucepans
100 ml water	Thermometer, −10 to 100 °C

Q 4, Q 5, and Q 6

Observing

As both water and milk are heated, bubbles of air can be observed rising to the surface. This is air which is dissolved in

Measuring

the two liquids and comes out of solution during the heating process.

Communicating (writing)

As discussed in section 12.1, milk has a lower surface tension than water and is more likely to froth. Bubbles at the surface of water soon break, releasing the air they contained. During the early part of heating, bubbles on the surface of milk will do the same, but they are trapped by the skin of denatured proteins. Worksheet FSM6 discusses the denaturation of proteins further.

The chemistry of proteins in the whey is complex. β-lactoglobulins are the most abundant proteins and α-lactalbumins the next most abundant. There are also a number of other proteins present in smaller amounts. Whey proteins are denatured as milk is heated above 60 °C.

When milk is heated to 74 °C a cooked flavour develops. This is due to the effect of heat on whey proteins, particularly β-lactoglobulins. The organization of the protein is altered by the heat and the parts of it which contribute to the cooked flavour, called sulphydryl groups, are exposed.

Q 7 and Q 8

Applying knowledge / Reasoning logically

The skin of denatured protein can be thought of as trapping bubbles of air as they reach the surface. The bubbles themselves will be surrounded by a thin layer of milk containing denatured protein, and are thus more stable and unlikely to burst. This accumulation of foam at the surface causes the milk to rise up in the pan and over-spill . . . .

Extension work

Assessing (relevant factors)

The pupils could investigate the ways in which gadgets to stop milk boiling over work. They work by channelling air bubbles to the sides of the pan. The bubbles escape into the air from the periphery of the skin and are not trapped beneath it.

12.3 MAKING MERINGUES

Main idea in this section

The incorporation of gas during food preparation and the production of a stable foam can influence eating quality.

Q 9

Selecting equipment

Egg whites are used in making meringues and air is incorporated by whisking. Thus a foam is produced.

Practical skills / Measuring

Egg albumen consists of a number of proteins dispersed in water. These include ovalbumin, globulins, and ovomucin. As egg whites are whisked some albumen proteins become denatured, particularly ovomucin. This becomes denatured at the interface between the air and the egg white. The effect of this is to stiffen and stabilize the foam. The globulins are important for their foaming property. These and ovalbumin are denatured by heat when meringues are baked, giving a stable foam structure.

Q 10

Communicating (writing)

The denaturation of albumen protein makes the foam more stable than the detergent foam. A stable dispersion of air bubbles in the egg white is thus achieved.

12.4
UNDER-BEATING AND OVER-BEATING

Main ideas in this section

As the beating time of egg white is increased, so the volume of foam increases and then decreases.

Similarly, the foam becomes more stable and then stability decreases. Maximum stability is reached before maximum volume.

Practical skills

The pupils make egg white foams using different beating times and compare them: by measuring stability (Test A); by measuring density (Test B); and by test baking (Test C).

The test baking takes two hours and so assessment of the baked product should be left to a subsequent lesson.

You will need for each pair or group of pupils

2 eggs	Scales
Salad oil	Baking tray
	Grease-proof paper
Mixing bowl	Bird-seed
Whisk	15-ml (table) spoon
Small egg-cup	2 small plastic sandwich boxes
10-ml glass measuring cylinder	Cooling rack
Small glass funnel	Oven (110 °C, Gas regulo ¼)

Designing tests

Assessing (validity)

The beating or whisking method should remain constant throughout the experiment. However, if the same experiment is carried out by different groups each using different mixing methods, a comparison of methods is possible. The characteristics of the foams produced will reflect the method as well as the time. Different people will also produce different results.

Assessing (relevant factors)

Reasoning logically

Excessive beating leads to breakdown of the foam structure, as evidenced by white flecks in the foam. The overbeating causes the incorporation of too much air and denaturation of too much ovomucin. The film surrounding the air bubbles becomes thin and less elastic. If the foam is to be baked, it is essential that the film is elastic so that it can accommodate expansion of incorporated air without breaking.

Q 11

Applying knowledge

Evaluating results

This requires comparison of the foams prepared. The lightest foam, the most stable, and giving the optimum volume when baked would be expected to be the sample beaten until firm, shiny peaks are obtained. The under-beaten sample will be yellowish in appearance, give maximum drainage, have a high density, and give low volume on baking. The over-beaten foam will show signs of foam breakdown and specks of white, and may show increased drainage. It will give low volume on baking.

Q 12

Applying knowledge

This requires an explanation of the changes taking place when the foam is baked.

a The bubbles of air will expand. This is made possible by the elasticity of the film surrounding them.

b The albumen proteins become denatured by heat, particularly the ovalbumin, and so stabilize the foam structure.

c During baking, the foam dries out as moisture evaporates from it. Further drying occurs if the meringues remain in the oven after baking for two or three hours. They can then be stored in an air-tight container where they will retain their crispness.

Extension work

Assessing (relevant factors)

Other ingredients used with egg whites have an effect on foaming. Sugar delays denaturation of protein during beating and during baking. For this reason, it is folded in late in the mixing process. The effect of adding sugar at different stages in beating can be investigated by repeating the experiment with sugar addition at different stages.

Reasoning logically

Acidic ingredients are used in making egg white foams to increase their stability. Pupils may be able to suggest that the reduced pH will encourage denaturation of albumen proteins during beating and during baking. They could prepare foams incorporating measured quantities of cream of tartar and measure their qualities using the methods already described (worksheet FSM6).

Designing tests

Extraneous material decreases the lightness and stability of egg white foams, particularly oils and the fat content of egg yolks. Pupils could investigate this too.

12.5 WHIPPING CREAM

Main ideas in this section

Cream is an emulsion of oil (or more properly fat) in water.

As air is incorporated into this structure, some protein denaturation occurs and fat globules clump together. The foam is thus stabilized.

Q 13

Suggesting hypotheses

The percentage of fat present in the cream influences its suitability for whipping. Single cream will not whip to produce a stable foam, while double cream is easily over-whipped. Pupils should be able to answer this question from their own experience.

Q 14 and Q 15

Assessing (relevant factors)

Pupils should understand the conversion of cream to butter from Chapter 11. Worksheet FSM10 may be used to revise emulsions at this stage. Whipped cream may be seen as a mid-way stage between cream and butter. Over-beating leads to further clumping of fat globules and the separation of yellowing specks of butter. Initially the volume of cream is increased by whipping, but this will decrease with over-whipping.

Applying knowledge

Q 16 and Q 17

Frozen whipped cream is a convenient and standardized product and has a long shelf-life. Manufacturers add stabilizers to whipping or whipped cream (see Chapters 11 and 15).

12.6 BREAD: ANOTHER FOOD FOAM

Applying knowledge

Baking powder and the reaction of its two main ingredients to produce carbon dioxide have been introduced in Chapter 7. (See also *The Basic Course*, Chapter 5.)

Main ideas in this section

Yeast cells act on sugar in a bread dough to produce carbon dioxide gas and this makes the dough rise.

Bread is an example of a solid foam.

Changes occur during the baking of a dough to give the characteristic bread texture.

Q 18

Scones and cakes are made using baking powder. During baking of these products the carbon dioxide is driven off. The gluten (Chapter 7) in which bubbles of carbon dioxide were trapped is denatured by heat and starch granules in the flour are gelatinized. These changes contribute to their texture.

Q 19, Q 20, Q 21, and figure 12.7

In bread making, yeast is used to produce carbon dioxide gas. Yeast is a unicellular micro-organism and is about 10 μm long (see worksheet FSM1). It may be bought in a compressed block which contains millions of cells or in a dried form. Particular species of yeast are cultivated to do particular jobs. *Saccharomyces cerevisiae* is a yeast used for bread making.

Using references

Yeast cells produce enzymes which enable them to use sugars as a source of food. They convert sugars by a series of chemical steps into carbon dioxide and alcohol (ethanol), and in so doing produce energy for their own metabolic requirements. This process is called fermentation and takes place in the absence of oxygen, *i.e.* it is anaerobic. (Yeast cells do not produce enzymes to convert starch into sugar, a commonly held misconception.)

Figure 12.10

Organizing data

In bread making the sugar on which yeast feeds is maltose. It is produced by naturally occurring enzymes in the flour called amylases. These attack starch molecules which are made of hundreds of glucose units joined together in chains (see Chapter 10 and worksheets FSM3 and FSM4), breaking them down into units consisting of two glucose molecules, the disaccharide sugar maltose, and short chains of glucose molecules, dextrins.

The amylase activity of flour is an important consideration when selecting flours for bread making.

Q 22

Reasoning logically

The main ingredients used in bread making are flour, water, salt, and yeast. Sometimes other ingredients such as fat and milk are used and these contribute to the texture, colour, and nutritional value of the bread. Sugar (sucrose) may be added as food for the yeast. Addition of too much sugar may actually retard yeast. Bread making is also discussed in Chapter 7.

Figure 12.11

Applying knowledge

Maltose, like sucrose, is a disaccharide and has the chemical formula $C_{12}H_{22}O_{11}$. Whereas sucrose consists of a molecule of glucose joined to a molecule of fructose, maltose consists of two glucose molecules joined together. In other words, although sucrose and maltose contain the same number of carbon, hydrogen, and oxygen atoms, they are arranged differently to give two quite different substances. This kind of distinction has been made in comparing glucose and fructose in Chapter 9.

In bread making, yeast cells produce an enzyme which hydrolyses maltose into its constituent glucose units. Other enzymes are produced which convert the glucose into ethanol and carbon dioxide.

Q 23

As carbon dioxide is produced, so pockets of gas are developed, trapped by the gluten. A foam is produced within the gluten. Pupils learned in Chapter 7 that gluten is an elastic network of proteins and lipids which is formed when flour and water are mixed to form a dough. It is essential that the yeast has been well dispersed in the dough to ensure development of pockets of gas throughout. After initial proving, the dough may be 'knocked back' to subdivide the gas pockets and further disperse the yeast cells. Further proving and development of carbon dioxide then takes place. Mechanically developed doughs and, in particular, the Chorleywood Process may already have been discussed as extension work in Chapter 7. If not, the topic may be introduced here.

Link with school science

The study of the use of yeast in bread making can be the starting-point for the exploration of the large and expanding topic of biotechnology.

The work is relevant to and draws upon the microbiology of yeasts and similar organisms; the chemistry of natural polymers (specifically saccharides) and of fermentation; and the physical theory describing the structure of complex molecules and technological systems design. It thus gives an excellent illustration of the integrated nature of real science and technology.

Q 24

The next stage in bread making is baking.

Observing

During the early stages of baking, yeast cells remain active and further production of carbon dioxide contributes to an increase in dough volume. Expansion of the carbon dioxide and air in the dough, as well as water vapour produced as the temperature rises, stretches the gluten and further contributes to increased dough volume. The alcohol and some of the water are driven off. At 60 °C the yeast cells are killed.

Suggesting hypotheses

Identifying causes

As the temperature rises, the gluten proteins become denatured and the starch granules absorb water and partially gelatinize (worksheet FSM4). The internal structure of the loaf firms and a crust develops. Thus the foam becomes stabilized and the characteristic crumb structure is produced.

Q 25

Observation v inference

Salt is used in bread making for flavour and to control the activity of yeast. The use of salt to control micro-organisms has been introduced in Chapter 5. If too much salt is used, too little yeast activity results in reduced production of carbon dioxide and loaves of low volume. Too little salt and the yeast would be over-active, producing a very open structure in the dough.

Q 26

Applying knowledge

Steam produced during baking contributes to the increase in volume of the dough. Insufficient moisture for starch gelatinization would result in a dry crumb. Too much water would produce too open a texture with large gaps.

Ideas for homework

Using references

Organizing data

Pupils could collect a list of food foams eaten during a single day, or make a list using recipe books. The principles which apply to meringues and bread apply equally to other products. Examples are soufflés and sponge cakes.

Pupils can also be asked to explain why fizzy drinks froth when they are opened, or find out what causes the 'head' on beer!

Processes and skills	Pupils may be able to:
12.1 *Blowing bubbles* Observing, suggesting explanations.	Recognize foaming. Explain the short-lived nature of some foams in terms of surface tension.
12.2 *Unwanted bubbles: why does milk boil over?* Using practical skills, measuring accurately. Observing, communicating (writing), reasoning logically, applying knowledge.	Explain why milk boils over when heated. Explain how gadgets to prevent milk from boiling over work.
12.3 *Making meringues* Identifying factors influencing a situation, reasoning logically, applying knowledge.	Recognize that a foam can be made by whisking egg whites. Recognize that the proteins in the egg white are denatured by mixing and by cooking, and that these denatured proteins form a layer around the air bubbles which stabilizes them.
12.4 *Under-beating and over-beating* Performing practical tasks skillfully, measuring accurately. Making observations and drawing conclusions, applying knowledge, using references.	Investigate the effect of over-beating egg whites. Test the stability of a meringue mixture.

Processes and skills	Pupils may be able to:
12.5 *Whipping cream* Identifying factors influencing a situation. Suggesting hypotheses, assessing (relevant factors), applying knowledge.	 Choose the right cream for whipping, and whip cream successfully. Recognize that over-beating cream will produce globules of butter.
12.6 *Bread: another food foam* Using references, organizing data, reasoning logically, applying knowledge, identifying causes, observation *v* inference.	 Observe the making of a bread dough and explain the development of the foam within the gluten. Identify a variety of breads and suggest differences between them.

Applying knowledge

The Background reading tells pupils about the manufacture of ice-cream, another food foam. As with so many other foods, quality control is very important in the modern industrial process. You could discuss this again with your pupils.

CHAPTER 13

Cooking methods

In this chapter, the changes taking place in foods are revised, and the stages in preparation and cooking are examined. The pupils measure the heat energy required for cooking. They revise the ways in which heat is transferred and apply this to different cooking methods. The chapter also looks at conservation of energy. There are some links with Chapters 2, 3, 4, and 5, and with *The Basic Course*, Chapter 4.

Time allocation
Section 13.1: 10 minutes class discussion; 13.2: 10 minutes class discussion plus 30 minutes homework; 13.3: 10 minutes class discussion plus 30 minutes practical work; 13.4: 5 minutes class discussion plus 30 minutes practical work; 13.5: 10 minutes; 13.6: 10 minutes; 13.7: 20 minutes (suitable for homework).

Extension work in this chapter
Section 13.4: investigating the cooking of Baked Alaska.

Worksheet and Assessment card Masters
FSM1 Measurement: accuracy and precision
FSM4 Carbohydrates II
FSM13 Heat and temperature
FSM29 Assessment card

13.1
COOKING CHANGES FOODS

Main ideas in this section

Certain temperatures must be reached to cook foods.

These temperatures must be maintained for long enough to cook the food.

Different foods need different cooking times and temperatures.

Q 1

Applying knowledge

a Meat proteins are denatured which tenderizes the meat. Flavour and colour are developed. (See Chapter 4.)

Reasoning logically

b The cellulose in the vegetables is softened, the starch is gelatinized, and flavours and colours are developed. (See Chapter 3.)

Q 2
Gelatinization of starch thickens the liquid. (See worksheet FSM4 and Chapter 10.)

Q 3, Q 4, and Q 5
Using references — Pupils should use recipe books to answer these questions.

13.2 HOW DOES HEAT TRAVEL TO FOODS?

Main idea in this section

Heat energy is conveyed to foods by conduction, convection, and radiation.

Link with school science
Applying knowledge — Pupils will probably have come across the methods of heat transfer in science (or in *The Basic Course*, Chapter 4). Remind them of the difference between heat (a form of energy) and temperature (one of its effects).

The work gives an excellent illustration of the use of scientific theory to explain long-developed craft practices. Here the concepts are those of heat transfer by conduction, convection, and radiation.

The importance of the use of instruments and measurement, both to provide 'objective' judgments of conditions and to record and communicate them, are well illustrated.

The heat pipe shown behind the meat thermometer in *figure 13.7* is a good example of a useful device developed by applying scientific patterns. It could be discussed here. It is a pointed metal tube about 6 mm in diameter and 230 mm long. The 'handle' on the left is a solid piece of metal, blackened to absorb heat more effectively. The tube contains a small amount of liquid (water and alcohol) which is vaporized at the hot end (the 'handle') and condensed at the cool end (inside the joint), giving out its latent heat of condensation. The liquid then flows back along a wick to the hot end to repeat the cycle.

Assessing (relevant factors) — Discuss the methods of heat transfer in relation to cooking. Worksheet FSM13 will be useful here.

Communicating (speech) / Assessing (ideas) / Planning experiments — Conduction is the flow of heat energy through a material which is not at a uniform temperature, without the material moving. Applications of conduction include flat-bottomed saucepans (good contact with heat source), copper-bottomed saucepans for uniform temperature distribution to prevent local scorching, and skewers for baking potatoes. Applications of insulation include handles for most kitchen utensils and oven doors, slow cookers, and insulating material inside oven and refrigerator doors. Home insulation is discussed in *People and homes*,

Applying knowledge

Chapter 13 and *The Basic Course*, Chapter 30. Clothing insulation is discussed in *Fibres and fabrics*, Chapter 7 and *The Basic Course*, Chapter 21.

Applying knowledge

Communicating (speech)

Convection is the transfer of heat energy by the circulation of a fluid (liquid or gas) due to temperature differences within it. You could discuss the following points with the pupils. It is necessary to stir some thick liquids because the natural convection currents will be too sluggish to produce adequate uniform heating. In a normal oven, the air at the top of the oven is usually considerably hotter than the air at the bottom, mainly because of the formation of natural convection currents. In a forced-air convection oven, where an electrically driven fan assists the air circulation, the temperature distribution is uniform (see *The Basic Course*, Chapter 4).

Reasoning logically

Radiation is the transfer of energy from one place to another by means of electromagnetic waves, usually infra-red waves. These waves have similar properties to light waves: they travel in straight lines, they are reflected from smooth bright metal surfaces, and they are absorbed by food and dark matt surfaces. Here are some points to discuss. Most grills are fitted with reflector plates behind the heating elements, so that more infra-red waves are reflected onto the food. The surfaces of kettles are bright, so that less heat energy can escape by radiation from the hot water inside.

Q 6 and figure 13.2
Stress that more than one method of heat transfer is usually operating at the same time. Conduction *and* convection are occurring in *figure 13.2a*, and radiation *and* conduction in *figure 13.2b*.

Reasoning logically

Q 7
The centre of the food must reach a certain minimum temperature before it is considered cooked. This also ensures that bacteria which might cause food poisoning are destroyed.

Applying knowledge

Q 8 and figure 13.3
These apply knowledge of methods of heat transfer to familiar cooking methods.

Q 9 and figure 13.5
The pictures apply knowledge of methods of heat transfer to a variety of cooking methods, some of them less familiar. The top lefthand picture was drawn in 1516.

13.3
THE EFFECT OF COOKING METHOD ON FOOD

Main ideas in this section

With 'moist' methods, the temperature is around boiling-point, the exception being pressure cooking which increases the temperature to around 120 °C.

'Dry' methods have much higher temperatures.

Q 10

Using references — Pupils can be encouraged to find a range of cooking temperatures from recipe books. Discuss the reasons why dishes require different temperatures.

Applying knowledge — The effects of cooking at high temperatures, particularly over 150 °C, are that sugars on the surface caramelize, giving a brown colour and distinctive flavour, and that protein and carbohydrate components react, producing a number of dark-coloured distinctively flavoured compounds. This is called non-enzymic or Maillard browning.

Q 11

Reasoning logically / Identifying causes — Cooking meat using a moist method, such as stewing, will tend to leach out the soluble nutrients and flavouring compounds, so it will be less tasty than roasted meat — hence the addition of herbs and spices.

COOKING POTATOES BY DIFFERENT METHODS

Suggesting tests — The pupils should be able to think of a wide variety of methods of cooking potatoes. This section makes a useful link with practical work.

You will need for each pair or group of pupils
(depending on what they do)

- Potatoes
- Cooking fats
- Salt
- Potato peeler
- Vegetable knife
- Thermometer
- Cooking equipment

Deciding criteria / Designing tests — More able pupils could probably make a table of the effects of different cooking methods from previous experience of cooking potatoes; the less able may need to use actual potatoes cooked by different methods. The following information should be included: approximate cooking temperatures (they should use a suitable thermometer), and changes in colour, texture, and flavour (described by one or two words).

Assessing (validity) — An alternative experiment could be planned using chips cooked in a variety of oils.

Q 12

Evaluating results

This should summarize the pupils' observations. They should mention differences in colour, texture, and flavour.

Q 13

Communicating (writing)

Meat and eggs are other foods that can be prepared by different cooking methods.

13.4 HOW DOES HEAT PENETRATE FOOD?

Main ideas in this section

All foods are poor conductors of heat.

Heat has to be conducted from the surface to the centre of the food. The time for this depends on: the temperature of the surface (the greater the temperature, the less cooking time required), the temperature required at the centre, and the distance between the surface and centre of the food.

Q 14

Reasoning logically

The right cooking time and temperature are needed so that the centre of the meat reaches the required temperature without burning the surface.

Q 15 and figure 13.6

Identifying causes

Insufficient time has been allowed for the heat to penetrate. (Alternatively, the oven temperature was low.)

USING A MEAT THERMOMETER

Observing

Suggesting hypotheses

Practical skills

As the temperature at the centre of the meat is critical, a thermometer is useful. This avoids under- or over-cooking and also uses only the minimum of heat energy for cooking. If the pupils are not familiar with the use of a meat thermometer, a simple experiment can be set up using a potato. This can be done as a class experiment, with the temperature recorded at 10-minute intervals.

You will need for the class

Potato (large)

Meat thermometer
Oven

Assessing (relevant factors)

Variations of this experiment could include different sizes and types of potatoes and an investigation of the effect of using a meat skewer or heat pipe (see *figure 13.7*). This is described in section 13.2 above.

Q 16
The effect of heat penetration will be the same if vegetables of the same size are in the pot. (See *The Basic Course*, Chapter 5.)

Extension work (Q 17)

Observation v inference

In Baked Alaska, the sponges and meringues act as a layer of insulation and the quick browning of the meringue takes place before the heat penetrates to the ice-cream. This would be an interesting demonstration, or it could be done by a more able pupil.

13.5 HOW IS HEAT ENERGY MEASURED?

Main ideas in this section

The specific heat capacity of a food is the amount of heat energy required to raise the temperature of 1 kg of the food by 1 °C, or alternatively the amount of heat energy 1 kg of food will store before its temperature rises by 1 °C.

A food with a high specific heat capacity value will need more energy to heat it than a food with a lower value.

Worksheet FSM13 may be used with this section.

Link with school science
The work gives an illustration of the usefulness of the concept of specific heat capacity, and of the way that it varies from material to material (being uniquely high amongst liquids with water). It could provide many useful practical examples of the calculations of quantities of energy transferred in joules.

Q 18

Reasoning logically

Communicating (maths)

Applying knowledge

1 kg of oil requires only 2000 joules to produce a temperature rise of 1 °C. This should be compared with the value for water (4200 joules). The implications are that when heating similar amounts of water and oil to the same temperature, water requires twice the energy, and that if the same amount of heat is given to a pan containing water and a similar pan containing oil, the temperature of the oil will rise twice as fast.

Using statistics

Pupils can work out the heat energy required to heat a given mass of food to a given temperature by using the formula given in the pupils' text.

Q 19

Communicating (maths) The amount of heat energy required to heat 1 kg beef from 5 °C (refrigerator temperature) to 75 °C is:

Quantity of heat = M × R × S
(M = 1 kg,
R = 75 − 5 °C
S = 3600 J/(kg °C)

= 1 × 70 × 3600
= 252 000 joules.

Q 20

2 litres of water weigh 2 kg.
Quantity of heat = 2 × 80 × 4200
= 672 000 joules.

Q 21

Reasoning logically *a* Water has the highest specific heat capacity value.
b This means that water requires more energy to heat it than other substances.
c As water requires more energy it is more expensive to heat.

Applying knowledge The overall fuel consumption will be high in a kitchen where large quantities of water are heated.

13.6
IS ALL THE ENERGY BEING USED TO COOK THE FOOD?

Main ideas in this section

Heat energy not being used to cook the food is wasted.

Ovens, grills, and saucepans all get hot when they are being used, and the water in the pan and the air in the oven also use up heat energy.

Normal cooking methods cannot be 100 per cent efficient, but well designed equipment can increase the efficiency significantly.

Q 22

Suggesting hypotheses The air in the kitchen gets warm because the heat energy being used in the oven is being conducted through the oven walls. Better insulation can reduce this heat loss.

Designing tests The pupils find out how much heat reaches water being heated in a saucepan. They are being asked to find the thermal efficiency of this cooking process.

Selecting equipment
Practical skills

You will need for each pair or group of pupils

Water	Spoon (wooden)
	Clock or stopwatch
Saucepan (small)	Thermometer
Measuring jug	Gas or electric cooker

Estimating
Measuring
Communicating (writing)

To make the calculations easier, use 0.5 kg or 1 kg (*i.e.* 0.5 litre or 1 litre) water in the saucepan (the saucepan should be about half full). The saucepan should only be placed on the boiling-ring or burner when it has had time to 'warm up' on its highest setting. It is only necessary to heat the water to about 60 °C; a preliminary check will tell you how long this will take (3 minutes is suggested in the pupils' text). The water should be stirred well after the end of the time and taken from the boiling-ring or burner. The highest temperature recorded is the final temperature of the water, as this may increase by a few degrees after taking it away from the heat source. The power rating for a boiling-ring or burner in the example used in the pupils' text is 1200 watts. The rating for different equipment can be checked from the maker's publicity materials, the Electricity Board, or British Gas. The British Gas home service may be able to help.

Organizing data

The following set of data illustrates the calculation method:
Mass of water: 0.5 kg
Initial temperature of water: 20 °C
Final temperature of water: 60 °C
Temperature rise (60 − 20 °C) : 40 °C
Specific heat capacity: 4200 J/(kg °C) of water
Heating time: 3 minutes (180 seconds)
Power rating of element: 1200 watts

Analysing data
Communicating (maths)

Q 23
a The temperature rise of the water may be about 40 °C.
b The amount of energy received by the water
= mass × temperature × specific heat capacity
= 0.5 × 40 × 4200 joules
= 84 000 joules (A).

Q 24
Amount of heat energy produced by boiling-ring or burner

= power rating × time = 1200 × 180 joules
(watts) (seconds) = 216 000 joules (B)

Amount of heat energy lost = value (B) − value (A)
= 216 000 − 84 000 joules
= 132 000 joules

Q 25
If the heating process were 100 per cent efficient then *no* heat would be lost.

Method	Comments/discussion points
Using electric kettle to boil water	electric kettle has a high thermal efficiency (about 80 per cent)
Using a pan larger than the boiling-ring or burner	more efficient transfer of heat through base
Using a meat thermometer	precise cooking time determined — no temptation to give an extra 10 or 15 minutes
Using a pressure cooker	high cooking temperature means shorter cooking time so less fuel is used
Using a microwave oven	shorter cooking time and less fuel used
Using a slow cooker	well-insulated container — less energy required to maintain cooking temperature
Using a casserole with a tight-fitting lid	prevents hot air escaping from food
Enclosing food in foil	prevents heat escaping from food
Using only a minimum of hot water required, or storing surplus in vacuum flask	water has high specific heat capacity and uses a large amount of energy
Make use of maximum oven space when cooking	the heat energy used to reach the operating temperature is stored in the air inside the oven and the body of the oven; this is lost when the oven cools
Use equipment approved by British Gas or Electricity Council	they test equipment for efficiency and safety

Table 13.1
Conserving heat energy.

Q 26

% efficiency

$$= \frac{\text{heat energy used by the water}}{\text{heat energy produced by the boiling-ring or burner}} \times 100$$

$$= \frac{132\,000}{216\,000} \times 100 = 61\ \%$$

13.7 USING HEAT ENERGY ECONOMICALLY

Main ideas in this section

Thermal efficiency of 40 to 50 per cent is likely in many cooking methods.

Energy-saving methods and better equipment design are essential.

Q 27

Assessing (relevant factors)

Observation v inference

The methods illustrated in *figure 13.10* are summarized in table T13.1. Induction heating may also be incorporated in cookers; an alternating magnetic field is produced which induces an electric current in any iron-based cooking utensil. Heat energy is generated at the point of contact between the pan and the boiling-ring, and this will save energy as only the utensil gets hot — not the cooker surface. The heat pipe shown in *figure 13.7* would be useful too.

Q 28

Organizing data

Evaluating

This may serve as homework. Thermal efficiency might be improved by better insulation, incorporation of micro-processors to programme cooking times and temperatures, and the use of thermocouple probes in foods attached to thermostat controls.

Ideas for homework

Pupils could try to design an energy efficient kitchen.

They could investigate fuel bills at home. If 10 per cent of the bill is fuel for cooking, how much does an average day's cooking cost?

Questions 8, 9, and 28 could be done for homework.

Assessing (relevant factors)

The Background reading reinforces some of the ideas discussed in this chapter: the amount of heat energy used to cook a meal depends on the method used. The pupils should realize that different styles of cooking can be adapted to the amount and source of heat energy available. (See also the Background reading for Chapter 7.) In some parts of the World fuel is scarcer than food. You may be able to find newspaper articles about this.

Processes and skills	Pupils may be able to:
13.1 *Cooking changes foods* Organizing data, applying knowledge, using references.	Recall work from previous chapters concerned with the denaturation of protein and the gelatinization of starch. Recognize that to cook food it must reach the right temperature and stay at this temperature long enough.
13.2 *How does heat travel to foods?* Applying knowledge, assessing (relevant factors), reasoning logically.	Recognize that heat is conveyed to foods by conduction, convection, and radiation. Give examples of cooking methods for each method of heat transfer. Choose equipment which will give the most efficient heat transfer.
13.3 *The effect of cooking method on food* Classifying data, designing tests, applying knowledge, using references.	List cooking methods under two headings: moist methods and dry methods. Recognize the various cooking media used. Compare the temperatures used. Compare the results of cooking a food (*e.g.* potatoes) by several different methods.
13.4 *How does heat penetrate food?* Observing, suggesting hypotheses, using practical skills, assessing (relevant factors), observation *v* inference.	Use a meat thermometer to test the temperature at the centre of the food being cooked. Apply knowledge of cooking meat to assess the cooking times of unfamiliar joints. Explain the principles involved in making a Baked Alaska or similar dish.

Processes and skills	Pupils may be able to:
13.5 *How is heat energy measured?* Applying knowledge, communicating (maths), using statistics, reasoning logically.	Know the term 'specific heat capacity' and understand how this applies to the heat used in cooking foods. Calculate the heat energy required to cook various foods.
13.6 *Is all the energy being used to cook the food?* Suggesting hypotheses, identifying causes, designing tests, selecting equipment, practical skills, estimating, and measuring.	Recognize that heat not being used to cook the food is wasted. Identify the situations where heat is wasted and suggest improvements in efficiency. Measure the thermal efficiency of a boiling-ring in heating water.
13.7 *Using heat energy economically* Organizing data, assessing (relevant factors), observation *v* inference, assessing (ideas).	Use ovens, boiling-rings, and burners efficiently. Use information from manufacturers of equipment to suggest ways of saving heat energy. Suggest economies which might be made in food preparation and cooking.

CHAPTER 14

More cooking methods

Three cooking methods are investigated in this chapter. This work follows on from Chapter 13 where the pupils are asked to discuss economical cooking methods. The chapter has some links with *The Basic Course*, Chapter 2, and with *People and homes*, Chapter 14.

Time allocation
Section 14.1: 20 minutes plus 5 minutes' class discussion; 14.2: 15 minutes plus 5 minutes for discussion and two periods of 5 minutes to record temperatures after one hour and overnight; 14.3: 20 minutes; 14.4: suggested for homework, with 10 minutes' class discussion (total 85 minutes).

Extension work in this chapter
Section 14.1: calculating time saved using a pressure cooker; discussing its effect on food quality.
Section 14.3: investigating the properties of microwaves (demonstration); finding the 'hot spots' in a microwave oven.

Worksheet and OHP Masters
FSM1 Measurement: accuracy and precision
FSM13 Heat and temperature
FSM30 Assessment card

Q 1
Suggesting hypotheses
Pressure cooking and microwave cooking are convenient because they reduce the conventional cooking time. Slow cooking takes several hours but can be left unattended.

14.1
THE PRESSURE COOKER

Main ideas in this section

Water boils at 100 °C at standard atmospheric pressure.

As the pressure increases, the boiling-point of water rises. This is why foods cook more quickly in a pressure cooker.

It is important that pupils understand the operation of the pressure cooker so that they may appreciate the safety aspects.
Applying knowledge
Discuss the operation of the pressure cooker before attempting the practical work. ⚠

Pressure setting	Pressure above atmospheric		Temperature (°C)
	(lb per square inch)	(kg per square cm)	
Atmospheric	0	0	100
Low	5	0.35	108
Medium	10	0.70	115
High	15	1.05	121

Table T14.1
Pressure cooker operating temperatures and pressures. (Note that pupils may have used the pascal (Pa), the SI unit of pressure, in their science work.)

Q 2
The air inside the pan is driven out by the steam through the vent.

Q 3
Reasoning logically
If the pressure control valve became blocked then the pressure would keep on increasing, causing overheating and possible explosion.

Q 4
A safety plug is required which would operate if ever the pressure control valve became blocked, thus preventing serious overheating or damage due to excess pressure.

WHAT IS THE BOILING-POINT OF WATER IN A PRESSURE COOKER?

You will need for each pair or group of pupils

Practical skills
Water
*RS temperature-sensitive labels:
scale B 71 °C to 110 °C
Estimating C 116 °C to 154 °C
Pressure cooker with trivet
Measuring
Bowl (heat-resistant)

*Alternatively, Philip Harris Ltd supply a pressure cooker fitted with a thermometer, reference number C11665/0.

Communicating (writing)
Observing
The temperature of the water boiling inside the pressure cooker is determined at various pressures. Each part of the label will change colour irreversibly whenever a temperature within its range is obtained. Therefore only an estimate of the temperature will be possible for each pressure. As the colour change is irreversible, it is best to start from atmospheric pressure and work up, so that the same labels can be used throughout the experiment. The pupils are asked to make a table like *figure 14.4* giving their estimated temperatures along with the temperature from the manufacturer's data.

Q 5
The temperature of the water boiling in the open pan is 100 °C; this can also be checked using a thermometer.

Q 6
The correct pressure is reached when a steady flow of steam escapes from the pressure control valve.

Q 7
The pressure cooker must be cooled before attempting to remove the lid because the pressure inside is much greater than atmospheric. It is almost impossible to remove the lid, and it would be dangerous to do so because of the danger from escaping high pressure steam. Cooling causes the steam to condense inside, thus lowering the pressure. ⚠

Applying knowledge

Q 8
Reasoning logically
The temperatures determined by experiment may not agree with the manufacturer's stated data because the temperature-sensitive labels (if used) only give an estimated value.

Extension work
Economic cooking with pressure cookers: the most important attributes of pressure cooking are the saving in cooking time and therefore the corresponding saving in fuel. The average percentage time saved can be calculated from the data given in *table 14.1*.

The percentage time saved =

$$\frac{\text{normal cooking time} - \text{pressure cooking time}}{\text{normal cooking time}} \times 100$$

It works out at about 90 per cent in each case. This could be checked by a group of pupils.

Q 9
Reasoning logically
The greatest fuel saving would be obtained for the dish needing the longest cooking time, in this case the beef stew.

Q 10
Using statistics
Two or more different items requiring the same cooking time can be cooked at the same time in partitioned containers. This technique is, of course, used in other cooking methods.

Link with school science
The action of the pressure cooker is deservedly the most popular illustration of the effect of pressure on boiling-point. It is explored in great detail here, offering a valuable resource for science teaching. The physicists' molecular theory explanation of the phenomena may help some of the pupils to organize the results of their investigations.

Extension work

Assessing (relevant factors) / Communicating (speech)

Foods retain water-soluble vitamins and minerals when cooked in a pressure cooker (see *Nutrition* Chapter 12). There is less weight loss and therefore a moister product. Cooking time is shorter and can be more accurately determined. These factors can be discussed with the class and compared with other cooking methods.

14.2 THE SLOW COOKER

Main ideas in this section

The slow cooker or crock-pot is a type of insulated cooker. The food is heated to boiling-point and then transferred to a well insulated container.

The temperature inside the container falls very slowly so that the cooking process can still continue for many hours, long enough to cook the food.

The only energy input to the system is the initial heating to boiling-point. This means that there is a considerable energy saving.

The modern domestic crock-pot has a low-powered heater (between 60 and 170 watts) designed to compensate for the small heat loss through the walls of the cooker.

Observing / Assessing (relevant factors)

Figure T14.1 on the next page shows the temperature of a home-made slow cooker and a modern domestic slow cooker. Note the gradual fall in temperature of curve B (the home-made slow cooker). The effective cooking time is about 45 minutes to 1 hour. The temperature of curve A is nearly constant at 72 °C because of the compensating heating element. The shape of curve B and the effective cooking time will vary according to the effectiveness of the home-made slow cooker.

Assessing (accuracy)

Q 11

a The temperature inside the container will gradually fall from 100 °C but remain above 70 °C.

b The food will continue to cook.

INVESTIGATING A HOME-MADE SLOW COOKER

Deciding criteria / Designing tests

You will need for each group of pupils or for the class

2 15-ml (table) spoons fresh medium oatmeal
550 ml water
Salt for seasoning
Saucepan
Dish with tight-fitting lid
Home-made slow cooker
Thermometer

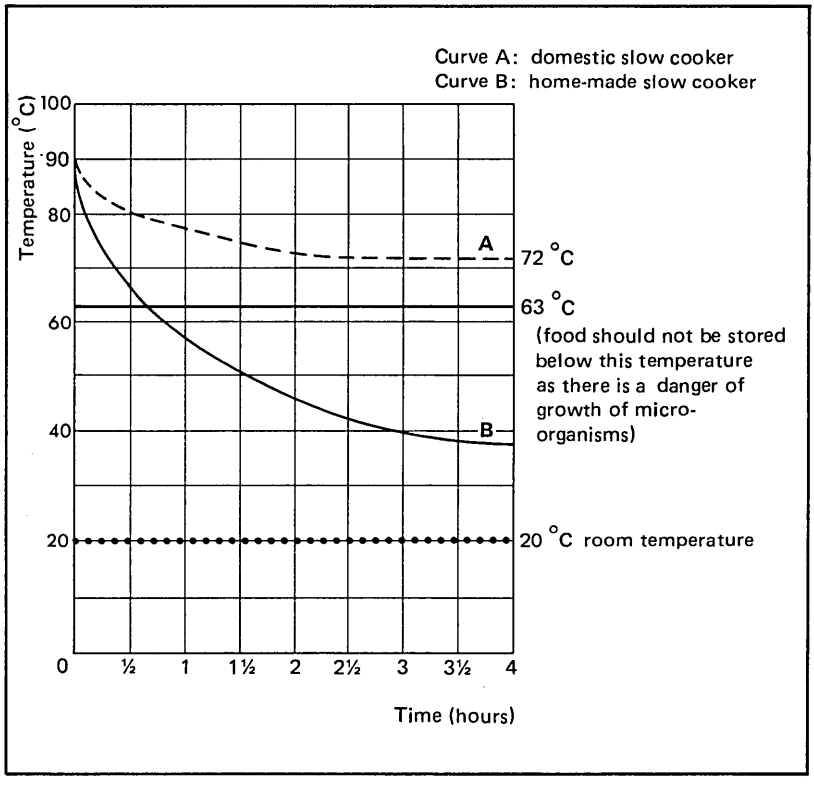


Figure T14.1
The temperatures obtained during the operation of a home-made slow cooker and a domestic slow cooker.

Selecting equipment

Practical skills

Estimating

Measuring

Applying knowledge

The pupils make a slow cooker and then use it to cook porridge from fresh oatmeal. The size of the box used depends on the size of casserole dish available. The box should be as well insulated as possible. Many modern packing materials can be used as well as the traditionally used hay (see *figure 14.5*). Stews, vegetables, soups, and puddings may all be successfully cooked using the insulated cooker. The cooking time of each dish can be found by trial and error.

It is important to note the following points. The food must be brought to boiling-point and simmered for at least 5 minutes before being put into the slow cooker. The casserole dish must be preheated. The operation of transferring the food to the dish and then the dish to the slow cooker must be done as quickly as possible. Allowance should be made for removing the lid for temperature readings unless an electric temperature probe is used. Note that a larger quantity of food will lose heat more slowly than a smaller quantity.

Worksheet M34 of *The Basic Course* looks at why babies have to be kept warm (they have a high surface:volume ratio).

Insulation in houses is dealt with in *People and homes*, Chapter 13. *Fibres and fabrics*, Chapters 8 and 12 include references to insulation and fabric structure.

Q 12
After the initial heating, no more fuel is used to cook the food.

Q 13
Identifying causes
The actual temperature fall will depend on the cooking time and the effectiveness of the insulation.

Q 14
Applying knowledge
It is necessary to pre-heat the dish because, if the dish were cold, heat energy would be transferred from the food to the dish and so reduce the temperature of the food.

THE COMMERCIAL SLOW COOKER

Observing
Assessing (relevant factors)
Using references
The slow cooker or crock-pot available commercially operates on the same principle as that discussed for the home-made slow cooker. The main difference is, of course, the compensating heating elements which produce a steady cooking temperature. Figure T14.1 shows the effectiveness of the heating elements. Note that the cooking time for the home-made slow cooker can be considered to be the time when the temperature remains above 65 °C (see curve B in figure T14.1).

Q 15
Reasoning logically
Dishes which need to be stewed or poached are the most suitable for this type of cooking. (Kidney beans are poisonous unless they are boiled.)

Q 16
The compensating heating elements maintain the temperature at 72 °C.

14.3 MICROWAVE HEATING

Main ideas in this section

Microwave heating is a completely different method of heating food. It does not rely totally on the normal processes of heat transfer.

The incident energy is in the form of microwaves which are part of the electromagnetic spectrum.

The wavelength used for domestic appliances is 122 mm, much larger than normal thermal radiation. The microwaves interact with molecules in the food which have an uneven electrical field;

Conventional oven (gas or electric)	Microwave oven
Preheating of oven required	no pre-heating necessary
High air temperature inside	air inside at room temperature
Food containers become hot	food containers (plastic and glass) do not heat up
Time and temperature control	time control only
Food cooks by conduction from surface inwards	food cooks where penetrated by microwaves, *i.e.* to a depth of about 20 mm; heating to a greater depth is by conduction
Surface of food browns	surface of food does not brown

Table T14.2
The main differences between the features of a microwave oven and a conventional oven.

Applying knowledge

these are called polar molecules. The polar molecules vibrate to the changing electrical field (frequency 2450 million times per second) of the microwaves. This rapid molecular movement makes the food hot. The most important polar molecule in food is the water molecule.

Link with school science
Microwaves are high frequency radio waves used by radar, in early-warning systems, and in long-distance tele-communications. Many school science laboratories have miniature microwave transmitter/receiver sets which they use to study the wave properties of this kind of 'invisible light'.

The work provides a good illustration of the transfer of a device (the microwave transmitter) from research science through other branches of technology to profitable applications in a quite alien branch (that of domestic and commercial food preparation).

Q 17

Reasoning logically

a The air temperature in the oven would be at room temperature.

Identifying causes

b The plate would not be hot to touch, although it can become warm due to the conduction of heat from the hot food.

c The surface of the food does not become brown because of the low air temperature in the oven. (See Chapter 13.)

Q 18

Applying knowledge

The largest piece of food to be cooked rapidly would be about 40 mm thick, assuming that the microwaves can penetrate to a depth of 20 mm and approach the food in all directions.

(The term 'microwave oven' is rather misleading, as it does not perform all the operations one would expect from an oven.)

INVESTIGATING HEATING USING A MICROWAVE OVEN

You will need for the class

Practical skills

Estimating

3 similar non-metal containers with:
100 g water (labelled A)
100 g cooking oil (labelled B)
100 g ice (labelled C)

Microwave oven
Thermometer, −10 °C to 110 °C

Make sure that pupils know how to operate a microwave oven safely. ⚠

Measuring

This demonstration shows the different absorption properties of water and oil. Before attempting the experiment, it is best to discuss the expected temperature rises. This can be done by referring to section 13.5 on specific heat capacities. Water has twice the specific heat capacity of oil. This means that when equal quantities of water and oil are given the same amount of energy, the oil will show twice the temperature rise of water when heated by traditional means.

Reasoning logically

Identifying causes

In this experiment, water should show about twice the temperature rise of oil — the complete opposite to the normal heating process. The pupils should conclude that water is very efficient in absorbing microwave energy.

Q 19

Observing

The temperature rise of the water should be between 25 °C and 35 °C, and that of the oil between 10 °C and 20 °C. These results agree with the information given in the pupils' text — water readily absorbs microwave energy.

Q 20

Communicating (speech)

When a quantity of ice is placed in a microwave oven, a large proportion is melted in a short time, so a microwave oven is efficient at melting ice. This result can lead to a discussion of the use of microwave ovens to thaw frozen foods rapidly.

Extension work

Suggesting hypotheses

Practical skills

The main properties of microwaves can be demonstrated using a 3-cm wave kit (Griffin & George Ltd reference number XFB-400+XFB-410+Accessories). The kit consists of a transmitter, a receiver, and a visual and/or audible detector. The science department may be able to supply and set up the apparatus

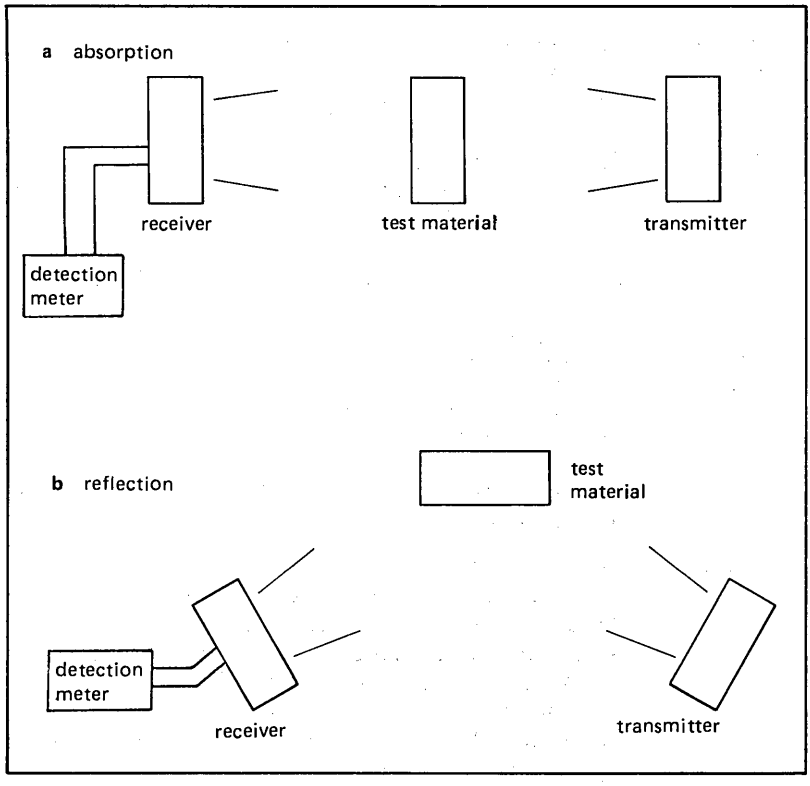


Figure T14.2
3-cm wave apparatus for testing the absorption and reflection properties of materials.

Estimating

shown in figure T14.2. A selection of suitable materials and objects can be used to demonstrate their microwave absorbence (see table T14.3).

The 3-cm microwave demonstration can also be used as an introduction to this section.

Figure 14.8
This is a diagram of a microwave oven. One technical problem that has confronted the design engineer is the need to produce an even intensity of microwave energy within the cavity. A mode stirrer deflects the incoming microwave energy, thus distributing the energy randomly throughout the oven. However, 'hot spots' do occur. They are areas which receive more microwave energy than other areas.

Selecting equipment

Extension work
This can be demonstrated by using a sheet of heat-sensitive paper (supplied by Griffin & George Ltd, reference number XHB-550-L). Cut it to lay flat on the base of the oven. Add

Suggested materials	Expected results
China dish or cup	no absorption; microwaves pass through unaffected
Paper dish or cup	no absorption; microwaves pass through unaffected
Plastic dish or cup (empty)	no absorption; microwaves pass through unaffected
Plastic cup (filled with water)	absorption of microwaves detected
Plastic cup (filled with various foodstuffs)	absorption of microwaves detected
Metal tray	positive absorption result obtained, but demonstrate that reflection is taking place (figure T14.2b)

Measuring

Organizing data

Table T14.3
The effect of microwaves on various materials.

Note that a high meter reading means *no* microwave absorption, so the material will *not* heat up in a microwave oven. No reading or a very small one means microwave absorption, so the material will heat up in a microwave oven. An exception to this latter result is when reflection is taking place on metal surfaces.

Estimating

Measuring

Observing

Measuring

Communicating (writing)

Assessing (relevant factors)

about 1 litre of water as a load. (Never operate a microwave oven when empty.) Switch on the oven for 2 to 3 ⚠ minutes. A pattern should develop on the paper, the 'hot spots' appearing as blue areas against a pink background.

An alternative demonstration is to fill 9 or 12 glasses with equal quantities of water and space them out evenly inside the oven. Note the temperatures of the samples after heating for about 1 minute. The temperatures should be within 2 or 3 °C of each other. Greater temperature differences indicate the presence of 'hot spots'.

Some models have a turntable inside the oven. Here the food should receive an even distribution of microwave energy as it rotates within the energy field. The demonstration discussed above can be adapted to demonstrate the benefit of a turntable. It can be done with the turntable in position and then with it removed. Check that it can be removed and put back easily!

Processes and skills	Pupils may be able to:
14.1 *The pressure cooker* Suggesting hypotheses, applying knowledge. Using practical skills. Using data and references, observing, estimating, measuring, communicating (writing).	Use a pressure cooker safely. Select foods best suited to pressure cooking. Observe that as pressure increases the boiling-point of water rises.
14.2 *The slow cooker* Interpreting graphs, observing, assessing (relevant factors), deciding criteria. Using practical skills, estimating, measuring. Communicating (writing), applying knowledge.	Make a simple slow cooker and cook porridge in it. Select foods best suited to slow cookers. Plot a graph to show how the temperature falls during slow cooking. Calculate the consumption of electricity for a slow cooker.
14.3 *Microwave heating* Applying knowledge. Using practical skills, estimating, measuring. Communicating, organizing data.	Use a microwave oven correctly. Choose correct cooking equipment for use with microwave ovens. Recognize the characteristics of this method of cooking. Understand and apply the safety precautions necessary.
14.4 *Can you help?* Applying knowledge, reasoning logically, communicating (writing).	Assess advantages and disadvantages of: pressure cookers slow cookers microwave ovens. Assess the cooking needs of different groups of people. Suggest priorities in choice of equipment to meet the needs of these groups.

14.4
CAN YOU HELP?

Main idea in this section

There are reasoned choices to be made when buying new equipment: people's income and life-style must be taken into account.

Applying knowledge

The material presented and discussed throughout this chapter can now be drawn together in a concluding session.

Q 21 and Q 22

Assessing (ideas)

Assessing (relevant factors)

Evaluating

Discuss each domestic situation in terms of the time available for preparation and cooking, and the probable financial situation. This is perhaps the most important exercise in the chapter. So far the chapter has concentrated on the scientific principles involved. All the advantages and disadvantages of the appliances have not been discussed. Throughout *Nutrition* the nutritional aspects of the various cooking methods are discussed. The current cost of each item can be obtained from a mail order catalogue or other sources.

The Electricity Council's information sheets for each appliance are good background material for this section.

Ideas for homework

The pupils could answer questions 21 and 22 in section 14.4.

They could read the Background reading and collect up-to-date information about the latest cooking appliances — possibly visiting gas and electricity showrooms.

The Background reading describes an example of the kind of job that home economists do in British industry. You could discuss such possibilities with the pupils. They may need some help in understanding the principle behind the reflectometer shown in *figure 14.10*: we see objects because of the light reflected off them; the more light reflected, the lighter they appear. This is also discussed in *Fibres and fabrics*, Chapter 10.

CHAPTER 15

Behind the labels

This chapter introduces some modern food materials. It starts by comparing foods of fifty years ago with those of today. The need for sources of protein cheaper than meat and fish is discussed. The pupils investigate T.V.P. as a substitute for fish. The text also considers other new ingredients and their uses. (*Nutrition* Chapter 9 compares different sources of protein.)

Time allocation
Section 15.1: 10 minutes; 15.2: 15 minutes; 15.3: 35 minutes; 15.4: 10 minutes; 15.5: 15 minutes; 15.6: 25 minutes (total 110 minutes).

To do this work within a lesson of 70 minutes, sections 15.1 and 15.2 could be done as preparatory reading and investigation. Alternatively, the tuna salad in section 15.3 could be made before the lesson and just tasted and compared during it. Section 15.6 could be done for homework.

Extension work in this chapter
Section 15.2: comparing the protein content of some foods (discussion).
Section 15.3: experimenting with texturized vegetable protein; looking for T.V.P. on convenience food labels.
Section 15.4: preparing dishes using peas, beans, or cereals; comparing them with dishes using T.V.P.
Section 15.5: making foods using new ingredients.

Worksheet and Assessment card Masters
FSM4 Carbohydrates II
FSM9 Micro-organisms
FSM10 Emulsions
FSM11 Sols and gels
FSM12 Foams
FSM14 Taste panels
FSM16 Quality assurance
FSM31 Assessment card

15.1
HOW DO FOOD SHOPS IN THE 1900s AND 1980s COMPARE?

Main idea in this section

Changes have taken place in the appearance and layout of shops, in methods of shopping, and in the types and varieties of foods sold.

Figures 15.1 and 15.3 and Q 1 and Q 2

Applying knowledge
Classifying

Many comparisons can be made. Tea was sold from bulk in the 1900s. In the 1980s there are choices of pre-packed varieties, tea bags, and even instant tea. Cheese was sold from bulk in the 1900s and is now often pre-packed. Margarine was considered a butter substitute, but is now sold in its own right.

Organizing data
Identifying causes

Discuss the wide variety of new foods available in the 1980s such as T.V.P., and convenience foods such as dehydrated potato, instant coffee, instant desserts, frozen foods, and refrigerated goods like coleslaw and yoghurt. What social factors may have affected their availability?

Q 3

This revises the concept of convenience foods (see *The Basic Course*, Chapter 1).

Figure 15.2 and Q 4

Reasoning logically

A range of convenience foods can be examined. They should include canned foods which only need heating, other instant foods such as coffee, mashed potato, desserts, pot noodles, and packet sauces which only require addition of water, and other processed foods where preparation time has been eliminated, such as frozen vegetables and prepared meats (pies, sausages, ready-cooked chicken).

Assessing (relevant factors)

Changes have taken place in the methods of growing and processing foods. As more is learned about how things grow and how human bodies behave, ideas change on how and what should be eaten (nutrition) and how to process foodstuffs economically, safely, and with minimum loss of nutritional and aesthetic quality. Economic pressures force the farmer and food manufacturer to use new methods and to adapt to new ideas; otherwise they fail to remain competitive in the market.

15.2 PROTEIN FOODS

Main ideas in this section

Meat is an expensive source of protein.

Soya beans are a cheaper source of protein. They can be processed to make them seem more like meat.

Identifying causes

Producing meat is usually expensive. Livestock have to be bred, and developing the most desirable type of meat-producing animals is costly to the breeder and therefore to the farmer. Compared with plants, animals take longer to grow to maturity and produce saleable quantities of food. All this time the animal has to be fed (with expensive feeds in winter), housed, and

looked after (using expensive resources such as buildings and manpower).

Suggesting hypotheses
Reasoning logically

In some parts of the World people do not eat meat at all. In areas where other sources of high quality protein (like milk, fish, or soya) are also in short supply, deficiency diseases such as protein/energy malnutrition may arise. Children suffer from retarded growth, wasted muscles, and (amongst other symptoms) anaemia.

Extension work

Communicating (speech)
Deciding criteria

Table T15.1 shows the protein content of some foods. You could discuss the biological value of protein, as well as its cost and availability.

Table T15.1

Food	Protein content (%)
Fish (cod)	84
Egg	50
Meat	49
Soya bean	43
Peas	28
Milk	28
Ground-nut	26
Wheat (bread)	14
Potatoes	9
Rice	8

Applying knowledge

Three reasons for seeking a source of protein other than animal husbandry are: to make better use of available resources; to provide a cheaper alternative to meat; and try to ensure an adequate supply of protein to those areas of the World suffering from protein deficiency diseases.

Communicating (diagrams)

If Man can obtain his protein direct from plants, the inefficient and expensive link in the chain from plant to animal to Man is broken. The inefficiency of the animal link may be illustrated by the following example. Cattle require 12 kg of vegetable protein to produce 1 kg of meat protein. As little as 15 per cent of the protein fed to an animal is actually converted into consumable protein. A 500-kg bullock only produces an extra 0.5 kg of protein a day.

Figure 15.6

Interpreting (graphs)

The efficiency of different protein producers can be compared. One hectare of land used to graze cattle will provide enough beef to meet the protein requirement of one man for 270 days, assuming a daily intake of 70 to 80 grams per day. If this

hectare is used for wheat production, 1400 days of protein supply can be produced, and if soya beans are cultivated, protein for 6800 days can be supplied. More energy is needed to produce animal foods than is derived from eating them.

Q 6

Using references

Soya beans are the best of the sources of protein shown in *figure 15.6*. Sunflower and cotton seed are second and third best. Beef is the lowest.

Pupils may ask about baked beans. The yield per hectare will be approximately that of broad beans. The available protein in canned baked beans in tomato sauce is approximately 5 per cent. Potato contains about 3.5 per cent protein.

Utilizing soya protein uses complex food processing techniques. Soya beans are not edible unless thoroughly cooked. The raw beans contain growth inhibiting compounds which have to be destroyed by heat, so some sort of processing is essential.

Q 7

Applying knowledge

a One of the problems associated with substituting soya bean protein for meat is *texture* and mouth-feel. You could refer back to Chapter 4 and meat texture. Food technologists have researched ways to process and alter soya bean protein to make it seem like meat. Whole fish, steaks, and hams have been fabricated using T.V.P.
b Oil is also obtained from soya beans.

The production of protein foods from soya beans is illustrated in figure T15.1. Functional proteins are used to emulsify meat products such as sausages, while T.V.P. is manufactured by spinning or by extrusion. In the extrusion process, soya flour is mixed with water into a paste, heated under pressure, and then extruded through fine nozzles. The paste undergoes further treatment and drying and ends up as texturized vegetable protein. The spinning process produces meat-like fibres of soya protein which are combined to make meat-like products.

15.3
USING TEXTURIZED VEGETABLE PROTEIN

Main ideas in this section

Texturized vegetable protein can be used to extend a wide range of food materials.

The replacement and extension of meat and fish is just one application of this versatile material.

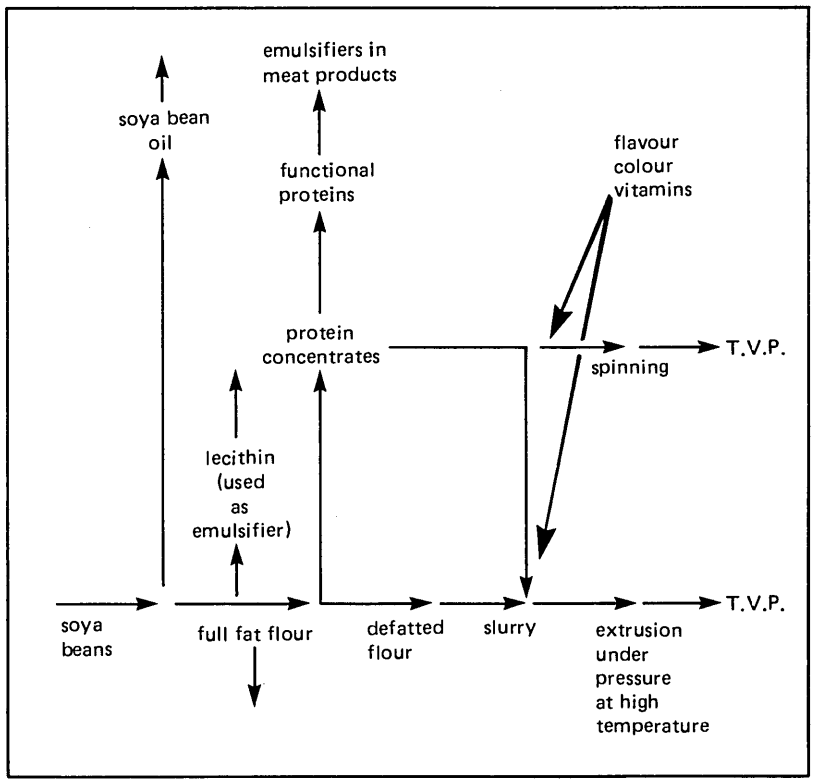


Figure T15.1
The manufacture of texturized vegetable protein from soya beans.

Practical skills

A dish which demonstrates the application of texturized soya protein is tuna salad. The experiment compares a tuna salad incorporating soya protein with a mix made without extender.

Observing

You will need for each pair or group of pupils

75 g canned tuna fish
15 g dry 'natural' T.V.P. mince
15-ml (table) spoon vinegar
Juice of ½ lemon (optional)
2 15-ml (table) spoonfuls mayonnaise
Seasoning
2 mixing bowls labelled A and B
Spoon
6 saucers
Labels

Assessing (validity)

The two mixtures are compared by a taste panel using the Triangle test. This is used to find out if there is a significant difference between two samples of food. The same test can be

Communicating (writing)

used to compare other dishes made with and without T.V.P. extender. Worksheet FSM14 will be useful here.

Reasoning logically

Panellists are presented with three samples of food, two the same and one different. They are asked to pick out the odd sample.

Observation v inference

In this case, three panellists are presented with two samples of the tuna mix without T.V.P. and one with extender. Three other panellists are given two samples of mix including extender and one without. This serves to make best use of the mixtures and avoids influencing the panellists by the order of presentation of of the samples. The samples could be presented on water biscuits if pupils prefer this.

Q 8

Reasoning logically

If there is a significant difference between the two mixtures, then five or six of the panel would be expected to pick out the odd sample correctly. Four correct selections suggests a less significant difference between the samples.

Q 9

If there is no significant difference between the mixtures, then each sample might be expected to be selected by two panellists.

Assessing (validity)

It is important that pupils recognize the significance of taste panel results. Ideally, results require statistical interpretation in order to assess their significance. Questions 8 and 9 introduce the idea that results require interpretation. This may prove a useful link with mathematics teaching.

Q 10

Evaluating

The tuna salad recipe provided should give a very acceptable mixture which is difficult to distinguish from a salad made with tuna alone. The taste panel result should demonstrate this.

Designing tests

It is important in all recipes that the correct type of T.V.P. is selected and used in the recommended proportions (taking care to note whether the recipe specifies hydrated weight or dry weight).

Q 11

Assessing (relevant factors)

An advantage which the use of T.V.P. provides is a reduction in the cost of dishes. Pupils might be asked to compare the cost of the two mixtures, as well as considering which they prefer, and why. *Nutrition* Chapter 9 discusses the nutritional value of T.V.P.

Extension work

Texturized vegetable protein is available in a range of shapes, sizes, colours, and flavours. Encourage pupils to develop recipes incorporating texturized protein to extend more expensive ingredients, such as the fruit in pie fillings, or mincemeat.

Observing

The labels of convenience products might be examined to discover whether texturized vegetable protein is used as an extender, for instance in sausages, meat pies, and canned meat products. Note that the meat content of such foods is governed by legislation. The use of T.V.P. in school meals could also be investigated.

15.4
NOVEL PROTEINS

Main ideas in this section

Proteins can be obtained from a wide variety of beans and other seeds.

They can also be obtained from single-cell organisms and from leaves.

Figure 15.8
One of the earliest attempts to produce protein from single-cell organisms was from an algae called *Chlorella*. It was found to require too much energy to be a worthwhile proposition. But yeasts and certain bacteria seem much more promising. There is now a whole new applied science called biotechnology. Yeast can now be grown on various products obtainable from crude oil, fungus can be grown on waste vegetable matter, and certain bacteria can utilize methanol, a by-product of natural gas production. These organisms can be harvested, processed, and converted into food materials. Stress the need for processing to remove harmful substances from the organisms to ensure that no live organisms pass to the food chain, and to render the protein more acceptable as a foodstuff in a convenient form.

Applying knowledge

Q 12

Using references

Assessing (ideas)

People already eat bacterial proteins in yoghurt and cheese, but there is an underlying suspicion about eating micro-organisms because of the association with disease and decay. There will almost certainly be resistance to the idea of eating them. Worksheet FSM9 may be useful here.

Communicating (speech)

Discuss the ways in which taste and texture problems are overcome by purifying the protein in a processing plant and by modifying the shape and structure of the protein (texturizing) and adding suitable flavours and colours. These problems are similar to those which are faced by the producers of T.V.P.

Leaf protein has been used to supplement diets in developing countries. It can be manufactured from a range of leafy plants, depending on what is available in the country where it is manufactured.

Q 13

Reasoning logically

The leaves are minced to release the protein-containing cell contents and the juice heated to 80 °C to denature the protein. The coagulated protein can be dried and added to foods in the normal diet of people in a developing country. This supplement also provides additional Vitamin A in the diet.

Sunflower and cotton seeds produce useful quantities of vegetable oil suitable for food purposes and are good sources of protein.

Extension work
As a practical activity, pupils could find recipes for dishes using peas, beans, or cereals and prepare some of them.

They could compare these with dishes which include T.V.P, both for ease of preparation and palatability.

They could also investigate 'whole foods' and the diets of vegans and vegetarians. This provides a useful link with *Nutrition* (Chapter 2).

15.5 OTHER FOOD INGREDIENTS

Main ideas in this section

Ingredients used by the food manufacturer are not always instantly recognizable, but are discovered amongst the ingredients listed on food packages.

They are added over and above those ingredients normally expected in foods and are referred to as 'additives'.

Q 14

Communicating (speech)

This is a question for discussion. Food manufacturers aim to produce goods that their customers want to buy. They need to make a profit and so most produce foods of acceptable quality at low cost. Market research and advertising could be discussed here. (See also the Background reading at the end of Chapter 10.)

Q 15 and Q 16

Suggesting hypotheses

The manufacturer uses these ingredients to:

1 enable foods to withstand processing (freezing, canning, and so on), *e.g.* anticaking agents and modified starches.
2 increase the shelf-life, *e.g.* preservatives.
3 improve texture, *e.g.* emulsifiers and stabilizers (see Chapters 10 and 11).
4 improve flavour, *e.g.* fruit flavours and crisp flavours.
5 improve colour, *e.g.* fruit drinks.
6 facilitate use by the consumer, *e.g.* colours in fruit squash to assist dilution, or additives to improve flow and prevent caking, *e.g.* sodium aluminium silicate (china clay) in coffee whitener.
7 give a consistent product.
8 keep costs as low as possible.
9 maintain nutritional standards (fortification).

Applying knowledge

The use of additives in food is a controversial topic. Remind pupils that food additives are constantly subjected to rigorous testing and legal control. Regulations vary from country to country. Very few additives are universally acceptable. With increased reliance on pre-processed foods, an increase in the consumption of food additives is to be expected. In the United States, calorie-reduced drinks containing saccharine carry a health warning label! Pupils might be asked which is best: low calorie drinks with saccharine or drinks made using sugar? There is also concern that people are becoming allergic to certain additives such as the colour tartrazine.

Questions in this section require pupils to formulate a definition of the term additive and to explain the role of different additives in foods. A satisfactory definition will indicate that they are substances not normally encountered in fresh foods, but are added by the food manufacturer for the reasons listed earlier. They are thus ingredients of preserved, processed, and convenience foods.

Pupils should recognize words like emulsifier, stabilizer, and preservative from previous chapters and be able to explain why they are used in foods.

Flavours and colours are added to give foods and drinks of standard quality and to overcome flavour and colour changes which occur during processing. Preservatives are added to extend shelf-life. Emulsifiers and stabilizers are used to improve the texture and shelf-life of sauces, desserts, and food emulsions.

Some ingredients used by the manufacturer need modification if they are to survive the processes to which foods are subjected. Sauces thickened by cornflour or wheat flour, for example, will curdle when frozen. This is because the starch molecules tend to 'clump together' or recrystallize, a process known as retrogradation. The water or liquid which was dispersed in the sauce between and around the starch molecules is 'squeezed out', giving a curdled or lumpy appearance (see Chapter 10). The separation of liquid is called syneresis.

This problem is overcome by chemically treating starch so that the molecules are more branched and cross-linked. The modified molecules will not retrograde and so sauces thickened with this type of sauce withstand freezing.

Alginates are widely used to stabilize food mixtures. They are manufactured to a variety of specifications to suit the different applications.

Worksheets FSM4, FSM10, FSM11, and FSM12 may be useful in this section.

15.6
WHAT FOOD LABELS SAY

Main ideas in this section

The ingredients in foods must be listed on the label.

The list is in order of decreasing amounts, but does not need to give actual amounts.

By reading the label carefully it should be possible to recognize substitutes and to avoid ingredients which may cause allergies.

Observing

A collection of food labels will reveal a wide range of ingredients, some familiar, some unfamiliar. Pupils should recognize many of these ingredients from work in previous chapters.

Suggesting hypotheses

Q 17, Q 18, and Q 19

Food science is a complex area of study. This text has introduced only some of the ideas and information from this fascinating and rapidly developing science. Additives with peculiar sounding names appear on food labels and understanding of their role in foods may be beyond the layman. The questions which complete the pupils' text should promote discussion of the current state of awareness by the consumer of the role of additives in food, reliance on the food manufacturer to provide food which is wholesome and safe to eat, and the usefulness of information which appears on food labels. The quality and quantity of additives used is strictly controlled by legislation and there is continued investigation of their safety.

Applying knowledge

A further question might be 'What kind of people require the detailed information which appears on food labels?' These would include people with food allergies, those on special diets, and those on reducing diets.

Extension work

Designing tests

An additional practical activity is the production of dishes using novel ingredients. These can be compared with dishes made by conventional methods.

Selecting equipment

Meringue can be made using methyl ethyl cellulose (offered by ICI as 'Edifas A' and from whom further information is available).

Practical skills

Gravies and sauces can be thickened using alginates (obtainable with further information from Alginate Industries Ltd, 22 Henrietta Street, London WC2E 8NB). Alginates may also be used to make jellies and flans.

Processes and skills	Pupils may be able to:
15.1 *How do food shops in the 1900s and 1980s compare?* Observing, reasoning logically, using data and other references. Communicating (speech), identifying causes, assessing (relevant factors).	Identify the changes in the foods on sale from the 1900s to the 1980s. Recognize that the changes involve a wider choice and new foods. Discuss what is meant by convenience foods and apply this knowledge in order to identify a variety of convenience foods. Understand that many of the changes during this century are due to changes in life-style and food production.
15.2 *Protein foods* Identifying causes, suggesting hypotheses, applying knowledge, reasoning logically, interpreting graphs, using references.	Recognize that meat is a costly source of protein. Identify alternative sources of protein. Compare the protein content of a variety of basic foods in Britain and other countries. Plan menus which have a satisfactory protein content and are reasonable and acceptable.
15.3 *Using texturized vegetable protein* Using practical skills, observing, assessing (validity), communicating (writing), reasoning logically, assessing (ideas).	Use T.V.P. to produce an acceptable tuna fish dish. Carry out a Triangle test to compare various adaptations of this recipe. Recognize the inclusion of T.V.P. in convenience foods by checking the labels.

Processes and skills	Pupils may be able to:
15.4 *Novel proteins* Using references, assessing (ideas), applying knowledge.	Recognize that proteins can be obtained from micro-organisms (S.C.P.). Understand that with suitable processing these proteins can be made into safe, acceptable foods, or used to feed animals.
15.5 *Other food ingredients* Observing, suggesting hypotheses, applying knowledge.	Recognize the ingredients listed on food packages and divide them into 'normal' ingredients and additives. List the additives most common in convenience foods. Recognize the names of these additives. Apply knowledge from previous chapters to identify the possible use of each additive. Recognize that the use of additives is controlled by law.
15.6 *What food labels say* Observing, suggesting hypotheses, applying knowledge.	Recognize ingredients which are: anti-caking stabilizers anti-foaming emulsifiers anti-oxidants preservatives. Observe and comment on labels of convenience foods new to the pupil. Design a label for a new food.

Ideas for homework

Pupils could design an advertising campaign to sell dried bacterial protein.

They could collect information from food manufacturers on careers in the food industry.

Assessing (relevant factors)

The Background reading describes old and new sources of protein and how they can best be used in different parts of the World. This has close links with *Nutrition*, Chapter 9. There are plenty of opportunities for projects in this area. A talk by a representative of one of the relief agencies might be appropriate here. Pupils could find out about 'intermediate technology' used to process foods in developing countries.

Reference material

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The Flour Advisory Bureau have very extensive teaching aids. These include leaflets, samples, and films. Leaflets include 'The why and where of wheat'; 'The storage of bread and flour'; 'Bread in Britain'; 'Home freezing bread and flour products'; 'Bread through the ages'. Films include 'Bread: something of a miracle', which is a general film on milling and baking and the role of bread in the nation's diet.

Food Standards Committee (1974) *Second report on bread and flour.* H.M.S.O. (Out of print.)

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Maljers, F. (July/August 1979) 'The ten fat years?' *Unilever magazine.* No. 33. 16-20.

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National Dairy Council. 'Dairy microbiology'.

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Nuffield Chemistry (Revised) (1978) *Handbook for pupils.* Longman. (See Chapter 9 The structures of elements and compounds.)

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'Seed crushing and oil processing in the U.K.'; 'The story of margarine'. Van den Berghs and Jurgens Ltd. They also supply Stork all-in-one leaflets.

Which? (September 1982) 'So you think you know what you're eating.' Consumers' Association.

Useful addresses

Names and addresses of organizations which provide educational material, for some of which a charge is made.

Advertising Association, Abford House, 15 Wilton Road, London SW1V 1NJ.
Bejam Freezer Food Centres Ltd, 1 Garland Road, Honeypot Lane, Stanmore, Middlesex HA7 1LE.
Belling & Co. Ltd, Enfield, Middlesex.
Birds Eye Wall's Ltd, Public Relations Department, Station Avenue, Walton-on-Thames, Surrey KT12 1NT.
Blackwell Scientific Publications Ltd (publishers of the *Journal of consumer studies and home economics*), Osney Mead, Oxford OX2 0EL.
Borwicks, H.J. Greens Limited, Portland Road, Hove, Sussex BN3 5ST. (Address requests for teaching materials and inquiries about baking powders to 'the home economist'.)
British Egg Information Service, 37 Panton Street, London SW1Y 4EW.
British Farm Produce Council, Agriculture House, Knightsbridge, London SW1X 7NJ.
British Gas Education Service, Room 707A, 326 High Holborn, London WC1V 7PT.
British Nutrition Foundation (publishers of *Nutrition bulletin*), 15 Belgrave Square, London SW1 8PS.
British Standards Institution, 2 Park Street, London W1A 2BS.
British Sugar Bureau, 140 Park Lane, London W1Y 3AA.
Cadbury Typhoo, Food Advisory Service, PO Box 171, Franklin House, Bournville, Birmingham B30 2NA.
Camera Talks Ltd, 31 North Row, London W1 2EN.
Canned Food Advisory Service, Tempo House, 15—27 Falcon Road, London SW11 2PJ.
Central Statistical Office, Cabinet Office, Great George Street, London SW1P 3AQ.
Consortium of Local Education Authorities for the Provision of Science Equipment (CLEAPSE), Brunel University, Uxbridge UB8 3PH.
Consumers' Association (publishers of *Which?*), 14 Buckingham Street, London WC2N 6DS.
T I Creda Ltd, Advertising Department, Blythe Bridge, Stoke-on-Trent ST11 9LJ.
Danish Agricultural Producers, Danish Centre, 2/3 Conduit Street, London W1R 0AT.
Design Council, The Design Centre, 28 Haymarket, London SW1Y 4SU.
Dimplex Heating Ltd, Marketing Department, Millbrook, Southampton SO9 2DP.

Electrical Association for Women, 25 Foubert's Place, London W1V 2AL.
Electricity Council, Understanding Electricity, 30 Millbank, London SW1P 4RD.
Flour Advisory Bureau, 21 Arlington Street, London SW1A 1RN.
Food Research Institute, Agricultural Research Council, Colney Lane, Norwich, NR4 7UA.
Forbes Publications Ltd (publishers of *Nutrition and food science*), Redan House, Redan Place, London W2 4SH.
Griffin & George Ltd, 285 Ealing Road, Alperton, Wembley, Middlesex HA0 1HJ.
The grocer, 5 Southwark Street, London SE1 1RQ.
Health Education Council, 78 New Oxford Street, London WC1A 1AH.
H.J. Heinz Co. Ltd, Hayes Park, Hayes, Middlesex UB4 8AL.
The home economist, Stonebridge Press, 823—825 Bath Road, Bristol BS4 5NU.
Hotpoint Ltd, Peterborough PE2 9JB.
Imperial Chemical Industries, Plastics Division, Academic Liaison Officer, PO Box 6, Bessemer Road, Welwyn Garden City, Hertfordshire AL7 1HD.
Institute of Agricultural History and Museum of English Rural Life, University of Reading, Whiteknights, Reading RG6 2AG.
Institute of Food Science and Technology, 105—111 Euston Street, London NW1 2ED. (For further information on courses and careers in food science and technology.)
International Wheat Council, Haymarket House, 28 Haymarket, London SW1Y 4SS.
Journal of consumer studies and home economics, Blackwell Scientific Publications Ltd, Osney Mead, Oxford OX2 0EL.
Journal of human nutrition, John Libbey and Co. Ltd, 80—84 Bondway, London SW8 1SF.
Lever Brothers Education Unit, International Teaching Resource Centre, PO Box 10, Wetherby, Yorkshire LS23 7EH.
John Libbey and Co. Ltd (publishers of the *Journal of human nutrition*), 80—84 Bondway, London SW8 1SF.
Long Ashton Research Station, Department of Agriculture and Horticulture, University of Bristol, Long Ashton, Bristol BS18 9AF.
Longman Group Limited, Longman House, Burnt Mill, Harlow, Essex CM20 2JE.
Longman Resources Unit, 33—35 Tanner Row, York YO1 1JP.
Lyons Maid Ltd, Glacier House, Brook Green, London W6 7BT.
Marine Harvest Ltd, Craigcrook Castle, Edinburgh EH4 3PF.
Marks and Spencer plc, Michael House, 47—67 Baker Street, London W1A 1DN.
Meat Promotion Executive, Meat and Livestock Commission, 5 St John's Square, Smithfield, London EC1M 4DE.

Microwave Oven Association, 16A The Broadway, London SW19 1RF. (Provides information and leaflets relating to microwave cooking.)
Milk Marketing Board, Dairy Products Advisory Service, Thames Ditton, Surrey KT7 0EL.
Modus, National Association of Teachers of Home Economics, Hamilton House, Mabledon Place, London WC1 9BJ.
National Coal Board, Press and Public Relations Office, Hobart House, Grosvenor Place, London SW1X 7AE.
National Dairy Council, National Dairy Centre, John Princes Street, London W1M 0AP.
National Vegetable Research Station, Wellesbourne, Warwick CV35 9EF.
Nottingham Educational Supplies, 17 Ludlow Hill Road, Melton Road, West Bridgford, Nottingham HG2 6HD.
Nutrition and food science, Forbes Publications Ltd, Redan House, Redan Place, London W2 4SH.
Nutrition bulletin, The British Nutrition Foundation, 15 Belgrave Square, London SW1 8PS.
Office of Population Censuses and Surveys, Information Branch (Dept M), St Catherine's House, 10 Kingsway, London WC2 6JP.
Philip Harris Ltd, Lynn Lane, Shenstone, Staffordshire WS14 0EE.
Pictorial Charts Educational Trust, 27 Kirchen Road, London W13 OUD.
Potato Marketing Board, Press and Public Relations Office, 50 Hans Crescent, London SW1X 0NB.
Poultry Research Centre, Agricultural Research Council, Roslin, Midlothian EH25 9PS.
Prestige Group Ltd, Prestige House, 14—18 Holborn, London EC1N 2LQ.
R.S. Components Ltd, 13—18 Epworth Street, London EC2P 2HA.
Ranks Hovis McDougall plc, King Edward House, PO Box 178, 27—30 King Edward Court, Windsor, Berkshire SL4 1TJ.
Royal College of Physicians of London, 11 St Andrew's Place, Regent's Park, London NW1 4LE.
Royal Society for the Prevention of Accidents, Cannon House, The Priory, Queensway, Birmingham B4 6BS.
Ross Foods Ltd, Ross House, Grimsby, South Humberside DN31 3SW.
J. Sainsbury plc, Stamford House, Stamford Street, London SE1 9LL.
Sea Fish Industry Authority, Sea Fisheries House, 10 Young Street, Edinburgh EH2 4JQ.
Solid Fuel Advisory Service, Coal House, Lyon Road, Harrow-on-the-Hill, Middlesex HA1 2EX.
Stonebridge Press (publishers of *The home economist*), 823—825 Bath Road, Bristol BS4 5NU.

T I Tower Housewares Ltd, PO Box 16, Wombourne, Wolverhampton WV5 8AQ.
Unilever Education Section, PO Box 68, Unilever House, London EC4P 4BQ.
United Kingdom Committee for UNICEF, 46—48 Osnaburgh Street, London NW1 3PU.
United Nations London Information Centre, 14 Stratford Place, London W1N 9AF.
Van den Berghs and Jurgens Ltd, Sussex House, Civic Way, Burgess Hill, West Sussex RH15 9AW.
Watt Committee on Energy Ltd, 75 Knightsbridge, London SW1X 7RB.
Which? The Consumers' Association, 14 Buckingham Street, London WC2N 6DS.

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